Wireless World

RADIO AND ELECTRONICS

MAY 1949

39th YEAR OF PUBLICATION

Proprietors : ILIFFE & SONS LTD.

Managing Editor : HUGH S. POCOCK, M.I.E.E.

Editor : H. F. SMITH

Editorial, Advertising and Publishing Offices :

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

Telephone : Waterloo 3333 (60 lines).

Telegrams : "Ethaworld, Sedist, London."

PUBLISHED MONTHLY

Price : 2/-

(Publication date 26th of preceding month)

Subscription Rate : 26/- *per annum. Home and Abroad*

Branch Offices :

Birmingham : King Edward House, New Street, 2.

Coventry : 8-10, Corporation Street.

Glasgow : 26B, Renfield Street, C.2.

Manchester : 260, Deansgate, 3.

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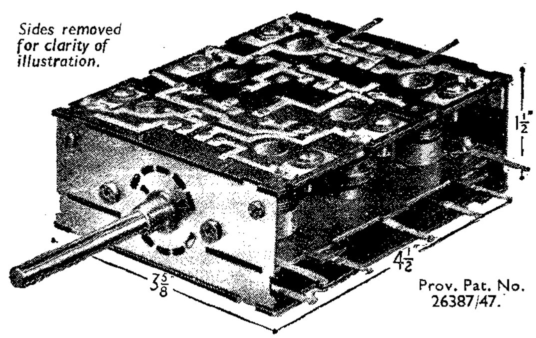

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Owing to raw material restrictions supplies, for the time being, are confined to Radio Receiver Manufacturers at home and abroad.

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Valves and their applications

HIGH FIDELITY AUDIO AMPLIFIER USING EF37, ECC33 AND EL37

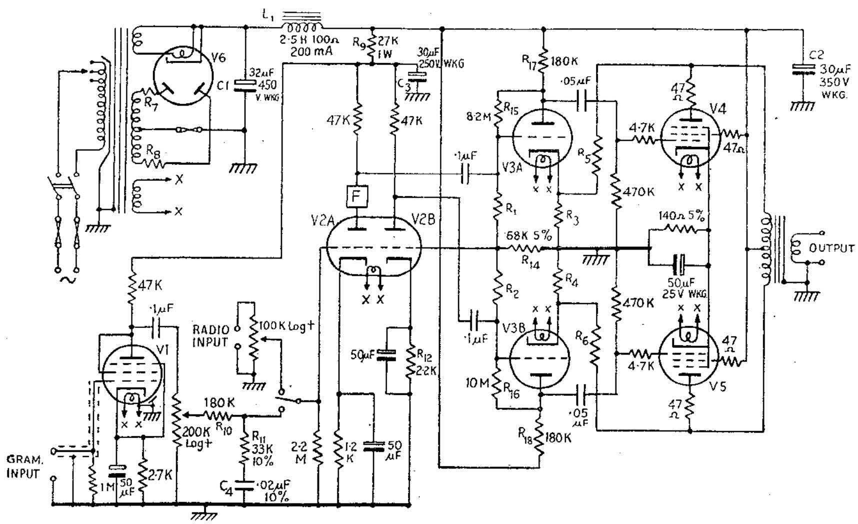
The introduction of wide frequency range gramophone recordings and pick-ups, together with the projected B.B.C. transmissions in the 90 Mc/s. band, means that if the extra fidelity so made available is not to be wasted, considerable care has to be exercised in the design of the reproducing equipment. One of the most important items in this is the A.F. Power Amplifier and Gramophone Pre-amplifier.

In a large room or small hall, say between 2,000 and 5,000 cu. ft. in volume, it will be found that the mean level of the electrical input to a normal type loudspeaker is of the order of 50 mW. As the peak amplitudes are 20 to 25 dB. above the mean level it follows that the available power output from the amplifier should be about 15 watts.

It is also necessary that the non-linear distortion is kept to a low level, in particular the high order odd harmonic and intermodulation products. It is not usually the presence of the higher frequency components which causes annoyance but the products of non-linear amplification, these are invariably present when a pentode output valve is working into an inductive load such as the speech coil of a loudspeaker.

The circuit of a suitable amplifier is shown in Fig. 1. It consists of a Gramophone pre-amplifier stage V1. (EF37) the output of which is fed into a volume control and then into a bass boost circuit R10, R11 and C4 for correcting the recording characteristic. Then follows a voltage amplifying stage V2A. and the paraphase valve V2B (ECC33). A low pass filter F. may be inserted in the anode circuit of V2A to reduce surface noise when gramophone records are being played. The two phases are then fed into the two halves of V3. (ECC33) which is inserted into the chain to facilitate the application of degenerative feedback to the two output valves V4 and V5. (2-EL37s). The feedback is direct coupled from each of the output valve anodes by the resistors R5 and R6 back into the cathode circuits of the driver valves R3 and R4. The resistors between the grids and anodes of V3 and in the cathode circuit of V2B are to maintain the correct D.C. operating conditions for these valves, whilst those in the grid screen and anode circuits of V4 and V5 are to stop parasitic oscillations. The power supply is derived from a 350—0—350V open circuit voltage H.T. winding on the mains transformer, the rectifier being a GZ32. Adequate smoothing is provided by the components C1, L1, C2, R9 and C3.

At less than 1% total distortion the full output is 18 watts for 0.3 volts at the grid of V2A or 0.12 volts at the gramophone input terminals. The hum level is more than 60 dB. below 18 W. The frequency response is 0.5 dB. below the 1 Kc/s level at 25 c/s and 12 Kc/s with an output transformer of reasonable design.



R_2=1.22 $R_1\pm2\%$=220K$\pm$10%, R_3=$R_4\pm2\%$=3.9K$\pm$10%
R_5=$R_6\pm2\%$=220K$\pm$10% (½W), R_7=R_8=100Ω Total Eff.Res. Mains Transformer H.T. Secy. 350-0-350 v. off load. Output matching load. 4000Ω anode to anode. Sensitivity :—Radio, 0.3 v. Gram., 0.12V.

Mullard

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MULLARD ELECTRONIC PRODUCTS LTD., TECHNICAL PUBLICATIONS DEPARTMENT, CENTURY HOUSE, SHAFTESBURY AVE., W.C.2

MVM89

VOL. LV. NO. 5

Wireless World

RADIO AND ELECTRONICS

MAY 1949

Comments of the Month

RADIO PRE-HISTORY

SEVERAL of the historians of radio have commented on the fact—strange to our generation—that some of the earliest radio pioneers dissipated their energies in unprofitable lines of work, and tended to ignore the possibilities of electromagnetic waves for communicating intelligence. Hertz summarily dismissed the whole idea of wireless telephony as quite impracticable: Popov's main early interest was in his "lightning recorder": Tesla gave much time to the still-unsolved problem of wireless transmission of power.

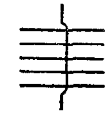
It now seems that Captain (later Admiral Sir Henry) Jackson, the father of wireless in the British Navy, at first failed to recognize its real significance for communications. At any rate, it would so appear from the Report for 1896 of H.M.S. *Vernon*, extracts from which have recently been made available to us by the Admiralty. Jackson suggested that radio emissions should be used for purposes of identification by torpedo boats: as a precursor, in fact, of wartime radar I.F.F. (identification of friend or foe). In fairness to his foresightedness, it should be noted that he quickly changed his views, and undoubtedly it was his persistence in the face of opposition that brought about such rapid development of Naval wireless communications.

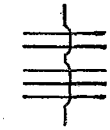
SYMPATHETIC CIRCUITS

ELSEWHERE in this issue we print an article on the technique of drawing circuit diagrams by an author who has made that subject very much his own. *Wireless World* does not endorse all the detailed proposals made, but does find itself in complete and wholehearted agreement with the underlying principles for which Mr. Bainbridge-Bell stands. Clearly, he believes that a circuit diagram should be something more than a collection of graphical symbols, grouped more or less at random and joined together as neatly as may be by connections following the shortest path. We assume that, like us, he regards a well-drawn diagram as an aid to understanding the functioning of the circuit concerned, and not merely a graphical record. In view of the increasing complexity of modern circuitry, that is more than ever desirable, especially when the diagram is likely to be studied by those with an imperfect knowledge of all the details which it purports to show. Indeed, we would go so far as to say that a small collection of diagrams, drawn with understanding and sympathy towards the difficulties of the potential user, constitutes almost a textbook in miniature.

Dissected Diagrams

Some twenty years ago, when the inception of broadcasting greatly increased interest in the technical side of radio, this journal published a series of so-called "dissected diagrams" with the object of familiarizing new readers with the graphical and symbolical representation of circuits. What was thought at the time to be a rather trivial contribution soon proved to be almost embarrassingly popular, being obviously considered as an easy short-cut to knowledge, both theoretical and practical. Times have changed, but the advantages of applying the principles which Mr. Bainbridge-Bell discusses are greater than ever.





We differ from him in the detail of "bridge cross-overs," and think he weakens his case by admitting that they may be used for "double security." When a number of leads are to be crossed, the "flyover" is clear, but a better plan is to divide the leads into groups, according to their functions. This answers most objections. With not more than three wires in a group, it is easy to trace any particular one.

COMMUNICATION THEORY

Establishing Absolute Criteria of Performance

By THOMAS RODDAM

THE last months have been heavy with the rumblings of an approaching revolution. True, it is a technical revolution, but it resembles a political revolution in that the thoughts of a few philosophers will set in motion many men who have no understanding of their philosophy. Until recently we have been living under the beneficient influence of Hartley's Law, which is the engineer's equivalent of "Everything is for the best in the best of all possible worlds." You can read all about Hartley's Law in two articles by "Cathode Ray" (*Wireless World*, June and July, 1947). Unfortunately the recent developments described by him can now be seen to have been steps away from a general communication theory, so that some of the conclusions reached apply only to the special problem of transmitting speech.

To develop the new theory in a simplified form it will first be necessary to treat Hartley's Law briefly in a rather different way from that adopted by "Cathode Ray" (*loc. cit.*). I shall start at the very beginning, because the new theory is the result of a more close examination of the fundamentals of communication, while Hartley's Law is obtained if you gloss over some of the elementary problems. I'm sorry that I shall have to break into mathematics at one point, but the important thing about the new theory is that it enables system performance to be calculated. If the reader wants to know what he has been spared in the way of "sums" he should refer to the *Bell System Technical Journal*, July, 1948.

To begin with, therefore, let us define a communication system. Fig. 1 shows a basic system. The transmitter, medium and receiver may be regarded as conventional units in either radio or wire transmission. The coder and decoder require some explanation.

Fig. 1. Basic elements of a communication system.

The message itself may be either speech, a picture, or a written message. First of all we shall consider a written message. A typical one would be:—

"Please buy me 1,000 Bongo State Loan 3% shares at 94." In ordinary telegraphic practice no one would write this, of course, but would write:—

"Buy 1,000 Bongo 3% 94" . . (A)

This change involves what are called the semantic aspects of communication, and is nothing to do with our problem.

If a teleprinter is used, this message comes out as a set of mark and space currents rather like those shown in Fig. 2. ("The actual teleprinter code has *not* been used here.) Each letter takes up five time units; a separate symbol is used to indicate that figures follow; each time unit is occupied by either a "mark" or a "space." The total coding operation therefore transforms the message (A) into a set of marks and "spaces" of electric current. The first coding, which derived (A) by leaving out some words, is outside our scope, as its efficiency depends on psychological factors. The message shown in Fig. 2 is a standard message type, and it was this sort of message which Hartley considered.

Fig. 2. Fragment of teleprinter message.

Hartley's treatment was made in the days before we were all aware of the nature of network pulse responses, and it will be a bit clearer if we look at it in post-radar terms. If we pass one mark signal through a band-limiting filter (a low-pass filter if we consider the "video" circuits) we shall get out a rather distorted pulse, as shown in Fig. 3. We can go on narrowing the band (or lowering the cut-off frequency) until the tail of the pulse is so big that we cannot decide whether we have one pulse or two. The limit is somewhere between (d) and (e) in Fig. 3. If the mark is made longer, of course, we can reduce the cut-off in proportion, because we know that we get quite a reasonable pulse shape if we pass all frequencies up to $1/\tau$, where τ is the width of the pulse: anyone who doesn't agree with that can look up dozens of television and radar papers which discuss this point. Now the speed at which we send our message depends on how long each mark or space must be to pass through the filter, because we need to send a definite number of these marks (from now on I shall often write "mark" to mean *either* an "on" or an "off"). For a given message, therefore, if we double the bandwidth we can make each mark last half as long, and so send all the marks in half the time.

That was Hartley's way of deriving what we have come to know as Hartley's Law. Suppose that we now present ourselves with another piece of information: we measure the actual response of the system from transmitter input to receiver output. This we can do either directly as the response to a pulse, or indirectly through amplitude and phase measurements. For a very short pulse we shall arrive at the response shown in Fig. 4, which is quite a typical curve. By Hartley's method we should not be able to put another pulse into the system until the time corresponding to B was reached. At time X, however, the head of what Brillouin calls the first precursor of the response will have arrived.

After a prescribed time the voltage has risen to A, which gives an amplitude proportional to the input pulse. We can start measuring from the arrival of infinitesimal signals, because we assume that the system is free from noise. We now know the whole characteristic of the curve (b), for the shape is settled by the system response, and the scale factor is settled by our measurement at A.

We can then construct a local circuit to generate the second waveform shown in Fig. 5. This waveform is such that when added to the received waveform it cancels it exactly at all times later than C. The output then becomes that shown in the third line of

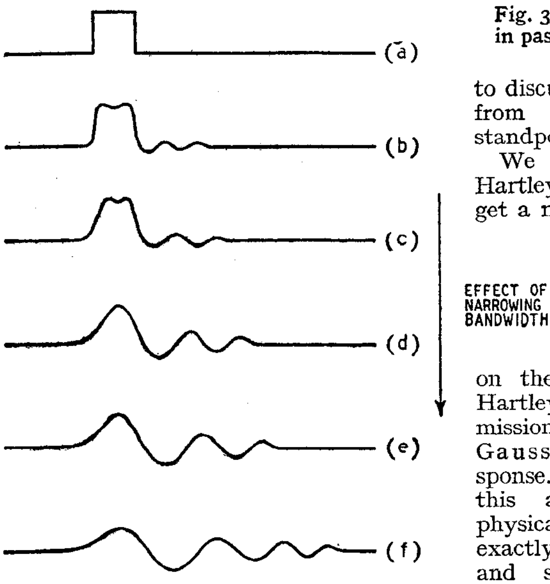


Fig. 3. Distortion of pulse in passing through a filter.

Fig. 5, and we can apply to the circuit a new pulse for which the new point A arrives at time C. The bandwidth in the actual channel has not been increased, but we now assume that we know exactly what the amplitude of the input pulse and the response of the channel are. The closer we make the matching of the compensating waveform, and the more sensitive we make the detector, the nearer together can X, A and C be brought, so that we can increase the number of pulses indefinitely. We can thus send as much information as we choose, in as short a time as we choose, using as narrow a bandwidth as we like. The sky, in fact, is the limit. The price we pay is simply that we must know the response of the system and the size of the input pulse with increasing precision as we speed up the operation. And, of course, the network which generates the cancelling waveform becomes more complicated. We do know a bit about networks for this job, however, because in some ways the problem is the same as that of cancelling "permanent echoes" in a radar system. The one thing which has enabled us to take this additional step is that we are assuming that we can predict the future exactly. As soon as we introduce noise, we lose this power of exact prediction, and the solution found here is no longer valid: it will be more convenient to discuss the effect of noise from a rather different standpoint, however.

We can see now why Hartley found it hard to get a numerical constant to equate to the product "bandwidth × time": there just isn't one. Gabor has arrived at the value 1/2, which depends on the application of the Hartley method to a transmission system having a Gaussian frequency response. The objections to this are, first that no physical system can have exactly a Gaussian response and secondly that anyway, such a system has its amplitude response defined over an infinite band, the "bandwidth" term being simply the bandwidth at half-amplitude.

The new theory does not stop at the point reached above, which is, in its own way, as limited as the Hartley treatment. The presence of noise must always be assumed in any real communication system, and looking at Fig. 4 again we can see that we cannot move A too near to X, or we shall not have enough signal to override the noise. To see what the effect of noise is, we code our message in a different way. Let us take the original message, and

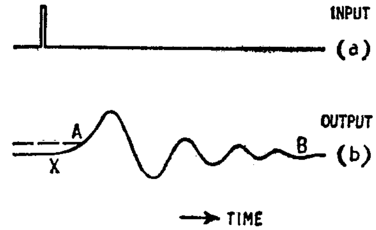


Fig. 4. Response of system to a very short pulse.

code it by numbering each letter:

B U Y	B O N G O
2 21 25	2 15 14 7 15

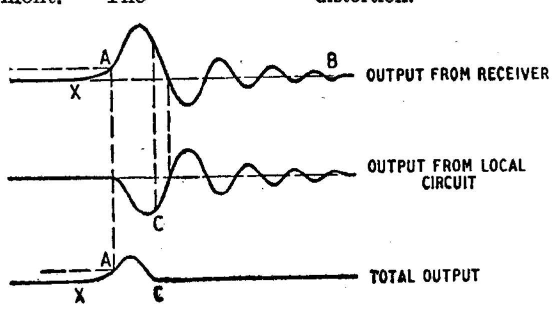
The message can then be sent in the form shown in Fig. 6, so long as the minimum level used is greater than that of noise. Now the amount of information in the message is dependent on the number of mark signals sent, and on the number of possible sizes of each mark signal. In fact, if we write for the "size" of the message, L for the number levels and n for the number of marks

$$M = L^n$$

n is now proportional to the product of bandwidth × time, since noise prevents us using the trick we used before to get round the Hartley relationship. We can follow Gabor and write $n = \frac{1}{2}BT$, or we can absorb the $\frac{1}{2}$ into M by redefining the "size" of the message.

L depends on the signal-to-noise ratio, and is equal, in the limiting case, to (1 + S), where S is the signal/noise ratio. If the receiving device works on peak voltages we take (peak signal) /(peak noise): if it works on energy we take (r.m.s. signal)/(r.m.s. noise). Finally, however, we have $M \propto (1 + S)^{BT}$

Fig. 5. Cancellation of pulse distortion.



Communication Theory—

First of all, we shall do a little mathematics using this expression. If we have two systems, with bandwidths B_1 and B_2, we can obtain the same value of M for the same time if

$$(1 + S_1)^{B_1T} = (1 + S_2)^{B_2T}$$

where S_1 and S_2 are the two signal/noise ratios. If we take $B_2 = kB_1$, $(1 + S_1)^{B_1T} = (1 + S_2)^{kB_1T}$ so that $(1 + S_1) = (1 + S_2)^k$.

Suppose, for example, that the value of S_2 is 3. For an increase of bandwidth by a factor of 4, the signal-to-noise ratio S_1 is given by

$$(1 + S_1) = (1 + S_2)^4 = 4^4$$
$$S_1 = 255$$

The increase of bandwidth has raised the signal-to-noise ratio from 9.5db to 48db. If the bandwidth had been increased by a factor 5, the signal-to-noise ratio would have been increased to 61.6 db. This corresponds to the bandwidth increase used in ±75db deviation in f.m. broadcasting, which gives only about 18db improvement, the corresponding value of signal-to-noise ratio being then 28db.

For the benefit of those who suspect the mathematics, I shall show how we can move the message into a wider band, at the same time reducing the required signal-to-noise. Our original message was BUY BONGO which we wrote as

2, 21, 25, 2, 15, 14, 7, 15

We can rewrite this in the scale of two, thus

00010, 10101, 11001, 00010, 01111, 01110, 00111, 01111.

In this, the digit abcde $= a \times 2^4 + b \times 2^3 + c \times 2^2 + d \times 2 + e$.

We could, if we liked, write it in the scale of 3, as

002, 210, 221, 002, 120, 112, 021, 120, in which

$$abc = a \times 3^2 + b \times 3 + c.$$

In Fig. 6(b) the message is shown, coded in the scale of 3, and arranged to occupy the same time as in Fig. 6(a), which is a 26 step system. It is easily seen that the message requires three times the bandwidth, since three times the number of steps are to be transmitted. For the same peak amplitude of signal, however, the noise can be more than ten times as great.

So far we have only considered the transmission of telegraphic messages. We can apply this to telephony by the technique called "pulse code modulation," which was described in a previous article. In simple terms, what pulse code modulation does is to send a string of messages which enable the receiver to plot the waveform of the speech to the desired accuracy. It is therefore possible to obtain these enormous improvements in signal-to-noise ratio for speech, or music, or television. Unlike

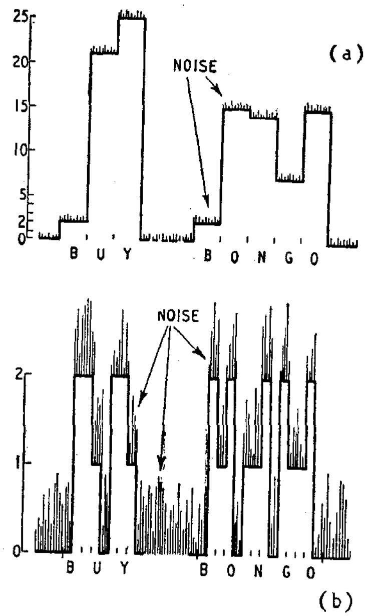


Fig. 6. Message coded (a) in a 26-step system, (b) in a scale of 3. The latter can tolerate a higher noise level.

the Vocoder, the system does not depend upon the special character of the signal, which must be speech to operate the vocoder.

If we want, as we often do, to reduce the bandwidth, we find the situation is rather unpleasant. Suppose that we wish to transmit a signal in 1/3 of the normal bandwidth—that is, we want to cram speech into 1,000c/s. We need a final speech-to-noise ratio of 40db, at least, so that we must have a value of S_1 given by $(1 + S_1) = (1 + S_2)^3 = 100^3 = 1{,}000{,}000$, or $S_1 = 120$db. We need, then, a power increase of 80 db, so that instead of sending out, say, 1 milliwatt we shall need 100kW. Clearly, there is not much value in reducing bandwidth at such an enormous cost in power.

The importance of the new theory lies in the fact that we now have a way of judging modulation systems in terms of their efficiencies relative to an ideal system. In the past we have always had to express the performance in terms of another system, so that we have said, for example, that f.m., with such and such deviation ratio, gives an improvement of so many decibels over amplitude modulation. Now we can say that f.m., with such and such deviation, gives a signal to noise ratio so many decibels below ideal. We can also see just how much more we can hope to gain by the use of systems which approach the ideal more closely. It may not be profitable to make use of these systems: we have seen that band compression is incredibly extravagant in power, so that it will never be adopted. We can, however, get down to the job of finding the cheapest way of providing a given signal-to-noise ratio at the receiving end.

One consequence should be a reconsideration of the policy of adopting frequency modulation for local broadcasting. We want to provide high-quality programmes at a minimum cost to the whole nation. If we have a million listeners, it is worthwhile to spend an extra £100,000 at the transmitters if we can save 5/- in the cost of each receiver. I have, in the past, urged a closer study of the possibilities of pulse transmission, especially if several programmes are to be radiated. It is most important that a fuller study should be made of the whole problem, especially from the point of view of national economics, not merely to find the policy which involves the least expenditure of B.B.C. money. The money all comes from the same place in the end. It is not impossible that the answer may turn out to be very high level amplitude modulation, say, 500kW. That sounds like a lot of power, but if it only amounts to 1 watt per listener, it can be saved by eliminating only one valve from a receiver.

LOWER-POWERED "BUSINESS RADIO"?

When the organization of e.h.f. "private" radio-telephone services was recently discussed by the Radio Section of the I.E.E., it was suggested that in many instances the licensed power was unnecessarily high, and should be reduced in order to lessen interference.

PLANAR ELECTRODE VALVES FOR V.H.F.

Reducing Interelectrode Capacitance and Transit Time

(Contributed by the Research Staff, M.O. Valve Company)

DURING the past ten or fifteen years considerable progress has been made in improving the high-frequency performance of triodes and pentodes by reducing the inductance of the leads to the electrodes. One of the first attempts in this direction was the "acorn" valve, which was designed with a very small electrode system, the leads from which projected as radial pins passing through the all-glass envelope. It is interesting to note that the earliest forms of this type of valve employed planar electrodes[1] similar in some respects to those which will be mentioned later. However, this construction was abandoned in favour of a very small cylindrical electrode system when "acorns" were eventually produced and marketed. The "acorn" type of valve, while enabling a considerable improvement to be obtained in the effective amplification at very high frequencies, has proved to be a difficult manufacturing proposition and has been superseded by valves with conventional electrode systems, mounted on flat glass bases through which pass the lead-out wires, which themselves form the valve pins. Two forms of such designs are represented in present-day commercial products in the button seal pressed-base valves, commonly known as the miniature, and the ring seal moulded-base type. In all these valves the electrode lead-out wires themselves form the connecting pins and the necessity for an external base with separate pins has been obviated.

These glass-based valves represent a big step forward in valve design, and there seems little doubt that the majority of receiving valves in the future will be mounted on this form of base. Quite apart from the advantages of this construction for high-frequency operation, it has led to a reduction in size and freedom from loose base troubles, which, under some conditions, occur with the cemented plastic base. Furthermore, with large-scale production the cost of manufacture of some forms of pressed glass base valves may be less than with earlier designs. Fig. 1 shows an "acorn" valve, a modern valve on a pressed-glass base and a valve mounted on the conventional glass "pinch," a feature which owes its origin to the electric lamp.

In a wide-band amplifier it is normal for the dynamic resistance of the circuits to be of a comparatively low order and several considerations arise in the design of a suitable valve for high gain combined with low noise in such amplifiers.

The gain of a single stage of a wide-band amplifier is proportional to the ratio of the mutual conductance (g_m) to the sum of the input capacitance (C_i), the output capacitance (C_o) and the stray capacitances (C_s). It is important therefore to make this ratio as high as possible. In addition, for successful high-frequency operation the interelectrode capacitances should be kept small, in order to keep as much as possible of the circuit external to the valve, and the electron transit time should be reduced to a minimum.

Now it can readily be shown that the requirements of high ratio of mutual conductance to capacitance and of low electron transit time require a high ratio of electron current density to grid-cathode spacing. The further requirement of low interelectrode capacitance necessitates a small cathode area. Thus the best performance is likely to be obtained with a valve having a small cathode area, small grid-cathode spacing and operating at a high current density.

The ultimate sensitivity of a high-gain amplifier depends on its signal-to-noise performance. If the gain of the first amplifier stage of a receiver is more than about 5 db then most of the noise output is contributed by the first stage. The amount of noise contributed by a valve is usually regarded as being equivalent to that generated in an imaginary resistance, R_s, in the grid circuit of the valve. R_s is known as the "equivalent noise resistance" of the valve and is approximately inversely proportional to the mutual conductance. If R_1 is the dynamic resistance of the input circuit, then it can be shown that the signal-to-noise ratio is a function only of the ratio R_1/R_s and will increase as this ratio increases. Now R_1 cannot be increased in-

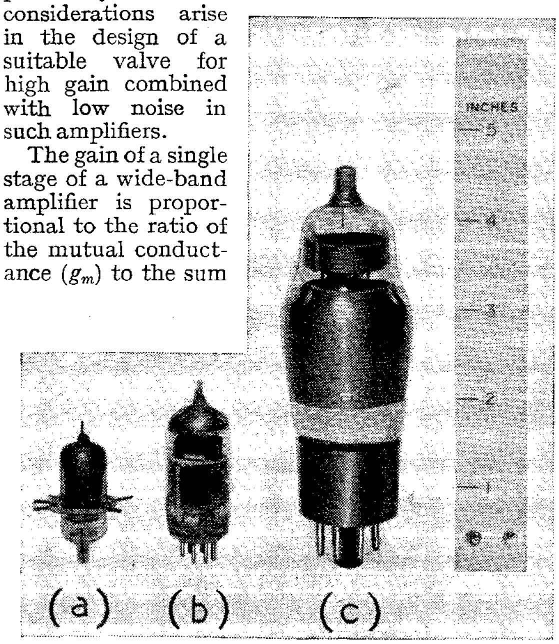


Fig. 1. Types of valve construction (a) "acorn," (b) pressed-glass base, (c) conventional "pinch" seal and moulded base.

[1] "Vacuum Tubes of Small Dimensions for Use at Extremely High Frequencies," B. J. Thompson and G. M. Rose, *Proc. I.R.E.*, Vol. 21, p. 1707, 1933.

Planar Electrode Valves for VHF— definitely owing to the inherent losses in circuit components so that the only way to improve the signal-to-noise performance is by reducing R_s and this means increasing the mutual conductance of the valve.

For frequencies above a few hundred megacycles per second a greater decrease in lead inductance proves necessary than has been achieved in the conventional concentric cylindrical arrangement of electrodes, and this improvement has been achieved by making the electrodes integral with metal discs which pass through the envelope and which may be directly connected to cavity resonators if desired. Such valves have been described elsewhere.[2]

These valves are known as the disc-seal type and such are capable of operation at frequencies up to about 4,000 Mc/s. The valves employ planar electrodes which allow very small interelectrode spacings to be achieved, permitting a high mutual conductance from a small cathode area and a high ratio g_m/C_{g-k}.

An example is the Osram and Marconi disc-seal triode type DET 23 in which the mutual conductance is 7.0 mA/volt at an anode current of 10 mA, and the total input and output capacitances including the discs which pass through the envelope are 2.4 pF and 1.1 pF respectively, of which the discs themselves account for about 0.7 pF in each case. Thus: C_{g-k} is 1.7pF and C_{a-g} is 0.4 pF. This high ratio of mutual conductance to input capacitance is better than has hitherto been achieved with concentric electrode arrangements, and is due to the fact that the spacings are small only at the operating surfaces of the electrodes.

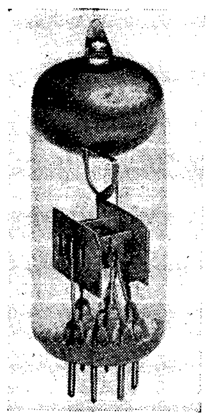


Fig. 3. Experimental parallel electrode triode (E1714) on pressed glass base.

These disc-seal valves (illustrated in Fig. 2) which were designed primarily for ultra-high frequencies will be seen to satisfy the wide-band amplification requirements set out above. It therefore seemed desirable to employ a similar electrode arrangement in valves designed for more general use in the u.h.f. range, such as valves mounted on pressed glass bases with the pins forming the lead-in wires. Valves of this type are easier to use and less costly than the disc-seal valves.

A typical triode of this class is the experimental type E1714 and is illustrated in Fig. 3.

The very small grid-cathode spacing employed (0.003 in) necessitates the use of extremely fine and closely spaced wires for the grid, and the design of the grid (Fig. 4) is one of the principal features of valves of this type. In the conventional type of electrode system in which the grid wires are located on two separating rods the wires themselves must be sufficiently strong to carry the separate rods so that the whole structure is rigid enough for handling during the assembly of the valve electrodes without risk of distortion, and this sets a lower limit to the diameter of wire which can be employed. In planar electrode valves a departure from convention has been made, which enables rugged grids to be manufactured with wires as small as 0.0006 in.

The grid is in the form of a metal plate pierced by a circular aperture across which the grid wires are stretched, while the cathode and anode are the end surfaces of two short cylindrical members, supported from or integral with a relatively thick and therefore rigid plate. These plates and the grid frame are located in slotted mica bridges which serve to hold the electrodes in the correct relative positions. Stray capacitances between the electrodes are in this way reduced to a minimum, only the operating surfaces of the electrodes being in close proximity. The leads connecting the electrodes to the pins in the valve base are also well spaced and contribute little to the total capacitances. The electrode assembly for this type of valve is shown in Fig. 5.

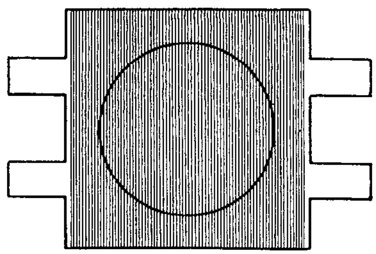


Fig. 4. Grid assembly of planar-electrode valve.

The very small diameters of grid wire possible with this construction allow adequate grid dis-

[2] "Triodes for Very Short Waves," Bell, Gavin, James, Warren, *Journal I.E.E.*, Vol. 93, Part IIIA, p. 833, 1946.

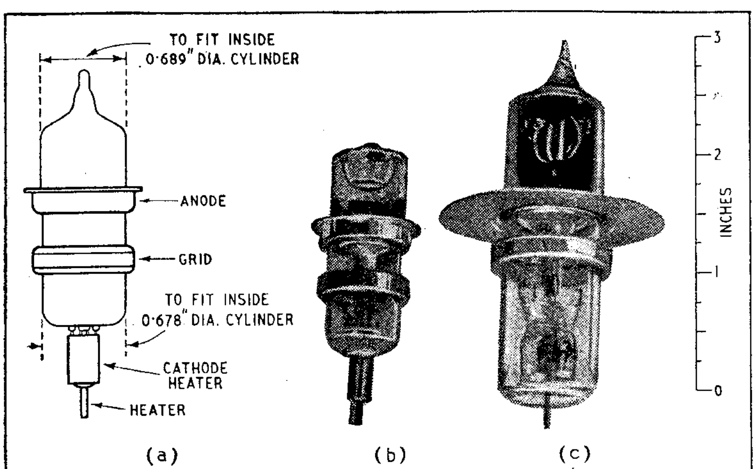


Fig. 2. Examples of disc-seal triodes (a) outline of DET23, (b) E1599, (c) E1368.

sipation for amplifiers and for low-power oscillators. Furthermore, the grid frame serves to radiate heat and thus minimizes the risk of primary grid emission.

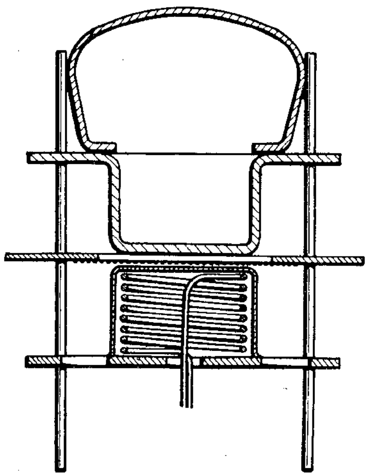


Fig. 5. Electrode assembly in the type E1714 triode.

The characteristics of the E1714 are as follows:—

Filament voltage..	6.3
Filament current..	0.5 amp
Anode voltage ..	250 max
Amplification factor	40
Mutual conductance	8.0mA/V

measured at anode voltage 150 and anode current 10 mA.

	Capacitances with cathode cold:	Capacitances with cathode hot (I_a=10mA)
C_{g-k}	1.6 pF	2.9 pF
$C_{g-all\ (except\ anode)}$	2.6 pF	3.7 pF
C_{a-g}	0.9 pF	—
$C_{a-all\ (except\ grid)}$	1.1 pF	—

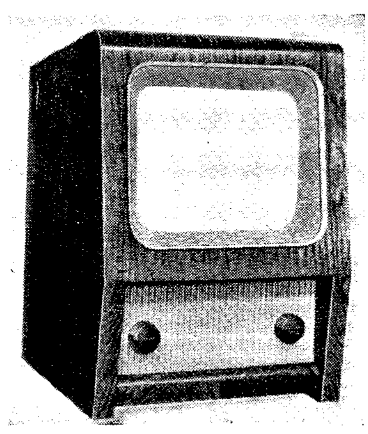
Equivalent noise resistance 500 ohms (I_a=10mA).

These characteristics undoubtedly represent the best performance which has been obtained with a triode operating at frequencies of the order of 45 Mc/s, covering a bandwidth of 10/15 Mc/sec.

MANUFACTURERS' PRODUCTS

H.M.V. Transformerless Television Receiver

THE new 1807 table model is of the transformerless type and suitable for use on a.c. or d.c. supplies of 220-250 V. A 10-in tube, with an aluminized screen, is used and operated at 5.5 kV, the supply being obtained from the line flyback. A permanent magnet is used for focusing and adjustment of focus is obtained by varying the e.h.t. supply by changing the flyback conditions. The picture size is 9in by 7in.



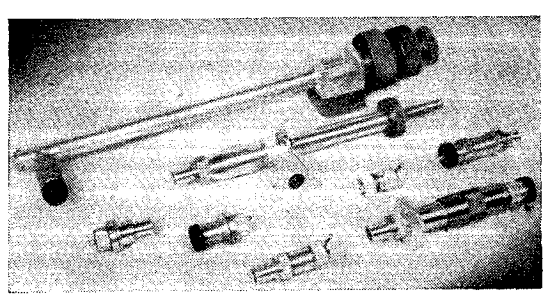
H.M.V. Model 1807 television receiver.

A metal rectifier is used to provide h.t., but a valve rectifier with its filament heated from the line-scan transformer is used in the e.h.t. circuit.

The receiver is of the straight type and of moderate sensitivity; for extreme range the addition of a pre-amplifier is recommended. The panel controls are Sound Volume and Picture Brightness, the on-off switch being combined with the latter. The set measures 19½in high by 19in deep by 13¾in wide and weighs 30lb. The price is £37 16s plus £8 12s purchase tax.

Standardized E.H.F. Components

A NUMBER of coaxial line components and measuring instruments for centimetre and decimetre wavelengths with standardized interconnections has been introduced by the Plessey Company, Ilford, Essex.

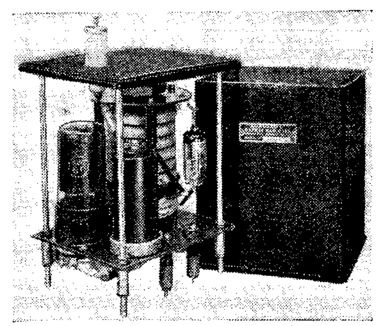


Representative components and instruments in the Plessey e.h.f. standardized range.

Coaxial / waveguide transformations matching 70-80-ohm lines can be made in a variety of forms, and standardized markings are used to distinguish power inputs and outputs. Among the components available are connectors, adaptors and bushes, loop-probe junctions, tuning plungers, matching stubs and crystal detector units. Measuring instruments include a bolometer in a bridge circuit covering 100 mW to a fraction of a milliwatt over a frequency range of 100 to 10,000 Mc/s, line attenuators using "Caslite" iron-dust cores, a piston attenuator for the non-dissipative "E" mode with a micrometer head calibrated directly in db, and coaxial-line wavemeters with ranges up to 20 and 40 cm

Television E.H.T. Supply

AN e.h.t. supply unit with an output of 5-8 kV at 300 μA has just been produced by Haynes Radio, Queensway, Enfield, Middlesex. It is of the r.f. oscillator type. A 6V6 valve is used as a 100-kc/s oscillator and draws 28 mA at 300 V. Rectification is by an EY51 which has its filament heated from the r.f. coil.



Haynes Radio R.F. E.H.T. unit, type 828.

The output is controllable below the maximum of 8 kV by reducing the h.t. voltage applied to the unit. The reservoir capacitor is of 0.001 μF only, so that a dangerous shock can hardly be obtained. The unit is completely screened and costs £5 8s.

SINGLE-VALVE FREQUENCY-

2.—Practical Details of Design and Use

By K. C. JOHNSON, B.A.

In last month's issue it was shown that it is possible to obtain electronic frequency modulation of an oscillator if an unusual circuit is employed with the tuning coil and condenser connected in series in the cathode circuit of a pentode valve, and with a second mutually-inductive coil carrying the anode current. The effect of the second coil is then simply to change the effective inductance of the first, and so the resonant frequency of the tuned circuit, as the suppressor grid voltage of the valve is varied and the fraction of the total cathode current which flows to the anode is changed. By this arrangement it is possible to obtain frequency modulation over ranges of as much as 30 per cent, using either of the circuits shown in Fig. 1.

In this article it is intended to discuss the many practical details which arise in the design and use of these circuits as "wobbulators" for receiver alignment.

The two-valve circuit shown in Fig. 1 (a) has several advantages over the single-valve version, for use in elaborate signal generators or as the local oscillator in panoramic superhet receivers, where the phase-inverter valve can conveniently be the triode section of a normal frequency changer. However, for a simple unit working on a fixed central frequency the single-valve version is more economical and can be made to give an almost equally good performance in range and constancy of amplitude.

Unlike reactance valve arrangements, these two-valve oscillators give practically constant amplitude over wide ranges without any difficulty, since the frequency-modulation mechanism would not be expected to affect the loop gain, and, moreover, there is a strong limiting action, since the peak oscillatory current cannot exceed the mean current through the valve. The single-valve circuit, however, is not quite so good in this respect, since there must inevitably be some change of gain with frequency due to resonance in the phase-inverter coil; but with careful coil design this need only cause a fall of about 10 per cent in amplitude at the extreme ends of a range as great as 30 per cent in frequency.

For most ordinary purposes, such as the alignment of i.f. band-pass circuits in broadcast receivers, a coverage of 20 kc/s at 1 Mc/s is adequate, so that the amplitude even of the single-valve circuit will be practically constant. The linearity, also, will be practically perfect, since the voltage swing on the suppressor grid need be no more than two volts, or one-fifteenth of the total grid-base. The most generally useful oscillator, then, will be designed to have a fairly wide frequency range, even if only a small fraction of it is actually required, so as to get linearity and constant amplitude.

Valves.—It would appear at first sight that the natural choice of a valve for use in this circuit would be one of the new "suppressor-slope" pentodes which are now available, but although these have the great advantage that their suppressor grids are made to close tolerances, they are not the best valves for the purpose. This is because the minimum screen current is much greater than in ordinary pentodes, so that the available range of current division is much less, and also because the high suppressor sensitivity means that the small, but inevitable, voltage swing on the cathode will affect the current distribution between screen and anode.

The valve chosen is the EF50, which has a suppressor grid with a moderate sensitivity and made to definite tolerances, but almost any r.f. pentode can be used if the suppressor connection is available. As already described the linearity of the valve is not important when only a small range is required, but the EF50 does in practice give quite reasonable linearity over the whole range of control.

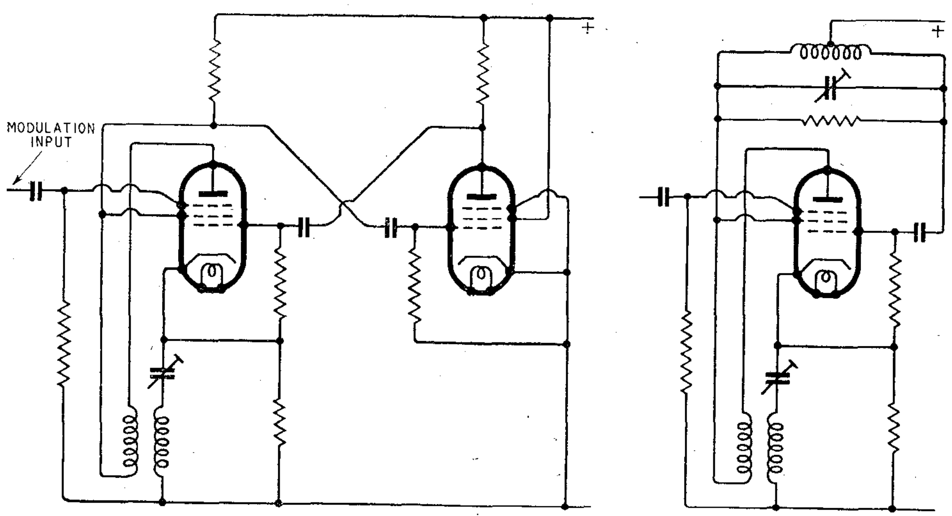
It must be remembered that in these circuits the valve may easily be run with the entire cathode current flowing to the screen grid and care must be taken that the h.t. supply voltage does not exceed about 180 volts. The cathode resistance is used to provide automatic bias for the suppressor grid in the usual manner, and the value for the EF50 is normally 2 kΩ, although it is convenient to use a 5 kΩ potentiometer so as to obtain a "d.c." frequency-shift control. This resistance is necessary also to carry the steady valve current and to avoid short-circuiting the tuned circuit; but it will be noticed that the tuned circuit behaves as an ideal bypass condenser at the oscillation frequency, so that the voltage swing at the cathode is actually extremely small and there is no need to put filters in the heater leads unless unusually good screening is required.

Tuning Coil.—The main tuning coil must be designed so that the frequency range available is as large as possible. This means that the mutual inductance between the two windings must be made negative and large so that it subtracts a maximum amount from the self-inductance. The self-capacitance of both coils must also be kept small so that there is no chance of the anode coil resonating even at the highest frequencies, and so that the maximum amount of the current in the cathode coil flows through the valve. The capacity between the windings must also be small, but this is not important if the tuning condenser is connected at the cathode end of the coil, so that the "dead" ends of the two windings come together. This has the additional advantage that the tuning condenser can then be used as the h.t. bypass and the windings of the coil need not be carefully insulated from each other. If, however, it is desired to use a variable tuning condenser with an earthed frame, the coil windings must be insulated and to avoid

MODULATED OSCILLATORS

capacity effects the connections will have to be reversed so that the mutual inductance is positive. The centre of the tuned circuit and the valve anode are the "hot" points where capacity must be avoided, but if the coil is so arranged that these voltages are in phase and roughly equal they can be close together in the winding without any serious effects. It will also be noticed that the valve anode impedances must be kept high to reduce damping effects, and this is assisted by bypassing the suppressor to earth at radio frequency with a small condenser.

The actual coil used for 1 Mc/s is wound on a ½in diameter former with an iron-dust core, and each winding is a layer of 100 turns of close-wound 34 s.w.g. enamelled wire, the second being wound directly on top of the first, spiralling in the same direction. If iron cores are not obtainable it is possible to use a similar design of air-cored coil with 120 turns of 38 s.w.g. enamelled in each layer, but this does not give such a good frequency coverage, since the iron increases the mutual-inductance in a greater proportion than the self-inductance and enables the self-capacitances to be reduced.



(a) (b)

Fig. 1. (a) Frequency-modulated oscillator with valve phase-inverter. (b) Single-valve version with a damped auto-transformer phase-inverter.

Phase Inverter Coil.—In the two-valve circuit the second valve serves simply to give a phase-inversion with a slight gain, and unless it is desired to have a variable tuning condenser or multi-range switching, the valve can quite satisfactorily be replaced by a tuned and damped auto-transformer. This must be adequately damped, however, so that the phase-shift and amplification remain nearly constant over the frequency range, and this can only be achieved by using a good coil of high L/C ratio and shunting it with a low resistance. This coil must be fitted with either a variable iron core or a normal capacity trimmer, and this must be adjusted until the amplitude falls off equally at either end of the sweep range, or so that the total valve current is a minimum, but this adjustment is not critical.

For 1 Mc/s a wave-wound iron-cored coil of 75 turns of 34 s.w.g. tapped at 25 turns from the "anode" end on a ½in diameter former is suitable, and 1,000Ω is a satisfactory damping resistance for an EF50, though this would have to be increased for a valve of lower slope. Again, it is possible to use an air-cored coil if iron cores are not available, and the same number of turns of wave-wound 38 s.w.g. is suitable, but the damping will not, of course, be quite so satisfactory. The two coils in this circuit must not be mounted too close together, but it is unnecessary to screen one carefully from the other and a few inches separation is sufficient.

Output Circuits.—The output from the two-valve circuit can most conveniently be taken from a tapping on the anode load of the second valve, and the low impedance which is available makes the design of an attenuator comparatively easy. The single-valve circuit is not so convenient, however, and the output must be taken, at much higher impedance, from the "anode" end of the phase-inverter coil or from a tapping on it. In any case the oscillator unit must be placed in a screened box to avoid radiation and interference with other receivers, since owing to the limiting action of the valve, harmonics as well as the fundamental are generated and may be radiated strongly.

For use in routine bandwidth adjustment of broadcast receiver i.f. amplifiers the frequency-modulated output is taken at low impedance to the frequency changer grid so as to avoid effects due to the preselector coils, and the 1 Mc/s signal is tuned-in in the usual way. The a.v.c. bias must be shorted and the signal at the diode-load volume control, or other suitable point, taken to the Y deflection of an oscilloscope. The X deflection of the oscilloscope and the modulation input of the wobbulator are then both connected to the 50 c/s mains, and

Single-valve Frequency-modulated Oscillators—

the set response curve will be obtained.

It will be noticed that the trace obtained on the oscilloscope is not quite the same in each direction. This is because it takes a definite time for the signal amplitude to build up in each tuned circuit, and unless the scanning is infinitely slow this will tend to make the second of two equal humps look higher. It can be shown that to obtain a "resolving power" of n c/s the rate of scan must not be greater than n^2 times per second, so that if a range of 20 kc/s is scanned 50 times each second it is only possible to distinguish two humps if they are more than about 1 kc/s apart. In practice this is more than sufficient for most purposes, but it is essential to use a sinusoidal scan and see "both sides of the picture" so as to be able to eliminate the distortion caused by the lag in building up the signal, which is far from negligible.

When the i.f. amplifier has been adjusted to any desired response characteristic the oscillator can be connected to the aerial terminal and the pre-selectors adjusted for maximum signal by trimming and padding in the usual way. One advantage of using a wobbulator at 1 Mc/s, rather than at the i.f., is that it can be used without alteration for any medium-wave set, and another is that a very rapid estimate of the pass bandwidth can be obtained simply by tuning the receiver and watching its wavelength scale whilst the response curve moves its own width across the screen.

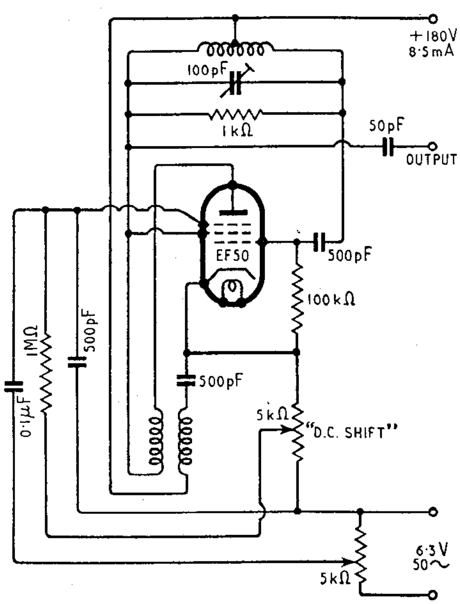


Fig. 2. Completed circuit of the single-valve wobbulator capable of a frequency deviation range of at least 30 per cent.

Practical Performance.—Fig. 2 shows the circuit of the single-valve wobbulator unit with all the component values and the details of the arrangements for obtaining a sweep of variable width and variable central frequency. This "d.c. shift" control is very convenient in practice, and it has the additional advantage that it makes it very easy to adjust the phase-inverter tuning by means of the current variations over the range. The two-valve equivalent of this circuit can be easily visualized, and it need only be said that the load in the first valve should be no greater than 50Ω, whilst an EF50 in the second stage will give sufficient amplification with an anode load of 1,000Ω. The single-valve circuit shown in Fig. 2 will give a frequency deviation range of at least 30 per cent with very nearly constant amplitude and reasonably good linearity.

There is no reason at all why this circuit should not be used for television receiver alignment at 45 Mc/s, but unless the experimenter possesses a tunable receiver for these frequencies it will be found to be almost impossible to check the operation of the oscillator. The author has, however, experimented with a circuit using a single EF50, a main coil with two layers each of 15 turns of close wound 30 s.w.g. on a ½in diameter air-cored former and a phase-inverter coil using 30 turns of the same wire on a similar former tapped at 10 turns. Tuning these coils with about 70 pF and 10 pF respectively it was found to be possible to get a coverage of 2 Mc/s at a central frequency of 11.25 Mc/s, but the amplitude variations of the fourth harmonic, which swept the whole television frequency band, could not be examined.

Clearly this is only one of the many interesting possibilities which this new principle offers and which remain to be developed. Some others which suggest themselves are simple wide-band panoramic or remotely controlled receivers working on either the superregenerative or synchrodyne principles, and single-valve portable f.m. transmitters, but there are many more possible applications and it would be impossible to discuss them fully in this article.

MOON ECHOES

New Method of Ionosphere Research

INVESTIGATIONS of the transmission characteristics of the F-region of the ionosphere, making use of radio echoes from the moon, are in progress in Australia; they are reported by Kerr, Shain and Higgins in the February 26th, 1949, issue of *Nature*. Arrangements have been made with the Postmaster-General's Department, by the Division of Radiophysics, Department of Scientific and Industrial Research, Australia, to have the use of transmitters VLC9 (50 kW, 17.8 Mc/s) and VLB5 (70 kW, 21.54 Mc/s) during periods when they are not in use for beamed transmissions to the U.S. and Canada.

As the aerials are fixed, it is necessary to wait for the moon to pass through the beam before making observations, but it has been found possible to carry out experiments on about 20 days in the year.

The receiver is an R.C.A. Type AR88 used in conjunction with a rhombic aerial system and both aural and c.r. tube observations of the echoes are made. By using a pulse length of 2.2 sec, short-term fluctuations of the returned signal have been studied, and particular attention is being paid to a comparison of the observed maximum angle of incidence on the F_2 layer for penetration, with the angles calculated from current ionosphere theory. It appears that the transmission through the ionosphere in different directions follows different paths, and that this lack of reciprocity could arise from the effect of the earth's magnetic field.

It is expected that the new technique will prove superior to observations of solar noise for exploring the higher levels of the ionosphere.

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Eliminate the switch-on surge in AC/DC receivers with BRIMISTORS. Wired in series with the valve heaters, a BRIMISTOR holds the starting current at a low value, allowing it gradually to rise to its working level, so eliminating the rush of current which shortens the lives of dial lights and valves.

When cold, a BRIMISTOR has a high resistance and this falls to a very low value as it warms up. Generally this low resistance can be ignored and at the most calls for a slight reduction in the resistance of linecord or other voltage dropper.

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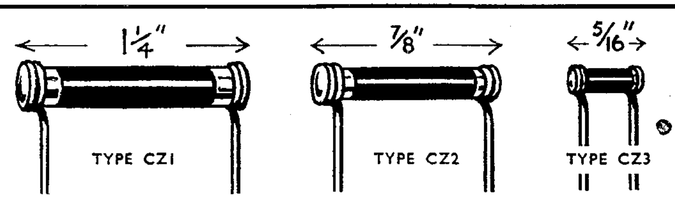


Use CZ1 for 0.3 amp. and the new 0.1 amp. valves.

Use CZ2 for 0.15 amp. and 0.2 amp. valves.

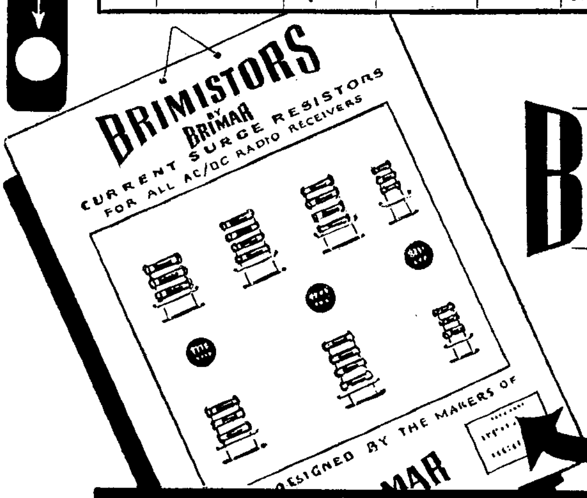
Wire type CZ3 across the dial lamp (in conjunction with a CZ1 or CZ2 as above).

CHARACTERISTICS OF BRIMISTORS

TYPE	COLD RESISTANCE	RESISTANCE WITH THE FOLLOWING CURRENTS FLOWING				LIST PRICE
		0.1 amp.	0.15 amp.	0.2 amp.	0.3 amp.	
CZ1	3000 ohms	180 ohms	100 ohms	75 ohms	44 ohms	3/6
CZ2	5500 ,,	170 ,,	90 ,,	66 ,,	38 ,,	2/6
CZ3	1500 ,,	100 ,,	50 ,,	35 ,,	Max. Current 0.2 amp.	1/6

IMPORTANT
Notes on the use of Brimistors

1. Owing to the high operating temperature (up to 250°C.), Brimistors must be spaced away from coils and waxed components.
2. They should be inserted in the "live" end of the heater chain—*i.e.*, between mains resistance and rectifier valve heater.
3. At least ½" of wire must be left at each end before soldering to a tag.



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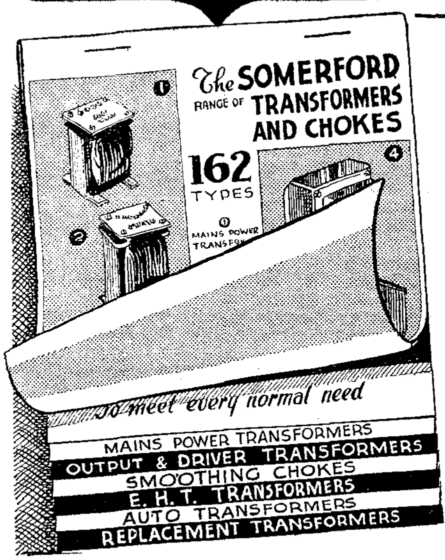

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TEST REPORT

G.E.C. MODEL BRT400

High Performance Communications Receiver

Distinctive features of the receiver is the convenient positioning of all the controls and the clarity of the frequency calibrated scales.

THERE are two versions of the G.E.C. communications receiver; one is the BRT400, which is a table model and housed in a steel cabinet measuring 21in wide, 10½in high and 14½in deep, and is the receiver illustrated here, the other is fitted with an overlapping front panel for mounting in the standard 19in rack and is known as model BRT402.

Electrically both sets are identical and consist of an 11-valve superheterodyne with an integral a.c. supply unit. This has three valves and operates from supply voltages of 95 to 130 or 195 to 250 at from 40 to 80 c/s. If necessary the receiver can be used with batteries, in which case an external power unit for 12-volt operation would be used.

One requirement of a communications receiver is that it must cover a wide range of frequencies, giving reasonably constant amplification throughout. In the case of the BRT400 (and of the BRT402 as well) the coverage is from 150kc/s to 33Mc/s in six switched ranges. Apart from a small gap between 350 and 550kc/s each range generously overlaps adjacent ones.

Selectivity being an all-important feature of a communications set, the G.E.C. model provides the choice of six alternative bandwidths selected by a switch. Three are for telegraphy reception, being 0.5 kc/s, 1 kc/s and 2 kc/s respectively, and the remainder are for telephony, being 5.5 kc/s, 7 kc/s and 9 kc/s wide. The inclusion of the 9-kc/s one may be thought unnecessary in a set of this kind, but it has to be borne in mind that, as a communications set, it has to serve all purposes, the reception of high-quality broadcast might well be one.

On frequency ranges one to four, which together cover 1.4 to 33Mc/s, the input to the set is arranged for a 75-ohm feeder either balanced or unbalanced, but on ranges five and six, 550 to 1,400 and 150 to 350kc/s a high impedance input of 400 ohms is allowed for.

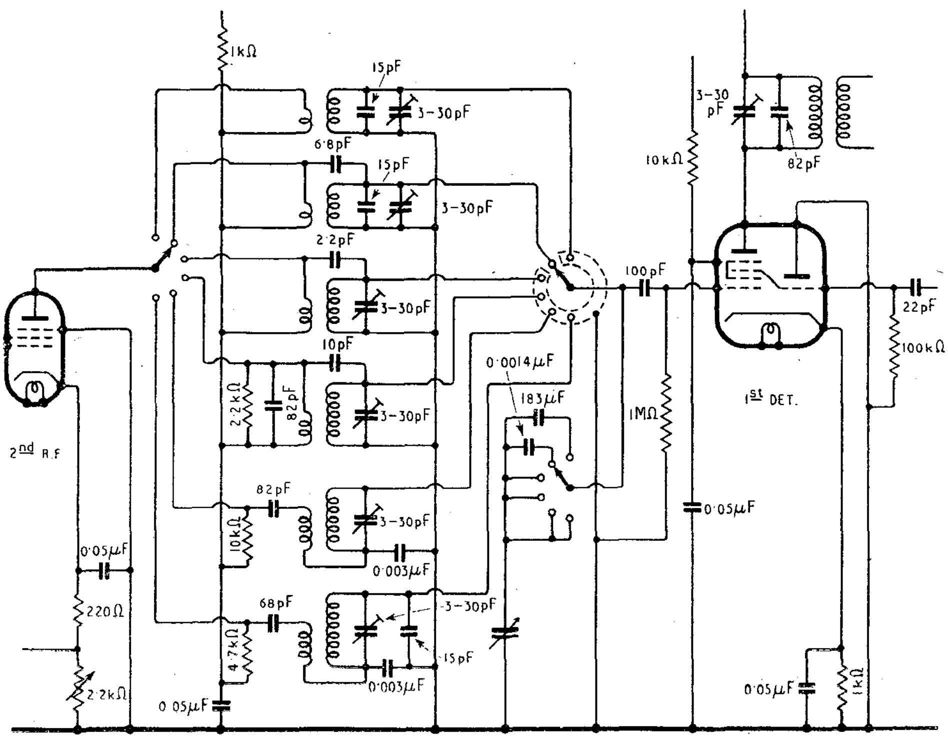


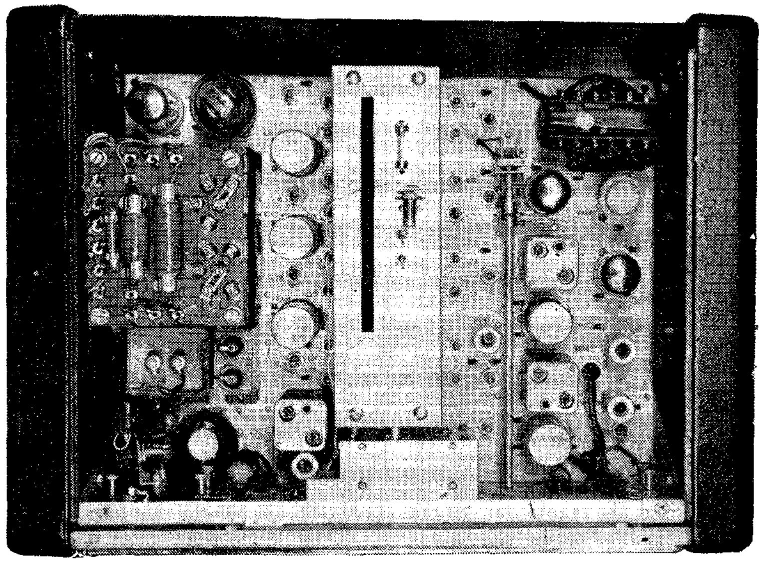
Fig. 1. Range switching of r.f. inter-stage couplings in G.E.C. BRT400 receiver.

The first two stages are r.f. amplifiers using W81 valves, the third is a mixer, for which the hexode section of an X81 is used, the triode part being ignored. The

G.E.C. Model BRT400—
local oscillator is a N77 valve with a shunt-fed anode circuit using a resistance and with the h.t. derived from a voltage stabilizer in the power unit. In other respects the oscillator circuit follows normal practice with grid and anode coils switched for band changing. All coils have dust-iron cores for inductance trimming as well as parallel capacitance trimmers.

In Fig. 1 is shown the coil assembly and switching for the intervalve coupling between the second r.f. and mixer valves, and this is typical of the other r.f. stages. Wafer-type switches are employed, of which there are nine double-sided plates in the r.f. and oscillator stages, and these are ganged for waveband changing. All idle coils are short-circuited to prevent absorption effects.

From the mixer stage the output is passed to a crystal filter transformer tuned to 455 kc/s. In the secondary circuit of this transformer is a quartz crystal with a split-stator phasing capacitor to neutralize the capacitance of the crystal. With correct neutralization the crystal is equivalent to a series resonant circuit having a very sharp response curve. Variations of the phasing capacitor change the response characteristic of the crystal from a series to a parallel resonant circuit at either a higher or a lower frequency so that according to the setting of the phasing condenser very high attenuation of the signal can be effected either just above or



With the lid of the set removed the mains voltage adjusting platform is readily accessible, so also are all the coil inductance trimmers. Note the trimming tool, spare lamps and fuse on top of the gang condenser housing.

just below the mean frequency.

This characteristic is the one known as "single-signal reception" and can be used to attenuate a signal only a few hundred cycles removed from the one it is desired to receive. The system is only applicable, of course, to telegraphy, as the selectivity is far too high for telephony reception.

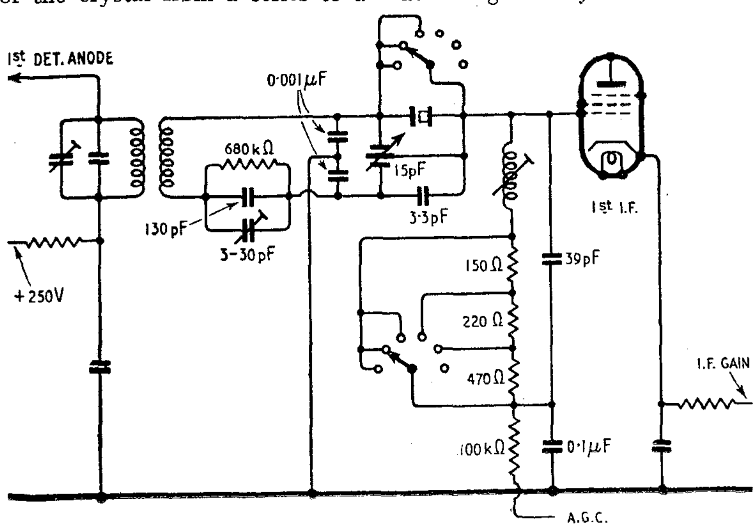


Fig. 2. Circuit details of the crystal filter and switching for the three narrower i.f. bandwidths.

The first i.f. transformer coupling also provides three of the six bandwidth conditions, this being achieved by varying the impedance into which the crystal works. A network of resistors is included in the grid circuit of the next valve and these are switched in as required. Details of the crystal filter and the switching are given in Fig. 2.

Two i.f. amplifiers employing W81 valves follow the crystal filter; the transformers are the variable selectivity type providing three alternative bandwidths for telephony reception.

Following the second i.f. valve is a double-diode-triode (DH81) serving the functions of detector, a.g.c. delay for the i.f. amplifier and first audio amplifier. Different delay levels before a.g.c. becomes operative on the r.f. and i.f. amplifiers are provided, a refinement not found in the general run of receivers. In addition there is also an a.g.c. amplifier valve. Delay for the r.f. amplifier is embodied in a double-diode, one half of which functions as an impulse noise limiter.

The complete a.g.c. circuit and noise limiter is shown in Fig. 3. The output terminal marked

" A.G.C." is provided so that two or more receivers can be operated in diversity. The " – 100V " supply for the a.g.c. amplifier is provided by a metal rectifier in the power unit. It takes its input from a tapping on the mains transformer. It also supplies the grid bias for the first a.f. amplifier through a potential-divider.

Resistance-capacitance coupling is used between the first a.f. amplifier and the tetrode output stage. The capacitance is reduced by a switch marked "Speech/Music" when in the "speech" position and gives a 6-db cut in bass response at 300 c/s. For speech and music negative feedback is applied over the output stage only and in this circuit is included a 1,000-c/s filter which can be brought in by a switch marked "Filter" for telegraphy, thereby further enhancing the overall selectivity.

Headphones, a loudspeaker or a 600-ohm line can be connected to the receiver *via* appropriate windings on the output transformer. Loudspeakers of either 2.5 or 15 ohms can be used.

A feature of interest in the power unit is the inclusion of a smoothing valve in order to avoid the need for large electrolytic capacitors. A tetrode, the KT81, as used in the output stage is employed, and it is connected across the h.t. supply after the normal smoothing system with the anode to the positive line and the cathode to the negative and a suitable resistor in the cathode for negative bias.

A portion of the ripple voltage is applied to the grid through a capacitance, its phase is changed by 180 degrees in the valve and it is fed back to the h.t. line as a ripple bucking voltage. The amount fed back is controlled by the gain of the valve, which in turn is controlled by a variable portion of the cathode resistor. The arrangement is simple but effective, as the background is very quiet indeed.

So much for the principal electrical features of the set. There is no doubt that much thought has been given also to the mechanical side, as everything inside that needs to be adjusted for routine maintenance purposes is exceptionally accessible. With the chassis removed from the cabinet all the r.f. capacitance trimmers are accessible from the underside, while all the inductance trimmers (dust cores) can be reached from the top deck of the chassis.

No less attractive is the general layout and appearance of the front panel, where all the controls are symmetrically arranged. The sible by the use of a precision-made gear box for operating the gang condenser and driving the scale pointer. This unit gives an overall reduction of 64 to 1, and 32 full turns of the tuning knob covers a range from end to end.

For purposes of station logging a circular vernier scale engraved

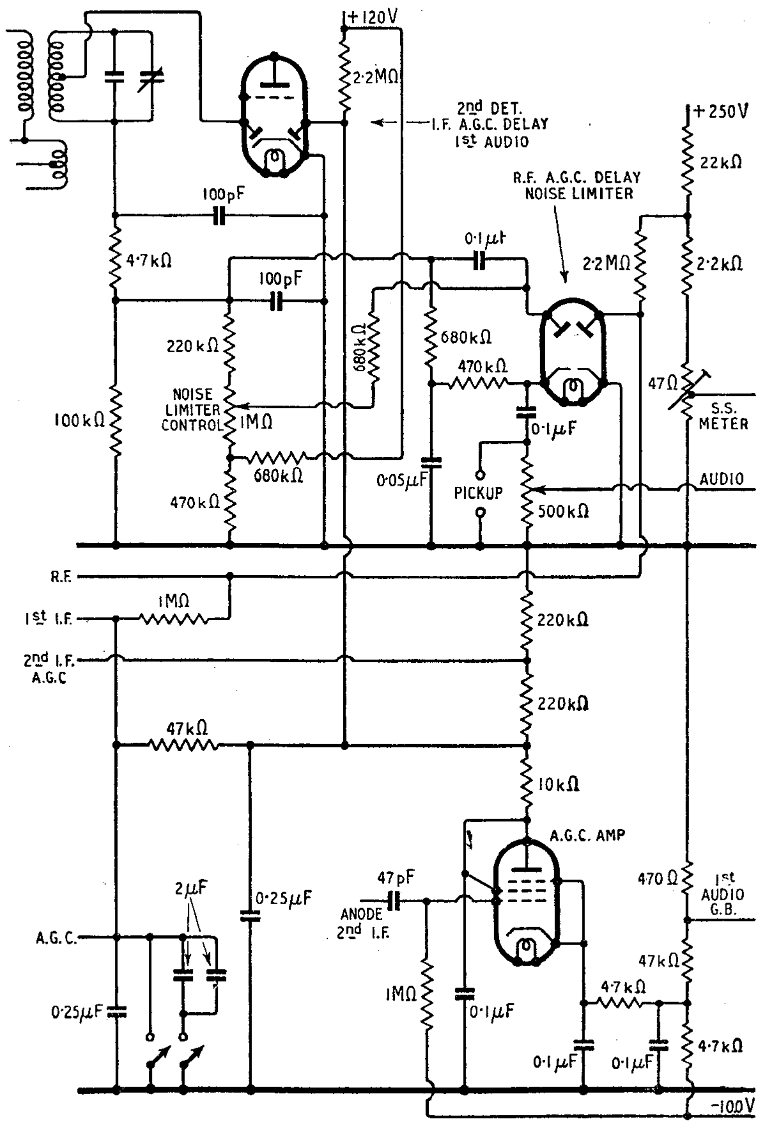


Fig. 3. **The a.g.c. and noise limiter circuits used in the BRT400 communications set.**

six tuning scales are individually calibrated in frequency but there is also provision for accurately logging any signal so that a return to it can be made with absolute certainty. This is made pos- 0-100 is fitted to the driving spindle and the top part of the scale is visible through a window located just below the centre of the main scales. Below the six main tuning scales and traversed

G.E.C. Model BRT400—

by the pointer is a further scale with 32 divisions. From the description of the gear box, it will be seen that one revolution of the tuning knob moves the pointer over $\frac{1}{32}$nd of the horizontal scale, or one division of the 0-32 scale. Thus a hypothetical station could be logged as R32052; interpreted, this reads, range three, 20 on the horizontal scale and 52 on the vernier. Spring-loaded split gears are used and there is no trace of backlash in the driving mechanism. Flywheel tuning is embodied.

Separate Perspex strips ½in wide and 10in long are used for each of the seven scales with illumination effected from the sides, the lighting being confined to the range in use and to the bottom (0-32) scale. For illumination of the dial, receiver and "S" meter no fewer than 10 lamps are employed.

The high precision of the tuning control makes the receiver a real pleasure to handle, the wide range of selectivity provides ample choice of bandwidth for the type of reception needed, while the crystal filter enables bad heterodynes to be readily removed. The phasing control, however, requires a little practice before it gives of its best, since the tuning and b.f.o. pitch control all play a part.

On the general sensitivity little need be said, since a receiver with two r.f. and two i.f. stages is not likely to be defective in this respect. What must be commented upon, however, is the very good signal-to-noise ratio, which at first gives the impression of low overall gain. This is very soon dispelled when a signal is tuned in.

The local oscillator and b.f.o. stability are above criticism, and c.w. signals can be held without adjustment for an indefinite time, using the 500-c/s bandwidth. No trace of mains ripple could be detected and all c.w. signals gave a pure T9 tone.

Manufactured by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, the price is £120 for the BRT400 and £114 for the BRT402.

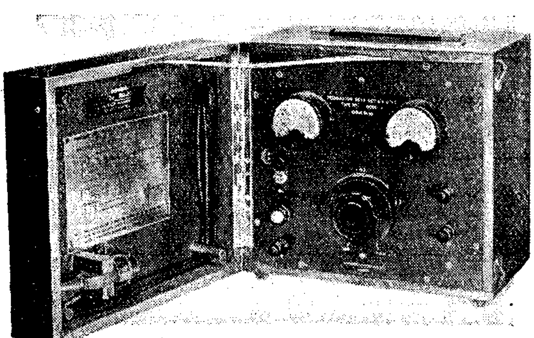
TEST AND MEASUREMENT

New Equipment at the R.C.M.F. Exhibition

THIS short review of apparatus shown at the recent exhibition of the Radio Component Manufacturers' Federation was unavoidably held over from the general description of the exhibition published in our April issue. A list giving the full titles and addresses of the firms concerned appeared in that issue.

Pointer-type meters form the basis of most test instruments, so much so that they are often taken for granted. It is only when one sees them as individual components that one realizes their importance and the development that has taken place in recent years. Robust moving-coil instruments of 500-μA range are now common and a 100-μA movement is nothing extraordinary.

In addition to such 2½-in and 3½-in single meters multi-range types are common. The well-known Avometer is one example and is typical in providing d.c. and a.c. current and voltage ranges as well as acting as an ohmmeter. The ordinary ohmmeter is usually limited to a maximum of about 100 kΩ, although some types go up to 1 MΩ. For higher resistances a form embodying a valve voltmeter is used. The Taylor model 290A megohmmeter is an example and covers 20k ohms to 50,000 MΩ in four ranges. It is for an a.c. power supply.



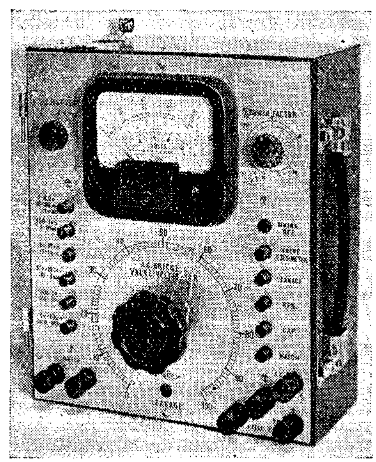
Insulation test set by Advance Components.

Bridge circuits are often used for resistance measurement and usually have capacitance ranges. The Pullin 666 bridge includes a valve voltmeter as well. It covers 1 Ω to 10 MΩ in six ranges and 10pF to 100 μF also in 6 ranges with an accuracy varying between 3% and 10% according to range. The valve voltmeter has six d.c. ranges from 1V full scale to 500V, and five a.c. ranges from 10 V to 500 V peak.

The Dawe 613B valve voltmeter covers 1 mV to 300 V with an accuracy of 3% of full-scale reading and has a frequency range of 10 c/s to 1 Mc/s. It needs no zero adjustment.

An insulation test set was shown by Advance Components. It provides a test output of 6 kV measured by an electrostatic voltmeter, and a microammeter for checking leakage current is included.

Advance Components also showed a range of signal generators. The



Pullin 666 bridge.

well-known E1 covering 100 kc/s to 60 Mc/s now has a companion, the E2 which covers 100 kc/s to 100 Mc/s. Even at the highest frequency the stray field is guaranteed less than 3μV. A higher grade instrument, the Advance D1, covers 9.8–310 Mc/s.

Among low-frequency instruments the B.S.R. LO800B should be mentioned. It is of the beat-frequency type and there are several models with maximum frequencies from 16 kc/s to 54 kc/s.

Wobbulator and double-beam units for the Miniscope oscilloscope were shown by G.E.C. The former has a mid-frequency of 400-520 kc/s and is intended for i.f. alignment. The latter is a tube unit which converts the Miniscope into a two-tube oscilloscope.

Makers: Advance Components, Automatic Coil Winder, Dawe Instruments, Ferranti, G.E.C., Measuring Instruments (Pullin), Salford Electrical Instruments, Taylor Electrical Instruments.

WORLD OF WIRELESS

British Vision Channels ✦ Films and Television ✦ 625-Line Demonstration

Television Frequencies

ALTHOUGH at present television transmissions in this country are limited to the 41.0 to 66.5-Mc/s band, plans have been made by the B.B.C. for five channels extending to 68 Mc/s in anticipation that the full width of the band as allocated at Atlantic City, will ultimately be available.

By the adoption of asymmetric sideband transmission in the new channels it has been possible for the Alexandra Palace station to continue double sideband transmissions on its present frequency. The carrier frequencies in each channel are:

	Sound	Vision
1. (Alexandra Palace)	41.5	45
2.	48.25	51.75
3.	53.25	56.75
4. (Sutton Coldfield)	58.25	61.75
5.	63.25	66.75

It will be seen that the spacing between sound and vision carriers is standardized at 3.5 Mc/s and that the spacing of the vision frequency of any one of the new channels from the sound carrier of the channel next higher in frequency is 1.5 Mc/s.

The design of the vision chain of all future transmitters will permit, as at Alexandra Palace, the transmission of vision signals substantially undistorted in amplitude and phase up to a vision frequency of 2.75 Mc/s. The carrier and the complete lower sideband of the a.m. vision signal, together with the upper sideband for vision frequencies up to 0.75 Mc/s, will be transmitted substantially unattenuated and with negligible phase distortion. This corresponds to a pass band of 3.5 Mc/s in width. For vision frequencies above 0.75 Mc/s the upper sideband will be considerably attenuated. An ideal frequency response for a receiver is given as 100% from $f_c - 2.75$ Mc/s to $f_c - 0.75$ Mc/s; 50% on the carrier frequency (f_c) and no response over 0.75 Mc/s above the carrier. The receiver will need to attenuate, by at least 30 db, the sound carrier on $f_c - 3.5$ Mc/s in order to avoid interference from the sound modulation of the adjacent channel. It is pointed out that the more sensitive type of receiver will also need to attenuate by at least 50 db a signal on $f_c + 1.5$ Mc/s as in fringe areas of reception the field strength of wanted and unwanted transmissions may be approximately equal. It is stressed that interference due to a beat frequency of 1.5 Mc/s is very evident on the picture.

Despite the fact that Alexandra Palace will continue to radiate both sidebands, a receiver designed on the above principles will receive its transmissions.

B.B.C. Expansion

RUMOURS have been current for some time that the B.B.C. was seeking a site for another Broadcasting House because of the inadequacy of the existing building even when extended to the limits provided in the original plan.

It has now been stated by the London County Council that it has agreed to make 13 acres of the 26-acre site of the old White City exhibition at Shepherd's Bush, West London, available to the B.B.C. for this purpose. If this project materializes, it will be possible for the Corporation to bring under one roof most of the sections which operate outside Broadcasting House in the 40 odd London premises they at present occupy.

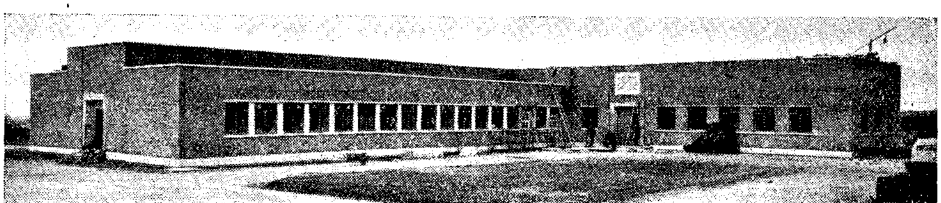
To meet the immediate need for increasing the space available for television studios, the B.B.C. has rented a further section of Alexandra Palace, thereby doubling the studio capacity. The ultimate aim is to concentrate the television service in the proposed "Radio City."

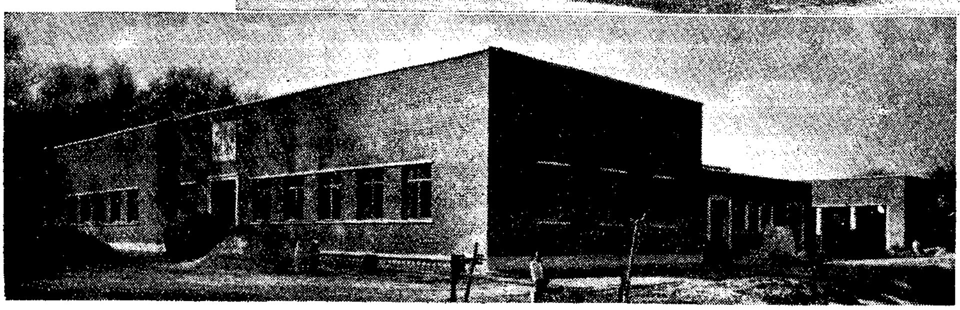
Research work is to be centred at the new laboratories at Kingswood, Surrey.

Cinema Television

THE G.P.O. has announced that the resumed talks between representatives of the film industry and the B.B.C. have once again been adjourned owing to the participants being unable to agree on the general principles of a co-operative experimental arrangement for exchange of material. This gives added interest to the proposals put forward by S. Seeman, managing director of Scophony-Baird, in a 16-page booklet "The Cinema and Television." Mr. Seeman, after comparing the progress of television in this country and the U.S.A., states, that in spite of the comparatively slow progress made in Great Britain, "there can be no doubt that in the not too distant future . . . . this new medium will prove a serious competitor to the film industry."

A plan to "co-ordinate the advancement of television with the





PROGRESS pictures taken a few weeks ago at the sites of (right) the Sutton Coldfield, Birmingham, television station and (below) the e.h.f. broadcasting station at Wrotham, Kent, showing the advanced stage reached in the building programme. It is anticipated that, preparatory to opening in the Autumn, test transmissions from Sutton Coldfield will begin during July.

World of Wireless—

interests of the cinema industry" is put forward by the author. The basic provisions are (1) the granting of licences to large-screen television manufacturers to reproduce B.B.C. programmes to a paying audience in one cinema for each manufacturer, and (2) the granting of a licence to the cinema industry to establish its own transmitter and chain of relay stations providing a high-definition service of, say, 900 lines, to cinemas throughout the country.

The second proposal also calls for the establishment of a Cinema Television Corporation to implement the scheme.

Air Navigation

ABAS, the British version of I.L.S., the instrument landing system required by the regulations of the International Civil Aviation Organization to be used at all international airports, is being installed at two South African airports near Johannesburg and Cape Town. The equipment, valued at £20,000, has been developed and manufactured by Pye Telecommunications of Cambridge, and will be installed by Marconi's Wireless Telegraph Co., who are responsible for the installation and maintenance of the Abas.

The system provides not only beam-approach guidance for aircraft in both the horizontal and vertical plains by means of a crossed needle instrument on the dashboard, but also a glide path as a further element in the safe landing of planes.

The azimuth approach system operates on a frequency around 100 Mc/s and the glide path transmitter on about 330 Mc/s.

Télévision Française

EXPERIMENTAL transmissions from the new high-definition 819-line television station at the top of Eiffel Tower in Paris were due to begin in April on 213.25 Mc/s. Sound is on 202.1 Mc/s.

During experiments the power of the transmitter will be limited to 100 watts but will in the near future be increased to 3 kW. The scheduled power is 5 kW. The single side-band transmitter employs positive modulation and the transmission is vertically polarized.

The second high-definition station at Lille, which according to *La Télévision Française*, is expected to begin experimental transmissions towards the end of the year, will operate in the 160-174-Mc/s band.

The number of hours of transmission from the 455-line Paris transmitter, which is to continue to operate until 1958, has been increased to 21 per week, with daily afternoon and evening programmes.

Mobile Television

THE boat race on March 26th was unique in that viewers were able to watch it from start to finish. Seven television cameras were placed at suitable points along the course but, in addition, a camera was fixed in the bows of a launch which followed the whole race. This is claimed to be the first occasion on which a mobile television unit has been used for broadcasting.

A Marconi image-orthicon was mounted on a tripod in the bows of the launch, which carried a Pye transmitter for the radio link and a 3-kVA generating set. Three Pye receiving stations were used, one at each end of the course and one near the middle.

The pictures from the launch were marred by interference at the start of the race, but this gradually disappeared and excellent results were secured over the major part of the course. Towards the end it reappeared to some degree. The impression was that two of the receivers were picking up an interfering signal, but that the third was free from it—presumably, the null of its aerial was poled on to it.

B.I.F.

EXPORT-STANDARD 625-line television will be publicly demonstrated for the first time at the Birmingham section of the British Industries Fair, which opens simultaneously in London and Birmingham on May 2nd. Marconi equipment, similar to that described on page 181, will be used for the demonstration transmissions, which will be on a closed circuit. Fifteen-inch tubes will be used to monitor the transmissions. Most of the domestic radio equipment to be shown at the B.I.F. will be exhibited at Olympia, London, and industrial electronic gear at Birmingham.

PERSONALITIES

Sir Ben Lockspeiser, who has succeeded **Sir Edward Appleton** as Secretary of the Department of Scientific and Industrial Research, has been elected a Fellow of the Royal Society. Sir Edward, who is now Vice-Chancellor of Edinburgh University, has been awarded the James Alfred Ewing medal for 1948 on the joint recommendation of the Royal Society and the Institution of Civil Engineers.

A.V-M. R. S. Aitken, C.B., C.B.E., M.C., director of Radio and Television Trust, Ltd., and Airmec Laboratories, Ltd., has been elected president of the Radar Association for this year.

E. Cattanes, who was until recently sales manager of Airmec Laboratories, has been appointed manager of the Industrial Electronics Department (Stafford) of the English Electric Co.

A. J. Gale has been appointed television production manager of Scophony-Baird's factory at Lancelot Road, Wembley. He was, until recently, in charge of Philco television development.

C. D. C. Gledhill is now in charge of the London Office of Sound Sales, Ltd., at 57, St. Martin's Lane, W.C.2. His predecessor, **G. H. Hodgkison,** is no longer with the company.

T. Hands, O.B.E., has been appointed director of manufacture to the Edison Swan Electric Co., and therefore relinquishes the post of general manager (valves) which he has held since the amalgamation of Cosmos with Ediswan in January, 1948. He was with B.T.H. from 1914 to 1946, where for ten years he was works manager. In 1946 he was appointed managing director of Cosmos and a director of Ediswan.

P. V. Hunter, C.B.E., has been appointed chairman of the Radio Gramophone Development Co. He is also director and engineer-in-chief of British Insulated Callender's Cables and chairman of British Telecommunications Research, Ltd. The new general manager of R.G.D. is **G. H. Walton,** who is also a director.

A. E. Lawson, London area representative of E.M.I. Sales and Service, has been appointed television manager to the company.

G. F. Mansbridge, O.B.E., retired from the Board of the Dubilier Condenser Co. on March 31st. Mr. Mansbridge, whose name has been associated with condensers for many years, applied for his first patent in this field 50 years ago.

A. E. Newland has been appointed home sales manager of the Gramophone Co. (H.M.V.) and **H. C. Goodman** is his assistant. **G. D. Putler** continues as export sales manager.

J. D. Percy, who has been in charge of large-screen television engineering in the J. Arthur Rank Organization (Cinema Television, Ltd.) since 1937, has joined Scophony-Baird, Ltd., as director of television development. Prior to joining Cinema Television he was with Baird Television, Ltd.

H. J. Perkins is retiring from the general secretaryship of the Radio Officers' Union which he has held for twelve years.

E. Yeoman Robinson, who has been chief engineer of Ediswan's Brimsdown Works since 1929, has been appointed chief engineer and manager (valves) to the company. In 1922 he joined Metro-Vick's Research Department, and in 1927, when valve production was transferred to Cosmos, he was appointed chief engineer of Cosmos valve department. He became a director of Ediswan on the amalgamation of Cosmos and Ediswan last year.

R. T. B. Wynn, C.B.E., assistant chief engineer, B.B.C., has been elected to the Council of the Engineers' Guild, and **M. J. L. Pulling,** superintendent engineer (recording), B.B.C., has been elected to the provisional committee of the Metropolitan Branch of the Guild.

IN BRIEF

Licences.—February's total of 11,639,500 broadcast receiving licences in Great Britain and Northern Ireland included 120,100 for television. The month's increases were: "sound" 71,350 and "vision" 8,250.

Cost of Suppression.—During the report stage of the Wireless Telegraph Bill in the House of Lords, an amendment was carried to limit to two shillings a person's liability in fixing an interference suppressor to domestic equipment.

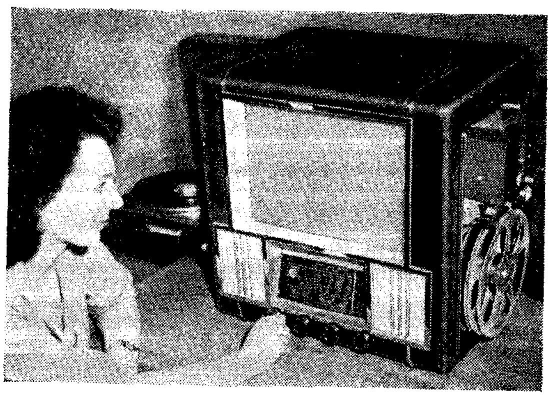
Standards for Plastics.—A revision of B.S.771:1948, "Synthetic Resin (Phenolic) Moulding Materials," has been issued by the British Standards Institution and is obtainable from the Sales Department, 24, Victoria Street, London, S.W.1, price 5s. The Institution has also issued a Standard (B.S.1493:1948) for polystyrene moulding materials which covers both general-purpose moulding material and also that specially suitable for radio and electrical use. It costs 2s. A further Standard in the series is B.S.1524:1949 for cellulose acetate moulding materials and it costs 3s.

Comparisons.—Murphy states that in a standard television receiver, such as the V116, there are 2,200 parts, requiring 650 soldered joints, compared with only 450 and 223, respectively, in the A124 broadcast receiver. Whereas there are only four valves in the A124, there are 19, including rectifiers and c.r.t., in the television set.

E.M.I.—High-definition (637-line) television was recently demonstrated to members of the Belgo-Dutch television delegation when they visited Hayes.

Ship-Shore Radio.—The thirteen Post Office stations situated at strategic points round the coasts of the British Isles last year handled over 10,000 radio-telephone calls and nearly 750,000 radio-telegrams from ships at sea. The stations also handled 281 distress calls and 252 requests for medical advice. The latter are dealt with under the Medical Advice to Ships at Sea service through which the Master of a ship can obtain advice in serious cases.

Marconi Veterans.—The thirteenth annual reunion luncheon of Marconi Veterans will be held on May 7th at Caxton Hall, London, S.W.1.



COMBINED radio-gramophone and film projector, shown at the Cinema and Photo Salon in Paris, incorporates a three-band receiver, disc reproducer and a 16-mm sound or silent film projector. The film screen is above the tuning scale.

"Queen of Bermuda".—In addition to the standard Marconi marine radio and radar equipment in the reconditioned Furness liner *Queen of Bermuda* a Marconi Printer has been installed. High-speed morse transmissions are converted by the Printer into plain language and automatically printed on tape. The public-address equipment installed in the ship by the G.E.C. includes 116 loudspeakers. The P.A. system provides for the simultaneous relaying in different parts of the ship of both a broadcast programme and two programmes originating on board. Emergency announcements from the captain's microphone automatically supersede other matter being relayed.

Engineers' Guild.—In addition to the Metropolitan Branch of the Guild which was formed last October, a West Midlands Branch, with headquarters in Birmingham, a Northern Branch with headquarters in Newcastle, and a North-Eastern Branch, centred on Leeds, have now been formed. Information regarding the Engineers' Guild, the aim of which is to further the professional interests of engineers, is obtainable from the honorary secretary, W. A. M. Allan, 28, Victoria Street, London, S.W.1.

Alleged Patent Infringement.—Electric & Musical Industries, Ltd., state that a writ has been issued against Pye, Ltd., for alleged infringement of Letters Patent No. 442666 which relates to the E.M.I. Super-Emitron camera.

Reprints.—The articles describing a long-range television unit (February and March, 1949) are being reprinted as a booklet. In addition to the two articles it includes reprints of the map giving the service area of the Alexandra Palace transmitter and another showing the disposition of the stations in the London-Birmingham radio link and also the anticipated service area of the Sutton Coldfield station. It should be pointed out that the receiver will need changes to three coils for reception of the Birmingham transmissions. The reprint will cost 2s 6d, or 2s 8d by post. Reprints are also being prepared of the article giving details of a midget a.c. receiver (March, 1949). It will cost 6d, or 7½d by post.

Valve Manufacture.—A 16-mm coloured film showing the manufacture of v.h.f. transmitting valves has been prepared by the G.E.C. and was used by E. Morgan of the G.E.C. valve department to illustrate a lecture given to the City & Guilds Radio Society.

Amateur Convention.—The first National Convention to be held by the R.S.G.B. since 1938 is scheduled for October 22nd to 23rd at Belle Vue, Manchester.

Frequency Spectrum Chart.—A new and improved version of their frequency spectrum chart showing the Atlantic City allocations to the various services has been issued by Mullard. It measures 2½ feet by 3 feet 4 in, is printed in 16 colours and costs 6s 6d (including postage). It is obtainable from the Mullard Communications Division, Century House, Shaftesbury Avenue, London, W.C.2.

Marconi communication and radio-navigational equipment is to be used by the British Overseas Airways Corporation on the new aircraft it is to operate. The first of the new aircraft to be fitted are twenty-two Canadair IVs, the radio equipment for which has been installed in the aircraft factory at Montreal. The installation includes two AD/107 h.f. transmitters (100/150 watts), two AD/108 nine-valve m.f./h.f. superhets and two AD/7092 automatic direction finders. By the use of miniature components, the size and weight of the installation has been drastically reduced.

FROM ABROAD

Australian Television.—Pye 405-line television transmitters and receivers were recently flown to Melbourne for an "on the spot" demonstration—claimed to be Australia's first. Pye has submitted specifications to the Australian Government in response to its request some months ago for tenders for the supply of transmitters for the six State capital cities.

Canada.—It was announced in the Canadian House of Commons at the end of March that television stations will be operated by both the Canadian Broadcasting Corporation and privately owned commercial stations.

Danish Television.—Some details of the experimental television transmitter which Philips (Holland) are installing in Denmark have been supplied by a correspondent. The 567-line vision transmitter, using negative modulation, will operate in the 60-70-Mc/s band. The F.M. sound transmitter will operate in the 70-80-Mc/s band with 75 kc/s deviation. The picture ratio will be 4: 3.

West Africa.—The extension of the radio-telephone service to link the four British West African colonies, Gambia, Sierra Leone, Gold Coast and Nigeria, has now been completed by Cable & Wireless. The colonies are linked with London via Accra, Gold Coast.

Germany.—The broadcasting authority in the British zone of Germany—Nordwestdeutscher Rundfunk — has brought into service a new 0.4-kW transmitter at Kiel-Krongshagen, which operates on 1,586 kc/s (189 m), one of the frequencies allocated to Germany in the Copenhagen Plan. This has been introduced to give listeners the opportunity to alter their sets to cover this lower wavelength—which is outside the present broadcasting band —in readiness for the introduction of the Plan next year. An e.h.f. transmitter, operating on 90 Mc/s, has,

World of Wireless—

according to the O.I.R., been erected at Munich-Freimann in the American zone.

Technical Publications Wanted.—The Brazilian journal *Antena* wishes to receive copies of British technical journals and technical catalogues which will be referred to in the bibliographical and industrial news sections of that journal. Materials should be addressed to Apollon Fanzeres, Caixa Postal 2483, Rio de Janeiro, Brazil.

Czechoslovakia.—The name of the Czech journal *Radioamatér* has been changed to *Elektronik*.

INDUSTRIAL NEWS

T.C.C.-U.I.C. Agreement.—The production and sale of silvered mica and ceramic capacitors, hitherto made by the United Insulator Co., will in future be undertaken by the Telegraph Condenser Co. Key members of the staff of U.I.C. research and development sections are joining T.C.C. The development, production and sale of ceramic materials will be continued by U.I.C.

Murphy in India.—A new company, Murphy Radio of India, Ltd., has been formed with headquarters in Bombay to assemble Murphy receivers from components exported from this country. Managing director of the new company is D. D. Lakhanpal and J. Wilson, service manager of Murphy Radio, is to be general manager.

Philips.—The production of electric lamps having been transferred from the Philips factory at Harlesden, London, N.W.10, to Hamilton, Lanarkshire, the vacated factory is to be used for the production of television components.

New Relay Company.—With the object of providing a television relay distribution system in localities on the fringe of the service area of a station, Pye and Murphy have jointly formed a new company called Link Sound and Vision Services, Ltd.

Components Tests.—The R.I.C. has published a specification giving general conditions of climatic and durability tests for components. The specification (RIC/11), which has not yet reached the stage of consideration by the British Standards Institution, is obtainable from the R.I.C., 59, Russell Square, London, W.C.1, price 1s.

Sargrove Electronics, Ltd., have moved from Walton-on-Thames to Effingham, Surrey (Tel.: Bookham 2707).

Ultra Electric, Ltd., have transferred their sales branch from Buckingham Gate, London, S.W.1, to their factory at Western Avenue, London, W.3 (Tel.: Acorn 3434), to which all communications, except those for the service department which remains at Erskine Road, N.W.3, should be sent.

Telcon.—A quarterly house magazine, including some technical matter, is being produced by the Telegraph Construction and Maintenance Co. An article in the current issue records that the company's head offices have been in Old Broad Street, London, E.C.2, for 85 years.

General Sonic Industries is the new name adopted by the General Electrical Radio Co., makers of the "Mighty Midget" a.c./d.c. receiver. The firm's address remains unchanged—21-24, Shene Street, London, E.C.1.

"Mullard World Review" is the title of a new publication being issued by Mullard Electronic Products as a link between representatives abroad and headquarters in this country.

CLUBS

Birmingham.—A lecture on wave interaction, better known as the "Luxembourg Effect," will be given to members of the Slade Radio Society on May 13th by F. J. Hyde, who is studying the subject at Birmingham University. The president of the Society, Dr. W. Wilson, will talk on electronic music at the meeting on May 27th. Meetings are held fortnightly at the Parochial Hall, Slade Road, Erdington, at 8.0. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23, Warwick.

Bristol.—Members of the Bristol and District S.W.L. Club will visit the B.B.C. transmitters at Clevedon on May 7th. Meetings of the club are held on Fridays at 7.30 at the St. Mary Redcliffe Community Centre, Guinea Street, Bristol, 1. Sec.: N. G. Foord, 71, Brynland Avenue, Bristol, 7, Glos.

Enfield.—The Enfield Radio Society, which was disbanded in 1939, has now been re-formed and regular meetings are held on alternate Tuesdays at 8.0 at Chase Side School, Enfield. On May 10th the subject for consideration is the design of small transmitters. Sec.: F. Tickell, 10, Cowdrey Close, Enfield, Middlesex.

Liverpool Exhibition. — Three amateur societies—Merseyside, Liverpool and Wirral—are organizing an amateur radio exhibition which it is planned to hold in the Crane Buildings, Hanover Street, Liverpool, from May 2nd to 7th inclusive. The exhibition, in which a number of manufacturers have been invited to participate, will be open daily from 9 a.m. to 7 p.m., except Saturday, when it will close at 9 p.m.

MEETINGS

Institution of Electrical Engineers

Radio Section.—Annual lecture on "The Development and Applications of the Synchrotron and Linear Accelerator for Physical Research and for Therapeutical Purposes," by Sir John Cockcroft, C.B.E., F.R.S., at 5.30 on May 4th.

Measurements Section.—"Some Electromagnetic Problems," by Professor G. W. O. Howe, D.Sc., LL.D., Technical Editor of *Wireless Engineer*, at 5.30 on May 3rd.

Discussion on "Graphical Methods of Teaching Electrical Engineering (including Radio)," opened by S. N. Ray, M.Sc., B.Sc. (Eng.) at 6.0 on May 9th.

London Students' Section. — "A Method of Carrier-Frequency Synchronization for Broadcasting Transmitters," by D. J. Whythe and "An Application of Wave Analysis to Routine Frequency Response Measurements," by I. J. Shelley at 7.0 on May 2nd.

The above meetings will be held at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group.—"Magnetic Amplifiers," by A. G. Milnes, M.Sc. (Eng.) at 6.0 on May 10th at the Cambridgeshire Technical College.

British Institution of Radio Engineers

London Section. — "Electronics in Heavy Industry," by W. W. Wilson, D.Sc., B.Eng., at 6.0 on May 19th, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Merseyside Section.—"The Measurement of F.M. Transmitter Performance," by D. R. Willis at 7.0 on May 4th, at the Incorporated Accountants' Hall, Derby Square, Liverpool, 2.

South Midlands Section. — "The Measurement of F.M. Transmitter Performance," by D. R. Willis at 7.0 on May 26th at the Technical College, The Butts, Coventry.

North-Western Section. — "Ceramic Capacitors," by W. G. Roberts, B.Sc. (Eng.), at 6.45 on May 5th, at the College of Technology, Sackville Street, Manchester, 1.

Institution of Electronics

North-Western Section. — "Radio Astronomy," by Dr. A. C. B. Lovell, O.B.E., at 6.30 on May 26th, in the Reynolds Hall, College of Technology, Manchester.

British Sound Recording Association

London.—Annual general meeting and conference at 2.30 on May 21st, at the Clarendon Restaurant, Hammersmith, London, W.6.

Birmingham.—Lecture and demonstration of a home constructed disc recorder by Desmond O'C. Roe, B.Sc., at 3.0 on May 7th, at the Grand Hotel, Birmingham.

MANUFACTURERS' LITERATURE

Illustrated folders describing the Bush PB12 table model receiver and TV11A television set, from Bush Radio, Power Road, London, W.4.

Osram Technical Publications: OV1 (battery miniature receiving valves), OV2 (a.c. and a.c./d.c. valves for radio receivers), TP1 (amplifiers for high-fidelity sound reproduction, a.c. operation), TP2 (high-fidelity amplifiers for d.c./a.c. and battery supply), TP3 (the KT66 valve in a.f. power amplifiers, r.f. amplifiers and voltage stabilizers), from the General Electric Co., Magnet House, Kingsway, London, W.C.2.

Data sheet No. 2100, "Silver Brazing Alloys," from Johnson Matthey and Co., 73-83, Hatton Garden, London, E.C.1

"Outstanding Features of S.E.I. Copper Oxide Rectifiers"—an illustrated folder from Salford Electrical Instruments, Silk Street, Salford, 3, Lancs.

Technical data and characteristic curves of "Brimistor" current surge resistors, from Standard Telephones and Cables, Valve Works, Foots Cray, Sidcup, Kent.

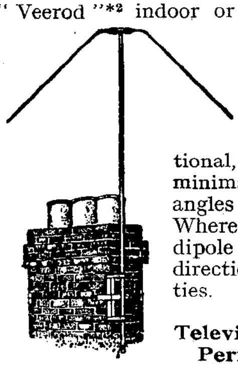
THE "BELLING-LEE" PAGE

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

"Costly aerials unnecessary in many areas."

This heading appeared recently in certain Midland newspapers and we heartily agree. There is no doubt that in the London area many " H " type aerials*1 were erected because of their snob appeal. The resulting signal being so strong that attenuators had to be fitted to reduce signal input.

So very much depends upon the site. We have always said that the " H " type should be used more often to reduce the pick-up of interference rather than to boost the signal. We do most sincerely ask readers to bear in mind that the " Veerod "*2 indoor or outdoor (as illustrated) or a " Doorod "*3 used as a " Veerod," are both directional, with a sharp minima at right angles to their axis. Whereas, a single dipole is without directional properties.



Television Aerial Performance

After an examination of television receiver sensitivities for peak vision white it would appear that the majority lie between 100 and 200 microvolts.

Taking 150 microvolts as a representative figure and using the latest B.B.C. field strength contour map, it is now possible to give for various " Belling-Lee " aerials, the range at which good reception should be almost certain. Since the B.B.C. field strengths on a given contour can vary ± 10 db the most pessimistic field strengths are firstly used for giving the more certain range.

In the second column are given the distances when the higher field strength is encountered.

These tables will explain why unexpected ranges are often encountered. All these figures are for two storied houses. Greater ranges are to be expected on taller buildings.

> Readers of this page, visiting the B.I.F. Castle Bromwich are invited to call on us Stand No. C 712 in the electrical section.

Corroded Aerials

We know only too well that since the war we have not been able to maintain the same high standard of finish that we could demand in pre-war days. Many hundreds of our pre-war " Skyrod "*4 and television aerials are still giving good service; they had double plating, both zinc and cadmium, followed by a coating of pigmented chlorinated rubber. Even if we could obtain adequate supplies of such materials the public would not pay the price.

Even when a specification of raw material is accepted by a supplier it is rarely kept, and we find ourselves compelled to accept something inferior or do without.

Immediately after the war we used the finish called for by the Services for the aerials we made for them, i.e., zinc plate and chromate passivate. We soon found this otherwise good finish would not stand up to prolonged exposure to sulphur laden atmospheres from chimneys. This was followed by bonderising plus aluminium paint. If the paint had been to specification, or of pre-war quality this would have been a considerable advance, but it was not.

We have consistently advertised in this and other publications, that aerials should be painted again at the time of erection, and this is mentioned in instructions.

The public would not pay the price of galvanised elements. Galvanising in itself is not expensive, but the removal of tears, lumps, etc., to ensure close fits, would raise the cost.

AERIAL	MAXIMUM CERTAIN RANGE IN MILES	OCCASIONAL RANGE IN MILES	KNOWN EXTREME RANGE IN MILES
Standard " H " on chimney ...	35	60—70	over 100*
Dipole on chimney	18	50	no data
Inverted " V " on chimney ...	14	35	no data
Inverted " V " or " Doorod " in attic	10	30	no data
On second floor	6	16	30

* Johannesburg, South Africa.

The figures in this table are scientifically compiled and are therefore very conservative and subject to local influences, e.g., anything might happen if a gas-holder was close to and between an aerial and transmitter.

Steel or Light Alloy

Now, by " controls," we have been forced over to high tensile light alloy. This gets over the trouble of finish, but new troubles arise. To ensure the same margin of safety, we have to use heavier gauges of material than is usual, this brings " humming in the wind " as one of the teething troubles but we have cured that one.

Very often we know a change unavoidably to be a retrograde step, but as it looks different everybody thinks it must be better.

Generally, when a change is made to one of our aerials it is not just to create something new. It is often because we can no longer maintain by the old method, the quality we like to have associated with our products and we are often disappointed with the change. " Belling-Lee " television aerials are stronger than any we have tried, and while we know their elements are designed to withstand gusts of 100 m.p.h. we don't feel happy about their retaining the straightness usually associated with aerials of our manufacture. If we could obtain supplies of steel, and give them our pre-war protection we would not hesitate to change back.

In very bad cases, where steel aerials have seriously corroded within a month or two of erection, we replace faulty parts free of charge.

The illustration shows the " Belling Lee " " Veerod "* chimney mounting inverted " V " aerial List No. L606 (London) L635 (Midland).

*1. " Viewrod " (Regd. trade mark) television aerials. L. 502/L London. L634 Midland. **£6/6/-.**

*2. " Veerod " (Registration applied for) Attic aerial L605 London. L646 Midland. **£2/12/6.**
Chimney mounting L606 London. L635 Midland. **£4/10/-.**

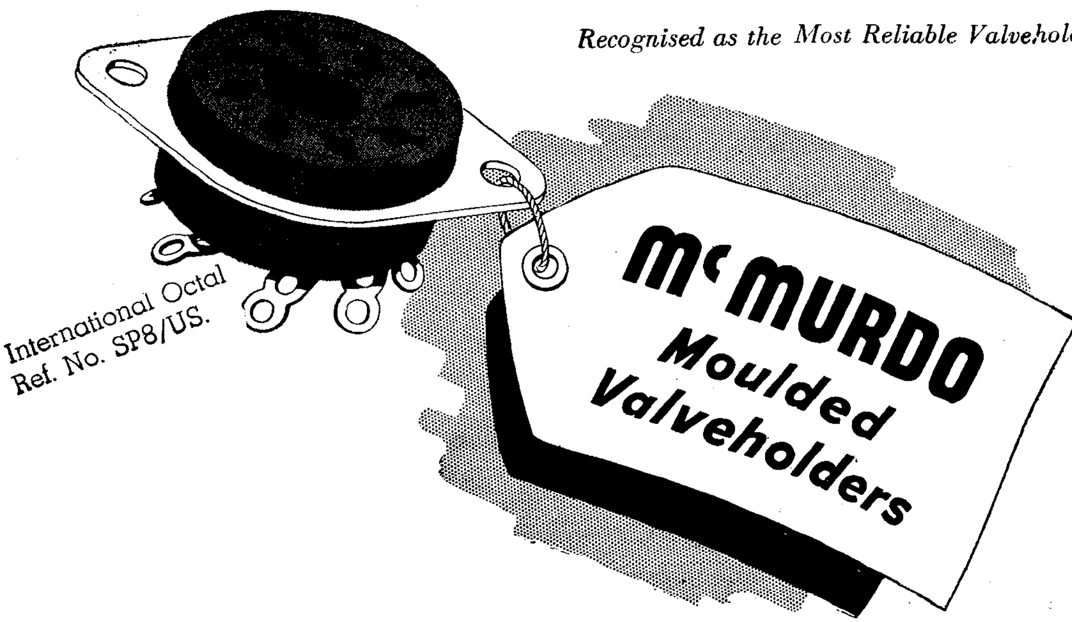
*3. " Doorod " indoor television aerial. L645 London. L678 Midland. **£1/10/-.**

*4. " Skyrod " (Regd. trade mark) anti-interference vertical aerials, now known as L638/K chimney mounting with " Eliminoise " (Regd. trade mark) transformers and feeder. **£10.**

BELLING & LEE LTD
CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX
ENGLAND

VITAVOX LTD., WESTMORELAND ROAD, LONDON, N.W.9. Tele: COLindale 8671

Recognised as the Most Reliable Valveholders



THE McMURDO INSTRUMENT CO., LTD., VICTORIA WORKS, ASHTEAD, SURREY ASHTEAD 3401

DRAWING CIRCUIT DIAGRAMS

Representation of Leads Which Cross Without Connection

A Personal Statement on This and Allied Questions

By L. BAINBRIDGE-BELL (Royal Naval Scientific Service)

IN the December, 1948 issue of *Wireless World* I contributed an an account of the new British Standard on Circuit Symbols (BS-530:1948). To this the Editor appended a note which read: "Mr. Bainbridge-Bell's approval of our practice in the matter of bridge cross-overs seems to cancel out his disapproval of our use of collinear connections. When bridges are used, the risk of errors through this cause automatically disappears." This reference to collinear connections was occasioned by my comment on the rule "Of wires meeting at a connecting point, not more than two should be collinear." I drew the attention of the *Wireless World* drawing office to this rule which has had "a rather unnoticed existence for fourteen years."

The above interchange of remarks seems a fitting cue for a statement of my considered opinions—which have developed during many years of experience in planning the drawing of circuit diagrams.

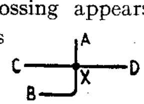
In the course of delivering lectures on the subject, I have often been asked the following questions:—

1. When leads cross without connection should they (a) go straight across, (b) have a bridge or (c) have a gap?
2. When leads cross with connection, how is the connection indicated?
3. (a minor question) Should tee-joints have dots on them? or not?

Here is a summary of my opinions. Regarding question 2, leads need never cross with connection; the question, therefore, does not arise. As for question 1, *if leads never cross with connection,* the answer to that question is not very important. For simplicity use (a) "straight across" In certain cases where a mistake would be disastrous, and for readers accustomed to it, I recommend (b) the bridge, but hope that it may die out in favour of (a). In rare cases I recommend (c) the gap instead of (b) the bridge. If diagrams are drawn so that leads cross with connection; (b) the bridge or (c) the gap *must be used.* Regarding question 3, tee-joints should always have dots on them (but see my later remarks about "curved junctions").

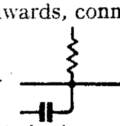
Now for my reasons. I say "Leads need *never* cross with connection." It is interesting first to consider how the appearance of such a condition has arisen.

The term crossing with connection (or equivalent term) is misleading. The circuit draughtsman does *not* usually say, having drawn two leads AB, CD which intersect: "These are now required to touch where they cross." What really happens is this:— He says "I want a lead from A to make contact with CD," and he draws one making the contact at X. He then says: "I want a lead from B to make contact with CD." With a mistaken idea of tidiness—or possibly from laziness—he draws the lead from B to meet CD at X, so that a crossing appears at X, and the harm is done.

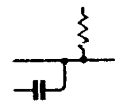


Functionally, the "incident" is not a crossing, i.e., it is not indicating a flow of anything from A to B—it is indicating a flow from A to C (or D) and from B to C (or D). The configuration therefore can actually be misleading.

As an example, suppose that a diagram contains a resistor above the earth-line, and a capacitor below it. The draughtsman wants to show that they are both connected to earth. He draws a line downwards from the resistor to the earth-line and then continues it downwards, connecting the capacitor to it.



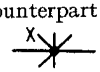
Usually he puts a dot at the intersection. The novice, seeing this continuous line from the resistor to the capacitor, may think that there is a flow of something from one to the other and so be confused. If the draughtsman had taken the leads to separate points on the earth line, confusion would have been avoided.



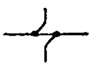
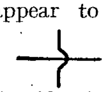
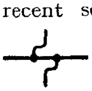
An analogy drawn from the plumber's trade may help to emphasize this point. The waste pipes of my washbasin and bath are connected to a common drainpipe. No one would try to explain the system by saying that the two waste pipes were connected together, although an aquatic insect could crawl from the bath to the basin. The common drain-pipe corresponds to the common earth-line; the connection of the resistor and capacitor to the *same* point corresponds to a statement "the resistor and capacitor are connected together."

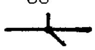
There is another very practical reason for "staggering the cross-roads." In my experience, the "crossing of two leads with connection" or (as I would rather call it) the "four-way joint" has been responsible for most of the mistakes in drawings. When a connection is intended the dot is often missed out by mistake; when a connection is not intended (using the "straight-across" convention) an unwanted dot is sometimes produced by an over-filled drawing pen causing the ink to run or by a fault in the printer's block. A tear in a wax stencil sheet can produce a similar effect.

The above remarks apply only to joints which are created by the draughtsman; it is sometimes neces-

Drawing Circuit Diagrams—
sary—for instance, in short-wave circuits—to show that a number of leads are taken to the same point. There can be no confusion or possibility of error if (at least one) connection (X) has no counterpart in the same straight line. 

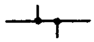
I often hear it stated that "cross-roads" are necessary in order to preserve symmetry (for example, in a push-pull valve stage where the two cathode leads are brought to the same point on the earth line). I consider that it is more important to obey the "staggered crossroads" rule *without any exception* then to preserve symmetry in minor details. Would the "symmetrical" die-hard insist on the upper valve being called V8 and the lower valve A 8?

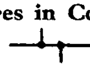
I recommend that the cathode leads approach the earth-line and diverge just before reaching it.  (The alternative, more symmetrical solution, of taking the two leads to a point on the same side of the vertical  is objectionable as it can, when carelessly drawn, appear to be a bridged crossing.)  A paper in a recent scientific journal uses this  which is neat and may suit those who object (why?) to sloping lines.

The rule is put thus in a recent amendment to an interservices publication: "In order to avoid confusion with wires which cross without connection, wires which are in contact should be shown staggered thus:—  or thus  (correct) and not thus  or thus  (incorrect) because the central dot can fail to appear, by accident owing to faulty printing, and thus lead to error."

Question 1: *Crossings without connection.* If the rule is obeyed *without any exception* and if it is realized that it *is* obeyed, the best method for showing crossings without connection is the simplest—straight across. This convention is observed by most of the engineers who draw circuit diagrams of telephone equipment.

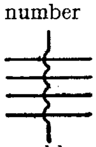
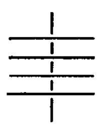
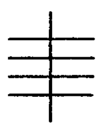
Doubts about the fulfilment of the second condition (if it is realized that the "stagger" rule *is* obeyed) make me hesitate to advise draughtsmen to abandon the use of the bridge. Another difficulty is that a large number of readers of radio literature are accustomed to the bridge. (A count showed that 60 per cent of modern text-books and periodicals preferred the bridge.) Perhaps the recent action of a Service department (in changing from first- to third-angle projection) of putting a "rubber stamp" notice on every drawing "Third-Angle Projection"—may act as a guide.

I would recommend:— Use the "stagger  and straight across  " convention. If any confusion is likely to be caused to certain classes of readers by a change from bridges, a note should be prominently displayed:

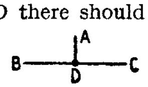
Wires in Contact
Joints thus:  not: 

and this action should be continued until the correct convention is well-known.

In exceptional cases—where confusion may cause fatal results—(as in some "Service" applications)—the bridge might still be used as a form of double security.

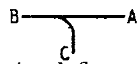
To those who still prefer the bridge, I would add that it is difficult to use where one lead crosses a number of closely spaced leads  A number of small bridges is "messy," and one large bridge may be difficult to detect if its curvature is small. I would recommend the use of gaps or, better, go straight across as illustrated here.   No one would intentionally connect a number of leads together by a lead crossing them—no confusion can arise.

In a wiring or installation diagram the bridge or gap need never be used. In these diagrams the fact that two leads, which happened to cross, were connected together would be shown by the presence of a terminal or junction-box.

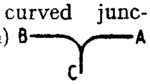
On question 3 (representation of "tee" joints) I would say that when a lead AD is shown connected to BC at D there should *always* be a dot at D 

The reason for the recommendation (which may appear somewhat far-fetched, but which is nevertheless real) is that, if the dot is omitted, the reader associates the "dot-less" junction with electrical connection, and is led (by a false analogy) to think that the "dot-less" *crossing* is also a connection. I have witnessed this confusion on several occasions: if readers were so accustomed to the "stagger and straight across" that they instinctively rejected crossings with connection, there would be no confusion.

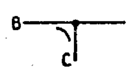
Finally, I would like to draw attention to a convention well known to "power" engineers that is gaining in popularity among radio engineers:—

This is a variant of the "tee" joint which can display additional information, with little extra trouble. To quote the "Services" book: "Clarity in circuit diagrams is sometimes enhanced by substituting a tangent quadrant for a tee at a junction (e.g., at the junctions of leads to an H.T. bus-bar) in order to emphasize a particular path; thus 

When there is a functional flow along AB and CB, but *not* along AC the above configuration suggests it—Note that no dot is used, as it would interrupt the idea of smooth flow."

Other possible "curved junctions" (as I call them) 

are and  though for the latter, the conventional tee would probably be used.

I find a hybrid arrangement sometimes useful, particularly if I am trying to clarify an existing drawing and do not want to erase anything. I draw a curved line near the tee thus 

showing an important path BC.

Some of my friends may be astonished at my conclusions. I must confess that I have changed from insisting on the almost universal use of bridges to the realization *that in the absence of four-way joints* , the straight-across convention is the best.

I repeat that I would be glad to hear of any objections to my "recommendations."

TELEVISION TRANSMITTING EQUIPMENT

APART of the Marconi's W.T. Company's exhibit at the British Industries Fair will be a demonstration of 625-line television. The firm is advocating this standard for use in countries where there is no possibility of linking up with existing services, but where such a possibility does exist it can provide equipment designed for 405 lines or 525 lines—the British and American standards.

Transmitters with peak powers of 5 kW or 500 W can be supplied. Amplitude modulation is used for vision but frequency modulation with a deviation of ±25 kc/s for sound, the vision and sound carriers being spaced by 6.5 Mc/s in the 625-line system. For linking cameras to the transmitters, microwave links are available, and give a range of the order of 15 miles. Greater distances can be covered by using a number of links in tandem.

Operating on 6,500-7,100 Mc/s (around 4.5 cm) klystrons are used both for the relay transmitter and for the receiver local oscillator. The power is 100 mW, but the 6-ft paraboloid recommended for the aerial system gives a gain of 40 db. Frequency modulation is used, peak white corresponding to a deviation of 10 Mc/s.

Since the success of television depends, in great measure, upon outside broadcasts, it is important that the cameras and their associated apparatus should be as portable as possible. A great advance in portability has been achieved by suitable sub-division of the equipment into units.

The camera, in particular, is unusually compact. It embodies an image-orthicon tube in which the picture is focused on to a semi-transparent photo-cathode to produce an electron image on the further side. This image is, in its turn, focused magnetically and with unity magnification on to a target electrode which consists of a very thin glass plate, faced on its input side with a metallic screen of extremely fine mesh.

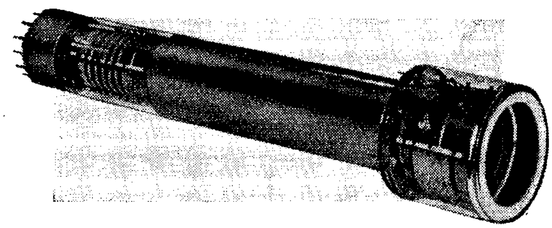
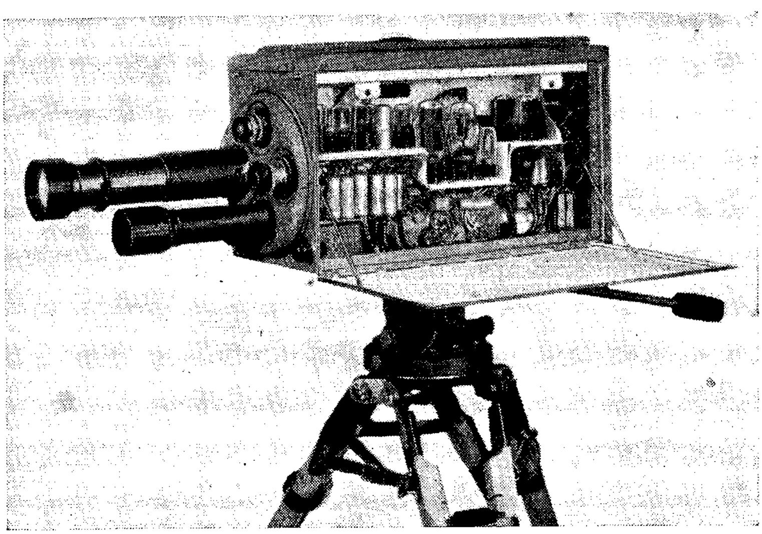


Image-orthicon tube used in the Marconi camera.



Interior of the Marconi mobile camera showing the lens turret.

The electron image builds up a "picture" on the target in terms of charge distribution. This is done by means of secondary emission from the target and the whites of the original scene correspond to areas of most positive charge (i.e., areas most deficient in electrons).

The target is scanned on the other side by a low-velocity electron beam. It is of such low velocity that an uncharged area of the target repels it sufficiently to return the beam towards its starting point! Charged areas, however, accept sufficient electrons to neutralize the charge and the returned beam is then deficient in electrons by the number accepted by the target. In this way the return beam is modulated.

The return beam is induced by a "persuader" electrode to enter a five-stage electron multiplier which produces an output current of 40 μA for an illumination of 0.3ft candle on the photo-cathode. Subsequent amplification is used and incorporated in the body of the camera so that the camera output is 0.5 V in 50 Ω. The scanning waveforms are generated in the camera, e.h.t. being derived from the line fly-back.

An electronic viewfinder is used, in the portable equipment, it is a separate unit which clips to the top of the camera. Like the camera, it contains its own time bases.

The diagonal of the picture on the photo-cathode is only 1.6in. As a result, the optical lenses do not need to be large, and it is possible to employ standard double cine-frame miniature camera lenses. Four lenses mounted in a turret head are used and focusing is carried out by moving the tube relative to the lens. Preset adjustments on the lens mountings can be provided, however, so that all four can be preset to need substantially the same setting of the operator's control.

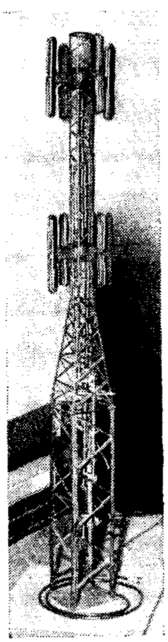
For mobile use, the associated camera units comprise a synchronizing generator in two units, a camera control and preview monitor unit, and a power-supply unit. In addition, a vision-switching and communication unit, which can handle the outputs of six cameras, is needed.

PHYSICAL SOCIETY'S EXHIBITION

Electronic Research and Measuring Equipment

The fourth post-war exhibition of the Physical Society, held in London from 5th-8th April, was not, as on previous occasions, divided into research and trade sections. We have, however, picked out items connected rather with research than routine production, and these are described in the opening section of this review of the exhibition.

A SCALE model of the proposed television aerial system for the Sutton Coldfield transmitter was shown by the B.B.C. The scale is 7.5 : 1, and tests of power gain, impedance and both horizontal and vertical radiation characteristics have been made at proportionally higher frequencies (450-500 Mc/s) to check the design. Compensated folded dipole elements have been adopted. These are fed in phase quadrature so that the mast is virtually in a neutral field. There is also little vertical radiation, with a consequent power gain in the horizontal direction. Phase rotation is opposite for the sound channel, and it is claimed that this helps in reducing intermodulation between sound and vision.



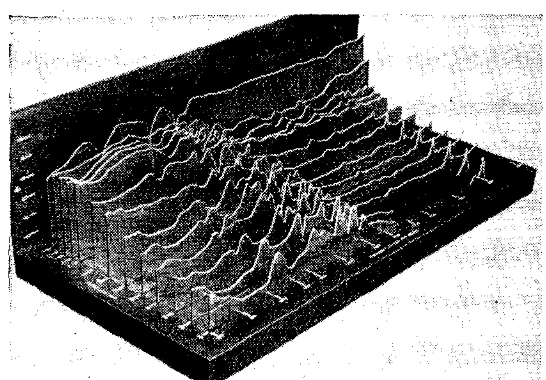
Working model, to a scale of 7.5:1, of the Sutton Coldfield television transmitting aerial (B.B.C. Research)

A wide range of waveguide components used in research on millimetre waves was shown by the Telecommunication Research Establishment. An optical bench and components for a Michelson interferometer working in the 8-9 mm range were shown, and also methods of measuring dielectric constant in which a frequency stability of better than 1 part in 10^6 had been achieved.

Specimens of quartz crystal resonator plates, grown by a synthetic hydrothermal process, were shown by the Research Laboratories of the G.E.C. The process depends on the higher solubility and lower density of silica glass, compared with crystalline quartz in aqueous solution, and is carried out in an autoclave at a temperature of 350-400 deg C and a pressure of the order of 1,000 atmospheres, starting with a sodium metasilicate solution with potassium bifluoride as a catalyst to promote regular deposition. Thin plates of natural quartz are used as "seed" crystals. Specimens of ethylene diamine tartrate grown crystals were also shown. This substance is a promising substitute for quartz, and cuts with zero temperature coefficient are possible.

Working demonstrations of germanium triodes, on the lines of the Bell Telephone Laboratories' "Transistor" (see October, 1948, issue, p. 358), were given by Standard Telephones and the Research Laboratory of the B.T.-H. The former showed an amplifier stage with a power gain of about 14 db, and the latter an oscillator working at a frequency of 1 Mc/s.

In the field of applied acoustics the B.B.C. gave a demonstration of portable equipment for the investigation of the transient response of studios. A lightweight 7½-W amplifier and tone generator, giving pulses variable from 0.001 to 20 sec, energizes a loudspeaker, and the rise and decay of sound is examined on an oscilloscope. Transient response measurements on loudspeakers were also shown, and a three-dimensional model served to indicate the complex second-order resonance effects which may be experienced.



Three - dimensional model of delayed transient response curves of a loudspeaker (B.B.C. Research)

Apparatus for measuring the overall frequency characteristic, reverberation time and pulsed echo patterns of studios was also shown by the B.T.-H. Research Laboratory.

An interesting adaptation of radio technique to the measurement of the salinity of water was shown by the Admiralty Experimental Establishments. It involves the measurement of the "Q" of an r.f. circuit containing the solution to be measured and eliminates the necessity for immersed electrodes.

Other research items on the borderline of radio which should be recorded were the demonstration of nuclear spin in the proton, involving the investigation of resonance effects at a frequency of 6 Mc/s in a steady magnetic field at right angles to the r.f. field (Ministry of Supply, S.R.D.E.); electronic calculators and simultaneous equation solvers (Elliott); an electronic simulator for solving electro-mechanical problems in servo-mechanism design (Sperry); a compact revolving-cylinder high-voltage generator working on the Van de Graaff principle (B.T.-H.), and a magnetic recorder for monitoring surge transients on power supply lines (British Electrical & Allied Industries Research Association).

Valves.—The Mullard EQ40 nonode is a multi-grid valve designed for use as a combined f.m. detector and limiter. It has seven grids, of which two are control grids and one a suppressor, the remainder being screens. Its characteristics are such that it does not pass anode current unless both control grids are simultaneously above a certain minimum potential. The frequency-modulated signal is fed to the two control grids, one of which is connected to the primary of the i.f. transformer and the other to the secondary. The f.m. signal is in this way converted to a phase-modulated one, and from this the valve produces anode-current pulses of a duration dependent on the phase modulation. In effect, the anode current is pulse-width modulated and so needs only integration to produce amplitude modulation. The output is claimed to be sufficient to drive an output valve directly.

This firm also had on view a complete range of sub-miniature valves with indirectly-heated cathodes rated for 6.3 V and for currents of 0.15 A and upwards. Known as the VX series, the valves are 1-cm in diameter and are provided with wire leads for soldered connections. Among them, the VX8029 has a mutual conductance of 3.5 mA/V and is rated for 100-V anode and screen supplies.

Ferranti showed a range of electrometer valves. Among them the BM6A tetrode is of interest. Its cathode needs 0.23 A at 4 V, and at 8 V and 6 V respectively for anode and screen it has a mutual conductance of 100 μA/V, the amplification factor being 2. The grid current at -3 V grid bias is between 6 and 300×10^{-15} A. Miniature high-voltage rectifiers and cold-cathode valves were also displayed.

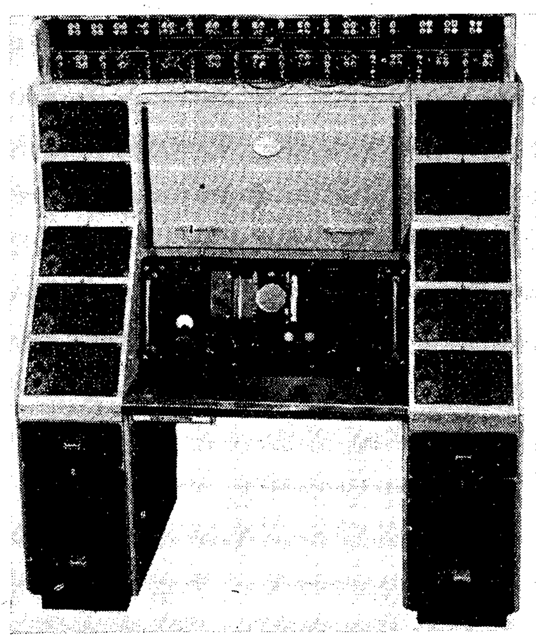
The General Electric Company had an unusual c.r. tube on view; designed for television monitoring, it is a flat-faced 9-in tube with electrostatic deflection. A c.r. switch tube having 40 contacts around the periphery of the screen was shown. Used with circular deflection the beam passes over each contact in turn. The contacts are coated with fluorescent material so that a visual indication of the beam position is obtained.

Cathode-Ray Apparatus.—As an example of modern circuit technique the Cintel Universal Valve Tester is outstanding. It is designed so that any valve can be plugged in and any of its characteristics displayed on the screen of a c.r. tube. Ten curves are shown simultaneously so that the usual family of curves can be seen and, by turning a knob, another parameter—say, the suppressor-grid voltage—can be varied and its effect on the family is immediately seen. It should be invaluable when investigating unusual valve characteristics.

The input is 3-phase a.c. from the mains and this is converted into a 12-phase supply, each of which generates a saw-tooth. Ten of these are used to provide the sweep voltages for the ten curves to be shown. Provision is made for peak anode currents from 5 mA to 1 A.

Protection devices are fitted to prevent overloading valves under test and there is a limiter to return the valve anode voltage to zero as soon as a curve reaches the edge of the screen. A calibration system is included so that the curves displayed can be provided with accurate ordinates.

The oscilloscope retains its pre-eminence for all but the depiction of the slowest phenomena. W. Nethercot showed a high-speed oscillograph operating at 10 kV and which, with an f/1.0 lens, has a writing speed of 20,000 km/sec. The sweep has a duration of 0.05 μsec.



Electronic simulator for solving electro-mechanical problems in servo mechanism design (Sperry Gyroscope Co.)

The miniature oscilloscope is more common than previously and Metropolitan-Vickers showed one including a push-pull saw-tooth generator covering 20 c/s-100 kc/s and having a Y-amplifier with an amplification of 60 times to 150 kc/s or 10 times to 3.5 Mc/s.

The Furzehill 1684D/2, although not a miniature, is interesting in having d.c. push-pull amplifiers and a response to 3 Mc/s with a sensitivity of 18 mV/cm. The time base is recurrent or single-sweep, and covers 2 c/s to 150 kc/s. With an external capacitor it can be lowered to 0.2 Mc/s.

Provision is made for recording in many of the laboratory-type instruments, such as Southern Instruments ME15, and cameras are available for many others. Avimo, for instance, showed a range of most elaborate recording cameras. One includes 15 1½-in c.r. tubes, so that 15 traces can be recorded simultaneously.

For very slow phenomena there is a revival of paper-tape recording methods and one example is to be found in the Dawe Instruments a.f. recorder. This is intended for recording response curves of amplifiers, loudspeakers, etc., and has a writing speed of 600 db/sec without overshoot.

Industrial Electronics.—There has been a significant increase in the number and variety of electronic scalers and counters, and examples were shown by Airmec, British Telecommunications Research, Cintel, Labgear, Lydiate Ash, Marconi Instruments, Mullard, Panax and Plessey. Developed originally for nuclear and cosmic-ray research, these instruments are now available as industrial batching counters, revolution indicators, etc. British Telecommunications Research showed a machine for batching in dozens and gross, as well as decimal units, while in the Cinema Television counter any group from 1 to 1,024 can be selected.

Mullard gave demonstrations of the use of their high-power ultrasonic generator for emulsifying difficult liquid mixtures, and also as an aid in soldering aluminium. The agitation breaks down the oxide film and enables the solder to wet the aluminium effectively.

Electromedical Apparatus.—A compact transportable electro-encephalograph (Type oA180A) was shown by Marconi Instruments. It is mounted on a desk trolley and is for operation from a.c. mains. There are six channels and the three-speed recorder carries six signal and two marker pens. The specification conforms to recommendations of the Technical Sub-committee of the E.E.G. Society.

Another neatly designed piece of apparatus was the Cossor electrocardiograph (Model 1314) weighing only 42 lb and contained in a light-alloy carrying case. It is completely mains driven and has a sensitivity of 1 cm/mV and a bandwidth of 0.1 to 100 c/s.

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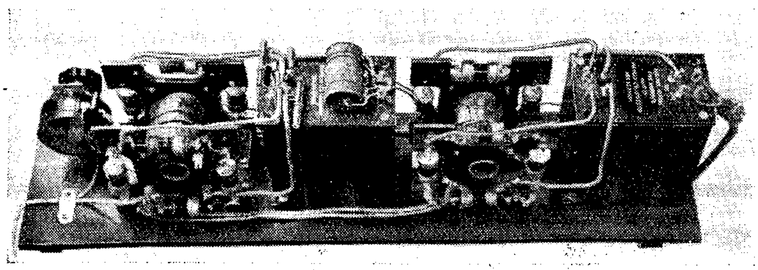
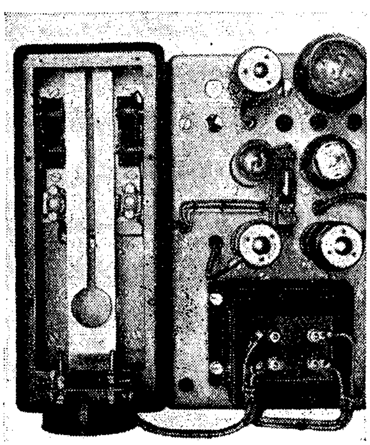
Ediswan were showing a diagnostic nerve and muscle stimulator with provision for surging at rates of 8 to 60 per minute.



Mullard audio-frequency magnetic amplifier

Magnetic Amplifiers.—For the amplification of small d.c. inputs from low-impedance sources, the magnetic amplifier shows many advantages over valve amplifiers, and it is now being widely used for temperature control in conjunction with thermocouples, for strain-gauge work and for servo-control mechanisms. Examples were shown by Electro Methods, Elliott Bros. and Everett Edgcumbe. The latter firm were showing a "d.c. current transformer" for use on power circuits in which the field associated with the d.c. was used to determine the working point on the iron characteristic of toroidal windings carrying a.c. and surrounding the conductor.

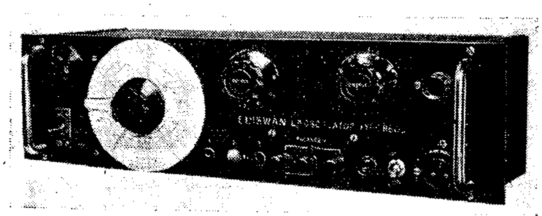
To show that magnetic amplifiers are not necessarily restricted to low- or zero-frequency currents, Mullard demonstrated a two-stage push-pull audio-frequency amplifier with a power gain of 40 db working directly from a gramophone pickup of ½-ohm impedance. The energizing current is at 100 kc/s from an 80-watt local oscillator, and the transductors are wound toroidally on "Ferroxcube" ring cores. At present the output is only 0.25 W and the time constant causes a falling characteristic at 6 db/octave above 200 c/s, but there is no fundamental reason why these deficiencies in the original experimental design should not be overcome. A non-microphonic audio amplifier of this nature should have many useful applications.



Muirhead 50-c/s standard frequency valve-maintained fork.

Signal Sources.—Among the more specialized forms of signal generators shown this year is an old one in a new guise. It is a valve maintained low frequency tuning fork, its revival having been brought about largely by the need for an alternative 50-c/s standard to the a.c. supply mains. It was shown by Muirhead as a general-purpose model type D418A. The fork has a very low temperature co-efficient and the frequency stability due to all causes is within ±0.005 per cent. The whole equipment is assembled on a standard 19-in panel for rack mounting. Although normally giving a 50-c/s output its range can be extended to 200 c/s if required.

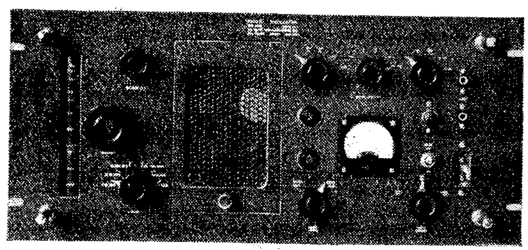
Another unusual form of signal source is a pulse generator which was shown by Dawe. It is the Type 412 and produces a rectangular pulse of variable amplitude and with choice of 1, 10 or 100-μS pulse widths. The repetition frequency is adjustable over the range 1 to 5,000 c/s, which, with external triggering can be extended to 10,000 c/s. The output is 75 V maximum at either negative or positive polarity.



Ediswan type R666 a.f. oscillator covering 1.4 to 5,500 c/s.

Sullivan had a beat-frequency oscillator, mains operated, in which the interaction between the two oscillators is so reduced that a 1-c/s output can be obtained. The range is 0-20 kc/s and the short-time stability is better than 5 c/s per day. An output of 4 to 5 watts is available. Included also by Sullivan was a variable-frequency RC oscillator for any number of frequencies from 40 c/s to 100 kc/s with plug-in RC units.

Another high-precision beat-frequency oscillator was seen on the Furzehill stand. Covering 20 to 20,000 c/s it, also, had a short-time stability of 5 c/s per day with low hum and harmonic content. A meter-type monitor is fitted and the output is variable up to 10 V. Labgear had a variable-frequency a.f. oscillator of the phase-shift variety covering 50 to 16,000 c/s, in three ranges.



Wayne Kerr video oscillator covering 7 kc/s to 7 Mc/s.

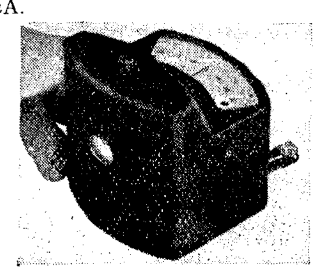
A precision frequency standard, Type 761, taking the form of a temperature controlled crystal oscillator, was seen among the Airmec exhibits. Starting with a 100-kc/s crystal, outputs are obtainable at the fundamental and in decade steps down to 100 c/s. Both sinusoidal and square-wave outputs are available at 100 c/s, 1 kc/s, 10 kc/s, 100 kc/s and also at 1 Mc/s. A 2½-in c.r. tube is included for comparing external frequencies, and there is also a beat-note detector and small loudspeaker as aural indicator of zero heat.

There were seen this year some oscillators covering frequencies in the video range. One was shown by Wayne Kerr covering 7 kc/s to 7 Mc/s with the output level within ±0.1 per cent and of 3 V maximum. Marconi Instruments had one also covering 20 c/s to 5 Mc/s. Another exhibit of the latter firm was a television sweep generator giving six pre-set output frequencies from 45 to 216 Mc/s. The r.f. oscillator can be frequency modulated and used for measurement and testing purposes in connection with television aerials, feeders and receivers.

Among the various a.f. oscillators was a very compact RC model made by Ediswan for bench or rack mounting. It covers 1.4 to 5,500 c/s in seven ranges.

Meters.—A noteworthy feature of the exhibits was the large number of highly sensitive galvonometers. George and Becker, for instance, showed an instrument measuring only $3\frac{1}{2}$-in square by 4-in high with a 7-cm scale and a 50-Ω coil. Used with a light beam, it has a sensitivity at 1 m of 40 mm/μA and a period of 1.2 sec. Cambridge Instruments had a number of mirror-types, including a.c. models and vibration galvonometers. Baldwin showed a model having a 1-deg deflection for 0.05 μA, while Tinsley had an instrument with a multiple-reflection optical system multiplying the sensitivity six times and giving a deflection at 1 m of 10,800 mm/μA.

The more robust instruments for everyday use ranged from micro-ammeters to heavy-current meters of all grades and included many multi-range test meters. Ferranti exhibited sealed types operating while immersed in hot water. Sangamo-Weston had meter-type movements fitted with contacts to operate as relays; the S124 closes a contact on 2μA.

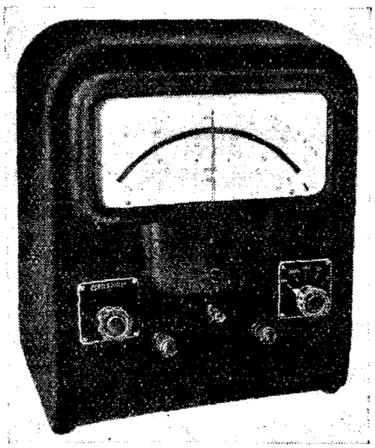


George & Becker Nivoc mirror and pointer galvonometer

Valve voltmeters have long been accepted as measuring instruments, and Avo exhibited an unusual pattern. Of more or less conventional form as regards the meter itself, it is designed for operation from a 6-V accumulator, the h.t. supply being derived from a built-in vibrator power unit.

The Dawe Instruments 613B requires no zero adjustment and covers 1 mV-300 V at 10 c/s-1.5 Mc/s. B.T.-H. exhibited a d.c. millivoltmeter having an error less than 0.2 per cent of full scale on all ranges. It covers 5 mV-1 V with an input resistance of more than 100 MΩ and includes a d.c. feed-back amplifier. This principle of using a stable d.c. amplifier is also adopted by W. Edwards in an electronic microammeter having ranges with full-scale deflections of 0.05-500 μA.

The valve voltmeter is also applied to resistance measurement and British Physical Laboratories have a megohmmeter RM175-LZ, which covers 0.1-10^6 MΩ in six ranges. Measurements can be made at up to 1 kV and provision is made for pre-charging elements of a capacitive nature. Another example is the Electronic Instruments 20 Million Megohmmeter which covers 0.3-20 $\times 10^6$ MΩ in seven decades.

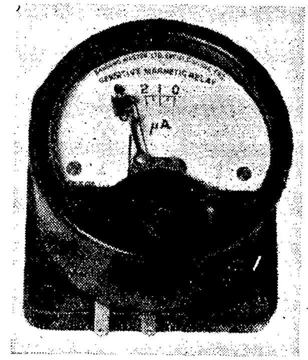


Pullin Series 85 industrial bench-type ohmmeter

Bridges.—A bridge providing the unusual facility for direct measurement of the inductive coupling coefficient *k* was shown by the British Physical Laboratories. It is made to a Post Office design and covers *k* quantities from 0.001 to 0.999. In addition it gives measurements of inductance from 1 μH to 1 H and of "Q" between 0.1 and 500. Measurements are carried out at a frequency of 23.88 kc/s.

A new r.f. bridge, Type 940073, which is in effect an admittance bridge, was seen on the Pye stand. It operates over the frequency range 100 kc/s to 20 Mc/s, and has facilities for measuring the proportions of inductive and capacitative reactance present. Capacitance from 0-600 pF, inductance 0.5 μH to 50 mH, and resistance 2 to 10 kΩ are covered.

There was a number of accessories for use with bridges either for the purpose of extending their scope or improving the accuracy. For example, Baldwin had a visual null indicator with the response range 40 c/s to 20 kc/s; it provides some amplification, giving null indications with an input as low as 0.05 mV. Another visual indicator



Sangamo - Weston Sensitol relay, Model S124

was the Sullivan aperiodic detector consisting of a robust microammeter and amplifier. It can be used on either high or low impedance circuits and covers the range 40 c/s to 20 kc/s.

Another useful accessory is a small amplifier for increasing the sensitivity of existing measuring equipment, especially of bridges, by amplifying the output before applying it to the null indicator. Dawe had one for including in their Universal Impedance Bridge, and Avo showed a versatile amplifier, which, when interposed between their Standard Signal Generator and Electronic Tester, provides facilities for measurement of capacitance, of "Q" and also for testing i.f. transformers. Measurements can, in many cases, be made with the component *in situ*. The amplifier is aperiodic over the

Avo battery-operated valve voltmeter

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range 30 c/s to 1 Mc/s and functions as a flatly tuned amplifier from 1 to 20 Mc/s in switched bands. Inductance from 0.5 μH to 50 μH and capacitance from 1 pF to 1,000 pF are covered by this Avo Electronic Test Unit.

Miscellaneous Measuring Equipment.—Apparatus for separating and measuring the component frequencies of a complex wave was shown by Wayne Kerr and also by Dawe. The former's Waveform Analyser operates on the superhet principle and gives voltage measurements of the individual frequencies from 50 to 20,000 c/s. Balanced detectors and crystal i.f. filters with an 8-c/s bandwidth are used, and the attenuation so obtained is about 30 db at 20 c/s from the mid-band intermediate frequency.

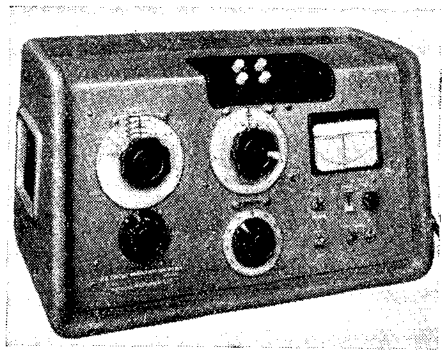
The model shown by Dawe also functions on the superhet principle and accepts a signal up to 16 kc/s. This is mixed with a local oscillator, passed to a balanced detector and

Dawe wave analyser for measuring component frequencies of a complex wave

then to a very selective 20-kc/s i.f. amplifier. Measurements of the amplitude of the individual component frequencies are recorded on a built-in meter.

Several improvements have been embodied in the Marconi Instruments Circuit Magnification Meter. This is basically a direct reading "Q" meter with certain refinements, one being the monitoring by a differential method of the r.f. voltage injected into, and that developed across, the circuit under test. By this means the amplitude of the built-in oscillator is made relatively unimportant. The range covered is 15 to 170 Mc/s.

Among the general-purpose wide-



Marconi Instruments circuit magnification meter

range portable test sets was a new Avometer of exceptional ruggedness and designed for rough handling. It has 18 ranges for alternating and direct voltage and current, also resistance. Taylor Instruments had a robust multi-range meter also with 17 ranges for a.c. and d.c.

Apparatus for determining the breakdown voltage of accessories, components or materials without having actually to destroy the part under test was shown by Airmec. It is an ionization voltage tester (type 732) and gives an audible indication when the applied voltage, which is variable from 200 V to 5 kV, reaches the threshhold of breakdown and ionization begins to occur.

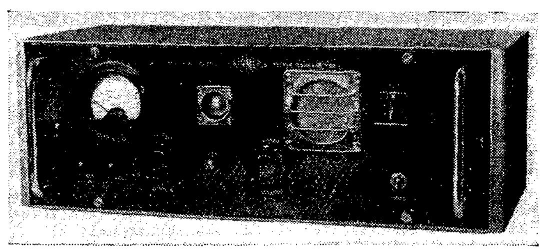
Components.—A new range of T.C.C. capacitors has a plastic (polystyrene) film dielectric. The case is of metal and the wire leads are brought out through bushes of PTFE (polytetrafluorethylene). These capacitors have exceptionally high insulation resistance of the order of 250,000 MΩ per μF, which is maintained at high temperatures, and a power factor of 0.0002. They are especially suitable for use in timing circuits and similar applications, and are made in a range from 100 pF to 5,000 pF.

The latest development in variable resistors was shown by Berco. This was a potentiometer sealed in a metal case usng rubber ceramic seals for the connections and a neoprene spindle seal. Cooling fins have been fitted, and the unit is rated at 6 watts. Because of the metal case, its size is less than that of a 4-watt unit in a conventional moulded case. Pre-set resistors of the slider type in values up to 4,500 ohms were seen on Electro-Methods' stand. The size is roughly $1\frac{3}{4} \times \frac{3}{4} \times \frac{1}{2}$in and the rating 3 watts. Sperry were demonstrating the advantages of a multi-contact wiper consisting of a number of staggered fine resistance wires. Its use results in greatly reduced noise, compared with a single contact on wire-wound potentiometers.

A switch of high current capacity and low contact resistance is a new product of Taylor Electrical Instruments. Primarily designed for use in multi-range instruments it is also sold separately. The shorting type will carry 10 A and is available in 12- or 18-way decks.

Materials.—Plessey's experience in powder metallurgy has enabled them to produce satisfactory substitutes for solid permanent magnets, laminations and high-frequency cores. The first, known as Caslox, is in use in pickups where a moulded magnet is a great help to designers. The lamination substitute is known as Caslam, and can be used at power frequencies, as in fluorescent-lighting chokes; at audio frequencies, and at high frequencies up to at least 100 kc/s, as in the line-output transformer for a television receiver. The core need only consist of two parts, such as an E and an I, so assembly is absurdly simple compared with normal laminations.

Johnson Matthey had a display of silver-clad copper, brass, phosphor-bronze and beryllium-copper for use as contacts in switches, etc. Rhodium-plated contacts, for variable resistors and the like, were also to be seen, as were the fine resistance wires with which variable resistors are wound.



Airmec ionization tester for non-destructive voltage breakdown measurements

ELECTRONIC CIRCUITRY

Selections from a Designer's Notebook

By J. McG. SOWERBY (Cinema Television Ltd.)

COINCIDENCE circuits have been widely used in nuclear research, but they have various applications of a more mundane nature, and that is the excuse for these brief notes.

Coincidence Circuits

As readers may know, a Geiger-Muller tube is commonly used for the detection of cosmic rays and the products of nuclear disintegrations. Such a tube can be made to provide a pulse each time a quantum or particle of sufficient energy is incident upon it, and the number of pulses obtained in a given time is a measure of the intensity of the incident radiation. To discover the *direction* from which radiation is coming, two or more G-M tubes are sometimes arranged in a suitable geometric array, and connected in a coincidence circuit. Fig. 1 shows how two tubes might be arranged, and it is obvious that any source of energy lying within the indicated solid angle will be "seen" by both of them, and that if the energy of the incident radiation is sufficient to penetrate both tubes, nearly simultaneous pulses will be obtained. Provided we can design a circuit to transmit a pulse (to some form of indicating device) whenever simultaneous pulses are obtained on two channels, we can record only the effects of a source lying within the solid angle.

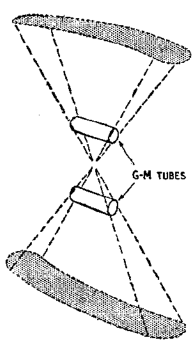


Fig. 1. Typical arrangement of Geiger - Muller tubes for coincidence measurements.

Coincidence circuits[1] to meet the requirements roughly outlined above are, of course, the small change of the nuclear physicist, and have been in use for many years. One type of coincidence circuit used by the writer recently is shown in Fig. 2, and the general design follows common practice.

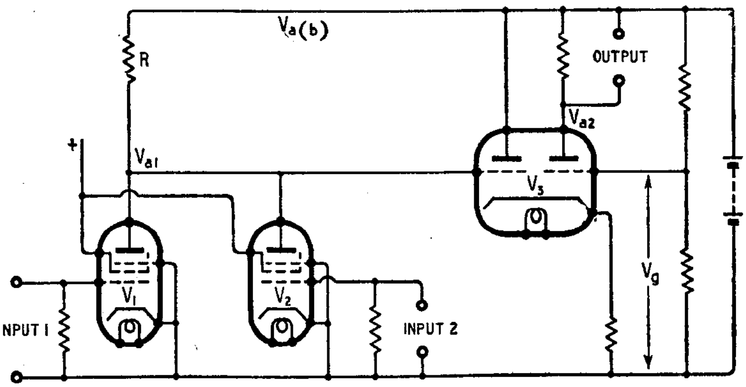


Fig. 2. A two-fold coincidence circuit.

The two inputs are applied to the two similar pentodes V_1 and V_2, which are normally at zero bias. It is assumed that the inputs, which are to be transmitted when in coincidence, are both negative-going. The essential feature of this class of circuit is that if either V_1 or V_2 is cut off, the remaining valve is "bottomed," so that the anode potential, V_{a1}, is relatively low.

This is achieved by making R sufficiently large, and with most pentodes V_{a1} will be less than about thirty volts. The choice of R is dictated by the characteristic curves of one of the pentodes, as shown in Fig. 3.

A load line LL_1 has been drawn on the curves of Fig. 3, from the h.t. supply potential through the knee of the zero-bias curve. This line represents the minimum value of R, and any value greater than this may be used; that corresponding to LL_2 probably represents a good compromise. A compromise is sometimes necessary, because the effect of the stray capacitance across R is to slow the action, and if R is too large this may become seriously disadvantageous. On the other hand if the minimum value of R (for a new valve) is chosen, it may well be rather too low for the same valve after several hundred hours of service, or for another sample of slightly different characteristics.

By now it will be obvious that if both V_1 and V_2 are conducting, V_{a1} will be very low in a good design—say 20 volts. If V_1 or V_2 is now cut off by an input signal, V_{a1} will rise to the value shown in Fig. 3—say 30 volts. But if V_1 and V_2 are *simultaneously* cut off V_{a1} will rise until it approaches the full h.t. potential. Consequently, for a single signal at either input V_{a1} rises by only a few volts, but for a dual signal it rises by anything up to two or three hundred volts. We may

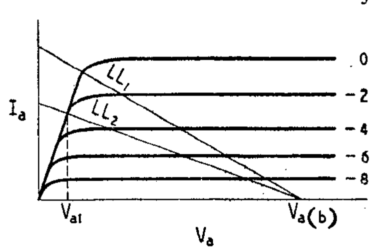


Fig. 3.

put as many pentodes in parallel as we please to extend the scheme to three- four- or many-fold coincidences. The double triode

[1] "Electrical Counting," by W. B. Lewis. O.U.P. 1942. p.61.

Electronic Circuitry—

V_3 is used merely as a clipper[2] to ensure that only the large signals at the pentode anodes shall be transmitted. To obtain this result it is only necessary to make V_g greater than V_{a1} of Fig. 3 by more than twice the grid base of V_3. In practice V_g is conveniently between 50 and 100 volts, and then the current in V_3 is controlled almost entirely by the value of the common cathode resistor.

Overall then, on the receipt of two simultaneous signals of sufficient amplitude to cut off V_1 and V_2, a positive signal of large and controllable amplitude is obtained at the output. Under any other conditions no output is obtained.

Coincidence circuits such as these have applications other than those mentioned above. For example one can arrange matters so that an output signal is obtained only on the simultaneous interruption of two crossing light beams falling on to two photocells. By this means an indication is provided only when an object appears in a pre-determined position. As the circuit given is direct-coupled, slow-moving objects are easily handled.

[2] *Wireless World.* J. McG. Sowerby. Aug. 1948. p. 283.

Simple Time Base

DETAILS of a simple time-base circuit of some interest have recently been published[3] in the U.S.A., and on enquiry the writer finds that the circuit has been used for some time past in this country as a pulse generator.

The circuit in question is shown in Fig. 4 and it will be noticed that it bears a family resemblance to the cathode-coupled multivibrator discussed recently. In this arrangement C is rapidly charged in a cyclic manner through R_k (about 1 kΩ), V_1, and the h.t. supply in series; it is cyclically discharged slowly through R (0.2 to 1 MΩ). Let us assume that the circuit is oscillating, and consider its behaviour through one complete cycle.

Suppose that the cathode of V_1 is so positive with respect to the grid that the valve is cut off; it follows that V_2 must be conducting. C now discharges slowly through R so that the cathode potential of V_1 "runs down" negatively. This position of the cycle represents the forward sweep of the time base. Eventually V_1 begins to conduct as its cathode potential approaches that of its grid. Because C represents

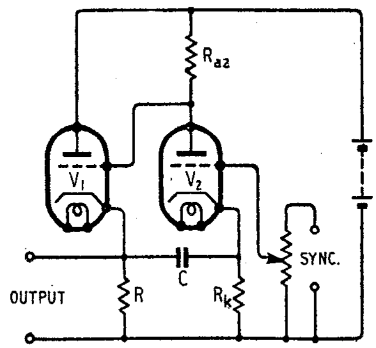


Fig. 4. Simple time-base circuit

an instantaneous short circuit, part of the current of V_1 flows through R_k, so that the cathode potential of V_2 moves positively. This reduces the current in V_2 so its anode potential rises, taking with it the grid of V_1. This action is cumulative so that V_2 is abruptly cut off and a large positive bias is applied to V_1, which consequently takes a large pulse of current and recharges C. As the replacement of charge in C approaches its conclusion, the current in V_1 falls, and V_2 begins to conduct again. This initiates another cumulative action in which the state of affairs is reversed, V_2 becomes fully conducting and V_1 is cut off by the fall in its grid potential. The discharge of C through R begins again, and the cycle is complete.

Obviously synchronisation can be effected by the injection of a signal into the grid of V_2 as shown in the diagram, and this is most effectively achieved by the negative-going part of any input waveform.

The output amplitude available from the circuit as it stands must be low (20 to 30 volts) for a reasonable approach to linearity, as the standing potential across R will be of the order of 100 volts and the sweep is essentially exponential. Alternatively R may be replaced by a pentode or cathode-follower discharge circuit consuming an approximately constant current. Again, R_k must not be too low or there will be insufficient loop gain for correct operation, nor too high or the flyback will be slow. R_k is probably best made variable as in the original design.

As a pulse generator, a low resistance, R_{a1}, is placed in the anode lead of V_1, and a negative pulse is obtained across it each time C is recharged. This is better than taking the positive pulse across R_{a2}, as for the same output amplitude it is easy to make R_{a1} smaller than R_{a2}, so that stray capacitances assume less importance.

It is of interest to note that one can make good use of both pulse and saw-tooth outputs simultaneously. The saw-tooth could well be amplified by a cathode-coupled pair of pentodes (for example) for normal c.r.t. X-deflection in an oscilloscope, and the pulse is of the correct sign for the application of flyback suppression at the c.r.t. grid. Pentodes or triodes can be used, but as a pulse generator the former are preferable. In either case the circuit has the disadvantage that the flyback pulse across R_k is coupled to the sync. terminals by the grid-cathode capacitance of V_2.

[3] *Rev. Sci. Inst.* P. G. Sulzer Vol. 20. No. 1. Jan. 1949, p. 78.

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WE are informed that the convention adopted for marking the polarity of germanium-crystal rectifiers has been changed to conform to that used for metal rectifiers. The plus terminal now corresponds to the cathode of an equivalent diode.

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The change of convention means that crystals are in existence marked in both ways and there is no external way of distinguishing them. It is, however, readily possible to do so with an ohmmeter. A test with an ohmmeter shows lower resistance when it is so connected that the positive of the battery is joined to the equivalent anode (i.e., the minus terminal on the new convention) than when the leads are reversed. Since the positive of the battery is joined through the circuit to the positive meter terminal, this means that under the new convention the lower resistance reading is obtained with the positive meter lead joined to the positive crystal terminal.

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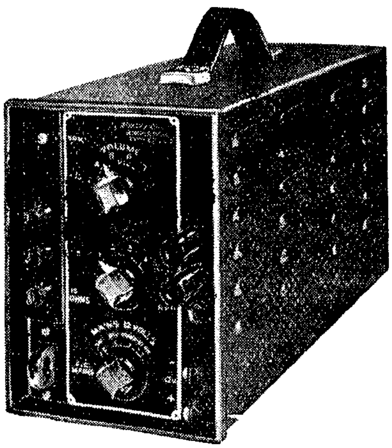

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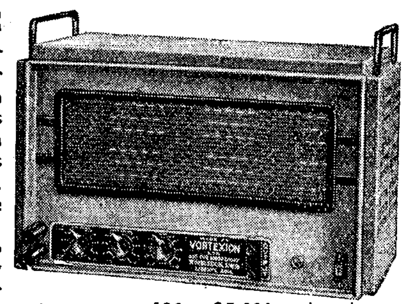

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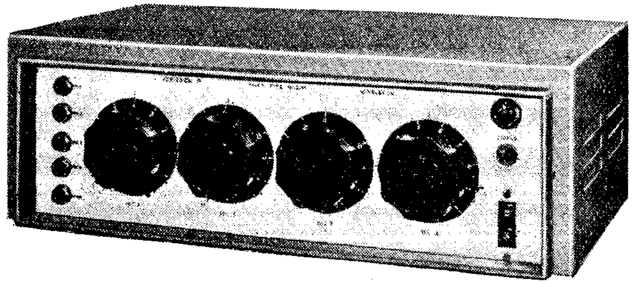

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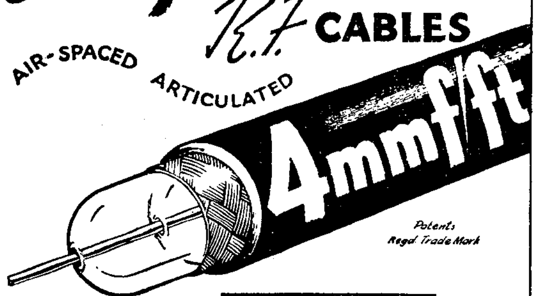

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WHEN NEGATIVE FEEDBACK ISN'T NEGATIVE

The Cause and Prevention of Oscillation and Distortion

By "CATHODE RAY"

MOST experimenters who have played about much with negative feedback must have had some results that were not according to plan. Unless, that is, they confined their researches to a single resistance-coupled stage. For it is well known that when the output of an amplifier is fed back over several stages there is a great risk of oscillation, usually at some frequency outside the working range of the amplifier. An audio amplifier, for example, would most probably oscillate at an inaudible frequency. Being inaudible, it might go unnoticed as oscillation, and the inexperienced experimenter would be at a loss to account for the disappointingly low output and quality of the amplification.

It may not be so generally realized that even if there is no oscillation there may be peaks in the frequency characteristic—quite contrary to what one usually intends!

This seamy side of negative feedback has been pretty fully dealt with in what highbrow writers refer to as "the literature," but mostly in a mathematical style that only the brighter students are likely to regard as other than forbidding. Actually it is not a really difficult subject, and requires only an elementary knowledge of vectors or of the "*j*" notation, or preferably both. Readers who have been able to follow my dissertations on these[1] should find it an excellent example to test their proficiency. Probably the real stumbling block in most cases is that the basic principles of negative feedback itself are a trifle hazy. So before we start considering how negative feedback can go wrong, let us make sure we see the thing itself quite clearly.

We start off with any ordinary amplifier, represented by the dotted box in Fig. 1. We know that when we apply a certain signal voltage to its input we get a certain signal voltage at the output. For convenience let us call these voltages v_i and v_0 respectively. Then v_0/v_i is the voltage amplification; let us denote it by A.

Negative feedback is next applied; in this example, by connecting part of the output voltage in series with the input. It is something done entirely outside the dotted box; and so, provided that the load impedance is kept the same, *it has no effect on what goes on inside the box.* The amplification there is still A, and an input signal of v_i volts still delivers an output of v_0 volts. In practice, of course, the amplifier and the feedback circuit are both made up into a single unit, represented by the outer box. The dotted line in Fig. 1 is an invisible boundary, and its input "terminals" may be merely unmarked points on the wiring.

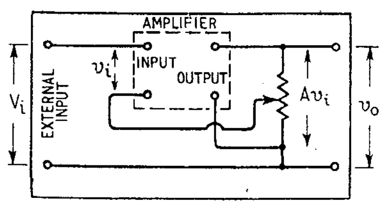

Fig. 1. In an amplifier using negative feedback, the amplifier proper (within the dotted lines) works quite normally, and the results of the feedback are accounted for by what is done outside it.

So the voltage which it is necessary to apply to the external input terminals (call it V_i) in order to get v_0 at the output is equal to v_i plus the fed-back voltage, which is a fraction of v_0. If we call this fraction B, then the fed-back voltage is Bv_0, which is equal to ABv_i.[2] So the total external input must be $v_i + ABv_i = v_i(1 + AB)$, and the gain of the whole outfit is $A/(1 + AB)$, as everybody knows.

What I want to emphasize is that in any inquiry into negative feedback it is fatal to use the external input, V_i, as the starting point. Always begin with v_i or v_0. Then the other (v_0 or v_i) follows from ordinary amplifier knowledge, without any feedback complications. And when once you have decided how much of v_0 to feed back, V_i is arrived at merely by adding this fed-back voltage to v_i.

Though I say "merely by adding," I don't mean that it is always just as simple as adding 2 and 3. If it were, then the complications we are about to consider would not arise. The source of all the trouble is what we have denoted by the deceptively simple letter A.[3] It is what is known as a vector quantity. That is to say, it doesn't merely denote the number of times the output voltage is greater than the input, but it must also specify the phase of the output relative to the input. One could say, for example, that A was 150, with 30° lag. Another way of presenting this information is by means of a vector in a diagram. Still another—and generally the most convenient—is by the "*j*" notation, which in this case would be $130 + j75$.[4]

[1] "*j*". Feb., 1948, p. 68.
"A.C. Bridges," April, 1948, p. 139.
"Phase," June, 1948, p. [illegible].

[2] If the whole of v_0 is fed back, B = 1.

[3] Strictly speaking the same complications apply to B too, but they are usually less important there, provided that one sticks to simple resistance feedback circuits and does not try any tricks with inductance or capacitance, to make the feedback depend on frequency.

[4] 130 and 75 are derived from 150 and 30° in the usual way by multiplying 150 by cos 30° and sin 30° respectively.

When Negative Feedback Isn't Negative—

The simplest case is the one with zero phase difference between output and input voltages, because then the fed-back voltage adds directly to v_i to give the input voltage, V_i. This can be shown in a simple vector diagram, Fig. 2.

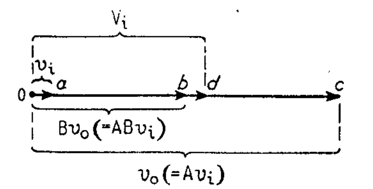

Fig. 2. Vector diagram applying to Fig. 1 when the output voltage is in phase with the input.

The vector *oa* is drawn to represent v_i, and *oc* is drawn A times as long, to represent v_0. Being in the same direction, it represents an output exactly in phase with the internal input (v_i), such as would be the case with an ideally simple cathode follower or 2-stage resistance-coupled amplifier. *ob* is then marked off along *oc* to represent the fed-back fraction, Bv_0; the external input, *od*, is *oa* + *ob*. (In a cathode follower, the whole of the output is fed back, so *ob* coincides with *oc*, and the input voltage is greater than the output by the amount v_i.)

Since in this case all the quantities are in phase, it is much easier to add them by simple arithmetic than to draw a vector diagram. The only purpose of Fig. 2 was to show the principle of the thing, for comparison with other cases. And of course the *j* method is quite unnecessary in this case, because *j* indicates the out-of-phase component, which is non-existent.

Next, consider a simple resistance-coupled audio amplifier, Fig. 3 (in which provision for grid bias and other details have been omitted for clearness). The only visible components whose behaviour depends on frequency are the coupling capacitors C_1 and C_3, and they are normally chosen so that their reactance at all working frequencies is negligible, in which case the output voltage is in phase with the input and Fig. 2 applies.

At very low frequencies, however, the reactance of C_1 is appreciable in comparison with R_2, and these two components form a sort of potential-divider. Only part of the output of V1 reaches the input of V2. What is more, the current through a capacitor leads the voltage across it by 90°; and, since the voltage across R_2 must be in phase with the current through R_2 and C_1, the voltages across R_2 and C_1 are 90° out of phase with one another. So when the frequency is low enough for the reactance of C_1 to be appreciable, not only does the amplification begin to drop, but also the phase of the output starts to lead the input.

As a matter of fact, it is the phase that is the first to start changing noticeably. This doesn't matter in a "straight" amplifier used for listening purposes only, because the ear cannot detect even the maximum phase shift. But if negative feedback is used it does matter. To see how, we must go into the matter more closely.

Assume that the signal input to V1 can be varied in frequency but is constant in amplitude, yielding a certain output (v_{a1}) at the anode. If the resistance R_2 is very large compared with R_1 and r_{1a} (the anode resistance of V1), then the additional impedance of C_1 at very low frequencies will not affect v_{a1} appreciably. So we shall assume that v_{a1} is constant too, and therefore can be represented by a vector line of fixed length (*oe* in Fig. 4).

The voltages across C_1 and R_2, which we can call v_{c1} and v_{g2} respectively, can also be represented by vectors, which will have to fulfil two conditions. The first is that they must of course always add up (vectorially) to equal v_{a1}. And since, as we have just seen, they differ in phase by 90°, their vectors, *fe* and *of* in Fig. 4, must always be at right angles to one another.

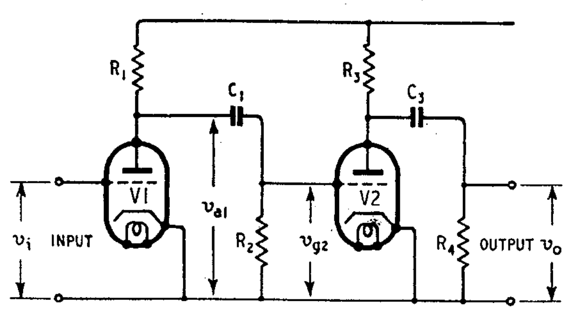

Fig. 3. The effects of the coupling capacitances, C_1 and C_3, and the stray capacitances (not shown) in this amplifier circuit are considered in detail.

You can make a working model of this vector diagram under these conditions by sticking pins in the points *o* and *e* and pushing the right-angled corner of a card between them, ignoring the part of the card below *oe*. One edge of the card will form the vector *of* and the other *fe*.

Except at low frequencies, the reactance of C_1 is so small compared with R_2 that the voltage across it (v_{c1}) is negligible; this condition is represented by holding the card so that its edge *of* coincides with *oe*, and *fe* disappears. But as the frequency is reduced, v_{c1} correspondingly increases, as can be shown by bringing *fe* into view, still keeping the card pressed against the pins.

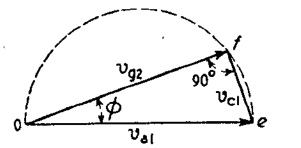

Fig. 4. Vector diagram applying to the C_1R_2 portion of Fig. 3 (and also to C_3R_4), showing how v_{g2} is related to v_{a1}

To do this you must turn the card anti-clockwise, so that its edge *of* indicates a phase-shift, ϕ. But at first its length is hardly affected. As v_{c1} grows, however, v_{g2} dwindles at an increasing rate; until finally, when v_{c1} becomes relatively large, v_{g2} rapidly disappears while the angle of phase difference approaches 90° quite slowly. The corner of the card (as is proved in geometry) traces out the circumference of a semicircle, dotted in Fig. 4.

To make the changes in v_{g2} and ϕ clearer in relation to frequency, they can be plotted on a frequency base as in Fig. 5. The frequency scale shown holds good for all combinations of C_1 (in μF) and R_2 (in MΩ), which when multiplied together are equal to 1 megohm-microfarad. For other combinations the shapes of the curves are the same but the frequency figures

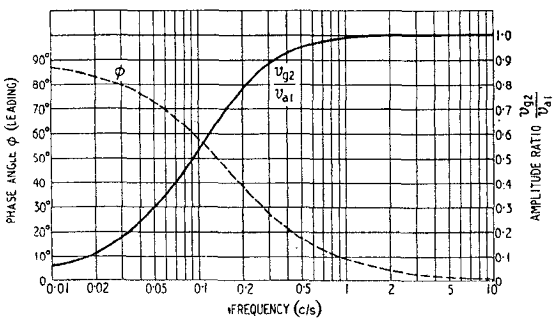

Fig. 5. Both ϕ and v_{g2} in Fig. 4 depend on frequency ; here they are plotted on a frequency base to bring out this relationship.

must be divided by the number of megohm-microfarads.

If there is another coupling, C_3R_4 in Fig. 3, it behaves similarly ; and the combined effect of the two is calculated by adding their individual phase shifts and multiplying amplitude ratios. So the total phase shift due to the two couplings approaches 180° lead at the lowest frequencies.

In practical amplifiers this very-low-frequency behaviour is generally a good deal more complicated. Capacitors used for smoothing the main power supply, decoupling individual valve feeds, and by-passing bias resistors, tend to become ineffective ; with the result that the impedances they are supposed to short-circuit cause various positive or negative feedbacks that may do almost anything to the frequency characteristic of the amplifier. The cunning designer can sometimes turn these effects to his advantage, as for example in bass-boost circuits ; or he may make the capacitances as large as can be afforded, to push the trouble below the lowest working frequency. But, as we shall see, that may not dispose of it.

So much in the meantime for the low frequencies; what about the high ?

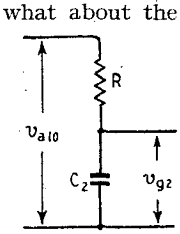

Fig. 6. The effect of stray capacitance in Fig. 3 is made clear with the help of this "equivalent circuit."

If an amplifier could be made strictly according to Fig. 3 there would be no limit; but unfortunately there are the "invisible components"—stray capacitances. One lot of these, including the input capacitance of V2 and the output capacitance of V1, comes across R_2, so we shall call it C_2. By using Thévenin's theorem[5] we can boil down the parts of the circuit concerned to Fig. 6, in which R is equal to R_{a1}, R_1 and R_2 in parallel, fed by a generator giving a constant voltage equal to v_{a1}, when C_2 is removed. This voltage has been marked v_{a10}.

Now the only difference between this problem and the one already solved for C_1R_2 is that the desired v_{g2} comes across the capacitance instead of the resistance ; so of course one wants this capacitive reactance to be as large as possible relative to R. The appropriate

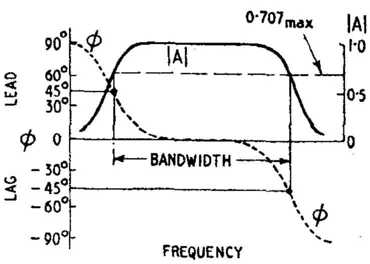

Fig. 7. Typical frequency characteristic of an amplifier of the Fig. 3 type, without feedback. The cut-off frequencies, which limit the effective bandwidth, are determined by the RC (time-constant) values of the circuit.

vector diagram is like Fig. 4 in reverse. The frequency curves have the same shape as those in Fig. 5 except that they too are reversed ; the amplitude ratio is practically 1 until some fairly high frequency, when it begins to fall off, and at the same time the phase shift begins to grow—but this time it is a lag. As with C_1R_2, at the frequency which

[5] "Thévenin's Theorem," March, 1949, p. 109

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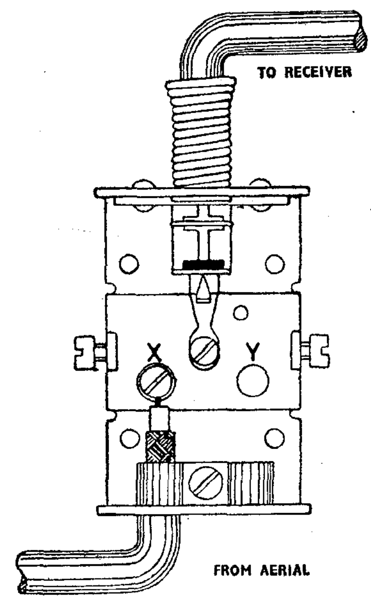

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When Negative Feedback Isn't Negative—

makes the reactance equal to the resistance, the phase shift is 45° and the amplitude ratio 0.707 (i.e. $1/\sqrt{2}$). Obviously the lower the combined valve and coupling resistance (R) the higher the frequency before the phase begins to shift and amplification falls off.

Putting all this together, then, the frequency characteristic of a resistance-coupled amplifier with one series-C coupling and one shunt-C stray capacitance, and leaving out of account any other influences such as power-supply impedance, is as shown in Fig. 7. The two curves together specify A; |A| being the symbol for its numerical magnitude alone. The two sloping ends are copied from Fig. 5 and its mirror image, and can be made to apply to any amplifier by placing them so that the points where |A| has dropped to 0.707 times maximum come where the appropriate resistances and capacitive reactances are equal. The amplifier frequency band is commonly regarded as extending from one of these frequencies to the other.

One of the objects of negative feedback is the widening of this frequency band. How it does this can be seen from Fig. 2. Let *oc* represent the wanted output. Then *oa* represents the input required to give it, with no feedback. Over the flat-top part of Fig. 7 the length of *oa* will be constant, corresponding to constant amplification. But at low or high frequencies, where the amplification falls, the length of *oa* has to be increased to keep the output constant. For example, at the marked frequencies, where |A| drops to 0.707 of its maximum, the input voltage must be increased by the factor $1/0.707 = 1.41$.

With feedback, a greater input, *oa* + *ob* say, is needed, so |A| is low even over the flat region. But *ob*, which can be made by far the larger part of *oa* + *ob*, is a constant proportion of *oc*, so a falling off in the internal gain of the amplifier, which affects *oa* only, has relatively little effect on the overall gain.

It must be remembered that the phase is affected too, so at the high frequency end the vector diagram becomes something like Fig. 8a. *ob* is of course unchanged, but *oc* has been made 1.41 times longer and given the corresponding phase lag of 45°. The required input, given by vectorially adding *ob* and *oc*, is *od*, which is much less than 1.41 times longer than *ob*, and also its angle of lag is much smaller than ϕ. The more negative feedback is used, the less is the phase shift and drop in amplification due to whatever *oc* does.

So the effects of negative feedback on the frequency characteristic, Fig. 7, are: (1) The flat top is lowered (from A to A/(1 + AB), as we saw at the beginning); (2) the fall-off at each end is less pronounced; (3) the phase shift at each end is less. But the benefits (2) and (3), can't last for ever as the frequency is raised. In the end the internal input, represented by the vector *oc*, must become large—even larger than *ob*—and

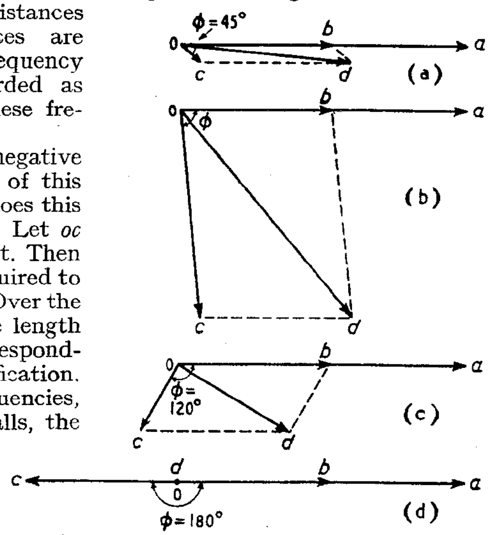

Fig. 8. Vector diagrams showing various conditions in amplifiers with feedback. The vectors represent the same voltages as in Fig. 2.

at the same time it swings round nearly at right angles to *ob*, Fig. 8(b). So finally the amplification and phase suffer almost as badly as they did (at some lower frequency) without feedback. Similarly, at the low-frequency end.

With an amplifier that includes within the feedback loop two RC circuits of the same tendency, the vector *oc* grows twice as fast, and its phase shift approaches 180°. This is where things begin to get interesting. Fig. 8(c), for example, shows the condition where each of two similar RC circuits is giving a lag of 60° and from Fig. 5 it can be ascertained that the relative amplification is 0.5 × 0.5, so *oc* must be four times as long as in Fig. 2. In spite of this, *od* is actually shorter than in Fig. 2, so the overall gain is higher. (This assumes, of course, that the amplifier can handle the internal input without being overloaded; if not, distortion may be violent). So instead of the overall amplification falling off, as it would with no negative feedback, it rises. This can't go on, though; as ϕ approaches 90° per RC circuit the internal amplification drops off so rapidly that *oc* becomes immense, and *od* likewise.

But now consider what may happen with three similar RC circuits. At the frequency where each introduces a lag of 60°, the total lag is 180°. And if *oa* in Fig. 2 was one-eighth of *ob*, it is now equal to it, so we get the result shown in Fig. 8(d), where *od* has shrunk to nothing. In other words, the amplifier will give output at this frequency without any input at all. In still other words, it is self-oscillating.

The same thing is liable to happen at a frequency lower than the working range, if there are three RC circuits of the series-C type.

At first it might seem a very unlikely coincidence that *oc* would be exactly equal to *ob* when ϕ was exactly 180°, and so the risk of oscillation would be small. But this is not so. Make *oc* in Fig. 8(d) any length you like, less than *ob*. Then the external input, *od*, must be in phase with *ob*. So if *od* is reduced, say to zero by shorting the external input terminals *oc* must increase correspondingly to preserve the balance. But that makes *oa* and consequently *od* increase, so *oc* must increase more. And so on, until the amplifier is overloaded and its amplification reduced to the point at which *ob* = *oc* and oscillation is maintained at a steady amplitude.

We have just found that if an

amplifier circuit embraced by a negative feedback loop contains three similar RC circuits there will be oscillation unless AB is less than 8. (By "similar" I mean having the same RC values and tending to cut frequencies at the same end.) With four such circuits the critical phase shift in each is only 45° and the ratio in each (see Fig. 5 again) is 0.707, so the oscillation value of AB is only $1/0.707^4 = 4$. But we can easily see from the diagrams that even if feedback is kept well below these fatal figures it may still be enough to raise peaks, as in Fig. 9; and these may cause things like gramophone scratch and motor rumbles to be brought into undesirable prominence.

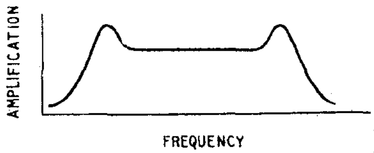

Fig. 9. Typical effect of applying negative feedback to an amplifier having more than one circuit cutting off at about the same frequency.

If a transformer is included in the system, the danger is greater, at least at the high-frequency end. As is explained in the books, at high frequencies a transformer usually becomes approximately equivalent to a series resonant circuit, composed of the leakage inductance and the stray capacitance. A feature of such a circuit is that the phase angle between the output (across the capacitance) and the input (across the whole) swings from a small lag below the resonant frequency, to 90° at resonance, and approaches 180° above resonance. So feedback across one transformer and one RC circuit can easily cause high-frequency oscillation.

It can be shown that at the low-frequency end the transformer is roughly equivalent to one RC circuit.

To make an extremely stable and level amplifier it is necessary to use a lot of feedback. Yet, paradoxically, in using it one seems certain to run a serious risk of causing oscillation and peakiness. The advice one usually gets about this is to see to it that the amplification has fallen well below the danger point at the frequencies where the phase shift is 180°. But, as we have seen in arriving at Fig. 5, the drop and the shift are bound together by the nature of the circuit.

One line of policy is to feed back over only one stage, including no transformer. But one stage with heavy feedback gives hardly any amplification. Two stages, again with no transformer, offer more useful possibilities, without risk of oscillation, but can develop peaks. Is it possible to include more than two phase-shifting circuits (counting one transformer as two circuits), to combine high amplification with a full measure of the benefits of negative feedback? If one adopts what would normally be a sound economical principle — to design each stage to cover the same frequency band— the answer would be No. But if you try combining the effects of circuits having *different* cut-off frequencies you will find that more feedback can be used before peaks appear. In particular, if three shunt-C circuits are included, as there usually will be in three stages, it is best to make one of them cover a narrower frequency band than the other two.

The truth of this can be shown in a more professional manner by the "*j*" method; and anybody who wants to go into the matter more deeply is advised to consult an article by C. F. Brockelsby in the March 1949 *Wireless Engineer*. He shows how one can design for "maximal flatness," which means "staggering" the cut-off frequencies of the circuits so that feedback can be used to extend the frequency coverage as far as possible, just short of allowing peaks to appear. The tendency to peak, controlled in this way, is useful for squaring the shoulders of the amplification/frequency curve, without going so far as the curve of Fig. 9.

If your amplifier gives trouble when you feed back over three stages, then try using a low anode coupling resistance for the middle stage and higher values for the two outer ones. Or, if a transformer is included, make sure that the other circuits cut off at a higher frequency. Of course, it is best to work out the design fully and check by tests; but the foregoing trial-and-error hints are better than nothing.

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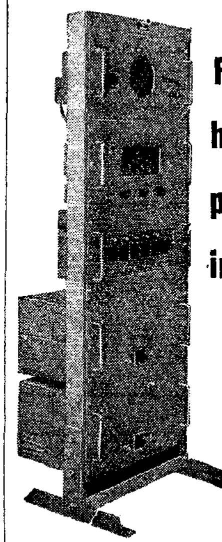

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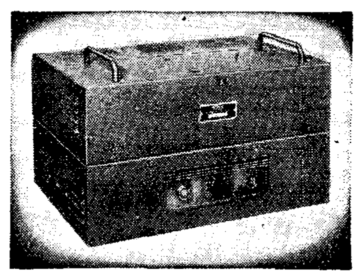

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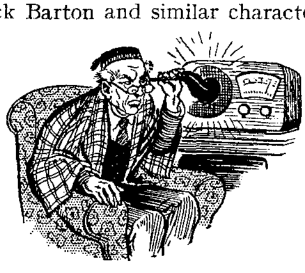
Radio Tompions Wanted

TIME switches were, of course, in use long before the days of radio but with the coming of broadcasting they entered a new field of usefulness. They enabled us to select our programmes for the day and leave the time switch to do the necessary switching on and off for us. The popularity of these programme clocks was not long lived because, I think, like Macbeth, they were in advance of their time. Lately, however, they have appeared again.

Now this, in my opinion, is all to the good but I, for one, should like to be able to select my programmes not only for a day but for a whole week ahead so that I need only look at the *Radio Times* once and then put it out for salvage. Unfortunately, however, so far as I know none of these programme clocks enables me to preselect my entertainment for even twenty-four hours ahead, let alone a week.

The sort of gadget which I and a lot of other listeners want is one which will enable us to flit from station to station picking up the various items we want regardless of wavelength. My requirements are not really extravagant for I only wish to be able to change at will from the "Home" to the "Light" wavelength and vice versa; I do not even demand the Third Programme. Those who do demand the Third Programme are usually content to remain on it and want no truck with Dick Barton and similar characters.



Third Programme Listener.

I am well aware that I could easily rig up what I want by means of two programme clocks and a little jugglery with the innards of a pre-set type of push-button set but I am getting old and well-stricken in years and want to be able to buy a ready-made outfit. Surely the ancient skill of the horologist, which is responsible for the complicated evolutions performed by the famous clocks at Strasbourg, Prague and Stockholm, to mention three among many, is capable of tackling this small job. Is there no one in this country upon whom the mantle of Thomas Tompion has fallen or must we send abroad for the necessary chronological craftsmen?

Personal Participation

I WAS very interested in "Diallist's" reference in the March issue to the different sound levels at which listeners prefer their programmes. As a family man I fully endorse his remarks regarding the noise level normally produced by youth, but, having silently suffered so often during Mrs. Free Grid's tea-time talks for tired tale-bearers, I consider the sound level maintained by the adult female far in excess of that of the younger generation.

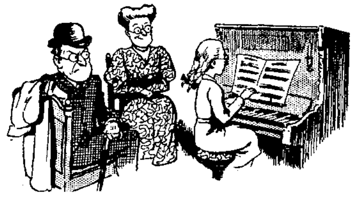
However, be that as it may. It was his reference to the likes and dislikes of listeners regarding the volume level of broadcast programmes which particularly interested me. It recalled to my mind a gadget demonstrated recently to a friend of mine by an enthusiastic experimenter in Gipsy Hill, South London. Its point of interest lies in that it gives a feeling of personal participation in the programme broadcast. It consists merely of a number of metal knobs—mounted on a suitable little "keyboard"—which are connected to the aerial terminal of the set. By touching the keys, and in this way using the body as an aerial, the volume is increased at will and, moreover, instantaneously. This is just the thing for those who think they can improve on the B.B.C. renditions. By incorporating a number of "keys" the designer has provided the humble listener with an opportunity to display his musical ability.

Itinerant Tuners

NO doubt a goodly number of the older generation of *W.W.* readers will recollect pre-broadcasting days, when the main source of music in the home was the ubiquitous piano. At the keyboard the pig-tailed daughter of the house used to sit and thump out a travesty of Rachmaninoff's Prelude in C Sharp Minor. Not even Mr. Punch's famous joke about the execution of such females could stem the flood of base and bass noises which she produced.

But it is an ill wind that blows nobody any good, and the itinerant piano-tuners reaped a goodly harvest. Often these people were men of foresight and initiative who realized that the average householder was not sufficiently musical to know when his piano needed tuning, and so did not call in the local piano-tuner. There were, therefore, good pickings to be had by the independent, itinerant tuners who went from door to door with their bag of tools.

Those days, however, have long since passed, and the pig-tailed, piano-thumping daughter of the house has grown into a respectable matron with daughters of her own who can get equally excruciating noises out of a wireless set by tuning it "on edge." Even push-button sets are far from perfect and are subject to frequency drift and consequently to the emission of weird noises, just as much as the manually operated type when tuned by our ham-handed Hetties. It is here, I think, that a very great opportunity opens out for energy and initiative on the part of men, or even women, who are prepared to take the place of the old itinerant piano-tuners and go from door to door in search of business. Equipped with the proper gear it should not take them long to retrim the errant tuning circuits of any type of set, and they ought to have no difficulty in working up a good connection and arranging to call every so often to readjust circuits.



Pre-broadcasting Days.

I should not like it to be thought that I am encouraging the unskilled to poach on the local dealers' preserves, but unless dealers themselves organize some sort of house-to-house tuning service of this nature they will find that somebody else will. It is not much use sitting down expecting the average set-owner to ask for his receiver to be re-trimmed, for often he doesn't know that it needs it. Itinerant tuners are the answer. They must, of course, do the job in the home, and there is no earthly reason why they should not if they bring the proper instruments with them.

LETTERS TO THE EDITOR

Pulse Code Modulation ✦ Clarity in Circuit Diagrams ✦ Improving Relay Circuits ✦ Improvised E.H.T. Supply ✦ High-gain Television Aerials

P.C.M.

THE advantage of pulse code modulation (your March issue) lies in the fact that noise other than quantizing noise can be practically eliminated even though the transmission medium is noisy, always provided that the presence or absence of each pulse can be detected. The limit to the amount of noise which can be present arises when the number of errors in detecting the presence or absence of these pulses is no longer negligible. This therefore determines the minimum power which is required for a particular system.

All systems, so far described (to my knowledge), make use of a binary scale, so that the "weight" of pulses in a seven-pulse code, as described by Thomas Roddam, are respectively 1, 2, 4, 8, 16, 32 and 64 units. Thus a random error in detecting the seventh pulse can produce 64 times more noise voltage in the output than a similar error in the first pulse. Thus, for a certain minimum noise output, the number of errors which can be tolerated is less for the heavily weighted pulses. This suggests that a larger portion of the transmitted energy should be devoted to these "heavy" pulses. This might be achieved by increasing the pulse amplitudes of the heavier pulses, or increasing their widths. The latter method would generally require a larger bandwidth for a given number of pulses.

The practical improvement which could be obtained by such a method would depend on the characteristics of the particular pulse reforming circuit at the threshold of failure.

It is likely that the decrease of errors with increase of power follows a high power logarithmic law near the threshold, in which case the improvement would not be as great as at first appears.

D. G. HOLLOWAY.

Taplow, Bucks.

The author of the original article writes:—

Certainly, false operation of the decoder by noise will be more disturbing if a 64-unit pulse is simulated than if a 1-unit pulse is simulated: neglecting the effect of the compressor-expander a noise pulse of 50 per cent modulation will be produced. We can prevent this by replacing the 64-unit pulse by two 32-unit pulses. We then have three chances out of eight of getting a 25 per cent noise pulse, instead of one in seven of a 50 per cent noise pulse and one in seven of a 25 per cent noise pulse. The bandwidth must be increased by 14 per cent. I suspect that the result of this rather involved horse-dealing is to leave the system exactly where it was before. Mr. Holloway talks of increasing the pulse amplitudes, but of course this really means, in most practical cases, reducing the amplitudes of the 1-unit (etc.) pulses: this, I think, would degrade the system.

The limits which can be reached are discussed in my article "Communication Theory."* PCM comes very near to the limit which can be attained. Allowing for the margins needed for path variability and other practical aspects I think it probable that PCM systems will always be operating so far from threshold that the noise statistics becomes invalid. As Eddington has pointed out, there is a finite possibility that the kettle will freeze when put on the gas: natural phenomena do not seem to follow statistical laws right down to the tail of the curves. In any event, quantizing noise will form the practical limit.

THOMAS RODDAM.

* See p. 162, this issue.—Ed.

Circuit Symbols

HAVING on many occasions found it necessary to redraw published circuit diagrams on conventional lines before I could fully understand them, I was interested to read the comments made by Mr. L. H. Bainbridge-Bell in your December, 1948, issue on the recently issued BS530, "Graphical Symbols for Telecommunications."

Part of one paragraph states, "Diagrams should be drawn so that the main sequence of cause to effect goes from left to right . . . When this is impracticable, the direction should be shown by an arrow." The reason is, of course, that we are used to thinking in terms of from left to right—most writing, graphical recording, and keys to group photographs, etc., being laid out in this convenient manner. Any departure from the

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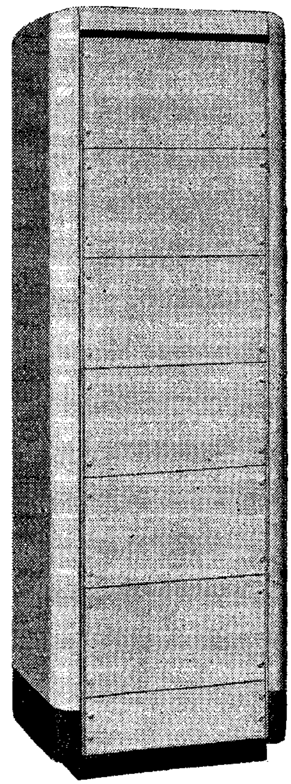

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Letters to the Editor—

convention calls for closer concentration on the part of the reader, and may lead to misunderstanding or mistakes.

Technical lecturers and writers too often arrange their demonstrations and diagrams in a manner which involves a minimum amount of preparatory work, regardless of the fact that this may cause others unnecessary mental strain. Then they wonder why the subject has failed to arouse interest or has not been thoroughly understood.

Something of this sort may, perhaps, be responsible for the bridge symbol being "officially deprecated" when illustrating crossing of conductors. Like Mr. Bainbridge-Bell, I trust that *Wireless World* will continue to set a good example by laying-out diagrams in the clearest possible form. Doubtless the draughtsmen will be pleased to do so now that they know their extra efforts are appreciated by at least two readers.

J. H. SAVAGE.
Welling, Kent.

Long-range Television

CAN anyone explain the absence from the British market of high-gain television beams suitable for the "fringe" areas? I have used 3- and 4-element arrays for many years now with tremendous success, and it is very disheartening to pick up every American magazine and see so many of these very excellent high-gain beams with folded dipoles for sale.

Can some of our manufacturers be persuaded to produce one, thus extending the normal 60-80 miles fringe to 100-150?

W. GEARING-SHERRATT.
Newport, Isle of Wight.

Long-delay Relay Circuit

AS co-patentee (with the Marconi Company) of this circuit (designed for the same purpose) I was interested in the note by J. McG. Sowerby on p. 51 of your February issue. One slight improvement on the circuit shown in Fig. 5 was included; a resistor was connected in series with the grid connection in order to limit the rapidity of resetting. By proper choice of this resistor the circuit can be made to tolerate short interruptions of supply of, say, one second or less without any delay when the supply is restored.

This circuit has been used extensively in the type TME2 frequency measuring equipment, made by Marconi Instruments, and also in some radar equipment during the war (G41 range calibrator). In the latter equipment the valve used in the delay circuit was also used as a radio-frequency cathode-follower.

The TME2 master oscillator has been re-designed recently to have a day-to-day frequency stability of the order of 1 in 10^8 or better and a drift of not more than about 3 in 10^8 per month. While this was being done the delayed switching arrangements were altered to an entirely electronic control in which the potential across the cathode resistor is used to key a switch-on signal to the gas-filled relay. This relay is normally cut off by a.c. bias.

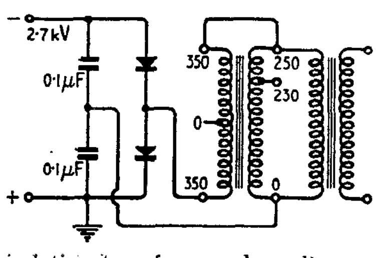
W. S. MORTLEY.
Marconi's W.T. Company,
Chelmsford, Essex.

OUR COVER

Two new 100-kW transmitters, one of which is shown on our cover, have been supplied by Standard Telephones and Cables for the B.B.C. Welsh Regional station at Washford, Som. Notable features of the transmitters, which replace 60-kW equipment, include the use of a single grounded-grid valve in the final r.f. amplifier, a cathode-follower driven Class B modulator, electrically operated tuning controls and performance of less than 1% distortion from 50 to 10,000 c/s up to 95% modulation with 38% overall mains conversion efficiency.

Auto-transformer E.H.T.

CONSTRUCTORS using the ex-Govt. VCR97 c.r. tube, as in the "surplus" television receiver (*Wireless World*, July, 1948) may be interested in a simple method for obtaining the 2.5 kV necessary for this tube. A mains transformer is used, and this may be of the usual type having taps at 230 and 250 volts on the primary winding and a 350-0-350 secondary. The method is to connect this as an auto-transformer by joining one end of the 350-0-350 winding to the primary winding. The mains voltage may then be applied in the usual way, or the correct voltage for any of the other taps may be fed from an



isolating transformer, depending on the requirements of the subsequent circuit. The end of the 350-0-350 winding which is connected should be chosen so that the other end of the winding has the best insulation to earth, and the end of the primary winding to which it is connected must be found by trial, so that the voltages are in phase.

The voltage obtained from this transformer is then $700+250=950$ volts r.m.s. This is fed to a voltage doubler, so that the final voltage is $2\times950\times1.41=2{,}680$v peak.

A circuit which has been in use for several months is shown, and here several other windings on the isolating transformer are made use of. However, this transformer is not necessary if a form of voltage doubler is used which has the same earth line. This causes the receiver to have the chassis joined to one side of the mains, as in "universal" television receivers.

J. CHARNOCK.
Purley, Surrey.

Copenhagen Comments

ARE P. Batham Jones' figures correct in his letter in the March issue? According to the list published in *Wireless World* (November, 1948), Holland and Belgium each have one exclusive channel (746 and 926 kc/s respectively) and one shared channel (1007 and 620 kc/s respectively)* Belgium may have been allocated lower frequencies because of greater attenuation in that country.

Much more glaring is the apparent absence of Spain and Germany from the Copenhagen Conference. Spain has been denied a frequency in the long-wave band, so incidentally has Italy; both are large countries. The virtual elimination of Germany from the ether seems to be the purpose of the Plan. Germany is given only three channels (all shared) over 300 m, none of which is in the long-wave band. I think the result of this policy will be the appropriation of a number of additional channels by German high-power transmitters at a later date, and perhaps the Deutschlandsender will join Luxembourg in a hunt for the quietest spot on the long waves.

To end on a domestic note. How am I to receive the Third Programme after 1950 when the transmitters on 203 m are moved to 194 m, as my sets do not tune lower than 200 m? The 514 m transmitter is no use to me.

R. CLEGHORN.
Beverley, E. Yorks.

* P. Batham Jones said "*substantially* clear channels." The channels are shared with lower-powered stations at a considerable distance from the countries in question.—Ed.

SHORT-WAVE CONDITIONS

March in Retrospect : Forecast for May

By T. W. BENNINGTON and L. J. PRECHNER (Engineering Division, B.B.C.)

DURING March, maximum usable frequencies for this latitude decreased slightly by day, but increased considerably at night. These are the normal seasonal variations, which should now continue towards midsummer. The month was somewhat more disturbed than February, ionosphere storms being observed on 4th, 14th-19th, 22nd-24th, 29th and 31st; the 17-19th and 22nd-23rd were particularly disturbed. Working frequencies for the month were generally rather high, although reception conditions varied from circuit to circuit. Thus, while South American transmissions were received quite well, on the Antipodes and North Atlantic circuits reception was generally poor. At times the maximum usable frequencies reached very high values, particularly in southerly directions. Thus Alexandra Palace sound and vision transmissions were received in Cape Town quite frequently, while, conversely, in England G6DH has reported a contact with South African amateurs on 50 Mc/s towards the end of the month.

Although the rate of incidence of Sporadic E was less than in February, it was still abnormally high, and very much greater than the corresponding values for the previous years.

Seven "Dellinger" fadeouts were recorded in March (9th, 21st, 25th, 26th, 28th, 29th and 31st), the fadeouts on 26th and 28th being particularly violent.

Sunspot activity in March was considerably less than in February. Only two large groups crossed the central meridian of the sun (on 15th and 19th), and they were very probably associated with severe reception disturbances which occurred around that period.

Owing to the generally unfavourable weather conditions, long-range tropospheric propagation was observed on relatively few occasions.

Forecast.—During May m.u.fs should continue to decrease by day and increase by night, but moderately high frequencies will remain of use for considerably longer periods than during April, because of the longer duration of daylight at this end of the circuits. There will be in May, therefore, less change in working frequencies as between night and day than in April.

Except on southerly transmission paths, daytime communication on very high frequencies (like the 28-Mc/s band) should be relatively infrequent. However, over many circuits frequencies as high as 15 Mc/s will remain usable till well after midnight, and during the night frequencies lower than 11 Mc/s should not really be necessary at any time.

The E and the F_1 layers will largely control transmission for distances up to about 1,800 miles, and for these distances daytime as well as night-time working frequencies should be higher than during April.

Sporadic E usually increases sharply in May in its rate of incidence. Transmission by way of Sporadic E layer may be frequently possible at irregular times for distances up to 1,400 miles on frequencies exceeding 21 Mc/s. Frequencies as high as 50 to 60 Mc/s may be occasionally reached for a very short time.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during May for four long-distance circuits running in different directions from this country. (All times GMT.) In addition, a figure in brackets indicates the highest frequency likely to be usable for about 25 per cent of the time during the month for communication by way of the regular layers:—

Montreal :	0000	11Mc/s	(16Mc/s)
	0300	9 ,,	(13 ,,)
	0700	11 ,,	(15 ,,)
	1000	15 ,,	(20 ,,)
	1400	17 ,,	(23 ,,)
	2200	15 ,,	(21 ,,)
Buenos Aires :	0000	15Mc/s	(20Mc/s)
	1000	17 ,,	(25 ,,)
	1100	21 ,,	(29 ,,)
	2100	17 ,,	(23 ,,)
	2300	15 ,,	(20 ,,)
Cape Town :	0000	17Mc/s	(23Mc/s)
	0100	15 ,,	(19 ,,)
	0600	17 ,,	(26 ,,)
	0700	21 ,,	(29 ,,)
	1200	26 ,,	(34 ,,)
	1700	21 ,,	(27 ,,)
	2000	17 ,,	(23 ,,)
Chungking :	0000	11Mc/s	(15Mc/s)
	0400	15 ,,	(20 ,,)
	0600	17 ,,	(24 ,,)
	1800	15 ,,	(19 ,,)
	2100	11 ,,	(15 ,,)

During May ionosphere storms are not usually prevalent, nor are the effects of those which do occur often disastrous to radio communication. At the time of writing it would appear that storms are more likely to occur during the periods 7th-12th, 15th-18th and 22nd-24th, than on the other days of the month.

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HIGH FIDELITY
H. F. TUNING UNIT
5-2,000 metres

A Wilson "White Rose" Product.

SPECIFICATION

This is a superheterodyne circuit with a high gain R.F. stage (S.P.61) on all wave bands, feeding into a mixer valve (6K8) with separate triode oscillator (6J5), in which frequency drift has been reduced to a minimum, followed by an I.F. amplifier (6K7), this stage is controlled, giving a selectivity of 3 K/cs to 14 K/cs from the variable selectivity transformer coupler to I.F. gain control, turning knob to right, increases I.F. gain and selectivity, bringing in foreign stations at full volume. Turning knob to left, results in a wide band, for local station reception only, with high fidelity. The R.F. sensitivity may be increased or decreased by the R.F. gain control, operating on the R.F. valve (S.P.61). The output from the I.F. stage, is fed into a cathode follower detector, a double triode (6SN7), capable of being modulated to 100 per cent. without distortion : the second section of the double triode being used for A.V.C. only. The output from the detector stage passes through an Audio filter stage, controlled by a potentiometer, to an output socket, with colour coded leads ready for connection, to an L.F. amplifier. The coil unit used, is our well known six wave band box type, fully screened and fitted with high grade ceramic trimmers and iron cored coils with adjustable cores, these cores are easily accessible for adjustment through holes in the side of the H.F. unit. The wavebands covered are 5-10, 10-30, 30-70, 70-200, medium waves 200-540, long wa ves 800-2,000 metres.
The chassis is made of 16 S.W.G. aluminium, with rigid corners.
The dial is calibrated in megacycles, kilocycles, and metres, on a black background, with white markings, and measures 9in. x 5¾in.
A tuning indicator is fitted (EM34), working on all wave-bands.
The overall measurements are :—10¾in. high, 10in. wide, x 8in. deep.

CONTROLS

1. Main Tuning.
2. R.F. gain (sensitivity).
3. I.F. gain, with selectivity.
4. Audio filter (attenuator).
5. A.V.C. on/off.
6. Wave change switch.

Dial lamps are fitted, and all control knobs are mounted symmetrically in front of unit.
Each unit is aerial tested on a standard broadcast aerial.
This unit is a combination of radio technique and English engineering craftsmanship of which we are justifiably proud.
This H.F. unit has been fitted to well known quality L.F. Amplifiers, including our own new "NATURAL" TONE 12 WATTS AMPLIFIER.

(Write for specification)

We honestly believe this to be the finest Tuning Heart on sale anywhere, for sensitivity, selectivity, and the High Fidelity obtained, on the medium wave band, and combination of both units is unbeatable.

The price of the 6 wave-band H.F. unit is **£16/19/11.**, plus £4/5/- P.T.
The price of the Amplifier is **£25.**

Cordially invited to come in and listen.

307, HIGH HOLBORN,
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RANDOM RADIATIONS

By "DIALLIST"

Circular Television Images

Two kind correspondents, writing from places in the United States a long way apart, send me slightly different versions of a delightful "explanation" of the launching of a televisor showing circular pictures on the American market. If it isn't true, it is anyhow *ben trovato*. A number of the designers and the research engineers of the company concerned, the story goes, served for long periods in the U.S. Navy during the war. There they grew so accustomed to viewing the world through portholes that any non-circular vista came to seem unreal! Hence their craving for round images and the latest thing in American television receivers. On second thoughts, though, it's not quite the latest thing, for the Hallicrafter people have gone one better. They have two receiver models, with seven-inch and ten-inch tubes respectively, which incorporate something quite new in the way of presentation. The normal image on the screen is rectangular with the 4/3 ratio used in the U.S. But suppose that there is something near the middle of the picture that you'd like to see on an enlarged scale. All you do is to press a button, whereupon the entire screen is occupied by a circular picture showing, considerably magnified, just the central area of the original image. No details of "how it works" are given; but I expect that the method employed is akin to that of the high-speed time bases, which could be brought into play at will in some wartime radar sets. Electrostatic c.r.ts. were used in these, the normal X-plate voltage being of the order of 1,000V. By turning a switch the X-plate voltage could be increased to 4,000V, with the result that the whole screen was occupied by only about one quarter of the original trace. I'm not suggesting that electrostatic tubes are necessarily employed in the Hallicrafter sets. I'm just indicating one way in which the magnification of part of the image could be accomplished. If pressing the button considerably increased both X and Y deflecting voltages, the greater part of the image would be off the tube altogether and the central part of it in much magnified form would occupy the whole of the screen. It's certainly good sales engineering and our folk might give it a thought.

A New Solder

If you've ever had a job of soldering to do on stainless steel, nickel or other "difficult" metals you've no doubt realized that, even with the correct special flux, a neat, firm joint takes a bit of making. Whilst talking to Richard Arbib on the Multicore stand at the R.C.M.F. show I referred to this and said what a pity it was that cored solders were useful only for the "easy" metals. For answer he picked up a piece of ¼-in clockspring, still wearing its familiar blue surface, clamped it into a small vice and then ran solder on to it like butter on to hot toast, using an ordinary electric iron and a piece of cored solder of a brand new kind. I was told that it dealt just as easily with stainless steel and other metals classed as difficult. If that is so it will be a heaven-sent boon to radio factories and amateur workshops alike.

Television in Europe

At the R.C.M.F. Exhibition I had talks with several visitors from Continental countries, all of whom were enthusiastic about the products displayed on the stands. Two of them, one from Denmark and one from France, told me that they had spent the previous evening watching the television programme. It was the first time that either had seen 405-line post-war television and they were very much impressed by the steadiness, the brilliance and the definition of the images. The Frenchman wondered whether his country had not been a little hasty in deciding to plump for 819 lines. The Dane said: "It will be about two years, I think, before we decide what standard to adopt. A great deal may have taken place in television development in that time. I do feel, though, that we should tackle the problem by realizing that modulation bandwidths must necessarily be limited and that to get a

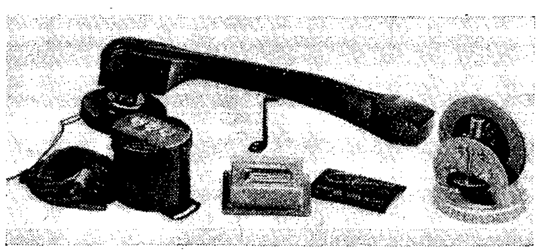
LIGHTWEIGHT PICKUP

The movement of this pickup is similar in design to that used in the original "Hypersensitive" and Type 12 models, and consists of a tubular high-permeability iron armature into which miniature needles are inserted as a push fit, and locked by wedge action under the frictional drag of the record while playing. The weight on the needle point is 1½oz.

The most significant change in the new Type 14 design is in the tone arm, which is a moulding of trapezoid section. This gives excellent torsional rigidity and should remove all possibility of resonances in the middle of the frequency spectrum.

It is stated that the response, with the customary bass correction, is substantially linear from 50 to 8,000 c/s. A bass compensating circuit is incorporated with the matching transformer, the output of which is 1½ V on an average record. Without the transformer the equivalent terminal voltage of the pickup is 6 mV.

The pickup is designed to use "Columbia Miniature 99" steel needles and a permanent sapphire stylus is also available. To meet the demand of those who think that fibre needles are necessary, the "Columbia Miniature Thorn" needles have been introduced together with a neat and efficient repointing machine.



New Marconiphone Type 14 pickup and accessories.

The price of the No. 14 pickup is £4 16s 8d including matching transformer, or without transformer (Type 14A), £3 11s 8d. Sapphire-pointed needles cost 17s 5d each, and the price of the Columbia thorn needle sharpener is 10s 9d, all prices including tax.

The pickup and its accessories are marketed by E.M.I. Sales and Service, Ltd., Hayes, Middlesex.

good service we must use the bandwidth available to the best advantage." That seems sound common sense to me.

Technical Terms

THE RAPID PROGRESS made nowadays in radio and kindred techniques makes the coining of new technical terms constantly necessary. Sometimes existing words are given new specialized meanings (some forty years ago a catswhisker meant nothing but a strand of pussy's moustache; a grid was a kitchen utensil and nothing but that; the only flip-flop known was part of the equipment of the White City amusement park); sometimes entirely new words are coined. They're not always very beautiful and too often they are hideous hybrids of Latin and Greek. But they have the advantage of possessing one meaning only and they thus serve very useful purposes. This country and the United States seem to be the most fruitful sources of new technical words, but they soon become international. In the Latin Countries they are generally taken over as they stand, except for minor adjustments in the spelling where necessary. German and some Scandinavian tongues translate them literally before adopting them: "Television," for example, becomes simple "Télévision" in French, but in German it is "Fernsehen" and in Norwegian "Fjernsyn."

Two interesting newcomers to the list are, "Miniaturization" and "Tropicalization," both of which seem to have secured international acceptance. I should, perhaps qualify the bit about technical terms having one and the same meaning everywhere. Generally speaking, that's true; but there's a regrettable tendency in some countries to depart from the special meanings accepted in the great majority of others.

"W.W." INDEX

THE index to the material published in Volume LIV of *Wireless World* (January to December, 1948) is now available from our Publisher, price 1s 1½d by post. A cloth binding case is also available which, complete with index, costs 4s 10d, including postage. Our Publisher is able to undertake the binding of readers' copies, the cost of which, including binding case, index and return postage on the bound volume, is 13s 3d.

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Rotary

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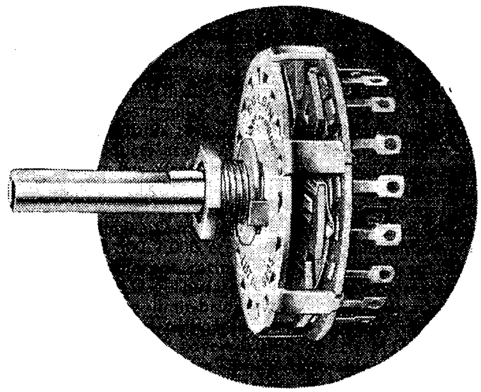
Make-before-break.		Break-before-make.
S.205		S.435
S.206		S.436
S.207		S.437
S.208		S.438
S.249		—



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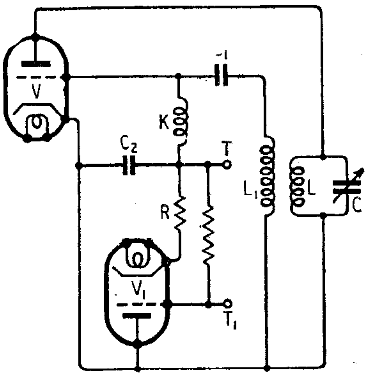
RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

Frequency Control Circuits

IT is known that the frequency of a back-coupled oscillator is influenced by the value of the grid current to a degree that is increased when the phase



Frequency modulation circuit.

displacement between the grid and anode voltages is made to differ materially from 180 deg.

The diagram shows a circuit designed to take advantage of this fact, say for frequency modulation. It consists of a main oscillation generator V, back-coupled through the coils L, L_1, and having a grid-leak circuit which includes a choke K in series with a resistance R and a control valve V_1, to which the signal voltages are applied across terminals T, T_1. The back-coupling condenser C_1 is made much larger than usual, so as to act as a phase-shifting device, producing substantially opposite phase shifts across the resonant circuit L, C. Any change in the grid current of the valve V, due to the alteration of the anode-cathode resistance of the valve V_1 as the signal voltages are applied to the terminals T, T_1, will create the phase-shifts described in the reaction circuits, and produce corresponding changes in the frequency of the oscillations being generated. A condenser C_2 short-circuits the control valve from the carrier frequencies, whilst the choke K prevents amplitude modulation.

Philips Lamps, Ltd. Convention date (Belgium), February 8th, 1945. *No.* 607798.

Short-wave Signalling

THE use of ultra-short waves for mobile communication systems is handicapped by the difficulty of giving reliable coverage over the whole service area, particularly in urban districts where screening and reflection create serious local variations in signal strength.

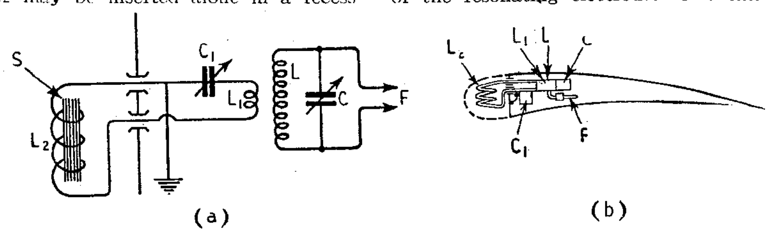
According to the invention, the problem is met by transmitting the same signal synchronously on two or more slightly different carrier frequencies from aerials which are suitably separated in space. Precautions are, of course, taken to ensure that the separate modulations are identical in amplitude and phase. In a given example, one transmitter radiates a carrier tuned to 80 Mc/s plus 17.5 kc/s, whilst a second aerial, located 100 feet away from the first, uses a carrier of 80 Mc/s minus 17.5 kc/s. It is stated that a standard single-tuned receiver will accept both signals without any appreciable interference or intermodulation between the different carriers or their sidebands.

J. R. Brinkley. Application date, May 2nd, 1945. *No.* 603584.

Aircraft and Aerial Systems

THE metal wings, and fuselage, of an aeroplane are used, either alone or in combination, as an aerial system which may be given directional properties. This avoids air drag, and prevents the risk of damage to which separately installed aerials are liable when flying at high speed.

A circuit diagram of the arrangement is shown in diagram (a) and a practical embodiment in diagram (b), the same references being used in both drawings. Feed lines F from a radio transmitter or receiver are coupled through a primary circuit LC to a secondary circuit comprising a variable condenser C_1 and coils L_1, L_2, the latter being wound around a laminated strip or core S. The strip may then be wound bodily over a section of the wing, so as to excite a magnetic field around it. Alternatively, as shown in (b) the coil L_2 may be inserted alone in a recess formed in the leading edge of the wing, and faired over with insulated material, the other coupling components being housed inside the wing. The fuselage may be similarly excited. The two wings may be arranged to operate either as a single or dipole aerial, and the combination suitably phased to produce various directional results.



Built-in aircraft aerial system.

W. A. Johnson. Application dates, January 28th, 1946, *and January 31st,* 1947. *No.* 607159.

Automatic Selectivity

THE i.f. stages of a superhet set are arranged to vary their selectivity automatically in accordance with changes in the strength of the incoming signals. This is done by changing the degree of coupling between the resonant circuits, and also the amount of regeneration applied to at least one of them, the two controlling factors being varied simultaneously in opposite directions.

The two amplifiers are coupled through primary and secondary circuits, which are linked to an accessory pair of circuits that are arranged to transfer energy in opposite directions, the whole forming a variable bandpass filter. The primary includes a regenerative valve which is subject to the normal source of a.v.c., whilst the secondary is associated with a damping valve which is also controlled by the prevailing level of signal strength. For maximum selectivity, the out-of-phase link circuits are only slightly unbalanced, the coupling between the primary and secondary is loose, and regeneration is high. As signal strength rises, the reaction is cut down, and the damping of the coupled circuits is increased.

E. P. Rudkin & Standard Telephones & Cables, Ltd. Application date, December 7th, 1945. *No.* 602785.

Generating Micro Waves

IT is comparatively easy to construct discharge tubes of the hollow-resonator type for generating frequencies of the order of 3,000 Mc/s, but it becomes progressively more difficult to meet the conditions required for efficient operation at much higher frequencies, where the dimensions of the resonator must be correspondingly reduced. For frequencies above 20,000 Mc/s, for instance, the size of the resonator is only 5×2 mm, so that the gap becomes too small to pass a large current, and its shunt impedance similarly falls off.

To avoid these difficulties, the inventor proposes to operate a rhumbatron tube of normal size at a selected harmonic of the fundamental frequency of the resonating electrode. For this purpose, separate electron streams are projected through different pairs of apertures, which are formed at the ends of trumpet-shaped projections, and are situated at, or near, voltage loops, corresponding to the selected harmonic of the resonator. The biasing potentials applied to the different electrodes must also be such as to produce the electron transmit times required for this harmonic mode of operation.

N. C. Barford. Application date, September 14th, 1945. *No.* 605469.

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