Wireless World

VOL. LVI. No. 12. DECEMBER 1950

Half a Loaf

IN spite of constant pressure for several months, the authorities hold out no promise of restoring the Airmet transmissions of meteorological data. In November, the Postmaster General, answering in Parliament several questions on the subject, acknowledged the value of the service to various sections of the community but expressed regret that it had been found impracticable to make any broadcast frequency available for the restoration of the service. He went on to say the possibility of improving the weather information available to the public was being considered in conjunction with other departments and the B.B.C., and he understood that some amplification of the B.B.C. weather forecasts would be introduced shortly.

From this we gather there is little prospect of resumption of the original Airmet service, transmitted either by the Air Ministry or the Ministry of Civil Aviation, and we are confirmed in our belief that any improved service for which we may hope will eventually be broadcast by the B.B.C. The Corporation is, we believe, the proper authority for distributing a service that, after all, is of more or less direct benefit to the whole community, though only of incidental concern to any particular Ministry.

Unfortunately, however, the "amplified" B.B.C. weather service foreshadowed by the Postmaster General has turned out to be something that can barely be called even a compromise. All we can say in its favour is that the change in the method of forecasting does at least acknowledge the possibility of improving the old system. The total time given daily to the weather has not been increased, but the 6 p.m. bulletin has merely been improved insofar as the various stations deal with the weather in their own areas, and so can treat it in somewhat greater detail than if they were dealing with the country as a whole. That, of course, is a step, but only a very small one, in the right direction. The B.B.C. authorities must go much farther when they ultimately assume the responsibility—which we believe will inevitably be theirs—for distributing the improved service of weather bulletins of which this country, with its uncertain island climate, stands so much in need.

It is no business of *Wireless World* to go into the question of what constitutes an acceptable service. All we need say is that it should be much more detailed, localized and frequent than at present. Our concern is merely to press for a proper use to be made of radio in the one sphere where it is the only practicable medium for the distribution of information to the general public. We believe fresh weather charts are prepared at the Central Meteorological Office every three hours of the twenty-four, and it can be argued that broadcasts should be no less frequent. It must be galling for a forecaster to be unable to pass on up-to-date information for the reason that there may not be another broadcast for as long as 13 hours. Then there is the question of data (as opposed to forecasts) which, on the Airmet system, allowed the listener to follow the pattern of rain or sunshine across the country and, if not to do his own forecasting, at least to cross-check the official assessment of the situation as it affected him personally.

We doubt whether it was worth while disturbing the old-established B.B.C. routine for the trivial change that has been made. Something much more drastic, providing the detailed localized and frequent bulletins admitted to be necessary, must be done if radio broadcasting is to establish itself as the source *par excellence* of up-to-date weather information.

Fairly obviously, the ideal bulletin, or rather system of bulletins, would be planned by a meteorologist with a sympathetic understanding of the needs of the widest possible circle of listeners. Not only should the information most needed by the majority be given, but the timing and make-up of the various sections should be so arranged and standardized that the user of the service would be able to obtain what he wanted without wasting too much time in listening to those parts of the bulletin outside his individual concern.

Aerial Feeder Connections

Balance-to-Unbalance Transformer

By W. T. COCKING, M.I.E.E.

THE connection between the aerial and the receiver does not always receive the attention which it deserves, even in these days when so much is known about cables and their terminations. The need for matching is generally realized but the desirability of including balance-to-unbalance transformers is all too often unrecognized.

The ordinary receiver requires an unbalanced input; that is, of its two input terminals one is earthy and the other is live. The dipole aerial, however, is balanced to earth. Neither of its two terminals is earthy, but they undergo equal and opposite variations of potential with respect to earth.

Feeder cables are of two kinds, balanced and unbalanced. The first is the twin-wire feeder, which may or may not have an outer screening sheath. It is intended to operate in the balanced condition so that at any point along its length the potentials of its two wires are equal and opposite with respect to earth. Such a feeder is clearly suited for direct connection to a dipole aerial, both being balanced structures, but is not suitable for connecting directly to the receiver.

The second type of feeder, the unbalanced, is the coaxial cable. Equally clearly this is suitable for connecting to the receiver but does not fit into a direct connection to the aerial.

In practice, both kinds of feeder are commonly used in direct connection to both aerial and receiver and these improper operating conditions do not have any very obvious effect on the performance. The loss of signal is usually negligible, and although the polar diagram of the aerial may be affected somewhat the alteration is not at all evident.

Twin-wire Feeder

One characteristic of the system, however, is greatly affected. The feeder becomes liable to pick-up signals and so acts in some measure as an aerial instead of merely conveying the signals picked up by the aerial to the receiver. In many domestic installations this does little harm. However, if the feeder passes through a region of local interference it picks it up and passes it to the receiver, whereas it should be immune to it.

There is no doubt at all that in buildings containing electrical machinery a serious amount of interference can be picked up by the feeder. It is probable, too, that in the domestic installation more ignition interference may be picked up by the feeder than by the aerial in certain cases. It may well be that this will occur only in exceptional cases, but it is a point to watch.

A twin-wire feeder connected between the aerial and the first circuit of the receiver is shown in Fig. 1(a). Even if the earth connection to one side of the feeder is omitted, this feeder wire will be effectively earthed by capacitive coupling between the windings of the input transformer. The feeder is operated in a balanced condition at the aerial and in an unbalanced at the receiver and there is a gradual transition from the one to the other along the feeder. Now any voltages induced in the feeder, say at point A, by a local interference field, are equal in each wire and act in the same direction in both. Interference currents thus flow in the same direction in both wires.

At the receiving end the current in the earth wire flows to earth without harm but the current in the live wire flows through the coupling coil and so induces an interference voltage into the tuned circuit. However, if the feeder is terminated by a balanced circuit, such as a push-pull transformer, this can be avoided. This is shown at (b). The equal currents in the two wires flow through the two halves of the coupling coil and oppose each other in the winding. There is then no interference voltage induced into the tuned circuit.

In practice, the capacitance between the windings has a serious effect and the precise arrangement of Fig. 1(b) does not provide adequate immunity from interference. The effects of the capacitance can be overcome, however, by interposing a screen between the windings, as indicated in Fig. 1(c). If the secondary is the tuned-grid coil of the first valve, the use of a screen may not be permissible, however. The screen greatly increases the capacitance of the circuit and so necessitates a lower inductance and a smaller shunt damping resistance if the bandwidth is

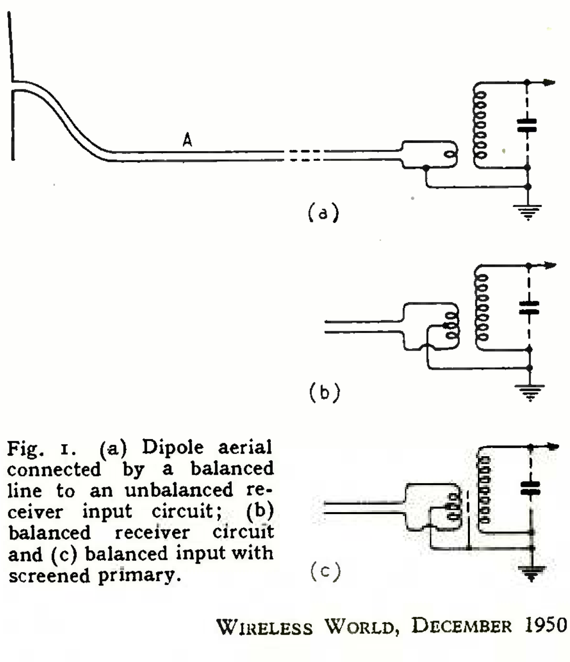


Fig. 1. (a) Dipole aerial connected by a balanced line to an unbalanced receiver input circuit; (b) balanced receiver circuit and (c) balanced input with screened primary.

to be maintained. In its turn this means a reduction of the voltage step-up between the feeder and the grid of the valve.

With a coaxial feeder the difficulty arises at the aerial end. Referring to Fig. 2, an interference e.m.f. induced in the outer of the cable sets up a current in it which flows round the complete circuit cable outer, lower half of dipole, capacitance to earth. The field here naturally energizes the upper half of the dipole also and a current is passed through the inner of the cable to the receiver. In effect, there is one closed circuit from earth through the cable outer, the lower dipole element and its capacitance to earth and there is a second closed circuit from earth through the receiver coupling coil, the cable inner, the upper dipole element and its capacitance to earth.

The capacitance to earth of the two halves of the dipole is largely common to both circuits and couples the two so that interference picked up in one circuit is transferred to the other.

Transformer Coupling

This effect can be avoided by including a push-pull transformer at the aerial end of the cable, as shown in Fig. 2(b). An interference current in the cable outer is now passed to the centre tap on the transformer primary and ideally divides equally through the two halves of the winding and passes to the two halves of the aerial. The currents are in opposition in the transformer and nothing is induced into the secondary which is connected to the inner of the cable.

Exact equality of currents may not be achieved because the capacitances to earth of the two halves of the aerial may not be equal. An electrostatic screen between windings is also often advisable, just as in the case of a receiver input transformer.

This form of transformer is very effective in reducing the pick-up of interference by a coaxial cable and in cases of bad interference can improve the signal/interference ratio by 20 db or more. It is not a method commonly adopted, however, largely because of the practical difficulty of weather-proofing the transformer. More often an equivalent result is achieved with resonant sleeves.

The use of such sleeves, or of resonant lengths of line, offers severe difficulties to the experimenter because it is not easy to determine their proper dimensions. They require adjustment *in situ* on the aerial. In addition, proper weather-proofing is not easy. The transformer of Fig. 2(b) is much more suitable for the amateur since it requires no adjustment, but the problem of weather-proofing is a difficult one for him to solve.

Although the actual coupling difficulties are much the same with any type of feeder the twin wire has the great advantage that the coupling transformer can be in the receiver and need not be up with the aerial exposed to the weather. Because of this, any adjustments to it can be carried out much more easily. It does seem, therefore, that the twin-wire feeder is more suited to amateur use than coaxial. It is also becoming more widely used in commercial television receivers, partly because it is cheaper and partly because there are no weather-proofing difficulties of the balance-to-unbalance transformer or "balun."

The precise arrangement of Fig. 1(c) is not often used at television frequencies, largely because the screen between the windings makes the capacitance

Fig. 2. (a) Dipole aerial connected by an unbalanced feeder to a receiver, and (b) a balance-to-unbalance transformer at the aerial.

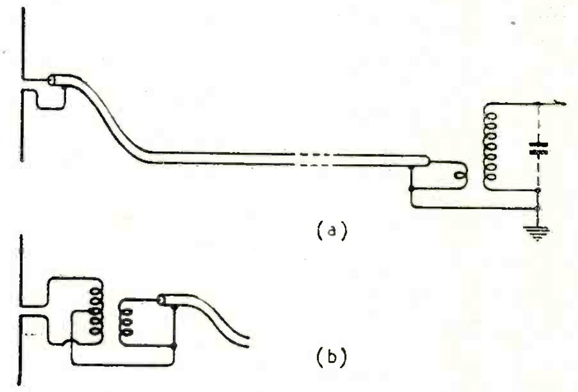


Fig. 3. In order to avoid a high-capacitance circuit at the receiver input a separate balun can be used.

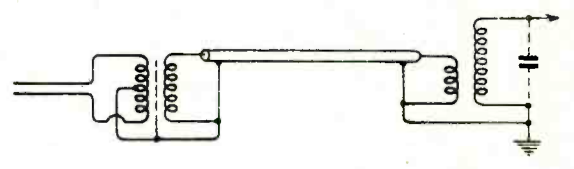
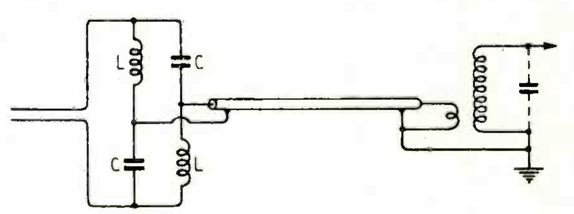


Fig. 4. The LC network shown gives a balun action without being a transformer.



on the tuned circuit so large that the voltage step-up in the transformer is greatly reduced. Instead a separate coupling transformer is often used. This arrangement is shown in Fig. 3 and the transformer is of 1 : 1 ratio with a centre-tapped winding and a screen between the windings. Because of the low impedance of the circuit—$72\,\Omega$ on each side—the capacitance is relatively unimportant.

If the transformer is physically close to the input circuit of the set the two can be directly connected, but if it is more than a few inches away a length of coaxial cable should be used to join them, as shown in Fig. 3.

This form of balun is not hard to construct and would be very easy were it not for the screen. Very tight coupling between the windings is necessary and the screen makes it difficult to get this. It is, however, possible to approach the screened condition very closely, without actually using a screen, by a particular form of construction. The secondary is wound with a strip of copper foil interleaved with paper for insulation. About 12 turns of $\frac{3}{8}$-in strip, interleaved with a $\frac{1}{2}$-in strip of paper, on a $\frac{1}{4}$-in diameter former is about right. The inside end of the winding is the "hot" end and the outside end is earthed. The centre-tapped primary of about 12 turns is wound as a single layer of wire outside the earthy turn, so that capacitive coupling exists only to one turn of the secondary.

It is possible to obtain the balun effect without an actual transformer, however, and an interesting circuit which is used in the latest Pye receivers is shown in Fig. 4. It has been previously described,[1] but is not as well known as it should be. The balance-to-unbalance is obtained from the network comprising the two equal inductances L and the two equal capacitances C.

The network has the configuration of a bridge and exact analysis can be quite complex. Fortunately, much of this complexity can be avoided if a little ingenuity is employed in devising equivalent circuits. The well-known star-delta theorem, in particular, is a great help.

We want to know three things about the circuit :—

(a) Its input and output impedances.

(b) The ratio of the input to the output voltages (or currents or powers).

(c) Its balance.

Impedance

Let the impedance of the circuit connected to the input be Z_B and that connected to the output be Z_U. The circuit can then be drawn as in Fig. 5(a). The first thing to be noticed is that it is reversible. If we find the input impedance in terms of L, C and Z_U the output impedance is given by the same expression if we substitute Z_B for Z_U in it. We can see also that if Z_B and Z_U are equal the input and output impedances will also be equal.

To find the impedance we re-draw the circuit as in Fig. 5(b) where Z_U is split into two impedances in parallel. The network comprises the series connection of two triangles of impedances (deltas), but twisted at their connection. If we apply the star-delta theorem to each we get the arrangement of Fig. 5(c), the corresponding points of connection in (b) and (c) being similarly numbered.

We can see at a glance that the input impedance is

$$Z_{IN} = 2Z_3 + (Z_1 + Z_2)/2$$

and inserting the L, C and Z_U values by means of the star-delta theorem (see Appendix) we get

$$Z_{IN} = Z_U \frac{2L/CZ_U + j\omega L + 1/j\omega C}{2Z_U + j\omega L + 1/j\omega C}$$

It can at once been seen that if $L/C = Z_U^2$ all terms in the fraction cancel and $Z_{IN} = Z_U$ at all frequencies. Similarly, the output impedance $Z_U = Z_B$.

If L/C does not equal Z_U^2, then at the resonance frequency of LC, and only at this frequency, $Z_{IN} = L/CZ_U$. The circuit then acts as an impedance transformer of ratio $Z_{IN} : Z_U :: L/CZ_U^2 : 1$. This action is not usually necessary and in what follows it will be taken that $L/C\ Z_U^2 = 1$, so that $Z_U = Z_B = Z_{IN} = Z_0$. The terminal impedances must, of course, be pure resistances in this case, but this is the assumption usually made with circuits of this nature.

Transfer Ratio

It is possible to determine the ratio of output to input power from the circuit equations, but it is unnecessary to do so in this case. In the matched condition $Z_B = Z_{IN}$ and $Z_0 = Z_U$. The whole of the power delivered by the input feeder of impedance Z_B is, therefore, absorbed by the network without reflection. The whole of the output power of the network is absorbed in the output feeder of impedance Z_U equal to Z_0 and again there is no reflection. The network itself comprises pure reactances L and C and so can itself dissipate no power. Hence, the input and output powers must be equal.

With $Z_U = Z_B = Z_{IN} = Z_0$, therefore, the output voltage, current and power are equal to the input voltage, current and power at all frequencies and the network introduces no loss.

In practice, of course, there will be some loss associated with L and C but this can be kept small by using high Q components.

Balance

Under one condition the balance is very easy to determine. This is when the unbalanced signal in the feeder is such that the two input terminals of the LC network are always at the same potential to earth. This means that in Fig. 5(a) the two ends of Z_B are at the same potential. They can, therefore, be joined together without affecting anything. One LC circuit then becomes a parallel-resonant circuit in shunt across the input and the other becomes a parallel-resonant circuit in series with Z_U. The equivalent circuit has the form shown in Fig. 6.

Since we are ignoring resistance losses in L and C this parallel-resonant circuit is of infinite impedance at resonance and at this frequency offers an infinite barrier to unbalanced signals at the input. At any frequency the ratio of output to input voltages is

$$\frac{e_0}{e_1} = \frac{1}{1 + jx/(1 - x^2)} = \frac{1}{\sqrt{[1 + x^2/(1 - x^2)^2]}}$$

where $x = \omega\sqrt{LC}$.

If f_0 is the resonance frequency and Δf is a small change of frequency from this value ($\Delta f \ll f_0$) then approximately

[1] "Aerials for Metre and Decimetre Wavelengths," by R. A. Smith, p. 105, Cambridge University Press.

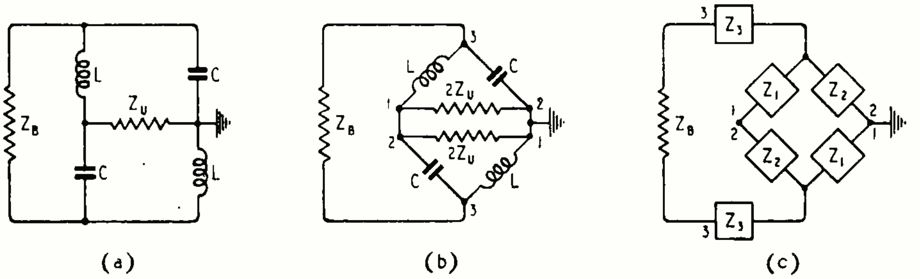
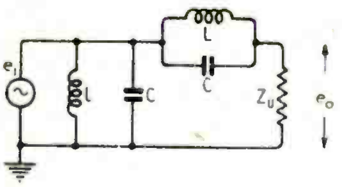


Fig. 5. Circuit of balun with its terminating impedances (a), an equivalent (b) and a further equivalent (c) obtained by the star-delta theorem.

Fig. 6. Equivalent circuit of balun to unbalanced voltages in the feeder.



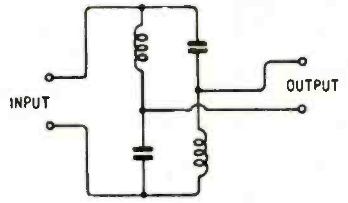


Fig. 7. The balun as a unit.

$$\frac{e_0}{e_1} = \frac{1}{\sqrt{[1 + (f_0/2\Delta f)^2]}} \approx \frac{2\Delta f}{f_0} \text{ when } 1 \ll (f_0/2\Delta f)^2$$

In television applications we are interested in a band of 3.5 Mc/s covering the sound and vision carriers. The maximum value of Δf is thus 1.75 Mc/s, so that the smallest value of $f_0/2\Delta f$ is 43.25/3.5 = 12.35.

The discrimination of the circuit against unbalanced signals in the feeder is infinite at the centre of the band and falls to about 22 db at the band edges in the worst case.

Circuit Values

The choice of L and C values for the circuit is very easy. For the conditions discussed, namely, $Z_B = Z_U$, only two conditions have to be met and these are $L/C = Z_U{}^2$ and $LC = 1/\omega_0{}^2$. Therefore, $C = 10^6/\omega_0 Z_U$ and $L = Z_U/\omega_0$ where $\omega_0 = 6.28$ times the mid-band frequency. The units are pF, μH, Mc/s and Ω.

As an example, if the frequency is 43.25 Mc/s and Z_U is 72 Ω, we get C = 51 pF and L = 0.265 μH.

Adjustment

Having computed the circuit values the proper values of capacitance should be used since capacitors can usually be bought with values sufficiently close to the correct ones. In any case, the values are such that they can easily be measured.

The inductances should be adjustable. Consider the LC network as a unit, Fig. 7, with two output terminals joined either directly or through a coaxial cable to the receiver. Join the two input terminals together and to a signal generator operating at the mid-band frequency. Adjust the inductance joined to the non-earthy output terminals for minimum output from the receiver. Reverse the output connections, so that the other inductance is joined to the non-earthy output terminal and adjust this second inductance for minimum output.

Adjustment is probably unnecessary when the proper dimensions of the coils have been determined. In production, an adequate balance is probably obtainable without individual adjustment once the proper winding has been determined.

This circuit has the great practical merit of being very simple and over the bandwidth of a television signal it gives a discrimination against an unbalanced signal of over 20 db, which is probably all that is needed. It has the disadvantage that it must be adjustable for different stations whereas it is possible to make a transformer which will cover the whole television band. As usual, every system has its advantages and disadvantages and, again as usual, the choice depends on the importance which is attached to each in individual circumstances.

APPENDIX

Star-delta Theorem

Referring to Fig. 5 we designate the delta impedances by the terminal numbers between which they are connected and the star impedances by the terminal numbers to which they are connected. Then

$$Z_1 = Z_{12}Z_{13}/Z$$
$$Z_2 = Z_{12}Z_{23}/Z$$
$$Z_3 = Z_{13}Z_{23}/Z$$

where $Z = Z_{12} + Z_{13} + Z_{23}$.

Wireless Servicing Manual

THIS book has long since become established as the radio serviceman's friend and adviser, dealing as it does with the location and cure of the innumerable faults which can develop in broadcast receivers and their associated equipment. Radio amateurs, as well as professionals, however, have also found it invaluable in solving many of the problems that arise in experimental and constructional work.

This eighth edition has been revised and brought fully up to date; in particular the chapter on television receiver defects has been completely rewritten. Apart from domestic sets, short-wave receivers and converters are covered, and there is also a special chapter devoted to servicing with the cathode-ray oscilloscope. Methods of ganging receivers of both the "straight" and superhet types are given in detail, and the all-too-common problems of hum and distortion are treated with the same thoroughness.

A useful appendix contains much information of the kind constantly required in everyday servicing work, and a very complete index has been provided to give the book added value for reference. "Wireless Servicing Manual" can be obtained from our Publishers, price 12s 6d (postage 5d), or from any bookseller.

Technical Instruction for Marine Radio Officers

ONE important feature of this book which will appeal to radio officers is that it provides a complete theoretical course for the P.M.G.'s certificates in radiotelegraphy and radiotelephony, together with a syllabus and a specimen examination paper. Originally published as the "Handbook of Technical Instruction for Wireless Telegraphists," it is now available in a ninth, revised, edition, the title having been changed in recognition of the fact that the sphere of activity of the marine radio officer has grown considerably in the course of the years. Nevertheless, the main object of the book remains unchanged—to provide simple instruction in general radio principles and practice for all those who operate marine wireless equipment.

Revision has been carried out on an ambitious scale. New chapters have been added on the cathode-ray oscilloscope, on e.h.f. generators such as the magnetron, and on radar recognition systems; whilst descriptions of new apparatus put in service since the war replace those of older equipment now out of production. The Instruction can be obtained from our Publishers, price 60s (postage 9d), or from any bookseller.

Simple Valve Voltmeter

An Inexpensive Instrument with Good Zero Stability

By S. W. AMOS,* B.Sc.(Hons.), Grad.I.E.E.

DURING the past year the author has constructed and used a number of simple types of valve voltmeter consisting of a detector followed by a d.c. amplifying stage. One result of this experience has been to underline the importance of two properties which are not sufficiently stressed in constructional articles on such instruments, yet are as important as accuracy of calibration, good linearity and high input impedance. These properties are zero stability and zero error and may be defined as follows:—

Zero Stability. The instructions for operating a valve voltmeter usually recommend that the zero control be operated to adjust the reading to zero, with the input short-circuited, and after the instrument has been switched on for at least several minutes. The instrument is then ready for use. With a perfect instrument the reading for no signal input will remain steady at zero without further adjustment of the zero control no matter how long the instrument is in use. This ideal is difficult to obtain, and there is usually some fluctuation of the no-signal reading. The steadiness of the no-signal reading is known as the zero stability.

Zero Error. After the zero control has been operated to adjust the no-signal reading to zero, there should be no change in reading when the range switch is operated. In this article such a change in reading is termed zero error and, by good design, can be eliminated completely.

Time Saving

If zero stability is poor the no-signal reading must be adjusted to zero before every reading. It is usually necessary to short-circuit the input before adjusting the control, and this may involve disconnecting the input terminals or the probe contact from the source of voltage under measurement. If the reading obtained on re-connecting the voltmeter in circuit is too small or too large, the range switch must be operated, and if the instrument has appreciable zero error, this will change the no-signal reading, necessitating a further adjustment of the zero control and disconnection of the input. With a poor instrument, therefore, it may be necessary to adjust zero before every reading and after every alteration of range.

To show how large the change in no-signal reading may be, the following figures were noted for two of the valve voltmeters used during the tests. In one model the no-signal reading varied over 30 per cent of full-scale reading during a period of several hours and never reached stability; in another, when zero was adjusted on one range, a reading of 50 per cent of full-scale deflection was obtained on switching to another range.

By combining the best features of all the instruments tested in a single valve-voltmeter circuit, an instrument was produced having good zero stability, no zero error and a satisfactory performance in other respects. It is a simple two-valve instrument incorporating a robust 0 – 0.5 mA. moving-coil meter and can be built using ex-Government components for less than £4. Details of the performance are given below.

1. After an initial warming-up period of 10 minutes, the no-signal reading of the instrument does not vary by more than 2 per cent of full-scale deflection no matter how long the instrument is in use and is unaffected by fluctuations in mains voltage. This is the maximum no-signal variation and occurs on the most sensitive range; on other ranges the zero stability is better.

2. If the no-signal reading is adjusted to zero on the most sensitive range, there is no change in reading on switching to the less sensitive ranges, i.e., there is no zero error.

3. The input resistance is unaffected by range switching and, in the particular circuit described, is approximately 3.8 MΩ. If a particularly high input resistance is required, a value of over 5 MΩ can be obtained by a slight sacrifice in zero stability. The input capacitance depends on the construction of the detector circuit, and by careful probe design can be reduced to approximately 5 pF.

4. The model described gives a full-scale deflection for 2.5, 25 and 250 volts peak input, but intermediate ranges can easily be added if desired. The range switch is a single-pole type, and, for each additional range, only one extra fixed resistor and one extra contact on the switch are required. The range resistors must be accurate, but are not of high value, the highest being 200 kΩ.

5. The linearity of the instrument is illustrated by the curves of Fig 1; it is good except near zero on the most sensitive range. Non-linearity on this range as a whole is less serious than might be expected, because full-scale deflection corresponds to a higher input voltage (2.5 volts peak) than is usual for the most sensitive range of a valve voltmeter. This insensitivity must be accepted to obtain high zero stability with such a simple circuit, but it has the advantage that no calibration curve is necessary on any of the ranges and no alteration to the meter scale is required.

The basic circuit of the valve voltmeter is given in Fig 2. It contains a signal diode V1 direct-coupled to the grid of a cathode follower V2. The meter M is connected between the cathode of V2 and that of V3, which is a similar triode with the

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same value of cathode load. The grid of V3 is connected to a diode circuit which is similar to that feeding V2 and completes the symmetry of the circuit.

When a signal is applied to V1, the diode conducts and a negative potential equal to the peak value of the applied signal is developed at the diode anode. This is applied to the grid of V2, reducing the valve current and causing the cathode potential to fall, with the result that the meter shows a reading. Similarly if a signal is applied to V4, the grid of V3 is driven negative and the meter gives a reading in the opposite direction. If the same alternating signal is applied to both diodes, the same value of steady negative potential is applied to the triode grids and the meter gives no deflection. This circuit thus measures the *difference* between the peak values of the signals applied to V1 and V4. Normally, however, no signal is applied to V4 and the meter indicates the peak value of the signal input to V1.

Neutralizing Supply Fluctuations

The zero stability of this circuit can be appreciated from the following argument. The simplest type of d.c. amplifier for a valve voltmeter consists of a single valve with a meter in the anode circuit, and possibly a circuit for backing off the standing anode current. The zero stability of such a circuit is poor because the anode current varies with changes in h.t. and l.t. supply volts. An improved performance is obtained with a double valve circuit, the meter being connected between the anodes; the anode currents now rise or fall together with variations in h.t. and l.t. supply. This circuit is capable of good zero stability provided the two valves have identical characteristics, but difference between the valves will cause the no-signal reading to wander.

In Fig. 2, both triodes have considerable current feedback due to the large value (47 kΩ) of cathode resistor; this effectively equalises any differences that may exist between the characteristics of the valves, and the two valves need not necessarily be identical. The cathode currents, and hence cathode potentials, rise and fall to the same extent with variations in h.t. or l.t. supply, and provided the cathode potentials are initially the same the meter does not respond to such variations.

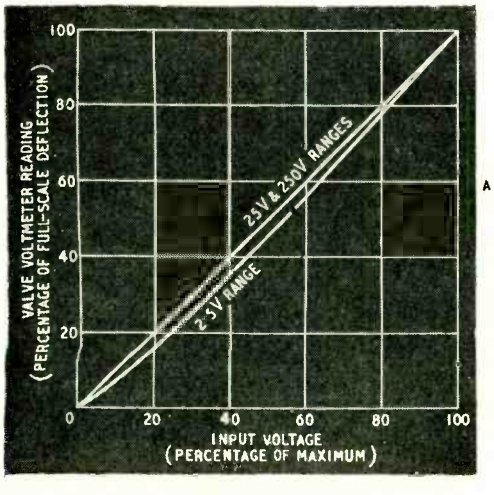
Fluctuations in no-signal reading can result if the grid-circuit resistance is increased beyond a certain limit. For the particular valve used (6SN7), the zero stability is good, if the resistance is 10 MΩ, or less.

Fluctuations in no-signal reading can also be caused by the diode detector. A diode with a high-value load such as is used in valve-voltmeter circuits gives an output of approximately 1 volt even with no signal input; this output is caused by arrival at the anode of electrons released from the cathode with appreciable initial velocities. This standing output varies and gives rise to changes in no-signal reading; it is also responsible for considerable zero error in valve voltmeters. Changes in no-signal reading due to this cause are eliminated in this instrument, as in others, by use of the balancing diode V4 in the same envelope as V1 and with the same load value. Any variations in standing output from V1 are accompanied by similar variations in output from V4; these outputs are applied to V2 and V3 in the same sense and thus produce no meter deflection.

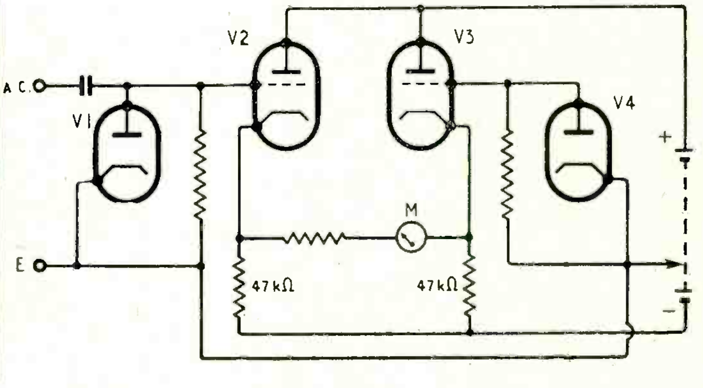
The magnitude of zero error depends on the method of range switching. If range switching is carried out by a potential divider in the diode load circuit, the fraction of the standing output applied to the amplifier is varied by the range switch and zero error is inevitable unless a balancing diode with a similar potential divider is used. This involves two sets of close-tolerance resistors and two switch units; for this reason the method was rejected.

Range-switching is effected in this instrument by a single-pole switch which alters the resistance in series with the meter. When the zero control has been adjusted until there is no current in M, alteration of the resistance in series with M cannot change the reading, and there is thus no zero error. It is best to adjust zero on the most sensitive range.

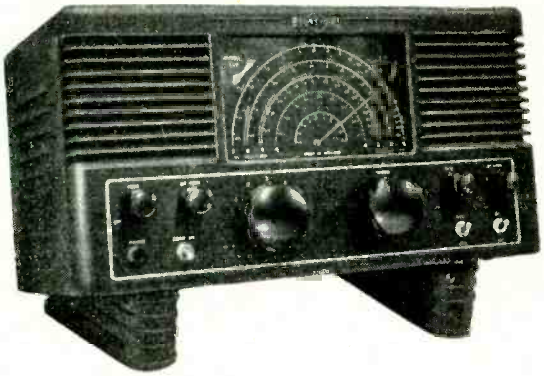
On the least sensitive ranges V2 must be capable of accepting large inputs without distortion and this is only possible if the p.d. across the cathode load for no diode input signal (known as the standing p.d.), exceeds the maximum input to V2. If there is no potential divider between the output of V1 and the input to V2, the maximum input to V2 would be 250 volts for a 250-volt peak input signal to V1. This implies a p.d. across R_6 of at least 250 volts and an overall h.t. supply of the order of 400 volts. The necessity for so high an h.t. supply is avoided in this instrument by including a fixed potential divider R_1R_3 between V1 and V2 which reduces the input to V2 to 0.4 of the diode output,



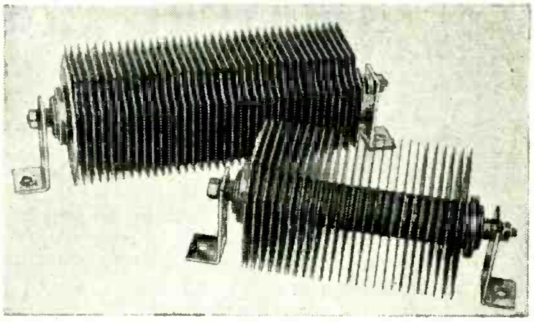
Left: Fig. 1. The calibration curves show good linearity.



Below: Fig. 2. Basic circuit of valve voltmeter.



The new Eddystone Model 740 inexpensive communications receiver shown by Webb's Radio.



Westinghouse full-wave selenium rectifiers, the HT53 (back) and HT52 (front) for 500-0-500V and 350-0-350V r.m.s. input respectively and 200 mA d.c. output.

really comprehensive displays. The Webbs Radio exhibit was one, and this included a well-represented range of Eddystone parts, while the other was Q-Max who included some very well-made transmitter tank coil assemblies in single and multi-band types, each incorporating a split-stator condenser, self-supporting anode coils, variable coupling coils and switching where appropriate.

Oliver Pell Control helped to extend the component display into the field of mains transformers and chokes, and they were ably supported by Woden Transformer Company with a range of potted types.

A minor surprise was to find E.M.I. Sales and Service showing a few components. They were grouped in a section devoted to exclusively amateur apparatus and comprised a big selection of i.f. transformers and some mains transformers. Here were seen also some 10½-in and 13½-in elliptical loudspeakers of 5 ohms impedance and an inexpensive nickel-plated hand-type carbon microphone.

Quality enthusiasts were catered for by the Decca Record Company in the form of their 12-in Duo-Centric loudspeaker which is said to have a flat response from 30 to 20,000 c/s. It has a 2-in diameter speech-coil of 18 ohms impedance and will handle 10 watts if necessary.

It was a little disappointing to find so few valves this year, especially transmitting valves, and the visitor had to be satisfied with the very limited range shown by G.E.C., which consisted mainly of receiving types in the miniature series. One exception was a v.h.f. double tetrode, the TT17, but its price placed it beyond reach of the average amateur. Incidentally, some of the new miniatures could find application in the early stages of transmitters.

Rectifiers there were in abundance, but apart from the G.E.C. germanium crystal valve, they took the form of selenium or copper-oxide types shown by Westinghouse and Salford Instruments. Among the exhibits of Westinghouse, the HT2 and HT3 units were of particular interest, as they are rated at 350-0-350 V and 500-0-500 V r.m.s. input respectively and give 200 mA d.c. output as full-wave rectifiers. E.H.T. rectifiers and voltage-doublers and treblers for c.r. oscilloscopes and television sets were appropriately included by Westinghouse, as equipment of this kind holds considerable interest for a large body of amateurs.

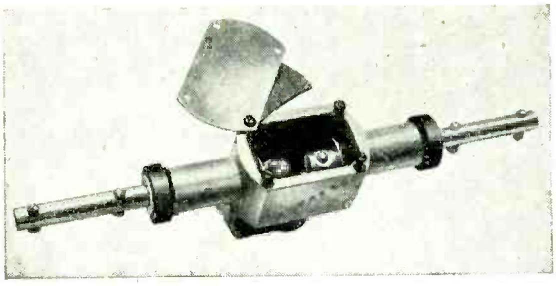
Whilst there was nothing outstandingly new in test apparatus, what it lacked in this respect it made up for in quantity. More than half the total number of firms exhibiting had something in the nature of a test set. Avo, as usual, had a very comprehensive display which included nine different types of the well-known Avometer. Sangamo-Weston showed two versatile instruments in the shape of the S75 multi-range set and the E772 Super Sensitive Analyser; Taylor had bridges, signal generators and a fine display of single-range pointer instruments suitable for rack-mounted transmitters and also for small portable sets; G.E.C. showed the Miniscope oscilloscope with its various accessories and E.M.I. had a range of frequency measuring sets introduced especially for the amateur station. There were some miniature absorption wavemeters on Q-Max and Webbs' stands, while Salford included a quartz crystal activity measuring set.

Three firms showed communications receivers this year. The BRT400 occupied the most prominent place on the G.E.C. stand and attracted considerable interest. This handsome receiver covers 150 kcs to 33 Mc/s, can be operated from mains or batteries and contains 14 valves. The bandwidth is variable in six steps from 500 c/s to 9 kc/s and it has a crystal filter.

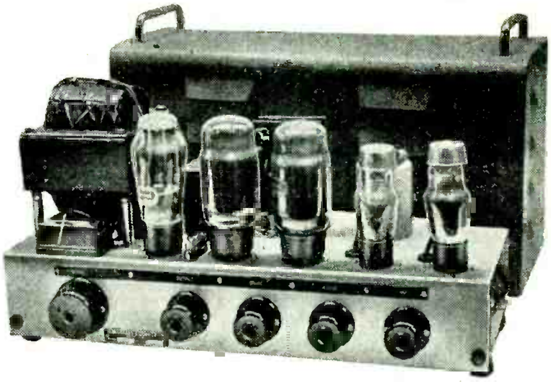
A set designed especially for the amateur bands is the Q5/10X communications receiver made by Q-Max. It covers the six amateur bands only between 1.8 and 30 Mc/s, including the awaited 21-Mc/s one, employs the double superheterodyne principle with the first i.f. at 5 Mc/s and the second at 465 kc/s. A crystal filter is fitted, also an "S" meter and a six-position selectivity switch giving bandwidths of from 200 c/s to 15 kc/s; there is also a 100 kc/s crystal calibrator and the price is just over £50.

A new and inexpensive communications receiver is the Eddystone Model 740, shown by Webbs Radio. This is an orthodox superheterodyne with the i.f. on 450 kc/s and its coverage is 485kc/s to 30.6 Mc/s, in four overlapping bands. All-glass miniature valves are employed and despite the low price of under £30 it has all the usual communications receiver features of b.f.o., noise limiter, provision for "S" meter, r.f. and a.f. gain controls and bandspread.

Some unfamiliar types of aerial were seen on G.S.V.'s stand. One, which took the form of a cone surmounted by a disc, has been developed for wide-



Compact water-tight centre unit for dipole aerials shown by Telecraft. Ebonite bushes are used for the dipole rods and a rubber washer is fitted underneath the cover plate.



E.M.I. Sales and Service 20-W speech amplifier, the Model PA181. There is a model for rack mounting also.

band operation. Two models are available; one covers 400 to 1,200 Mc/s and the other 800 to 5,000 Mc/s. It is claimed to be an efficient radiator with low-angle, omni-directional characteristics. Various forms of broad-band ground-plane aerials, and a corner reflector for 420 Mc/s, completed an interesting display.

A neat and compact centre unit, designed primarily for television aerials, but equally applicable to amateur aerial assemblies, was shown by Telecraft. Described as a "dipole feeder box," it is made of die-cast light alloy and all inlet points, such as for the dipole elements, cross arm member and cover plate, are fitted with waterproof seals.

Modulation amplifiers form an important part of every amateur transmitter and for many purposes the commercially made gramophone amplifier answers the purpose admirably. A wide range tone control is most useful, especially for DX operation. This facility was provided in the models shown by E.M.I., their Type PA181, rated at 20 watts output, has an input (microphone) sensitivity of 0.1 V and is designed for 15-ohm microphones. The circuit comprises two stages of voltage amplification, bass and treble tone controls and a push-pull output stage using KT66s in class AB1.

A gramophone amplifier, also with provision for a microphone input, is the Decca model AP/IX. Its response is flat from 20 to 20,000 c/s and it gives 7 watts output using a pair of PX25s in a class A push-pull and with negative feedback. A wide-range tone control is incorporated.

Self-Tuning Car Radio

Automatic Programme Selection by Foot-operated Switch

IN order to simplify programme selection on car radio receivers the Delco Radio Division of General Motors in America have developed a tuning system which is possibly the nearest approach to the automatic yet evolved. The tuning system of the radio set is actuated by a spring motor which, when set in motion, sweeps from one end to the other of the waveband. When the tuner reaches the end of its travel an electrically operated solenoid mechanism returns it, almost instantaneously, to the beginning, at the same time rewinding the motor spring.

Immediately a radio carrier is encountered the mechanism is stopped and the receiver locks in on the station. It is claimed that the lock-in takes place within 1 kc/s of the carrier frequency. If the programme so selected by the set holds no interest the station-seeking process can be set in motion once again merely by depressing a conveniently placed foot-switch.

It would obviously be impracticable for the tuner to be arrested by every carrier intercepted, as the system would be halted every 8 or 10 kc/s throughout the waveband covered. An over-riding control is, therefore, incorporated which establishes a minimum receiver sensitivity so that carriers of a certain strength only actuate the stopping mechanism. This control can be set to operate on any desired strength of signal, from one almost obscured by local electrical noise to the most powerful likely to be encountered in normal use.

The system of radio networks employed in America favours continuity of a programme when travelling long distances as it ensures the best possible reception under all conditions. But the ability to change stations so readily, and with such perfect safety when the driver is alone in the car, is a feature that should have a great appeal to those who like to have the receiver working when negotiating crowded thoroughfares or driving along difficult, twisty roads where the driver cannot afford to take his attention off the road for a moment.

The system has so far been applied to single-waveband receivers only, but there seems no reason why it should not be extended to multi-waveband sets. However, in order to avoid undesirable complications a manual wave-change switch might have to be incorporated.

Sidelights on

Loudspeaker Cabinet Design

(Concluded from page 385 of the previous issue)

Motional Impedance and Acoustic Output in Vented Cabinet Systems

By D. E. L. SHORTER,* B.Sc.(Eng.), A.M.I.E.E.

IN the first part of this article it was seen that although an "infinite baffle" type cabinet of ample volume is often regarded as the ideal mounting, the full potentialities of such a system cannot always be realised in practice.

Consider now the case of a vented cabinet. Here, an auxiliary sound outlet is provided in the form of an aperture which, in conjunction with the cabinet volume, forms a Helmholz resonator tuned to some frequency near the lower end of the band to be covered by the loudspeaker. Such an arrangement possesses the advantage that the acoustic impedance presented to the cone at low frequencies is relatively high, so that the cone velocity, and hence the motional impedance, are restricted. The electrical mismatch referred to in the last section is therefore much less serious than in the case of a closed cabinet. This feature of the vented cabinet, coupled with the extra sound output obtainable from the vent, make it possible to maintain a uniform low frequency response down to the limit imposed by the size of the cabinet and the constants of the unit. It may, however, be remarked in passing that because the difference in performance between the closed and vented cabinet systems depends so much on the difference in electrical impedance characteristics, no general comparison between the two can be made without taking account of the efficiency of the cone unit employed and the output impedance of the amplifier used. This article is concerned only with the conditions of high unit efficiency and low source impedance (less than one third of the minimum loudspeaker impedance) met with in modern high-quality equipment.

The general properties of the vented cabinet are treated in existing technical literature and need not be discussed here. It may be well, however, to mention certain special features which must be borne in mind if the best results are to be obtained.

The normal mechanism of electrical damping of a loudspeaker depends on the e.m.f. generated by the motion of the speech coil. This e.m.f. provides a circulating current via the output of the driving amplifier, and any energy left stored in the system at the cessation of the incoming signal is thus dissipated. However, at the frequency of the vent resonance (i.e. the rèsonance between the acoustic inductance of the vent and the acoustic capacitance of the cabinet volume), the motion of the speech coil is so small that no appreciable electrical damping can take place. The energy dissipated by mechanical resistances and by the radiation of sound is generally small, so that the vent resonance, on which the maintenance of the bass response depends, is quite lightly damped. This condition, which shows itself in a relatively sharp cut-off in response at the lower end of the frequency band, inevitably involves bad transient response and may lead to "boomy" quality. Fortunately, the tolerance of the ear for resonance effects increases rapidly with decreasing frequency and it seems to be a safe rule, for the highest quality of reproduction, to make the vent resonance frequency 60 c/s or less. Where this requirement cannot be met, the effect of closing the vent altogether should be determined by ear. Male speech is probably the best programme material for this test. In some cases it may be found that the loss of bass occasioned by the closing of the vent is in fact the lesser of two evils

Impedance Tests

Some caution is necessary in interpreting the results of electrical impedance measurements on a vented cabinet system. Impedance measurements are of great assistance in setting the vent resonance to the desired frequency, while many of the standing wave effects can be shown up clearly by balancing out the static component in the manner described in the first part of this article. However, since the cone is not the sole source of sound, the simple relationship between motional impedance and acoustic output existing in a closed cabinet does not hold in this case. To illustrate the argument, let us draw the equivalent electrical circuit, shown in Fig. 6. This consists of the circuit of Fig. 4 extended by the addition of R_V, representing the radiation resistance of the vent and L_V, the acoustic inductance of the vent plus the effects of its radiation reactance. Let f_V be the frequency of the vent resonance, i.e. the resonance of L_V with C_C; and assume for the sake of simplicity, that the cone resonance frequency is the same. Below f_V, the series combination $L_U C_U$ appears as a capacitance and the parallel combination $L_V C_C$ as an inductance; and the overall effect is to produce a series resonance at some frequency f_1 in this region. Above f_V, $L_U C_U$ appears inductive and $L_V C_C$ capacitive; and a second series resonance appears at some

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frequency f_2. The resonances at f_1 and f_2 are responsible for the characteristic double hump in the electrical impedance frequency characteristic of a vented cabinet and, it may be noted, are subject to the circuit damping represented by R_S.

It is very tempting to assume that because the addition of a vent has produced an impedance hump at some frequency f_1 below that of the cone resonance, the frequency range of the loudspeaker has been correspondingly extended. To see whether or not such a hope is justified it is necessary to consider the phase relationship between the alternating air currents which flow in the cone and vent apertures and which are represented in Fig. 6 by I_U and I_V respectively. I_U originates at the back of the cone and I_V must therefore be reversed in phase with respect to I_U if the acoustic output of the vent is to reinforce that from the front of the cone. Consider now the parallel resonance circuit L_VC_V for which I_U represents the total current and I_V the current in the inductive branch. At f_v, the frequency of resonance, I_U and I_V are approximately in quadrature; above f_v the desired antiphase condition is approached, but below f_v the two currents become more nearly in phase. This reasoning, which is independent of the values of L_U and C_U and therefore holds good whether or not the cone and vent resonance frequencies are equal, shows that f_v represents a turning point in the phase relationship between the cone and vent outputs. The resonance at f_2, which is above f_1, indicates an increase in the sound output of the system while that at f_1, which is below f_v, indicates a decrease. Thus the effective frequency range of the system can hardly be expected to extend to f_1.

Before leaving the circuit of Fig. 6, it may be pointed out that by the reasoning already applied in the case of E_{LU} in Fig. 4, the variation of the voltage E_{LV} with frequency represents the frequency

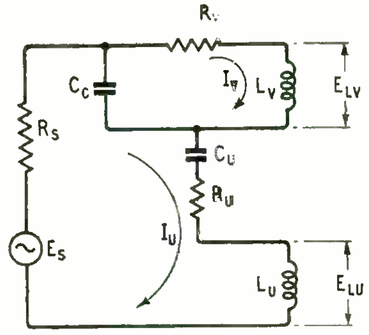


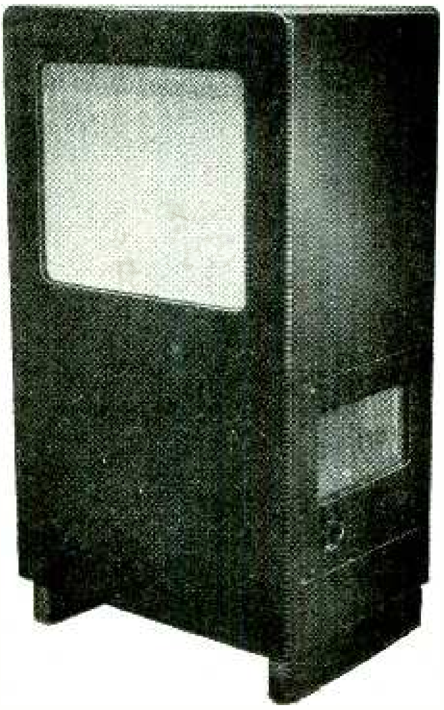
Fig. 6. Equivalent electrical circuit of vented cabinet loudspeaker at low frequencies.

characteristic of the sound emanating from the vent alone. Care must be taken, however, not to carry the analogy too far. To take the voltage across an inductance, instead of the current through it, is a convenient way of introducing a factor proportional to frequency; the artifice is however limited to giving frequency characteristics for a given set of circuit constants. E_{LU} and E_{LV} do not represent actual sound levels and cannot be directly added to give the total output from the system.

Cabinet Volume

In designing a vented cabinet, the first quantity to be fixed is usually the vent resonance frequency f_v, since this roughly determines the low frequency range of the system. Although the value of the product L_VC_C is thus automatically decided, the performance of the system is not yet fixed; the response characteristic for the first octave or so above f_v depends very much on the ratio L_V/C_C. Thus, with a large cabinet and a large vent opening (C_C large, L_V small) the response can rise to a peak in the bass while a small cabinet with a small vent (C_C small, L_V large) will give much the same effect

Vented cabinet for 15-in coaxial monitoring loudspeaker, with back removed to show the damping partition. The vent opening is in the base of the cabinet.



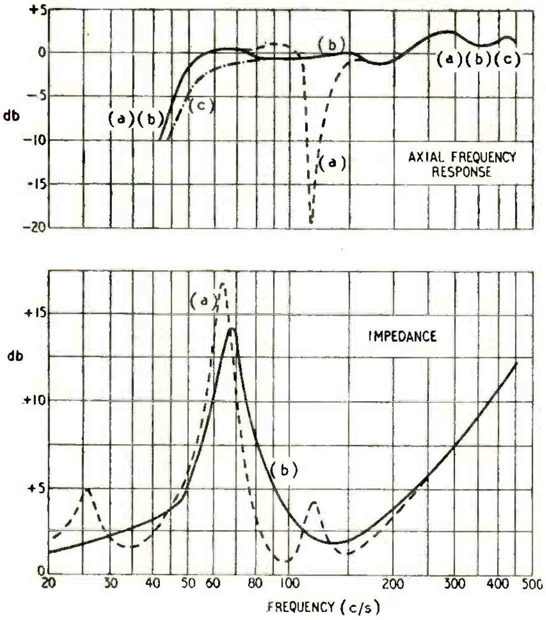


Fig. 7. Free-air axial response of a vented loudspeaker and corresponding impedance characteristic (a) inner surface of cabinet lined in conventional manner (b) with the addition of felt partition giving optimum damping (c) excessive damping in partition.

as a completely closed cabinet, i.e., there may be a bass loss. Between these two extremes, there will be a pair of values for L_V and C_C which gives the best approximation to a flat frequency response. The cabinet volume required for this last condition depends on the efficiency of the cone unit and the output impedance of the driving amplifier; a practical example will be given later to show the type of result that can be obtained.

It will thus be seen that no spectacular reduction in the size of cabinet required for a given low-frequency response can be obtained by simply raising the value of L_V. To be on the safe side, it is better to work out the volume of a new design on the basis of a plain (i.e., unflanged) vent of area approaching that of the cone itself[1], even though the vent to be used finally may be somewhat smaller.

Many of the points discussed in the foregoing paragraphs can be illustrated by the example of a vented cabinet designed for use with a 15-in. coaxial unit for high quality studio monitoring. A photograph of the experimental prototype appeared in the first part of this article; two views of the final model produced from this by the B.B.C. Designs Department are shown on the previous page. Fig. 7 gives the free-air axial frequency response and impedance characteristics. As in the case illustrated in Fig. 1, the output impedance of the driving amplifier was low (in this instance, about ⅙th of the minimum loudspeaker impedance). The impedance characteristics show, to a decibel scale, the variation in voltage appearing in the speech coil fed with constant current, no attempt being made in this case to balance out the static component.

The dotted curves of Fig. 7(a) show the performance of the loudspeaker when the cabinet was lined with kapok quilt and carpet felt and the internal space left free. In this condition, a serious internal resonance, the effect of which can be seen on the impedance characteristic, occurs just below 120 c/s. The full line curves (b) show how this resonance was suppressed by introducing into the cabinet a partition having a window about 170 sq. in. in area covered with three layers of quarter-inch carpet felt. The position of this window is indicated in the photograph by dotted lines. It will be seen that the damping partition introduced to remove the 120 c/s resonance does not seriously affect the frequency response elsewhere in the pass band of the system, although the smaller of the two remaining humps in the impedance characteristic, which lies outside the pass band, is suppressed altogether. The quantity of material used on the damping partition, while not critical, must not depart too far from the optimum; the chain dotted curve of Fig. 7(c) shows the effect upon the frequency response of using too many layers of felt between the two parts of the cabinet. In this particular design, the cone unit and vent are respectively above and below the division so that the reponse obtained with a very high impedance partition naturally tends towards that of the top compartment alone acting as a closed cabinet.

The volume of the cabinet of Fig. 7 was restricted by considerations of space to 10½ cu. ft. The response was not required to rise at the bass and it was therefore possible to make the acoustic inductance of the vent relatively high and to keep the resonance frequency low. The radiation from the vent is made just sufficient to maintain the response curve almost level down to the cut-off point and the design thus represents the optimum for the particular set of conditions in which it is used.

It should be noted that the fall in response below 50 c/s is quite sharp and on a transient signal, the system " rings " in the region of cut-off; but at this low frequency the result is not offensive to the ear.

The cabinet of Fig. 7 has passed a number of subjective tests involving a direct comparison between original and reproduced sounds and the satisfactory performance indicates that a vented enclosure is capable of doing justice to the best loudspeaker units at present available.

[1] " Vented Loudspeaker Cabinets," by C. T. Chapman, *Wireless World*, October, 1949.

Register of British Manufacturers

THE 1950-51 edition of the "F.B.I. Register of British Manufacturers," the standard work of reference on British goods and their manufacturers, is now available. This new edition has more than 1,000 pages, and contains a classified buyers' guide listing in alphabetical order 5,000 products and services (showing under each heading the British firms that supply them). In another section are the postal and telegraphic addresses of all members of the Federation of British Industries, their main products and, in many instances, details of home and overseas branches and agencies. An alphabetical list of brand and trade names is also given.

Published for the Federation jointly by Kelly's Directories and our Publishers, home inquiries for copies should be addressed to Kelly's Directories Ltd., 186, Strand, London, W.C.2, and overseas inquiries and those from the book trade should be made to F.B.I. Register, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. The price is £2 2s.

WORLD OF WIRELESS

Viewers Now 511,000 ♦ Amateurs' Charter ♦ Festival Station ♦ U.S. Uproar Over Colour

Half a Million Viewers

TELEVISION licences in the U.K. passed the half million mark during October. At the end of the month the total was 511,150, an increase of 40,350 during the month and 322,800 on the October, 1949, figure. The number of "sound" licences in force was 11,805,700, giving a grand total of 12,316,850, an overall increase of 192,600 during the previous twelve months.

Australian Television

WE learn from a report in our associated journal *Wireless Trader* that standards for the projected television stations in Australia have now been fixed. As in the "European" standard, details of which were given last month, there are to be 625 lines per picture with interlaced scanning, the picture aspect ratio will be 4:3, negative picture modulation (black level 75 per cent of carrier) will be employed, and frequency modulation used for sound.

Vestigial sideband transmission in a channel of 7.5 Mc/s within the 181.5 to 204-Mc/s bands will be employed.

The power of the first station at Sydney will be 5 kW, vision, and 2.5 kW, sound.

Amateurs' Freedom

WHEN opening the R.S.G.B. Amateur Radio Exhibition, which is reviewed elsewhere in this issue, the Managing Editor of *Wireless World*, referring to the late Lord Derby as "the father of amateur radio," said that had it not been for his attitude towards the amateur when, as P.M.G., he introduced the first Wireless Telegraphy Bill in 1904, it is quite conceivable that private experimental licences might never have been granted.

Lord Stanley, as he then was, in introducing the second reading of the Wireless Telegraphy Bill, addressed the House with these words, which Mr. Pocock quoted:—"The class with whom I have the greatest sympathy are those who wish to go in for experiments in this science, and I have been able to frame a clause which will give absolute freedom in that direction, merely requiring registration on the part of those who wish to engage in experiments. In a matter of this description the House will doubtless desire that the Act should be administered as liberally as possible, and I shall certainly do my best in that direction. For what it is worth I will give an undertaking that no request for a licence for experiments shall be refused unless the refusal has been approved by me personally."

Festival Amateur Station

DURING the summer of 1951 a mobile version of the Festival of Britain exhibition on the South Bank in London will visit four of the great inland cities of Great Britain where, among the 5,000 odd exhibits, an amateur radio transmitting station will be set up and operated by local amateurs.

The cities to be visited and the dates concerned are:—

Manchester, May 4th to 26th.

Leeds, June 23rd to July 14th.

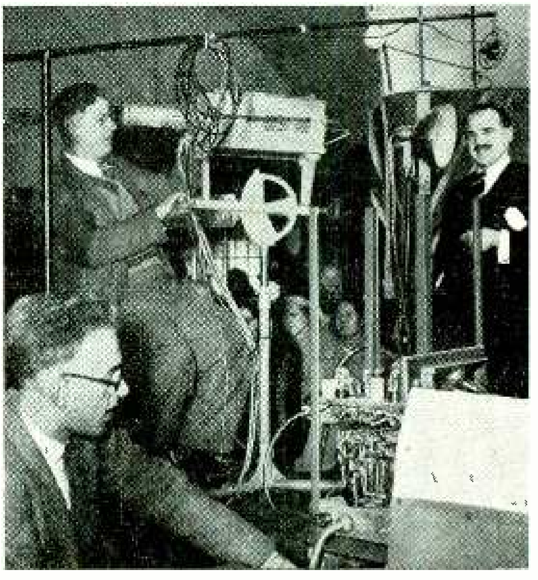
Birmingham, August 4th to 25th.

Nottingham, September 15th to October 6th.

The transmitting station will have its own call sign and a QSL card is being designed especially for the occasion.

Up-to-date equipment is to be supplied by the radio industry and the station will be enclosed by glass so that while visitors can see, and hear—by means of external loudspeakers—what is going on, the operators can work undisturbed.

The full co-operation of local amateurs is needed to ensure the success of this enterprise, and an amateur in each town—in whose name the licence will be taken out—will be responsible for maintaining a rota of operators to man the station. An announcement will be made on this matter at a later date.



CLOSED CIRCUIT television transmission, using home-constructed gear, was demonstrated by members of the British Amateur Television Club during the recent R.S.G.B. amateur exhibition.

Colour Quandary

AS recorded elsewhere in this issue, it would appear that American opinion has crystallized strongly against the F.C.C. decision to adopt the C.B.S. frame-sequential system of colour television.

A temporary injunction to restrain the F.C.C. from enforcing its order for the adoption of the C.B.S. system was successfully brought before the Chicago Federal Court by R.C.A. and N.B.C. a few days before the C.B.S. was due to start regular transmissions. A correspondent in New York writes "This, of course, is just the opening gun on a long legal battle which will probably go all the way up to the Supreme Court, which may take years. Unless something unforeseen takes place, C.B.S. will be prevented from starting their colour broadcasts (except experimentally, of course). Meanwhile, R.C.A. and other manufacturers are working overtime trying to perfect their all-electronic systems." A description of the new General Electric system is given on page 443.

Engineers' Protest

THE recent announcement by the Durham County Council making membership of a professional body or trade union a condition of employment has called forth a statement from the Engineers' Guild—an association of chartered civil, mechanical and electrical engineers. In it the Guild states that to require that "professional engineers be members of a trade union or any other organization, apart from such as are recognized as conferring an appropriate professional qualification, constitutes an unwarrantable interference with their professional and personal freedom and is contrary to the interests both of the engineering profession and of the public which it serves."

Rutherford Memorial

ALTHOUGH the name of Lord Rutherford (1871-1937) is inseparably linked with the study of nuclear physics it was in the realm of wireless that he made some of his early studies. It is recorded that in 1896 he succeeded in transmitting signals over a distance of half a mile using a magnetic detector of his own invention.

To commemorate the work of Rutherford an appeal is made by the President of the Royal Society for donations to create a memorial fund. The committee set up by the Royal Society under the chairmanship of Sir Henry Tizard proposes that the memorial, for which £100,000 is the target, should take two forms:—

(1) Rutherford Scholarships tenable for three years, to be awarded to post-graduate students within the British Commonwealth, for research in the natural sciences with a preference for experimental physics. A scholar will normally be required to carry out his research in an Institution in some part of the British Commonwealth other than that in which he graduated; and

(2) A Rutherford Memorial Lecture to be delivered at intervals at selected university centres in the British Commonwealth overseas, at least one in three to be given in New Zealand, where he was born.

Contributions should be sent to the Rutherford Memorial Committee. The Royal Society, Burlington House, London, W.1.

"Long-range Television"

IN the article under this heading which appeared in our last issue a line of type was inadvertently omitted from the paragraph following the sub-heading "Comparison with Ionospheric Data" on p.408. The paragraph should read:—

"It is not feasible to compare these results with any measured m.u.f. (maximum usable frequency) data, because no such charts are published, and there do not exist enough measured critical frequencies over this path on which to estimate the actual m.u.fs which prevailed. It is possible, however, to compare the results with the predicted m.u.f. for the path, as obtained from the world ionospheric contour charts, which are compiled on the basis of past measured data supplied by the world network of ionospheric measuring stations."

Ambulance Radio

MORE than fifty ambulances and vehicles for sitting patients are being equipped with Pye 15-watt transmitter-receivers by the Essex County Council in readiness for the inauguration of the Ambulance Service radio-telephone system early in the new year. The main 100-watt station (Pye PTC 300), working on 86.975 Mc/s and using a 120-ft aerial mast on Danbury Hill, will cover most of the county.

The transmitter and its standby set will be remotely controlled by land line from the Ambulance H.Q. at Chelmsford—a distance of about five miles.

B.B.C. Year Book

CAPITAL cost and running costs of a modern 150-kW broadcasting station, broken down to show the comparison between expenses on staff, equipment, maintenance, power, etc., are given in an article by R. T. B. Wynn, the B.B.C. Deputy Chief Engineer, in the B.B.C. Year Book, 1951. He is writing on the use of unattended multi-unit transmitters employing "electronic listeners" as a saving in manpower and reduction in running costs. The staff released from the tedium of monitoring are being employed for development work.

In the table of running costs for a transmitter operating for eighteen hours a day, power accounts for 41 per cent; staff, 31 per cent and valve replacements, 14 per cent.

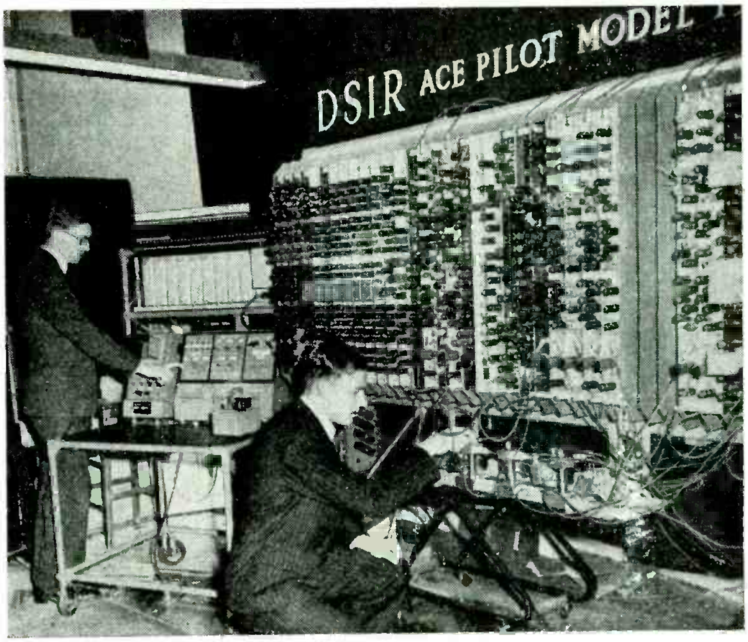
In addition to the usual numerous illustrations and programme matter there are a number of contributions dealing with various technical aspects of the corporation's activities both in sound and television. In the report on the work of the Engineering Division it is recorded that the total power of the B.B.C. stations employed for overseas transmissions is 3,140 kW. The transmitters radiating the Home, Light and Third Programmes account for 923.5, 661.55 and 78.45 kW respectively. The Year Book costs 3s 6d.

Television Receivers

THE long-awaited third edition of W. T. Cocking's "Television Receiving Equipment" is now available from booksellers, price 18s, or by post from our publisher, price 18s 8d. This edition, which has been completely revised and enlarged by some 50 per cent, gives an exhaustive and lucid description of each stage of a television receiver and deals with practical details of receiver design. Two of its twenty-three chapters are devoted to fault-finding and servicing.

PERSONALITIES

Sir Edward Appleton, G.B.E., K.C.B., F.R.S., has been awarded by the Royal Society one of the two Royal Medals for this year "for his work on the transmission of electromagnetic



ELECTRONIC COMPUTER.—This picture shows the Automatic Computing Engine designed and constructed at the National Physical Laboratory. Employing some 800 valves it will tackle any problem in arithmetic and carry out in a few minutes computations which take many months.

waves round the earth and for his investigations of the ionic state of the upper atmosphere." He recently received at the hand of H.R.H. Princess Elizabeth the Society's Albert Medal, the award of which was recorded in our July issue.

Major H. S. Prince (Retd.), M.B.E., M.Brit.I.R.E., Assoc.I.E.E., has been appointed Deputy Chief Inspector (H.Q.) in the Inspectorate of Electrical and Mechanical Equipment (Ministry of Supply) which carries with it an Assistant Directorship in the Engineers' Pool in the M.o.S. During the 1914-18 war he was attached to R.E. (Sigs.) and during and since the last war he was on several technical missions to the U.S.A. Between the wars he was with Burndept and later with Philips.

J. Vivian Holman, who is a director of Philco (Overseas), Ltd., and Philco (Great Britain), Ltd., has relinquished the executive posts he held with Radio and Television Trust, Ltd., and its subsidiary companies.

OBITUARY

J. Joseph, C.B.E., M.I.E.E., who founded Radio Instruments, Ltd., in 1922, and was a director of Aeronautical and General Instruments, Ltd., which took over R.I. in 1936, died recently at the age of 76. For some years prior to founding R.I. he was with H. W. Sullivan, Ltd.

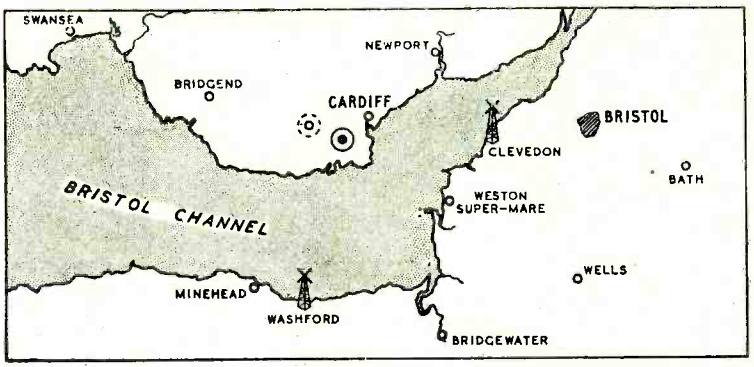
William D. Loughlin, the designer of the original "Q" Meter, who was chairman of the Boonton Radio Corporation of Boonton, New Jersey, of which he was founder, died on November 11th.

IN BRIEF

Amateurs' Exam.—The report of the City and Guilds examiners on the Radio Amateurs' 1950 Examination records that the number of candidates was slightly fewer than in former years—823 compared with 885 in 1949. The percentage of passes was, however, 79.4 compared with 71. In addition to the candidates in this country there were 10 overseas entries against last year's 13, of which 7 and 8 passed, respectively.

Marconi's famous yacht *Elettra,* the floating laboratory on board which he conducted many of his important experiments, is to have a modern successor, *Elettra II,* recently purchased by the Marconi International Marine Communication Co. After Marconi's death, the *Elettra* was acquired by the Italian Government to serve as a wireless museum. *Elettra II,* a 72-foot twin-screw diesel yacht, will be fitted out as a floating laboratory to enable the development of marine radio and navigational aids to be carried out at sea.

"W.W." Diary.—Readers are reminded that copies of the *Wireless World* Diary for 1951 are obtainable from booksellers and stationers—to whom our publisher has distributed all available copies. In addition to the week-at-an-opening diary section it includes eighty pages of reference matter of the type frequently required but rarely readily available. The price of the Rexine edition is 3s. 8d. or in Morocco leather 5s. 6d.



THE NEW LOCATION of the Welsh television station at Wenvoe is indicated on this map on which is also shown the original site (dotted) at St. Nicholas and the existing broadcasting stations in the Bristol Channel area.

Welsh Television.—Local objections to the use of the site originally chosen at St. Nicholas, Glamorgan, for the Welsh television station has necessitated the acquisition of another. The P.M.G. stated in the House that negotiations were proceeding for the acquisition of a site on St. Lythan's Downs, near Wenvoe, Glam.

Ocean Weather Ships.—Changes in the call-signs of the British Ocean Weather Ships stationed in the North Atlantic are announced by the Ministry of Civil Aviation. The W/T call of station "I" is now 4YI instead of MEA and that of station "J" is 4YJ instead of MEB. The R/T calls have also been changed. They are now "Ocean Station Item" and "Ocean Station Jig." The m.f. non-directional beacon identification signs used by the ships have also been changed. They are now YI and YJ instead of QI and QJ. The frequency of beacon station "I" has been temporarily changed from 390 to 388 kc/s.

Electronics Exhibition.—The Second Exhibition of Industrial Electronics to be organized by the Midlands Branch of the Institution of Electronics will be held in Birmingham from 1st to 6th January. The second day of the exhibition will be set aside for a private trades preview for which free admission tickets are obtainable on request from the Chairman, Institution of Electronics, 31, Beech Road, Bournville, Birmingham, 30.

Suppression.—It is announced by British Transport that all petrol-engined vehicles regularly operated by the organization within the service areas of the present television stations are to be fitted with interference suppressors. The number of vehicles to be suppressed is sixteen thousand. Another contribution to the campaign for the suppression of interference is announced by City Motors of Oxford. All new and used cars and petrol-driven commercial vehicles supplied by them or their branches are being fitted with suppressors and will bear a label stating this.

Experiments on the confidential transmission by television of banking records are being carried out by Pye in collaboration with Glyn Mills & Co., the bankers, whose records office is situated some miles from the company's head office.

Measuring Interference.—The British Electrical and Allied Industries Research Association (E.R.A.) has issued a report entitled "The Measurement of the Time Constant of a Critically Damped Meter," by S. F. Pearce, which analyses the response of such a meter in equipment for measuring radio interference. The 8-page duplicated report is obtainable from the E.R.A., Thorncroft Manor, Dorking Road, Leatherhead, price 3s. 3d., including postage.

Tactile Training.—Among the exhibits used for the Exhibition for the Blind and Partially Sighted recently held at the Science Museum, South Kensington, was a five-foot cut-away model of a Mullard all-glass valve. By means of this model and descriptive labels in Braille the sightless were able to feel the disposition of the various electrodes.

"How the Brain Works."—During the recent television programme with this title, which was one of the Reith series of lectures, the Ediswan eight-channel electro-encephalograph was used to demonstrate the method by which electrical impulses from the brain can be measured and recorded.

E.I.B.A.—Among the prizes awarded at the recent Electrical Industries Ball at Grosvenor House in aid of the Electrical Industries Benevolent Association were a television receiver given by Ekco, two all-dry portables given by Cossor and a broadcast receiver given by Ferranti.

I.E.E. Students.—This year's chairman of the London Students' Section of the I.E.E. is I. J. Shelley, who is in the television transmission section of the B.B.C. Designs Department.

"Telefunken-Zeitung." the journal published by Telefunken Gesellschaft für drahtlose Telegraphie, Berlin, which ceased publication during the war, has reappeared. The first post-war issue is numbered 87/88.

Next Year's Ideal Home Exhibition, organized by the *Daily Mail,* will be held at Olympia, London, from March 6th to 31st.

Television Viewers.—A leaflet has been prepared by the British Television Viewers' Society setting out the objects of the Society which has developed from the Croydon and District Television Viewers' Society formed in 1947 A recent addition to the activities of the Society is the formation of a Technical Branch. Particulars of membership are obtainable from the Secretary, L. G. Pace, 140, Fairlands Avenue, Thornton Heath, Surrey.

BUSINESS NOTES

New Brimar Factories.—In an effort to increase the output of Brimar receiving valves and cathode-ray tubes, the Receiving Valve Division of Standard Telephones & Cables at Footscray, Kent, is opening a number of Feeder Plants, mainly in country districts, in the county. The main purpose of these Feeder Plants is to take advantage of relatively small groups of suitable labour in country districts. The exception is at Rochester where a fairly large area of a former aircraft engine factory at Rochester Airport has been acquired.

Pye inform us that the decision of the Swedish Air Force to use a.m. equipment instead of f.m. for its ground and air radio services was considerably influenced by the demonstration of Pye mobile and fixed equipment working on a frequency of about 160 Mc/s. A range of some 33 miles was attained between the 15-watt fixed station and the 5-watt mobile. Similar equipment has been ordered by the Luxembourg authorities for use on fire tenders at the airport.

Turkish S.W. Station.—A new 100-kW short-wave broadcasting station at Elimesgut, about 10 miles from Ankara, was opened by the Turkish Broadcasting Administration at the beginning of the month. The transmitter, aerial system—consisting of five 250-300ft masts supporting the arrays —and some ancillary equipment were provided by Marconi's. The company also supplied an Outside Broadcasting unit incorporating a short-wave radio link.

C.R.T. Testing.—A new service depot for testing Ediswan cathode-ray tubes has been opened by the Edison Swan Electric Co., at Perfecta Works, Henstead Street, Bromsgrove Street, Birmingham, 5 (Tel.: Midland 6425).

Belling-Lee.—In the review of television accessories at the radio exhibition in our October issue it was inadvertently stated that Belling and Lee used a folded dipole in their multi-element aerial systems. This firm has always favoured the plain dipole, even for fringe-area arrays, and they fit a quarter-wave transformer to match the aerial to the feeder.

United Nations Headquarters at Lake Success, New York, is calling for tenders by December 27th for equipment for a sound-reinforcing system. Among the apparatus required are 1,500 table and chair loudspeakers, a number of horn-type and cone reproducers and associated transformers. Particulars are available from the Commercial Relations & Exports Department (Industries Branch) Board of Trade, Room 1080, Thames House North, Millbank, S.W.1. Reference CRE (IB) 70985/50.

G.E.C. announce that their communications receiver BRT.400 is used by all the Swedish armed forces and the Post and Telegraphs Department.

Market Investigation.—Whilst visiting the Rhodesias and South Africa between March and September next year the managing director of W. J. Groom & Co., of 22, Fenchurch Street, London, E.C.3, offers to investigate and report on the question of representation for British manufacturers in these countries.

J. H. Brierley, Ltd., the well-known manufacturers of sound recording and reproducing equipment, are moving on January 1st from 46, Tithebarn Street, Liverpool, to new factory premises on the Kirby Trading Estate, Liverpool.

Robshaw Brothers, Ltd., of 232-4, High Street, Rochester, Kent, have been appointed the sole distributors in the United Kingdom to the wholesale and retail trade of Igranic jacks, plugs, rheostats and potentiometers.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"The Use of Saturable Reactors as Discharge Devices for Pulse Generators," by W. S. Melville, B.Sc. (Eng.), at 5.30 on January 10th at Savoy Place, London, W.C.2.

North-Eastern Radio Group.—"The Operation and Maintenance of Television Outside-Broadcast Equipment," by T. H. Bridgewater at 6.15 on January 15th at King's College, Newcastle-on-Tyne.

Northern Ireland Centre. — "Fifty Years' Development in Telephone and Telegraph Transmission in Relation to the Work of Oliver Heaviside," by W. G. Radley, C.B.E., Ph.D. (Eng.), at 6.45 on January 9th at Queen's University, Belfast.

Western Centre. — "Oliver Heaviside," by Professor G. H. Rawcliffe, M.A., D.Sc., at 6.0 on January 8th at the Technical College, Bath.

British Institution of Radio Engineers

London Section.—A Symposium on Hearing Aids—"Deafness; its Clinical Aspects, and the Possibilities of its Alleviation Medically and by Deaf Aids" by E. R. Garnett Passe, F.R.C.S.; "A Master Hearing Aid" by E. Aspinall, B.Sc.; and "The Design of Commercial Hearing Aids" by J. P. Ashton, B.Sc (Eng.), at 6.30 on January 10th at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1.

North Eastern Section.—"Stages in the Development of a Small High-Frequency Oscilloscope" by H. A. Dell, B.Sc., Ph.D., at 6.0 on January 10th at Neville Hall, Westgate Road, Newcastle-on-Tyne.

North Western Section.—"Marine Radar" by G. W. L. Davis at 6.45 on January 4th at the College of Technology, Manchester.

Scottish Section.—"Frequency Modulation and F.M. Measuring Equipment" by E. D. Hart, M.A., and A. G. Wray, M.A., at 6.45 on January 11th at the Institution of Engineers and Shipbuilders, Glasgow.

South Midlands Section.—"Ultrasonic Generators for High Powers" by B. E. Noltingk, Ph.D., at 7.0 on January 17th at the Exhibition Gallery, Public Library, Rugby.

GOVERNMENT RESEARCH

Published Reports on the Work of the N.P.L. & D.S.I.R.

A REPORT of the work carried out at the National Physical Laboratory during 1949 is now obtainable from H.M. Stationery Office. It covers the activities of the ten Divisions of the Laboratory and that of the Electronics Section which, until 1948, was attached to the Radio Division. The recently published report of the Department of Scientific and Industrial Research for 1948/49 also devotes a few pages to radio research.

During the year preliminary work for the inauguration of regular transmissions of standard radio frequencies was undertaken, the Electricity Division accepting responsibility for the actual standard of frequency and the G.P.O. for the transmissions which are made from Rugby. Other activities of this division included work on dielectrics at the extra high frequencies and examination of polytetrafluorethylene (P.T.F.E.) as a dielectric in radio-frequency cables.

Among the subjects investigated by the Radio Division is the measurement of radio noise of all kinds and improvement in the technique of locating thunderstorms and atmospheric disturbances by radio direction finding.

Curiously enough, more precise knowledge of the propagation characteristics of the really long waves (2,000 to 20,000 metres) was found necessary during the development of new marine and aeronautical navigational aids. It has so far been revealed that for frequencies of about 16 to 20 kc/s the effective reflecting region in the ionosphere appears to be about 70 km during daytime and 85 to 90 km at night.

Ionospheric observatories are maintained and operated by the Radio Division at Radio Research Station, Slough; Fraserburgh, Scotland; the Falkland Islands and Singapore. Hourly measurements are made of the height, critical frequency and absorption factor of the ionosphere. These observations are correlated with those made by other authorities throughout the world.

The N.P.L. Report costs 1s 9d and the D.S.I.R. Report 5s 6d.

Colour Television

Frequency-Interlace System

By A. DINSDALE

IF the bandwidth available for television signals were to be arbitrarily divided into three equal parts, one for each message (or colour), the rate of transmission of the entire information would have to be slowed down to one-third that used in monochrome. This could be done, of course, but the flicker problem would be a serious limiting factor to commercial acceptance. A way of transmitting the three message simultaneously in the same frequency spectrum, by the use of frequency multiplexing, or "frequency interlace," is therefore desirable.

As the term frequency interlace implies, the frequencies employed by the three messages are sandwiched so as to be non-interfering. This can be done in scanned information systems like television because it has been found that the video frequencies associated with a television signal are bunched around harmonics of the line frequency, and that a large part of the available spectrum is unused. It has been estimated that about 46 per cent of the space between harmonics is not occupied.*

Suppose the video-frequency bandwidth available is 4 Mc/s. Furthermore, let it be assumed that scanning frequencies compatible with monochrome television are to be used, namely, a vertical or frame frequency of 60 c/s, and a line rate of 15,750 c/s. This results in the U.S. standard 525-line system employing two-fold interlace. Suppose that the three primary colours elected to be used in the system are green, red and blue.

At the camera the composite television picture being televised is split by electro-optical means into three separate groups of signals associated with the three primary colours. Each channel may contain frequencies extending up to 4 Mc/s. The signals associated with the colour green may be regarded as the basic signals, and may be used to modulate the picture carrier in the same manner as in a monochrome transmitter.

Since the line frequency is 15,750 c/s, it will be found that the sideband energy is chiefly bunched at frequencies spaced from the carrier by 15,750 c/s, 31,500 c/s, 47,250 c/s, etc., out to 4 Mc/s. It is planned to use the spaces between these harmonics to transmit the information associated with the two remaining colours.

The video frequencies associated with a second colour (e.g., red) may be utilized as modulating frequencies for a video-frequency subcarrier. This subcarrier frequency is carefully selected to lie exactly midway between two harmonics of the line frequency, or in other words, at an odd multiple of half the line frequency. Half of 15,750 c/s is 7,875 c/s, so that a

* "A Theory of Scanning and its Relation to the Characteristics of the Transmitted Signal in Telephotography and Television." Pierre Mertz and Frank Gray, *Bell System Technical Journal*, Vol. 13, No. 3 (July 1934), pp. 464-516.

IN the United States the subject of colour television has been under heated discussion for some time, and the Federal Communications Commission has been holding hearings and viewing demonstrations of rival systems developed by Columbia Broadcasting System, Radio Corporation of America, and Color Television, Inc. The main issues have been which system to adopt, and which frequency bands to assign to colour. While discussion rages, some 7,000,000 black-and-white sets have been sold, and manufacturers are turning out more at the rate of half a million a month.

Recently, the F.C.C. announced that it was prepared to recommend the C.B.S. system, even though this system uses a mechanically driven colour disc, and cannot be received on existing black-and-white receivers. In making this "threat" the F.C.C. blasted receiver manufacturers for not making their black-and-white sets so that they could be used to receive C.B.S. colour transmissions in black-and-white, and gave the manufacturers thirty days to make up their minds what they wanted to do. If manufacturers complied, the F.C.C. promised to reopen the entire discussion and consider other systems which might become available, and which promised to provide receivers easily interchangeable from colour to black-and-white. If the manufacturers will not agree to modify their present sets, then the F.C.C. threatens to issue an immediate order adopting the C.B.S. system.

Meanwhile, the General Electric Company, at the eleventh hour, announced a new system of its own, a system worked up by R. B. Dome, an engineer in G.E.'s Electronics Park plant at Syracuse, N.Y. Although still in the strictly theoretical stage, G.E. took the extraordinary step of announcing it to try and get under the wire of any F.C.C. decision. If, in spite of everything, the F.C.C. adopts the C.B.S. system, this new, proposed G.E. system may never be developed to the point of practical application.

The description of the new proposed frequency-interlace system given in this article is based on data supplied to the F.C.C. by the General Electric Company.

frequency of 3,583,125 c/s, which is the 455th multiple of 7,875 c/s, may be selected. Now this subcarrier is modulated with video signals of the red channel, and the modulated wave is superimposed on the green channel signals. It is evident, then, that the red video signals will lie halfway between green signal line-frequency harmonics, in unused parts of the spectrum.

The entire red spectrum is not used as modulating frequencies, since a number of investigators have found that acceptable colour reproduction may be obtained by identifying only the lower video frequencies with their respective colours. The higher video frequencies may be transmitted either by green alone or by the principle of mixed highs. Good reproduction will be obtained if red is transmitted as red out to only 1 Mc/s. Furthermore, use may be made of vestigial-sideband transmission of the red signal, so that the lower sideband is the dominant one. The spectrum of the combined green and red signals may therefore be as shown in Fig. 1.

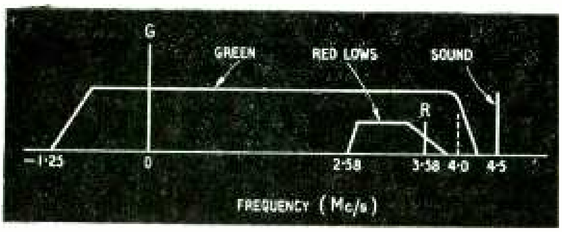


Fig. 1. Spectrum of green and red video frequencies as radiated.

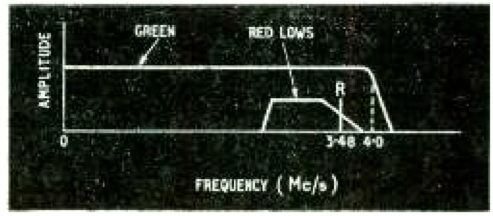


Fig. 2. Spectrum of green and red video frequencies at detector output.

This signal may be received by a conventional monochrome receiver insofar as the r.f., i.f., and second detector are concerned. The video frequency spectrum out of the detector would then be as shown in Fig. 2. A more detailed view of the frequency spectrum in the vicinity of the red sub-carrier is shown in Fig. 3.

Colour Signal Separation

The way in which the signals associated with the two colours are interleaved is now clearly revealed. It is necessary now to provide some means at the receiver for separating the signals for portrayal on the picture tube of the correct colour. One way of accomplishing this would be to employ an elaborate wave filter having multiple pass bands for the desired frequencies, and multiple elimination bands to exclude the undesired frequencies. Such a filter would probably be too expensive for home receivers because of the large number of sections indicated.

Fortunately, a cheap natural filter is available in the form of the human eye. The satisfactory operation of the system depends to a considerable extent on the physiological phenomenon known as persistence of vision. It will be observed that any one line of the green television picture will be modulated in intensity at the rate of the red sub-carrier, but that two frames later in time, namely, in 1/30th of a second, the modulation effect will be 180° out of phase with the modulation of the first frame. Thus, a lighter "dot" on field No. 1 will appear as a darker "dot" on frame No. 3, and *vice versa*, so that in the eye the mean illumination tends to average out to a medium background.

This principle is illustrated in Fig. 4, in which are depicted light intensities along a single green line in frame No. 1 and in frame No. 3. The sine wave is the red sub-carrier simultaneously present, and is shown here to be amplitude-modulated by low-frequency red picture signals. If the eye were a perfect long-time integrator the visual sensation would be given by the line marked "mean intensity" which corresponds in this case to the desired green signal. The repetition rates involved here are not fast enough to give perfect integration, but the practical result is believed to be sufficiently close to the ideal to be commercially acceptable.

Moreover, the superposition of frames yields twice the number of dots per line as one frame alone gives, so that a very fine dot structure results. Its fineness is comparable to horizontal scanning line structure and disappears at substantially the same distance away from the picture tube that normal line structure disappears. Thus, although both the red and green signals appear on the green gun, the red is effectively filtered out by the eye and only the green remains.

The information contained in the red camera signal

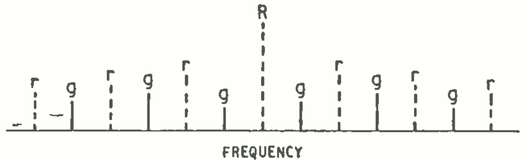


Fig. 3. Detail of frequency band in vicinity of the red subcarrier.

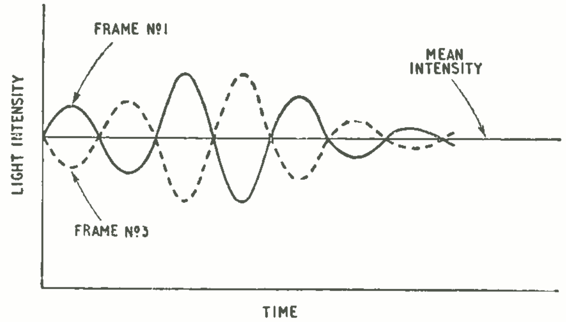
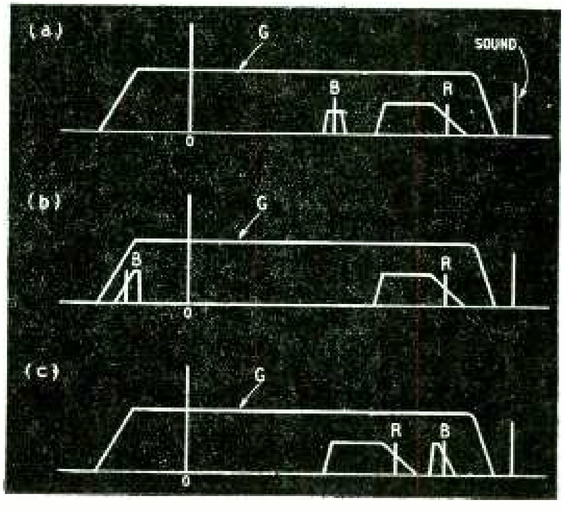


Fig. 4. Light intensity along the same line on alternate odd frames.

Fig. 5. Alternative possibilities for the location of the blue subcarrier.



above 1 Mc/s and up to 4 Mc/s may be superimposed on the green signal to yield a mixed-high signal above 1 Mc/s.

The video frequencies associated with the third colour, blue, may be transmitted as modulation on a second sub-carrier. Again, as in the case of the red signals, only the lower blue frequencies need be transmitted, so that a comparatively narrow channel should suffice. A blue video band up to 0.2 Mc/s may be sufficient. Fig. 5 shows several alternate possible locations for the blue sub-carrier. It is not yet known which of these various methods is likely to provide the best all-round performance. Consider, for example, the third alternative in which the red subcarrier is shown moved down to about 3.2 Mc/s, or to 3.189375 Mc/s, the 405th multiple of 7,875 c/s, while the blue carrier may be located just under 4 Mc/s at 3.898125 Mc/s, the 495th multiple of 7,875 c/s. (The 3.189375 Mc/s signal may be derived from the 3.898125 Mc/s signal by dividing the latter by 11 and then multiplying the quotient by 9.)

Again, as was the case with red and green, the blue signal appearing on the green gun is effectively filtered out by the eye, as are the green signals appearing on the red and blue guns. The blue and red signals, since they do not overlap in frequency, do not exhibit this effect.

As stated before, the high video frequencies may be represented by the green channel alone. In order to avoid a greenish tinge to high frequencies the green highs may be taken off the green video channel by the shunt connection of a suitable high-pass filter and added to the blue and red guns (as well as direct connection to the green gun) of the reproducing means to produce black-and-white fine detail. Alternatively, blue and red highs may be added to the green channel at the transmitter and taken off from the green video channel in the receiver to feed the blue and red guns as well as the green gun. The cut-off frequency of the high-pass filter would be selected at approximately the cut-off frequency of the red-channel low-pass filter, or in the example given, at about 1 Mc/s.

A schematic of the colour section of a simple receiver for the reception of a television transmission of the form of Fig. 5 (c) is shown in Fig. 6. The i.f. is kept wideband at the anode of the last i.f. amplifier purposely, so that the blue channel will not be adversely attenuated before it is detected in the blue detector.

Following this detector is an amplifier and tuned circuits centred around the blue subcarrier to remove effects of the sound carrier and the red subcarrier. The blue detector yields the blue low-frequency video signals which are amplified and fed to the blue gun grid.

Appropriate sound traps (and if desired blue subcarrier traps) are employed before the green and mixed-highs detector. The output of this detector is amplified and fed to the green gun. Two shunt circuits leading from the anode of the green-channel amplifier feed respectively the red detector through a 3.2-Mc/s band-pass circuit and the mixed-high filter for the addition of mixed highs into the red and blue guns. The 3.2 Mc/s filter feeds a red signal detector and the output of the detector feeds a red amplifier connected to the red gun.

Inter-colour Cross-talk

The receiver as shown here employs six sets of valve elements over and above those a receiver would employ if designed to receive black-and-white pictures. By using available combination type valves, the actual number of valves may be as low as three. The polarity of the detectors may be reversed from

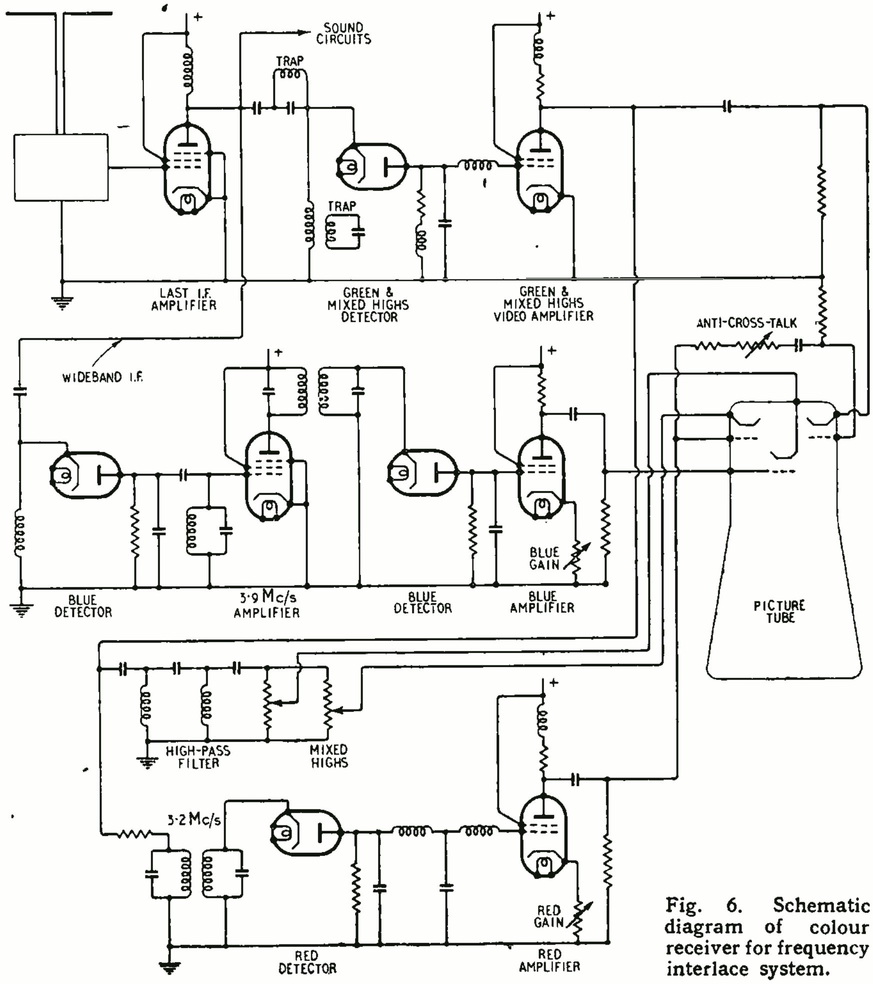


Fig. 6. Schematic diagram of colour receiver for frequency interlace system.

those shown to produce the right phase of light intensity; i.e., a positive picture. Alternatively, the picture tube gun connections may be reversed to achieve the same result.

A mathematical analysis of the action of the green detector shows that some of the red low video frequency modulation will appear as low frequency in the detector output because the system is single sideband. The presence of this low-frequency spurious signal in the green channel may cause an undesirable cross-talk effect making itself evident in a change in hue but not in geometrical design. This colour shift cross-talk effect may be reduced to a small amount if desired by feeding some low-frequency red signals into the green gun in phase reversal to the cross-talk. Again depending upon the modulation polarity of the red signals, the anti-cross-talk connection may be made either to the cathode or to the grid of the green gun as required. It is shown here connected to the grid of the green gun.

The simpler receiver shown in Fig. 6, while it contains sufficient circuit elements to receive colour pictures, has for simplification purposely omitted two factors which may be desirable in a commercial product. These are d.c. restorers and a.g.c. The green a.g.c. and the green restorer are the same as for black-and-white receivers and need not be discussed in detail. The red and blue d.c. restorers are likewise conventional.

A.g.c. for the red and blue channels will probably be needed in a practical receiver to take care of receiver i.f. response variations due to tuning and effects of a.g.c. on the i.f. response shape.

Many methods of transmitting reference signals for use by the a.g.c. systems will suggest themselves, but one of the simplest methods is that adopted by communication services which employ suppressed carrier channels. This method is to transmit a pilot signal of fixed amplitude, which may be continuous except for blanking intervals, but which lies outside the normal communication channel frequencies. Thus, in the red channel, a continuous unmodulated wave at a frequency of 1.1 Mc/s from the red carrier might be used as a pilot frequency.

Another pilot frequency 220 kc/s from the blue channel carrier could be used for blue a.g.c. In a practical receiver, however, it is quite likely that the red and blue signals would maintain their relative

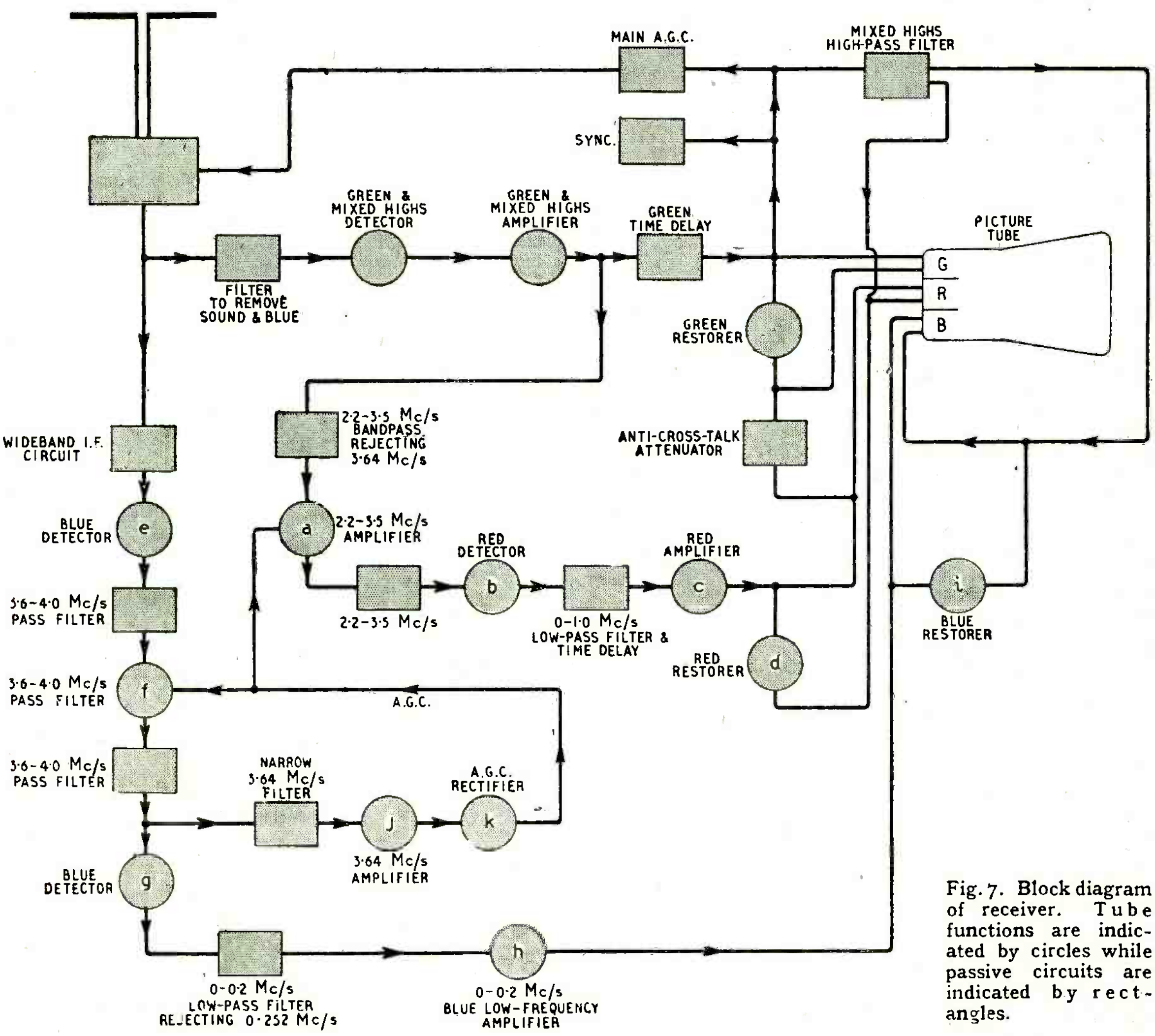


Fig. 7. Block diagram of receiver. Tube functions are indicated by circles while passive circuits are indicated by rectangles.

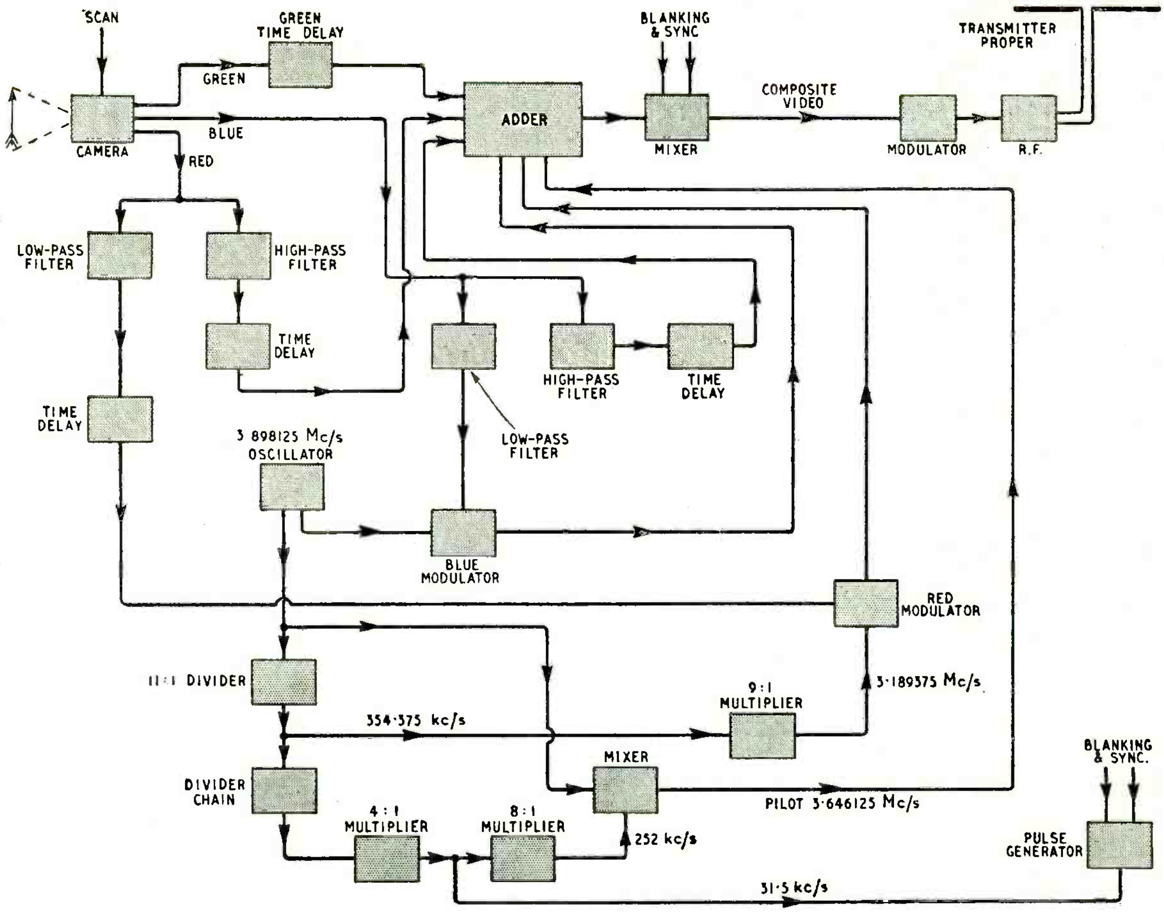


Fig. 8. Transmitter block diagram.

magnitudes fairly well, but that the green might change with respect to them depending upon the position of the green carrier along the slope of the i.f. response characteristic. Therefore, a single a.g.c. for the red and blue channels may prove to be adequate, in which case a pilot frequency may be radiated in the vicinity of 3.65 Mc/s in the guard band between the blue and red channels shown in Fig. 5 (c).

The exact frequency for the pilot may be 3.646125 Mc/s, the 463rd harmonic of 7,875 c/s. This frequency may be generated by subtracting the eighth harmonic of 31,500 c/s from 3.898125 Mc/s. This pilot would then lie 252 kc/s below the blue carrier, or 456.75 kc/s above the red carrier in a position so that the pilot carrier can be eliminated from the blue and red low-frequency signals by the use of suitable traps, and so that its effect on the green picture will be cancelled by the eye.

The pilot a.g.c. signal may be amplified and rectified to obtain a.g.c.-d.c. control voltage which may be applied to the 3.9 Mc/s blue signal amplifier as control grid bias. The d.c. may also be applied to an amplifier which may be inserted in the system shown in Fig. 6 just prior to the red detector. D.c. delay voltage may be employed on the a.g.c. rectifier to make the output become quite uniform regardless of variations in output over a suitably wide range in magnitudes. Actually, of course, since the receiver as a whole has its gain controlled by the green channel, it is not likely that very extreme ranges in input variations to the red and blue channels would occur.

The d.c. delay voltage may be made adjustable if desired so that the service man at the time the receiver is installed may adjust this control (as well as the individual red and blue gain controls) for best colour balance.

Time-delay networks may be required in the green and red channels to give a resultant overall uniform time-delay equal to the time-delay of the blue low-frequency channel, because the blue channel is the narrowest and therefore will probably have the greatest inherent time-delay.

A block diagram of the colour portion of a receiver incorporating some of the finer points mentioned in the above discussion is shown in Fig. 7. This receiver employs the following valve functions above what is required for a black-and-white receiver:

(a) One 2.2-3.5 Mc/s Red i.f. amplifier.
(b) One Red diode detector.
(c) One 0-1 Mc/s Red video amplifier.
(d) One Red restorer diode.
(e) One Blue diode detector.
(f) One 3.6-4.0 Mc/s Blue i.f. amplifier.
(g) One Blue diode detector.
(h) One 0-0.2 Mc/s Blue video amplifier.
(i) One Blue restorer.

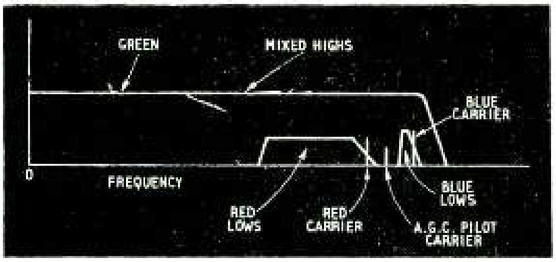


Fig. 9. Spectrum at output terminals of transmitter adder

(j) One 3.64 Mc/s a.g.c. carrier amplifier.
(k) One a.g.c. rectifier diode.

These eleven valve functions can, of course, be obtained by employing fewer than eleven separate valves when use is made of double-purpose valves.

The picture tubes which may be employed as an electro-optical transducer in the receiver may be any of the forms described in the literature including:

(a) Three separate tubes, one for green, one for red, one for blue.
(b) A three-gun single tube as demonstrated by R.C.A.
(c) A single-gun single tube as demonstrated by R.C.A.

The first two forms of the transducer, (a) and (b), require no additional apparatus, but the third form would require a circular sweep generator and an auto-sampler, the total number of added valves possibly being as high as six. For this reason, and for reasons of avoiding the problems attendant to optical registration, form (b) would appear to be the preferred form for the transducer.

The transmitter for the frequency-interlace colour system would be a standard transmitter with some modifications. A block diagram is shown in Fig. 8. An adder having six input terminals is shown in this diagram into which may be fed:

1. Green video signals.
2. Red lows on a subcarrier.
3. Red highs direct.
4. Blue lows on a second subcarrier.
5. Blue highs direct.
6. A.G.C. pilot signal.

The adder output frequency spectrum would then look like that shown in Fig. 9.

Time-delay networks may also be required in the transmitter, and, if so, would probably go into the green and red channels, since once again the blue channel will be retarded the longest inherently because of the relatively narrow bandwidth devoted to blue low-frequency components. Time-delay networks may also be required in the red high and blue high circuits as indicated in Fig. 8.

The video signal is capable of being transmitted over cable and radio-relay networks without loss of fidelity providing the characteristics of the network are such as to provide good transmission up to 4 Mc/s. If the cable or radio link has a pass band of only 2.8 Mc/s, the picture is still usable as a black-and-white picture, but not as a colour picture because the blue and red information would be missing or incomplete.

Anomalous transmission vagaries at u.h.f. are rare and hence it is not anticipated that any difficulties will be encountered which would temporarily blot out a portion of the radiated band, thereby removing a blue or a red carrier and their sidebands. Instead, it is to be expected that a continuous flow of all of the information would be received.

This colour system is compatible in that present black-and-white receivers, regardless of video bandwidth, may be used to receive colour transmissions in black-and-white. The green picture would constitute the signal employed in reception. Cross-talk would cause no trouble because it is geometrically in the same position on the screen as the green signal itself. If the polarity of modulation is chosen carefully, the black-and-white tube may actually be aided by the cross-talk to give lights and shadows even when the green component is weak.

When the colour receiver is tuned to a black-and-white transmission, all of the guns may be fed from the main signal. The operator of the receiver may do this manually in low-priced receivers. Switching would be indicated because the red and blue channels would be dead and the picture would be green. On the other hand, if the receiver were switched for standard black-and-white reception, and a colour signal were tuned in, the operator would have no positive signal that the transmission was in colour and would have to "try" the colour switch to see if it were in colour. On a more expensive receiver, the switching could be accomplished automatically. For example, if the pilot signal at 3.64 Mc/s is employed its presence in colour transmissions could be used to operate a relay to do the colour switching. An absence of 3.64 Mc/s would fail to close the relay so that the receiver would automatically be set up for black-and-white reproduction.

As yet this system has not been completely set up and demonstrated. However, preliminary laboratory tests have been made to verify some of the basic principles.

For example, a continuous-wave oscillation frequency representative of a red carrier has been superimposed on a black-and-white picture and it has been determined that the best frequencies for it are any of those lying between line frequency harmonics. When the injected frequency coincides with a line frequency harmonic, vertical black-and-white bars are visually evident. When the frequency of the injected wave is shifted to lie midway between harmonics of the line frequency, two effects are noticed:

(1) A dot pattern replaces the vertical line pattern.
(2) The variations of light intensity are reduced.

These points substantiate the theory.

Secondly, low-frequency amplitude modulation has been applied to the injected carrier and low-frequency cross-talk observed; but the low frequencies at the output of a detector, tuned to the injected frequency, when inserted into the video channel in the proper corrective phase, substantially removed all traces of low-frequency cross-talk. This experiment therefore verified the anti-cross-talk possibilities referred to in the description of the system

When the injected carrier frequency is above 3 Mc/s the fine dot pattern has about the same quality as normal line structure and disappears at about the same viewing distance from the picture tube. No observable "twinkle," "flicker," or "crawling" could be obtained in any of the tests, indicating freedom from these particular types of disturbance.

The proposed frequency-interlace colour television system appears to offer the following advantages over other known systems:—

1. All precision equipment is localized at the

transmitter, so that the receiver can be relatively low in cost, reliable in operation, easy to adjust and maintain, and simple in construction. It is estimated that only six more valves are required than in a monochrome receiver.

2. The receiver should be free from colour shifts due to noise interference.

3. The system is inherently compatible with present (American) monochrome standards.

4. The receiver should exhibit a complete absence of twinkle, crawl, or flicker and of field-sequential colour fringing.

The anticipated disadvantages of the system are:—

1. The requirement of either (a) more accurate receiver alignment and tuning, or (b) an effective automatic gain control on each colour.

2. Possible colour fringing due to differential time-delay in propagation between colour carrier frequencies. (This is not expected, but tests ultimately should be made to check it.)

3. Full 4 Mc/s bandwidth is required in relaying.

4. Possible second-order colour fringing due to incomplete "physiological filtering" in rapidly moving objects.

NEW BOOK

The Theory and Design of Inductance Coils. By V. G. Welsby, Ph.D., A.M.I.E.E. Pp. 180; 61 diagrams and photographs. Macdonald & Co. (Publishers), Ltd., 43, Ludgate Hill, London, E.C.4. Price 18s.

ANY radio engineer worthy of the name can design an air-cored tuning coil or an iron-cored smoothing choke with confidence that a sample made up to his instructions will turn out to have an inductance reasonably close to specification. His expectations regarding its a.c. resistance or Q may be rather vaguer, however. When it comes to designing a dust-cored coil to a specified Q (as well as inductance), and to a specified harmonic distortion limit, very many will have to admit the necessity of falling back on trial-and-error, aided by such experience as they possess. The pre-calculation of losses, especially in high-frequency iron-cored coils, and clear knowledge of how they are related to dimensions and frequency, is not a widely distributed ability. There is, therefore, ample need for this new book, by a specialist on the subject at the G.P.O. Research Station. It covers the design of the many types of inductors used in communications, and is applicable to others, such a fluorescent lighting chokes.

One source of difficulty is the large number of variables, both physical and electrical. Another is the non-linearity of ferromagnetic materials. The author has gone far towards reducing such matters to routine design, and has devised graphical methods to minimize labour; but it must not be supposed that one can skip the theory and employ a few, cut-and-dried results. Many of the results are valid only within certain limits, and must be used intelligently. Some of them admittedly can give no more than a rough idea. Their main value is to point in the direction one should go. The first trial sample gives a result that is not quite acceptable; how can it best be modified?

After two introductory chapters defining inductance, a.c. resistance, and Q, in relation to series and shunt equivalent circuits, and dealing with the effect of self-capacitance, the calculation inductance and losses of air-cored coils is treated. The design of stranded wire is an original contribution by the author, who then goes on to deal in turn with coils having laminated and dust cores. The self-capacitance of coils is the subject of a short chapter. The results are then applied to the problem of Q and its variation with dimensions and frequency. Harmonic distortion and impedance measurements are then discussed; and finally there are some numerical examples of how typical design problems might be solved.

The treatment is on the whole clearly and logically presented. One could wish that wherever the author had fallen back on "it can be shown" he had provided a reference. A list of symbols would also have been a great help. "Qo" appears on p. 45 without a clue to its meaning (until p. 108, and there both the nomenclature and the equation disagree with the earlier chapter referred to). Errors are rather disconcertingly frequent; for example, equation 34 is wrong by a factor of 4, and is by no means in its simplest form; and the *Proc. I.R.E.* reference at the foot of p. 147 is 10 years out. Notwithstanding these criticisms, the book can be highly recommended.

M. G. S.

CLUB NEWS

Bexley.—Meetings of the North Kent Radio Society (G3ENT) are held on the second and fourth Mondays of the month at 7.30 at the Freemantle Hall, Bexley. Sec.: L. E. J. Clinch, 8, Windsor Road, Bexleyheath, Kent.

Coventry.—Among the subjects to be dealt with at forthcoming meetings of the Coventry Amateur Radio Society, which are held on alternate Mondays at 7.45 at the B.T.H. Social Club, Holyhead Road, are "Top Band Transmitting" and "Super Modulation." Sec.: K. G. Lines, G3FOH, 142, Shorncliffe Road, Coventry.

Edinburgh.—Arrangements made for members of the Edinburgh Amateur Radio Club, who meet on Wednesdays at Unity House, 3, Hillside Crescent, include a lecture on "U.H.F." and a visit to the local Police radio station. The club's transmitter GM3HAM is in operation on 80 metres, c.w., on alternate Wednesdays. Sec.: D. A. E. Samson, GM3EQY, 56, Elm Row, Edinburgh, 6.

Richmond.—Meetings of the Richmond & District Radio Society are held on Wednesdays at 7.30 at the Richmond Community Centre. Sec.: W. Crossland, 1, Spring Grove Road, Richmond, Surrey.

Southall.—Future meetings of the West Middlesex Amateur Radio Club, which meets on the second and fourth Wednesdays of each month, will include an exhibition of home-constructed gear and a general discussion on "My Interest in Radio." A morse class is held for half an hour prior to each meeting. Sec.: P. F. Blomfield, G3EDH, 213, Harrow View, Harrow, Middlesex.

Southwick.—The Southwick and District Radio & Television Club has been re-organized and weekly meetings are being held on Tuesday evenings at the "King's Head," Fishersgate, Sussex. Sec.: E. Basilio, 111, Vale Road, Portslade, Sussex.

Sunderland.—At the meeting of the Sunderland Radio Society on January 11th at 8.0 in the Y.M.C.A., Toward Road, R. V. Duesbury will speak on "Hams Abroad." Sec.: C. A. Chester, 38, Westfield Grove, High Barnes, Sunderland.

Wakefield.—A series of Mullard film strips covering the characteristics and applications of valves are being shown to members of the Wakefield and District Amateur Radio Society. Meetings are held on alternate Wednesdays at 7.30 at Service House, Providence Street, Wakefield. Sec.: W. Farrar, G3ESP, "Holmcroft," Durkar, Wakefield.

Watford.—Lectures on radio fundamentals and the early history of television will be given at the meetings of the Watford and District Radio and Television Society on the first and third Tuesdays in January and February. Meetings are held at 7.30 at the Cookery Nook, The Parade, Watford. Sec.: R. W. Bailey, G2QB, 32, Cassiobury Drive, Watford, Herts.

exerting pressure on them, so causing gaps to appear between the stylus point and the opposite wall of the groove. From the foregoing it would therefore appear that the important factor in this question of continuous contact between stylus and groove walls is the degree to which "looseness" occurs rather than the fact that it does occur at all.

Coming back to the fine thorn point it seems clear that the extreme tip will very rapidly be worn to the contour of the bottom of the groove and may thus fit it well enough as long as the total damping and inertia, as reflected at the needle tip, is light enough not to prevent the needle tip from following the lightest guidance from the groove. At the end of its life, before re-sharpening, the thorn point has worn large enough to fill the groove to the maximum allowable extent before distortion becomes apparent and it seems probable that it reaches the minimum size for sufficient fit very quickly after being put into use. One advantage of the fine point would appear to be that it will be less subject to "pinch effect."

To a possible criticism that a long very acute point on a thorn will tend to increase the pliability of the thorn material, which was one of its main weaknesses in the old heavyweight pickup era, it might be answered that the amount of "bending" of the thorn needle, under the influence of the recorded vibrations, will surely be a function of the damping, mass and inertia of the moving parts it has to drive. Provided these load factors are small enough there seems very little to bend the thorn against.

However, even if it is accepted that the thorn does flex slightly under the influence of the highest frequencies, it seems not inconceivable that it may still be a good medium for transmitting to the voltage-generating element transverse vibrations induced in it by the record groove, in the same way that paper loudspeaker cones successfully transmit complex waves from their apexes to their peripheries up to really high frequencies. The analogy between cones and styli must not be carried too far, of course, because the whole surface of the cone (more or less) is radiating the sound we hear, whereas the stylus is not. Nevertheless it may be legitimate to suggest that just as metal cones, used as direct radiators, i.e., not horn-loaded, result in more prominent resonances (*vide* Briggs, "Sound Reproduction," 2nd ed., p. 66) compared to paper cones, it may perhaps be that metal-shafted semi-permanent styli are also subject to more pronounced natural resonances, if and when they vibrate in wave motion, than the softer and lighter thorn. These thoughts are offered as no more than possible theories to explain the surprisingly good performance of thorn needles, when most of the generally accepted factors making for good reproduction are apparently against them.

Long-playing Records

In connection with long-playing records, it may be of interest to the experimenter to note that the writer has been able to obtain excellent reproduction with a very finely pointed thorn, used in the pickup referred to above, but with the weight reduced to 5 or 6 gm. One thorn under these conditions will play one side of a 10-inch record without noticeable deterioration. One 12-inch side is just within its capacity though there is a tendency towards a slight falling off in quality right at the end, depending largely on one's success in producing a really fine point initially. The decline is not serious, but it can be distinguished. As might be expected, a certain amount of care is essential in inserting the finely pointed thorn into the pickup. Fig. 6 shows one of the thorns after playing one side of a 10-in L.P. record. The writer was not able to photograph it with a 0.001-in radius sapphire for comparison, but again some idea of its final size can be estimated by reference to the other photographs. The particular advantage of using thorns in connection with L.P. records is that one pickup head can be used for both L.P. and standard 78 r.p.m. records, as long as the downward pressure is variable within the appropriate range.

Record Wear

A further criticism of thorn needles has been that they wear records quite appreciably by picking up dust in the grooves and holding it, turning themselves into a kind of abrasive instrument. It is naturally not easy to get direct visual evidence of this fact one way or the other, and the frequent changing and sharpening of thorns would be no joke if one seriously attempted endurance tests. The record would most probably endure longer than the tester. The writer unfortunately is not in a position to offer any photographic evidence of records before and after playing with thorns in lightweight pickups, but it can be reported that the aforementioned "Danse Macabre," after some fifty playings exclusively with thorns in the moving-coil pickup referred to, still plays indistinguishably from new (the comparison, of course, being made against recent new records). Most keen record collectors take the trouble to brush their records before playing in an attempt to remove as much dust as possible, and it therefore seems likely that abrasion by dust held by the thorn, if it exists, can be reduced to negligible proportions if light pressures are used and the point itself is kept down to minimum size for tracing accuracy at high frequencies

As has been said, and on the lessons of bitter experience, thorn users will take a lot of convincing that their needles do not result in minimum record wear, whatever the thorn's other shortcomings. If lightly damped pickups with needle pressures in the region of 14 gm are used in conjunction with properly shaped thorns it seems likely that even longer lives can be expected from records than has been the case in the past, allied to reproduction of a very high order.

MANUFACTURERS' LITERATURE

Broadcast Receiver, Marconiphone Model T26A; brief details in a leaflet from E.M.I. Sales & Service, Ltd., Hayes, Middlesex.

Government Surplus Equipment, an illustrated catalogue from Lyons Radio, Ltd., 3, Goldhawk Road, Shepherds Bush, London, W.12.

Radio-frequency Cables catalogued in an illustrated brochure from the Telegraph Construction & Maintenance Co., Ltd., 22, Old Broad Street, London, E.C.2.

P.M. Focus Units, Elac Mark II, described briefly in a leaflet from Electro Acoustic Industries, Ltd., Stamford Works, Broad Lane, Tottenham, N.15.

Cable Manufacture; a descriptive brochure to mark the opening of a new factory, from W. T. Henley's Telegraph Works Co., Ltd., 95, Aldwych, London, W.C.2.

Radio-telephones and their applications described in a well-illustrated catalogue from Pye, Ltd., Radio Works, Cambridge.

VOLTAGE

By "CATHODE RAY"

What is the Difference Between an E.M.F. and a P.D.?

THE word "Voltage" is a general term covering both electromotive force (e.m.f.) and potential difference (p.d.). Most of the books that teach electrical principles emphasize the importance of distinguishing between these two things. One reason why e.m.f. and p.d. tend to become confused may be because they are both measured in volts. Not in itself a very good reason, surely; nobody finds it difficult to distinguish between tomatoes and parsnips because they are both sold by the pound. The chief difficulty, probably, is that neither e.m.f. nor p.d. can be seen, and many of the necessary circuit calculations can be done quite successfully in terms of "voltage," so why bother?

The answer is that the ability to cope with the trickier problems in electricity depends on a clear mental picture of what goes on. And a clear mental picture of an electrical circuit is impossible with only a hazy idea of "voltage."

This distinction between e.m.f. and p.d. is one of the most difficult of the basic ideas to grasp. Or so I think. A useful working picture of it can be formed by any reasonably intelligent student in a few minutes. But later on he may wonder if the dividing line is quite so clear-cut as it seemed at first.

Morecroft's Distinction

These thoughts came into my mind when I happened to turn back to an old guide and counsellor—Morecroft's "Principles of Radio Communication," dated 1921. This book has stood the test of time much better than many that have been written since. Only the other day I read a post-war article (War No. 2; not No. 1!) in which the author stated very cocksurely that whatever else might happen the signal current in the anode circuit of a valve must always be in phase with the grid voltage. If he had looked up his Morecroft he would have spared his readers this misdirection, for the contrary is shown not only in theory but backed up by photographed oscillograms from actual circuits. And this author evidently had Morecroft handy, because he referred to his teaching on e.m.f. and p.d. That was how I came to look it up.

Curiously enough, it was just here where, for the first time I wondered if Morecroft hadn't slipped just a little. He illustrated the distinction with two diagrams (reproduced here as Fig. 1), one of them showing a current being maintained through a resistance by a battery—a source of e.m.f.—and the other a momentary current passing through a wire joining two balls, one charged positively and the other negatively and therefore having a p.d. between them. Regarding the latter Morecroft says, "There is no action taking place which tends to maintain the difference of potential between the two balls; such a combination does not generate an electromotive force."

Now, I suppose that strictly according to the wording of this it is perfectly correct. That is, if the emphasis is on "maintain" and "generate." My only objection is that as the chosen example for illustrating the difference between e.m.f. and p.d. it is likely to lead the reader to suppose that in the charged-ball system there is no e.m.f., and especially that the distinguishing feature of an e.m.f. is its ability to maintain the flow of current for a relatively long time, as a battery does. (Do I hear cries of protest from owners of battery-driven sets!)

I am not using this quotation for the purpose of trying to show how much cleverer I am than Prof. Morecroft. Far from it; if everything I had written in the last thirty years could bear such close scrutiny now as "Principles of Radio Communication," I might really have something to boast about. No; it just happened to set going some thoughts on exactly what are the distinguishing marks of an e.m.f. This is not just technical hairsplitting or armchair theorizing; one of the most useful practical "laws" in circuitry is Kirchhoff's second, which in its most usual form says that if you add up all the e.m.f.s round a circuit (with due regard for + and − if there are any opposing one another), and also add up all the potential drops due to resistance, the two totals will be equal. And there is this important point, that the "sign" (+ or −) of a p.d. depends on the direction of the current, but that of an e.m.f. does not. So one really ought to be able to tell with certainty which is which.

P.D. Without an E.M.F.?

In purely d.c. circuits, with only resistances and batteries, there is no real difficulty. Anybody who has had the elements of the matter explained to him should be able to see that the voltage between the terminals of a battery when it is supplying current is not the e.m.f. of the battery (nor, to satisfy the legally-minded, is it even equal to the e.m.f. of the battery), because there is a voltage drop inside it due to its own resistance and this drop is deducted from

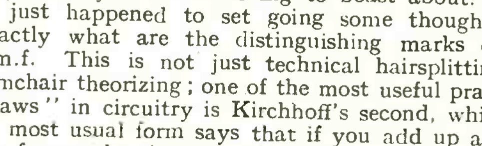


Fig. 1. Is it fair to use these examples to illustrate the difference between e.m.f. and p.d?

the e.m.f. to give the terminal voltage. The only thing that might start an argument here is the question of whether it is possible to have an e.m.f. without a p.d., or vice versa. A dead-shorted battery might possibly qualify as an example of the former. And Morecroft seems to give the charged balls as an example of a p.d. without an e.m.f. But that is going beyond a d.c. circuit in its strictest sense, by bringing in a capacitance.

Well, let us bring it in. I think we can agree with Morecroft that a pair of stationary oppositely-charged balls—or capacitor plates—cannot *maintain* a p.d. steadily while it is causing a current to flow, and does not *generate* an e.m.f., if that must be understood to mean returning the positive charges that have reached the negatively-charged ball back by a different route to the other ball, there to continue through the conducting path to keep the current going. His charged capacitor can be likened to a switchback in which the cars have, by some means unspecified, been lifted to the upper stage. From there they can "flow" to ground level around the track "circuit." And then the movement stops. To maintain the flow of cars, a source of power is needed to return the cars against the force of gravity to the upper or "high potential" level. Morecroft would no doubt explain that this power lifting gear is the "e.m.f.", without which the flow of cars ceases when the original "charge" has reached the ground. You can, if you prefer, substitute a filled reservoir on top of a hill to represent the p.d. and a pump to represent the e.m.f. Either way it seems to clinch the matter pretty definitely and clearly.

But wait! Let us approach the thing from a different direction by a rather roundabout route and see how it looks.

The most important sources of e.m.f., it will be agreed, are not batteries but electromagnetic generators. Now continuity of voltage is not at all a characteristic feature of this method of generating an e.m.f. To make it continuous necessitates an elaborate system of multiple poles, distributed armature windings, innumerable commutator segments, and brushes. Even then there is a ripple. So electrical engineers have more or less given that up and standardized on power systems delivering voltage in alternate positive and negative pulses each lasting only a hundredth of a second or thereabouts; less time perhaps than our "momentary" capacitor discharge. So the mere length of time that a steady current flow can be maintained hardly seems to be the proper criterion of an e.m.f.

True Mark of an E.M.F.

A more fundamental basis for identifying e.m.f. is by considering the transfer of power. In a power station it is abundantly obvious that the generators are giving out electrical energy in exchange for mechanical energy. We learn that there is a fixed rate of exchange. To raise the potential of an electric charge so that the charge can flow through the circuit resistance necessitates the expenditure of some kind of energy. In fact, the real measure of an e.m.f. is the amount of energy that is put into the charge. If a charge of one coulomb is given an energy of 100 joules (= watt-seconds), then the e.m.f. doing it must be 100 volts, and to generate this electrical energy 100 joules of some other sort of energy must be spent. (The usual answer, that one volt is the e.m.f. required to drive one amp through one ohm doesn't really define voltage, as you discover later when you have to define resistance and find yourself in a vicious circle.)

In an electrical generator the e.m.f. is produced by moving a magnet. If the e.m.f. acts in a closed circuit so that it causes current to flow, then the current sets up its own magnetic field, and it is the mechanical force needed to move the magnet against the attraction or repulsion of this field that demands an input of mechanical energy. The fact that the e.m.f. only lasts as long as the possibly brief moment that the magnet is kept in motion relative to the circuit does not in any way disqualify it from being an e.m.f.

As we all know, it makes no difference whether the magnet is a permanent magnet or an electromagnet, and if the latter then it is not necessary for it to be actually moved—a change in strength of magnetism is enough. In this case the input of energy can be of the same kind as the output—electrical—yet I imagine nobody would say that all the books are wrong in speaking of the induced *e.m.f.* Anybody who, like me, had just said that e.m.f. is a result of the expenditure of some other kind of energy could easily talk himself out of any criticism by pointing out that there is a double conversion of energy in this case: first from electrical into magnetic, so that the immediate cause of the e.m.f. is an expenditure of magnetic energy.

Squaring up Kirchhoff

This argument holds even if the input and output circuits are the same, giving *self*-induction. It may be worth thinking this out in some detail. Consider the arrangement shown in Fig. 2(a), in which all resistance except R is negligible. If S_1 is now closed (b), a current flows, of strength I equal to E/R. Or, as Kirchhoff would put it, the p.d. IR, between *c* and *d*, is equal to the e.m.f. E acting from *a* to *b*. Neglecting the inductance of the leads, etc., the current jumps to its full value immediately the switch is closed. If now S_2 is also closed (c) the voltage E is placed across the inductance L. Since L has no resistance, the ultimate current would theoretically be infinite; but directly any current starts to flow it sets up a magnetic field around the coil, and the growing field generates an e.m.f. E_L that tends to oppose the growth of current. This e.m.f. must obviously be equal to E. So the rate at which the current grows is such as to make it so. If L is in henries, the required rate is E/L amps per second. There is no IR drop in the battery-and-coil circuit, but also there is no net e.m.f. ($E - E_L = 0$), so Kirchhoff is satisfied.

While current is flowing through R, the electrical energy put into it by E against the resistance is being converted into heat energy. The electrical energy put by E into the L branch against E_L must also be going somewhere; it is being stored as magnetic energy.

Next, suppose that after the current through L has grown to a substantial number of amps, S_1 is opened (d), cutting off the source of e.m.f. The current through R from E instantly ceases. But the current through L cannot instantly cease. If it did so, the strength of magnetic field would cease with it, and induce an infinitely high voltage across the resistance, which if it weren't absurd would be highly interesting. What actually happens is that the current diminishes gradually, and the resultant diminishing of the magnetic field generates an e.m.f. in the opposite direction, from *e* to *f*, driving current in the same direction as before through L, but in the opposite direction to the original through R. Applying Kirchhoff, we now have E_L equal to the p.d. across R. As the current falls, so does this p.d., and so does the e.m.f., and so does the rate at which the current falls. So it gradually tails off, just like the current discharge of a capacitor.

Just like the current discharge of a capacitor. Perhaps you were forgetting Morecroft's brass balls in Fig. 1. We have nearly worked our way back to them. Can anybody deny that E_L in Fig. 2 was an e.m.f.? It even has a full official title—the e.m.f. of self-induction. Without it there would be no end of a job squaring up old Kirchhoff. From the energy transfer point of view, too, E_L ranks as an e.m.f.; magnetic energy is disappearing and an equal amount of electrical energy is being created; this in turn being converted into heat energy in R.

Now go through the whole Fig. 2 process again, substituting a capacitor C for the inductor L. There is no need for me to describe it in detail. The main thing is that a certain amount of energy will become stored in C as an electric field, and in the final event this stored energy will develop a voltage which will drive a tailing-off current through R. The two cases are so closely parallel that I for one would not care to deny the driving force for this current the title of e.m.f. The only argument even a prosecuting lawyer could try would be to claim that in the case of the discharging capacitor the source of energy is an *electric* field, so that there is no conversion to electric energy from a different kind. And although an analogy isn't strictly evidence, what about the switchback?

The defence would then point out that the switchback with its raised cars can, even without a driving engine, lift weights from ground level. All one needs is a pulley arrangement, whereby the raised cars can be allowed to fall and the energy so released is capable of raising other cars (admittedly not so heavy, owing to frictional losses). The fact that this process cannot be kept up indefinitely makes no difference in principle. As a matter of fact, a Wimshurst machine is an example of how a capacitor discharge *can* be kept up continuously, by the expenditure of mechanical energy. Even if the argument about the electric field not being a different kind of energy from the electric current were sound—which is distinctly doubtful—it would not only make the discharging capacitor circuit a very awkward customer for Kirchhoff's second law; it would also be a very inconvenient point of order to press, for it would mean upsetting the beautiful balanced pattern of two opposite kinds of reactance. A.c. would be opposed, in inductive reactance, by the *e.m.f.* of self-induction —and in capacitative reactance by heaven knows what. Wherever the dividing line is to be drawn between e.m.f. and p.d., please don't let it be here. It would be about as unhappy as the 38th parallel in Korea.

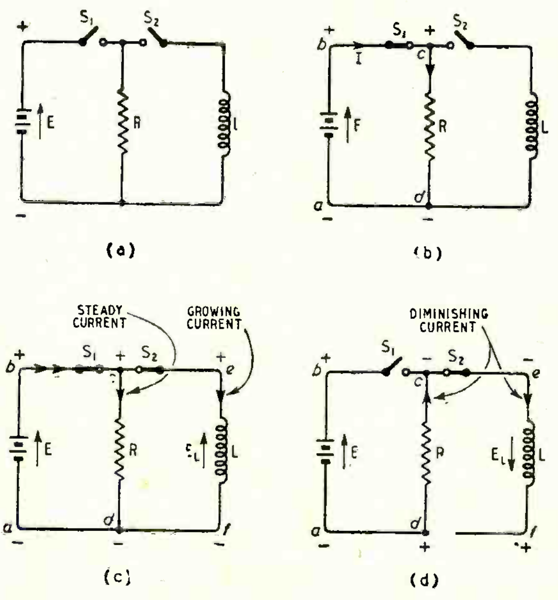


Fig. 2. Sequence of switching in an imaginary experiment to shed light on the difference between e.m.f. and p.d.

Cause-and-Effect Fallacy

Where *should* the distinction be drawn? I warned you that this question was not going to be quite so simple as it is sometimes made out to be. But if you must ask, I would say that an e.m.f. is present only where the exchange of energy in the circuit is reversible. The voltage across a resistance is a p.d., set up by the operation of an e.m.f. somewhere else, but not itself an e.m.f., for no part of the electrical energy which is being lost in the resistance as heat can be directly restored to the circuit by the resistance. But when electrical energy is used to run a motor or charge a battery or magnetize a coil—or charge a pair of brass balls—a back-e.m.f. is set up which is capable, given suitable conditions, of reversing the energy transfer.

I looked up all the books I could lay my hands on, and all except one were careful never to mention e.m.f. in connection with a discharging capacitor. Why?

A broad difference is that e.m.f. is a cause; p.d. the effect. On this basis it might seem right to say that the charge on the balls is the effect of an e.m.f. that must have been exercised previously—and therefore not itself an e.m.f. But those few added words, in my opinion, are just where the fallacy lies. For, you see, an effect can in turn be a cause. When you pump your bicycle tyre you exert an "air-motive force," and the result is a pressure difference between the inside of the tyre and the outside. Nothing but such a force could make the air more against the internal pressure. But this effect, this "p.d.", could in its turn be used as an "a.m.f." to inflate a toy balloon.

So is there any need to be so shy about calling the voltage across a charged capacitor an e.m.f.? The main thing, of course, is to be quite clear in one's mind. What we call it is not quite so important. Calling the funds expended on entertaining lady friends "expenses" may not prevent a man from understanding quite clearly what he is doing. It may (for a time) mislead other people. It may (in time) even mislead his own judgment. The best thing is not only to understand things clearly but to express them so that everybody else knows what is meant.

Some of the things one hears about voltages don't quite come up to this ideal. We all know the newspaper paragraph reporting that "10,000 volts passed through his body," followed by a statement on the subsequent lamentable condition of the said body. And when someone tells us that he got a shock of about the same voltage from his sparking plug without any such dire results, he is likely to account for it by saying that "of course there wasn't so much current behind it." Such statements are liable to confuse seekers after true knowledge, who find difficulty in reconciling them with Ohm's Law. Are there different kinds of voltage, some of which are more hurtful than others? The question crops up a good deal now in connection with television sets. Some of these, we are told, are liable to cause a death in the family if handled internally before switching off, while the recent types, in spite of delivering somewhat higher voltages, are more or less harmless.

It is true that the effect on one's body of maintaining a given voltage across it depends not only on the voltage but also on its duration. Whereas a 1 μF capacitor charged to 2,000 volts can give a dangerous shock, a few pF charged to the same voltage is quite harmless because it is all over so quickly. Even if the brief voltage is continually repeated, as from a r.f. source. the result is heat rather than shock. That alone would explain the relative harmlesness of those few television models that derive their e.h.t. from a r.f. oscillator. But in these and also the popular "flyback" types the fact is that if your body becomes an unintentional load resistor in the circuit the voltage is just not maintained. The internal impedance of the source is so high compared with that of the body that most of the available voltage occurs across it, and you receive only a low voltage. The idea that you are standing thousands of volts is therefore quite wrong.

Transmission Through Tunnels

Characteristics and Performance of Metre and Decimetre Waves

By J. B. LOVELL FOOT, A.M.I.E.E. (General Electric Company's Research Laboratories, Wembley).

DURING the past year a series of tests has been carried out by the Research Laboratories of the General Electric Company to determine the propagation characteristics and behaviour of decimetre radio waves in railway tunnels. The practical applications of this work have still to be decided, but the subject is of sufficient general interest for an examination at this stage of the more important results obtained.

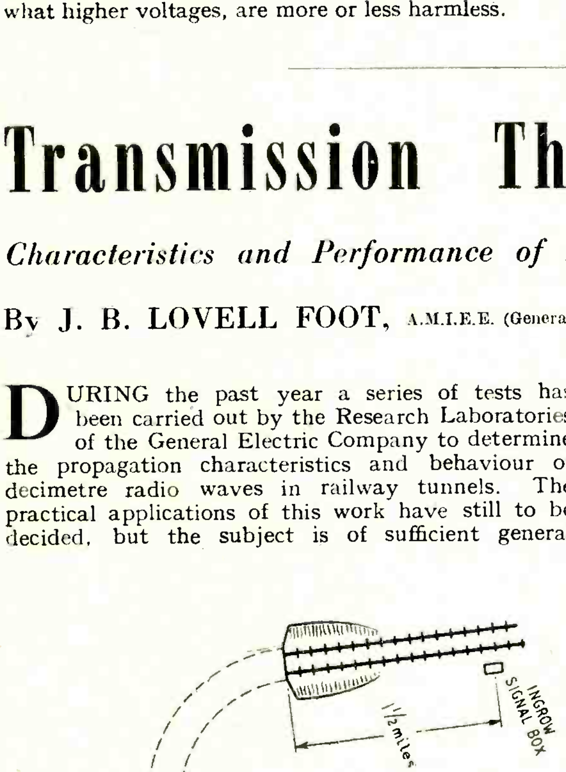


Fig. 1. Lees Moor tunnel where the tests on 82 Mc/s were carried out.

The tests to be described are a continuation of earlier work carried out in the metre-wave band, one of the objects of which was to determine a system suitable for communication between a moving train and signal boxes. Although long tunnels on main lines are relatively infrequent in this country, it is the comparatively small stretch of track through the tunnels that presents the greatest technical difficulty. Any radio system must be capable of operation without interruption, and communication from within a tunnel is of considerable importance. The chief interest is consequently centred on the problem of how this can be provided.

The Keighley district of Yorkshire was chosen for the original metre-wave tests, since the track here is one of the most difficult stretches in the country to cover by radio. Part of the route includes the Lees Moor tunnel, which is 1,527 yards in length and curves considerably (see Fig. 1). At the northern end, the Ingrow signal box is about 1½ miles from the tunnel mouth and a further ½-mile separates the southern end of the tunnel from the Cullingworth signal box.

Two 10-watt f.m. transmitters operating on a frequency of 82 Mc/s were installed with receivers at these two signal boxes and omni-directional aerials were mounted 20 ft above the ground. A similar equipment was placed on a platelayers' trolley which had an aerial fitted on the back. Communication between the signal boxes was satisfactory over the intervening hill but, between the mobile set and either of the fixed stations in the signal boxes, signals became too weak for satisfactory communication when the trolley was taken into the tunnel for more than 15 yards. The signal box equipments were then taken to positions 20 yards inside the ends of the tunnel. The aerials were mounted on 7-ft tripods and placed in the middle of the track. It was now found, by moving the set on the trolley, that the distance of penetration for satisfactory signals was increased to 600 yards.

From these results it was concluded that three relay stations—one placed near the middle and one at each end of the tunnel—would be required to give reliable communication over the whole distance. At the time the tests were made, it was thought that the high attenuation of signals in the tunnel was mainly due to a screening effect between the transmitting and receiving aerials produced by the curvature of the tunnel walls. Subsequent tests carried out in a straight tunnel at Watford, however, have shown that the limiting distance is dependent more on frequency than on the curvature of the track or the transmitter power. The maximum distance for satisfactory communication obtained in the Watford tunnel with a power of 10 watts and at a frequency of 82 Mc/s was no greater than that for the Lees Moor tunnel. It was therefore decided to make tests with decimetre-wave equipment when this became available.

Tests on 1,400 Mc/s.—The first of these tests was made through the straight Watford tunnel. This is a brick-lined double-track tunnel 1,800 yards long and is situated about 1 mile north of Watford Junction station. The equipment used for the test consisted of a pair of f.m. transmitter-receivers; the radiated transmitter power was about 0.5 watt at a frequency of 1,400 Mc/s and the receiver sensitivity for good communication about 10 μV. A compact type of directive aerial, consisting of separate transmitting and receiving dipoles mounted in a simple corner reflector, was used at each end. These aerials gave a beam width of about 40 deg (to points 6 db down) and a gain of 9 db compared with a simple dipole.

For the first test, the sets were placed with the aerials in the open at opposite ends of the tunnel and close to the bank by the side of the track. The aerials were directed towards the tunnel ends, a distance of about 40 ft (see Fig. 2). Strong signals were exchanged and it was at first suspected that some freak reflection was providing a path over the hill. The arrival of a train, however, proved that the radio frequency path was in fact through the tunnel. As the train proceeded from one end to the other, a series of about 6 fades occurred; this showed up as a background noise in the receivers during periods of low signal strength, but communication was not interrupted at any time. An audible howl was noticed in both receivers as the train entered the tunnel mouth, and this occurred again as the train emerged at the distant end.

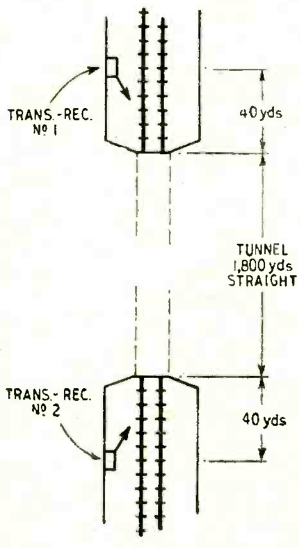


Fig. 2. Tests on 1,400 Mc/s were made in the Watford tunnel with the transmitters located outside as shown and the receiver mounted on a mobile trolley inside the tunnel.

It was next decided to make a test with one set mobile, and for this it was necessary to wait until the section of track would be closed to railway traffic. Some months later, the section was closed for a period in order to allow maintenance work to be carried out, and the equipments were again taken to the site. One set was placed at the northern end of the tunnel with its aerials mounted on a 6-ft tripod and placed between the tracks near the mouth of the tunnel, the other set was placed with its aerial on a trolley and wheeled into the tunnel from the southern end. During the tests a light engine and four trucks were standing in the tunnel. Strong signals free from any noticeable standing-wave effects were obtained. Simple dipole aerials without reflectors were tried and noise-free signals were still obtained. Satisfactory communication was also possible when the mobile aerial was placed within a few inches of the track, or close to the tunnel wall.

Having obtained strong signals inside the tunnel for the whole length it was next decided to run the mobile set into the open southwards towards Watford station, leaving the other set in the same position at the northern end of the tunnel. There was the expected fall in signal strength as the distance increased, but it was still possible to obtain satisfactory communication as far as the station platform, which is 1,800 yards beyond the tunnel mouth.

So far the 1,400-Mc/s tests had been carried out in a straight tunnel and under line-of-sight, or near line-of-sight, conditions, but it was now thought desirable to repeat them in a curved tunnel. For convenience the London area was chosen and a section of the Primrose Hill tunnel between South Hampstead and Chalk Farm stations became available during a diversion of traffic. This also is a double-track brick-lined tunnel; its length is 1,180 yards and it is considerably curved (see Fig. 3). Again one equipment was set up just outside one end as in the Watford trials, and a trolley was provided for the mobile set. The performance in this instance proved very similar to that obtained at Watford, and no noticeable increase in the attenuation due to the curvature was found to take place. In this case the track curved away outside the tunnel mouth behind a high brick wall towards Chalk Farm Station. When the mobile set was taken along

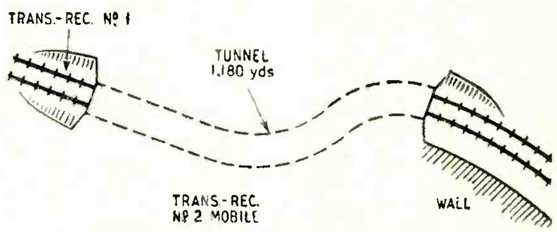


Fig. 3. The Primrose Hill tunnel where tests were carried out on 1,400 Mc/s to study the propagation in curved tunnels at this frequency.

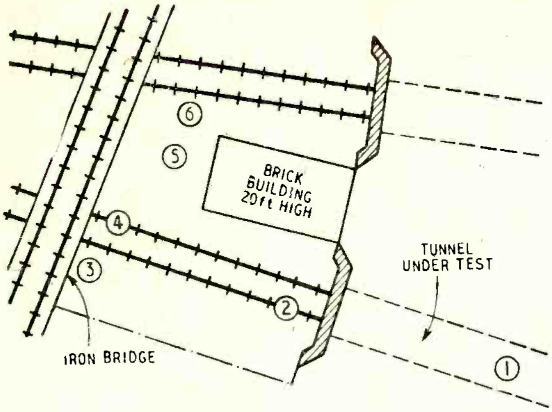


Fig. 4. The six alternative positions of the 460 Mc/s aerial (five outside the tunnel) from which the signal strength measurements given in the text were compiled. The receiver was at the distant (eastern) end of the tunnel.

here with the fixed equipment still at the distant end, a more rapid decrease in the signal occurred. The limit of good communication was at a point about 400 yards beyond the tunnel mouth and off the line-of-sight path.

Tests on 460 Mc/s:—There are many practical reasons why it is preferable to use the lowest possible frequency in any application for which transmission through a tunnel is required. In the first place circuits and valves can be more orthodox so that the equipment is cheaper to manufacture. Frequency control difficulties are eased if direct crystal control can be used and the power consumption is generally lower for lower frequency equipment. Against this, the size of the aerial is an important factor, for the aerial may have to be fitted to a train and clearances between rolling stock and the tunnel walls does not allow the attachment of a large aerial.

In order to assess these advantages and disadvantages, the next tests were made at a frequency of 460 Mc/s. In this range the radiator of a quarter-wave ground plane aerial is about 6in long only, and this could be fitted to a train without too much difficulty should propagation prove satisfactory.

Primrose Hill tunnel was used for the propagation trials. A transmitter was set up at the western end of the tunnel and operated from the supply mains. An omni-directional aerial was used and 70 ft of coaxial feeder provided to allow its position to be moved as desired. The equipment employed frequency modulation with a maximum deviation of ± 45 kc/s. The radiated power was 6 watts, and this could easily be reduced to 0.25 watt for the purpose of the trials. The receiver sensitivity for a usable signal was about 4 μV. Crystal control was applied to both the transmitter and the receiver local oscillator.

The transmitter aerial was first erected in the open, between the tracks 10 yards from the tunnel mouth. The receiver was placed with a simple dipole aerial on a trolley as in the earlier tests. As the trolley was moved relative to the transmitter aerial, the signal strength at the aerial terminals was estimated from readings of the limiter grid current in the receiver taken at frequent intervals. The experiment showed that strong noise-free signals were obtained throughout the tunnel length. A level of about 150 μV at the receiver at the western end, falling to 70 μV at the eastern end, was recorded and no noticeable standing wave pattern occurred, this being almost independent of the position of the receiving aerial. The trolley was then run out into the open at the eastern end where the track curved behind the high brick wall; here there was a more rapid decrease in signal strength though good communication was still possible at 200 yards beyond the tunnel.

With the mobile set returned to the eastern end of the tunnel, the position of the transmitting aerial at the western end was moved from the outside to a spot 20 yards inside the tunnel (No. 1, Fig. 4); the effect on the received signal at the eastern end was a reduction from 70 μV to 23 μV, or nearly as much as reducing the output power from 6 watts to 0.25 watts. This interesting result was unexpected; the explanation is not obvious and there would appear to be a field for further investigation. The transmitting aerial at the western end was finally taken further away from the tunnel mouth and a number of short tests were made with the radiator placed in positions indicated in Fig. 4. In the worst position (No. 6) a brick building screened the radiating aerial from the tunnel mouth, but in spite of this a 14-μV signal was received at the far (eastern) end.

The received signal with the aerial in the various positions was as follows:— (1) 23 μV, (2) 70 μV, (3) 74 μV, (4) 150 μV, (5) 25 μV and (6) 14 μV.

In conclusion, the work has shown that the lowest frequency for operation in a tunnel appears to lie between 82 Mc/s and 460 Mc/s. At the lower frequencies the tunnel attenuation is high and relay stations at intervals are required. At the higher there would appear to be no serious difficulties, though to go above 460 Mc/s would probably introduce more problems in the equipment and increase the cost.

The choice of the aerial position on a train raises many problems, but the smaller size of the higher-frequency type is a great advantage. The possibility of mounting the aerial at axle level should not be overlooked since tests have shown a good field strength near the ground. This, however, may be ruled out owing to electrical noises produced by axles and wheels, and will certainly give poorer results when the train is in the open.

The author wishes to thank British Railways, whose helpful co-operation made the work described possible.

Colour Television in Trouble

JUDGING from technical journals recently received from America, opinion in that country has crystallized strongly against the decision to adopt the C.B.S. system of colour television. The F.C.C., as the responsible body, has come in for some hard knocks. *Tele-Tech*, in the November issue, characterizes the decision as "fantastic" and accuses the F.C.C. of taking steps never contemplated by those who framed the radio laws of the U.S.A. *Tele-Tech* maintains it is not in the public interest:—

To render obsolete 10 million existing sets.

To require future set buyers to spend \$30 to \$130 on gadgets they may never use.

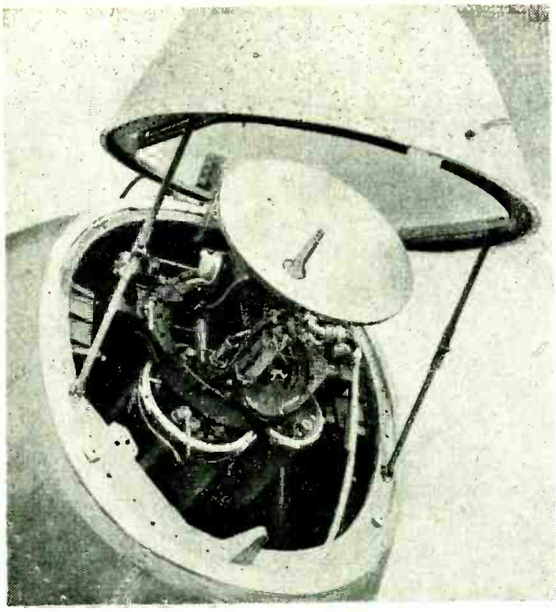
To degrade picture quality and impose on the public a small-picture system.

To disrupt the entire television industry.

To divert to colour television components that are needed for the defence programme.

Radar Cloud Detector

Versatile New Warning Equipment for Aircraft



The scanner and associated equipment on its stabilized mounting in the nose of an aircraft.

OF all the types of cloud which make life difficult for an air pilot and unpleasant for his passengers, probably the worst are those known as cumulo-nimbus. They have a solid and threatening appearance which is due to their being composed of heavier water droplets than the more soft and misty cumulus clouds, and an aircraft passing through them usually has to put up with thunderstorms, static electricity and bad air pockets, all of which make the flight extremely uncomfortable. There has consequently been a definite need for some kind of device in the aircraft to give warning of cumulo-nimbus clouds and enable a course to be steered through them—particularly at night and in poor visibility—and in view of their considerable density, it is not surprising that radar has proved successful. Early wartime experiments showed that 3 cm was about the most suitable wavelength, and now a complete airborne equipment, using modern techniques such as sealing and pressurization, has been produced by the Electronics Division of Ekco (E. K. Cole, Ltd.) in conjunction with the Ministry of Supply. It has a p.p.i. display and therefore can also be used for "map-painting," as well as for giving warning of high ground and preventing those collisions which occur so often with the sides of hills and mountains. Trials carried out by B.O.A.C. on this equipment show that it has a range of up to 40 miles for cumulo-nimbus clouds and for coastlines with cliffs, up to 25 miles for medium-sized ships, and up to 12 miles for other (large) aircraft. Any clouds which do not give a good response when they are ten or more miles away are usually harmless.

The aerial system consists of an 18-inch parabolic reflector with a back-fed dipole and reflector positioned at the focal point. This produces a scanning beam which swings back and forth in azimuth, passing through an angle of 150° once per second. By way of illustration, Fig. 1 (a) shows how the entrance to Southampton Water would be scanned by an aircraft approaching from the sea, the beam S being swung through the 150° arc from C to D. At the same time, on the screen of the p.p.i. tube (b) the time-base T is swung in synchronism through a corresponding arc of 150°—as if it were pivoted at O at the bottom of the screen. It therefore traverses a wedge-shaped sector of the screen, *c* to *d*, corresponding to the wedge-shaped sector C to D on the map. The

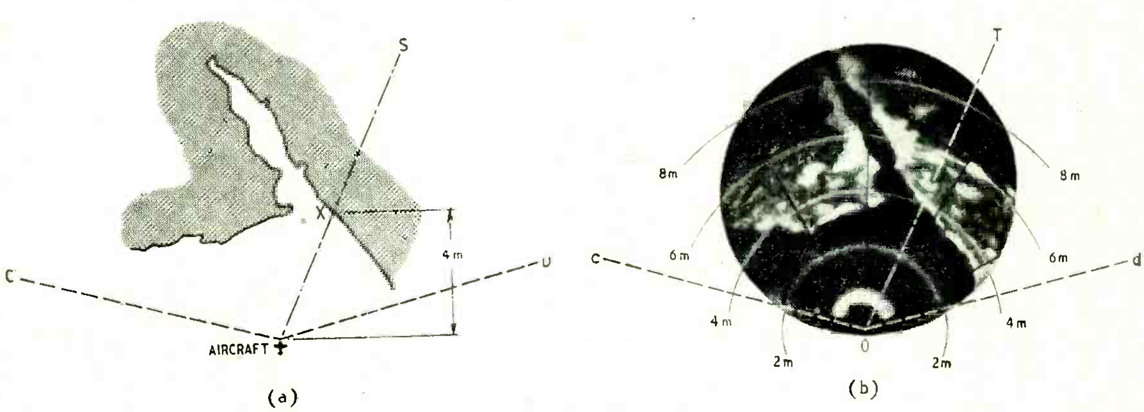


Fig. 1. At (a) is a map of Southampton Water, showing how it would be scanned by an aircraft approaching from the sea, at 4 miles from point X on the coastline. At (b) is the actual p.p.i. display as seen in the aircraft.

trace of the time-base is normally kept invisible by a negative bias on the grid of the tube, but the radar responses are applied to it as brightening modulation. So, regarding point O as corresponding to the position of the aircraft, or zero range, the responses appear at various distances along T from O according to the actual distances on the map, and as T scans in synchronism with the search beam S a true representation of the coastline is built up on the screen. For the purpose of estimating distances, bright-spot markers are applied to the time-base trace at known intervals, and when scanning is in progress these appear as brightened arcs which indicate distances in miles from O. The range of, say, a point X on the coastline in (a) can be seen to be 4 miles because it appears on the 4-mile arc on the screen. When there are a number of radar echoes at short range the screen around point O tends to become congested and bearings cannot be taken with certainty, so a device has been fitted to enable the centre of the display to be opened out when required. The time-base sweep, instead of being initiated simultaneously with the brightening and marker waveforms, is started in advance. This time interval is adjustable, and the effect on the screen is that zero range is now represented by a small arc some way out from the centre, which is left clear. The time-base speed can be altered to give two ranges, 0-10 and 0-40 miles.

Circuit Arrangement

A general idea of the radar system, which follows conventional practice, can be gathered from the simplified block diagram, Fig. 2. The master timing pulse for the whole equipment is produced at a repetition frequency of 700 per sec. by the master pulse generator, a cathode-coupled multivibrator. On the one hand this pulse triggers a thyratron-controlled modulator and so the 10-kW magnetron, which generates a 1-μsec. pulse of r.f. energy at 9375 ± 30 Mc/s. At the same time, the master pulse also triggers the time-base generator and range-marker generator, thereby synchronizing them with the transmitted pulse. To obtain the back-and-forth scanning effect on the p.p.i. tube, the time-base waveform is fed through a magslip which is driven by the actual scanning mechanism of the aerial system such that the relative phases of its two outputs vary directly with the angular position of the radar beam. These two saw-tooth outputs in quadrature are then fed into two corresponding pairs of deflector coils placed at right-angles to each other on the p.p.i. tube, and the effect of the varying phases in this deflection system is to rotate the time-base trace about point O (Fig. 1) in accordance with the rotation of the radar beam about the nose of the aircraft. The whole process can be likened to a remote position control system in which mechanical angular movement is transformed into variations of electrical phases, only the coils at the receiving end, instead of transforming the phases back into mechanical movement by rotating an armature, are simply used for deflecting a c.r.t. trace.

The output from the magnetron passes through a wave-guide duplexer which permits the aerial to be used for both transmitting and receiving. In the receiving section of this duplexer are two mixer crystals coupled to a common klystron local oscillator. One of these crystals mixes the local-oscillator frequency with a small portion of the magnetron output and the difference frequency is fed to the automatic frequency-control unit, which controls the frequency of the local oscillator so that an i.f. of 45 Mc/s is always maintained in spite of drift in the klystron or in the magnetron. The other crystal mixes the received radar signals with the local oscillator and so produces i.f. signals which are detected, amplified and then passed to the p.p.i. tube as brightening modulation.

An essential feature of the equipment is that it enables the pilot to tilt the plane of the radar scan up and down from the horizontal to any angle within $\pm 10°$. This is necessary in the first place, of course, to permit scanning of the terrain below. Secondly, it enables the pilot to estimate the height of clouds and high ground—and, in fact, a navigational technique for safe clearance of high ground has been worked out which depends on there being no p.p.i. responses within a certain range when the radar scan is tilted downwards at a certain angle.

The mechanism consists of a remote positioning servo system which tilts the parabolic reflector up and down with respect to the dipole. Aeroplanes, how-

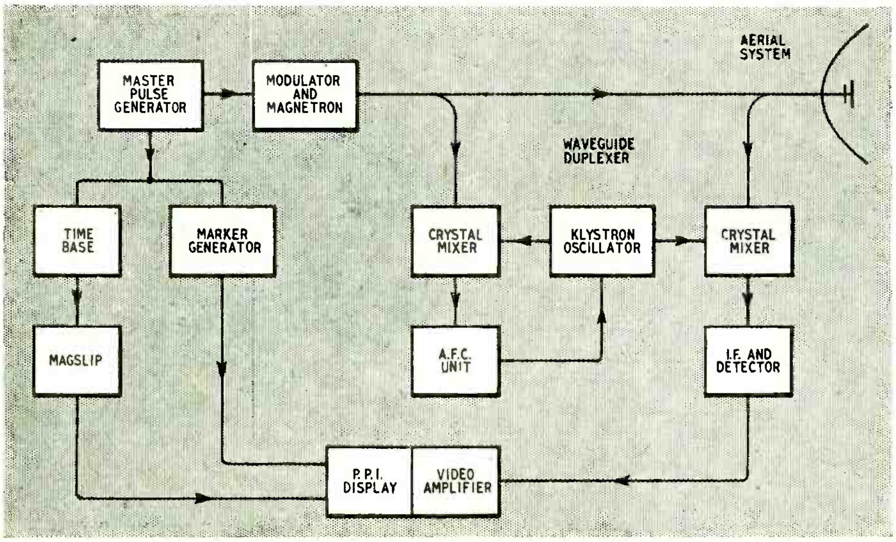


Fig. 2. Simplified block diagram of the radar system, the essential parts being the transmitter, receiver, frequency-control system, synchronized time-base, and c.r.t. display unit.

ever, cannot be relied on to remain horizontal for very long, and as this would normally make height estimation and map-painting impossible, it has been necessary to provide a stabilizing system to keep the scanner truly horizontal, irrespective of the position of the axes of the aircraft. The reference horizontal is provided by a gyroscope mounted with the scanner on a gimbal ring which can be moved about with respect to the aircraft. Two coils in the gyroscope provide electrical error-signals for aircraft roll and pitch, and these signals actuate a servo system which drives the gimbal ring so that it compensates for the aircraft movement and returns the complete scanner and gyroscope assembly to the horizontal. Once in the horizontal, or balance condition of the servo, the error-signals cease and the gimbal ring is left stationary. Also mounted on the stabilized gimbal ring are the transmitter-receiver unit and the servo-system unit, so that the number of wave-guide rotating joints and flexible cables required is kept to a minimum. If desired, however, the gimbal ring can be dissociated from the stabilization and locked permanently in a plane parallel to the axes of the aircraft.

The equipment will work satisfactorily up to an altitude of 25,000 ft when unsealed. Those units which are likely to be fitted in unpressurized parts of the aircraft, however, can be sealed and pressurized, and they will then operate up to 40,000 ft. All components are within their ratings at ambient temperatures up to +55° C and the equipment is unaffected by low temperatures down to −40° C. Its total weight is in the region of 150 lb.

Speech and Music

Preferred Relative Sound Levels Investigated by the B.B.C.

OPINIONS will always differ as to whether the B.B.C. modulates too deeply on speech compared with music (or vice versa), but there is little doubt that an optimum relationship exists, and some interesting results are given in a recent report* of research work undertaken by the Engineering Division of the B.B.C.

Originally, the object of the research was to establish quantitatively the known preference of musicians and programme engineers for listening at higher levels than ordinary listeners in the home, and to make due allowance for this when adjusting tonal balance. The results are summarized in Table A, and it is interesting to note the wide divergence in preferred levels between men and women programme engineers, particularly when listening to speech.

Subsequently, the investigation was extended to discover listeners' preferences in changes of level from one type of programme to another. Sixty subjects of both sexes, and ages varying from 15 to 65 years were asked to participate; and each test, consisting of thirty-six programme changes, included speech to speech, music to speech, speech to loud-starting music, speech to quiet-starting music and speech to the interval signal (Bow Bells). In each case the second programme was introduced at various levels up to 10 db above and below that of the first programme, which was set by means of an N.P.L. sound meter to the optimum level indicated by Table A. Listeners were given a score card and asked to mark each test "Too loud," "Too soft" or "Satisfactory." Results were averaged and plotted, and the conclusions summarized in Table B.

As might be expected, no change is indicated between the preferred levels of speech following speech, and these tests were introduced primarily as a check on the validity of the method. The most striking difference is between speech and the interval signal, and there was less tolerance for changes in the relative level of the interval signal than for other programme changes.

TABLE B

	Preferred change in level (db)
From speech to speech	0
From music to speech	−4 to −5
From speech to loud-starting music	+2
From speech to quiet-starting music	+2 to +3
From speech to interval signal ...	−19

* "Listeners' Sound-Level Preferences," by T. Somerville and S. F. Brownlees, *B.B.C. Quarterly*, Vol. 3, No. 4, and Vol. 5, No. 1.

TABLE A

Preferred Maximum Sound Level (db above 10^{-16} watts/cm^2).

	Public		Musicians	Programme Engineers		Engineers
	Men	Women		Men	Women	
Symphonic Music	78	78	88	90	87	88
Light Music	75	74	79	89	84	84
Dance Music	75	73	79	89	83	84
Speech...	71	71	74	84	77	80

UNBIASED | By FREE GRID

Exhibition Nightmare

IN 1951 the radio exhibition is due to make its debut at Earls Court and I do hope that the opportunity will be taken to arrange matters so that it is less tiring than hitherto, especially for the provincial visitor with limited time to spare.

To my mind the mistake in the past has been that manufacturers have exhibited all their goods on one stand. Thus, if you were in search of a first-class radiogram and wished to compare the efforts of one manufacturer with another, you had to go from stand to stand and elbow your way through a lot of plebeian clutter like table-top sets and portables to get at the radiograms. Having seen manufacturer A's radiograms you had to fight your way to the other end of the hall to compare them with manufacturer B's products.

I think, therefore, that we might borrow an idea from the 1950 Motor Show where all the makers of tyres were grouped together in splendid isolation. In this section they exhibited tyres only and showed their inflators and other wares on separate stands elsewhere in the show. I should not like it to be thought, however, that I am handing a bouquet to the motor industry at the expense of our own, for, except for this particularly striking instance of forethought and orderliness, the rest of the accessory stands seemed to me to be scattered in the same confusion as the Children of Israel in the prophet's famous vision. I learned of this confusion by bitter experience when searching for a good headlamp for the pram of Free Grid Minimus, the offspring of my daughter Faradia. She needs this when collecting him late at night from one of the crèches which some cinemas, as a counterblast to the stay-at-home attractions of television, now thoughtfully provide so that mothers can leave their infants to be washed and refuelled while they are enjoying the show.

Refuelling Service.

At Earls Court next Autumn, therefore, I hope to see radiograms all grouped together in one section, table-top sets in another and so on so that the choice between one maker's product and another's will be made easier. It will mean, of course, that some manufacturers will have to have half-a-dozen stands in different parts of the show, but what does that matter? Earls Court is quite big enough to contain them.

Who Invented It?

I SEE that an American journal has raised the old and rather pointless question of "who invented radar and when?" A lot depends on what we mean by radar. It may make it a bit easier if we call it radiolocation as we did originally. But even this does not really enable us to solve the problem for radiolocation obviously means the locating of things by radio, and if we take that definition I suppose we must hand the palm to Professor Röntgen and put the date at 1895 when the word "radio" had purely an X-ray association. "Röntgen Revealing Rays" as they were once called are most certainly used to find hidden objects, more especially by the medical profession, who, by their aid, find with great precision the exact location of Aunt Maria's Bevan-sent teeth when she accidentally swallows them.

However, most people when they talk of radiolocation have in mind the position-finding of aircraft and therefore they think of names like Watson Watt and the year 1935. But even so they are hopelessly out of date for the N.P.L., as far back as 1928, used radio waves to find the position of meteorological balloons which, being neither land, sea nor submarine craft, are undoubtedly aircraft.

The truth is, of course, that the pinning down of an invention to a man and a date is an almost impossible task.

Stereoella

IN his resignation statement a few months ago the erstwhile controller of television made it clear that in his opinion television is the Cinderella of the B.B.C. services.

Cacophonous infantile stage.

But nobody need shed any tears over that for it won't remain so for long whatever the panjandrums of Portland Place may decide. For all Cinderellas, following the example of the original creation, have a cuckoo-like habit of starting in a small and humble way and finally throwing all others out of the nest. Sound broadcasting itself, now grown as old and cantankerous as one of the ugly sisters, started life as a Cinderella not only in the entertainment world but in the radio world also.

In the entertainment world we heard in 1922 that broadcasting was just a passing novelty soon to be buried in the British Museum alongside the musical box and the zoetrope. In the radio world it was considered as just a clutterer-up of the ether which must not be tolerated and which would, in any case, never grow beyond the cacophonous infantile stage.

Way back in the late nineties and early nineteen hundreds radio itself was the butt of the cable companies in their none too gentle jesting; an upstart minx to be put in her proper place. But in due course the jokes ceased and we learned that a marriage had been arranged and would shortly take place; and a most fruitful marriage it has been, judging by the sturdy offspring which the State eventually took over from its proud parents. So, too, it will be with television which will, before long, rule the roost at Broadcasting House and another Cinderella will take its place. It looks as if this new Cinderella is likely to be called Stereoella unless a fairy godmother can be found to outwit the evil stepmotherly machinations of Mr. Bishop, the B.B.C.'s Chief Engineer, which, with bold *mein-kampf*-like candour, he made no bones about in his famous *De-Hereticis-Comburendis* letter to the Editor of this journal (*W.W.*, April, 1950).

LETTERS TO THE EDITOR

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

E.H.T. Circuit

I FEEL sure that students of the craft of pulse technique would welcome your comments on the e.h.t. supply circuit described on pp. 365–6 of the October issue.

The circuit is described as a "tripler," whereas all good "fly-back" engineers know this circuit as a "doubler," only V_3 and V_5 being active in the generally accepted role when the pulse is on.

V_4 can be substituted by a coupling resistor of a few megohms resistance with little change in performance when the pulse source is of low impedance.

With a ringing transformer source it is obviously necessary to use V_4 as then the damping due to such a coupling resistor is removed.

The question now arises: Does V_4 play an active role beyond its function as a one-way coupling resistor in view of the applied waveform?

If it does not then the design for 25-kV using a 9-kV pulse will be some 30% low in output voltage.

Reference is suggested to RCA Review, March 1950, or to RCA publication ST-545, p. 21.

R. POLLOCK.

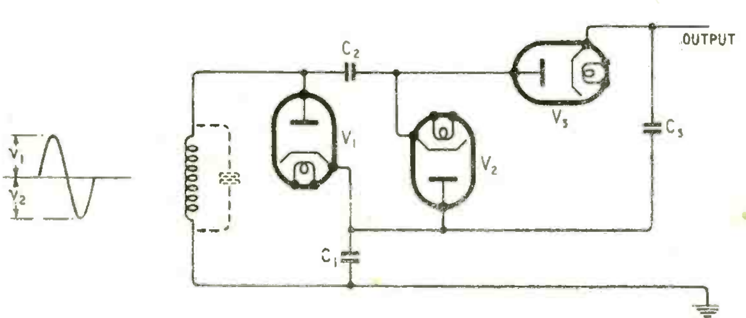
N. Wembley,
Middlesex.

Editorial Note.—Our correspondent is confusing the operating conditions of a voltage-multiplying rectifier system operating on a pulse input with those which exist with a sine-wave, or damped sine-wave, input. The so-called ringing-choke circuit produces a damped sine wave and the three rectifiers do in fact act as a tripler and are all necessary.

Referring to the figure, on the first half-cycle of amplitude v_1, V_1 and V_3 conduct and on the second half-cycle of amplitude v_2, V_2 conducts. C_1 is charged to v_1 on the first half-cycle. On the second v_2 and the voltage across C_1 act in series to charge C_2 through V_2 and so C_2 is left charged to $v_1 + v_2$.

When V_3 conducts, on the first half-cycle, v_1 acts in series with the voltage across C_2 and the cathode of V_3 becomes $2v_1 + v_2$ above earth. If C_3 were returned to earth it would be charged to this voltage. It is, however, returned to C_2 and so is charged to $2v_1 + v_2$ minus the voltage across C_2; that is, to $v_1 + v_2$. The rating of C_3 can, therefore, be less than if it were returned to earth, but in each case the output voltage is $2v_1 + v_2$ and in with a high-Q circuit this is nearly $3v_1$, since $v_2 \approx v_1$.

If the input were a pulse, v_2 would be zero and the circuit would be a voltage-doubler only. V_2 could then be replaced by a resistor with slightly poorer regulation and efficiency.



Measuring Bass Resonance

RECENTLY I have been constructing a vented loudspeaker cabinet, and, having no beat frequency oscillator, was up against the problem of measuring the resonant frequency of my moving coil unit.

The problem was solved by using a bicycle fitted with a rear-wheel dynamo which is a simple form of alternator.

The procedure is to invert the bicycle and connect the loudspeaker to the dynamo with a protective resistance of suitable value in series. The pedals are then turned by hand until resonance is obtained. The detection of resonance is assisted by placing a small wood shaving on the diaphragm. The pedals are then rotated steadily at that speed and the number of revs. in half a minute counted (a watch with centre seconds hand is helpful). All that is necessary then is to count the number of revs. of the dynamo per rev. of the pedals. The revs./sec. of the dynamo gives the required frequency (since it has two poles).

The speaker I tested was a 10-inch, and initially a 100-Ω series resistor was used. The voltage generated at low speed is small, and after the resonance has been located the resistance can often be reduced or even omitted.

I made three tests:

(1) With 3-speed in "normal."

(2) With 3-speed in low gear.

(3) As in (2) but with a rubber band round the dynamo friction wheel.

The results in order were 71.5 c/s, 72 c/s and 72.8 c/s.

If the dynamo is properly set the question of slip does not arise and with a steady hand and careful timing consistent results should be obtained.

The waveform of such a dynamo is probably pretty shocking, but apart from simplicity and cheapness the method has the further advantage of being an "absolute measurement" and is not subject to calibration errors or zero wandering, etc.

A further use is to detect and measure frequencies of l.f. resonance in panels of a speaker cabinet.

I do not wish to claim to be the first to use the idea, but thought it might be useful for other readers who, like myself, cannot afford or obtain the use of expensive gear.

ANTHONY W. BOVILL.
London, N.2.

Valve Heaters

I HAVE read C. F. K. Gaulder's letter in your October issue with interest, and wonder whether the following might be of any interest.

Having been for many years very keen on "quality reproduction," and living in a country district with no access at that time to an a.c. supply, but having a 50-volt d.c. installation, I decided, about 15 years ago, that something must be done to overcome the difficulty. The result was that I built a superhet receiver with six 4-volt 1-amp. a.c. valves with the heaters in series. The output of this was fed into a paraphase push-pull a.f. amplifier with two more 4-volt valves and two special indirectly heated power valves giving 5 to 6 watts output. This gave me eight 4-volt heaters in series. A small regulating resistance plus a low-voltage gas-filled lamp acting as a barretter completed this heater circuit across the 50-volt supply. The power valves had 32-volt heaters also supplied by the 50 volts. The H.T. supply was provided by a small rotary converter.

Now, the point of all this is that with occasional trifling modifications and improvement, I have run this set for 15 years, and my valve renewals, apart from one or two new power valves, have been quite negligible. They have been tested periodically and their efficiency has remained remarkably high. I attribute this to two main causes:—(1) the heaters are switched on 20 to 30 seconds before h.t. and (2) when the convertor is switched on the h.t. voltage builds up from zero volts, producing no surge or shock.

There may be other causes, but the arrangement has certainly given good service.

JOHN OGILVY.
Forfar, Scotland.

The Coupling Capacitor

AS an addendum to "Cathode Ray's" article in the October issue, the attention of readers is directed to the basic relation:

1 amp into (or out of) 1 farad produces a change of 1 volt in 1 second.

For practical use this is conveniently converted to

1 mA : 1 μF : 1 volt : 1 millisecond.

Many smoothing and decoupling problems are easily solved, with sufficient accuracy, by the use of this simple relationship, which does not even demand a knowledge of the value of π.

As an example, consider a valve which is to be used as a pentode cathode follower. The screen current varies from 5 mA by ±5 mA, and the lower frequency is 50 c/s. What capacitance must be used to decouple screen to cathode?

A half-cycle lasts 10 millisec, so that we have

1 mA : 1 μF : 1 V : 1 millisec.
5 mA : 1 μF : 5 V : 1 millisec.
5 mA : 1 μF : 50 V : 10 millisec.

And finally, if the screen-cathode voltage is not to vary by more than ±5 volts:

5 mA : 10 μF : 5 V : 10 millisec.

The answer, of course, is then to use a 16-μF electrolytic, so that a more academic approach has no justification.

THOMAS RODDAM.

Television Visor

I RECENTLY noticed that there is a distinct improvement in my television picture when it is viewed through a small aperture held close to the eye. The effect consists in a useful increase of image contrast and of the detail perceived and, particularly with a foggy, unevenly lit picture, can be quite remarkable. It is equally evident with an aluminized as with a non-aluminized tube and is greatest when viewing in darkness or reduced room lighting. As I am reactionary enough to hold that this is still the best way to view a television picture, whatever the tube or the gadgets affixed to it, I find a "visor" constructed on the above principle to be a useful aid to maximum realism in viewing It consists of an old pair of spectacles with black card substituted for the lenses and a pair of one-eighth inch holes punched the correct distance apart. This distance was found by preliminary trial with a piece of cardboard.

Should any reader try this out and confirm the effect I would be glad of suggestions as to an explanation. The effect of interposing the aperture is evidently to "stop down" the eye as with a camera lens; it seems that the iris mechanism of the eye may not fully adjust itself to the brightness of a scene when this subtends an angle as small as a television picture. Probably some defect of the eye prevents the full detail being perceived in these circumstances, there being a degradation due to flattening or halation. However, I find that the "visor" gives no improvement in a home cinema picture under any conditions. If the above suggestions have any weight this may be bound up with a difference of spectral content, or of the means of presentation of the picture. Regarding the former, I find personally that a noticeably bluish screen colour gives me a better impression of detail, other things being equal, than a warmer toned one.

E. G. HARRISON.
Sandiacre, Nottingham.

Circuit Diagrams

WHEN drawing circuit diagrams it is often difficult to cram in component values by the side of the appropriate symbol; things are made even worse if one wishes to draw attention to ratings, such as wattage, voltage-working or tolerance. So it has become usual to enumerate the various components and give ratings in a separate panel and/or discussion in the text. The disadvantage of this method is finding, say, "R_{10}" or "C_{27}" in a maze of circuitry. There seems to be no consistency in the method used to code the components, and I suggest as an alternative a division of the receiver, etc., into stages, or, where this is ambiguous, arbitrary divisions of the circuit by vertical dash-dot lines. The components could then be given a reference number first, to locate the section, and then an identifying number—e.g., $R_{4\cdot3}$ being a resistor in the 4th section (working, say, from the left).

A further convention for numbering is needed when drawing the circuit, and the most obvious one seems to be marking the components in the order one would "read" down the section, i.e., left to right, moving downwards from H.T.+ to the zero-potential line.

M. BAMFORD.
Macclesfield, Cheshire.

Television Relay Loss?

DURING the televising of the current Radio Exhibition at Castle Bromwich it was noticed that the quality of picture was exceptionally good in this district.

The Exhibition programme came, of course, from Birmingham and hence the transmission was direct, viewers to London receiving it third-hand.

At the end of the item the programme was switched back to Alexandra Palace, and a decided lessening in quality of picture was noticed.

I am given to understand that there are two link transmitters for vision, making 3 "hops" in all (including the main service transmitter) and if the loss in quality is linear per link, one may wonder what the picture will be like from the proposed Scottish transmitter.

It would be interesting to know whether viewers to the London transmitter noticed a change in quality, to the better of course, at the above-mentioned change-over.

C. LAWSON.
Burnley, Lancs.

Educating the Public

I FULLY endorse your editorial comment on the lack of technical explanation and demonstrations at our National Radio Exhibitions.

It would appear that the radio industry does "face with complacency a situation where receivers are bought on eye appeal," even if that complacency is confined to the publicity department.

So long as radio receivers are dressed up as pieces of furniture "eye appeal" of the cabinet will have to be considered, but I see no reason why that should prevent the manufacturer from explaining the difference between his 18-guinea and 26-guinea models.

I have long advocated that the radio industry should go further than this, and that instead of plugging the old, old story of "Finest Value," "Greatest Performance," "Sweetest Tone," etc., regardless of price and specification, the industry should advise the public on the technical attainments and limitations of their various models and demonstrate that should a superior performance be desired it can be obtained in a higher-priced model.

H. WILLAN CRITCHLEY.
Scarborough, Yorks.

RANDOM RADIATIONS

By "DIALLIST"

Slow Warming Up

No-one could agree more wholeheartedly than I with those readers who lament over the length of time that modern mains valves take to warm up. Having realized all of a sudden that it is just about the moment for a time signal, or for some programme item that you specially want to hear, one switches on and waits with growing exasperation for what seems ages, although, in fact, the actual time taken for the set to come to life is only 30 or 40 seconds. C. F. K. Gaulder's suggestion in the October *Wireless World* that we should leave heaters permanently switched on and merely cut out the h.t. has much to recommend it. A good deal of the radio and radar equipment in the Services was treated in that way during the war and no particularly dire effects on valve life were noticed. I am not sure, though, that I would be altogether happy about doing this with some kinds of pentodes. I suppose the ideal thing would be an arrangement allowing the h.t. to be run up smoothly from zero to full value in a second or two. Keeping the heaters switched on, by the way, is not nowadays a complete safeguard against switch-on surges: What about those all-too-frequent power cuts?

Overcrowded Wavelengths

Things are pretty bad just now on the medium-wave band. In one recent week there was for two days a poisonous high-pitched and rather wavery heterodyne afflicting the London Regional transmission, whilst the National programme on three other wavelengths suffered from over-close neighbours. Part of the trouble is due to American Army broadcasting stations in Germany, but they are not the only ones to be guilty. There appears to be too much wavelength-wandering by stations which juggle with their carrier frequencies in efforts to avoid interference with their programmes. What we are going to do about it I don't know, for there doesn't seem much likelihood of getting agreement amongst all European countries to do the necessary tidying up. What is surprising is to find our own country, which is usually ready to do the right thing, permitting the Bovingdon Airport beacon to go on operating on 223 kc/s, which falls between the frequencies of Oslo and Warsaw, and so causing bother on the long-wave band.

A Fine Opportunity

There's a wonderful opportunity awaiting anyone who can devise a small, simple and inexpensive electronic calculating machine capable of dealing in the twinkling of an eye with the odd problems in addition, subtraction, multiplication and division with which so many of us have to cope daily. The first two are always laborious if large figures are concerned—and it's so easy to make footling mistakes. The slide-rule is a great help to multiplication, division and more intricate processes in which these are involved; but unless the slide-rule is a very elaborate affair and its users very skilled, the degree of accuracy is only about that of two-figure log. tables. Logarithms are fine—so long as you can put your hand on the book of tables when you want it. They are hardly worth while, though, if you are confronted with an isolated problem such as, say, 3572×2196 or $\sqrt{4126}$; it's quicker then to work out the answer. What a boon it would be if one had on one's desk a little instrument with a set of keys and switches which could be relied upon to give the right answer to such problems in a brace of shakes.

Battery Manufacturers' Please Note

The dry batteries, and particularly the H.T.Bs. that we get nowadays, aren't always as good as they should and could be. It's difficult, I know, to obtain first-grade materials except at prohibitive prices and that fact, no doubt, accounts for a good deal of trouble. Still, I don't think that the dry cell which comes to a premature end through the puncturing of its can should be seen quite so often as it is. For some reason, ascribable only to the pernicketiness of fate, if one cell of a H.T.B. decides to blow up, the casualty almost invariably occurs somewhere in the middle of the battery. You read the e.m f. of the battery under load one evening and find that it is something like 1.2 V per cell. Next day the set won't work and the H.T.B. has no e.m.f. worth talking about. If you care to investigate the innards of the battery, you can locate the faulty cell and short it out. But that may be a fiddling and rather messy business. It may be messier still and not without dire results if a punctured cell goes on oozing.

CLASSIFIED INDEX

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