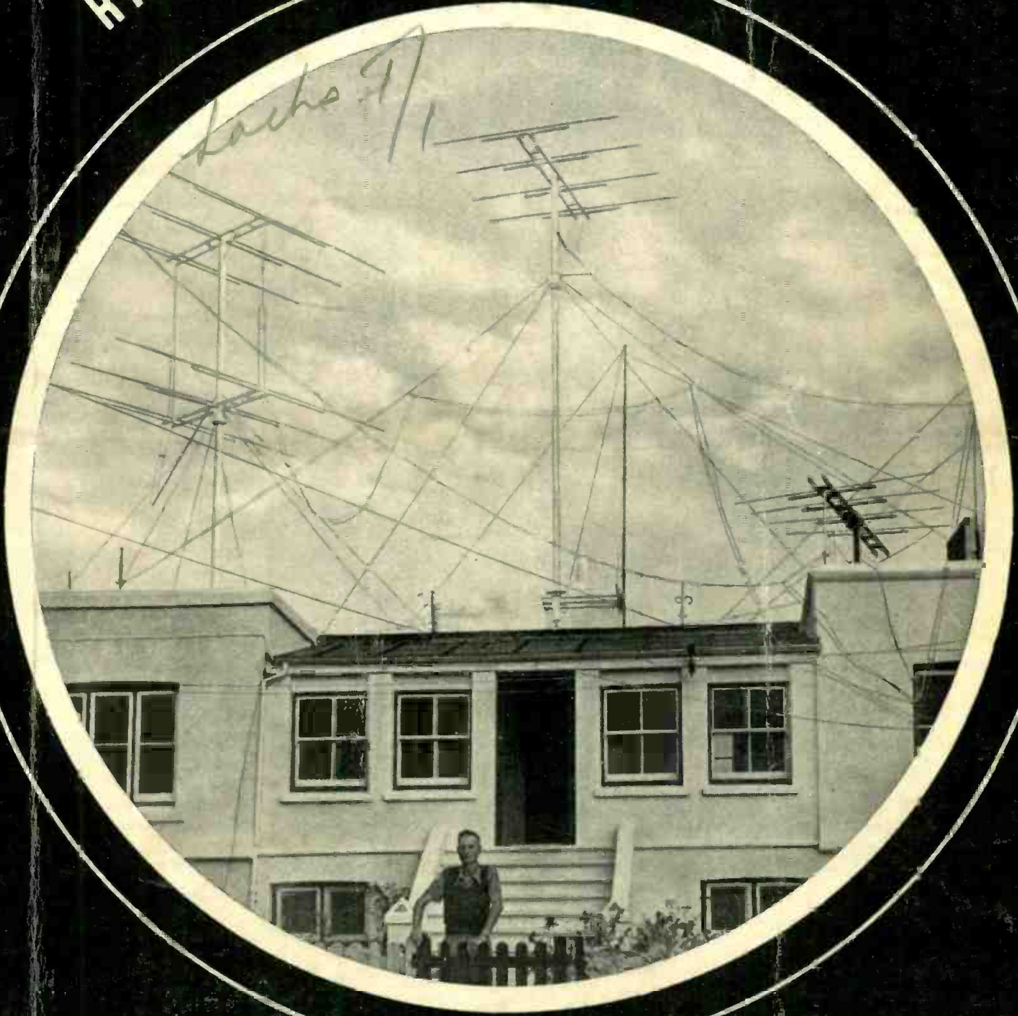
# Wireless World

RADIO AND ELECTRONICS



JAN. 1948

1/6

Vol. LIV. No. 1

IN THIS ISSUE: HIGH-QUALITY AMPLIFIER WITH TETRODES

# Pre-heat for Increased Production

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# Wireless World

RADIO AND ELECTRONICS

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## In this Issue

# VALVES AND THEIR APPLICATIONS

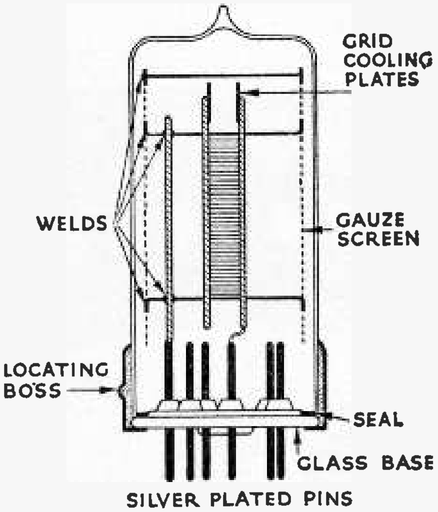
By M. G. SCROGGIE, B.Sc., M.I.E.E.

## No. 13: Mullard HIGH-SLOPE R.F. PENTODE EF42

IT is well known that for television and other wide-band v.h.f. purposes the important characteristic is high slope ($g_m$). . Since the load impedance is necessarily small, making the slope large is the only way of obtaining a useful stage gain.

One also expects a modern valve to be miniature and single-ended.

Achieving a design that fulfils these requirements is less than half the job. However attractive the specification, it is worth little if the valve is difficult to produce in large quantities, or is inconsistent. The EF42 is interesting on account of its performance, but perhaps more so because it is at the same time a good valve to manufacture. That is why I am leaving until next month its characteristics and applications (except to say the the slope is very nearly 10 mA/V) and dealing first with its construction.




To maintain the close spacing necessary for such a high slope, the electrode structure must be strong and rigid. Several features make for this in the EF42. Firstly, the structure is supported directly on the contact pins set in a ring around the pressed-glass " button " base. This base, the new British standard B8A, is like the EF50 type reduced in diameter. The fact that the structure it supports is much smaller in itself makes it more rigid. But the exceptional feature is a metal gauze cylinder enclosing the whole electrode system and welded to it at top and bottom — only 14 mm. apart. The result is so firm that there is no need for mica spiders or other supporting contacts with the glass bulb, and microphony from that cause is absent.

As a screen, the position of the cylinder inside the bulb excludes a certain type of noise associated with bulb charges.

Mechanical distortion or strain that would impair consistency is minimized in two ways: the cylinder enables the electrodes to be more uniformly heated during outgassing; and the bulb is " soldered " to the base by means of a low-temperature sealing cement.

Other details of the base are the silver plating of the pins to minimize contact resistance, the absence of spigot (optional in the B8A), and the side boss to ensure correct and visible location.

Summarizing: the EF50 technique has been developed several stages further in the EF42 with the following beneficial results:—

(1) Higher slope, with improved v.h.f. performance.

(2) Miniature size.

(3) In spite of (1) and (2), remarkable consistency of production.

(4) Exceptional rigidity and absence of microphony.

(5) Freedom from bulb charge noise.

Mullard

*This is the thirteenth of a series written by M. G. Scroggie, B.Sc., M.I.E.E., the well-known Consulting Radio Engineer. Reprints for schools and technical colleges may be obtained free of charge from the address below. Technical Data Sheets on the EF42 and other valves are also available.*

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# Post Office Control

EVERYTHING touching on the technical use of radio communication channels demands the closest and most detailed regulation by a national authority, working in its turn within a framework decided upon by international agreement. On that there can be no argument; a "free-for-all" radio spectrum would soon be free for nobody. There will be almost equal unanimity on the proposition that there should be unified control of all forms of radiation, whether for communication or not.

Here we come to one of the weaknesses of British wireless legislation, which for all practical purposes is confined to the Wireless Telegraphy Act of 1904. Those responsible for that archaic document can have had no conception of the ramifications of radio in later years, and it is not surprising that the Act, in spite of its supplement of 1925, fails to provide means for dealing with modern developments. In exercising the monopoly conferred on him by the Act, the Postmaster General has gradually extended his powers to cover such developments as radio telephony, picture transmission and television. But the P.M.G. has, in general, shown some diffidence—presumably on legal grounds—on assuming control of radio developments less directly concerned with communication. Except under powers conferred on him by wartime Orders, we believe he claims no legal right to control potential sources of radio interference such as, to take an extreme case, R.F. heaters. Until recently, there has been no indication that the latest non-communication radio device —radar—has been considered as coming within his purview. Indeed, reasoned arguments have been adduced in this journal that it does not do so.

But now we learn that legal opinion has been taken, and it has been decided that "radar apparatus is apparatus for wireless telegraphy within the meaning of the Wireless Telegraphy Acts." Accordingly, the P.M.G.'s licence is required before a radar installation can be set up and worked.

At first sight this assumption of control seems arbitrary and unjustified, being quite out of keeping with the wording and spirit of the 1904 Act. If the P.M.G. can sweep radar into his net at a stroke of the pen, cannot he do the same with any other application of radio technique that is even more remotely connected with the "transmission of messages or intelligence?" However, more mature consideration leads to the conclusion that, if only as a matter of expediency, the national radio authority must at least be responsible for the allocation of radar frequencies. We assume that responsibility for detailed administration of radar will remain with the Ministries of Transport and Civil Aviation, depending on the application.

Another aspect of Post Office control that has recently given us concern is what we have termed restrictive uses of the authority vested in the P.M.G. In the August, 1947, issue of *Wireless World* we suggested that neither the broadcast licence or any other form of licence available to the public conferred authority to listen to transmissions such as calibrated frequencies, time signals, weather reports, scientific test signals and the like when transmitted by stations in the "special service" category. Most of these transmissions are in fact directed either specifically or by implication to the public, and it seems highly restrictive that any barrier should be placed in the way of their reception.

## What is a Broadcasting Station?

The Post Office does not confirm or deny our interpretation of the regulations governing the issue of broadcast licences but now offers us a new definition of the term "broadcasting station" (on which the matter largely depends). This definition reads:—

> "a station in a radio communication service of transmissions radiated for direct reception by the general public on frequencies assigned to such services."

It would perhaps be unwise to attempt a re-examination of the problem in the light of this new definition, into which it is at least possible to read a more favourable interpretation. We will content ourselves by expressing the hope that the issue of the new definition betokens a desire on the part of the Post Office to allow the public to make use, without cumbersome formalities, of services that are clearly intended for the benefit of all. There the matter must rest until the findings of the international conferences are adopted.

# High-Quality Amplifier

## Advantages of Tetrodes in the Output Stage

By P. J. BAXANDALL, B.Sc. (Hons.)
(Telecommunications Research Establishment)

IN the April and May issues of *Wireless World* a design for an audio amplifier was described using triodes in all stages and giving an output of about 14 watts, the non-linearity distortion and hum being reduced to a very low level by the application of about 20 db of negative feedback over all four stages.

The present article describes an amplifier employing tetrodes in the output stage, with high-slope pentodes in the one previous stage. The output power is rather over 10 watts, and the non-linearity distortion and hum-level are of the same order as in the previously described amplifier. The input voltage for maximum output is approximately 4 volts R.M.S., and it is intended that the unit shall constitute the "main amplifier" section of an installation involving a radio receiver unit, gramophone and perhaps microphone preamplifiers. Most high-quality radio receiver units will provide an output of well over 4 volts, and this level is also a convenient level for feeding through a cable from a multi-channel preamplifier and mixing unit.

Considerable economies can be effected by avoiding the use of triodes, for the following reasons:—

(1) The power efficiency of output tetrodes or pentodes, in Class "A" operation, is greater than for triodes in Class "A," resulting in economies in power-supply components for a given output power.

(2) The input grid-swing required by output tetrodes or pentodes is less than with triodes for a given output power, so that even with high-slope pentodes in the pre-output stage, this grid-swing can be supplied with reasonably low non-linearity distortion.

(3) To reduce non-linearity distortion to a given level, it is, of course, necessary to apply considerably more negative feedback with tetrodes and pentodes than with triodes, but this has great advantages from the point of view of reducing hum.[1] It allows one to use less smoothing of the H.T. supply, and also the output transformer can be mounted closer to the mains transformer for a given amount of hum output due to magnetic coupling between these components.

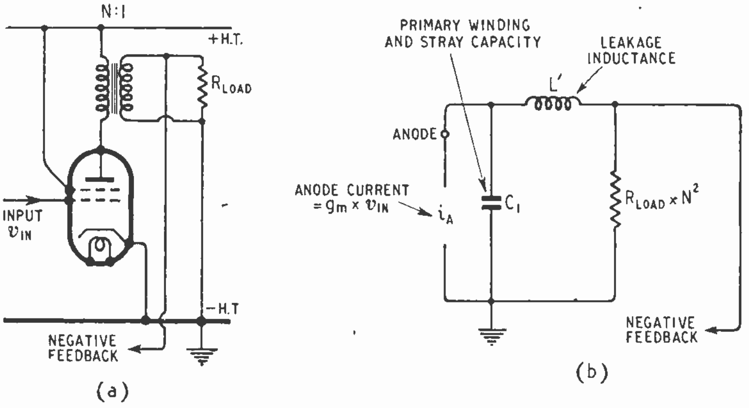



Fig. 1 (a). **Circuit with negative feedback from secondary of output transformer. (b). Approximate equivalent circuit at high frequencies.**

When contemplating building a 10-watt amplifier of very low distortion, the writer therefore decided to use tetrodes, with high-slope pentodes in the pre-output stage, *provided* that it proved possible to apply an adequate amount of feedback with complete stability. It was considered essential to include the output transformer inside the feedback chain to enable the feedback to reduce the non-linearity distortion caused by the transformer on large-amplitude low-frequency signals, and to permit the lowest possible hum level to be obtained.[1]

The solution to the problem of applying a large amount of feedback over the output transformer was found to lie in the use of a very ingenious design of transformer, developed by C. G. Mayo, of the B.B.C. Engineering Research Department, in conjunction with Messrs. Tanner and Ellis.[2] Unfortunately space does not permit a full account of the design principles of this type of transformer, which has a specially positioned third winding for negative feedback, but the basic idea may be explained as follows.

Fig. 1 (a) shows a circuit in which an output valve feeds a resistive load through an output transformer, negative feedback being taken from across the load. Fig. 1 (b) shows the approximate equivalent circuit applicable at high frequencies, the transformer having first been replaced by one of unity turns ratio with a suitably modified secondary load impedance. The effects of the main winding inductance, the core losses and the winding resistance may be neglected to a first approximation at high frequencies. Assuming a low secondary impedance, the secondary winding capacity may also be neglected.[3] With this arrangement, it will be

# Design

AMPLIFIER CHARACTERISTICS

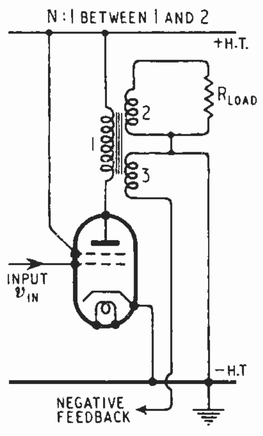
| | |
|---|---|
| Output power | 10 watts into 15-ohm load. |
| Input voltage | Approx. 4 volts R.M.S. for 10 watts output. |
| Working frequency range | 30 c/s to 16,000 c/s. |
| Low-frequency response | Less than 0.1 db down at 30 c/s. |
| High-frequency response | Less than 1 db down at 16,000 c/s on loudspeaker load. Less than 2 db down at 16,000 c/s on 15-ohm resistive load. |
| Non-linearity distortion | Less than 0.1 per cent. at 10 watts output. |
| Output impedance | Approx. 0.8 ohms in series with 100-$\mu$H. |
| Hum | 80 db below 10 watts output (100 db with extra care). |

seen that the feedback voltage will lag in phase relative to the anode current by an angle tending to 180 deg at very high frequencies, or more than 180 deg if there is appreciable capacity across the load. Since the rest of the amplifier circuit will inevitably produce slight phase lags at high frequencies, the circuit will be unstable if too much feedback is applied, for, as the frequency is raised, the total phase shift will then reach 180 deg before the loop-gain has fallen to unity.

It is, of course, possible to raise the frequency at which the transformer phase shifts become serious by sectionalizing the transformer windings and thereby reducing the leakage inductance. If provision is also made in the amplifier circuit to reduce the forward gain to a low value, with small phase shift, at a frequency lower than that at which the transformer shifts become serious, then a fairly large amount of feedback may be applied with stability, especially when the amplifier is always used to feed an inductive load such as a loudspeaker. This sectionalizing, however, increases the constructional difficulties of the output transformer, and in any case it will be found very difficult to obtain good stability with such a transformer if as much as 40 db of negative feedback is applied in an amplifier intended to operate with low distortion over a frequency range as wide as 30 c/s to 16,000 c/s.

The phase of the *anode* voltage in Fig. 1 (b) can never lag by more than 90 deg relative to the anode current, so that if by some means the feedback voltage could be taken from a point equivalent to the anode as far as phase shifts are concerned, though actually derived from a secondary winding, then stability would be readily obtainable and the advantages of including the transformer inside the feedback loop also secured.

This result is obtained if the feedback is derived from a separate secondary winding correctly positioned on the bobbin relative to the other windings. The approximate equivalent circuit at high frequencies for such a three-winding transformer,



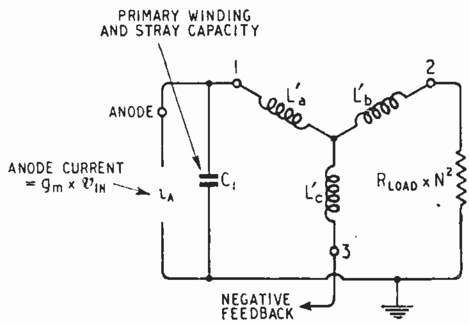




Fig. 2 (a). Circuit with feedback from third winding on output transformer. (b). Approximate equivalent circuit at high frequencies.

again with the transformer reduced to unity ratio, is shown in Fig. 2 (b), the actual circuit being as shown in Fig. 2 (a). The values of $L'_a$, $L'_b$ and $L'_c$, which are due to the leakage inductance between windings, depend on the relative positioning of the windings, and by adopting the right arrangement it is possible to make $L'_a$ very small relative to $L'_b$ and $L'_c$.

If $L'_a$ is zero, then, provided no appreciable current flows in $L'_c$, the feedback voltage will be always in phase with the anode voltage. The current in $L'_c$ can be made negligibly small by arranging that the impedance of the circuit connected to the feedback winding is very high compared with the impedance of this winding. In practice, with the winding arrangement used, $L'_a$ is slightly negative. This gives the feedback voltage a slight phase lead at high frequencies and does not adversely affect the stability.

The simplest winding arrangement which achieves the above result is a concentric one, with the primary winding between the main secondary winding and the feedback winding. Though an amplifier using such a simple design could be made quite stable, the frequency response, on load, would fall off more at high frequencies than is desirable, owing to the rather large leakage inductance between the primary and output windings. The feedback would not correct this, because the effect of the feedback is only to make the response from the amplifier input to the *feedback* winding nearly flat, whereas if $L'_b$ is too large there will be a considerable voltage drop across it at high frequencies, due to the load current.

In the transformer designed for this amplifier and described in the

**High-Quality Amplifier Design—**
Appendix, the primary is divided into two sections, with the output winding between them and the feedback winding in two sections, one at the inside of the bobbin and the other at the outside. This gives a response which is less than 2 db down at 16,000 c/s with a 15-ohm resistive load, and less than 1 db down when feeding a 15-ohm loudspeaker. These figures could be improved by further sectionalizing the windings, but this seems quite unnecessary for practical purposes.

In designing the output transformer from the point of view of its low-frequency performance, no account was taken of the low-level primary inductance value, since even if this were so low as to cause the response without feedback to be several db down at 50 c/s, the response would be made almost dead level down to a much lower frequency than this when a large amount of negative feedback was applied. The important factor was rather to ensure that the transformer was capable of delivering the full output voltage at the lowest working frequency, taken as 30 c/s, without requiring too large a peak magnetizing current for the output valves to supply without overloading. Space does not permit a full discussion of the factors governing the choice of core material, core size and winding turns, but by using a Radiometal core, working with a peak flux density of about 9,000 gauss for 10 watts output at 30 c/s, the output transformer made for this amplifier fulfils the requirements of high efficiency, low leakage inductance and reasonably small size and weight.

The complete circuit diagram is shown in Fig. 3. A "see-saw" phase-inverter is used—otherwise called "floating paraphase" or "anode - follower." [4, 5, 6] The coupling condensers between the two stages have been made exceptionally large, to ensure that as the operating frequency is lowered the output transformer produces a large attenuation before the coupling circuit phase-shift (a lead) becomes large. Additional attenuation of the low-frequency response is produced by having suitably small values for the screen bypass condensers for $V_1$ and $V_2$; as the frequency is lowered, the phase lead due to these condensers reaches a maximum, and then tends back to zero again at the very low frequencies, where the inter-stage coupling condensers give a large phase lead. By correct proportioning of these time constants, it has been possible to ensure that the total phase-shift is comfortably less than 180 deg at all frequencies for which the loop-gain is greater than unity, and hence good low-frequency stability is secured.

The condenser and resistor joined in series across the anode load of $V_1$ cause the forward gain of the amplifier to fall off as the frequency is raised, ultimately reaching a level of about −20 db relative to the response at medium frequencies, with a very small phase-shift. Stability is then assured at high frequencies, since the remaining 20 db or so of loop gain is lost largely in the output stage, with well under 180 deg total phase-shift. The loop gain

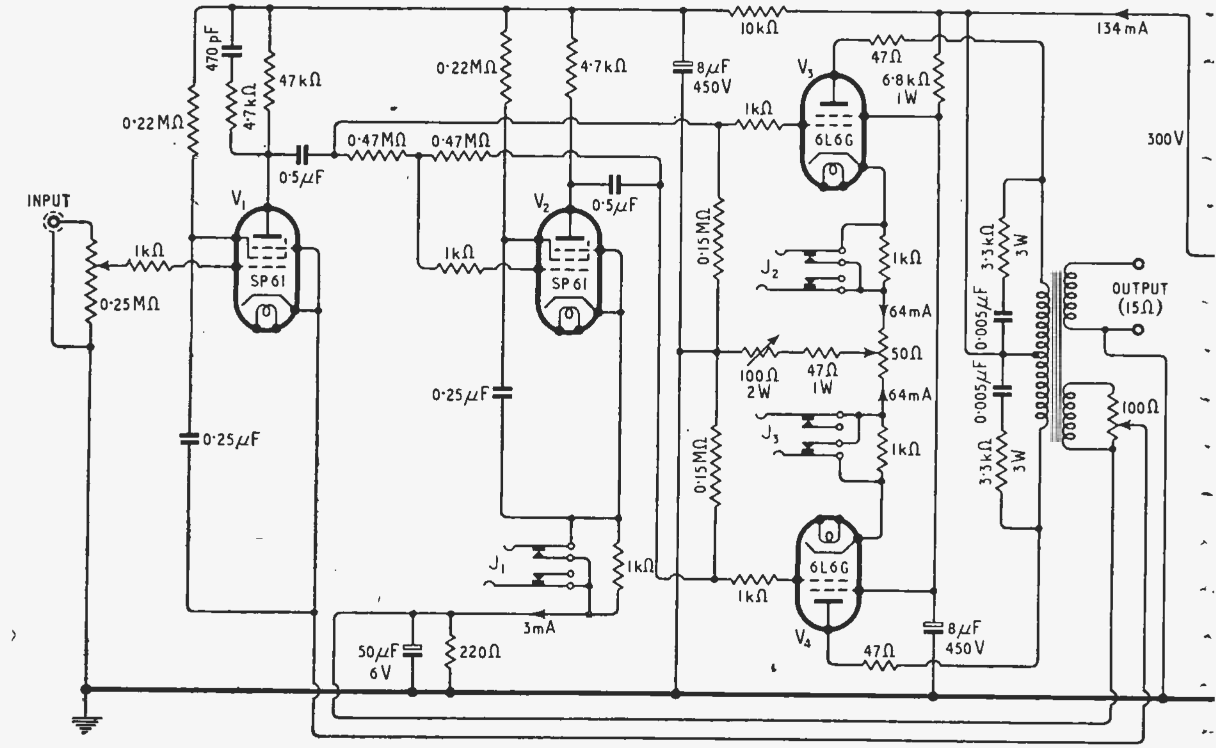
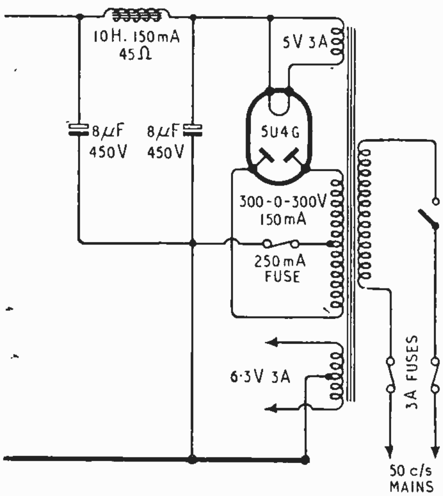


Fig. 3. Circuit diagram of amplifier. All resistors are ½-watt, ± 20 per cent unless otherwise marked.

drops to unity at a frequency of the order of 600 kc/s.

The condensers and resistors across the primary of the output transformer are mainly for the purpose of preventing the production of destructively high instantaneous voltages in the event of drastic overloading of the amplifier. If the amplifier is feeding a moving-coil loudspeaker or recorder cutting head, which have a high inductive impedance at high frequencies, these resistors and condensers ensure that the output valves work into a reasonably constant load at all frequencies. so that even if, due to an excessive input signal, one output valve is cut off and the other driven into grid current, the current turned into the transformer primary will not be able to develop too high a voltage across it If, for some special purpose, the amplifier is to be used for feeding a pure resistance load, these condensers and resistors should be disconnected, as their presence will prevent the amplifier from delivering its full output voltage




at high frequencies without overloading. The amplifier is perfectly stable without them, even on open circuit.

The output valves are operated at a higher anode current than is necessary for delivering full output power at medium frequencies, so that they can supply the necessary peak magnetizing current for the output transformer at very low frequencies without overloading. The amplifier will give an output of over 10 watts at 30 c/s without serious distortion.

In building the amplifier, the interstage coupling condensers (0.5 μF) should be mounted on an insulating support well clear of the chassis, to minimize stray capacities. Very good quality condensers should be used, as their leakage resistance should not fall below about 100 megohms. Dubilier "Nitrogol" condensers are very suitable.

Meter jacks have been included for checking the D.C. circuit conditions. Only three of these, representing the minimum requirements, have been shown in Fig. 3. $J_2$ and $J_3$ permit the output valve currents to be set up to 64 mA each, or a little less if desired. The currents are first equalized by means of the 50-ohm potentiometer, and then set to the correct absolute value by adjusting the 100-ohm potentiometer. They should be reset whenever it is found that they are different by more than 5 mA. A milliammeter (preferably 0-5 mA) inserted into $J_1$ serves as a very sensitive overload indicator, for as soon as any grid current flows in the output valves, this biases back the grid of $V_2$, thus reducing its cathode current. Quite a large reduction occurs before the amplifier output waveform becomes visibly distorted, so that if the programme level is kept down to such a value that only slight movements of the needle occur on loud passages, no serious audible distortion will result.

The potentiometer across the feedback winding of the output transformer may be omitted if desired, as the amplifier is perfectly stable with the maximum feedback of 36 db. Its presence, however, enables one to demonstrate easily the improvement in distortion and hum reduction obtained by applying the feedback, and may also be useful in cases where the gain of the amplifier is not quite high enough, since the gain may be increased by ten times by means of this control, still leaving about 20 db of feedback. The distortion will still be under 1 per cent at 10 watts output, which is tolerable for many purposes, such as P.A.

The non-linearity distortion produced is mostly 3rd harmonic, and Fig. 4 shows the variation of 3rd harmonic distortion with output power, using the maximum amount of feedback—about 36 db.

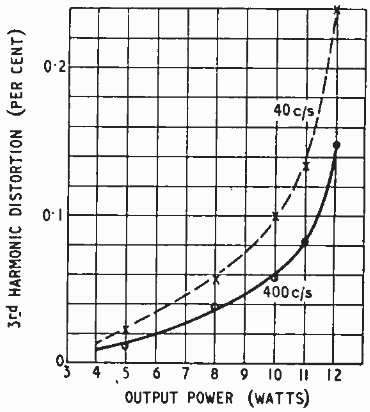



Fig. 4. Variation of third harmonic with output power. Feedback at maximum (36 db).

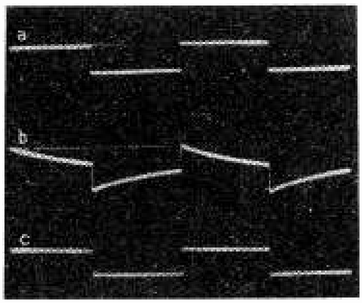
These measurements were made with a 15-ohm resistive load, as it was found that if a loudspeaker load was used, a several times increase in the distortion of the output voltage occurred, due to non-linearity distortion in the current drawn by the loudspeaker; this was, of course, a fault of the loudspeaker and not of the amplifier, and emphasizes the fact that a normal present-day loudspeaker gives much more non-linearity distortion than an amplifier such as this. It would seem desirable to devote much attention to improving loudspeakers from the non-linearity distortion point of view.

The hum-level, with full feedback, is about 80 db below maximum output. This is just audible in a quiet room at about 1ft from the loudspeaker, and is therefore quite negligible for normal purposes. It can be reduced to 100 db below maximum output (a) by replacing the 10-kΩ resistor feeding the H.T. supply to the first stage by two 4.7-kΩ resistors in series, with an additional 8-μF condenser to earth from their junction, and (b) by connecting a 100-ohm "hum-dinger" across the heater winding, with its slider. taken to about 10 volts D.C. positive with respect to earth. Good screening and layout of the input circuit to $V_1$ is also essential, and a valve specimen should be chosen

**High-Quality Amplifier Design—**

having low hum characteristics.[7] The output transformer should be mounted at right angles to the mains transformer and smoothing choke, but there is no need for wide spacing between these components.

A quick method of investigating the performance of an amplifier from the point of view of frequency and transient response, is to observe the output voltage waveform with a square input voltage waveform. The accompanying oscillograms show very convincingly the improvement in performance due to the application of a large amount of negative-feedback. (a) shows the 50-c/s square-wave input, (b) shows the amplifier output waveform, with a 15-ohm resistance load and no




**Square-wave test signal (a), and output into 15 ohm load, (b) without, and (c) with negative feedback.**

feedback, and (c) shows the output waveform with 36 db of feedback. The sloping shape of waveform (b) indicates an imperfect low-frequency response—actually nearly 3 db down at 30-c/s as measured by normal sine-wave methods. The clearly visible lines at the changeover positions indicate that the high-frequency response is also not ideal. The output waveform with 36 db of feedback is, however, almost identical to the input waveform, and the fact that there is no overswing at the changeover positions, which has been checked with a faster time-base, shows that the high-frequency stability is also excellent.

A further verification of the stability of the amplifier was obtained by shunting the output terminals with a capacitance, which was continuously varied up to a value of several microfarads. No trace of self-oscillation could be detected with any value of capacitance. With an amplifier having negative feedback from the main secondary winding, shunting this winding with capacity would increase the phase-shifts at high frequencies, and produce oscillation if too much feedback was in use.

The characteristics of the amplifier described are summarized in the table at the head of this article.

## APPENDIX

### OUTPUT TRANSFORMER

**Core**

1½in. stack of Type 404A Radiometal laminations, 0.015in. thick. (Telegraph Construction and Maintenance Co.)

T's and U's inserted in bobbin in groups of 8, in alternate directions. (To reduce tendency to saturate near joints.)

**Bobbin**

To suit core, with 1/16in. central division, and slotted to take interconnections.

**Windings (see diagram)**

Section (1). 24 S.W.G. enam. 10 turns each side of division, uniformly spaced out across bobbin. 20 turns total.

Section (2). 32 S.W.G. enam. 800 turns total, layer-wound with 0.001in. transformer paper between layers. 12 layers, approx. 70 turns per layer. The last layer should be spaced out uniformly to occupy full width of one side of bobbin.

Section (3). As 2, but wound in reverse direction.

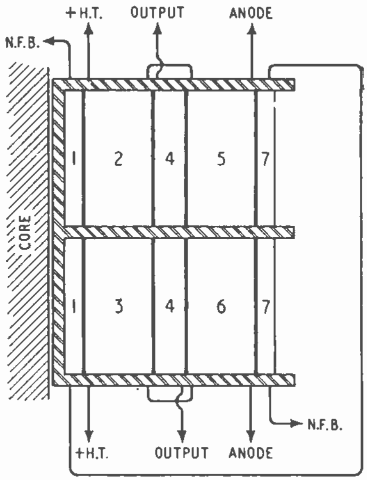
Section (4). Three layers of 20 S.W.G. enam., paper interleaved, total 128 turns for both sides of bobbin. Multiply turns by $\sqrt{\frac{Z}{15}}$ for impedance Z other than 15 ohms, and choose suitable wire size. All layers should occupy full bobbin width, to avoid excessive leakage inductance.

Section (5). As (2).

Section (6). As (3).

Section (7). As (1).

Note.—Three layers of 0.005in. Empire cloth to be inserted between all sections.




**Tests**

| | |
|---|---|
| Total primary resistance | = 160 ohms approx. |
| Total primary inductance, measured at 1,000 c/s on low-level A.C. bridge | = 60 henrys approx. |
| Leakage inductance; measured across whole primary, with output winding shorted | = 50 millihenrys approx. |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# Push-Pull Input Circuits

## Part I.—General Principles

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

THE use of push-pull amplification is now widespread in high-quality apparatus. An amplifier working on this principle requires an input voltage which is balanced to earth or, to put it another way, it requires two input voltages of equal amplitude but of opposite phase.

Most sources of input voltages are two-terminal devices, however, and most of them have one of their terminals earthy, so that in many cases the voltage pro-

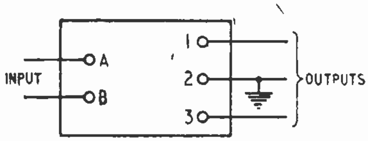



**Fig. 1. Diagrammatic representation of an unbalance-to-balance transformer.**

vided by the source is unbalanced to earth. Some device which will transform an unbalanced voltage to a balanced one then becomes necessary to connect the input source and the amplifier.

One of the oldest of such devices is a push-pull transformer, but arrangements embodying RC-coupled valves are now more common and are known by various names, such as phase splitters, phase reversers, phase inverters, paraphase amplifiers, see-saw circuits.

Although much has been written on these circuits there is surprisingly little published material on the degree of balance obtainable over a wide frequency range. While general information about them is plentiful, detailed information is scarce.

Whatever its actual nature, the general unbalance-to-balance transformer can be represented by the box of Fig. 1. The output voltage $E_{AB}$ of the source is applied to terminals A, B, and there are developed at terminals 1, 2 and 3, 2 voltages $E_{12}$ and $E_{32}$ of equal amplitude and opposite phase, so that $E_{12} = -E_{32}$. No specific relation between the amplitude and phase of $E_{AB}$ and $E_{12}$ is necessary.

Before proceeding, a word about the double subscripts used above in describing the voltages may be advisable. The full meaning of $E_{12}$ is that terminal 1 is positive with respect to terminal 2 by the magnitude of voltage E; $E_{21}$ means that terminal 2 is positive with respect to terminal 1 and is, of course, the same as saying that terminal 1 is negative with respect to terminal 2. Hence $E_{12} = -E_{21}$. This double-subscript method of specifying voltages is very convenient because it avoids any ambiguity.

Transformer coupling is not being dealt with in this article, but it is well to show how it fits into the box of Fig. 1. It is a very simple case and is illustrated in Fig. 2. If the transformer has a turns ratio of $1:n$ between terminals A, B and 1, 3, then $E_{12} = \pm E_{AB}\,n/2$ and $E_{32} = \mp E_{AB}n/2$.

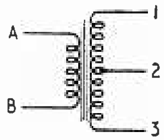



**Fig. 2. The push-pull transformer is one form of phase-splitter.**

The accuracy of balance between the two depends mainly on the transformer and is usually good, although it generally falls off at the higher frequencies on account of winding capacitances.

It is to be noted that the primary winding can be earthed or not as the requirements of the rest of the circuit may dictate.

Turning now to resistance methods, there is one very simple system possible when conditions are such that no part of the input source need be earthed. These conditions sometimes occur with a gramophone pickup, and it is

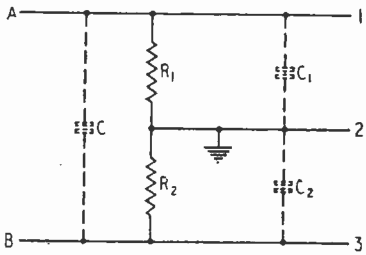



**Fig. 3. The basic resistance phase-splitter.**

then possible to use the arrangement of Fig. 3, in which the inevitable stray capacitances are shown dotted.

In order that $E_{12}$ may equal $-E_{32}$, it is necessary only to have $R_1 = R_2$ and $C_1 = C_2$; the value of C, any capacitance directly across the input terminals, does not affect the balance. Under this condition $E_{12} = E_{AB}/2 = -E_{32}$. The capacitances thrown on 1, 2 and 3, 2 by the following push-pull amplifier will usually be very nearly equal, for the two sides of the amplifier will be alike. Any discrepancy between $C_1$ and $C_2$, therefore, comes chiefly from different stray capacitances to earth from two sides of the pickup or other input source.

With some equipment this may be large, while with other apparatus it may be negligibly small. It is, however, always possible to

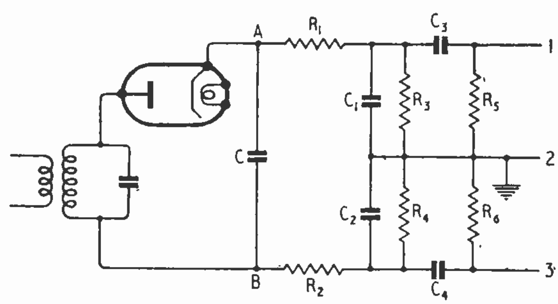



**Fig. 4. Here the phase-splitter of Fig. 3 is shown applied to a diode detector.**

**Push-Pull Input Circuits—**

equalize the capacitances by adding to the smaller, but it is rarely convenient to do so.

The circuit is not much used because it raises difficulties in obtaining a simple volume control and in most practical cases it is desired to have one input terminal earthy. This basic method can also be used with a diode detector, and one way of doing this is shown in Fig. 4. For balance it is necessary to have $R_1 = R_2$, $R_3 = R_4$, $R_5 = R_6$, $C_1 = C_2$, and $C_3 = C_4$. In addition stray capacitance to earth from A should equal that from B, and capacitances to earth from 1 and 3 should also be equal.

The floating R.F. input circuit is often inconvenient and can be avoided by the arrangement of Fig. 5. Here again, $R_1 = R_2$, $R_3 = R_4$, $C_1 = C_2$, $C_3 = C_4$, $C_5 = C_6$, $L_1 = L_2$. The circuit looks unbalanced because earth is connected to one side of the R.F. coil instead of to a centre-tap, but in all ordinary cases the impedance of the tuned circuit is negligible at audio frequencies, and it is unnecessary to complicate matters by tapping the coil.

Suitable values of components are: $R_1 = 50\,\text{k}\Omega$, $R_3 = 2\,\text{M}\Omega$, $C_1 = C_3 = 100$ pF, $C_5 = 0.01\,\mu$F, $L_1$ = suitable R.F. choke for the input radio frequency.

This circuit is more convenient than the gramophone one, because volume control can easily be carried out in the pre-detector circuits. As in the other circuits, stray capacitances from A and B to earth must be equal, and also those from 1 and 2 to earth.

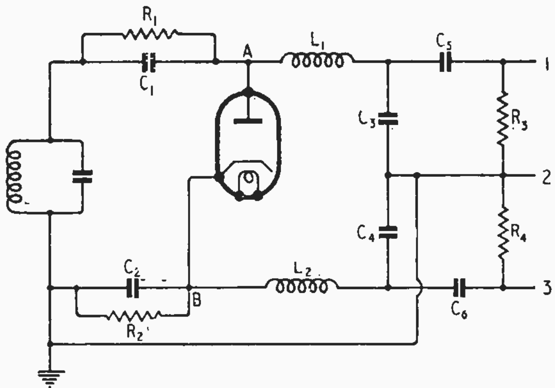



Fig. 5. A modified form of Fig. 4 permitting one terminal of the tuned circuit to be earthed.

These circuits have been previously described,[1] but they are included here since they do not seem to be very well known, and although they are not often useful, there are occasions when they are convenient. They have one great merit, which is that if the components are carefully matched the balance can be perfect at all frequencies.

Circuits of this type, including some others of great practical importance, are usually termed phase-splitters to distinguish them from another group known as phase-reversers. The essential thing about a phase-splitter is that the output voltages are developed by the passage of the same current through two equal impedances in series. Thus in Fig. 3, ignoring stray capacitances, an input voltage $E_{AB}$ drives a current $i$ through $R_1$ and $R_2$, so that $i = E_{AB}/(R_1 + R_2)$. The output voltages are $E_{12} = iR_1$ and $E_{32} = -iR_2$. Because they are developed by the same current, equality of the outputs requires only equality of the resistances. These are static elements which are easily made equal in practice and which retain their equality over long periods.

The second group—the phase-reversers—depend on the use of a valve amplifier of unity gain. They are illustrated diagrammatically in Fig. 6. The input terminals are common with one pair of output terminals so that $E_{AB}$ and $E_{12}$ are actually identical. $E_{32}$ is provided by applying $E_{AB}$ also to an amplifier, represented by the box, giving phase reversal and unity amplification so that $E_{32} = -E_{AB} = -E_{12}$.

It is obvious that perfect balance is obtainable only if the amplifier is perfect over the whole range of frequencies required. It is also obvious that the gain of the amplifier must in some degree depend on the characteristics of the valve used. Consequently, it is less easy to maintain balance over a wide range of frequencies or over long periods of time than with phase-splitters in which the balance is independent of valve characteristics.

[1] "Push-Pull Input Systems," by W. T. Cocking. *Wireless World*, September 21st, 1934, Vol. 35, p. 245.

This should not be taken to mean that phase-reversers are, in practice, greatly inferior to phase-splitters. They are not, and with good design they can give an adequate performance. Some types are widely used.

Before we start to consider in detail the various circuits of both categories which find considerable practical application it may be as well to treat one more phase-splitter of a type not often used. We shall consider this because it is very similar to the well-known cathode-follower type phase-splitter and its analysis will serve to clarify the action of the latter.

The circuit diagram is shown in Fig. 7 (a) and its equivalent at (b) and it will be assumed that the bias resistance $R_b$ is adequately by-passed by $C_b$, so that at all frequencies in which we are interested these components can be regarded as short-circuited. For the moment it will also be assumed that the decoupling capacitance $C_d$ is large enough to be considered a short-circuit.

Now suppose the input voltage $E_{AB}$ increases; that is, suppose terminal A becomes more positive than terminal B. This changes the grid potential with respect to the cathode by the same amount and the anode current increases thus increasing the voltage drops across $R_a$ and $R_c$. The increase of current through $R_c$ makes its cathode end more positive to earth and the change of voltage is positive-going; thus, the cathode output $E_{32}$ is positive.

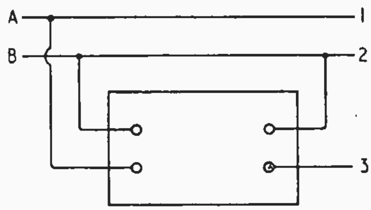
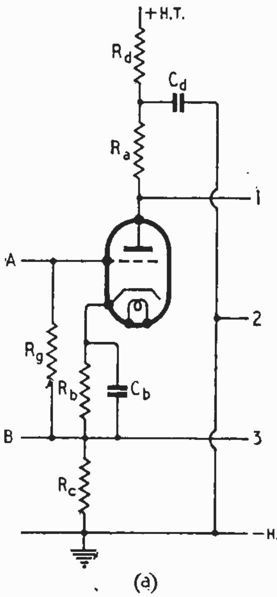



Fig. 6. Unbalance-to-balance achieved by a phase-reverser.

The increased voltage drop across $R_a$ makes the anode end more negative with respect to positive H.T. and so less positive with respect to earth. The change at the anode is thus negative-going and the output at the anode $E_{12}$ is negative. Terminals 1 and 3 thus vary in potential in opposite directions with respect to 2.

The magnitudes of the changes are $i_aR_c$ and $i_aR_a$ where $i_a$ is the change of anode current; and so for equal magnitudes of output we must have $R_a = R_c$.

The circuit is one which lends itself to a simple mathematical analysis and the relevant equations are given in the Appendix. The degree of unbalance is expressed by $U = (E_{21} - E_{32})/E_{32} = (A_a - A_c)/A_c$. Its physical meaning is most easily seen by considering the currents in the anode circuit of a following ideal push-pull stage. The individual alternating anode circuits are proportional to $A_a$ and $A_c$, the amplifications between grid and the anode and cathode outputs respectively, and the current in the common H.T. lead to their difference. The unbalance is expressed by the ratio of this out-of-balance current in the H.T. lead to one of the anode currents.



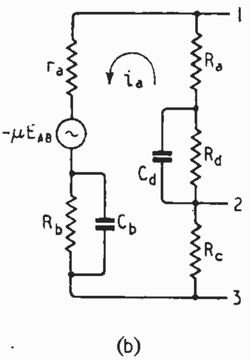




Fig. 7. A triode phase-splitter based on Fig. 3 is shown at (a) and its equivalent circuit for low and middle frequencies at (b).

The condition for balance is clearly $Z_a = R_c$. On account of the decoupling components $C_d$ and $R_d$ this condition can never be met exactly. It is, of course, possible to insert a similar circuit in the cathode lead, but even then a perfect balance is not possible because the impedance of the H.T. supply system is in series with $R_d$. It cannot readily be taken into account and its effect is small over the A.F. range.

When $C_d$ and $R_d$ are large enough for effective decoupling their effect on the balance is small. Their effect on the amplitudes of the output voltages is negligible, but $C_d$ alters the phase of one output voltage slightly relative to the other, and it is this phase angle which is responsible for the major part of the unbalance.

As an example of the sort of thing encountered in practice consider a stage using the following typical values:— $\mu = 28$, $r_a = 18\,\text{k}\Omega$, $R_a = R_c = R_d = 50\,\text{k}\Omega$ $C_d = 8\,\mu\text{F}$. When $C_d$ is of negligible reactance $Z_a = R_c$ and Equations (1) and (2) give

$$A_c = A_a = \frac{28 \times 50}{18 + 50 + 50} = 11.8$$

At 50 c/s, $\omega C_dR_d = 6.28 \times 50 \times 8 \times 10^{-6} \times 5 \times 10^4 = 125.6$ and the approximate formulae (7) and (8) are sufficiently accurate. From (8) $U_2 = 1/125.6 = -0.008$ and from (7) $U_1 = 0.000064$. The amplitude unbalance is clearly negligible and the phase unbalance is small enough to be ignored for most purposes. What this means is that the anode output consists of two component voltages one of which is negligibly different in amplitude from the cathode output and in phase opposition to it and the other of which is in phase quadrature and of only 0.8 per cent of its amplitude.

This phase unbalance can be reduced as desired by increasing $C_d$ and if otherwise possible it is helpful to use large values for $R_a$, $R_c$ and $R_d$.

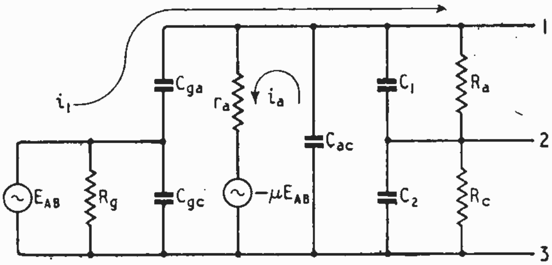



**Fig. 8. The equivalent circuit for high frequencies of Fig. 7 (a) is shown here.**

At high frequencies the equivalent circuit has the form of Fig. 8 in which $C_{ga}$, $C_{gc}$ and $C_{ac}$ represent the inter-electrode capacitances of the valve and $C_1$ and $C_2$ are the capacitances in shunt with $R_a$ and $R_c$. They are mainly the input capacitances of the following stage. If the circuit is balanced and the outputs are equal $C_{ac}$ can be replaced by two capacitances in series each of capacitance $2C_{ac}$. This junction will always be at earth potential and so can be connected to 2 without affecting matters.

When the circuit is balanced, therefore, and this means $R_a = R_c$, $C_1 = C_2$, the effect of $C_{ac}$ can be assessed by replacing it by $2C_{ac}$ in shunt with $C_1$ and $C_2$.

The grid-cathode capacitance $C_{gc}$ comes in shunt with the input voltage and has no effect on the balance and this is also the case with the grid leak $R_g$. There remains the anode-cathode capacitance $C_{ga}$. The input voltage is responsible for driving a current round the circuit including $C_{ga}$ and both anode and cathode impedances and it is in opposition to the anode current. As it flows through both impedances and these are equal it has no effect on the balance.

The voltage acting to drive current through $C_{ga}$ is $E_{AB} + E_{21} + E_{32}$ and so the input current is $i_1 = j\omega C_{ga}(E_{AB} + E_{21} + E_{32})$. The input impedance is $Z_{in} = E_{AB}/i_1 = 1/\left[j\omega C_{ga}\left(1 + \frac{E_{21} + E_{32}}{E_{AB}}\right)\right]$.

**Push-Pull Input Circuits**—Now $E_{32}/E_{AB} = A_c$, the amplification between input and the cathode output, and $E_{12}/E_{AB} = -A_a$, the amplification between input and the anode output; also, $A_c = A_a$.

Hence $Z_{in} = 1/j\omega C_{ga}(1+2A_c)$; that is, the input capacitance due to feedback in $1 + 2A_c$ times the grid-anode capacitance. This is the well-known Miller effect.

It will be seen that from the point of view of balance this stage is not far from ideal, for the only disturbing effect is that of $C_d$ and it is not hard to keep this very small. For most applications, however, there is the serious drawback that neither input terminal can be earthy, and it is for this reason that the circuit is rarely used.

The time that has been spent on it is far from wasted, however, for one of the most widely used circuits is very similar to it and much of the analysis still applies. This circuit will be dealt with in Part II.

APPENDIX I

Referring to Fig. 7(b) and assuming that $C_b$ is large enough for its reactance to be negligible

$$\frac{E_{32}}{E_{AB}} = A_c = \frac{\mu R_c}{r_a + R_c + Z_a} \qquad (1)$$

$$\frac{E_{12}}{E_{AB}} = -A_a = \frac{-\mu Z_a}{r_a + R_c + Z_a} \qquad (2)$$

The unbalance

$$U = \frac{A_a - A_c}{A_c} = \frac{Z_a}{R_c} - 1 \quad .. \quad (3)$$

$$= 0 \text{ when } Z_a = R_c$$

At low frequencies

$$Z_a = R_c + \frac{R_d}{1 + j\omega C_d R_d}$$

Therefore,

$$U = \frac{R_d/R_c}{1 + j\omega C_d R_d} \quad .. \quad .. \quad (4)$$

$$= \frac{R_d}{R_c} \cdot \frac{1 - j\omega C_d R_d}{1 + \omega^2 C_d^2 R_d^2}$$

This represents an in-phase amplitude unbalance of

$$U_1 = \frac{R_d/R_c}{1 + \omega^2 C_d^2 R_d^2} \quad .. \quad .. \quad (5)$$

and a quadrature unbalance of

$$U_2 = -\frac{R_d}{R_c} \cdot \frac{\omega C_d R_d}{1 + \omega^2 C_d^2 R_d^2} \qquad (6)$$

When $1 \ll \omega^2 C_d^2 R_d^2$

$$U_1 \approx 1/\omega^2 C_d^2 R_c R_d$$
$$(= -U_2/\omega C_d R_d) \quad .. \quad (7)$$

$$U_2 \approx -1/\omega C_d R_c \quad .. \quad .. \quad (8)$$

In practice $R_c$ and $R_d$ are usually of the same order of magnitude; if then $U_2$ is small $U_1$ will be very small and the total unbalance will be negligibly different from $U_2$.

# Short-wave Conditions

## November in Retrospect : Forecast for January

By T. W. BENNINGTON (Engineering Division, B.B.C.)

NOVEMBER was a very interesting month in the short-wave world—a month during which several significant events occurred. The first of these was the fact that a decrease—the first since 1944—occurred in the running average sunspot number, indicating, though not certainly, that the maximum in the current sunspot cycle may be past.

The second was that predictions that the ionisation of the regular F2 layer would reach values capable of sustaining fairly frequent communication on frequencies as high as 50 Mc/s proved true, such communication providing valuable information as to the peak frequencies for long-distance communication during the winter day of an exceptionally high sunspot maximum year.

During the month the maximum usable frequencies continued to increase by day and to decrease by night, in accordance with the seasonal trend and the high solar activity. On undisturbed days exceptionally high frequencies were therefore usable, and many transatlantic amateur contacts of 50 Mc/s were made. Night-time working frequencies were such that, on undisturbed occasions, frequencies lower than 9 Mc/s were seldom really necessary.

Conditions were less disturbed than has been the case during the past few months, though some ionosphere storms did occur. The most disturbed periods were 9th/12th, 13th/16th, 19th, 24th and 30th.

**Forecast.**—There should not be much change in either daytime or night-time M.U.F.s as between December and January. Daylight working frequencies during January will therefore be relatively high and those for night-time relatively low. The 28-Mc/s amateur band should be regularly usable over daylit paths, and, if conditions should prove favourable, contacts on higher amateur frequencies may become possible on odd occasions. Night-time working frequencies as low as 7 Mc/s may have to be used over some paths, though over those passing in southerly directions higher frequencies than this should remain usable throughout the night.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during January for four long-distance circuits running in different directions from this country. In addition a figure in brackets is given for the use of those whose primary interest is the exploitation of certain frequency bands, and this 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. Times throughout are in G.M.T.

| | | | | |
|---|---|---|---|---|
| **Montreal :** | 0000 | 9 Mc/s | | (14 Mc/s) |
| | 0300 | 7 ,, | | (12 ,, ) |
| | 0900 | 9 ,, | or 11 Mc/s | (16 ,, ) |
| | 1100 | 17 ,, | or 21 Mc/s | (26 ,, ) |
| | 1300 | 26 ,, | | (38 ,, ) |
| | 1800 | 21 ,, | | (29 ,, ) |
| | 2000 | 17 ,, | or 15 Mc/s | (22 ,, ) |
| | 2200 | 11 ,, | | (18 ,, ) |
| | 2300 | 9 ,, | | (15 ,, ) |
| **Buenos Aires:** | 0000 | 11 Mc/s | | (16 Mc/s) |
| | 0500 | 9 ,, | | (14 ,, ) |
| | 0700 | 11 ,, | | (18 ,, ) |
| | 0800 | 21 ,, | | (28 ,, ) |
| | 0900 | 26 ,, | | (40 ,, ) |
| | 1900 | 21 ,, | | (32 ,, ) |
| | 2000 | 17 ,, | or 15 Mc/s | (22 ,, ) |
| | 2200 | 11 ,, | | (18 ,, ) |
| **Cape Town :** | 0000 | 11 Mc/s | | (16 M/cs) |
| | 0300 | 9 ,, | | (15 ,, ) |
| | 0500 | 11 ,, | | (20 ,, ) |
| | 0600 | 17 ,, | | (29 ,, ) |
| | 0700 | 26 ,, | | (40 ,, ) |
| | 1700 | 21 ,, | or 17 Mc/s | (29 ,, ) |
| | 2000 | 15 ,, | | (21 ,, ) |
| | 2200 | 11 ,, | | (18 ,, ) |
| **Chungking :** | 0000 | 7 Mc/s | | (12 Mc/s) |
| | 0400 | 9 ,, | | (14 ,, ) |
| | 0500 | 11 ,, | | (16 ,, ) |
| | 0600 | 17 ,, | or 21 Mc/s | (23 ,, ) |
| | 0800 | 26 ,, | | (36 ,, ) |
| | 1200 | 17 ,, | or 15 Mc/s | (24 ,, ) |
| | 1700 | 11 ,, | or 9 Mc/s | (15 ,, ) |
| | 2300 | 7 ,, | | (13 ,, ) |

January is not usually a particularly disturbed month, though ionosphere storms which do occur are often particularly troublesome at this time of year over dark transmission paths. At the time of writing it would appear that disturbances are more likely to occur within the periods 3rd/5th, 8th/10th, 13th/14th, 18th, 24th, and 30th/31st than on the other days of the month.

## Ships' Electrical Gear

A SUPPLEMENT containing alterations and additions to the current "Regulations for the Electrical Equipment of Ships" has recently been issued by the Institution of Electrical Engineers, Savoy Place, London, W.C.2 (Price 1s). It covers matters regarded as needing urgent attention that have arisen since the issue of the 3rd edition in 1939.

# Government Hearing Aid

## FIRST DETAILS OF THE SPONSORED DESIGN

THE Committee[1] appointed to advise the Medical Research Council upon the design of hearing aids has now published its report[2] and it is possible to disclose the technical specification of the hearing aid which it is proposed to distribute when the new National Health Service is brought into operation.

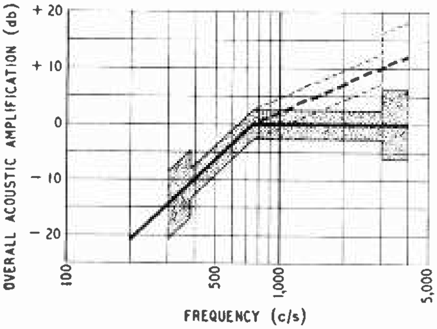
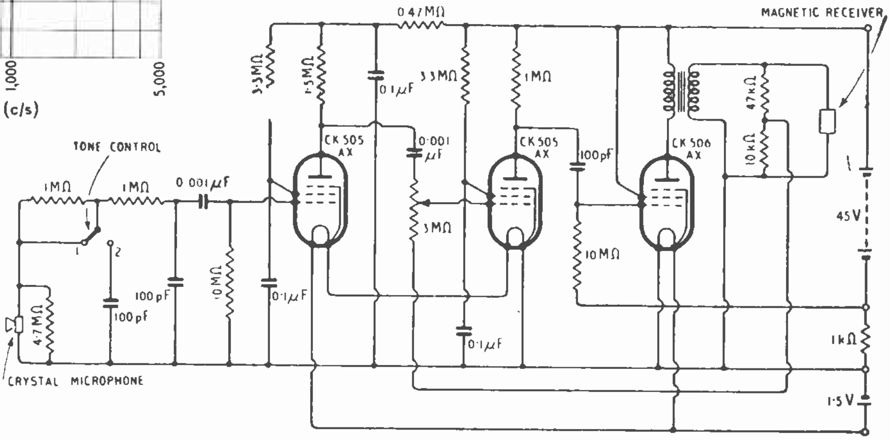



Fig. 1. Frequency response characteristic (with permissible tolerances). Zero level corresponds to a minimum amplification of 40 db.

The first problem was to enunciate the performance which might be expected to satisfy the requirements of the majority of the deaf persons who will benefit by the scheme. To this end clinical experiments were conducted with the aid of specially prepared articulation test records played through high-quality reproducing systems, built by the Post Office Research Station and fitted with variable frequency characteristics. Tests were made with 228 subjects, representing all types and degrees of deafness, and it was found that a response curve with a loss of 12 db per octave from 750 c/s down to 200 c/s and either a level or a rising response, at 5 db per octave from 750 c/s to 4,000 c/s, gave the best results. Permissible tolerances were established and are indicated by the shaded areas in Fig. 1. It was further established that with new batteries the acoustic amplification corresponding to 0 db in the curve should be not less than 40 db, that the acoustic input/output curve at 750 c/s should be linear up to pressures of 200 dynes/cm², and that the noise level with volume control at maximum as expressed by the ratio of the voltage across the telephone with and without an



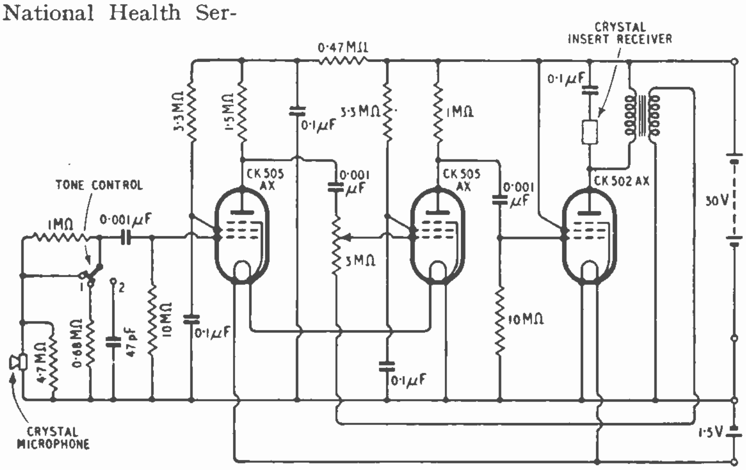
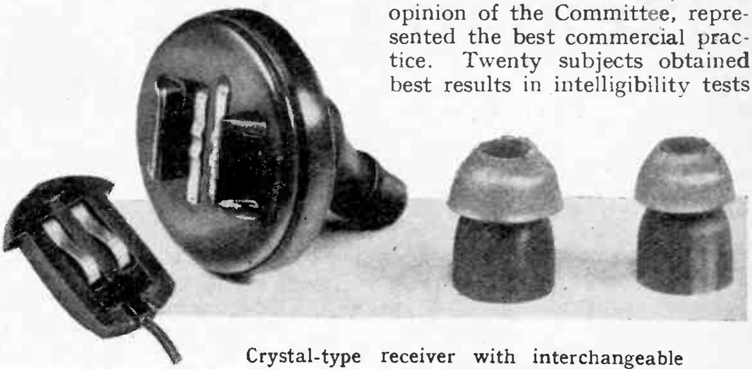




Fig. 2. Circuit diagrams of prototype amplifiers for use with magnetic or crystal type earpieces.

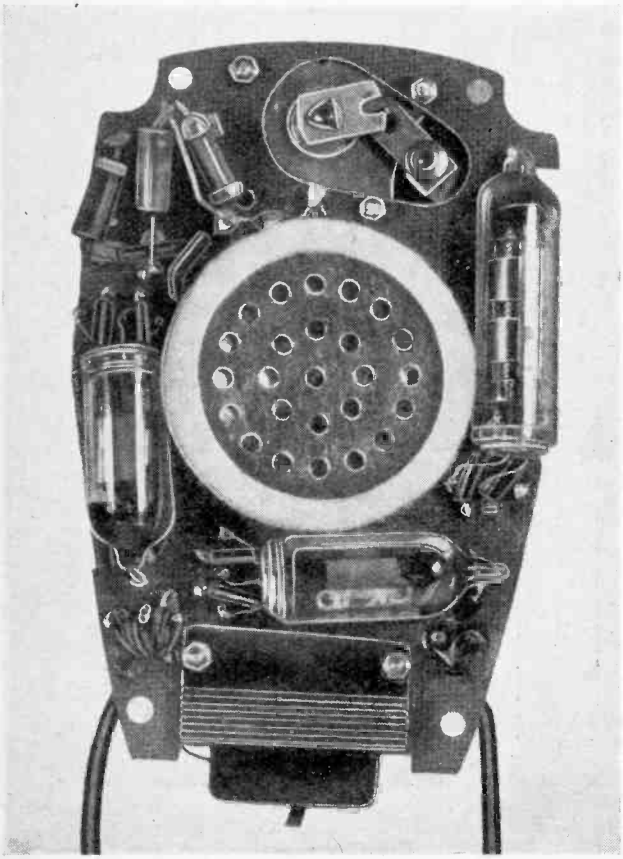
**Government Hearing Aid—**
acoustic input of 200 dynes/$cm^2$ at 750 c/s should not exceed 40 db.

When the battery voltages are reduced to two thirds (1.0 volt per cell) the amplification should not be down by more than 6 db and linearity should be maintained up to 100 dynes/$cm^2$. Tests to be made at or corrected to a temperature of 27° C on account of the known variability in sensitivity of piezo-electric microphones and receivers with temperature.

The report recommends that considerable freedom should be permitted in the development of designs to attain this performance, provided that there is standardization of battery sizes and plug and socket connectors. For guidance, circuit diagrams are given of two prototype aids which have been constructed by the P.O. Research Station, one for use with a lightweight non-resonant moving-iron diaphragm receiver of a type developed by the Ministry of Supply and the Ministry of Aircraft Production, and the other for use with an insert receiver of piezo-electric type and of American manufacture. American (Raytheon) valves are also recommended pending the development of equivalent types in this country. The hearing aid with piezo-electric insert made use of a 30-volt H.T. battery, but a 45-volt battery was needed for the magnetic receiver type of circuit. Both H.T. batteries give a life of about 150 hours. The L.T. filament cells gave 50 hours on intermittent service and 35 hours on continuous service of 15 hours per day with the magnetic receiver type of circuit. About 50 per cent longer life for the L.T. cells was obtained when used with the piezo insert receiver circuit.



Crystal-type receiver with interchangeable rubber adaptors.



Amplifier panel removed from moulded case. External dimensions are 3⅝in. × 2½in. × 1in.

To check the validity of the specification, tests were carried out with 27 subjects with varying degrees of deafness, who possessed and had several months' experience of the best available commercial hearing aids. Comparisons were made of the results obtained with the subject's own hearing aid, the Committee's two designs with external and insert earpieces, and an American aid with insert receiver which, in the opinion of the Committee, represented the best commercial practice. Twenty subjects obtained best results in intelligibility tests with one or other of the Committee's models. All preferred the Committee's models on the score of quality of reproduction.

The report deals with the design of audiometers, and gives details in appendices of simple objective methods of testing the performance of hearing aids.

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[1] W. G. Radley, C.B.E., B.Sc. (Eng.), Ph.D., M.I.E.E., Controller of Research, Engineering Department, General Post Office (Chairman).
Sir W. Lawrence Bragg, O.B.E., M.C., M.A., D.Sc., F.R.S., Cavendish Professor of Experimental Physics, University of Cambridge.
R. S. Dadson, M.A., National Physical Laboratory.
C. S. Hallpike, M.B., F.R.C.P., F.R.C.S., Medical Research Council.
Colonel D. McMillan, O.B.E., B.Sc.(Eng.), A.M.I.E.E., Post Office Engineering Research Station.
L. C. Pocock, M.Sc. (Eng.), A.M.I.E.E., Standard Telephones and Cables, Ltd.
T. S. Littler, M.Sc., Ph.D., University of Manchester (Secretary).

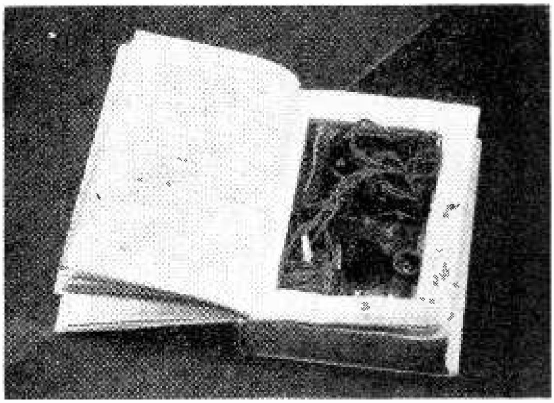
[2] Medical Research Council, Special Report Series, No. 261. "Hearing Aids and Audiometers." H.M. Stationery Office.

## "Radio Data Charts"

A NEW edition of this publication, which comprises a series of Abacs giving in graphical form most of the essential data required for receiver design, has now been issued by our publishers. It reduces the labour of calculation in upwards of 40 design problems. The book, which is now bound in stiff boards, costs 7s 6d from all booksellers, or, by post 7s 11d. The subjects covered range from the design of R.F. coils and transformers to the calculation of loudspeaker dividing networks and include problems relating to parallel-wire, coaxial and quarter-wavelength transmission lines.

# Clandestine Radio

## Some Ruses Adopted by the Dutch



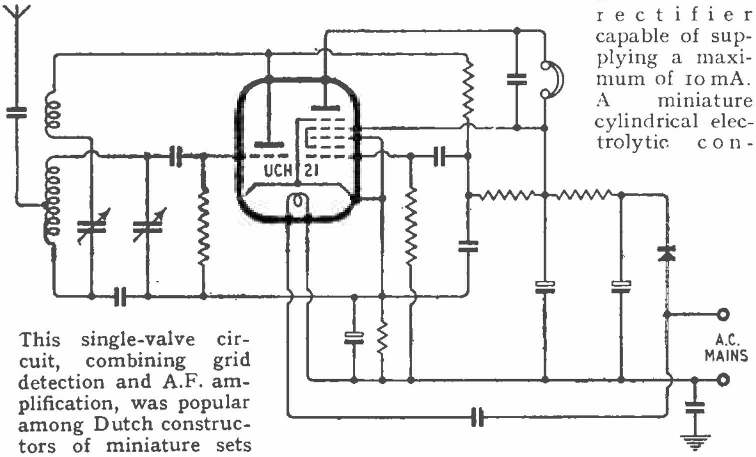
The cut-out pages of a prayer book concealed this receiver.

THE secret production of midget receivers was so well organized in Holland by the spring of 1944 that when a coded request for parts for a set was received from a Dutch prisoner of war in Germany it was decided to send him a complete receiver concealed in a tin of vegetables. The single-valve receiver, employing a triode-hexode as detector and A.F. amplifier, was assembled in the empty tin which had been fitted with a special lining so that it would produce the correct sound if tapped and its weight was made up to the proper value. the circuit is shown in the accompanying diagram.

This is one of the ruses employed by the Dutch resistance movement and described by a contributor to *Philips Technical Review*, November, 1946. Members of the resistance movement used receivers assembled inside a wide variety of articles in everyday use. Two of them, seen at an exhibition of equipment used by the resistance movement, are illustrated on this page.

During the German occupation of Holland the Dutch were forbidden to listen to foreign broadcasts. To enforce this order all sets were confiscated in 1943. As a result there was a great demand for miniature receivers. The article states that it was primarily the Philips organization which met the demand for components and, in some instances, complete receivers. Although production could not openly be properly organized, personal initiative was not lacking and it was not long before home construction was revived on an intensive scale.

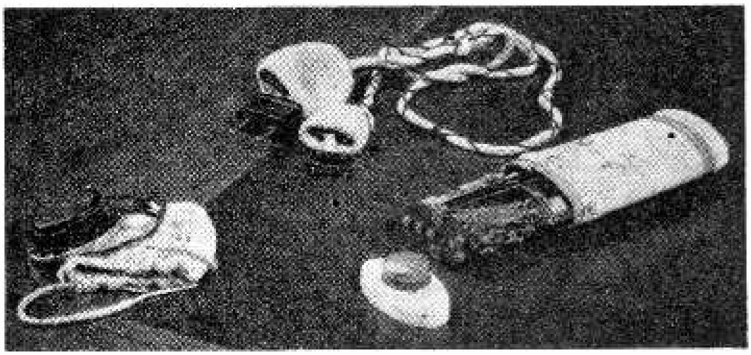
Practically all the miniature receivers were made for operation from the mains. The anode voltage was obtained by rectifying the mains voltage with either an "acorn" valve or, as shown in the diagram, a selenium rectifier capable of supplying a maximum of 10 mA. A miniature cylindrical electrolytic condenser, comprising two 8 $\mu$F units, measuring only 18 mm by 50 mm long, was used for smoothing. It will be seen that a condenser was used as a series impedance in the heater circuit as miniature transformers were not easily obtainable. A valve like the Philips UCH21, designed for a small heater current and a high heater voltage, was specially suitable for use in this circuit.




This single-valve circuit, combining grid detection and A.F. amplification, was popular among Dutch constructors of miniature sets during the German occupation.

Another circuit which was popular among set makers because of its high sensitivity was a two-valve reflex arrangement. Trimming condensers (3 to 30 pF) were used for tuning, and, with well-chosen coils, the 30-, 40- and 50-metre bands could be satisfactorily received with a very short aerial.

In conclusion the article states: "Needless to say, this wartime venture had its dangerous side, and unfortunately some who took part forfeited their lives."



A baby's powder duster concealed this set. The mains lead was camouflaged as a dressing-gown girdle and the earpiece as a baby's rattle.

# Amateur Radio Equipment

## Exhibits at the R.S.G.B. Show

IT is not surprising that the emphasis was on transmitting equipment at the November exhibition held in London by the Radio Society of Great Britain. Of the fifteen firms participating the majority had something of interest

Odeon 50-watt output transmitter covering the 3.5- to 28-Mc/s bands and including modulator and power supplies.

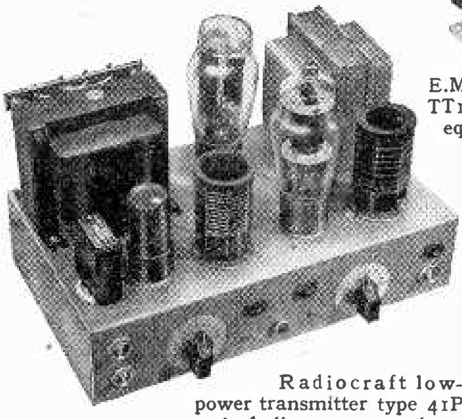
to the amateur transmitter. Complete sets were shown ranging in size from a C.O.-P.A. set of 25 watts rating for the beginner to a large rack-built 150-watt transmitter shown by Odeon Radio and costing £230. Labgear had a multi-tier transmitter with a variable-frequency master oscillator, which by means of switching provides for operation on 10, 14, 20, 40 and 80 metres. An 813 valve is used in the output stage and the full 150 watts allowed by licence can be employed. Complete with modulator, all power supplies and a crystal monitor the price is £175.

In addition to the large transmitter Odeon Radio had a number of low-power sets, some of which are designed for the beginner requiring an unexpensive set for C.W. operation. An intermediate model of 50 watts output proved an attractive set, covering as it does all the amateur bands from 3.5 Mc/s to 28 Mc/s. It is crystal controlled, contains modulator and power supplies and, assembled in a three-tier rack, costs £98. It is also available as a kit of parts.

Transmitters for the beginner were shown also by Radiocraft, some of their models being very modestly priced. The model 41 for example, which is a combination of tritet oscillator and P.A. of flexible design and fitted with plug-in coils, costs only £7 1s 6d or £12 10s with a self-contained power supply, when it becomes the model 41P.

Receivers of various kinds were well in evidence and they ranged from a simple O-V-1 set to the most up-to-date communications receiver. Some of both varieties were seen on the Eddystone stand, the simpler sets and converters being assembled from the designs given in the firm's "Short Wave Manual."

The Eddystone model 640 is an outstanding example of a communications set designed for the amateur and it embodies all the special features one expects to find in a set of this kind. It has an R.F. stage, two I.F. amplifiers on 1.6 Mc/s, noise limiter, B.F.O., crystal filter, provision for headphones and covers 1.7 Mc/s to 32 Mc/s. Separate band-spread condensers are used and the price is £42 plus purchase tax.

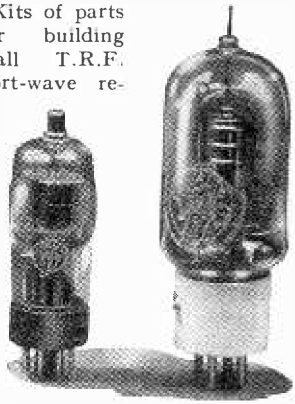


Radiocraft low-power transmitter type 41P including power pack.

Denco were showing a prototype of a new communications set which covers 175 kc/s to 36 Mc/s in six ranges. A turret coil assembly is used and band-spread is provided by a cam-operated mechanism which rocks the stator sections of the gang condenser. The set has one R.F. stage, two I.F. amplifiers on 1.6 Mc/s, crystal and audio filters giving an 800-c/s band-width at high selectivity, noise limiter and B.F.O. The price is expected to be about £48. Miniature valves are used.

Another example of a modern communications receiver was shown by E.M.I. Sales and Service. This also has an R.F. stage, two I.F. amplifiers on 465 kc/s, noise limiter and crystal filter. It covers 550 kc/s to 30 Mc/s.

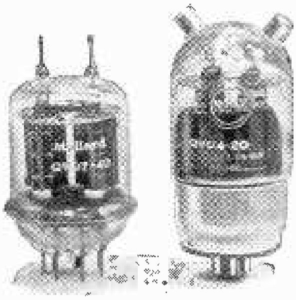
Kits of parts for building small T.R.F. short-wave receivers using plug-in coils and having bandspread are sold by Southern Radio and Electrical Supplies; an O.V.2 kit, for example, costs £5 17s 6d complete.



E.M.I. transmitting valves: the TT11 tetrode and DET18 triode, equivalent to the American 35T.

British equivalents for most of the popular types of American transmitting valves are now available. E.M.I. Sales and Service showed a range including the TT11 R.F. tetrode with top anode connector and on an octal base. It is rated at 7.5 watts anode dissipation and can be used up to 200 Mc/s. There was also the KT8C, a replacement for the well-known 807, the DET18 triode replacing the 35T, the DA41, substitute for the TZ40 and the DET19 double triode, an equivalent to the RK34. Mercury vapour and hard vacuum rectifiers were also shown.

Mullard had a very comprehensive range of valves in both transmitting and receiving types. The popular EF50 with its companion V.H.F. types EF54 (RL7), EC52 (RL16) were shown together with a new valve, the EF55, for us in wide-band amplifiers and having a slope of 12 mA/V. A special non-microphonic pentode for us in early stages of modulation amplifiers has been

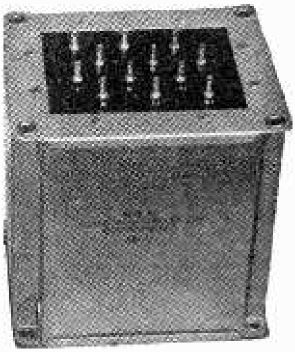


Mullard VHF double tetrodes ; the QVO7-40 and the QVO4-20.

developed and is given the type number EF37.

Among the Mullard transmitting valves is the QVO4-7, a tetrode suitable for use as crystal oscillator, doubler or tripler up to 150 Mc/s. It operates at 300 volts H.T. and its anode dissipation is 7.5 watts. Other Mullard types are the QVO5-25, a direct equivalent of the 807, and two double R.F. tetrodes, the QVO4-20, equivalent to the 815, and the QVO7-40, equivalent to the 829B. The former will give a C.W. output of 40 watts and functions up to 200 Mc/s, while the latter's output is 60 watts with a limit frequency of 250 Mc/s. A feature of the QVO7-40 is the inclusion of a built-in screen by-pass capacitor.

For high-power operation, where

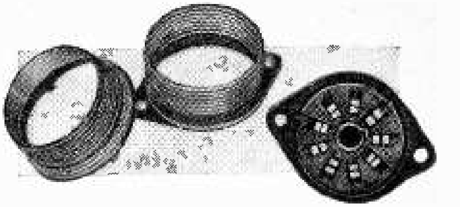


Woden Multi-Match modulation transformer, type UM2, rated to handle 60 watts of audio.

an 813 might be used, Mullard have an equivalent in the QY2-100, giving 260 watts output up to 120 Mc/s. In addition there is a comprehensive range of audio-frequency amplifying valves and mains rectifiers of the mercury vapour type.

Aerial equipment was shown by Antiference, Belling and Lee, and Eddystone, with co-axial and flat-twin feeders by the Telegraph Construction and Maintenance Co.

Belling and Lee showed



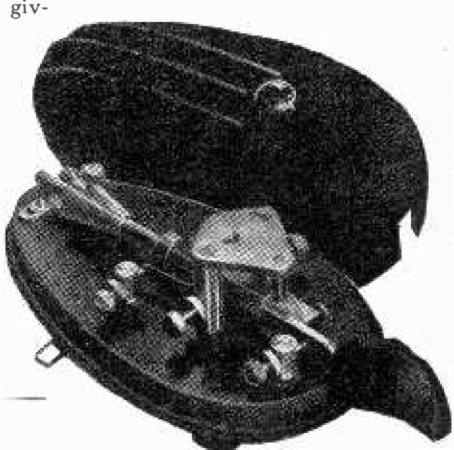
Belling-Lee EF50-type valve holder and valve retaining ring.

a wide range of co-axial plugs and sockets also a new EF50-type valve holder and valve retaining ring.

Some well-made coil turrets were seen on Labgear's stand together with plain and split-stator condensers, also a special wide-band R.F. coupling unit for transmitter and receiver stages. Denco showed a coil turret for use in receivers and many coils and components with polystyrene insulation.

A new range of transmitting condensers with ceramic insulation was seen on Eddystone's stand, where, among other items of interest, was a new automatic key, more familiarly known as a "Bug," which is priced at £3 17s 6d.

Meters of various kinds from single-range pointer instruments to



Eddystone automatic key; this type is usually described as a bug-key.

multi-range test sets were shown by Taylor and Pullin.

Mains and modulation transformers, the latter potted and filled with pitch to prevent "chatter," were seen on Woden's stand, while a range of components for receivers and transmitters was exhibited by Odeon Radio, Radiocraft, Radiomart, and Eddystone.

### List of Exhibitors

Antiference, Ltd., 57, Bryanston Street, London, W.1.
Belling and Lee, Ltd., Cambridge Arterial Road, Enfield, Middlesex.
Denco (Clacton), Ltd., 355-359, Old Road, Clacton-on-Sea, Essex.
E.M.I. Sales and Service, Ltd., Sheraton Works, Hayes, Middlesex.
Labgear, Willow Place, Fair Street, Cambridge.
Measuring Instruments (Pullin), Ltd., Winchester Street, Acton, London, W.3.
The Mullard Wireless Service Co., Ltd., Century House, Shaftesbury Avenue, London, W.C.2.
Odeon Radio, 56, College Road, Harrow, Middlesex.
Radiocraft, Ltd., 11, Church Road, Upper Norwood, London, S.E.19.
Radiomart, Ltd., 48, Holloway Head, Birmingham.
Southern Radio and Electrical Supplies, 85, Fisherton Street, Salisbury, Wiltshire.
Stratton and Co., Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham.
Taylor Electrical Instruments, Ltd., 419-424, Montrose Avenue, Slough, Bucks.
The Telegraph Construction and Maintenance Co., Ltd., 22, Old Broad Street, London, E.C.2.
Woden Transformer Co., Ltd., Moxley Road, Bilston, Staffs.

# Television Picture Size

## WHAT IS BEST?

By "CATHODE RAY"

DEMONSTRATE television to anyone previously unacquainted with it, and you are almost sure to hear some comment about the size of picture. "Is that as big as you can have it?" or "When will they be larger?" You may reply that television pictures anything up to 20 feet by 16 can be obtained *now* (at a price); or that the picture your friend is looking at is really the ideal size if only he had the sense to know it. Anything you say is likely to start a first-class argument. For there are quite a number of interesting things in this question, and also a good deal of confused thinking, possibly because it is outside the usual radio engineering curriculum.

Of course we all know that the price goes up very steeply as the size of the picture is increased, and that in these days most of us will be lucky to have any picture at all; but taking a more detached view, it is interesting to consider what would determine the ideal size of picture, (*a*) assuming perfect definition, and (*b*) with 405-line or any other particular definition.

Question (*a*) is an optical and psychological one. Obviously the best size of picture is closely connected with the viewer's distance from the screen. In fact, the important quantity is the ratio of the two, or, what comes to the same thing,[1] the angle subtended at the eye by the screen (Fig. 1). If this ratio or angle were the only thing to be considered, then it would make no difference to the viewer what size the screen was so long as it was placed at the right distance to subtend the approved correct angle.

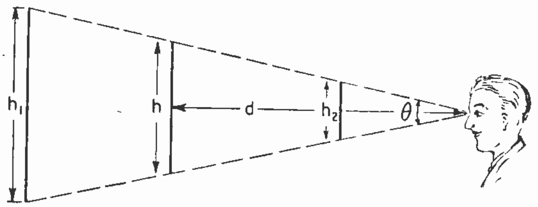



Fig. 1. The size of a picture to a viewer is not just its own size, but the angle θ. Pictures of different dimensions, h, $h_1$, and $h_2$, all look the same size if viewed at proportionate distances.

[1] Because $2 \tan \frac{\theta}{2} = \frac{h}{d}$

But what *is* the approved angle? As that is a fairly complicated question to answer, we will dispose of one or two simpler matters first. For although $\theta$ is certainly a very important factor, it is not the only one. To see that, one has only to suppose that in order to save money and room the picture is brought very close. The most obvious result is to restrict the number of people who can all comfortably get their heads at the distance which makes $\theta$ right, and at the same time within a sufficiently small angle from the axis for distortion of the picture due to the foreshortening to be tolerable. In Fig. 2 the maximum tolerable angle off the picture axis (PO) is marked $\phi$. Given the size of audience, XOY, and the angle $\phi$, the shortest possible distance, $d$, follows. If $\phi$ is in degrees, $d$ is $\frac{180}{2\pi\phi}$ times the length of the arc XOY. Incidentally, in determining the length of XOY it cannot always be safely assumed that everyone will be happiest when they're viewing cheek to cheek.

The value of $\phi$ is decided by how much distortion viewers are prepared to put up with. Anybody who grumbles at 38° ought, in times of austerity, to be turned out to make room for someone else. It narrows the picture by 22 per cent, so that its apparent width is about equal to its average height; and one might suppose that the viewer would get the same effect as if the width control were adjusted to make the picture square and the persons on the screen appear as if suffering from starvation. This is not necessarily so. As a matter of fact, the worst distortion is usually due to the curvature of the tube face; but this can be overcome by using a flat-ended tube. My impression (see Fig. 3) is that the foreshortening effect of viewing a frame of the standard proportions (*a*) at 38° off the axis, where it looks like *b*, makes the viewer unconsciously compensate for the distortion, which he would not do if the picture were viewed right on the axis and the narrowness produced by insufficient amplitude of line scanning (*c*). I have tried to settle this by viewing the screen as at *b* through a square mask, but it is difficult to ensure fair conditions for testing these subtle psychological effects, and the results were inconclusive. By the way, the top and bottom edges in Fig. 3*b*, if drawn accurately, are not quite straight; and the ratio of the two sides depends on $\theta$ as well as on $\phi$. Here $\theta$ is taken as 14°.

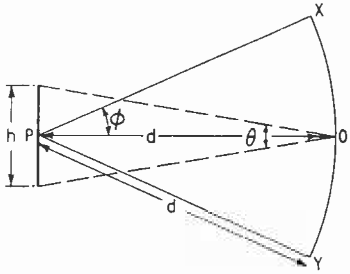


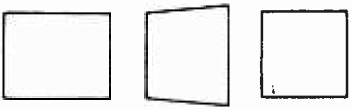

Fig. 2. For a given "spread" of audience, XOY, the largest angle $\phi$, that can be tolerated by them sets a minimum limit to the distance, d, from the screen. For a specified $\theta$, the minimum dimensions of the picture then follow. Normally $\phi$, is in the horizontal plane, and $\theta$ vertical, but there is no objection to drawing them on the same diagram as here.

Accepting $\phi = 38°$ as a working limit for hard times, $d_{min} = \frac{3}{4}$ times XOY. So if we knew $\theta$, we could then work out $h_{min}$; and $w_{min}$ (the minimum picture width) is, in the B.B.C. realm, 5/4 times $h_{min}$.

Before tackling the $\theta$ question, there are reasons why even an audience of one cannot economize *ad lib* by viewing a small picture close up. If it is too close, he cannot focus his eyes on it at all. The minimum distance varies with individuals, and tends to increase with age, necessitating the use of spectacles; but even with normal sight most people find it difficult to focus much nearer than 9 inches. Even if possible, it is not desirable to view a picture anything like as near as that. The mere fact of having to focus the eyes at close range on a picture representing something at a much greater distance is one more thing tending to destroy the illusion. Ideally, the picture should be at the same distance as the principal object depicted; but as the distance increases the focusing becomes less and less critical. I wouldn't like to dogmatize on this point, but I suggest that for typical television scenes, and especially for outdoor events, there is appreciable loss of illusion on this count if the screen is nearer than about 6 feet. The realism of distant outdoor scenes such as sporting events is undoubtedly much increased, at the expense of close-ups, by having the screen 40 or more feet away, as in a cinema. Always granting, of course, that the appropriate $\theta$ is maintained.

Now perhaps we are ready for $\theta$. Since it is a measure of apparent picture size—the size as seen by the eye, without reference to its distance—it would be just a question of how large we wanted it, if everything else could be made to meet our choice. Possibly the ideal $\theta$ would be 360°, so that we could see the performers even if they moved round behind our chairs; but the advantage of being able to do that would hardly be worth the miracle that would have to be performed in order to obtain it. One will have to wait a long time for completely realistic reproduction of floor shows.

In most forms even of "live" entertainment, as at a theatre or football match, there are limits to one's field of view—and that doesn't count the people in front. This limitation is not altogether a question of economy or convenience. Schoolboys asked to inscribe their answers on the board know only too well how much more difficult it is to see them there, where the $\theta$ is excessive, than at a safe distance. As the eyes are able to exploit only quite a small field at a time, the vast extra expense of a television screen to go much beyond that field would be difficult to justify.



(a) (b) (c)

**Fig. 3. A frame of the British standard ratio of width to height (5 : 4) is shown at *a*; and *b* is the same as seen at an angle $\phi$ of 38° ($\theta$ = 14°). Although the width of *b* is actually slightly less than in *c* (a square frame), the perspective effect makes a picture seen in this way seem less distorted.**

In practice there is another consideration—perspective. Any camera lens—television or otherwise—has its own $\theta$. One with a large $\theta$ is described as a wide-angle lens; a telephoto lens has a very small $\theta$, because $d$ is very large in comparison with $h$. If the resulting picture is of such a size or viewed at such a distance as to make the viewing $\theta$ different from the camera $\theta$, there is perspective distortion. There are plenty of examples in newspaper pictures, such as those of cricket matches or battleships at sea. Viewed in the normal way, with the paper 12—18 inches from the eyes, the scene looks as if it had been squashed flat. Batsmen at both ends of the pitch measure the same height on the paper, because with the telephoto lens their $\theta$'s were practically the same (Fig. 4*a*). Such a picture looks natural only when viewed from the other side of the street or whatever distance is needed to equal the very small $\theta$ of the actual scene from the site of the camera. If the scene were viewed at a distance which would make the batsmen look as large as they do in the picture held close up, their $\theta$'s would be very different (Fig. 4*b*). The effect of taking the photo with a telephoto (small $\theta$) lens and then looking at the resulting picture close up (large $\theta$) is to make A A look as if it had been moved to A′A′, close to BB.

Amateur photographers (or their victims) are more familiar with the opposite perspective distortion, for their cameras are most often wide-angle, and the resulting pictures so small that to view them so as to subtend the same angle they would have to be at the end of one's nose. Seen at a reasonable distance, the picture subtends a much smaller $\theta$ than did the camera, with grotesque results if the photographer had been indiscreet enough to have snapped his fiancée with her feet much nearer to the camera than her face.

The relevant factor in television is of course the $\theta$ of the television camera. And that is awkward, because in the B.B.C. studio Emitron it varies from 28° at infinity to 22° for a close-up. However, the difference between these and an average of, say, 25° is not enough to distort the perspective appreciably, so one need not worry unduly about the technical problems of providing

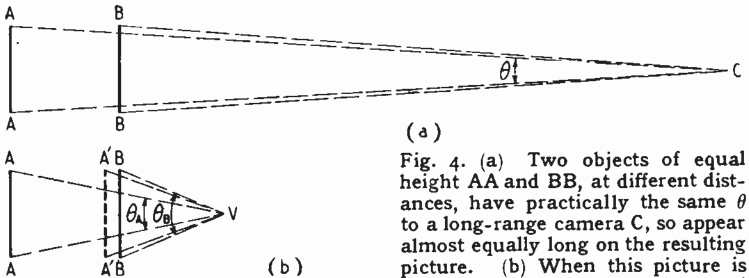



**Fig. 4. (a) Two objects of equal height AA and BB, at different distances, have practically the same $\theta$ to a long-range camera C, so appear almost equally long on the resulting picture. (b) When this picture is viewed close-up, the nearly equal (though much larger) $\theta$'s make the objects appear very close together (A′A′, BB); viewed with the actual separation (AA, BB) the $\theta$'s are widely different.**

a viewing chair that would shift its distance from the screen in synchronism with the focusing of the camera. What is more awkward is that in the cricket match type of broadcast the B.B.C. uses a camera with a $\theta$ of about 2°. This perspective can

**Television Picture Size—**
easily be reproduced by standing a long way from the television screen. *Standing* (not sitting), to be ready to rush forward whenever the producer decides to change to a long shot! So, as you see, to take perspective as the guiding principle lands one into absurdity. People are quite ready to sacrifice perspective, plus a stiff price for a pair of field glasses, in order to gain a close-up view at the races; so televiewers can hardly grumble if the same facility is provided at no extra expense and without even the trouble of taking their hands out of their pockets. Nor do the vast number of cinemagoers grumble about the liberties that the film producers take with perspective.

## Studio Perspective

Just as a matter of interest, though, let us see where it takes us if we make our screen size correct for perspective in studio scenes; that is to say, $\theta = 25°$. Suppose the width of the audience, XOY in Fig. 2, is 8ft, and that it tolerates $\phi = 38°$. Then the distance of the screen must be at least 6ft. At that distance the height of the picture must be 32in and its width 40in. Rather expensive.

Or consider a lone viewer prepared to have the screen at ordinary book distance, say $13\frac{1}{2}$in. The screen size for correct perspective is then $6 \times 7\frac{1}{2}$in, which is what one gets quite economically from a 9in tube. Moral: don't marry.

It may be as well to remark here that if the B.B.C. were not cramped for studio space they would probably use a smaller $\theta$, like film producers, which would help the perspective-conscious viewer.

What it boils down to, then, is that it is nice to have the perspective right most of the time if one can, but it is quite impracticable to do so all the time, and anyway nobody seems to worry about it much, even subconsciously, so in the end it is a question of what size people like to have the picture and whether they can afford it.

In a cinema there is a fairly wide choice of $\theta$, so it is instructive to see what people do choose. One thing that seems quite clear is that seats which make $\theta$ very large are unpopular, even when they are right on the axis; for people have to be bribed by lower prices to sit in them. The most popular $\theta$ is not very clearly defined, but seems to be round about 10°, say picture distance 6 times picture height. The largest C.R. tube size normally available is the 15-inch, giving a picture 10in high, so on a cinema basis one would expect people to sit about 5 feet away. At that distance they would have to keep within a $6\frac{1}{2}$-foot frontage to conform to the 38° $\phi$ limit.

So much for a picture with perfect or nearly perfect definition. How does the 405-line standard affect the matter? It is not very easy to say, but one would expect there would be little inducement to come nearer (or have the picture larger) than the point at which the lines were clearly distinguishable. At least, that is the theory. My experience doesn't altogether support it, for I find that when Mr. Philip Harbin holds out the final result of his cookery demonstration I almost have to come to the assistance of the safety glass window in front of the screen.

That may be a rather special case, arousing deep-rooted and highly strained instinct; but the tendency is there with any very near close-up, and it is opposite to the appropriate movement for maintaining right perspective.

However, let us see what happens if we assume that the viewer gravitates to the distance where he can just detect that the picture is made up of lines. There are actually 377 of them (the rest being blacked out between frames), and normal eyesight is unable to distinguish them if they are closer than about 1 minute $\left(=\frac{1°}{60}\right)$.

So the $\theta$ for the whole picture, on this basis, would be $\frac{377}{60} = 6.3°$, which means that a 9-inch tube should not be viewed closer than $4\frac{1}{2}$ feet, and a 15-inch tube closer than $7\frac{1}{2}$ feet. At 6.3° the perspective is wrong for the present studio performances, and (what cuts much more ice) the picture is smaller than most viewers like.

The line structure argument, by the way, seems to me to have very little force in itself, being only a guide to the $\theta$ beyond which one sees no more detail in the picture. Viewers are quite entitled to prefer to sit closer, even though they see no more, just because for a variety of other possible reasons they may like the picture to look larger. If the line structure itself is disliked (though in certain types of drawings, much used in advertising, it is not only tolerated but seems to be highly favoured) it can easily be made almost invisible by adjusting the focusing control until the edges of the lines join up. The width of the spot, if circular, is then about half of one cycle at 2.5 Mc/s, so is not a seriously limiting factor in horizontal definition. As a matter of fact, most televisors suffer from slight astigmatism; that is to say, the setting for sharpest focus in the vertical direction does not exactly coincide with that for the horizontal. My policy is to adjust for sharpest line structure and then defocus slightly to merge the lines, choosing that rotation of the control which improves horizontal definition.

## Sight and Sound

How about the sound? One of the earliest gloomy forecasts about television was that it would be absurd to have a big voice coming from a tiny figure on the screen. That was a fine example of the muddled thinking I mentioned. The size of a singer to the onlooker is primarily $\theta$, not the number of feet or inches high in the flesh or on the screen. There is no need to have a picture millions of miles wide in order to show the sun at the size it appears to the eye. In normal circumstances it is within the capacity of televisors to present to the eye and ear the same size and loudness as they would experience direct at a performance. If the B.B.C. do their job properly the televiewer should not have to adjust his volume control as the camera approaches the performer, or vice versa.

Because screens are generally smaller than they would be if expense were no object, one does tend to sit rather close to them; and the question may well be raised about the possible loss of illusion when the sound (even when adjusted to give the correct loudness in the ear) is coming from a source at the same short distance. Whether it is another case of our illusions having been well and truly pre-destroyed in the cinema I wouldn't like to say, but in practice the question does not seem to arise. Any readers who do feel unhappy with the loudspeaker close up (again, assuming correct volume) may care to try a separate loud speaker at the estimated actual distance of the performer. Personally I think that any effect which might be gained in this way is likely to be obscured by the acoustics of the studio, which may or may not be beneficial, depending on circumstances. When listening to something going on some distance away in an ordinary room or hall, the sound received direct is modified by the sound reflected from the surroundings. Listening close up, especially in a room with plenty of upholstery and curtains, this added sound is almost negligible. Assuming that the studio and microphone are arranged to yield an appropriate ratio of indirect to direct sound, it seems unnecessary, if not actually undesirable, for the sound to be further modified by the listening room. So the only objection to the close-up loudspeaker is that the sound all comes from one source, which is what one would get by listening to what was going on in the studio through a hole in the wall. Placing the loudspeaker at a distance, so that reverberation does come from all directions, might be helpful if the listening-room acoustics fitted the scene and studio reverberation were absent—a not very likely combination of circumstances.

Some people go to the trouble of making the sound come from round the edges of the C.R. tube, instead of just below or to one side. Presumably with the usual arrangement they find it an effort to associate the sounds with the sights. If so, I think they must be in rather a small minority.

While on the subject of sound and sight it may be a good opportunity to stir up controversy still further by referring once again to what I named "scale distortion" (*Wireless World*, September 27th, 1937). However perfect the sound reproducer may be in other respects, it fails if the loudness (as heard by the ear) is not the same as if the performance were being heard direct. Altering the loudness inevitably alters the balance of sound frequencies. A quiet voice reproduced loudly sounds unnaturally deep. There is some degree of analogy between this and the perspective of the picture. Altering the size (as seen by the eye), that is to say, the $\theta$, inevitably alters the balance of dimensions, so that (for example) a distant scene reproduced close up looks unnaturally flat. Most people will tolerate both effects unless carried to extremes.

My conclusions on the whole matter of picture size are that the present sizes, even the smallest (9in tube) are perfectly all right for solitary viewers and courting couples. On special occasions, upwards of 20 people find it worth while to crowd round a 9in screen, but they would enjoy it better if the screen were much larger. The most popular choice, if it were free, would probably make $\theta$ about 10°, but is not at all critical. At a distance suitable for the average living room, 8 feet, 10° would require the picture to be 16 × 20in as provided by at least one model on the market, using a 4in projection tube. This $\theta$ is wrong for perspective with the present studio lenses, but may be nearer the mark later on; anyway, nobody worries. It is also more than close enough to the picture to show up the lack of definition in a 405-line system; the standard ought to go up to about 700 lines, but that is because the public would like more detail, not because they are afraid of seeing lines. If the accommodation would run to a longer distance, a larger picture still would suit the eyes better, for all except close-ups, and cinema fans would tolerate even these. The disadvantages of the present short-range viewing are not materially increased by the accompanying short range of the hearing. And finally the public can get used to almost anything, and in these days most of them have to.

## "Wireless World" Television Receiver

It should be pointed out that certain electrolytic capacitors are used in this equipment with normal applied voltages which are only slightly below their rated voltages. It is, therefore, necessary to take care that the equipment is not misused in such a way that an appreciable voltage rise can occur.

As an extreme example of such misuse, the operation of the power unit on open-circuit would almost certainly result in a voltage rise sufficient to damage the 32-$\mu$F electrolytic capacitor in it. Other conditions likely to result in a less serious rise of voltage are the operation of the equipment with the line or frame time-base output valves removed, or with *many* of the receiver valves removed.

As the removal of individual valves is often convenient when testing, there is no objection to the removal of any individual valve other than the line or frame time-base output valves. With the exception of these the current taken by any other is too small for its removal to cause any great rise of voltage.

**Correction.**—An error occurred in the circuit Fig. 1 of "Television Receiver Construction," Part 10 (*Wireless World*, December, 1947, p. 481) in which an EA50 D.C. restoring diode is shown. This valve was inadvertently included and should be entirely omitted.

### Manufacturers' Literature

CATALOGUE "DL" of Drydex batteries for radio receivers, hearing aids, etc., from Chloride Electrical Storage Co., Clifton Junction, nr. Manchester.

Leaflet describing electrical process timer, Model TDX-2, from Electro Methods, 220, The Vale, N.W.11.

Illustrated list of "Somerford" mains transformers (59 types) from Gardners Radio, Somerford, Christchurch, Hants.

Brochure describing the Type AL/5 cabinet loudspeaker for indoor P.A. application from Goodmans Industries, Lancelot Road, Wembley, Middlesex.

Leaflet describing Model 1200 cathode-ray oscilloscope from Industrial Electronics, 229, Hale Lane, Edgware, Middlesex.

Descriptive leaflets from Metropolitan Vickers Electrical Co., Trafford Park, Manchester, dealing with Oscilloscope and Test Set for "Seascan" radar, Cathode-ray Oscilloscope (Type 253), Signal Generator (Type 231), Miniature Cathode-ray Oscilloscope (Type 244), Stabilized Power Unit (Type 215), Valve Voltmeter and Test Set, R.F. heater (Type 310A).

Illustrated catalogue of accumulators in sealed glass boxes from the Tudor Accumulator Co., 50, Grosvenor Gardens, London, S.W.1.

# What is Good Reproduction?

## Discussion by the British Sound Recording Association

AT the Royal Society of Arts on November 21st the B.S.R.A. met to discuss the essentials of good reproduction of sound, and heard a lucid and comprehensive exposition of the problems involved.

M. G. Scroggie who opened the discussion said that there were two possible definitions of good reproduction, that which aroused in the listener the same sensations as the original sound or that which aroused the most pleasurable sensations. Both involved the subjective opinion of a listener and quantitative assessment was difficult; it was practically impossible to compare results obtained at different times and places.

Attempts had been made over the last 25 years to substitute objective measurements of reproducing equipment, but in spite of an enormous variety of tests from which to choose, no reliable system of objective testing had emerged. There seemed to be an unbridged gulf between the physical nature of sound waves and the emotional effect they produced. Hence it was necessary to be guided at all times by subjective effects and to continue to try to make objective tests agree with them. In correlating subjective and objective tests one should be on guard against hasty conclusions; bad reproducers often created strong harmonics, but it did not follow that all reproducers that created strong harmonics would necessarily be bad.

On the question of perfect, or pleasing, reproduction Mr. Scroggie referred to the frequent preference of listeners for a restricted frequency range, even when offered reproduction which was as perfect as present knowledge could make it. Recent experiments by Dr. Olsen in America, dispensing with electrical reproduction and using direct listening with and without acoustic filter screens, showed that listeners had no inherent distaste for high frequencies. The conclusion to be drawn was that the ear was capable of detecting distortions too small to be measured by the instruments of the engineer. Possibly the high-order odd harmonics such as the 11th, 13th, etc., in small fractions of one per cent may be the cause, but, in general, harmonics are relatively unimportant symptoms of non-linearity.

Harmonic distortion was easy to measure, but the single-tone input generally employed was singularly lacking in entertainment value and bore little relation to normal programmes. Non-linearity resulted in combination tones by intermodulation as well as harmonic distortion; whereas the lower harmonics harmonize with the original tones, the intermodulation products do not. The ear itself is non-linear; how then does it distinguish externally produced harmonic and combination tones? Possibly because the non-linearity is of a different kind producing different tones; if so, one would expect it to be more tolerant of high- than of low-order tones.

Mr. Scroggie then dealt with distortions arising in the loudspeaker and referred to recent measurements of transients which persist after the signal has been cut off. He also mentioned the Doppler-effect modulation of high by low notes; where amplitudes were large enough to make this serious, it was worth while using separate loudspeakers for high and low frequencies.

Modifications of the original sound pattern not usually classed as distortions included differences in the size and position of the sound source, also the effect of reverberation at both ends of the reproducing chain. The apparent reverberation time could be increased by placing the main loudspeaker at a distance, perhaps in an adjoining room, and using an extension loudspeaker with volume control near the listener; an echo effect could be produced by an almost inaudible output from the close-up source.

In the discussion which followed, one speaker thought that the effect of room acoustics at the receiving end could be solved, given the necessary finance, by covering one wall with loudspeakers to simulate a full orchestra, switching to a single central unit for speech, and substituting an infinitely absorbing labyrinth for the opposite wall! Denman[1] had approached this ideal many years ago when the audience virtually sat in the mouth of a large experimental horn loudspeaker let into the ceiling and, together with a thick carpet, themselves provided the requisite sound absorption. Several speakers underlined the importance of reverberation, and all were agreed that it ranked higher than wide frequency response in its emotional effect on the listener. In assessing the merits of a loudspeaker the listener should not allow the effects of reverberation to cloud his judgment. As an aid to reaching an appropriate psychological frame of mind for the test it was suggested by one speaker that the loudspeaker should be regarded as an aperture in a wall separating the listeners' room from the original performance in an adjoining studio.

Nine speakers, including W. S. Barrell, H. A. Hartley, J. Moir, M. J. L. Pulling and P. G. A. H. Voigt, took part in the discussion.

[1] *Wireless World*, July 31st, 1929.

### OUR COVER

This month's illustration shows some of the aerial arrays at G5BY, the amateur station operated by Hilton O'Heffernan at Bolt Tail, South Devon. In addition, there are two other multi-element rotating beam aerials for the V.H.F. bands and a 50-Mc/s rhombic aerial radiating towards N. America. G5BY has been particularly successful lately on the 50-Mc/s band, on which he has worked most U.S. districts, South Africa, Canada and Egypt.

# WORLD OF WIRELESS

## B.B.C. Management ♦ Purchase Tax Changes ♦ New Television Gear ♦ Nobel Prize for Ionospherist

### *B.B.C. CHANGES*

A BOARD of Management has been established at Broadcasting House under the chairmanship of Sir William Haley, the Director General. The other five members of the Board are:—Sir Noel Ashbridge, who has been deputy D.G. since 1943, becomes Director of Technical Services; B. E. Nichols, the new Director of Home Broadcasting, has been Senior Controller of Programmes since 1944; Maj. Gen. Sir Ian Jacob, who has been Controller of the European Service, assumes the control of both the overseas and European divisions as Director of Overseas Services; Air Chief Marshal Sir Norman Bottomley is to be Director of Administration; and a Director of the Spoken Word, who has yet to be appointed.

This arrangement does not alter the position of the Board of Governors who are responsible to the Government for the control of the Corporation.

Another change affects the television service. Maurice Gorham, who has been head of the television service since it reopened in June, 1946, has resigned and is succeeded by N. Collins, until recently Controller of the Light Programme. Mr. Gorham has been with the Corporation for 21 years and was at one time Editor of *Radio Times*.

### *P.T. ON VALVES AND BATTERIES*

THE effect of the change in Purchase Tax from 33⅓ per cent to 50 per cent on valves and cathode-ray tubes is shown in the following selection of prices from the revised schedule issued by the British Radio Valve Manufacturers' Association. The increased purchase tax does not, of course, apply to stocks in retailers' hands on which the lower rate had already been paid. The pre-Budget Purchase Tax is given in brackets.

| Valve list price | Purchase Tax |
|---|---|
| s. d. | s. d. |
| 4 9 | 1 7 (1 1) |
| 9 0 | 3 0 (2 0) |
| 10 0 | 3 3 (2 2) |
| 11 6 | 3 9 (2 6) |
| 15 0 | 4 11 (3 3) |
| 17 6 | 5 9 (3 10) |
| 20 0 | 6 6 (4 4) |
| **C.R.T. list price** | |
| £9 (9in) | 70 3 (46 10) |
| £12 (12in) | 93 8 (62 5) |

Cathode-ray tubes for oscilloscopes are not affected by the increase as they are not subject to Purchase Tax.

An amendment to the Finance Bill has reduced the Purchase Tax on batteries and accumulators from 50 per cent to 33⅓ per cent.

### *B.B.C. TELEVISION O.B. UNIT*

THE B.B.C. is to use the Pye Videosonic system of television for some of its outside broadcasts. The Corporation has ordered one of the Pye O.B. units which, it will be recalled, is a complete transmitter—from camera to aerial—in a "shooting brake."

One of its main features is its reduced size compared with the convoy of vehicles which constitutes the present O.B. units.

The Videosonic transmissions, in which the sound channel is conveyed by width-modulated pulses inserted in the line sync pulses, will be received at Alexandra Palace where vision and sound will be separated before retransmission.

### *NEW TELEVISION CAMERA*

ONE of the new C.P.S. (cathode-potential stabilizers) Emitron camera tubes was used by the B.B.C. for televising the Royal Wedding. Situated opposite Westminster Abbey, it was used to televise the procession as it approached Parliament Square. A Super-Emitron then took over while the C.P.S. Emitron was panned round on to the Abbey door to give close-ups of the bridal party and some of the guests alighting from the coaches.

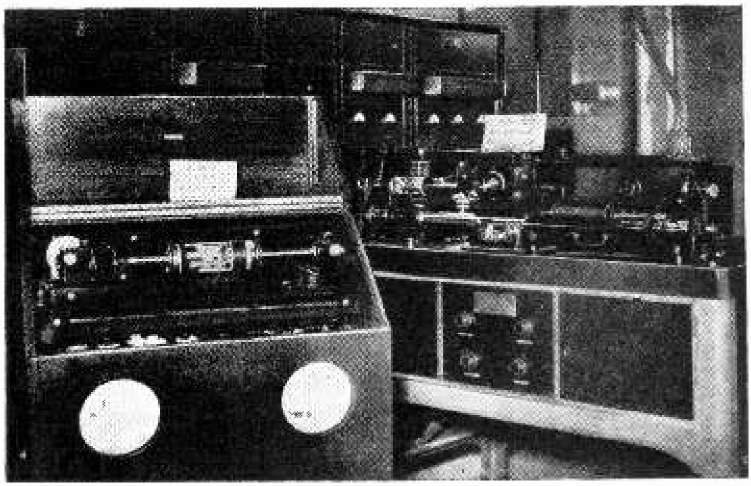
This new E.M.I. tube is of increased sensitivity and is largely free from the shadow effects which demand "tilt and bend" correction.

### *PICTURE TRANSMISSION*

WHEN completed, the new phototelegraphy equipment now being installed by Cable & Wireless in Electra House will provide for the simultaneous transmission and reception of pictures on five radio channels.

The company's phototelegraphy equipment was completely destroyed when its Central Telegraph Station was burnt down by incendiary bombs in 1941. It was temporarily re-equipped with Post Office gear and more recently with the G.E.C. console phototelegraphy transmitter-receiver. New equipment has also been purchased from Muirhead's, of Elmers End, Kent, and Edouard Belin, of Malmaison, France.

The Muirhead equipment, which



PICTURE TELEGRAPHY. The new Belinographe phototelegraphy equipment (right) and the G.E.C. consol transmitter-receiver installed by Cable & Wireless in Electra House.

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has not yet been installed, is basically the same as that fitted in H.M.S. *Vanguard* for the Royal tour of South Africa, to which reference was made in our March issue.

Two Belinographe units have already been installed.

With the installation of this equipment six additional photo-telegraph services will shortly be opened—mainly with Empire countries.

The largest volume of traffic ever handled by C. & W. was on the occasion of the Royal Wedding. In all 222 pictures were transmitted to fifteen countries.

## R.S.G.B. STATION

THE headquarters' station of the R.S.G.B. is expected to be on the air early in the new year. Initially it will operate as a frequency marker.

It is proposed to radiate a short automatically transmitted message at a speed of 12 w.p.m. during the first two minutes of each hour from 0600 to 2400, on 3500.25 kc/s.

## DISC OR TAPE ?

THE oft-repeated rumour that the gramophone record companies have attempted to restrain the development of new methods of recording, such as those on magnetic tape and wire, to protect their interests in disc manufacture, have been discredited by Sir Ernest Fisk. In his statement as vice-chairman and managing director of E.M.I., Sir Ernest announced at the annual general meeting that the company is energetically developing these new methods of sound recording and reproduction.

In defence of the disc he instanced the cheapness and the ease of mass production, adding that at present there is no practical method for the mass production of wire and tape records.

## REMINISCENCES

THE Silver Jubilee of the B.B.C. brought forth a spate of articles in both the specialist and lay press by old-timers. Some of them included interesting reminiscences which are worth recalling.

Arthur Burrows, whose death is recorded in these pages, reminded readers of the three-minute interval which followed each seven minutes of broadcasting. This was a condition of the B.B.C.'s original licence to avoid possible interference with distress calls.

Sir William Haley, B.B.C. Director General, states "Any celebration of British broadcasting would be incomplete without a tribute to Lord Reith [the B.B.C.'s first general manager]. Few men have had opportunity to render so vital a service to their generation. No man has discharged a great responsibility with more seriousness or higher purpose."

## NOBEL PRIZE WINNER

SIR EDWARD APPLETON, F.R.S., is the first radio physicist since the days of Marconi to be honoured by the award of the Nobel physics prize. In announcing the award the Swedish Academy of Science stated that it was "for his work on atmospherical physics, and especially for his discovery of the Appleton layer."

The last radio award was made jointly to Marconi and Braun in 1909.

Sir Edward, who has been Secretary (Administrative Head) of the D.S.I.R. since 1939, started his research into the existence of the ionosphere whilst in the Cavendish Laboratory, Cambridge, where from 1919 he taught physics under Sir J. J. Thomson. From 1924 to 1936 he was Wheatstone Professor of Experimental Physics, King's College, London, and from 1936 until his present appointment he was Jacksonian Professor of Natural Philosophy, Cambridge. He has been president of the International Scientific Radio Union since 1934.

SIR EDWARD APPLETON, G.B.E., K.C.B., F.R.S.

It will be recalled that Sir Edward was recently awarded the U.S. Medal of Merit for his wartime contributions to radar and to Anglo-American scientific collaboration during the war.

The value of the Nobel prize is £8,000.

## RECEIVER EXPORTS

ALTHOUGH there was a marked decrease in the export of domestic receivers during October as compared with the 1946 figure (29,493 as against 54,492), the figures for the period January to October show an increase of nearly 80,000 sets. The increase in value is considerably greater. The 262,218 receivers exported during the ten-month period in 1946 were valued at £2,470,220, whereas the value of this year's 340,873 sets was £3,849,920.

The biggest market continued to be India, which purchased 92,740 sets during the ten months under review. The 1938 figure for the same period was 4,088. The Indian Government recently decided to place a ban on the import of broadcast receivers.

TAXI RADIO.—**Two-way radiotelephony gear installed by Pye in one of a fleet of sixteen taxis in Cambridge. Its use, to give orders to taxis, accounts for a considerable reduction in "dead mileage".**

## REGISTER OF MANUFACTURERS

AMONG the 4,500 British manufacturing organizations listed in the first post-war edition of the "F.B.I. Register of Manufacturers" which has just been published, are a considerable number in the radio industry. This 1947/48 edition of the Register, which is published jointly by Kelly's Directories and Iliffe and Sons, is the only complete guide to the members of the Federation of British Industries.

One section of the volume classifies the manufacturers under 5,250 headings of their products or services. Reference facilities are given in French and Spanish.

Distribution is being handled by Kelly's Directories, Ltd., 186, Strand, London, W.C.2, from whom copies are available, price £2 2s. There are special terms for F.B.I. members.

### INDUSTRIAL BURSARIES

THE British Council has inaugurated a scheme for awarding short-term bursaries to enable technical workers from overseas to see something of industrial techniques in this country. Although so far there have not been any applications from workers in the radio industry it is included in the list of trades covered by the scheme.

The bursary will cover travelling expenses and a maintenance grant during the three or four months' stay in this country. Candidates should apply to the offices of the British Council in their own country.

### MARINE RADAR

THE original date fixed for the termination of the agreement whereby Admiralty radar equipment Type 268 is fitted in merchant ships as an interim measure was June, 1947. This was extended to December and has again been extended as, so far, no commercial equipment has been submitted to the Ministry of Transport for approval.

Some 260 ships of the Merchant Navy have been fitted with Type 268 radar and the arrangements for maintenance in this country and overseas have been extended to cover the continued use of the gear.

### NAVIGATIONAL FILMS

RADAR is featured in the latest of the "Britain Can Make It" series of films sponsored by the Central Office of Information. This film, No. 6, which has been produced jointly by the Ministry of Transport and the C.O.I., shows the production of radar equipment and its application to marine navigation. Available on both 16 and 35 mm film, this 10-minute sound reel can be borrowed from the Central Film Office of the C.O.I., London, W.1, or in the case of overseas readers from the Information Officer attached to the British Embassy in their own country.

Another radar film (16 mm sound) is available from the Ministry of Supply. "R.D.F. to Radar," as its title implies, traces the history of radar from the early experiments of Watson-Watt to its latest applications to air navigation. Produced by the Telecommunication Research Establishment, Malvern, the 40-minute film is available from the Information Branch, Ministry of Supply, Shell Mex House, London, W.C.2.

Two films featuring marine radar have been produced by Metrovick. One, "Radar Goes to Sea," shows the production and use of the Seascan equipment and the other, "Radar Record," includes a photographic record of the P.P.I. picture taken during a trip up the Firth of Clyde.

The successful use of Decca in speeding the passage of colliers during last year's fuel crisis is featured in the film "The Decca System of Navigation." This 16 mm sound film, which runs for 30 minutes, can be borrowed from the Decca Navigator Co.

### SUPERSONIC HIGH FIDELITY ?

AT a meeting of the Royal Society of Arts on November 19th, under the chairmanship of Sir Noel Ashbridge, a paper was read by Sir Ernest Fisk on the "Development of Sound Recording and Reproduction." In it he disclosed that E.M.I. had been successful in recording frequencies as high as 20,000 c/s on lateral-cut discs. In the discussion which followed several speakers, including Sir Malcolm Sargent, expressed the opinion that we might have to record supersonic frequencies in order to ensure complete realism of reproduction.

Comments on this apparent paradox will be found on p. 36.

ARTHUR BURROWS, whose death is announced on this page, broadcasting from 2LO in 1922. He was Director of Programmes of the original B.B.C.

### PERSONALITIES

**Air Cmdre. L. Dalton-Morris,** C.B.E., is relinquishing the post of Director of Signals, Air Ministry, on his appointment as commandant of the Central Signals Establishment at Watton, Norfolk. The C.S.E. provides flying facilities for the calibration and testing of radar and radio navigational aids and is the training station for operating crews for all ground control approach installations.

**Air Cmdre. E. H. Richardson,** C.B.E., who has been Director of Radio at the Air Ministry since August, 1946, is to become Director of Signals in succession to Air Cmdre. L. Dalton-Morris (see note above). In his present position he is responsible for the technical direction of the R.A.F. signals service; he will in future be responsible for signals policy, planning and organization.

**S. H. Capon** has been appointed Sales Engineer of T.C.C. He was formerly senior production officer in the Ministry of Aircraft Production.

**C. A. Ingram,** B.A.(Cantab), has been appointed secretary of the Radio Section of the I.E.E. in succession to K. W. T. Brown, who held the post for a few months. Prior to joining the I.E.E. in 1946, Mr. Ingram was a Naval radar officer.

**Leslie McMichael,** director of McMichael Radio and past president of the Brit.I.R.E., is visiting Australia and New Zealand for a few months during the early part of 1948.

### OBITUARY

It is with regret we record the death of **Arthur Burrows** at the age of 65. "Uncle Arthur," as he became known to thousands in the early days of the B.B.C., was a pioneer of broadcasting. In 1920 he radiated a daily programme from a liner during her trip across the North Atlantic. The transmissions, radiated from the ship's 3-kW set, were received at 1,200 miles. Burrows left the B.B.C. in 1925 to become general secretary of the International Broadcasting Union, a position he held until early in the war, when he rejoined the B.B.C. He became Director of Broadcasting at the Ministry of Information in 1942.

### IN BRIEF

**Car Radio Licences.**—Motorists can obtain a refund, at the rate of 1s 8d per month, on the unexpired portion of their car radio receiving licences where a car has been laid up because of the withdrawal of the basic petrol ration. Application should be made to the nearest Head Postmaster, enclosing a formal signed notification stating that the car had been withdrawn from service.

**Preparatory** to the All-American wavelength allocation conference to be

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held next year in Canada, a meeting of the signatories to the Havana Treaty of 1937 was held in Havana in November. The original Havana wavelength treaty was extended in 1946 for a further two years. The allocations will cover all wavelengths for North and South America in the medium-wave band.

**An increase** of 2,800 television receiving licences during October is recorded by the G.P.O. The total number was 27,850.

**A.F.N. Aerial.**—The introduction of a new aerial for the American Forces Network transmissions from Munich-Stuttgart on 240 metres was marked by a special programme during which the switchover took place. The old aerial was directed to this country for "Lord Haw-Haw's" broadcasts. The new installation is intended to give better coverage in Southern Germany. There was no noticeable break in the transmission during the switchover and no apparent diminishing in signal strength in the home counties.

**Consol.**—Because of the possible closing down of the North Atlantic chain of Loran stations with the re-allocation of frequencies consequent upon the Atlantic City decisions, the International Civil Aviation Organization has been urged to erect Consol stations in Norway, N. Ireland, Iceland, the Azores, Newfoundland and Bermuda.

**Aircraft Relay Stations.**—To ensure the reception of the hourly weather reports from aircraft on the North Atlantic route when adverse conditions for H.F. transmission prevail, air liners are now operating as E.H.F. relay stations. A constant watch in the E.H.F. band is kept by radio officers in aircraft belonging to members of the International Air Transport Association, who will pass on reports from one to another until they are within range of a ground station.

**Phototelegrams.**—A phototelegraphy circuit between the U.K. and Bermuda was recently opened by Cable and Wireless. The usual Empire charges apply for a picture measuring up to 24 sq in:—commercial, £5; Press, £3.

**Amateurs' Course.** — Prospective amateur transmitters in the Southport area may be interested to learn that the Southport Technical College has arranged a course covering the syllabus for the City and Guilds' examination for a transmitting licence.

**Pakistan.**—The administrative headquarters of the Pakistan Broadcasting Service has been established in Karachi, where a new station is to be built. It is to be equipped with two 50-kW American transmitters. At present Pakistan has only three stations, all medium-wave, at Lahore, Peshawar and Dacca.

**Society of Relay Engineers.**—We have received from the Society of Relay Engineers a copy of the constitution under which the society was formed in 1945. Among the objects are the improvement of the status and efficiency of those engaged in relay engineering. T. H. Hall, A.M.Brit.I.R.E., has been appointed secretary of the society. The society's offices have been transferred to 23, Dalkeith Place, Kettering.

**Radio and Radar** are featured in the "Highways of the Air" exhibition staged by the Royal Geographic Society at its headquarters in Kensington Gore, London, S.W.7 (December 22nd-January 15th). The Ministry of Civil Aviation is exhibiting Consol, Gee and I.L.S. equipment. The exhibition is open on weekdays, except Christmas Day and Boxing Day, from 11.0 to 5.0.

**I.E.E. Conference.**—The I.E.E., in collaboration with the British National Committee for Scientific Radio, is planning to hold a conference on radio physics, radio noise, propagation and the standard of measurement. The proposed dates are April 7th and 8th.

## INDUSTRIAL NEWS

**Baird.**—The office of John Logie Baird, Ltd., has been transferred from Upper Grosvenor Street, London, W.1, to 466, Alexandra Avenue, Rayners Lane, Pinner, Mddx (Tel.: Pinner 2051).

**Cintel.**—To introduce the new range of Cintel electronic apparatus manufactured by Cinema-Television, Ltd., the company has arranged a trade exhibition at Brettenham House, Lancaster Place, Strand, London, W.C.2, from January 20th-31st. Admission to the exhibition, which will be open from 9.30 to 5.0 daily, except Sunday, will be by ticket obtainable from Cinema-Television, Ltd., Worsley Bridge Road, London, S.E.26.

**Foire de Paris.**—The 1948 Paris International Trade Fair will be held from May 1st to 17th. Some 200 of last year's 9,000 exhibitors were British. The London representative of the fair is Miss Lambert, 14-15, Rugby Chambers, Rugby Street, W.C.1, from whom details may be obtained.

**Manchester Radio Industries' Club.**—The Manchester Radio and Electrical Club, which has a membership of nearly 200, has become affiliated to the Radio Industries' Club, and will in future bear the above name.

## CLUBS

**Barnet.**—Non-members will be welcome at the next meeting of the Barnet Group of the R.S.G.B., which will include a sale of surplus gear. It will be held at 7.30 on January 17th at the Millicent Café, Lytton Road, New Barnet. Sec.: R. Walker, G6QI, 7, Potter's Lane, New Barnet, Herts.

**Burnham (Som.).**—The first meeting of the Burnham and Highbridge Amateur Radio Society, which is in course of formation, will be held in January. Interested amateurs in the Burnham area of Somerset should communicate with the acting secretary, A. D. Taylor, G8PG, c/o P.O. Radio Station, Highbridge, Som.

## MEETINGS

**Institution of Electrical Engineers**

*Radio Section.*—"Reference-Crystal-Controlled V.H.F. Equipments," by D. M. Heller and L. C. Stenning, on January 14th.

Discussion on "To what Extent does Distortion Really Matter in the Transmission of Speech and Music?" on January 20th; opener, P. P. Eckersley.

*Informal Meeting.*—Discussion on "The British Patent System and Procedure" on January 26th; opener, C. S. Parsons, B.Sc.

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

*Cambridge Radio Group.*—Address by C. E. Strong, O.B.E., Radio Section chairman, on January 13th at 6.0 at the Cambridgeshire Technical College. Sec.: J. E. Curran, M.Eng., University of Engineering, Trumpington Street, Cambridge.

*North-Western Radio Group.*—"Triodes for Very Short Waves," by J. Bell, B.Sc., M. R. Gavin, M.B.E., M.A., B.Sc., E. G. James, Ph.D., B.Sc., and G. W. Warren, B.Sc., on January 21st at 6.30 at the Engineers' Club, Albert Square, Manchester. Asst. Sec.: A. L. Green, 244, Brantingham Road, Chorlton-cum-Hardy, Manchester, 21.

*Scottish Centre.*—"Speech Communication under Conditions of Deafness or Loud Noise," by W. G. Radley, C.B.E., Ph.D.(Eng.), on January 27th at 6.15 at the Societies' Rooms, The Royal Technical College, George Street, Glasgow. Sec.: R. B. Mitchell, 154, West George Street, Glasgow, C.2.

*North-East Scotland Sub-Centre.*—"The Design of a High-Fidelity Disc Recording Equipment," by H. Davies, M.Eng., on January 7th at 7.30 at the Caledonian Hotel, Aberdeen, and on January 8th at 7.0 at the Royal Hotel, Union Street, Dundee. Sec.: P. Philip, c/o Electricity Supply Dept., Dudhope Crescent Road, Dundee.

*South Midland Radio Group.*—"The Cavity Magnetron," by H. A. H. Boot, Ph.D., and Professor J. T. Randall, D.Sc., F.R.S., on January 26th at 7.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham. Sec.: E. May, Birlec, Ltd., Tyburn Road, Birmingham, 24.

**Royal Society of Arts**

"Recent Progress in the Making of Precision Instruments," by A. J. Philpot, C.B.E., M.A., B.Sc., on January 28th at 2.30 at the R.S.A., John Adam Street, Adelphi, London, W.C.2.

**British Sound Recording Association**

"The Significance of the Amplifier in High-Fidelity Recording and Reproduction," by H. J. Leak, on January 23rd at 7.0 at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. Sec.: R. W. Lowden, Wayford, Napoleon Avenue, Farnborough, Hants.

**Radio Society of Great Britain**

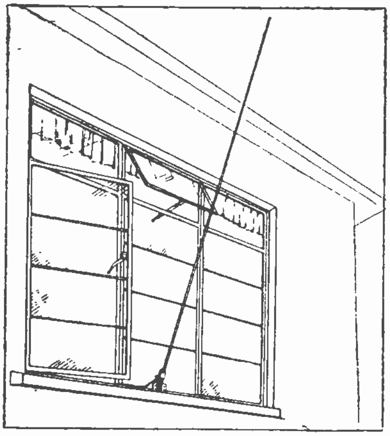
"The Design and Construction of Amateur Transmitters," by J. N. Walker (G5JU), on January 9th at 6.30 at the I.E.E., Savoy Place, London, W.C.2. Sec.: J. Clarricoats, New Ruskin House, Little Russell Street, London, W.C.1.

**British Kinematograph Society**

*Newcastle Section.*—"The Cathode-Ray Tube," by G. Parr, on January 6th at 10.30 in the Neville Hall, Neville Street, Newcastle-on-Tyne. Sec.: E. Turner, 30, Ettrick Grove, Sunderland, Co. Durham.

# THE BELLING-LEE PAGE

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



**The illustration shows the "WINROD" aerial L.581. Price 19/6. It is neat, inexpensive and easy to fix. An outdoor aerial of this type will always improve signal to noise ratio in relation to indoor types. (Note to dealers at foot of page.)**

We have re-established our "short run" department to enable us to undertake "special" work for customers, including Universities and Government Research Establishments from whom suggestions are welcome for the modification of Belling-Lee components, and the consideration of development contracts within our sphere of activities.

We appreciate that many research establishments are three to five years ahead of commercial practice and only by the closest co-operation with them in the earliest stages can we hope to reap the full benefit.

The policy behind the activities of this Company can be summarised as (1) Safety, (2) The elimination of interference with radio.

(1) Safety is provided by the adequate fusing of electronic circuits calling for fuses of considerable accuracy. It is possible for a radio receiver or any other appliance to cause fire before the blowing of a normal 5 amp. house fuse. In spheres other than radio and electronics, we assist protection by a comprehensive range of thermal switches which many manufacturers fit to motors used in refrigerators, etc. These obviate burnt out motors by cutting off current if excessive heat is generated by a fault.

(2) The elimination of interference is dealt with in two ways.

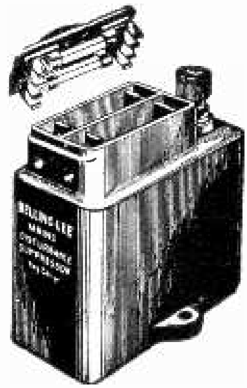
(a) By the production and encouragement in the use of better radio connections typified by terminals, plugs and sockets, and valveholders of many kinds.

(b) We claim to be the first firm to specialise in the suppression of electrical interference. This is dealt with both at the listener's end and at the source.

All the work we have done on the subject, supported by the findings of the Post Office, the B.B.C. and the Electrical Research Association, emphasises that suppression must be a co-operative effort. A reasonable aerial at the listener's end, and a reasonable amount of care taken in the design of the appliance, or the suppression of the interference it creates.

When we started this work we were alone. Many firms have since joined in the fight against interference by offering vertical aerials, matching transformers, window aerials, etc. The more firms manufacturing and advertising such appliances the better for the cause. Provided always that the products are technically worthy. It is possible to introduce losses in an aerial system that may give rise to much disappointment.

Suppression at the source is a tricky subject. There are few secrets in the design of suppressors. It may truthfully be said that any fool can make suppressors, but it takes craftsmen with experience to use them efficiently. Much the same may be said of aerials. Perhaps that is why we get so many of the difficult cases, e.g. those on the outer fringe of the range of Alexandra Palace, etc. Probably it also accounts for our being called upon to suppress interference on the Royal Train on the occasion of Their Majesties' visit to South Africa. When great shipping companies require suppression on the largest



**This type of suppressor is usually recommended by the Post Office, for fitting at the meter board or across the brushes of interference-creating motors and generators, etc. List No. L.1118/CT. Price 27/6.**

liners, Belling-Lee do the work. They are also honoured to serve the fishing fleets of home waters and those operating in distant deep sea fisheries.

### A soldering tip

The use of polythene insulant in plugs and sockets with particular reference to our coaxial range, raises one or two points. Firstly, official technical opinion is against any attempt being made to solder to the screen of cable with polythene insulant. More harm than good is likely to follow.

Parts to which you are likely to solder are silver-plated to ensure easy and quick "wetting." See that the iron is at the correct temperature. If it is running cool through electrical "load-shedding" and allowed to lie for a considerable time on the part to be heated, heat will travel to the polythene, with the result of a distorted plug or socket.

**★WINROD AERIALS CAN NOW BE SUPPLIED**

**EX STOCK**

**FROM YOUR WHOLESALER**

*(See illustration above)*

**BELLING & LEE LTD**

CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX

# More Low-Power Transmission

## Analysis of Present-day Results on 7 Mc/s

By W. OLIVER (G3XT)

PRE-WAR readers of the *Wireless World* may remember an article headed "Low-power Transmission—Long Ranges on One Watt," which appeared in the issue dated September 14th, 1939. This contained a detailed analysis of the results obtained with a very low-power transmitter at G3XT over a period of five months, and the performance of this set, with an input averaging one watt from batteries, was shown to be consistently good under all conditions in the overcrowded 7-Mc/s waveband and at times little short of amazing.

Strangely enough, an analysis of results obtained at G3XT during a corresponding five-month period recently shows that the low-power performance of this station has proved to be even more successful than before.

The analytical tables accompanying this article give a comparative record of the results obtained during the two periods, pre-war and post-war. One can see at a glance that the 1947 results are far superior in all respects.

**ANALYSIS OF RST REPORTS ON SIGNALS FROM G3XT OVER A PERIOD OF 5 MONTHS IN 1947**

| Strength (S) | Readability (R) 5 | 4 | 3 | 2 | 1 | Totals |
|---|---|---|---|---|---|---|
| 9 | 6 | — | — | — | — | 6 |
| 8 | 21 | — | — | — | — | 21 |
| 7 | 99 | 7 | — | — | — | 106 |
| 6 | 154 | 13 | — | — | — | 167 |
| 5 | 98 | 35 | 8 | 1 | 1 | 143 |
| 4 | 14 | 25 | 6 | — | — | 45 |
| 3 | 4 | 8 | 6 | 1 | — | 19 |
| 2 | 2 | 1 | — | — | — | 3 |
| 1 | — | — | — | — | — | — |
| Totals | 398 | 89 | 20 | 2 | 1 | 510 |

**ANALYSIS OF COMPARATIVE RESULTS FOR A CORRESPONDING PERIOD IN 1939***

| Strength (S) | Readability (R) 5 | 4 | 3 | 2 | 1 | Totals |
|---|---|---|---|---|---|---|
| 9 | 1 | — | — | — | — | 1 |
| 8 | 11 | — | — | — | — | 11 |
| 7 | 57 | 1 | 2 | 2 | — | 62 |
| 6 | 74 | 8 | 4 | 1 | — | 87 |
| 5 | 83 | 18 | 3 | 1 | — | 105 |
| 4 | 17 | 8 | 4 | — | — | 29 |
| 3 | 5 | 2 | 7 | — | — | 14 |
| 2 | 1 | 2 | — | — | — | 3 |
| 1 | — | — | 2 | 1 | — | 3 |
| Totals | 249 | 39 | 22 | 5 | 0 | 315 |

* "Low-power Transmission," by W. Oliver (G3XT), *Wireless World*, September 14th, 1939.

For this latter investigation three different transmitters have been used, and all have given broadly similar results, although they differed considerably in design, layout and power. The first transmitter is similar to that used in 1939 and the input, too, is the same—approximately one watt.

The second and third transmitters are single-valve sets and are pentode crystal oscillators. Among the valves tried in the second transmitter are the Z220, PM22A and 1C5, with inputs ranging from 1 to 3 watts. The third transmitter is a rather unconventional mains set with a 22A6 as the oscillator, and an input of 4 to 5 watts.

Although the mains transmitter is the most powerful of the three, in actual practice the average reports are much the same irrespective of which one is in use. In fact, experience has shown that other amateurs who were familiar with the signals from this station were quite unable to tell which of the transmitters was on the air at any particular time.

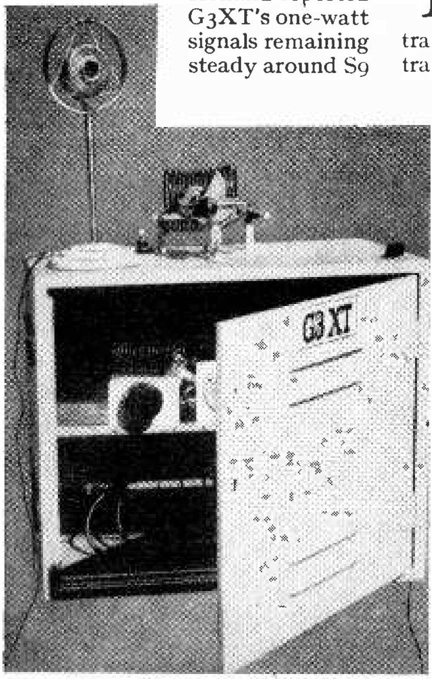
### Aerial

The present transmitting aerial is a 66ft. end-on type and is a few feet higher than those generally used before the war. It is also a little more in the open relative to surrounding trees and buildings, otherwise it shows little improvement over the earlier ones. It is obvious, therefore, that the immense improvement in results cannot be attributed to any increase in the efficiency of the transmitter, aerial or power.

The most plausible explanation of the superior results now obtained probably lies in a great improvement in the receiving

**More Low-Power Transmission—**
technique at the other stations contacted by G3XT. Many amateurs have undoubtedly gained a great deal from the training and experience they had as radio operators in the Services, and the majority seem to have better receiving sets now than they did before the war. The fact that so many ex-Service operators are at present working exclusively in C.W. may also be a contributory factor.

On one occasion a station in Holland reported G3XT's one-watt signals remaining steady around S9




One of the low-power transmitters at G3XT. The aerial tuner is mounted on top of the metal cabinet.

throughout a QSO which lasted for an hour. Only three out of the six "top-score" reports were obtained with the mains transmitter, using a power of 4 to 5 watts.

It will be seen that the S8, S7 and S6 signal reports are roughly double their 1939 total, whereas the reports of lower strength signals have remained round about the same as before the war. This is the most convincing proof of an all-round improvement. An even more encouraging point is the number of successful contacts which have been made by G3XT during periods of heavy QRM. Recent experience has shown that it is possible to get as many as fifteen or twenty contacts on 7 Mc/s during the height of week-end activities with signals fully readable, despite interference, throughout a conversation lasting ten or fifteen minutes.

# Output Transformer Efficiency

## A Simple Method of Measurement

By
*A. E. FALKUS*, B.Sc. (Eng.), A.M.I.E.E.
(Chief Engineer, R. & A. Ltd.)

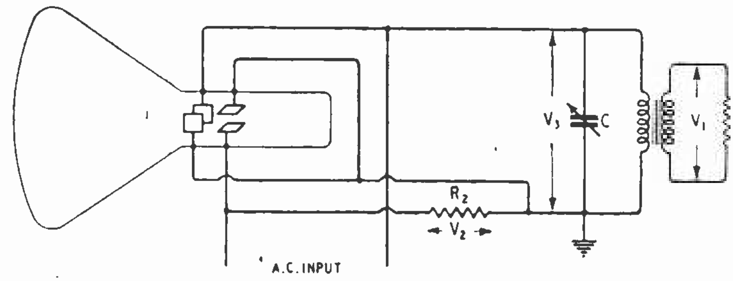
THE problem of measuring the overall efficiency of small audio - frequency transformers, such as the output transformer of a domestic radio set, offers certain difficulties as the power concerned is too small to be measured accurately with the usual type of wattmeter.

Transformer efficiency is normally specified working into a pure resistive load, nd the output watts may therefore be easily obtained from a voltmeter reading across this load. Measurement of the input power is, however, more difficult. Owing to the leakage inductance in the transformer, which may be quite appreciable, the input current will be out of phase with the applied voltage, and the product of input current and input voltage will give a falsely high value for the input watts.

It occurred to the writer that if the right value of capacity were shunted across the transformer input to compensate for the inductance, in the manner of the normal power factor correction condenser, the input current and voltage could be brought into phase, and their product would then give a true value for the input watts. This condenser must, of course, absorb some energy, but in practice the error is quite negligible.

If various values of condenser are connected across a transformer working into a constant load, one value of capacity can be found which will give a minimum for the product of input volts and amps for a constant output. A practical way of determining the right capacity is to connect a resistance in series with the transformer primary and to connect this resistance and the transformer primary to the X and Y plates of a cathode-ray tube, as shown in the figure. Care must be taken to make direct connection to the plates, as if this is made through an amplifier an unknown amount of phase shift may be introduced.

The trace on the screen will be an ellipse. If the capacity in shunt across the transformer is now varied the ellipse will be seen to swell or shrink in width, and a value is easily found for which the ellipse becomes a straight line. This occurs when the volts across




Cathode-ray tube connections for resonance indication in test for small A.F. transformer efficiency.

the series resistance are in phase with the volts across the transformer, that is, the input current and voltage are in phase.

If the value of the series resistance is $R_2$ and the voltage as measured across it by a valve voltmeter is $V_2$, then the input current is $\frac{V_2}{R_2}$. If $V_3$ is the voltage across the transformer primary, then the input power is $V_3 \times \frac{V_2}{R_2}$. If the load resistance is $R_1$ and the output volts $V_1$, the output power is $\frac{V_1^2}{R_1}$. The overall efficiency is therefore:—

$$\frac{V_1^2 R_2}{V_2 V_3 R_1} \times 100 \text{ per cent.}$$

It is of interest to note that the effective leakage inductance may be calculated from the value of C required to bring the input current and voltage into phase. It can be shown that the leakage inductance in henrys is:—

$$\frac{V_3^2 C}{(V_3 \omega C)^2 + \left(\frac{V_2}{R_2}\right)^2}$$

Where: C is in farads.
$V_2$ and $V_3$ are in volts.
R is in ohms.
$\omega$ is $2\pi \times$ frequency of test.

In practice it will be found a good plan to choose a value for $R_2$ somewhat smaller than the nominal input impedance of the transformer. The value of C for a small output transformer measured at a frequency of 400 c/s is likely to be about 0.015 $\mu$F.

# Electronics and Space Flight

## New Uses for Radio ?

IT is not many years since flight outside the earth's atmosphere was entirely visionary; fit for fantastic fiction, but not a subject for practical engineering. Although space flight has not yet been developed to the point at which cruises round the moon or planets can be advertised, that is an extension in detail, rather than in principle, of what has already been accomplished. So when Arthur C. Clarke spoke to the British Interplanetary Society* on the uses of electronics in this far-flung activity, he did not have to begin by apologizing for the subject matter. So far from being pure speculation, his lecture naturally included present-day practice in such initial ventures as the V2 and moon radar, and proceeded to quantitative examination of more ambitious projects for the future.

The word "electronics" in the title was used, for lack of a better one, to include not only valve and circuit devices but possible applications in the entire electromagnetic spectrum. It was pointed out that the longer radio waves on the one hand, and ultra-violet on the other, are stopped by the earth's atmosphere, but except for a few absorption bands the range from 10 to $10^9$ Mc/s is available. Owing to the great sensitivity of photo-electric devices, and the compactness of high-power radiators, it might well be that light waves would be superior to radio for communication from space ships.

The power required for radio communication was tabulated for typical cases. For example, using a 100 sq metre radiator on the earth and 1 sq metre on the ship at the distance of the moon, a power of only 16 watts would be sufficient, ideally, for speech communication on a wavelength of 10cm. If the large radiators were used at both ends, morse communication to Jupiter at 400 million miles would be within the capabilities of present-day equipment. But there would be an inconvenient time lag, due to propagation, of more than an hour between dispatch of the message and the reply!

Communication with reasonable power depends on two things: a narrow beam, and a narrow bandwidth. The first presents the problem of keeping the aerials trained on their targets; a problem which wartime development of "lock-follow" has gone a long way towards solving. The second involves an analogous problem due to Doppler effect; the receiver acceptance band has to be kept trained on a shifting frequency. The shift can be pre-calculated, however, and in this—as in the complex calculations of space navigation—electronic computors would no doubt be used to give quick and accurate answers. The Doppler effect would be of the utmost value for enabling the speed of approach at landing to be indicated. The sensitivity of this method was strikingly demonstrated at Radiolympia, where movement as slow as 0.1 metre/sec lit the indicator lamp.

Although weight aboard a space ship would be at such a premium as to allow only essential equipment to be carried, there would be no such restrictions on land, where electronics could be given a free hand in simulating conditions of flight in the trainers that would be necessary to enable prospective pilots to make their initial mistakes without suffering the drastic penalties that would follow in actual space flight.

Mr. Clarke discussed possible navigational aids. Celestial observations, with electronic computors, would probably serve most requirements in manned ships; but telemetering and control equipment would be required for pilotless craft. He mentioned the value to radio research of observations from outside the ionosphere, transmitted by rocket-propelled *ballons sondes*, which should be well within the scope of known techniques.

Any hopes that radar might be used to give space pilots warning when to take anti-meteor evasive action were completely demolished by the lecturer. The amount of power needed for giving even a few seconds notice of normal-sized meteors was fantastic—probably enough to volatilize all the said meteors in its beam! Nor would it be easy, in the moment or two available, to scan the relevant space, pick out from the numerous meteors present therein any that would collide with the ship, and compute the evasion that would dodge it without running into another. In actual fact, the risk of collision was one that could be faced fairly calmly, being of the order of once per million years per ship. M. G. S.

* 8th November, 1947.

# Air-line Radio

## Equipment for Operation on Long Routes

A GOOD idea of the radio equipment of a large modern air-liner is given by the accompanying photograph, which shows the gear installed in one of the Tudor IV aircraft of British South American Airways.

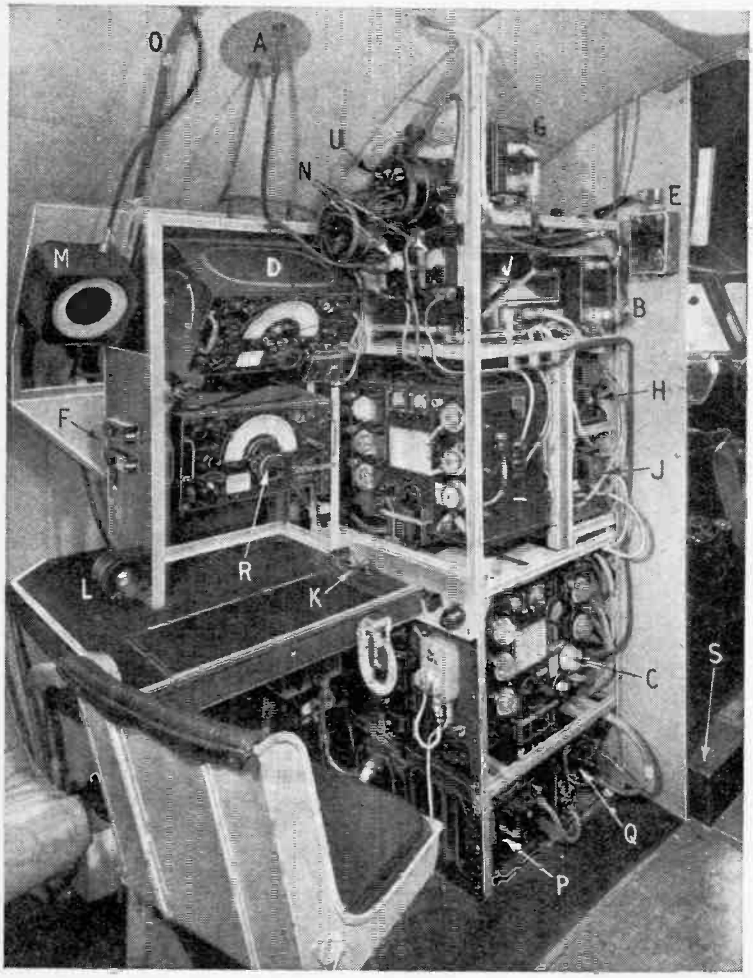
J. A. McGillivray, radio superintendent of B.S.A.A., makes some interesting comparisons between the present gear and that installed in the earlier Tudor I. That aircraft carried, for main communications, two American Bendix 100-watt sets with crystal control of 8 channels per set. Though crystal control is in itself an advantage, the 16 channels provided by the two sets are insufficient for all the requirements of B.S.A.A.'s long route, which extends to Santiago, Chile. Consequently, the R.A.F.-type TR1154/1155 40-watt equipment has been chosen. This gear, with its master oscillator control, has the disadvantages of low power and a tendency towards frequency drift, which have to be overcome by operating skill. The advantages are a large saving of weight plus standardization: the TR1154/1155 is widely used in B.S.A.A. aircraft.

For short-range work, the two American SCR274 sets with three receivers, as fitted in the Tudor I, have been replaced by a second TR1154/1155, again with a saving in weight, but also with the sacrifice of the simplicity of crystal control. Avoidance of duplication in equipment is another gain.

The D.F. installation, comprising a manually operated loop working with the R1155 receiver, plus a Marconator set providing direct readings of true bearings. Mr. McGillivray points out that automatic direction finders suitable for aircraft use are expected to be available soon in this country, and it is hoped before long to replace the manual gear by automatic.

A.S.V. radar equipment was installed in the earlier aircraft, but this has been replaced by Rebecca-Eureka equipment, for which the appropriate ground beacons have been installed by B.S.A.A. along its routes. This substitution makes a small saving in weight.

The radio altimeter and blind approach gear are as originally planned. Unfortunately, the failure—as yet—to attain standardization of ground equipment makes it necessary to carry receiving equipment for both the Standard Beam Approach and the I.L.S. system.




Radio installation on one of the latest Tudor IV aircraft of British South American Airways. A, aerial leads-in; B, approach beam receiver (108-111 Mc/s); C, short-range transmitter; D, D.F. receiver; E, inter-communication box; F, fuses; G, glide-path receiver (332-335 Mc/s); H, H.T. generator; J, L.T. generator; K, morse key; L, loop control; M, Marconator; N, aerial ammeters; O, loop lead-in; P, L.T. generator; Q, H.T. generator; R, main communication receiver; S, standard beam approach receiver (33-40 Mc/s); T, main communication transmitter; V, V.H.F. transmitter-receiver.

# Radio Amateurs' Examination

## Report on Results for 1947

OF the 326 candidates who sat for the Radio Amateurs' Examination in May, 1947, only 120, or 37 per cent, obtained a pass. This is a very much lower percentage than during 1946 when 295 out of 398 entrants passed.

The comments of the City and Guilds of London Institute on the papers submitted at the last examination is instructive and should be of value to those intending to enter for future examinations in order to qualify for an amateur transmitting licence.

In the examiners' opinion the falling off in the percentage of entrants obtaining a pass is attributed to the fact that a large number apparently sat for the examination without adequate preparation. One passage in the report is worth quoting in this respect; it states that . . . "From the phraseology and vocabulary used, and the general way in which the answers were given, it is apparent that a large number of entrants, unused to sitting for examinations had received little or no coaching for the Radio Amateurs' Examination. The use of abbreviated and corrupt English, such as is commonly used by amateur radio operators, is to be deprecated for examination purposes."

In order fully to appreciate the following detailed comments of the Institute the questions are given in full below.

### *Amateurs' Examination Paper, May 14th, 1947.*

Candidates should attempt as many questions as possible. Use should be made of diagrams where applicable.

1.—An alternating voltage of 10 volts at a frequency of $\frac{100}{2\pi}$ Mc/s is applied to a circuit consisting of the following elements connected in series:—

(i) an inductance of 10 microhenrys.

(ii) a capacitance of 10 picofarads.

(iii) a resistance of 10 ohms.

(a) What current flows through the circuit?

(b) What voltage appears across the inductance?

2.—What is meant by the "selectivity" of a tuned circuit? On what circuit constants does it depend?

Why is this quality necessary in a receiver?

3.—What is understood by the term "C.W." and what special method is needed to detect C.W. signals? Describe a circuit arrangement which could be used for this purpose, illustrating your answer by a diagram.

4.—What is meant by modulation? Describe a method of modulating a typical low-power R.F. amplifier.

5.—What are the relative advantages and disadvantages of a variable-frequency master oscillator over a crystal-controlled oscillator for use in an amateur transmitter? Describe a variable-frequency oscillator of good frequency-stability.

6.—Describe, with the aid of a diagram, the circuit arrangement of a low-power crystal-controlled transmitter for the 58.5 to 60 Mc/s frequency band.

7.—Describe FOUR types of aerial commonly used for amateur transmission and how they may be coupled to the transmitter. What are their relative advantages and disadvantages?

8.—Condition 8 of the Postmaster-General's licence to establish an amateur wireless station stipulates:—

"Where the sending apparatus is not crystal-controlled there should be kept at the station . . . a reliable frequency meter of the piezo-electric crystal type or other type approved by the Postmaster-General, for measuring the frequency to an accuracy of not less than ±0.1 per cent."

Describe an apparatus to meet the foregoing requirement. Illustrate your answer by a diagram and explain how the apparatus is used.

### Examiners' Comments

*Question* 1.—Comparatively few candidates attempted this question; of those who did less than half did so correctly.

*Questions* 2, 3 *and* 4.—Fairly well done by the better candidates.

*Question* 5.—The essential points in the design of a variable frequency oscillator of good frequency stability were not at all well understood.

*Question* 6.—Many incorrect answers were given concerning the required frequency of the crystal and the methods of multiplication suggested to obtain the required final frequency showed little regard to efficient operation.

*Question* 7.—Not well done in particular the methods of coupling to the transmitter were discussed very briefly.

*Question* 8.—Very poorly done by comparatively few entrants who attempted the question. They seemed to have a hazy idea of what a frequency meter of the piezo-electric type really is, and how to use it.

# BOOK REVIEWS

**Fundamentals of Radio.** By Jordan, Nelson, Osterbrock, Pumphrey and Smeby. Edited by W. L. Everitt. Pp. 400 + xiii. Constable & Co., Ltd., 10, Orange Street, London, W.C.2. Price 27s 6d.

THE writing of a comprehensive basic book on radio, especially for readers who lack the power of sustained abstract thought, is a problem. It resembles a game of patience in that the author is under an obligation to deal with each subject in such an order as not to have to use terms or ideas he has not yet explained. Whatever standard of intelligence readers are assumed to have should be maintained consistently. There is the need to avoid continuing theory too long at a time without practical application. Above all, there is the problem of combining accuracy, clarity, and conciseness. So it is not difficult to criticize a book that attempts such a task.

"Fundamentals of Radio" scores full marks for keeping theory closely related all the time to practical issues. Although the mathematical standard is kept within very elementary algebra (which is given in Chapter 1) and the necessary basis of electrical theory is included (Chapters 2 and 3), the book succeeds in covering a remarkably wide range—almost everything one can think of except radar and centimetre-wave techniques. Inevitably, in one moderate-sized volume, some of the topics are treated only superficially; but the working of transmitters and receivers (F.M. as well as A.M.) is explained fairly fully.

It is on the ground of clarity-cum-accuracy that the book is most open to criticism, because some of its shortcomings in this respect seem to be avoidable. The various distinct uses of symbols—for generalizing arithmetic, for indicating mathematical operations, for abbreviation, and for reference in a diagram—are all confused in one paragraph; and what clear idea can the beginner derive from the statement that "Mathematics packs much meaning into one symbol to make the symbol useful where words or numbers would not serve"? Incidentally, a collected table of letter symbols, to match that provided for graphical circuit symbols, would have been helpful. The reviewer, for one, failed to find any key to the symbols "f" and "ff" after many of the references in the index. The usual American practice is followed of using "m" to mean both "mega-" and "milli-." After all, they differ only by the factor of $10^9$!

Some of the terms whose technical significance is by no means easy to grasp at first are introduced without explanation. For example, "unstable"; the reader has to guess that on p. 133 it means "oscillating" and on p. 167 "unsteady." What is called a quarter-wave matching section is actually a stub, not what is generally understood by that term.

In dealing with wave-forms it is desirable that the student should be familiarized with the sine form wherever it occurs, instead of being shown triangular waves or semi-circular waves in lieu, as in Fig. 10-6, etc. On the other hand, where the purpose of a diagram is to show a *departure* from sine shape (due to F.M.), the form actually shown (Fig. 14-4) is apparently sinusoidal; and the text gives the impression that merely making the wave "slimmer or fatter" necessarily renders it non-sinusoidal.

If such details as these could be tidied up, "Fundamentals of Radio" would be an excellent book for the practical man who wants to know how radio equipment works, without going too deeply into mathematics. M. G. S.

**Radio Aids to Navigation.** By R. A. Smith. Pp. 110 + xiv; 37 figures. Cambridge University Press, 200, Euston Road, London, N.W.1.

THIS is another of the monographs of the "Modern Radio Technique series; it outlines the principles underlying radio and radar navigational aids, with particular reference to their application to aviation.

The treatment of the subject is non-mathematical but technical knowledge is assumed, and sufficient detail is given for any of the systems described to be clearly understood. There is also enough explanation of practical and operational problems for the reader to be able to form his own opinion of the relative merits of devices designed to perform the same role, such as, for instance, C.W. and radar omnidirectional ranges.

The two chapters devoted to aids to instrument landing give an excellent summary of what has been accomplished in this field to date, but it is disturbing to realize that even now there is no completely satisfactory system, due to the difficulties involved in producing guidance beams which are free from the effects of reflections from local sources. The author suggests that the solution of this vital problem may be found in the use of microwaves or short-pulse radar systems.

It is evident that the final aim of designers of such systems is to make it possible to achieve fully automatic blind landings. Already many successful landings of this type have been made with apparatus linked to the automatic pilot of the aircraft, but these have shown that the reaction of even slight beam-bends is serious and that the root of the problem lies in completely stable and reliable guide paths.

In the chapter dealing with radio altimeters perhaps mention should have been made of the application of the radio instrument to pressure pattern flying. The only reason for a civilian aircraft requiring an indicator which reads high altitudes is so as to be able to use the normal aneroid instrument for the detection of changes in atmospheric pressure whilst in flight.

Much of the book is concerned with descriptions of radar systems, but it would be a mistake for the reader to imagine that it is with these that the world's aircraft obtain their navigational aid; indeed the majority still use C.W. methods established before the war, and the airlines and authorities responsible for the safety of flying appear to be slow in adopting new techniques. Shipping, on the other hand, has already taken full advantage of wartime developments both in the field of anti-collision radar and radio position-fixing systems.

This book will appeal to radio engineers and aviators alike, as it is clear that the author has a thorough knowledge of the airborne as well as the chairborne aspects of the subject upon which he has written so lucidly. C. B. B.

**Electronics and Their Application in Industry and Research.** Edited by Bernard Lovell, O.B.E., B.Sc., Ph.D., F.Inst.P. Pp. 660 + xvi, with 404 illustrations. The Pilot Press, Ltd., 45, Great Russell Street, London, W.C.1. Price 42s.

ONE of the effects of modern research has been to dissolve the artificial divisions that had been erected between the sciences. Another has been to expand knowledge far beyond the grasp of any individual. So just when seeing the field as a whole is more than ever desirable, it has become impossible. But although it is no longer practicable, as it once was, for a person to have a fair grasp of all the arts and sciences, this should be no excuse for concentrating so exclusively on our own job that we cannot see even our corner of the wood for one particular twig.

A pleasant and profitable corrective for radio workers suffering from excessively restricted field of vision is the volume under review. Pleasant, because on the whole it is so well written and produced; and profitable because it is so likely to stimulate thought and ideas. Neuro-physiology, for example, might seem a forbidding and irrelevant subject for the radio engineer. But Dr. Pumphrey's chapter, on just this, is not only a lively piece of writing but his final section might well appeal to the most practical-minded radio man. "The physiology of the mammalian ear is necessarily largely based on work with experimental animals, cats, guinea-pigs, and so forth, whose auditory spectrum extends far up into the supersonic range. But there is literally no equipment available for reproducing or recording sound in the range 10-100 kc/s. . . . There is a crying need for a high-gain low-noise amplifier with a pass band of the order of 1 cycle—10 kilocycles per minute, but none exists and its development would require work for which few physiologists have the competence or time." And so on.

The man whose work lies, say, in valve or circuit design, can hardly produce the most effective device, or even know what device to produce, if he knows nothing of the other sciences or industries to which they are or could be applied. This year is the jubilee of the discovery of the electron—an appropriate time at which to review its position in physics and the many ways in which it is being manipulated to-day. Each chapter in this book is written by an authoritative worker and the whole is capably edited by Bernard Lovell, who contributes an introduction on the growth of electronics. To enable relatively new matter to be adequately presented, well-known branches of electronics such as radio communication, X-rays, and valves for medium frequencies have been omitted. The chapter subjects are: I, Electron Physics; II, Photo-Cells for the Visible and Ultra-Violet; III, Recent Advances in Photo-Cells for the Infra-Red; IV, Electronic Generation of Television Signals; V, Thermionic Valves for Very High Frequencies; VI, Radar; VII, Control Applications of Cold Cathode Valves; VIII, High Frequency Heating; IX, A Moisture Content Control Equipment; X, Electronics Applied to Servo-Mechanisms; XI, Electronics in Medicine; XII, Electronics in Physiology; XIII, The Betatron; XIV, Electron Microscopy and Electron Diffraction.

Most books on electronics are too superficial or too specialized. This one strikes a very happy medium. The first chapter is perhaps a little concentrated for readers who have no background in physics, and the treatment of servo-mechanisms and to some extent R.F. heating and radar, is mathematical, but not excessively so. The chapter by J. D. McGee on television is an excellent review of electronic camera tubes, and contains much hitherto unpublished information. "Radar," by R. A. Smith, is also a clear and well-balanced survey. The statement that the term "radar" is now associated with pulse technique rather than with echoes is misleading, however, for it has never been so used in America, where the term originated, and the tendency to do so in this country is to be deprecated. It would be far better to widen the redundant term "radiolocation" (which was never used by radar workers themselves—"R.D.F." was their name) to cover all systems for location by radio, in contradistinction to radio communication.

Each chapter is well referenced for the assistance of those who want to pursue the subject further. Illustrations are good, and there are full author and subject indexes. It is a pity that the symbols and abbreviations are not British standard, especially the sign for a cell, in which positive and negative are reversed, the long stroke being negative. There are a number of minor lapses in proof correcting; but the authority of the authors is sufficient guarantee of accuracy of the information. M. G. S.

## BOOKS RECEIVED

**Seizième Rapport Annuel, S.S.R., 1946.**—The annual report of the Swiss Broadcasting Company (Société Suisse de Radiodiffusion), which covers the transmissions from Sottens, Monte Ceneri and Beromünster. The reports on these stations are printed in French, Italian and German, respectively.

**A Modern Home-built Televisor.**—Constructional details are given of a television receiver using a 9-in electro-magnetic tube. A straight set is used with 4 R.F. stages, diode detector, V.F stage, D.C. restorer and phase-splitter. The sound channel is separate and has two R.F. stages. There is a two-valve sync separator and in each of the two two-valve time bases a thyratron is used as a saw-tooth oscillator. Pp. 71, with 32 illustrations. Electronic Engineering, 28, Essex Street, London, W.C.2. Price 2s 6d.

# Unbiased

## Designers Forward Please

OF all the trends of modern design in the field of radio receivers and other electronically operated apparatus intended for providing entertainment, I deem the most important to be the appearance of one or two makes of magnetic-tape home recorder giving a continuous run of entertainment without record changing.

I think so not because, in my opinion, they are likely in the foreseeable future to take the place of disc machines; indeed, for ordinary entertainment I much prefer the discs as they enable one to select very quickly any particular item of music without tediously wading through a lot of extraneous matter. Nor do I welcome the tape recorder because of its possibilities in the way of recording my voice and that of Mrs. Free Grid. That can be done equally well on a disc and, in any case, anybody who has ever possessed a home ciné camera will know that, for most people, that sort of thing has little more than novelty value.

No, the real scope of the tape recorder is for it to be incorporated as an integral part of a domestic radio receiver so that it can be switched on to bottle any programme desired. Most people have experienced the great annoyance of being interrupted by casual visitors when listening to a broadcast play; more especially if it be a serial.

Offensive females.

Many a time I would have gladly given up my nightcap of the real McCoy in exchange for the ability to switch my set over to "recording" on the unexpected entry of Mrs. Free Grid and some of her friends. As it is, I have had to be content with turning the wick up to the maximum in order to enable me to continue listening amid the racket of the childish prattle which passes muster for conversation among the offensive females whom Mrs. Free Grid insists on bringing home from time to time.

By
FREE GRID

Actually, of course, it wouldn't be a lot of good merely to be able to switch on the recorder in the middle of a play or other continuous programme, as when it came to the time when I was able to resume listening to it I should have forgotten the first part. What is wanted is for the magnetic-tape recorder to be in action all the time. It could be easily run through the "wipe out" coil afterwards unless it were desired to preserve the programme for future use.

A programme clock could be included so that it would be possible to bottle any item that happened to be due on the air at a time when the listener was out. We should then have the complete home radio entertainer.

## A Grave Menace

THE great argument against a wire broadcasting system has always been a political rather than a technical one, it being said in some quarters that it would play directly into the hands of any home-grown Hitler who might arise in these islands. The absence of ordinary domestic wireless sets would, of course, prevent listeners hearing the uplifting voices from the British freedom stations beyond the seas.

This is so, but all the same I could not help thinking that there was a lot in the remark made by P. P. Eckersley in his article in the December issue that if a dictatorship came, broadcasting by any technique would be cut off. This is no argument for a wire system of broadcasting, but a challenge to us to be up and doing to devise some scheme whereby every listener has the technical knowledge to improvise some method of overseas listening after the political police have descended upon him and taken away his receiver.

Now I am not suggesting that we are on the verge of a dictatorship from the extreme Left or the extreme Right, but there is undoubtedly a very grave danger of a dictatorship of another sort. Judging by the activities of Mrs. Free Grid and her friends, we may easily wake up one fine morning to find a matriarchy firmly established. Mr. Churchill, Sir Stafford Cripps and myself would then be seen busily engaged in pledging each other in a Loving Cup of watery cocoa during a brief respite from our enforced floor-scrubbing activities.

A Loving Cup.

If this sort of thing does happen we shall be in a far sorrier plight than if it had occurred twenty years ago. The listening public having been spoonfed with factory-built receivers, instead of having to make do and mend as we pioneers did a quarter of a century ago, home construction is almost a lost art.

There is only one remedy and that is for the Editor to publish immediately a comprehensive series of articles in which real austerity home construction is taught. Describing variable condenser vanes hewn out of old biscuit tins and coils made from old picture wire, the articles must take nothing for granted and even include home-made valves and the construction of the necessary pumping gear to create a vacuum.

I would also suggest that a Defence Regulation should be invoked making it impossible for anybody to buy a factory-built set until he had demonstrated his capabilities in austerity home construction. I know that the manufacturers will be against me, but they always have been and I would remind them that if my fears prove well founded they, too, will find themselves in the floor-scrubbing fatigue party.

# LETTERS TO THE EDITOR

## Output Transformers and Feedback ✦ Avoiding the "Single Point" Sound Source

### *High-Quality Amplifiers*

YOUR journal publishes from time to time some excellent circuits of high-performance audio amplifiers and the more recent ones are based on the application of a considerable degree of negative feedback. In many instances this feedback is applied over a portion of the circuit containing an iron-cored audio transformer or choke. The specification of this component thereby becomes considerably altered and hardly would it be fair to condemn a normally good transformer because of the inadequacy of its performance in such a circuit. It is to this I would like the attention of your readers drawn.

In circuits where the transformer is not included in a feedback loop, this component would be judged according to its properties (level frequency characteristic, low harmonic distortion, level phase change and frequency characteristic, optimum loading of the valves, high frequency, etc.) within the desired frequency range which might be from 20 to 20,000 c/s in the very highest fidelity equipment. The use of negative feedback introduces additional requirements which have no direct bearing on the fidelity of reproduction but are demanded merely by stability considerations. These additional requirements are obtained from the well-known Nyquist Regeneration Theory published in 1932 in the *Bell System Technical Journal* and lightly referred to by E. Jeffery in your August issue.

The condition for stability is that the feedback loop must not introduce a phase change as great as 180 deg at any frequency at which the gain of the loop (forward and return) has not fallen by *n* db where *n* db is the amount of applied negative feedback. H. W. Bode* has later simplified this for design purposes, in cases where the loop contains only substantially discrete elements such as resistances and condensers, by making use of the relationship that exists between frequency characteristic and phase change. All this is familiar to many of your readers but what is not always remembered is that Bode's simplification fails when the circuit includes distributed elements such as in a transmission line or when at some high frequency certain components such as valves or transformers cease to act as lumped constants. It follows from this that when a transformer is included in a feedback loop its phase change characteristic must be known over a band considerably wider than the normal audio band before the performance with regard to stability can be predicted. This characteristic can only be determined by experiment and it is usually easier to connect the transformer in circuit, adjusting the amount of feedback to the maximum giving unconditional stability with a margin allowed for component value variations.

For a production job the margin allowed must be adequate to cover the inevitable variations, especially of distributed constants, of transformers.

To sum up: if a transformer giving a performance beyond reproach over the audio spectrum is found to account for instability in a circuit with high negative feedback, it would be unfair from this to conclude that it is a bad component, a conclusion which might be derived from the wording of Major Jeffery's article (*vide* p. 276, col. 3, August, 1947).

TREFOR WILLIAMS.
Partridge Transformers, Ltd.,
London, S.W.1.

* *Bell System Technical Journal*, Vol. XIX. July, 1940, pp. 421-454.

### *B.B.C. Services*

WITH reference to Thomas Roddam's article, "Short Waves for Pleasure," published in *Wireless World* for October, 1947, may I draw attention to the fact that the B.B.C.'s "Over-

**Letters to the Editor—**

seas" Services are not primarily intended for listeners in Europe, who must not expect perfect reception when they happen on transmissions directed to Africa, Asia, Australia or America.

There is, however, a "European" Service in the B.B.C., and this includes transmissions both in Swedish and English which are received well in most parts of the country. Details of our Swedish transmissions are regularly printed in the official Swedish radio paper, and full details of all our European Service transmissions are contained in a bulletin which is at present sent on request to listeners in Europe.

GORDON WINTER,
European Publicity Officer,
B.B.C.

### *H.F.: Necessary and Nice ?*

I AM quite sure the average listener restricts high-frequency response in an effort to *improve* reproduction.

This horrifying statement is the result of a number of experiments I have carried out with a view to increasing the illusion of "presence" in reproduced sound.

The reproduction provided by the usual loudspeaker working through a hole in a baffle is quite unrealistic. It badly lacks the "roundness" of the original performance, and this is caused by the fact that much of the reproduced sound (particularly the high audio frequencies) reaches the ear in the form of a narrow beam from a relatively small point of origin.

The average listener finds that he can make things sound more natural by reducing his H.A.F. response (which reduces the beaming), and he also boosts the bass in an effort to achieve greater depth and roundness. The resulting "mellow tone," while anathema to you and me, undoubtedly pleases the average ear.

If, on the other hand, steps are taken to reduce the "beam effect" by more legitimate means which also give the illusion of a far larger point of origin, I have proved to my satisfaction that an extended H.A.F. response, far from being disliked, is welcomed with enthusiasm by the uninitiated.

I find that this is best achieved by the judicious placing of *large* reflecting surfaces in front of the loudspeaker in such a way as to increase the air loading on the diaphragm and to function to some extent as a very large folded horn. If this is properly done the increase in realism and "presence" is quite remarkable, but unfortunately this solution is, generally speaking, only practicable in a fairly large room, though in smaller rooms it is sometimes possible by placing the loudspeaker in a cupboard to make use of the door (if suitably solid), set at the correct angle, as the first reflector.

I have no doubt at all that high audio frequencies *are* necessary, and *can be* nice, but only when properly presented.

R. MARKER.
Honiton, Devon.

### *Amateur Operator's Qualifications*

I HAVE read with interest the letter from "Etheris" in your December issue, and in particular noted the number of licences issued each month and the possibly disastrous outcome.

Apparently the large number of licences issued per month is entirely due to those applicants who are exempted by virtue of some qualification—among many others, those who hold the Post-master-General's "Special" Certificate.

The examination for the "Special" Certificate does *not* include theory, and it is well known that a large majority of those who possess that Certificate have no theoretical knowledge. I am confident they could not pass the technical examination for the amateur licence.

It would appear to be an unjustified assumption that because an individual has acted in a wireless capacity in some branch of the Services he has in every case a sufficient knowledge of the subject to justify his exemption from the examination. And those who have the requisite knowledge would assuredly not hesitate to sit for the examination.

Accordingly, I suggest that it is in the interests of all radio amateurs that the licence should be awarded only on examination. By so doing all radio amateurs would be technically qualified and the chaotic conditions so ably forecast by "Etheris" would be avoided.

"AMRAD."

### *F.M. and Monopoly*

THE only really important advantage of a frequency-modulated national broadcasting system would be that it enabled domestic listeners to receive programmes without interference from badly maintained and unsuppressed electrical apparatus in their vicinity. A very secondary claim by F.M. partisans is that reproduction *can* be more faithful to the origin than with A.M.; this claim is and has always been weakened by the facts that (a) the improvement can only be slight under the best conditions, and (b) the great majority of the listening public do not like or want "super-high-fidelity" reproduction.

Against these advantages must be put the facts that (a) only long overdue legislation (already existing in certain European countries) prevents a selfish minority from being obliged to keep offending apparatus in good order and fit suppressors—the cost of which would be quite small: (b) the cost of setting up a nation-wide network of F.M. transmitters would be enormous and would have to come out of the pockets of already well-taxed citizens; (c) the listening public would be forced to buy F.M. receivers (or, possibly, in a negligibly small number of cases, "adaptors,") (d) a vast amount of material and labour would be required for the change-over, and both are not only in short supply but urgently required for export activities rather than for domestic use; (e) except for freak and very erratic chances, reception by the mass of non-technical listeners would be confined to that of the national F.M. network, with the consequent loss of the ability and liberty to listen to what the rest of the world had to say on important controversial issues—a deprivation which should be fully appreciated in the dangerous times ahead of us in regard to social developments.

W. H. CAZALY.
London, N.W.

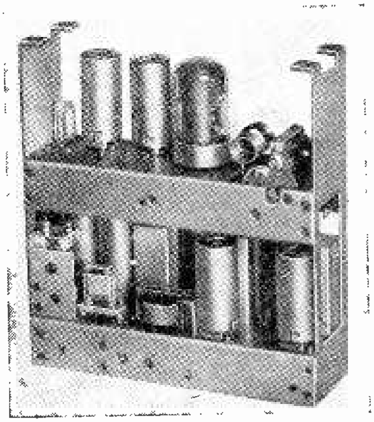
# Miniature F.M. Transmitter-Receiver

## Portable Radio-telephone for Pedestrian Use

AS an outstanding example of miniaturization it would be difficult to find an equal to the V.H.F. portable radio telephone made by Tele-Radio Development, 177, Edgware Road, London, W.2. This set measures 9in × 7in × 3$\frac{3}{4}$in, and weighs approximately 8lb including batteries.

The equipment is designed for operation on a fixed frequency in the 70- to 95-Mc/s band and different frequencies can be used for send and receive.

Crystal control is used in both the transmitter and receiver and the two circuits are virtually independent, the one common feature being that the receiver's audio stages are used as a microphone amplifier for the transmitter. This has three valves, the first is a crystal-controlled oscillator tripling the frequency in its anode circuit, the second combines the functions of frequency doubler and reactance modulator and the third is a push-pull Class C amplifier delivering about 700 milliwatts to a quarter-wave vertical aerial. A deviation of plus or minus 15 kc/s is employed. The microphone is a moving-coil type.



Tele-Radio miniature V.H.F. crystal controlled F.M. transmitter-receiver.

The receiver is a super-heterodyne with one R.F. amplifier a single-valve frequency changer with crystal-controlled oscillator, the sixth harmonic of which is applied to the mixer grid. There are two I.F. amplifiers working at 4.7 Mc/s (the second acts as a limiter) a discriminator with two Germanium crystals and two A.F. amplifiers.

When it is realized that this equivalent of an eight-stage superheterodyne is compressed into an overall space of approximately 7in × 4in × 2in it will be appreciated that the use of the word miniature in describing this equipment is fully justified.

Despite so much in so small a space all parts of the receiver are accessible, a point of no little importance from the maintenance aspect. Needless to say, the transmitter section, with its fewer stages, is equally accessible and the workmanship is of a very high standard.

There are two models of this radio telephone available; in one the receiver and transmitter are separate chassis assembled one above the other and a separate battery box is employed. In the other, which is the more recent development, receiver and transmitter are on one chassis with the batteries accommodated in the lower part of the case.

The switching for send or receive is effected by a multi-contact relay on the receiver chassis, which is actuated by a press switch in the handle of the microphone. A separate telephone head-set is normally used but it could be replaced by a combined hand-telephone and microphone.

Despite the relatively large number of valves for a portable set the H.T. and L.T. consumption is not heavy. The transmitter takes 650 mA at 1.4 volts and 23 mA at 90 volts, while the receiver accounts for 350 mA L.T. and 15 mA H.T. Only one of the two units is operating at any time.

There are many uses for a handy radio telephone of this kind. It falls within a similar category to the mobile V.H.F. radio telephones described in this journal from time to time but it is a pedestrian's or patrolman's equivalent.

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## "DEFLECTOR COIL EFFICIENCY": A CORRECTION

In this article, *Wireless World*, December, 1947, p. 460:—

For 'kilowatts' read 'kilovolts' just prior to Eqn. (5). For '$d_0^2$' read '$d^2$' in the denominator of Eqn. (12).

# RANDOM RADIATIONS

By "DIALLIST"

## Televised News

FOR years I've been urging in these columns that the television service should include illustrated news bulletins and I am glad to see that something of the kind is at last to be started. Within the next few days a weekly feature called "B.B.C. Teleciné Review" is to be inaugurated. It will run for a quarter of an hour. That is at any rate a beginning and I would not mind making a modest bet that it receives a very hearty welcome from viewers—provided, of course, that it's well done. My feeling has always been that television can make one of its biggest appeals by presenting pictures of current events. You can't, of course, expect highlights every day on a par with the Royal Wedding, the Boat Race, the Derby, the Cup Final or the fight for a boxing championship title. Even if you could, such events often take place at times which prevent a considerable proportion of television set owners from watching direct broadcasts. But interesting events are happening all day and every day. They can be recorded by the ciné camera and I am sure that an illustrated news bulletin made up of ciné films, accompanied by a good running commentary, would prove an enormously popular daily feature if sent out at a convenient time each evening.

## Immense Scope

A really live B.B.C. department, not stinted in the matter of finance, could make bulletins of this kind such a success that the television would rapidly become almost as indispensable a piece of domestic equipment as the broadcast receiving set is now. The combination of ciné camera and emitron-controlled vision transmitter opens up almost unlimited possibilities. Existing air transport facilities should enable films of daytime events in pretty well any part of this country (developed and processed *en route*, if need be) to be in London in ample time for the evening transmission. And is there a day between one end and the other of any year on which dozens of interesting events are not taking place somewhere in these islands? Look at the headlines in this morning's papers and ask yourself whether there were not yesterday all sorts of goings on in England, Scotland, Ireland or Wales of which you'd have liked to see televised pictures last night. And why stop at home news? Many European capitals are within 3-4 hours' flight. The evening illustrated news bulletin could certainly include events which happened on the same day in France, Belgium, Switzerland, Holland, Denmark and probably Norway, Sweden and the Western parts of Germany. Pictures from the rest of Europe need be only one day stale; we could have those from America and India and much of Africa two days after the event; even from Australia the delay would be less than a week.

## A Big Show

Naturally all of this would call for a large and expensive organization. A score or more of mobile ciné units would be needed in various parts of this country and the air transport would have to be maintained. Abroad the system could be expanded gradually from comparatively small beginnings—say a mobile ciné recorder in Paris to start with. The position would be eased to no small extent by the growth of national—and later international—relay links. As, for instance, these began to cover more and more of our own country the need for the physical conveyance of the films to London would diminish. The originals could be transmitted from the nearest television centre and relayed over the linking network. The more I think of it the surer do I become that the real job of television is to bring pictures of current events into our homes either as they occur or soon after they have happened. I don't believe that there is much future for entertainment produced in the studio specially for television purposes. Plays? Certainly; but let's have them straight from the theatres at which they are running. Concerts should come from a real concert hall, dance music from ballroom, restaurant or "palais." The studio stuff is far too artificial in its atmosphere—television should show the real thing—and far too limited in its possibilities. Can you, frankly, raise any enthusiasm over shots first of a dance band as a group and then of individual performers on various instruments? Are you at all thrilled by the sound-and-vision presentation of a studio singer or other soloist? Do you find the studio plays as satisfying as they should be? Don't you often feel, after watching a studio item, that the results as entertainment scarcely repay the hard work which all concerned have put into its production? If the V.I.P.s of television broadcasting can realize these things they'll see to it that the fifteen minutes once a week of the Teleciné Review becomes first fifteen minutes a day and then thirty minutes or more a day. The more television concerns itself with actualities, the sooner will it be on the road to becoming as much a part of our daily lives as some broadcasting now is.

## ". . . But Those Unheard are Sweeter"

AT a recent meeting of the Royal Society of Arts Sir Ernest Fisk announced that E.M.I. had been successful in recording frequencies up to 20,000 c/s on wax discs. In view of the fact that even the lissom ears of the human young can respond to nothing above about 16,000 c/s, whilst those of aged dodderers like myself have normally a cut-off in the neighbourhood of 10,000-12,000 c/s, your comment on this statement might be a ribald "So what?" But when Sir Malcolm Sargent and others who know both their musical and their acoustic onions maintain, as maintain they did, that even higher frequencies may have to be recorded in order to obtain complete realism in reproduction you begin to do some thinking. At first blush the idea seems utter nonsense: how can what we hear be affected by the presence or absence of frequencies that we can't hear? And then something at the back of your mind whispers that $f_1 - f_2 = f_3$; in other words, two supersonic frequencies may produce an audible beat frequency. It seems quite possible that when an orchestra is in action the supersonic upper harmonics of certain instruments do produce such beats. If they are absent from an electro-mechanical reproduction, it doesn't sound quite real.

If the original supersonic frequencies are, say, 19,000 and 21,000 c/s the beat will be at the audible frequency of 2,000 c/s. Assuming that there is such a beat and that I record and reproduce up to, perhaps, 6,000 c/s, why should not the beat frequency of 2,000 c/s be adequately brought out, even though the generating frequencies are removed by the cut-off at 6,000 c/s?

The answer is that non-linearity is required somewhere in the system to produce the beats. If the recording microphones, amplifiers and cutting heads are free from non-linearity distortion the beat frequencies will not be generated as such in the record, nor will they be present in the reproducing equipment if it is similarly free from "amplitude distortion." Not until the original supersonic frequencies reach the non-linear device known as the ear will the audible beat frequency emerge.

So if you cut off at 16 kc/s in recording you must do your mixing and introduce some non-linearity before or in the cutter head if you want to record those beats. Which poses the question: If one records only the whole gamut of audible sounds how much non-linearity distortion should be introduced for realistic reproduction?

□ □ □

## 'Phone Lines and Television

AT first blush the pair of wires which connects your telephone and mine to the exchange, or those which connect one exchange with another, might not seem to offer a very promising means of conveying the wide range of frequencies needed for television modulation. The former run $6\frac{1}{2}$ lb to the mile, the latter 10 lb or 20 lb. In ordinary use pairs are not called upon to handle frequencies higher than 3,000-4,000 cycles a second—and the full range of vision frequencies radiated from A.P. goes up to 2.7 megacycles a second. Yet during outside broadcasts there may be as much as eight miles of ordinary telephone line in use. It is true that they are normally made to carry frequencies only up to 2 Mc/s; but that is sufficient for a pretty good picture and, if it were thought to be worth the extra expense, there would be comparatively little difficulty about raising the limit to the full 2.7 Mc/s. An article in a recent issue of the *B.B.C. Quarterly* describes how it is done. Briefly, experiment showed that the main snags were heavy attenuation of the very high modulation frequencies and considerable phase distortion. Maintaining the high frequencies is just a matter of using plenty of repeaters in the lines. Telephone lines have ordinarily a repeater at every 20-25 miles; for television frequencies a repeater every $1\frac{1}{2}$ miles is needed. It has been found that phase distortion can be avoided by the use of suitable equalizers, so transportable repeater-equalizer units, weighing less than 150 lb apiece, were designed and brought into use. With these any telephone pair can readily be adapted for television purposes. The radius of O.B.s in the London area has been greatly increased without the expense of laying numerous branches of coaxial cable.

# RECENT INVENTIONS

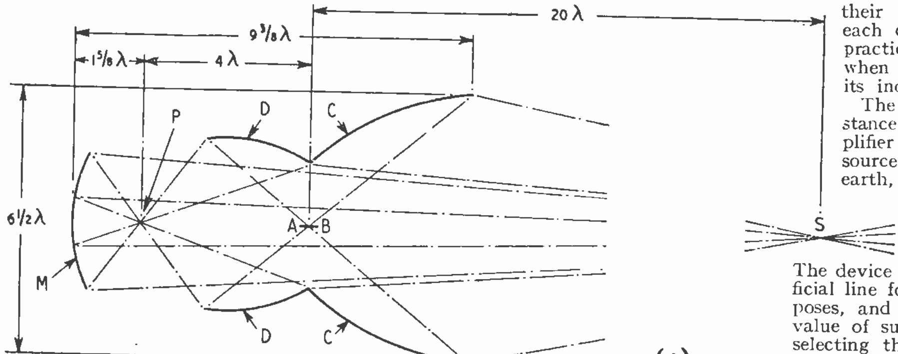
## *A Selection of the More Interesting Radio Developments*

### RADAR AERIAL SYSTEM

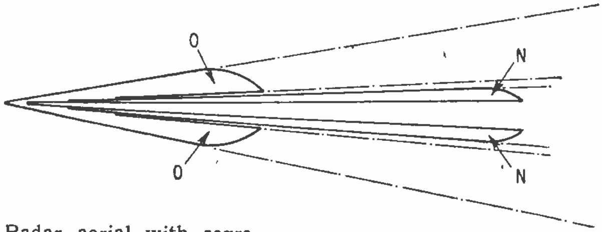
THE oscillation centre of a dipole A B, diagram (a), coincides with the common focus of two elliptical reflectors, C, D. Radiation from the right-hand limb of the dipole is collected by the mirror C and passed to its conjugate focus S; whilst radiation from the left-hand limb is first reflected by the mirror D on to its conjugate focus P, and is then concentrated by a back mirror M on to the first focus S. From this point the energy diverges in the form of two hollow concentric cones, one having a wider angle than the other, as shown at N and O in diagrams (b) and (c). The field strength is at a maximum along the interior angle of each cone, the relative amplitudes of the echo signals from a distant target, due to each beam or cone, being indicated at W and T. The receiving aerials (not shown) are located one behind and one in front of the transmitting dipole, in the radiation-free axis of the outgoing signals.

The arrangement is stated to be free from earth-reflection effects, and to give a direct indication of the bearing of the target, even at low angles of elevation. The outer cone serves to reduce the time that would be required to explore a given field of observation, if the sweep were confined to the inner cone alone.

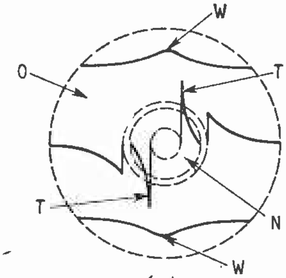
*H. M. Dowsett. Application date September 24th, 1940. No. 576941.*



(a)



Radar aerial with segregated go and return paths. (b)



(c)

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

### DISPLAY SYSTEM FOR RADAR

IF the fluorescent screen of a cathode ray tube is replaced by one coated with an alkaline halide, the transparency of the coating is momentarily varied by the scanning beam in such a way that the screen will modulate the rays of light projected through it from an external lamp on to an external viewing screen, thereby permitting the reproduction of images of a size that is not limited by the dimensions of the receiving tube.

This known arrangement is referred to as a "skiatron," and, according to the invention, it used to obtain a large-scale reproduction of the "picture" (P.P.I.) that is given on the C.R. indicator of radar equipment of the type in which an exploring beam is rotated in synchronism with a radial time base. A scale map or graticule of the terrain under observation is also separately projected on to the viewing screen, to facilitate the identification and correlation of the positional data (P.P.I.) that is produced by the echo signals from the pulsed exploring beam.

*R. A. R. Tricker, A. Tutchings, J. C. C. Stewart and C. S. Wright. Application date, April 14th, 1943. No. 584848.*

### TRANSMISSION LINES

TWO wires of equal diameter are laid in close proximity but separately from each other, to form a single-layer coil, which may have a magnetic or dielectric core of constant or graded characteristics. The arrangement is such that when the currents in both wires are in phase-opposition their respective fields neutralize each other, so that the coil has practically no inductance, though when the currents are in phase its inductance is high.

The coil can be used, for instance, to feed a push-pull amplifier from a coaxial line or other source that is unbalanced to earth, since any undesired in-phase currents are automatically choked out, and only a symmetrical load is put on the line. The device can also be used as an artificial line for matching and other purposes, and can be given any desired value of surge impedance by suitably selecting the nature or shape of the core.

*Patelhold Patentverwertungs and Elektro-Holding A.G. Convention date (Switzerland) October 8th, 1942. No. 585995.*

### ANTI-RADAR DEVICES

IT is known that the position of aircraft in flight can to some extent be camouflaged against the scrutiny of radar devices by releasing strips of metal foil or metal-coated paper from the craft. These reflect the exploring pulses and so confuse the observer.

Such strips are not very effective when used against centimetre waves. According to the invention, they are replaced by "floats" made of several sheets of metallized paper, which are so hinged together that they can be folded flat for storage, but which open out under spring pressure, when released, to form a many-cornered "balloon" with a slow rate of descent through the air. The corners act as efficient reflectors of short-wave energy, over a wide angle of incidence, and so provide false echo signals of considerable intensity.

*Marconi's Wireless Telegraph Co., Ltd., and J. C. Barton. Application date December 6th, 1944. No. 586904.*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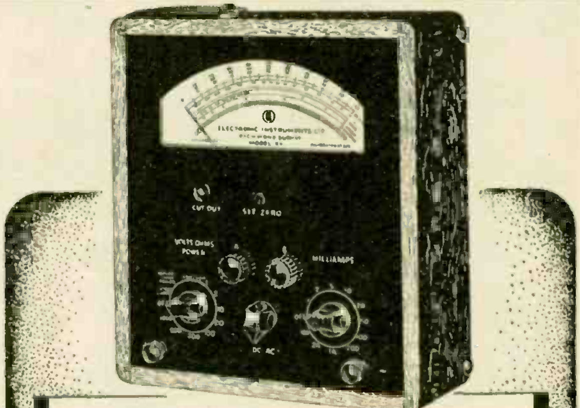

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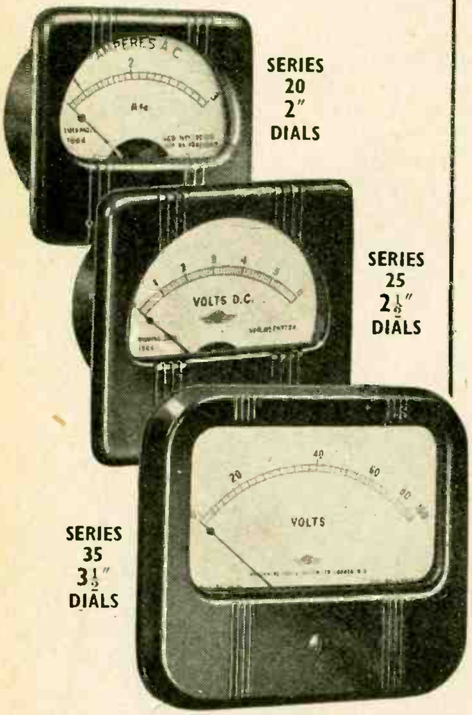


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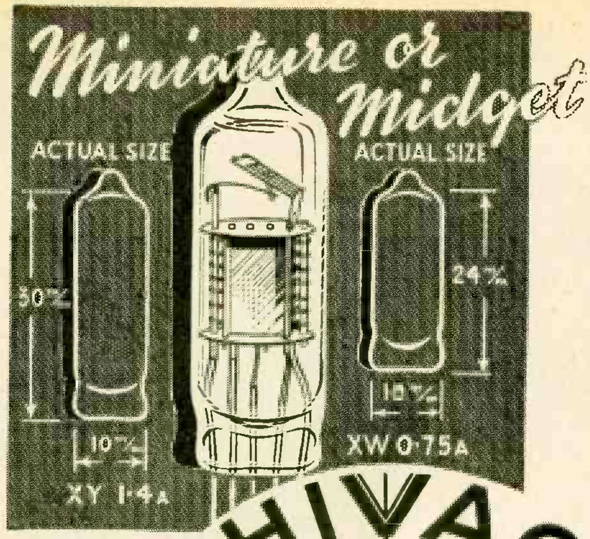


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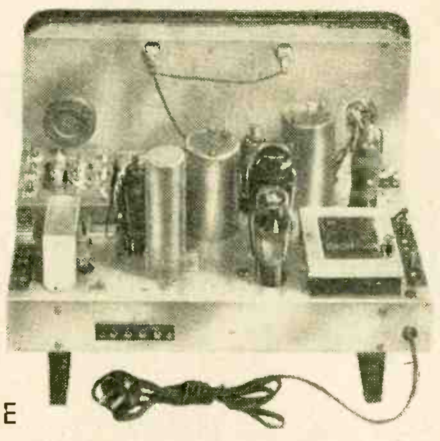

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# AMBASSADOR
*4756 Chassis*

★ ★ AN ENTIRELY NEW RECEIVER WITH
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***SPECIFICATION:*** This is a chassis which will appeal to the Short-Wave enthusiast who also appreciates quality reproduction. A 5 valve A.C. superhet with six wave bands, all coil ranges, with electrical bandspread on principal S.W. bands. Available with or without L.W. band.

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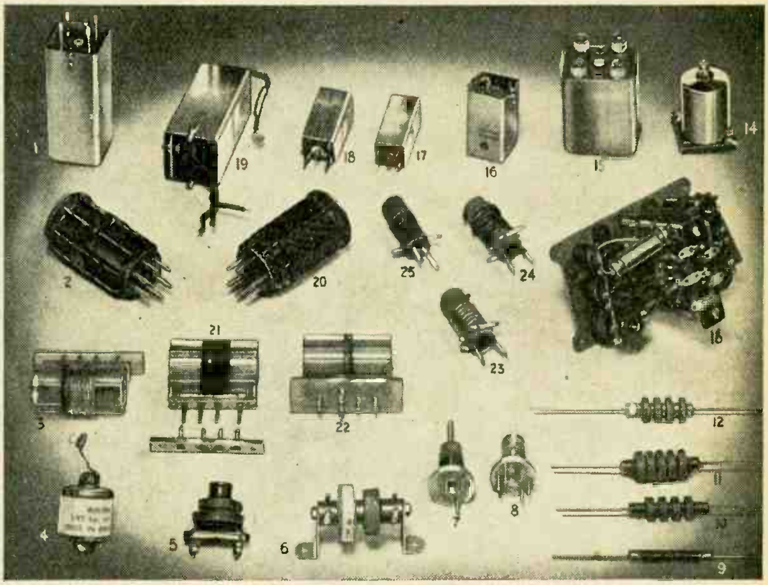


# INDUCTANCES

1. **WEARITE** I.F. Transformer Nos. 501/2. Size 1⅜ in. sq. by 3½ in. high, 450-470 Kc/s. No. 501 has critical coupling with flying lead. No. 502 has close coupling for diode input—no flying lead. Both types 10 0

**2 & 20. EDDYSTONE** No. 959 6-pin interchangeable coils. Three winding coils adaptable to most circuits. Tuning range with 160 p.f. allowing for average circuit capacities :—

| | | | |
|---|---|---|---|
| 6 BB 33.3 to 21.4 Mc/s | 5 0 | 6 W 3.95 to 1.8 Mc/s | 5 3 |
| 6 LB 25 to 11.5 Mc/s | 5 0 | 6 P 2000 to 924 Kc/s | 5 9 |
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| 6 R 7.3 to 3.2 Mc/s .. | 5 3 | 6 BR 612 to 300 Kc/s | 6 6 |
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**3, 21 & 22. DENCO** interchangeable coils on low-loss ribbed polystrene formers 2in. × 1⅛ in. dia.

Range 1. 1 to 2 Mc/s (tuned 100 pf)
2. 2 to 4.5 Mc/s (tuned 100 pf)
3. 4 to 9 Mc/s (tuned 100 pf)
4. 7 to 19 Mc/s (tuned 100 pf)
5. 16 to 34 Mc/s (tuned 100 pf)
6. 30 to 60 Mc/s (tuned 50 pf)
7. 50 to 90 Mc/s (tuned 50 pf)
8. 70 to 125 Mc/s (tuned 50 pf)

Full details on request.

4. **BULGIN** "Skeleton" general purpose H.F. Choke. All-wave type .. .. .. .. .. 6 6

5. **EDDYSTONE** No. 1066 All-wave Choke. One hole fixing. Inductance 17.9 millihenries .. .. 4 0

6. **BULGIN** Quench coil. Two winding unit for super regeneration .. .. .. .. .. .. 5 6

**7. & 8. DENCO** "Maxi-Q" Plug-in coils (Octal based). In eight ranges covering from 850 Kc/s to 130 Mc/s. Each range available in four types for all purposes. "Blue," 4/-; "Yellow," 4/-; "Red," 4/-; "Green," 5/0. (Coding as for Denco interchangeable coils also shown in this advertisement).

"Maxi Q" unwound formers with cores .. .. 2 3

9. **EDDYSTONE** No. 1011 U.H.F. Choke 120/25 Mc/s. Inductance 5.6 microhenries .. .. 1 9

10. **EDDYSTONE** No. 1010 S.W. Choke. 60/1.5 Mc/s. Inductance 1.25 millihenries .. .. 2 6

11. **EDDYSTONE** No. 1022. Transmitting S.W. Choke. 60/1.5 Mc/s. Inductance 1.5 millihenries carries 250 milliamps .. .. .. .. 3 0

12. **DENCO** 2.6 millihenry general purpose S.W. Choke on polystyrene former .. .. .. 2 3

13. **WEARITE** Coil pack series 600. Three ranges, Superhet coil assembly.
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14. **VARLEY** No. BP26. "Nicore" H.F. Choke, screened general purpose H.F. Choke .. .. 7 6

15. **EDDYSTONE** No. 645 I.F. Transformers. 450/465 Kc/s. Litz wound and permeability tuned, plated brass case gives efficient screening. Band-width for a pair of transformers is 5 Kc/s at 20 dB down. Two stages (three transformers) gives band-width of 5 Kc/s at 30 dB down .. .. .. .. .. 19 6

16. **DENCO** Midget I.F. Transformers, available in frequencies for 465 Kc/s and 3 Mc/s .. each 10 0

17. **WEARITE** Midget I.F. Transformers, available in frequencies 465 Kc/s, 1.6, 2.1 and 4.8 Mc/s each .. 10 6

18. **LABGEAR** I.F. Midget Transformers, 465 Kc/s each 9 6

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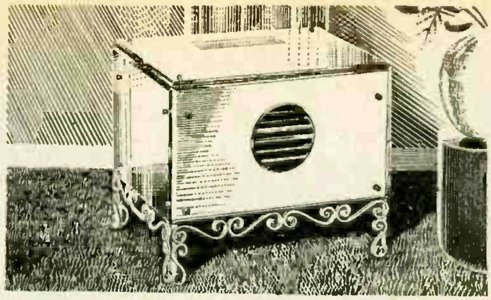

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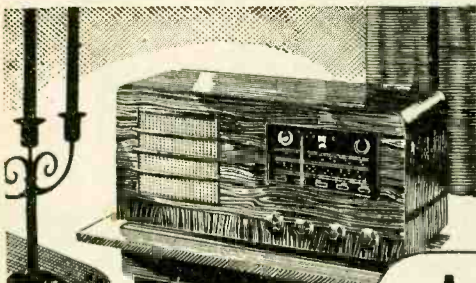

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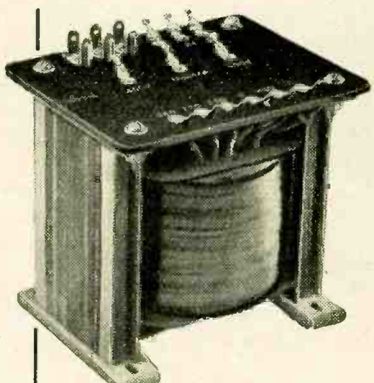

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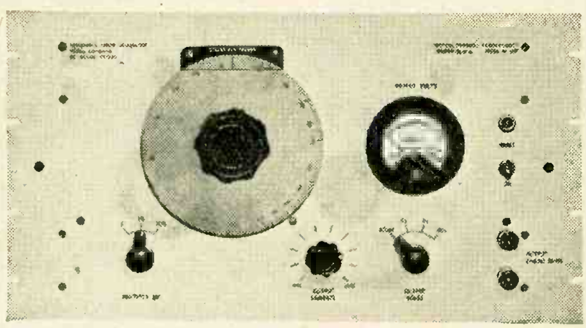

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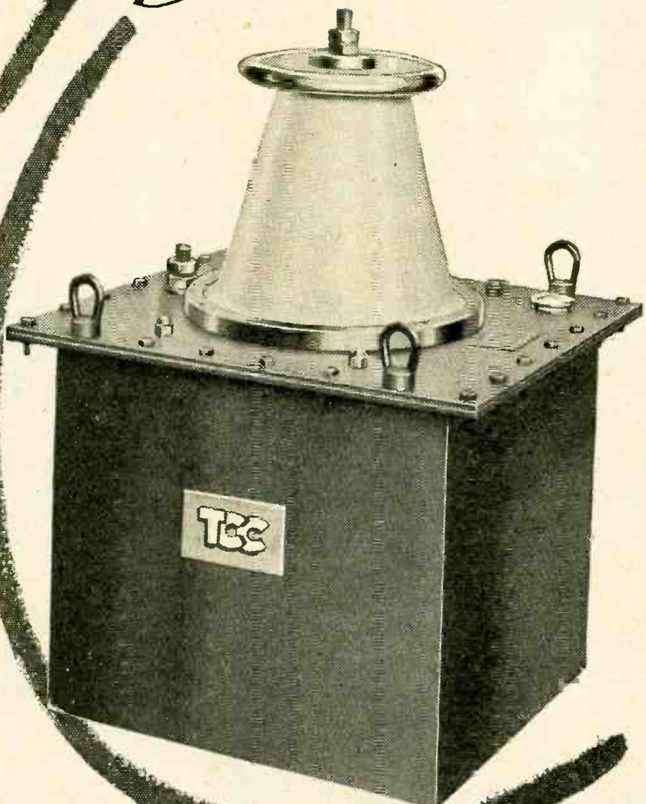

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*PRICES*

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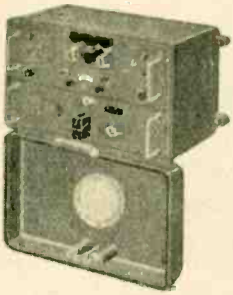
# *Announcing*... SIX ENTIRELY NEW

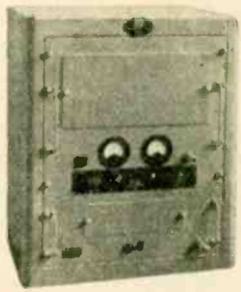
# ELECTRONIC INSTRUMENTS

## *by* CINEMA-TELEVISION LIMITED



### INDUSTRIAL ELECTRONIC METAL DETECTOR

An automatic inspection equipment for the detection of ferrous and non-ferrous metal particles of all kinds in non-metallic substances such as foodstuffs, plastics, textiles, tobacco, timber, pharmaceutical products, etc.



### STANDARD ELECTRONIC COUNTER

A high speed electronic counter of particular appeal to the industrialist. Facilities are provided for batching, selective counting etc., the maximum counting-speed for the equipment being 30,000 per minute.

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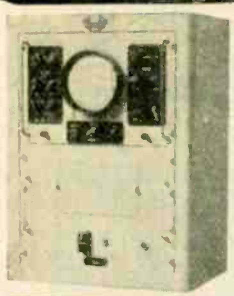
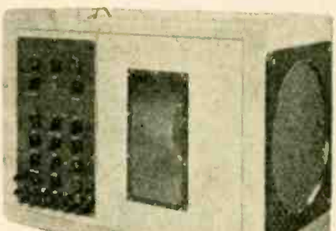
A unique instrument meeting fully the requirements of the serious users of oscilloscopes for laboratory and industrial purposes, arranged to permit readily the assembly of suitable units to fulfil every application. Complete range of units is available, e.g. stabilised time base, A.C. and D.C. amplifiers, 5 beam switch unit etc.



### LABORATORY OSCILLOSCOPE

A high grade 6" screen oscilloscope expressly designed for laboratory use, incorporating hard valve linear time base, 3 megacycle "Y" amplifier and 1 megacycle "X" amplifier. Cupboard and trolley are available if required.

### DEMONSTRATION OSCILLOSCOPE



Demonstrator and student alike will acclaim the features of this equipment — 15" tube with glare removing filter, 2 beam switch for simultaneous delineation of two recurrent wave forms, or their "addition" to produce a single resultant trace. Provision is made for setting up from rear of instrument, inspection windows permitting rear view of trace.

### PROCESS TIMER

A compact instrument, from the "CINTEL" range, providing simple and accurate electrical control for scientific and industrial processes of every kind. The timing range extends from 0.25 to 90 seconds.

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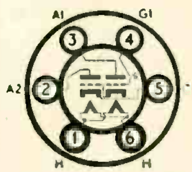
# 6B5's are short – it's true so *BRIMARIZE! with a 42

*THE 6B5 comprises two triode units in cascade, whilst type 42 is a pentode. Both valves have 6 pin bases so connected that replacement is possible without change of wiring.*

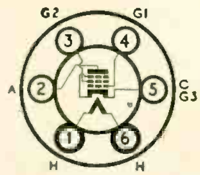
*Type 6B5 develops its bias internally and it will be necessary to include a bias resistor and condenser in the cathode lead of the 42 valve.*

*Reprints of the earlier sheets in this series are available for those who have not a complete set, so let us know which numbers you still require.*

PUNCH HOLES HERE




TYPE 6B5




TYPE 42

**RATED CHARACTERISTICS**

| | 6B5 | 42 | |
|---|---|---|---|
| Heater Voltage | 6.3 | 6.3 | volts |
| Heater Current | 0.8 | 0.7 | amp. |
| Anode Voltage | 300 | 285 | volts |
| Anode Current | 43 | 38 | mA. |
| Bias Resistor | — | 400 | ohms |
| Optimum Load | 7000 | 7000 | ohms |
| Power Output | 5.0 | 4.2 | watts |

6B5

| TYPE | CHANGE SOCKET | | CHANGE CONNECTIONS | | OTHER WORK NECESSARY | PERFORMANCE CHANGE |
|---|---|---|---|---|---|---|
| | FROM | TO | FROM OLD SOCKET | TO NEW SOCKET | | |
| 42 | U.X. NO CHANGE | 6-PIN | NO CHANGE | | Insert Bias Resistor (400 ohms 1 watt) and by-pass condenser (25 μF., 25 Volts) in series with the cathode lead to pin 5 of socket | NEGLIGIBLE |

★ *BRIMARIZING . . . A scheme devised by BRIMAR to keep repair lines on the move. This is especially useful at Christmas, when everyone wants his set at home and not on the shelf waiting for spares.*

**BRIMAR**
RADIO VALVES

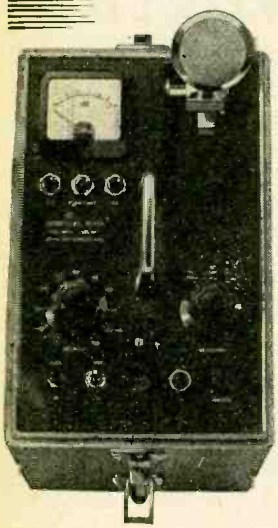
**STANDARD TELEPHONES AND CABLES LIMITED, FOOTSCRAY, SIDCUP, KENT.**

**A SERVICE PLAN FOR PLANNED SERVICE**

INSTRUCTIONS: Punch holes where indicated, cut away this portion and file in order of appearance for a quick reference guide.

10

# DAWE SOUND LEVEL METER



Suitable for all types of sound measurement ranging from the volume of noise of a whisper to that of a factory hooter. Simple to operate; completely self-contained; rugged and portable.

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| *Frequency Range* | *13.5 kc/s - 26 kc/s; 95 kc/s - 32 Mc/s; in eight bands.* |
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| *Sensitivity* | *Constant between 1-2 micro-volts over the entire range.* |
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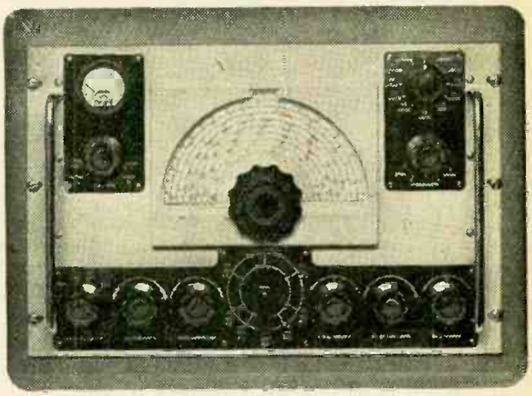

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*Readers are warned that Government surplus components which may be offered for sale through our columns carry no manufacturer's guarantee. Many of these components will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such components purchased.*

### NEW RECEIVERS AND AMPLIFIERS

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DEGALLIER'S, Ltd., will re-open for the sale of American receivers when restrictions permit.—Degallier's, Ltd., BCM/DEG.9, London, W.C.1. [8883

RECEIVER type R.3170A radar, used for anti-jambing devices, radio counter measure; contains 14 modern a.c. valves, including 8 Mullard EF50; all perfect and new; price 50/- each, plus 4/- carriage. UNCLE TOM'S RADIO CABIN, 5, Seven Stars Court, Manchester, 4. [8965

BRIERLEY ribbon and armature pick-ups, filters, amplifiers and pre-amplifiers. Arrangements are being made for the demonstration of these products by agents throughout the British Isles. Where arrangements for this have not so far been completed, it is possible for our sales representative to demonstrate in your own home when next in your district.—J. H. Brierley, Ltd., 46, Tithebarn St., Liverpool, 2. [8266

1948 Super de luxe five-waveband feeder unit, with tuned R.F. stage and magic eye, 15in×5½in station-named scale, 10/17, 16/35, 34/100, 200/550, 800/2,000 metres, communication type coil pack, high "Q" I.F. transformers, completely assembled and aligned and ready to connect to audio amplifier.—Send 2½d stamp for full details to the sole distributors, Coulphone Radio, 58, Derby St., Ormskirk, Lancs. [8959

SPECIAL offer: Midget communication receiver and power pack (M.C.R.I.), 5-valve superhet, complete with aerial and earth equipment, lightweight headphones; range 20-3,000 metres in four bands, operates on any voltage between 97 and 250 A.C. or D.C.; £9/10; send for one now before stocks are exhausted; another special offer, slow motion drives by "Muirhead," 50-1 ratio, 10/- ea, postage 6d; also milliameters, 0-1, 15/- ea; send for 6-page list; trade supplied.—L. Wilkinson, Wholesalers, 204, Lower Addiscombe Rd., Croydon. Add. 2027. [8264

GOODSELL, Ltd., 40, Gardner St., Brighton.—The Williamson amplifier to "W.W." specification fitted with best quality components, Partridge transformers and oil condensers on 425volt line, price £21; with voltage stabilised power pack (valve controlled) ensuring no volts in excess of 350 for the pre-amp and complete stability where high gain required, super amplifier, 26gns; pre-amp, including E.F.37 with 4-position bass boost and 4-position treble control and E.F.37 as straight triode for Hi-Fi pickups, for use with above, £4/4; a complete new range of feeder units using the new Denco 5 and 10-band turrets, improved I.F.T.s and large attractive glass dials with magic eye, available shortly; send for details.

A SUPERHET which will bring you hundreds of shortwave stations just as soon as batteries and 'phones are connected, 6 to 9mcs, 4 2volt valves, slow motion drive, size only 6in×5in×9½in, guaranteed O.K., price 29/6, postage and insurance 2/6; suitable double headphones fitted with plug in jack, 6/6; other interesting bargains: 12 assorted instrument switches, price 10/-; 12 assorted magnetic relays, price 11/-; 17-range ac/dc multi-meter for all radio sets, price £7; thermo couple H.F. meter, price 4/6; nuts, bolts and washers, small sizes for model making, three gross assorted, price 7/6; all post free.—The Instrument Co., Ltd., 244, Harrow Rd., W.2. [8864



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R.C.A. AR.77E 540kc/s to 31mc/s, 10 valves Xtal, £30 or highest offer.—Harman, Pentlands, Pentland Rise, Portchester.

HAMMARLUND HQ129X, 11 valve, latest 1947 communication receiver, with speaker, 6 wavebands, crystal filter and phasing, band spread, "S" meter, noise limiter, 115-250 volts, A.C.; £120.—Dr. S. Mellins, 50, Greatorex St., E.1. [8813

OVERWHELMING demand for some of our lines has caused delay in replying to our customers and has also cleared out some of our disposal bargains; there are, however, still a number of attractive items of appeal to the amateur enthusiast, but remember stocks are limited, so don't delay; R.A.F. radar amplifier, model 1124, complete 6-stage U.H.F. amplifier with 6 valves, 3 Westectors, 3 I.F. stages, 6 pre-set R.F. setting, makes an ideal base for television or F/M experiments, components alone worth £10, our price £4/10 ea.; class D. No. 1 wavemeter a few left only, complete with all spares and crystal check unit at £5/5; aerial couplers, type D, complete, at £1/15; R.A.F. dinghy sets, we have a small quantity of these portable transmitters, ideal for amateur field day work when modified, hand driven generator gives 6 volts and 400 volts, 6J7 and 6v6 valves, neon indicator, our price, £2/5; 3-stage amplifier panels for 1T4 type valves complete with condensers resistors and vol. control, can be made into midget portable by adding tuning device (20/- worth of components), to clear at 7/6 each; send stamp for complete bargain list; terms, cash with order or c.o.d. over £2.—Orders to Dept. W.W., Ariel Trust, Ltd., 188, Vauxhall Bridge Rd. London, S.W.1. [8106

BRAND new Canadian Type R.103 M.K.1 staff car radio, 6 volt, world-wide reception on short and medium wavebands, 7-valve superhet, complete with aerial and box of all spares; nearest offer to £30.—Box 6145, U.K. Advtg. Co., Ltd., 25, Shaftesbury Av., W.1.

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R.A.F. type 1124 receivers with 6 valves, 3 I.F. stages, ideal to convert for television base, definitely sound, 35/-; ex-Govt. surplus, Radar equipment, receivers, wavemeters, rotary transformers, motor generators, indicating units, calibrating units, for sale.—J. Rae, 39, Penn Rd., Wolverhampton. [8922

COMMUNICATION receiver, 2 r.f. osc M×R, 2 i.f., p.pp. triode output S meter, noise limiter, a.f.c. control circuits and b.f.d. 150 k.c. to 26 mc/s, £38; Midwest super radiogram, triple speakers, new Garrard autochanger; also fitted modern G.E.C. overseas "10" chassis; nearest £110. G3BNL, 53, Old Steine, Brighton. [8783

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BEAT frequency oscillator model 7600, range coverage from below 20cps to over 20kcs, a laboratory instrument, full technical details on application; price £28/17/6.—Radio Development Co., Moretonhampstead, Devon.

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AVOMINOR, £6; model 40 Avometer, £16; 5in voltmeter reading 180, 15/- ea; 5in ammeter 0/30, 15/- ea; 550ohm 0.25/1 amp, shunt regulators, 15/- ea; 2 volt Varley 40 A.H. dry accumulators, 12/6 ea; all goods new and unused.—Capper, Westbourne, Gorse Bank Lane, Baslow, Bakewell, Derbyshire.

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HIGH quality, precision-built speakers. Ticonal magnets, detachable diaphragms, die-cast chassis, twin cone.—Broadcast & Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich 26970. [6435

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BAKER super quality 12-inch permanent magnet triple cone speaker, Ticonal magnet, 15 ohms, complete with infinite baffle cabinet in the white, new, £6/10.—Box 4505.

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**DYNAMOS.** D.C. 50/70 volt 10 amps. shunt wound, ball bearing machines, 1,000 r.p.m., £14. 30 volt 5 amps. 1,500 r.p.m., £5. 12 volts 10 amps., £4.

**Resistances.** Var. slide vit. enamelled tube with laminated brush and slides, 14 ohms 5 amps., suitable with 50/70 volt dynamo for charging circuits at 5 amps., 25/- each. As new.

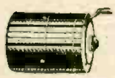
**Meters.** Ironclad A.C. voltmeters, G.E.C. 4in. switchboard, 0-60 volts, 45/-. Ammeters to match, 0-40 amps., 45/-. Frequency meter 40/60 cy. Crompton F.G. Ironclad switchboard, 50 volts 6½in. x 6½in. x 4in. with lamp on top to illuminate dial, £5 5s. Ammeter to match, 0-50 amps. A.C., 75/-. Voltmeter to match, 0-75 volts A.C., 65/-.

**Switches.** D.P. 50 amp. knife switch on Paxolin panel, 35/-.

**Motor Blowers.** 24 volt D.C. Keith Blackman 5in. inlet and outlet, £5.

**TRANSFORMERS.** B.T.H. 200/230/250 v. 50 cy., 2 volts 2 amps. and 75 volts 6 amps., with 15 taps, 70/-; carriage paid England and Wales. 2.2 K.W. Transformers, 400/220 volts, with equal tappings to 25 volts, £9 10s.

**Auto Transformers,** 230/110 volts 85 watts, 25/-; 150 watts, 35/-; 300 watts, 65/-; 1 K.W., £7 10s. Transformers double wound for models 230/20 volts 2 amps., 30/-; 12 volts 3 amps., 32/6.



**MOTORS.** Electradix Micro Motors for Instrument work and models 2in. x 1¾in., weight only 10 ozs., 12/24 volts; work from dry cells or A.C. Mains through transformer, laminated fields, ball bearings, totally enclosed, small vee pulley, centrifugal relay speed governor on shaft removable for second shaft drive. Precision made ex-W.D. stock. Worth 45/-. Price 21/- each. Limited stocks.

**Battery Chargers.** Keep your accumulator in condition while the car is laid up. Send for Special Battery Charger leaflet "W.W."

**Headphones.** Single low resistance for circuit testing, etc., with headband and cord, 5/-, or 7/6 per pair.

**Speed Meters** by A.T. Speedometer Co., 1,500 r.p.m., 4in. dia. black dial, white figures and scale, 20/-.

**Relays.** 1,000 ohm coil, G.P.O. type, enclosed, 2/6 each; 30 ohms 2-make 2-break contacts, 2/6 each.

**Spark Coils.** Ex-G.P.O., 6/12 volts, to give up to 1in. spark, with spark gap, 25/-.

**Battery Superseders,** 6 volts D.C. input, 230 volts 40 m.a. D.C. output, 55/-. Send for leaflet.

**Dimmer Rheostat Switches.** 1 ohm to 0 and off up to 3 amps. for regulation of 6 volts, 2/6.

**Invisible Ray Control.** Raycraft Kit with selenium bridge in bakelite case, 10,000 ohm relay, megostat, resistor, valveholder, etc., with instruction booklet, 45/-.

**Buzzers.** The Townsend high note Wavemeter Test Buzzer, plat. contacts, 5/-. G.P.O. double contact blade for distant signals (as illustrated), 5/-.

*Please include postage for mail orders*

# ELECTRADIX RADIOS

**214, Queenstown Road, London, S.W.8**

*(Late Queens Road)*

*Telephone: MACaulay 2159*

**DYNAMOS, MOTORS, ETC.**

DC to AC rotary converter, output kilowat, smooth for radio; £20 or offer.—Gee, 5, Riverside Close, Staines. Tel. Staines 883 after 6 p.m. [8940

BATTERY chargers for home and export, 4 models, 2-6-12v, 1, 2 or 4amp dc. any mains voltage; generous trade terms; write for catalogue.—Tel. Hoddesdon 2659. The Banner Electric Co., Ltd., Hoddesdon, Herts.

ALL types of rotary converters, electric motors, battery chargers, petrol-electric generator sets, etc., rotary transformers, input 12v dc, output 600v at 250ma; price £4/10 each nett, post paid; J.A.P. No. 2A engines, 1.2 b.h.p. at 2,600 r.p.m., complete and ready for use, £17 nett, ex works.—Ward, Lordscroft Works, Haverhill, Suffolk. Haverhill 253/4.

SANGAMO synchronous motors, self starting, 200-250v a.c., 50 cy., consumption 2½ watts, size 2¾in×2in, geared 1 rev. 60 mins., can be reset to zero by friction drive from front or back shaft, ⅝×1/10in, to run clockwise, ideal movements for making electric clocks, time switches, etc., nickel-plated finish, price 22/6 ea.; 12 to 1 dial trains to fit above spindle, 2/6 per set extra; f/3.5 lenses, 2in focus, by well-known makers, ex-Govt. stock, as new, fitted in oxidised mount, flange, etc., ideal for projectors, enlargers, cameras, etc., price 27/6 each, postage 6d.; to callers only. Bendex type R.A.10 receivers; Selsyn motors, K20, aerial cameras, heavy duty l.f. chokes, change-over relays as used in 1154 transmitter, 1,000v 200ma transformers, multi-way screened cable and plugs, test sets fitted with C.R. tubes; C.R. power units, type 526; performance meters, type 53874; a.c. mains wavemeters, type W1252; battery wavemeters, type W1095; receivers, type 1147; a.c. mains power packs for 1147; indicator modulators, auto transformers; receivers, type 76A; battery driven amplifiers, large assortments of volt, amp and milliammeters, neutralising units with R.F. meters, metal rectifiers, relays, vibrator packs, inter-com. sets, signal generators d.c. to a.c. converters; 12 and 24v d.c. to 230v a.c. Sun Vic delayed action control, 3,500watts, blower motors, G.E.C. gas-filled mercury relays; Brown's A type headphones; E.M.I. cathode-ray tubes; 6-valve receivers incorporating Clystron unit, etc.—H. Franks, 58, New Oxford St., W.C.1. Tel. Mus. 9594. [8970

**VALVES**

NEW 813 (1), 110/-; 872A (1), 807 (2), 25/- each.—Box 4494. [8895

BRAND new, boxed, RK34s, U.S.A., 6/-; 9001s, 10/-; R.C.A. 808s, 35/-; R.C.A. 8014s, 500w air-cooled triodes, £3.—Sykes, Oldfield Rd., Honley, Huddersfield. [8924

LARGEST and most comprehensive range in the country, British and U.S.A. types, at Board of Trade prices; send for lists (valves available), free, s.a.e.; valves sent c.o.d.; retailers not supplied. RANSOM, Bond St., Brighton. [7223

**GRAMOPHONE AND SOUND EQUIPMENT**

SIMON SOUND SERVICE can supply your needs. [8712

INFINITE Baffle corner deflectors, scientifically designed acoustic chambers as reviewed "Wireless World" June; send for catalogue.—Broadcast & Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich 26970. [6434

PROFESSIONAL recording equipment; to the trade, recording machines, blank discs, cutters, trailer needles, etc., from stock; recording amplifiers, matching transformers, ribbon and m.c. microphones; full trade terms.—Sound Discs (Supplies), Ltd., 83a, Bold St., Liverpool.

S.H.E.F.I. moving-coil pick-up is now available for both home trade and export; it combines for the first time high fidelity with high output voltage, enabling it to directly replace normal moving iron pick-ups without any extra amplification; it has an exceptionally clean response with no undesirable resonances, thereby reducing needle scratch. Price, in walnut and black plastic finish, 40/- each retail, including transformer, plus 10/4 purchase tax; wholesale and retail enquiries invited; illustration sent on request.—Brooks & Bohm, Ltd., 90, Victoria St., S.W.1.

ARE you interested in reproducing sound as nearly as possible to the original and doing this at a reasonable cost? If so, we invite you to either come to our demonstrations or write for full particulars: demonstrations daily, 9.30-10.30 a.m, 6 p.m.-6.30 pm., excepting Sat.—Rogers Developments Co., 12, Macclesfield St., Shaftesbury Ave., W.1. [8743

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CHARLES BRITAIN (RADIO), Ltd.

VIBRATOR pack, size 7in × 3in × 2¾in, black crackle case, 6 volts only, employs a Wearite Stratosil vibrator and gives 250v at 80ma, the output is not rectified but the outfit contains all the necessary filters, etc.; price 27/6, plus 1/6 carriage and packing. Components: We offer the following selection from our large and comprehensive stock: Loudspeakers, Rola 10in P.M. less trans, £1; Rola 8in P.M., less trans, £1; Page 5in P.M., less trans, 14/6; Goodmans 12in Hi-Fi twin cone (Axiom Twelve), £7/10, plus 5/- carriage and packing; Goodman's 12in 15ohm speech coil, £5/17/6, plus 5/- carriage and packing.

SPECIAL offers: 36 asstd tubular condensers, ·001mfd to ·1, 10/6; 72 asstd resistors, ¼, ½ and 1watt. all new, 100ohms to 6meg, 12/6; 72 asstd metal cased condensers containing ·01, ·1 15 and including 2, 01, 2,500v wkg, all new, 27/6; 36 mica condensers, ·0001 to 01, all new, 12/6; 12 volume controls, less switch, 5,000ohms to 3meg, 17/6; 24 valveholders, Loctal, Octal, 5 and 7-pin, etc., all new 10/-; send for list "W" of other bargains available.—Charles Britain (Radio), Ltd., Radio House, 2, Wilson St., London, E.C.2 Tel. Bis. 2966. [8961

G. W. SMITH & Co. (RADIO), Ltd., offers the following:—

GUARANTEED sound and perfect: R.A.F. type 39 aerial coupling units with 0-3 and 0-6amp thermo coupled meters and 100watt dummy aerial, 17/6 each; 1,000kc crystal units, new and boxed, 10/6 each; R.A.F. R1124 receivers, 41.3mcs, complete with valves very easily adapted for television, limited number only, 59/6 each; Admiralty 1149. 2 speed dials, very fine job, 4/6 each; condensers, 1mfd 5kv working, 10/- each; .25mfd 2kv working, 2/6 each; R.A.F. output testers with 2volt valves suitable for adapting to 5-metre receivers, brand new, 19/6 each; E.F.50 valve holders, Pax 6d, ceramic 9d, Octaland 7-pin 6d each; I.F.F. receivers, complete with valves, 29/6; selector 24volt step in relays, 1/6 each; 12volt stater relays, 3/6 each; 18 and 24-way screened cables, 4/6 each; 8volt ¼amp rectifiers, 3/6 each; 5ma rectifiers, 2/3 each; 60ma L.F. chokes, 2/6 each; 0-20volt ac meters, 2½in scale, 10/6 each; plus carriage.

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PARK RADIO OF MANOR PARK, 676-8, Romford Rd., E.12. Tel. Ilford 2066.

TELEVISION kits, £22/10, absolutely complete set of parts with working instructions, to avoid risk, tube supplied to callers only; Pye Co-Ax plug and socket, as used on wartime apparatus, 1/- each; large 12-pin sockets, 9 around 3 middle, 2/-; under-pillow extension speakers, play the kids to sleep, or don't disturb your wife while you listen to the end, 2/6 each; Tannoy double-button hand mikes, good hardwearing job with muting switch, lead and plug, 10/6; trickle chargers, 230v ac, charge 2 or 4v ¼a, 12/6; transformer and rectifier supplied for making up in 15 minutes; contact mikes for pianos, violins, guitars, etc., 2/6 each, transformer 6/-; tungsten contacts for renewing worn vibrators, 1/6 pair; self-energising telephones, will work up to 2 miles on 1 wire and earth return, a boon for the bedridden, keep in touch with the patient without running up and down stairs, fine also for farm outhouses, 2/6 each; who hears the radio, you or grandpa? Let the old folk hear the radio in comfort, modulated output unit with headphones, suit any set, 30/-, cash refunded if not satisfied; burglar alarms, 230v ac/dc, suitable for shop premises, intruder sets alarm bell ringing, 55/- complete; replacement bobbins for Garrard pickups, including new rubbers for reassembling unit. 4/9. [8960

GANG condensers, escutcheons, transformers etc., to be sold regardless of cost.—Send stamped addressed envelope for full particulars to Retail Sales, Ltd., 6, Chiltern Parade, Sycamore Rd., Amersham, Bucks. [8670

"W.W." moulded television coil formers, with feet and slugs, 9 for 7/6; blocking osc. trans., 1-1, 3/6; 100 ma chokes, cast case, 8/-; 5in P.M. speakers, 14/-; R1155, 6c 6o.p., £12.—Taylor, 24, Enmore Rd., S.W.15.

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YAXLEY type switch, 3-bank, 1 pole, 6-way each bank, short spindle, ex-Govt., 9/- doz.; 0.000127 tuning condensers, 42/- doz.; Mazda Octal valve holders, amphenol, 3/9 doz., in 500 boxes:—Will Owen, 538a, Mansfield Rd., Sherwood, Nottingham. [8920

METEOR ELECTRONICS.—Midget i/c coils, midget 2-wave coils; constructional kits for midget coil-packs and I.F. transformers; permeability tuners and S.W. coil units; send 2½d stamp for full lists, including smoothing chokes and O.P.T.s—Gloucester Row, Weymouth. [8951

DUAL output mains operated h.t. units, 650v at 400 ma and 300v at 120 ma, using separate rectifiers, also incorporated 12v vibrator-pack, £5; 1kw 230v to 115v transformer, £2/10, plus cost of carriage and packing; send for details.—Barton, 41, Bedminster Down Rd., Bristol, 3. [7851

COPPER wires, enamelled, tinned, cotton and silk covered, all gauges; B.A. screws, nuts, washers, tags; bakelite and ebonite panels, tubes, coil formers; headphones, flexes, solder, etc., list s.a.e.; trade supplied.—Post Radio Supplies 33, Bourne Gardens, London, E.4. Tel. Clissold 4688. [8231

A LARGE quantity of radio components, including condensers, flexible couplings, 3 pole 3-way switches, line cord, multi range ohms meters, screened wire single and twin, 3-core flex., 2- and 4-way fuse boxes, etc.—'Phone or call L. Goodman (Radio), Ltd., 9, Percy St., Tottenham Ct. Rd., W.1. Mus. 0216.

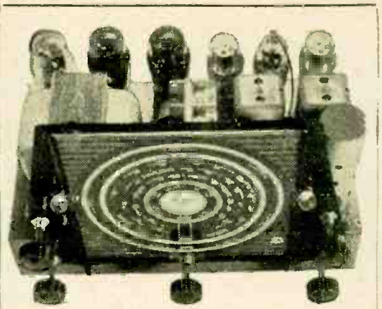
KIT sets, superhet A.C. or A.C./D.C., £7 19/6; amazing results, and easy to build without instruments; components matched and pre-set; no drilling; equal to any quality commercial receiver; elaborate building instructions; beautiful cabinets in walnut and bird's eye maple.—J. Morgan, 164, Whyteleafe Rd., Caterham, Surrey. [8831

GEE ELECTRIC, 15, Little Newport St., London, W.C.2. Tel. Ger. 6794.—Offers you guaranteed goods at the keenest prices, from large comprehensive stocks of radio goods; 6v or 12v car radio vibrator transformers 75ma 300v H.T., size 3×3×2¼, 15/- ea; 7-core 14-36 multi-cable, 1/3 per yd; 30ma pentode speaker transformers, small size, 3/3 ea, 35/- per dozen; 200ma 20 henries, tropicalised smoothing chokes, 18/6; 120ma ditto., 12/6; 1¼in condenser mounting clips, 3/- per dozen; 0-300v dc moving coil v.meter, 2¼in dial, complete with external shunt, brand new, 12/6 ea; 8in R. & A. P.M. speakers with transformers, 22/6 ea, £12 per dozen; even amount of mixed resistors from 1 watt down to 0.1 watt, our selection, £2/5 per gross; 6-1 epicyclic reduction drives ¼in spindle, 1in long, 2/3 each; 2¾in drum, drive, and spring, for slow motion tuning, 2/9 complete; International octal valve holders with pins 1 and 6 omitted, 5/- dozen; small flexible ¼in spindle couplers, 5/6 dozen; 4 valve T.R.F. chassis, 9½×4¾×1½ heavy gauge steel, sprayed grey, 3/9 each; Pye plug connectors, 1/- ea.

3½ Gee Scope an oscilloscope of outstanding performance, price £35; descriptive leaflet on application; also a very large selection of valves, condensers, line cord, knobs dials, etc.; special prices for large quantities; s.a.e. for all enquiries. [8789

NEW STC selenium rectifiers, f.w. bridge conn. dampproof finish, 17v 1a 12/1, 2a 15/5, 3a 21/6, 4a 25/-, all p.f.; 36v 2a 28/6, 4a 38/-, 50v 4a 53/8, all post 9d. Heavy duty type, 7in sq A1 cooling fins: 17v 6a 34/1, p. 1/-; 16v 10a 43/8, p. 1/-; 33v 6a 63/8, 30v 10a 71/2, 28v 20a 139/3, 54v 6a 89/6, 90v 6a 141/-, 110v 6a 166/4, all p. 1/3. Replacements for all valve-type chargers available, for Philips 367 by return of post (dealers note). H.W., push-pull and v. doubler rects. for all duties. Specialised rectifying equipment for labs., schools, etc. Kits, trans. rect. and rheostat for 16v 10a charger, £6/12/6; 17v 6a, £4/12/6; special 16v 5a, £3/2/6 vent steel case 7/6 extra; 16v 4a, £3, case 7/6; 16v 2a 28/6, case 7/6. Transformers: 130w for 17v 6a 47/6, p. 1/3; 220w for 16v 10a 65/-, p. and 6. 1/6; 790w for 1v 4a 35/6, p. 1/-; 17v 2/3a 26/-, p. 1/-; 150w slider res., all values 24/6, p. 8d; 5.5amp 1ohm s. rotary 7/6, p. 8d. H.D. six-way 15a switches 8/6, p. 8d. Fluorescent fittings comp. with tubes and starter gear: 40w from £6/9/3, 80w from £8/8, twinlamp £17/2/6, all carr. extra. Illus. list 2d stamp. C.o.d. on postal goods only, otherwise c.w.o or pro-forma in voice. Trade supplied. Special, one only, Delco-Remy 15v 200w petrol direct-coupled generator with tank volt and ammeter and fuses ready to run, £15—Pearce, 66, Gt. Percy St., London, W.C.1 (nr. Angel). [8930

# ARMSTRONG



## Model RF103

## 10 VALVE ALL-WAVE SUPERHET RADIOGRAM CHASSIS.

**SPECIAL FEATURES**

★ 10 VALVE CIRCUIT.
★ R.F. PRE-AMPLIFIER.
★ WAVE BAND EXPANSION.
★ LARGE GLASS SCALE.
★ 3 STAGES A.V.C.
★ TREBLE LIFT CONTROL. (Operates on both radio and gramophone.)
★ PLUS 6 db. BASS LIFT ON GRAMOPHONE. (To restore bass cut on some records.)
★ 10 WATT PUSH-PULL OUTPUT.

**To export buyers we can confidently recommend RF103 to any firm abroad who contemplates making a high-grade Radiogram or Console radio receiver.**

The lively short-wave performance coupled with the excellent quality reproduction ensure an outstanding performance.

We will gladly make any alterations to the specification to meet individual requirements.

**To home buyers demonstration model now available to interested callers to hear, and technical specification now available on request.**

It is hoped that a number (very limited unfortunately) will be available for early delivery.

The above model is for A.C. Mains.

We also have a similar model Type UNI 103 for DC/AC Mains.

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'Phone: NORth 3213

G. A. RYALL, 65, Nightingale Lane, London, S.W.12.—Mail order only, postages extra, c.o.d. £1 or over, please send large envelope for our full list; U.S.A. make metal cased 500v tubular 0.1mf, 7/6 dozen; Silver mica, 200pf, 300pf, 400pf, 500pf, 4/6 dozen; 500v wkg. Micamoulde d 0.004mf, 4/- dozen; Mica 0.01mf, 3-2/-; Mansbridge 1mf 500v wkg., 3-2/-; all condensers guaranteed; Amphenol type British 5-pin valve holders, 4/6 dozen; U.S.A. paxolin 4-5-6-pin, 3/6 dozen; volume controls, 10,000 medium spindle, 1/6 250,000ohm short spindle, 1/6; Bar type 3 gang, 0.0004mf short spindle, 5/-; Twin ceramic 0.0003mf, 5/6; Bar type 4 gang 0.0004mf, 5/-; Resistors, ¼watt, ½watt, 100 ohms to 2 meg level assortment, 40-5/-; Plastic group boards, drilled, less tags, 9w, types, 3-1/6; Switches SB.2P. 6w, 2/-; 3B.2P. 6w, 2/6; 2B.3P. 3w, 2/3; Res. panels, 5-way with 25mf and three res., 1/3; Twelve-way group boards with 9-1watt and ½watt res., 2/-; all new; twenty types in stock; Octal plugs, cap and socket, 3-2/6, with tags 3-3/-; high resistance 'phones with sponge earpads, with good class microphone all wired into plug, rubber padded, plug type 10H/10991, 10/9 pair; Metal boxes, black finish with quarter-inch paxolin panels, fixing lugs and corner sockets, size 8½×7½×3½in deep, 6/9 each complete; International Octal valve holders, Paxolin chassis type, 4/6 dozen; Metal-cased tubulars, 0.5mf, 350v, at 71d C., wire ends, 3-2/6; Fifteen relays in carrying rack, mounted, with cover, 42/6; Centre zero meter 0-20 microamperes, £3. [8928

MORE bargains for radio men.—Special this month; plated steel chassis, 13½in×6in×2½in, punched and drilled 5-valve set, 7/-; 16×8mf 450v can T.M.C. elect., 6/-; 25mf 25v elect., 1/9; new valves, 6K7G, 6J7G, 25A6G, 25Y5G, list prices; p.m. speakers, 6½in, 14/11; service kit containing 12-1w, 12-½w resistors, 12 tub. condensers, assorted values, 3 trimmers, 1-25mf 25v, 1-16×8 450v can., retail value 38/9, our price 20/-; resistors, 1w 4/-, ½w 3/-; tub. cond., 4/6 doz; transformers, chokes, volume controls, w.c. switches, coils, trimmers, chassis, many other lines all at rock-bottom prices; terms c.w.o., c.o.d. (over £1), carr. paid over £1, otherwise add 6d.—J. R. Trading Co., 126, Warwick Rd., Kenilworth, Warwicks. [8797

MARVELLOUS opportunity for laboratory, oil filled voltage regulating transformer, in 180-260v out., 218-242v in., 2v steps ±1%, 50 cycles, 1.6 kVA, wt. 5cwt, £25 on site; cable as Nov. advt.; rotary transformer, smoothed, in 12v out., 220v 80ma, U.S. Army, suitable for receiver CCT46145; ex-R.A.F. in 24v out., 250v 70ma H.T., 12.6v 2.6A L.T., 12v carbon pile voltage regulators, 5/-; iron cored R.F. chokes, 3d; Morse keys, 2/6; 30 P.F. condensers, 3d; 3 ohm 20w tapped vitreous resistors, 1/6; mic. transformers 2/6, side tone 1/6; double pole change-over switch, push button, G.P.O. type, 6d; Cord type 2-pin sockets (small), 6d; air spaced ceramic trimmers, 1/-; bargain parcels ex-R.A.F., etc., suitable for experimenters, magnificent opportunity to secure first class equipment at scrap prices, £1; ex-R.A.F. generators complete with ammeter, regulator, cut-out, etc., output 12-32v 9A, £7; generators only, £5/10; can also be used as 24v ¼hp motors or as repulsion induction motor on 230v A.C. mains; please include postage and packing; money returned if goods unsuitable.—Moseley, Electrical and Radio, Corse Lawn, Glos. [8905

SOUTHERN RADIO'S wireless bargains.—Latest radio publications: Amateur Transmitters' Construction Manual, 2/6; Radio Repairs Manual, 2/6; Car and Portable Radio Manual, 2/6; Radio Valve Manual, alternative and equivalent British and American valve types, 3/6; Radio Circuits, receivers transmitters, power packs, etc., 2/6; Short Wave Handbook, 2/-; Ultra Short Wave Handbook, 2/6; Manual of Direct Disc Recording, 2/6; Test Gear Construction Manual, 1/6; Radio Pocket Book, colour code, formulas, etc., 1/-; Midget twin ganged condensers, 2in×1in×1½in, 5/- each, postage 6d; Midget single gang condensers, 1½in×1in, 2/6 each, postage 6d; R.A.F. Morse keys, 2/6 each, postage 4d; instructors pattern Morse keys with bakelite case, 7/6 each, postage 8d; power packs M.C.R.I. pattern, input 90/250 A.C. or D.C., output 90 volts h.t. and 7½ volts l.t., D.C., £2 each, post 1/-; condensers, 1 plus, 1 plus 1, 2/6 each; ex-Army headsets, carbon mikes and cushioned moving coil ear phones, guaranteed perfect, post free 12/6; ex-Govt. input transformers, ratio 1:49 mu metal core, 4/6, post 1/-; ratio 1:7 mu, metal core, 4/6, post 1/-; Systoflex assorted sizes and colours, 2/6 per dozen lengths; Peribraid 2mm cotton covered plastic sleeving, 8/6 per 144 yards (minimum quantity).
SOUTHERN RADIO SUPPLY, Ltd., 46, Lisle St., London, W.C.2. Gerrard 6653. [8926

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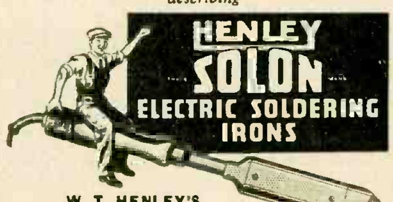


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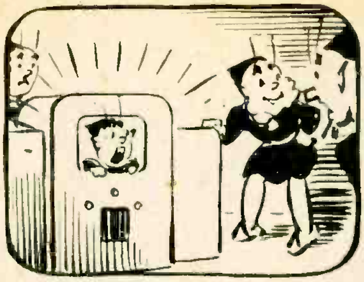

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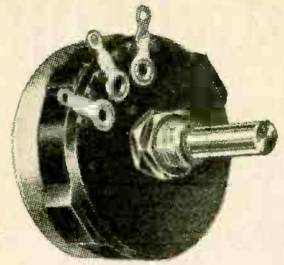

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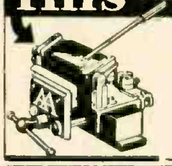

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