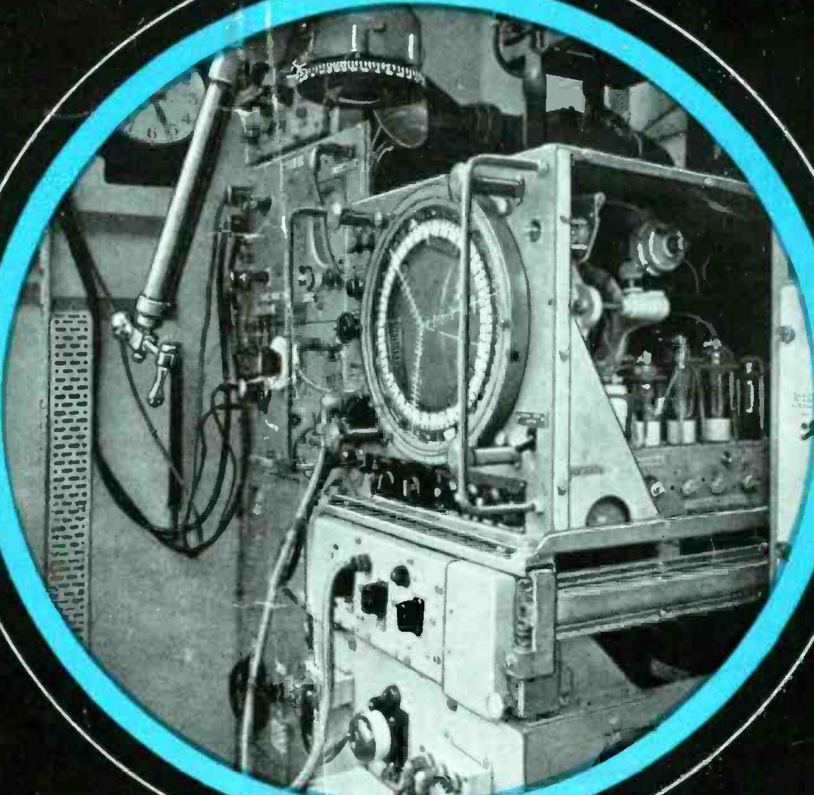
Wireless World

RADIO and ELECTRONICS



NOV. 1945

1/6

Vol. LI. No. 11

IN THIS ISSUE: GRAPHICAL FILTER DESIGN

WE KNOW–
we made most of them!

There is no exaggeration in the story that appeared in the National Press recently that over 13,000 types of condensers were produced for the fighting Services during the war—in fact, our records show an even greater variety. We know this, since most of them were made in our main and dispersal factories as well as in out-working units which we organised.

Reference was also made in the Press to the manufacture of condenser parts by disabled Ex-Servicemen, and we are proud to have been associated with this valuable means of obtaining extra production.

We make no complaint about the varied types and sizes of condensers we had to make—our skill and organisation were fitted for the work and we regarded it as our duty in the national interest. It also became part of our duty to make available generally our technical knowledge and manufacturing technique; if this helped in the final victory that has now been achieved, we are amply rewarded.

Now we shall be getting back into peace-time harness again and our Condenser service, which we claim to be the most comprehensive in the country, will once again be at the disposal of our customers. Our job is to make the kind of condenser YOU require.

TCC CAPACITORS

THE TELEGRAPH CONDENSER CO. LTD.

RADIO DIVIS

NORTH ACTON · LONDON · W.3 *TELEPHONE:* ACORN 0061

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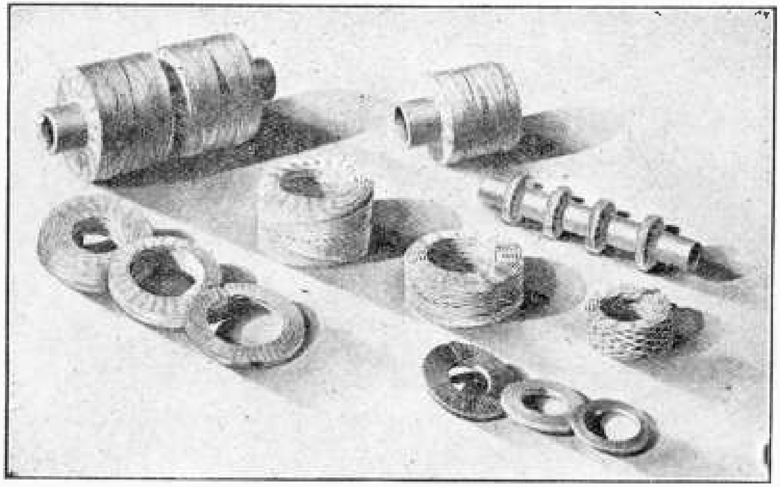
WAVE-WINDING



As designers and manufacturers of the original British Wave-Winding Machines we have specialised facilities for wave-winding, and are willing to undertake the winding of

★ *Prompt Service.*

I.F. TRANSFORMERS

INDUCTANCES **TUNING COILS**

H.F. CHOKES

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO LTD.,
Winder House, Douglas Street, London, S.W.1. *Tel.: VICtoria 3404-8.*

Exide

IN PARLIAMENT.....

In the House of Commons :

Mr. EVELYN WALKDEN asked the President of the Board of Trade why 120-volt Exide Batteries which are sold at 11s. 1d. are in short supply and other 120-volt batteries of less reliable make, and sold at 15s. 6d., only are available . . .

Mr. DALTON : Wireless batteries are now in short supply, owing to the heavy demands of the Services, and it is necessary, therefore, to make use of the output, although small, of the higher cost producers. Prices are controlled under the Price of Goods Act, 1939, and those charged for both classes of battery referred to by my Hon. Friend have been investigated and approved by the Central Price Regulation Committee.

Mr. WALKDEN : While appreciating what my Right Hon. Friend has said, is he not aware that batteries are used largely by people in small homesteads who cannot understand why good batteries cannot be obtained while there is a plentiful supply of inferior ones. . . ?

Mr. DALTON : I am very anxious to get a fair distribution of whatever supplies there are, but the best batteries are required for the Services in a very great and increasing quantity . . .

(Extracts from Hansard, Jan. 16)

THE CHLORIDE ELECTRICAL STORAGE COMPANY LIMITED

GROSVENOR GARDENS HOUSE · LONDON · SW1

W.M.C.81/45

★ "SKYROD" Aerials

★ TELEVISION Aerials

★ INTERFERENCE Suppressors

AT last we are able to offer our range of aerials and suppressors. They are not yet in stock all over the country, but difficulties are being overcome.

Dealers . . . are your showroom "Skyrod" and Television Aerials ready for showroom demonstration? Those of you in the area served by the Alexandra Palace transmitter should check up, or get in touch with us.

BELLING & LEE LTD
CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX

GA

SUPP: 11. SSW (iv)

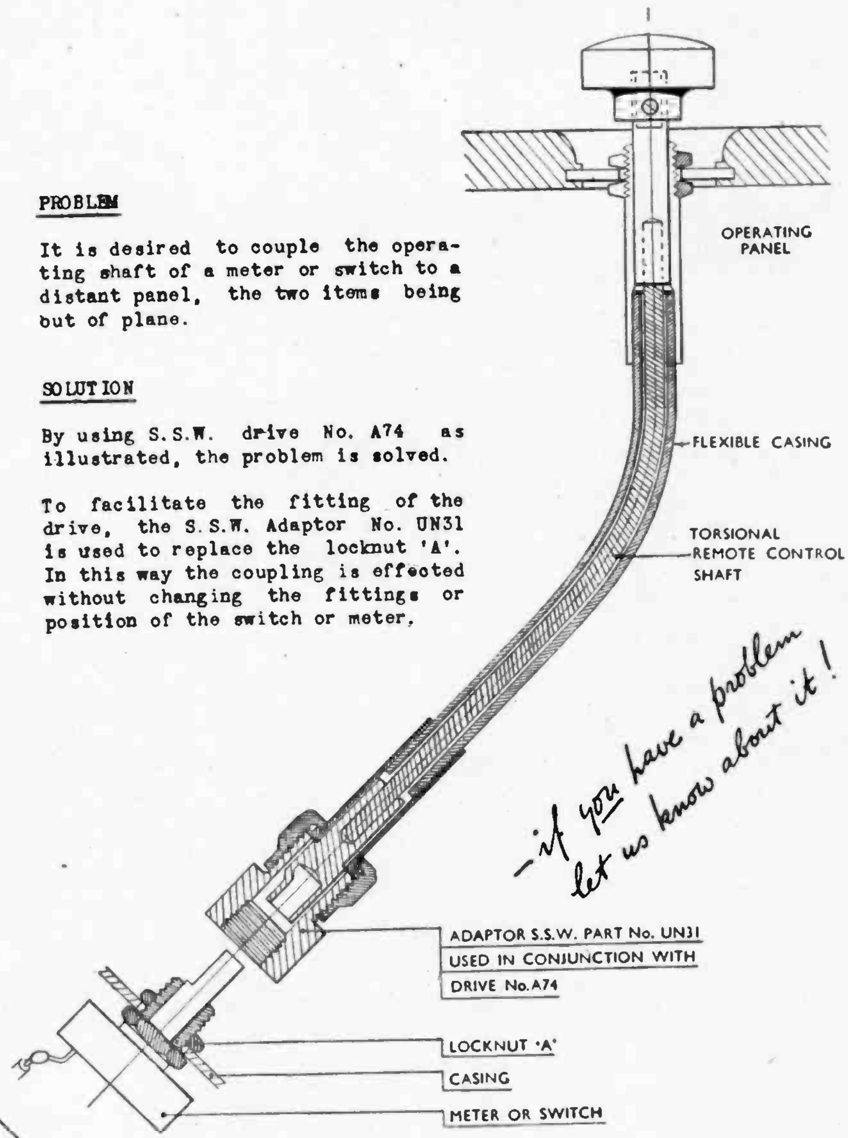
PROBLEM

It is desired to couple the operating shaft of a meter or switch to a distant panel, the two items being out of plane.

SOLUTION

By using S.S.W. drive No. A74 as illustrated, the problem is solved.

To facilitate the fitting of the drive, the S.S.W. Adaptor No. UN31 is used to replace the locknut 'A'. In this way the coupling is effected without changing the fittings or position of the switch or meter.



Centenary Year

W.T. 21

A PAGE FROM THE SUPPLEMENT TO THE TREATISE

This page is for insertion in the loose-leafed TREATISE on FLEXIBLE REMOTE CONTROL. Its position is clearly indicated by the top reference.

If your copy of this addition to the SUPPLEMENT has not yet been received, may we suggest that you cut out this page and place it in the correct position? Better still, of course, send to us for the sheets to the SUPPLEMENT numbered SUPP. 11. (ii) (iii) (iv). These are now in process of being distributed to holders of the TREATISE, a copy of which is still available to those who can put it to good use.

THE S.S. WHITE COMPANY, LTD., BRITANNIA WORKS, ST. PANCRAS WAY, N.W.1.


Weather Forecast . . .
High in the sky . . . above the clouds . . . soars a balloon . . . automatically sending by radio, data on the always topical weather.
The meteorological stations are regularly releasing these upper-atmosphere mobile transmitters to predict the future weather.
Standard Mazda Valves are used in these balloon transmitters and once again their reliability is proved by the use in a device where, when the balloon has ascended, it is obvious that an engineer cannot be sent to change a faulty valve.
The same care and thought go into the Mazda Valves in your set.
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RADIO VALVES
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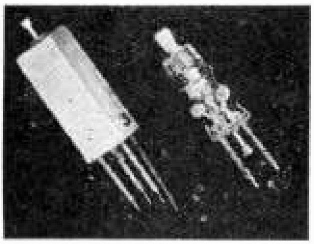

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The F. W. SICKLES Co.
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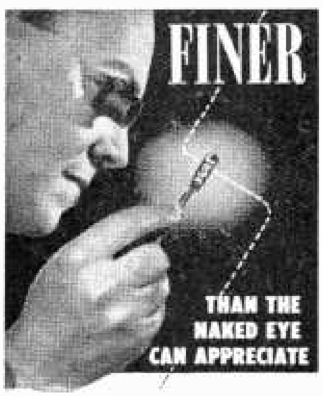

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You need a Jeweller's "eye-loop" to see the intricate construction, painstaking workmanship and engineering genius that go into each of these tiny Raytheon high-fidelity tubes. The result is such clear, rich tone that they're used in the finest hearing aids.

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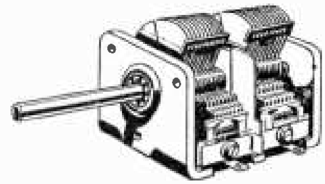

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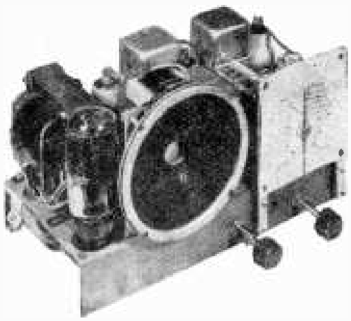

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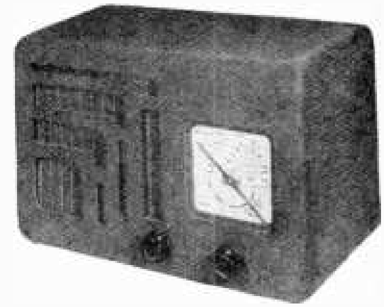
5-VALVE MIDGET SUPERHET CONSTRUCTORS KIT

Complete with Cabinet.
16-50, 200-550 metres.

A SUPER-SENSITIVE AND SELECTIVE CIRCUIT.

Brief specification: Frequency changer, 6 tuned circuit, 465 K.C.'s iron cored I.F.'s, 4-watt output. P.M. speaker and output transformer, all valves, chassis, practical and theoretical diagrams. Parts list, nuts, bolts and wire and modern cabinet, dimensions, 12in. × 8in. × 6in. deep. Ready to assemble. 200/250 volts. A.C. Parts, new, ex-television. Including purchase tax .. **13½ Gns.**
Case and packing, 10/- extra.



WE CAN NOW OFFER FROM STOCK THE FOLLOWING ELECTROLYTICS.

6-mfd. × 50 v. tubular, **1/3**; 25-mfd. × 35 v. tubular, **1/9**; 25-mfd. × 25 v., tubular, **2/-**; 50-mfd. × 12 v., tubular, **2/-**; 8-mfd. 500 v., tubular tag end, **4/9**; 8 × 8 mfd., 500 v., tubular tag end, **6/9**; 33-mfd., 350 v., tubular tag end, **6/9**; 4-mfd., 450 v., tubular tag end, **4/6**; 8-mfd., 440 v. wet aluminium can, **9/6**; 16-mfd., 440 v. wet aluminium can, **11/6**.

LOUDSPEAKER TRANSFORMERS. Pentode output, 40 : 1, 50 m.a., **4/-**; Multi-ratio, 40 : 1, 60 : 1, 80 : 1, and push-pull, 80 m.a., **10/6**; Pentode output, 12/15 ohms, 100 m.a., **12/6**; heavy duty, multi-ratio, 24 : 1, 41 : 1, 48 : 1, 58 : 1, 82 : 1, 116 : 1 and P.P., 80 m.a., **15/6**; 3 : 1 Inter-valve, **10/6**; push-pull output, 20-watt, 4,000-0-4,000 primary, 2.5, 7.5 and 12/15 ohms, secondary, **25/-**.

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Brown, with White, Green or Red grille. State colour preferred.
Dimensions, 11 × 12 × 5in., fitted with 8in. P.M. Speaker and Pentode Transformer, excellent in appearance and performance,

55/- complete

N.B.—In error the price was wrongly quoted last month.

AERIAL AND OSCILLATOR COILS. Best D.S.C. wire-wound, colour coded on bakelite formers. Short, medium and long-wave, 16/50 m., 200/550 m., 1,000/2,000 m., with circuit diagram, **15/-** the set.

I.F. TRANSFORMERS. 465 K.C.'s iron-cored, litz wound, alum. can. Limited quantity, **17/6**, matched pr. **9/6** ea.

S.M. and L. T.R.F. COILS. Philips, best quality in screened aluminium can; 17-51, 220-585; 725-2,000 metres. (These coils equal to performance of superhet.) Complete with diagram, **9/6** the pair.

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WAVE CHANGE SWITCH. To suit all above coils, **5/9.**

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Complete in leather and velvet-lined case. Spec. 1,000 ohms per volt on all ranges. 600 v. A.C./D.C. 0-750 milliamps, 0-50,000 ohms, without external batteries, up to 20 megohms, with external batteries. New and unused, complete with test prods, multipliers and instructions.

£8 16s. 6d.

2 SPECIAL KIT OFFERS

KIT 1.—Tuning heart, suitable for 6-valve superhet., comprising variable condenser and slow-motion drive, set of iron-cored I.F.'s 465 K.C.'s Litz wound, aerial coil, R.F. transformer and oscillator coil. All trimmers and padders with wave change switch for 3-wave bands. S.M. and L. Also circuit diagram for complete set, **£3 9s. 6d.**

KIT 2.—Tuning heart for 5-valve superhet, comprising variable condenser, and slow-motion drive, set of iron-cored I.F.'s 465 K.C.'s Litz wound, aerial coil and oscillator coil. All trimmers and padders with wave change switch for 3-wave bands, S.M. and L. Also circuit diagram for complete set, **£2 19s. 6d.**

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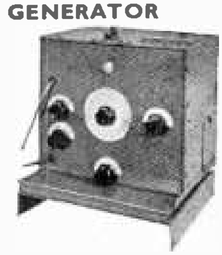
ELECTRIC KETTLES. 4-pint. Vitreous enamel, 950 watt 200/220, 230/250 v., complete with lead and adaptor, **41/3.**

DE LUXE ALL-WAVE SERVICE SIGNAL GENERATOR



A.C. mains, 200/250 v. 50 cycles, range covers from 20 M.C. to 100 K.C. all fundamentally in 5 bands without gaps. S/M dial. Direct calibration in frequencies. Coarse and fine output attenuator. Internal modulation. 400 c/s. Iron-cored coils. The generator is entirely screened in heavy metal cabinet. Dim. 10in. × 10in. × 12in., **16 gns.** Case and packing, 10/- extra.

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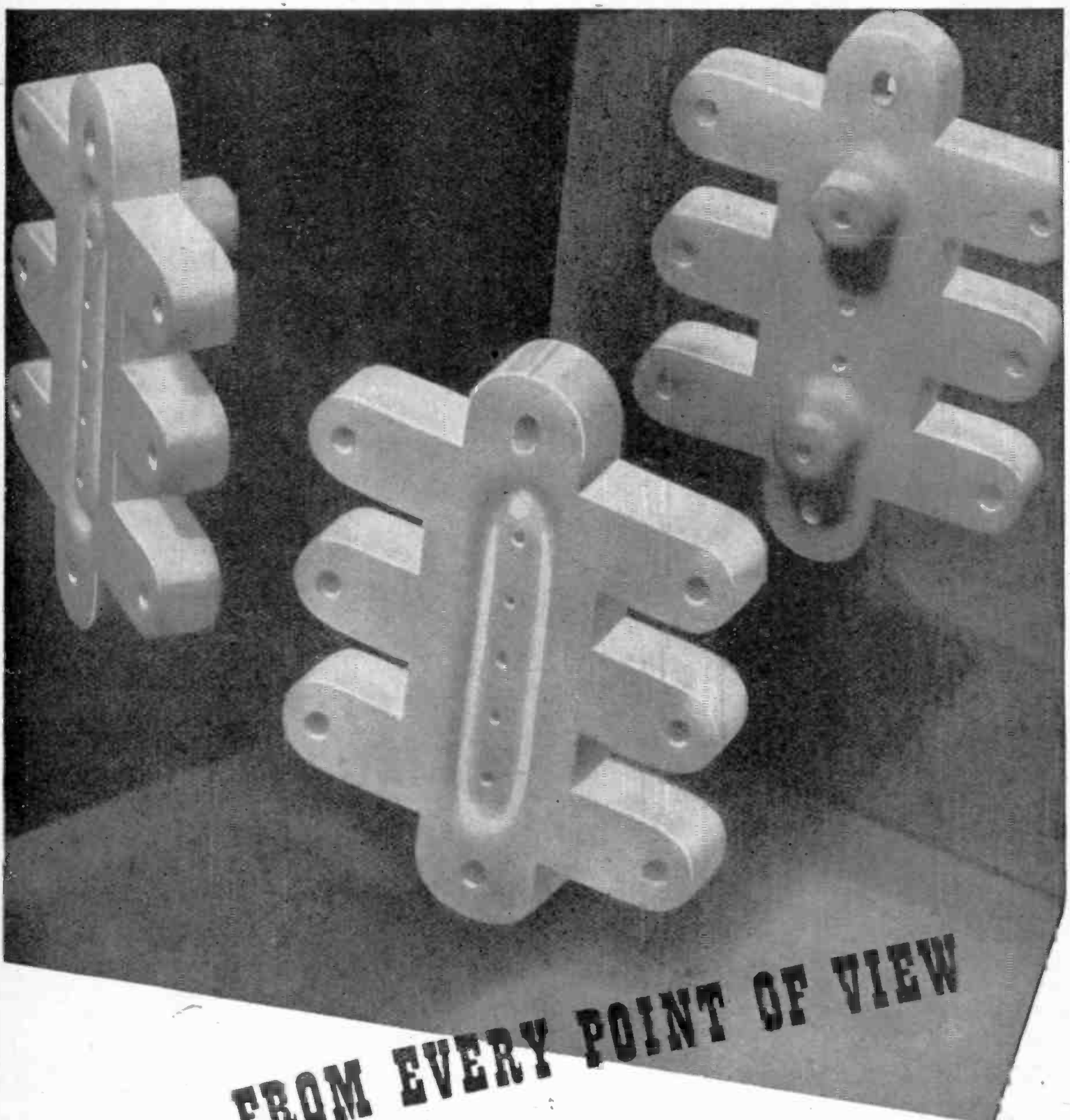

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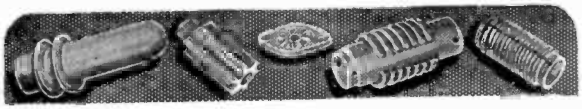

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AND HERE IS THE REASON . .

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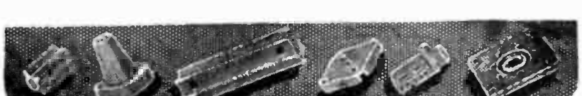

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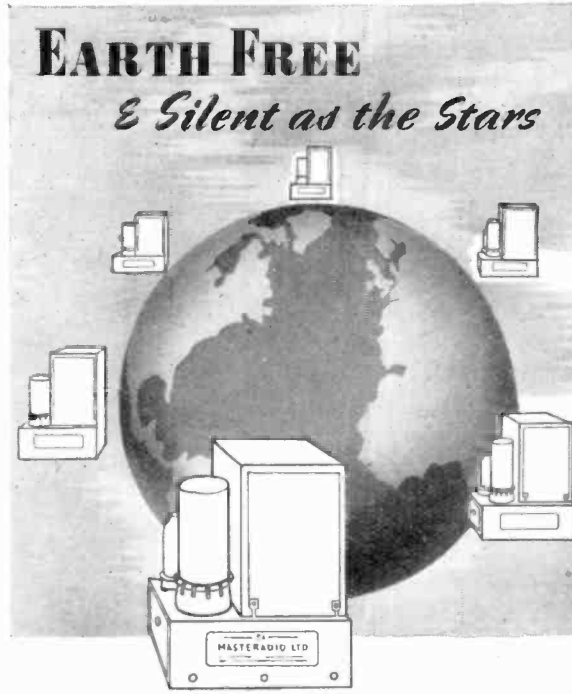

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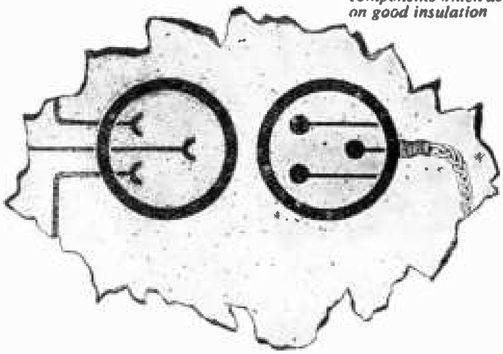
The plug and socket. Two of the many electrical components which depend on good insulation



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IF you are making a component, such as a plug and socket, for instance, you can do so a great deal more easily when you know that your plastic insulating material is uniformly effective, whether the section is thick or thin.

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P.A. PROJECTOR SPEAKERS employing the latest Vitavox P.M. Moving Coil Unit (15 ohms), handling 10 watts, with 42in. all-metal expon. Horn, £10 10s. (carr. 7/6). Same Unit with 30in. all-metal square dispersive Horn (very efficient), £9 10s. (carr. 7/6). **GOODMAN OMNI-DIFFUSION SPEAKERS** with radial six-section baffle for central suspension in dance-hall or public room, fitted 20-watt 15-ohm P.M. M/coil Unit, senior model 33in. diameter, second-hand, perfect (LIST £22). A few, for callers only, at £9 15s. each. **GOODMAN SPEAKER/MICROPHONE UNITS,** 8in., latest P.M., 27/6.

HEAVY DUTY OUTPUT TRANSFORMERS again available. Improved "W.W." specification, providing 11 ratios from 12/1 to 75/1 with centre-tap for push-pull, handling 25 watts, weight 9½ lbs., 59/6 (desp. 2/-).

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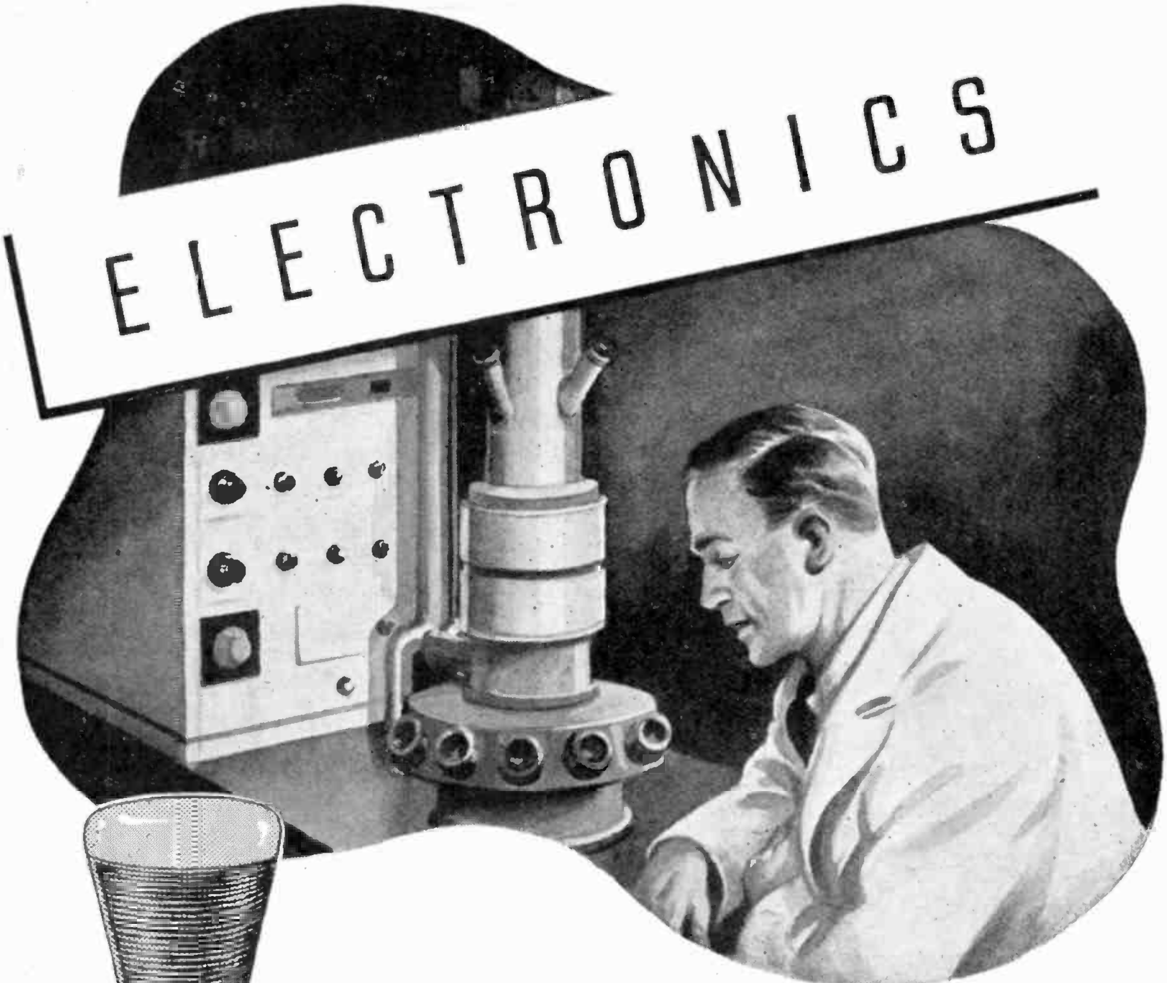

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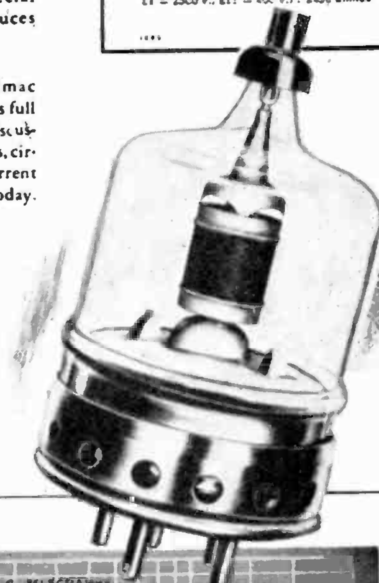

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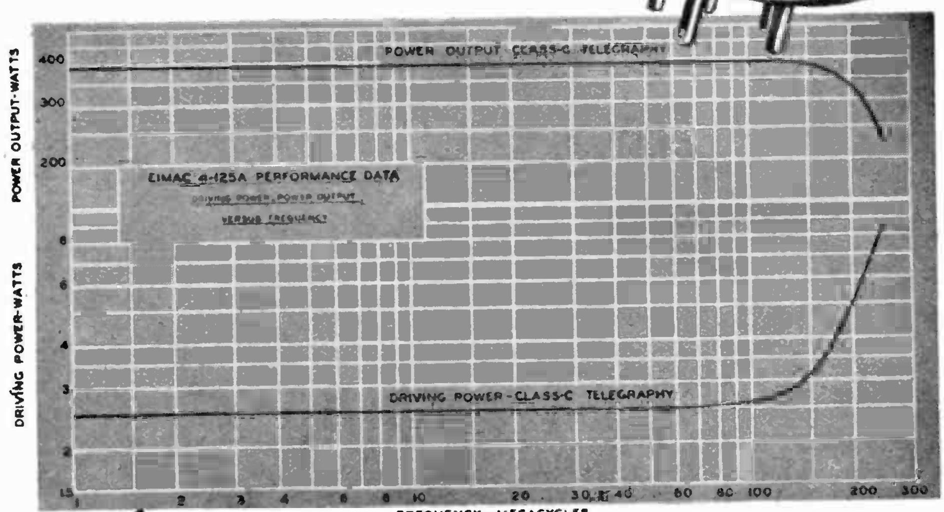

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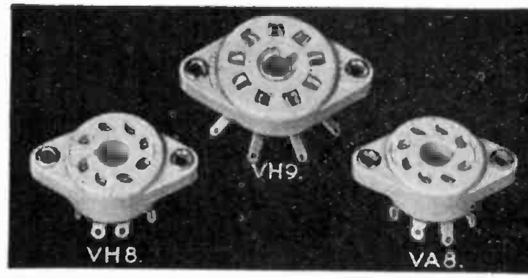

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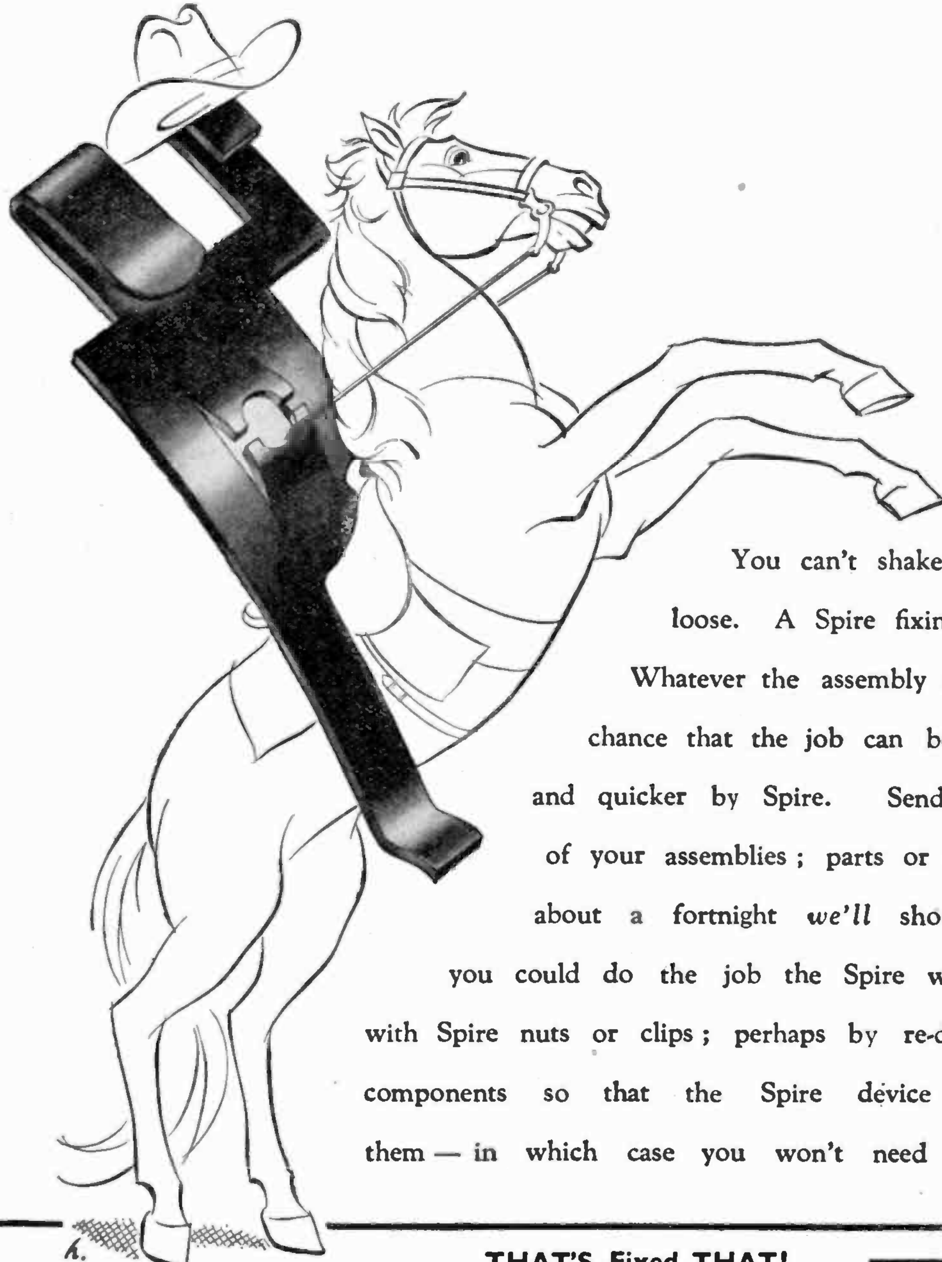

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Radio and Electronics

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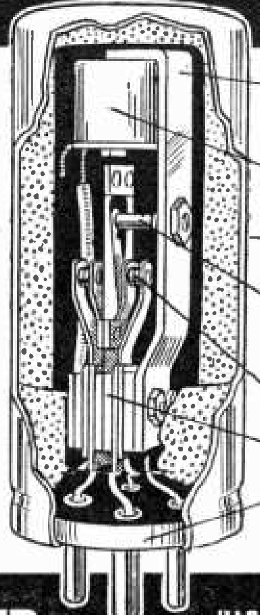

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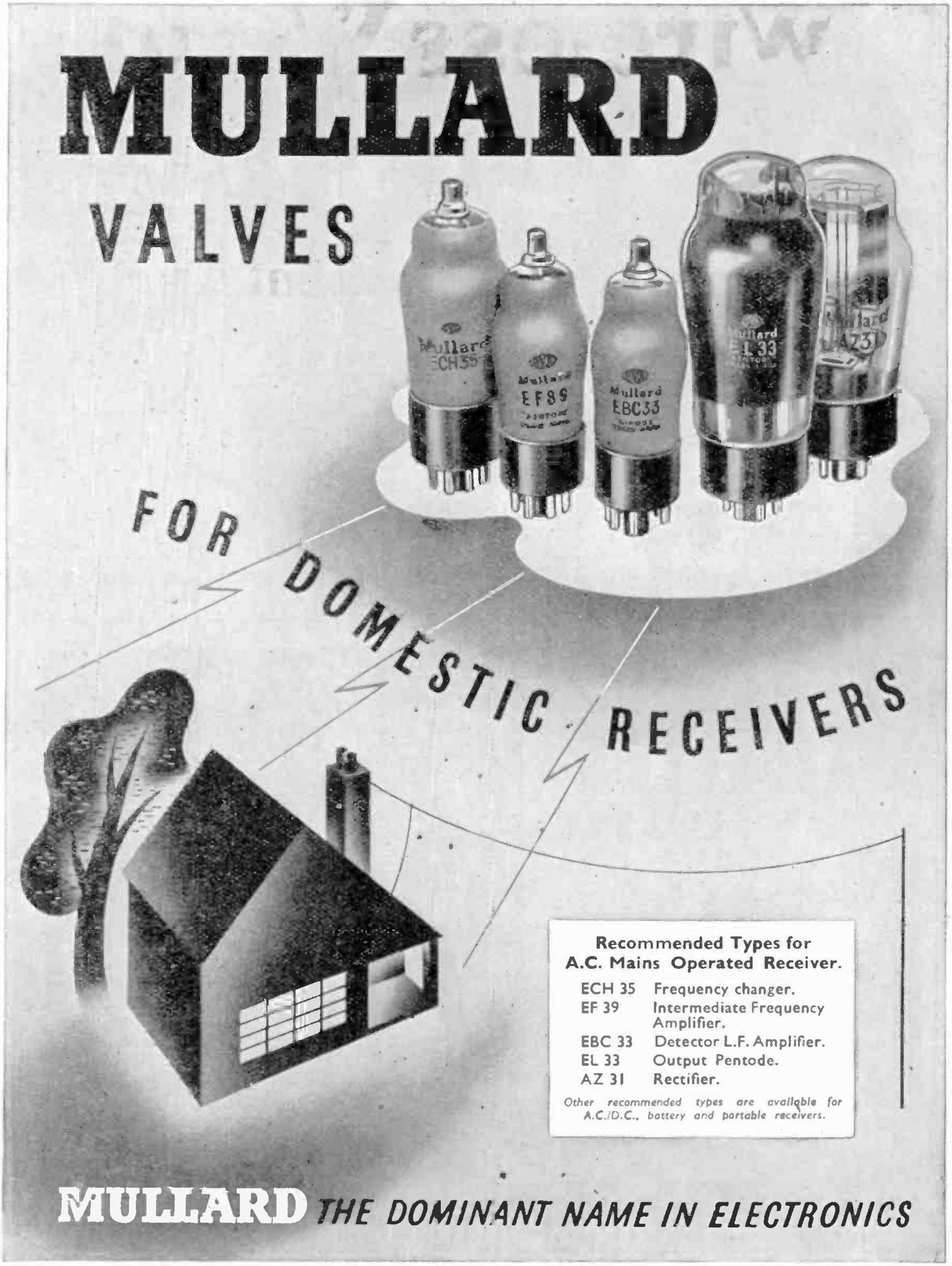

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Wireless World

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Monthly Commentary

Broadcasting Plan

THERE has been little in the way of criticism against the basic soundness of the British radio industry's plan for the drastic technical reorganisation of European broadcasting, described at length in our September issue. Most of the comments we have heard relate to comparatively unimportant details, but a rather more serious objection is that the plan fails entirely to take into account modern possibilities in the way of using directional aerial systems to give more efficient coverage of awkward shaped areas than that attained by omni-directional radiation.

So far as the longer wavelengths envisaged for the National services of the various countries are concerned, the use of non-circular radiation patterns would be impossible. A fairly large proportion of "wasted" radiation must therefore be accepted, and it merely remains to be decided whether the advantages of the long-wave scheme outweigh this loss. Turning to the Regional part of the plan, for which medium wavelengths were proposed, criticism of the sponsors' failure to specify directional radiating systems seem to carry much more weight. For instance, the proposed distribution of British regional stations, according to the map we published, would result in a waste of about 25 per cent. of the total radiation over the sea. Much of that could be avoided by the use of directional aerial systems—without, it should be added, running counter to the basic principles on which the plan was founded.

* * *

'Scope or 'Graph?

A CORRESPONDENT in U.S.A. draws our attention to a question of nomenclature that is likely to prove highly controversial. He says that in America there is a growing tendency to describe the well-known cathode-ray instrument that gives a visible indication of transient or oscillatory electrical phenomena as an oscillo*scope*; not as an oscillo*graph*. What is the accepted British term?

Oscillo*scope*, according to derivation and analogy, is surely the more descriptive term. Oscillo*graph*, used as a mere synonym, seems to have no justification; the uninitiated might well be forgiven for thinking that the two words denote substantially different things. To us it appears that oscillo*graph* might be forgotten, unless, as we suggest, the word be reserved exclusively to denote an instrument with means for making permanent graphical records as an integral part. The permanent pictorial record obtained from an oscillo*graph* should, by analogy, be described as an oscillo*gram*.

* * *

Over-Complicated Diagrams

WIDESPREAD agreement has been expressed with the view, put forward editorially in our July issue, that the present tendency towards the inclusion of a mass of practical detail in circuit diagrams is undesirable, and likely to defeat the object for which such diagrams were first evolved. The original object, surely, was to show circuit principles as nearly as may be at a glance, without distracting practical details that are not essential to the theory of the circuit. The original name of "theoretical circuit diagram" (in contra-distinction to "practical wiring plan") gives a good clue to its real purpose.

But, naturally enough, those concerned with the maintenance and servicing of wireless equipment generally are inclined to disagree with these views; for their purposes a circuit diagram can hardly show too much practical detail.

We are not entirely convinced that the serviceman's need for highly detailed circuit information cannot best be satisfied by lettering on the diagram and references in the inscription or text that accompanies it. But perhaps the conflict of requirements can best be met by the general acceptance of clear-cut principles to be followed in drawing circuit diagrams. For most purposes simplified "general symbols" should be used, the specialised symbol being restricted to diagrams intended solely as an aid to servicing.

THE CATHODE FOLLOWER

What It Does and How It Does It

By "CATHODE RAY"

> Radio Mech: "May I be excused Church Parade?"
> Sergt-Major: "Religion?"
> Radio Mech: "I'm a Cathode Follower."
> Sergt-Major: "One of the awkward ones, eh? Well, I suppose you'd better fall out."

ONE of the ways television and radar specialists have of creating an impression that theirs is real big medicine, too hard for the "ordinary" radio man, is to talk a lot about using cathode followers. Any explanations they condescend to give are generally wrapped up with sufficient mathematics to intensify that impression. So here are some—I hope—simple answers to such simple questions as: What is a cathode follower? Why is it so called? What does it do? And how does it do it?

Fig. 1a shows the familiar resistance-coupled amplifier, omitting all incidentals such as grid bias arrangements. Alongside for comparison is a cathode follower, also reduced to bare essentials. The only difference is that the load, the thing across which the output voltage comes, is on the cathode side of the valve instead of on the anode side. This apparently slight modification leads to remarkable differences in performance. But before we go on to that, I ought to mention that although resistance couplings, shown in these two circuits, are the commonest and (what is more to my point!) the simplest for purposes of explanation, it is possible to use other sorts of coupling—choke, transformer, etc.

Why is Fig. 1b called a cathode follower? That will emerge later. What does it do? Unlike Fig. 1a, it cannot amplify the signal voltage fed to it, but it can be used as a current amplifier over a very wide range of frequency. In particular, it is useful as a coupling between a high impedance and a low impedance, because a direct connection between them would cause signal loss and distortion. A slight elaboration of the cathode follower used to be called the "infinite impedance detector," but I believe it is now more usual for the relationship to be openly acknowledged by naming it a "cathode follower detector." It all sounds very sleuthy.

Referring again to Fig. 1a, when a signal voltage (within the limits the valve can handle) is applied between the points marked INPUT, a magnified signal voltage is given at OUTPUT. The amount of the magnification (the number of times the output voltage is greater than the input) depends on the characteristics of the valve and on R; let us call it A. If it were practicable to make R such a high resistance that in comparison the resistance of the valve, r_a, was negligible, then A would be practically equal to the amplification factor, μ, of the valve. With a typical triode valve having a μ of 35 and r_a of 10,000 ohms, if R is 25,000 ohms A is 25, so one volt input would give 25 volts output. (The well-known formula connecting these is $A = \mu R/(R + r_a)$. Sorry about all this dull recapitulation, but, like an army of invasion, we must have a springboard.)

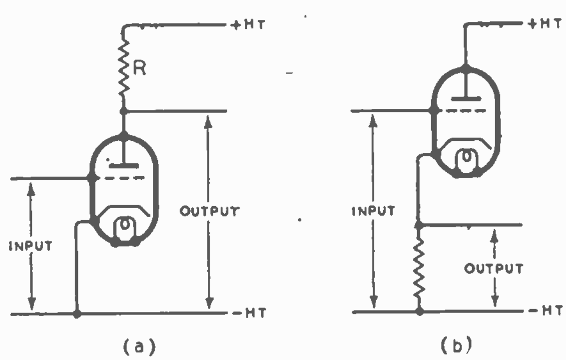


Fig. 1. Comparison between ordinary resistance-coupled amplifier (a) and the cathode follower (b).

Now reconnect this amplifier as a cathode follower, Fig. 1b. The points marked INPUT are no longer the effective input terminals of the valve. The only input voltage a valve takes any notice of is that between its own grid and cathode; and now we have both INPUT and OUTPUT voltages connected in series between those two points. As therefore we can't calculate the effective input until we know the output voltage, and that depends on the effective input, it begins to look like a vicious circle. To break it up let us suppose that 1 signal volt exists between grid and cathode, and see where it leads us. The fact that R is on the cathode side of the valve instead of on the anode side does nothing to prevent A volts appearing across it, exactly as in Fig. 1a. So we now know, for this particular case, the signal voltage between grid and cathode, and also that between cathode and – HT; and it is only necessary to combine them in order to get the voltage from grid to – HT, which is the required input voltage. The only possible catch is whether the output voltage must be added to that between grid and cathode, or subtracted from it. To settle this, assume the grid is being driven in the positive direction. That causes more anode current to flow, increasing the voltage drop across R and making the cathode more positive. So the A volts across R are directly added to the 1 volt between grid and cathode, as in Fig. 2; and therefore the INPUT signal voltage necessary to deliver the assumed

1 volt to the valve must be A + 1. Therefore, however much the valve itself may amplify, the output (A) can't help being always less than the input (A + 1). With the valve and resistance assumed for Fig. 1a, reconnected as a cathode follower, it would be necessary to put in 25 volts in

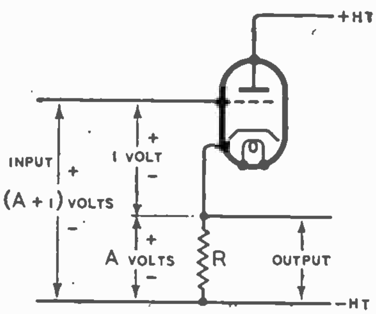


Fig. 2. If the valve, in conjunction with R, gives an A-fold amplification, used as a cathode follower its over-all "amplification" is A/(A+1), which is inevitably less than 1.

order to get 24 out; 1 volt actually to drive the valve, and 24 volts to neutralise the output voltage, which is being fed back in opposition to the INPUT. If A, the amplification of the valve, is 10, then 11 must be supplied to the cathode follower for every 10 to be taken out; and so on.

At first sight this may look a particularly silly way of using a valve. To understand the value of the cathode follower it is necessary to study it more closely. Up to the moment we have found out it differs from the ordinary resistance-coupled stage (Fig. 1a) in the following ways:—

(*a*) The voltage "amplification" is A/(A+1), instead of A.

(*b*) The "live" side of the output—the cathode—goes more positive when the grid is made more positive (and *vice-versa*); in other words, the output is in the same phase as the input, instead of being inverted as it is in Fig. 1a.

Following this up for our example in which A is 25 and the signal input is making the grid 1 volt more positive (reckoned from −HT as zero), compare the two systems again in Fig. 3. (Here, as everywhere in this story, only the signal voltages are counted. The steady voltage drop in R, and the grid bias voltage, although present, are ignored.) In (*a*) the 1 volt input is magnified by 25 and reversed at the anode, which is therefore −25 volts. So there is a difference of 26 volts between grid and anode. The dotted condensers in Fig. 3 represent the capacitances between grid and anode (C_{ga}) and grid and cathode (C_{gc}), made up of the valve electrode and connection capacitances, including the wires leading to the electrodes. Generally a valve itself contributes about 5μμF, and for illustration we shall take typical total values of 10μμF each for C_{ga} and C_{gc}. That is when the valve isn't working. When it is working, for every volt applied to the grid 26 volts appear between grid and anode. The amount of electricity that the source of the signal has to supply to charge up the grid-to-anode capacitance is therefore 26 times as great when the valve is working as when it is not; so this capacitance, for all practical purposes, is 26 times as great; namely, 260μμF. Believe it or not.

There is no such jiggery-pokery about C_{gc}, which has only the 1 signal volt across it, and so is 10μμF, live or dead. Total, 270μμF.

Now if the source of the signal is a high-μ valve, or a photo-electric cell, or any other high-impedance device, and the signal includes high frequencies, or sudden changes as in pulses (the same thing, really), this is serious. 270μμF at a frequency of, say, 100 kc/s, is about 6,000 ohms. Shunted across a high impedance, it is going to cause serious loss of the high-frequency parts of a signal. The effect is a rounding-off of pulses or other sharp-cornered signals used in television, radar, and high-speed telegraphy. By the way, this capacitance-multiplying by-product of amplification is the celebrated Miller effect.

The position can be greatly eased by using a screened tetrode or pentode, having such a small C_{ga} that even when multiplied by A + 1 it is not likely to amount to much. It does introduce a C_{gs} however—capacitance from grid to screen—so that the grand total in a typical case might be 25μμF. But that is a vast improvement. The cathode follower does better still, because it has a sort of inverted Miller effect. Look at Fig. 3b. Putting +1 signal volt on the grid causes the cathode also to go all but 1 volt positive; twenty-five twenty-sixths of a volt in this case, to be exact. The potential of the cathode *follows* that of the grid pretty closely wherever it goes. For every one signal volt put on the grid of a cathode follower, the voltage across the grid-to-cathode capacitance is only the small difference between input and output voltages, 1/(A+1) volt—in our example one twenty-sixth, and the effective or working capa-

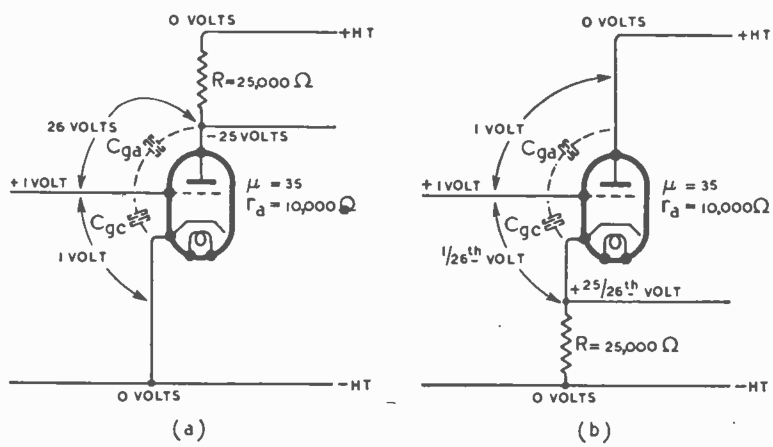


Fig. 3. More detailed comparison of cathode follower (b) with ordinary amplifier (a), showing the effect on the input capacitance in a typical example.

The Cathode Follower—

citance is in the same proportion ; so we have $\frac{10}{26}$ or about 0.4μμF. C_{ga} is its normal 10μμF, so the total is 10.4μμF. With a little care regarding C_{ga}, this figure could be improved upon. Whatever can be done by the other systems as regards minimising input capacitance, the cathode follower can beat it.

The same goes for stray resistance shunting, which is a rather more complicated subject. But it all adds up to this, that the cathode follower has an exceptionally high input impedance, and causes a minimum of loss or distortion in any circuit to which it is connected.

This alone is not so very helpful. If its own *output* impedance were also very high, nothing would be gained. The great value of the cathode follower is that its output impedance is extremely low—lower than that of any other high-impedance input system without a step-down transformer. And compared with a step-down transformer, the cathode follower throws away hardly any signal voltage, and can easily be made to cover a frequency range from zero up to megacycles per second.

Reducing Distortion

How this works can be seen by feeding a rather low-impedance load—a resistance of 500 ohms, say, from each of our Fig. 3 systems in turn. It makes very little difference whether the load is connected in parallel with R or substituted for it. (500 ohms in parallel with 25,000 is just over 490 ohms). For easy arithmetic let us substitute. Then in Fig. 3a, the new amplification—call it A′—is (35 × 500)/(500 + 10,000) or $1\frac{2}{3}$, a catastrophic fall from 25 ! If this amplifier is part of a system that has to work over a very wide range of frequency, it is likely that impedances may vary over such a range as 500 to 25,000, with consequent enormous variations in amplification ; this result is commonly called frequency distortion.

Substituting A′ for A in Fig. 3*b*, we get an output of $\frac{5}{6}$ volt instead of $\frac{35}{36}$—a comparatively slight drop.

Even this will no doubt fail to sell the cathode follower idea to some readers, who will be pointing out that if the orthodox amplifier has a 500-ohm resistor permanently connected, the amplification will be tied down to something in the region of $1\frac{2}{3}$ over the very wide range of impedance it may have to feed into ; and $1\frac{2}{3}$, although small, is at least bigger than the cathode follower's miserable $\frac{5}{6}$.

Part of the answer is that, whatever the range of impedance may be, the cathode follower's output

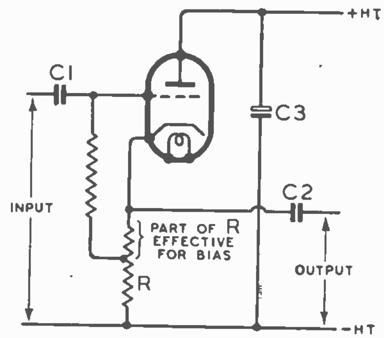


Fig. 4. Practical cathode follower circuit, showing tapping for reducing grid bias, blocking condenser (C2) to keep DC out of output, and by-pass condenser (C3) to keep anode potential steady.

varies less than the amplifier's on that account. This is not easy to prove other than mathematically, but it can be seen in a general way by considering what happens if the load resistance to which a cathode follower is connected is reduced. The amplification of the valve is reduced accordingly, so the output voltage drops. But in doing so it releases more of the input voltage to drive the valve, so largely offsetting the drop in valve amplification.

This is, in fact, a result of the cathode follower being an extreme case of *negative feedback* ; one in which *all* the output voltage is fed back in opposition to the input. Great constancy of output voltage for a given input is one of the features of negative feedback. Another feature—reduction of distortion—supplies the more important part of the answer to the question of why the cathode follower is to be preferred for feeding low impedances. If an ordinary amplifier is used to feed a load of only a few hundred ohms, the amplitude of signal it can handle within reasonable limits of distortion is very small indeed. The reason is that nearly all the impedance in the anode circuit is the resistance of the valve itself, and that is non-linear—varies over each cycle of signal voltage. As regards the cathode follower, it may be enough to repeat that it uses negative feedback 100 per cent. If that is not enough to satisfy the curious, some idea of its anti-distortion properties may perhaps be seen by considering that any parts of the output wave introduced by the non-linearity of the valve are fed back in reverse to the input and thereby largely cancelled out. There are limits to this, of course, but the cathode follower in its particular job does score heavily over the ordinary amplifier.

CF Features

Summing up, the cathode follower has these features :—

(*a*) Output voltage slightly less than input.

(*b*) Output voltage in phase with input.

(*c*) Input impedance very high.

(*d*) Output impedance very low.

(*e*) Because of the foregoing, the cathode follower is able to reproduce very accurately across a low impedance a signal voltage derived from a high-impedance source, even if the signal waveform is complicated (i.e., composed of simple waves of a wide range of frequency).

As regards (*a*) and (*d*), the effect of connecting a valve as a cathode follower is to make it behave as if both its μ and its r_a were divided by $\mu + 1$.

A practical cathode follower circuit generally includes a large condenser —40μF or so—across the HT to ensure that the anode voltage is undisturbed by the signal. Regarding grid bias, it is obvious that the load resistance R provides it. But it may provide too much. If so, a normal grid leak should be used to tap off the required bias voltage, as in Fig. 4. If the output is connected to something that has a variable or indefinite DC resistance, or if it is desired to keep the DC out of it, then a blocking condenser C_2 should be used, of sufficiently large capacitance to cause negligible drop of volts at any signal frequency.

As the effective output impedance is $r_a/(\mu + 1)$, which, for most valves, is nearly the same as r_a/μ, or $1/g_m$, other things being equal the best valve to use is the one with the highest mutual conductance.

Tetrodes or pentodes cannot be used as such; on account of the absence of anode load they revert to the habits of triodes. The screen is fed from a fixed positive voltage as usual, and the suppressor grid pin, if any, should be joined straight to the cathode.

For most purposes R may be 1,000 to 5,000 ohms. Unless there is any special reason to the contrary, it is good practice to make the resistance the greatest that is not too much for bias. If it is much less, it is likely to be too small as a load (or it shunts a parallel-connected load too heavily) and the anode current may be excessive; if it is larger it is too much for grid bias purposes and the complication of a tapping is necessitated. A high load resistance, especially with a small grid bias, may lead to trouble owing to the voltage between cathode and heater going beyond the safe limit—rated at 50 volts for most valves.

The cathode follower is not exclusive to television and radar engineers; at least three applications to the listener's gear have been discussed in *Wireless World*. One is as a final IF stage, with a view to dodging the various difficulties in designing a detector that can be attached to it without spoiling the selectivity and introducing distortion. Another is as the driver for a Class B output stage. Both of these were described by Cocking in the December 15th, 1938, issue. Then there is the idea of using the cathode follower, single or push-pull, as the output stage feeding a loud speaker, the object being to make sure that loud speaker resonances are thoroughly damped in the very low resistance of the stage. This problem was argued in every 1944 issue from April to September inclusive, and the conclusion I was left with was that the choice of cathode follower versus tetrode with negative feedback is made partly by what fits best on to the design of the rest of the set and partly just by the way one feels about it.

The cathode follower detector (still snooping in the background) is of course as much at home in the broadcast receiver street as anywhere else, but I do not intend to be drawn into a full account of it here and now. Its close resemblance to the cathode follower—the only difference is that R (Fig. 1b) is high in resistance and has a small condenser across it—is deceptive. Anything like a real explanation would take quite a lot of time and space. But the following clues may set interested readers on the way.

In the circuit, Fig. 5, the condenser C is the crux of the matter. It has to be of such a capacitance that to the radio frequency it is

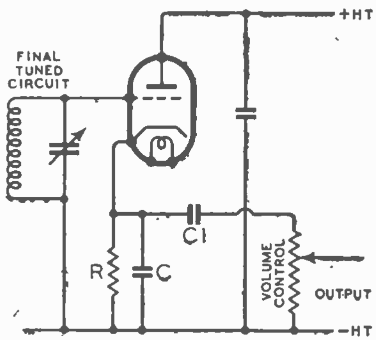


Fig. 5. Cathode follower detector or "infinite impedance" detector. The usual arrangement for volume control is included

an effective by-pass to R. The two together are just a device for giving the valve a steady bias. So far as the RF is concerned, then, the system is not a cathode follower at all. There is, or should be, no negative feedback, because there is no appreciable RF anti-phase voltage drop across C. R is high enough—about 50,000 to 250,000 ohms—to bias the valve well down on the "bottom bend"; and, as almost the only RF impedance in the anode circuit is the resistance of the valve itself, a relatively large rectified current flows in it when an RF signal is applied to the grid. This rectified current increases the charge on C and therefore the voltage across R. If the amplitude of the RF is varied at an audio-frequency rate—due to modulation by speech or music—this voltage drop varies accordingly, and the variations are passed on through C1 and become the output. But note that unless C is small enough to be negligible at all audio-frequencies, it will tend to smooth out the audio-variations too. As the capacitance of C cannot be infinite for radio frequency and zero for audio frequency, it must be a well-chosen compromise between these extremes. With 0.1 megohm for R, a typical value is 100 $\mu\mu$F.

Another reason why the value of C is important is apt to be overlooked because it depends on a condenser that does not figure on any component list — C_{gc} again (Fig. 3b). With C, this capacitance forms a potential divider across the RF tuned circuit feeding the detector, and the detector valve turns the whole show into a Colpitts oscillator circuit. Whether or not it actually oscillates depends mainly on the value of C. If it is equal to C_{gc} or not more than several times greater, the chances are that it will. The larger is C, the more stable the circuit. Making it smaller (which of course favours the audio-frequency performance) causes the input impedance to be less and less of a load on the tuned circuit; then to become an infinite impedance; and if reduced still further it begins to neutralise the losses of the tuned circuit, and finally to maintain oscillation. So if you use a pre-set condenser for C you ought to be able to arrive at a good compromise between your requirements for selectivity and high-note response. But don't try to use the drop across R for AVC—it comes the wrong way round!

CATALOGUES RECEIVED

A LEAFLET describing representative test equipment and electronic industrial control gear designed by the Dorland Electric Co., Ltd., 38, Brompton Road, London, S.W.3.

Two illustrated leaflets dealing respectively with public address equipment and automatic intercommunication telephones made by the Reliance Telephone Co., Ltd., Magnet House, Moor Street, Birmingham, 4.

FUNDAMENTALS OF RADAR

2. Night Fighter Equipment : Relation Between Power, Beam Width and Range

THE radar warning system round the coast provided, in its full form, the information required for defence against day raids. Night raids presented a more serious difficulty, for while in dealing with day raids it was sufficient to direct the fighters to within a few miles of an enemy formation, it was necessary to bring a night fighter to within a few hundred yards of a single enemy bomber if a successful interception was to be made. At first it was necessary to rely on ground radar alone to advertise the position of the enemy aircraft. Two ways of doing this were used: one was the use of radar-controlled searchlights, which exposed their beams only when the searchlight would light up the bomber immediately without further visual search. The Searchlight Control (SLC) equipments were very simple and differed little in principle from the Air Interception (AI) equipments to be discussed below.

Another way of indicating the position of a bomber to a patrolling night fighter was to shoot at it with radar controlled guns. If the shells burst sufficiently near the enemy bomber, the assistance of the night fighter was not required: if, as usually happened with the early gun-laying (GL) control, the bursts were near but not near enough, the fighter could fly into the indicated region and then hope to see the bomber. Close co-ordination was required so that the guns could be stopped when the fighter approached, and only occasionally did listeners to the R/T channels hear voices complaining, more in sorrow than in anger, that they themselves seemed to have become the gunners' target. The final interception usually depended on the eyesight of the fighter pilot, and obviously this was not enough. Fortunately steps had already been taken towards the solution of the night interception problem.

The first really practical air interception radar equipment worked in the 1½ metre band. An aerial mounted on the nose of the aircraft floodlit the sky in front of the aircraft with radar energy. If there was a target within some 2 or 3 miles of the aircraft, the reflected pulses were received in sufficient strength to allow the fighter to home on the target. Range could be measured in the usual way, by observing the separation of transmitted and reflected pulses on a calibrated time base. Direction had to be measured in azimuth and in elevation.

Two pairs of receiving aerials were used for this purpose. One pair was used for azimuth determination and one aerial was mounted on the leading edge of each wing. The aerials were arranged to look forward, that is, to have a single fairly wide lobe in their polar diagrams. They did not, however, look straight ahead, but had a slightly divergent squint. This is shown in Fig. 1: a target at T_1 reflects back pulses from the transmitter, and it is clear that the signal picked up by the port aerial will be very much stronger than that picked up by the starboard aerial. If the target moves to T_2, the starboard aerial signals will be stronger than the port aerial signals. The two elevation aerials are arranged in the same sort of way, but one looks slightly upwards, while the other looks slightly down. To compare the signal strengths, a switch is used to connect each aerial in turn to the receiver with its cathode ray tube. One tube is used for azimuth display and the other for elevation display, the tubes being switched by the aerial switching mechanism The operator, by comparing the amplitudes of the two received pulses appearing on each tube, could estimate the direction in space of the target and could thus direct the pilot to fly to within visual range in a suitable position for attack. Range, of course, could be determined from either tube.

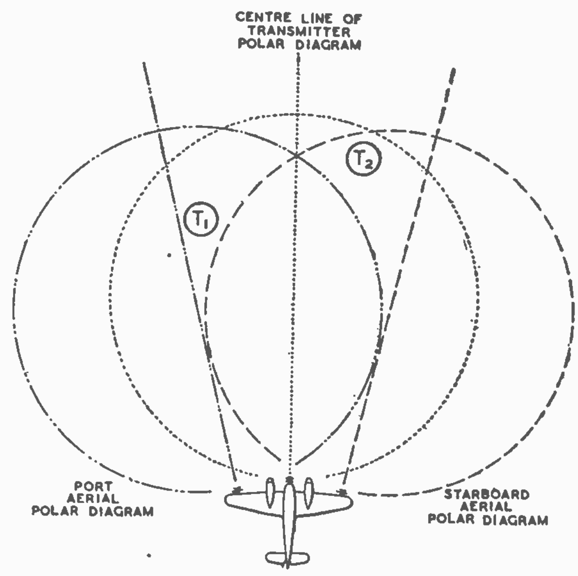


Fig. 1. Polar diagrams of transmitting and receiving aerials for azimuth indication in the 1½-metre AI equipment.

In this way the interception problem fell into three sections: the fighter was directed by the ground stations (GCI) to within a mile or two of the enemy bomber, and the navigator then began to use his AI; by means of the AI equipment he directed the pilot over the intercomm. to within a few hundred yards of the target; final identification of the target was made visually by the pilot.

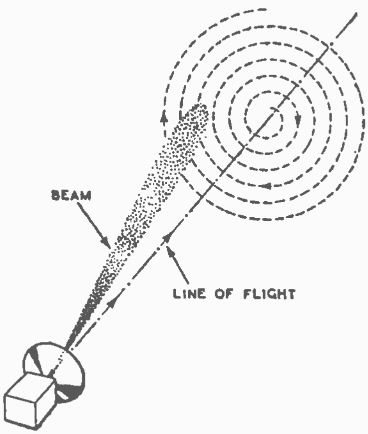
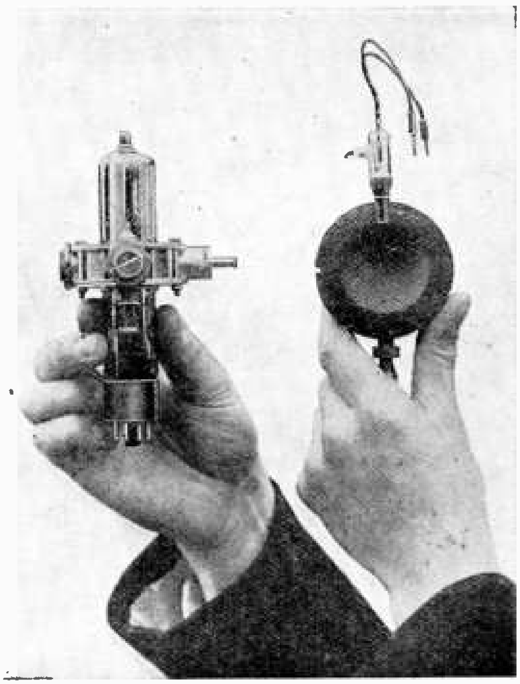


Fig. 2. Spiral scanning of a cone of sky in front of a night fighter.

This system was later elaborated so that automatic comparison of the signal strengths by peak voltmeter circuits controlled the movement of the spot of the cathode ray tube so that the spot moved up and to the right if the target was above and on the starboard and so on. The navigator then had to direct the pilot so that the spot remained central and they could home directly on to the target. Of course, tactical requirements affected the actual way in which the information was used in practice. Range was indicated by making the spot spread out into a line as the range got less; in the early stages of a chase the navigator sought to keep the spot near the centre of the tube face. Then, as the target was closed, the spot "grew wings," which got wider and wider as the range was reduced. Remembering that the approach was from the stern, the effect was that of a television picture of the target, growing from a spot in the sky to a line as the range shortened.

The disadvantages of 1½-metre AI were two. The range was limited, and although at first sight it would appear that GCI control made this unimportant, in fact it meant that the GCI station had to spend too long on each customer before AI contact was established. Furthermore, it gave the "jinking" bomber a chance of getting out of AI range. In addition, as the radar energy was broadcast forward, quite a lot of downward radiation was produced, and strong echoes were received from the ground. The ground echoes began at a range equal to the height of the aircraft and an enemy bomber at 5,000ft. could only be found when the fighter had closed to within less than a mile. This meant more work for the GCI.

At this stage, fortunately, centimetre AI was developed. With centimetre AI the radar energy was radiated as a fairly sharp beam, and the effect of the ground became unimportant. In addition, longer ranges were obtained and more accurate direction finding was also possible. The concentration of the whole radar aerial system in one place meant that the aircraft began to look less like a Christmas tree, and also that there were fewer projecting pieces to get distorted by the many airmen who swarm over an aircraft to put in petrol, oil and ammunition. The heart of the centimetre system was the magnetron and the reflection klystron. The one generated peak power of many kilowatts in spite of its small size; the other was a low-power local oscillator which could be tuned to the right frequency for its partner magnetron. A single aerial was used for both transmission and reception, just as had been done in the CHL system. The aerial was mounted at the focus of a paraboloid, and the aerial array, dipole and paraboloid, could be swung about to search the sky in front of the aircraft.



Sutton reflection klystron and (right) the Randall and Boot magnetron.

One method of scanning the sky was "spiral scanning." In this the beam started from the dead ahead position and described circles of increasing radius until the surface of a cone of about 45 degrees semi-angle was reached, when the radius was slowly diminished again. In this way the whole cone was examined bit by bit. A radial time base on the cathode ray tube was used. The time base for any one transmitted pulse went out in the same direction as the axis of the beam at that instant. If there was a target in the beam the time base was brightened. A target well off the line of flight produced a bright spot at a radial distance corresponding to the range and in a position corresponding to the direction of the target. As the line of flight was altered to bring the fighter towards the target the spot became a ring round the whole tube, so the smaller spirals of the paraboloid all lit up the target. Other presentations were also used, but this one was the only one giving a three-dimensional picture on a single tube.

Centimetre AI completed the defence problem until the appearance of the flying bombs. Here it was equally successful, but gunnery also came into its own again. Centimetre GL equipment is similar to centimetre AI in many respects. Magnetrons, paraboloids and the use of a single aerial for transmission and reception are common practice. In the GL equipment, however, the beam is swung in a small circle about the true axis of the system and, just as in the 1½-metre AI, the reflections at various points round the circle are compared to bring the axis of the cone described by the beam on to target. Range and direction can then be fed continuously to the predictors.

The CH, CHL and GCI warning system with SLC, GL and AI as aids to defence, complete the first half of the radar story. In the next part the offensive use of radar will be discussed. There are, however, some more fundamental problems to be examined.

It is important to be able to assess the effect of changes of power, beam width and wavelength on the maximum range of a radar system. As we saw last month, a narrow beam imposes some limitations on the use of a radar system, especially when a long range is expected, for the long range limits the pulse repetition rate, the narrow beam limits the sweep angle between pulses and, as we should expect, a narrow beam increases the range for a given power.

Mechanism for spiral scanning with a single paraboloid reflector in the centimetre-wave AI equipment.

In this discussion it is assumed that the propagation is in free space, so that the attenuation due to transmission over ground or sea does not appear. This assumption becomes completely justified for AI equipments and is generally correct for CHL. The attenuation of the wave in free space may be neglected in this calculation. Considering the flow of energy out from an omnidirectional radiator of power W, the energy crossing the surface of a sphere of radius R will be[1]

$$S = W/4\pi R^2 \text{ watts/(metre)}^2$$

If the polar diagram of the aerial system is such that the aerial is said to have a power gain G_T, we mean by this that at beam maximum the energy crossing the spherical surface is $G_T W/4\pi R^2$ watts/(metre)². This energy falls on the target and induces currents in it. These currents in turn radiate energy, and the scattering cross-section of a target is defined as the ratio of the scattered energy per second to the energy density of the incident wave.[2]

Writing the scattering cross-section of the target as Q, a term which includes the power gain or loss due to any directional properties of the scattering polar diagram, we now have a source of power $G_T WQ/4\pi R^2$ watts. The dimensions of Q are (metres)². The flux of energy across a sphere of radius R with the target as centre is therefore

$$G_T WQ/16\pi^2 R^4 \text{ watts/(metre)}^2$$

The receiving aerial system has a power gain in the direction of the maximum of $G_R \propto A_R/\lambda^2$, where A_R is the area of the receiving aerial array and λ the wavelength, so that the energy reaching the receiver is $\lambda^2 G_R G_T WQ/16\pi R^4$ watts.

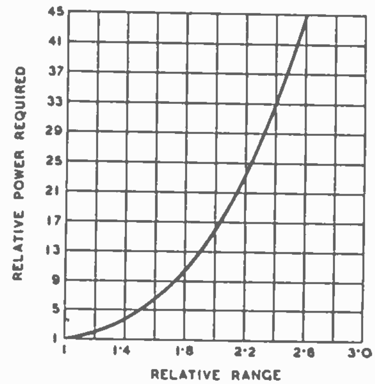


Fig. 3. Relationship between power and range of radar equipment.

The maximum range is obtained when this falls to the level determined either by noise or by the sensitivity of the receiver. If the least energy which will give an indication of an echo to the operator is W_n, the equation can be rearranged as

$$R = \sqrt[4]{\frac{W}{W_n} \cdot \frac{G_R G_T}{16\pi^2} \lambda^2 Q} \text{ metres.}$$

From this it is seen that the range increases only as the fourth root of the transmitted power. Thus if a 100 kW. station can detect a particular target at 100 miles, the effect of putting up the power to 500 kW. will be to increase the range by only 50 miles. This is shown in Fig. 3.

The range is also proportional to $(G_R G_T \lambda^2)^{\frac{1}{4}}$. If the same array is used for reception and transmission, obviously $G_T = G_R = G$, so that the range is proportional to $(G\lambda)^{\frac{1}{2}}$. An array of area A will have at wavelength λ a power gain G proportional to A/λ^2, and thus we have

$$R \propto (G\lambda)^{\frac{1}{2}} \text{ and also } R \propto (A/\lambda)^{\frac{1}{2}}$$

If we consider the first form, we know that the beam width and the power gain are only different ways of expressing the same thing. If therefore two systems of equal beam width at different wavelengths are compared, the range *increases* with the wavelength,

[1] "Electromagnetic Theory," Stratton, Ch. 8.
[2] loc. cit. p. 569.

being in fact proportional to the square root of the wavelength. On the other hand, if the area of the array is kept fixed, the range decreases as the wavelength is increased, again depending on the square root, but this time with inverse proportionality. These two results are shown in Fig. 4. If the wavelength is kept fixed, the range increases as the size of the array is increased, and, if the shape of the array is unchanged, the range is proportional to the square root of the linear dimensions. Thus a paraboloid of twice the diameter will give 40 per cent. increase in range.

It will be seen that the increase in range produced by a proper choice of wavelength and array size is much more rapid than that produced by an increase in power, and aerial design plays a very important part in the planning of a radar system.

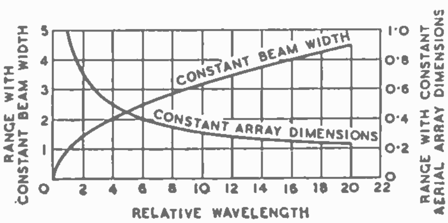


Fig. 4. Relationship between relative wavelength and range with constant beam width or constant aerial dimensions.

"WHAT IS RADAR?"

Sir Robert Watson Watt's Views

It would be pedantic, unrealistic and unhelpful to restrict "radar" to the "location of an object without active co-operation from that object."

* * * * * * *

Radar in war fell into three convenient categories, each of which has come to stay in the peace.

Primary radar is that form of radar which "does not require the co-operation of the object to be located." It is useful against icebergs and enemies generally; it is an extravagance when used against friends.

Secondary radar requires that small measure of co-operation which is involved in the fitting and switching on of an otherwise automatic responder. The responder sends back, when interrogated by radar pulses, reply pulses on a different wavelength — so that "ground clutter" disappears from secondary radar—coded with information about the "personal identity" of the craft carrying the responder, and about its flying height if it is an aircraft.

Radar navigation does not depend essentially on the return of an echo, amplified or unaltered, from the craft to be located. It may in some special cases like "Oboe" find that convenient; in some other and more frequency cases like "G-H" and "Babs" (Blind Approach Beacon System) and "Rebecca-Eureka" utilise coded responses sent back by a ground responder-beacon in reply to pulses from an airborne or ship-borne interrogator. And in "Gee" and "Loran" and related systems it will depend on a measurement in the craft of the time-difference of arrival of primary pulses from synchronised ground stations in accurately surveyed positions."—*Extracts from an article on "Radar in War and in Peace," by Sir Robert Watson Watt in the September 15th issue of "Nature."*

[These views may be compared with those expressed Editorially in our last issue; we suggested that the terms radar or radiolocation should be confined to systems involving the use of an echo. Support for this view is given in the U.S. official publication *Radar*, which says: "The British early developed and installed a new type of navigation system, which has been referred to as radar, because it uses pulses, but is not really radar, because it does not use echoes."—Ed.]

G.P.O. WAR WORK

Some of the Post Office Engineering Department's communication activities during the war years were described by A. H. Mumford, the new Chairman of the Radio Section of the Institution of Electrical Engineers, in his inaugural address on October 10th. These range—going up the frequency scale—from the installation at short notice of a stand-by high-power transmitter for the 16 kc/s Rugby (GBA) station, to the development of multi-channel VHF communication links with FM transmission. When England was threatened with invasion and the interruption of some of her communications, means were devised for superposing several telegraph channels on the long-wave transatlantic single sideband radio-telephony circuit.

On the short wavebands, equipment was developed for producing "synthetic fading," for use in testing receivers as used in long-distance circuits. The MUSA station at Cooling, Kent, came into commercial operation in 1942. Comparative tests show that reception by the MUSA system was, for 70-80 per cent. of the time, distinctly better than by means of the normal single-sideband receiver.

PREFABRICATED RADAR

This complete radar "office" is one of a thousand prefabricated units built by W. H. Smith and Co. (Electrical Engineers), of Manchester, for use by the Royal Navy and Mercantile Marine. An interior view appears on our front cover. This is equipped with PPI and IFF gear.

UNBIASED

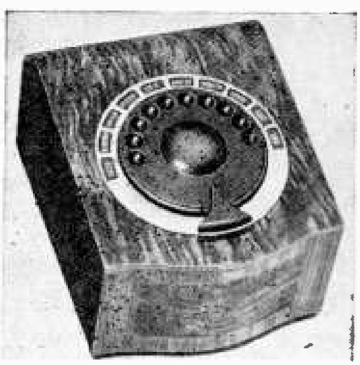
By FREE GRID

Home Entertainment.

Extension LS Improvements

BEFORE the war we heard a lot about a proposal to restrict our liberty of free choice by using "carrier current" technique, more succinctly known as "wired wireless," in order to pump half a dozen or more programmes down the telephone or electric light mains. There is nothing technically impossible about this, but the idea was quite rightly trodden on heavily, as it would mean that we should simply have to take what the BBC chose to give us in the way of entertainment and moral uplift and what the Government of the day chose to give us in the way of political pabulum.

I have often wondered, however, why no effort has ever been made to distribute wireless programmes to any room in the house by utilising the electric lighting mains together with the necessary extension loudspeaker which could have the needful auxiliary apparatus housed in its cabinet. One connection to any convenient wall plug or lamp socket would serve to pick up both power and programme. There is, so far as I know, no law or unrepealed wartime regulation which prohibits this, although this omission will soon be remedied if it catches the eye of certain Government officials. At any rate, if an official veto does exist I have already broken it, and when the local Gestapo come along I can only emulate the example of the man on the scaffold and say simply, "I done it."



Philco "wireless" tuning unit.

In actual fact I have done a bit more than use "wired wireless," as I have employed a pukka wireless link, having patently cribbed the idea adopted by a well-known firm of wireless receiver manufacturers in their "wireless" gramophone player which was described in this journal before the war. You will find the photograph of this gramophone player reproduced if the Editor is able to find it amid the clutter of final demands and unpaid bills on his desk; otherwise he will have to reproduce the photograph, which I have just found on my own desk, of the same firms' remote control "tuner" which also used a wireless link.

This highly ingenious gramophone player could be placed on the other side of the room or even in another room. Its range was very limited and its radiations were virtually confined to the house in which it was used and it did not therefore infringe the PMG's regulations. To make quite sure in my own case I have covered the whole of the outside of the house with wire netting and earthed it. A man in the train to whom I expounded my idea threw cold water on it by pointing out that a spare set in each room could be much more useful, far less complicated and no more expensive, but he turned out to be the sales manager of a well-known firm of receiver makers, with an obvious axe to grind.

The Gregarator

FROM time to time we hear a lot of rumours about the marvellous strides which television technique has made as the result of research work done during the war, mainly for radiolocation purposes. I have often thought, and indeed mentioned it in these pages before the war, that television would eventually put the cinemas completely out of business, since anybody with a grain of common sense would prefer to see the films by the comfort of his own fireside with feet securely perched upon the mantelpiece.

Unfortunately, however, common sense appears to be far from being a common virtue, as most people to whom I have spoken about my views seem to dissent strongly from them. They seem, almost without exception, to prefer the discomfort of a draughty cinema with all the wretched business of people crawling over each other on their way in and out. The reason for this is, I suppose, that most people are gregarious by nature and prefer to be thoroughly uncomfortable and miserable in each other's company rather than be happy and carefree by themselves. To realise the truth of this to the full one has only to witness the massed misery apparent at a popular seaside resort on a bank holiday.

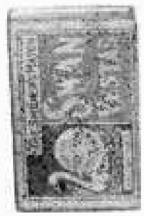
However, in spite of all this, an attempt is going to be made to induce people to see the latest films at home on their television screens after the war, for according to an article I have been reading in an American periodical an attachment known as a "gregarator" is to be provided for connecting up to the home television receivers at such times as a film is to be broadcast or "telecast" as they term it. The gregarator, it is claimed, will provide from a record all the "subtle psychological sensations of a crowded cinema, including both sound and olfactory sensations" (oranges?).

Unfortunately the author of the article omits to give any technical details. The noises should be easy enough, of course, but I don't see how they are going to do the olfactory part of the business. No mention is made of the "subtle psychological sensation" produced by people treading on your toes, falling over your knees and blowing down your neck.

Quite apart from all this the gregarator does not seem to cater for the quite considerable and perfectly respectable section of the population who go to the cinema mainly for the sake of a little privacy which in these days of housing shortage is not always to be had at home, even in the U.S.A.

PROXIMITY FUSE

Radio Station in a Shell



ONE of the most interesting of the wartime secrets now released is the use of radio automatically to operate the fuse of a shell when within lethal range of an aircraft or other target. In that the method depends on the use of a signal reflected from the aircraft, it is analogous to radar, but there its resemblance ceases.

The proximity fuse consists of a complete transmitter and receiver, with aerial, batteries, and the fuse-operating mechanism built into the nose of an anti-aircraft shell! It is a beautiful example of modern miniature technique. The compression of the apparatus was not the least of the headaches which confronted the designers, however. Sufficient ruggedness to withstand an acceleration some 20,000 times that of gravity was needed in both apparatus and valves.

The fuse depends on the "Doppler" effect for its operation. This effect is well known in acoustics, but is not normally noticeable in radio. It occurs when the source of radiation is moving relative to the receiver and it changes the apparent velocity by the velocity of relative motion.

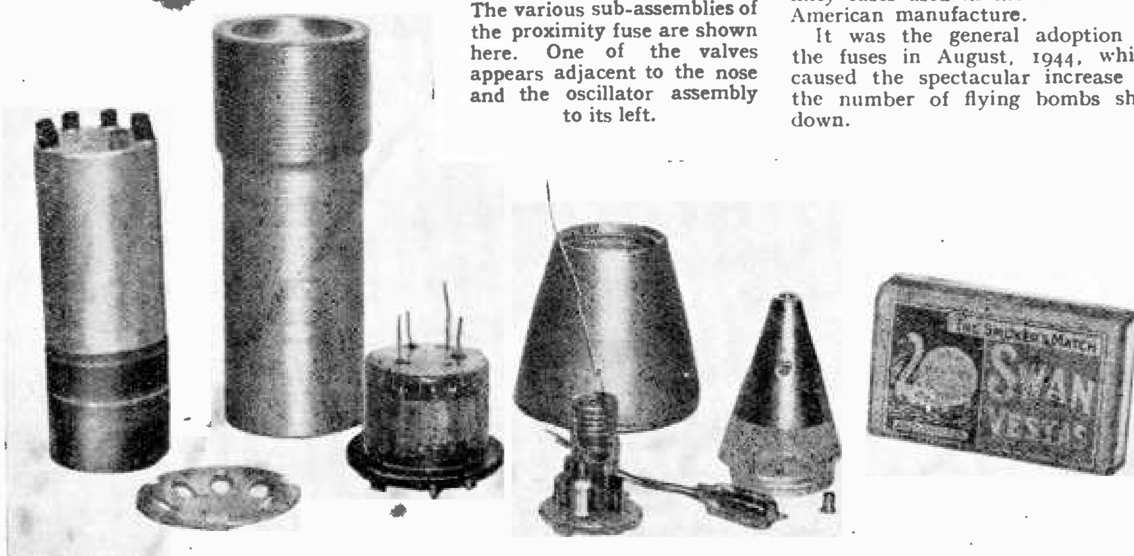
Most people must have noticed that the whistle of an express train changes pitch as it passes one. When the train is approaching there are more cycles per second reaching the observer than when it is receding from him, consequently the pitch drops as the train passes. The velocity of sound in air is about 1,100ft. per second, so that the wavelength of a note of 1,000 c/s is 1.1ft. If the train is moving at 60 m.p.h. (88ft. per sec.) and the whistle is of this frequency, then the effect is as if the velocity of sound had increased to 1,188ft. per sec. when the train is coming towards an observer, and 1,012ft. per sec. when it is going away from him. He, therefore, hears notes of 1,080 c/s and 920 c/s in the two cases.

This principle applies also to wireless waves, but on account of the high velocity of propagation of such waves, the change of frequency is appreciable only when the relative velocity of transmitter and receiver is high, as in the case of a shell. In the proximity fuse, the transmitter generates a continuous wave which is emitted from the nose of the shell as a cone of radiation. This travels to the target and is reflected by it and travels back to the shell. This received signal differs in frequency from the radiated because of the relative motion of the shell and the target. A beat note is formed, therefore, and this is amplified, and when it reaches sufficient intensity it sets off the fuse. This triggering intensity is adjusted so that it is obtained only when the shell is within lethal range of the target.

The great practical advantage of the fuse over the older types is that it relieves the gunner of the responsibility of fuse setting. His job is only to see that the shell passes within lethal range of the target. Provided that he does this, the fuse does the rest. Safety devices are included, of course, so that in the event of a miss the shell explodes before reaching the ground.

The idea of the proximity fuse was put forward as far back as 1940 by W. A. S. Butement and E. S. Shire, then of Air Defence Research and Development Establishment (A.D.R.D.E.). Early research was carried out in this country at a Ministry of Supply establishment. Full information was given to the U.S.A., and it was eventually agreed that the main production would be in that country. In fact, all proximity fuses used in the war were of American manufacture.

It was the general adoption of the fuses in August, 1944, which caused the spectacular increase in the number of flying bombs shot down.



The various sub-assemblies of the proximity fuse are shown here. One of the valves appears adjacent to the nose and the oscillator assembly to its left.

ABACS FOR FILTER DESIGN

(A). Component Values for Low-pass Filter Elements

By THOMAS RODDAM

Filter design by any but the most advanced methods usually involves the trial of several alternative designs. The reason for this is that the assumptions made in the impedance conditions break down near cut-off and the behaviour in this region is adversely affected. The abacs are intended to ease the labour of computation. They must only be used with due regard to the well-established canons of filter design.

The series begins with the so-called "constant-*k*" low-pass filter and later charts will deal with *m*-derivation, high-pass filters and with the simpler forms of bandpass filter

THE basic low-pass filter elements are shown in Fig. 1. They are shown in this form to indicate that they are the components of an infinite ladder network. A prototype or constant-*k* *section* takes one of the forms shown in Fig. 2, in which it will be noted that the

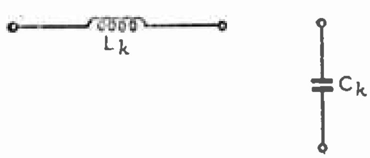


Fig. 1. Low-pass filter elements.

values of some elements are now divided by two. The simplest form for remembering the elements to be divided is given by the half-section of Fig. 3. It will be seen that the full sections of Fig. 2 can be obtained by the tandem connection of two half-sections, one of which is the mirror image of the other. It must be noted that the half-sections must be connected ⅂Γ or Γ⅂, not as a chain of half sections of the same kind.

The element values are

$$L_k = \frac{R}{\pi f_c}$$

$$C_k = \frac{1}{\pi f_c R}$$

where R is the impedance, and f_c the cut-off frequency. If R is in ohms and f_c in cycles per second, L_k and C_k are in henrys and farads respectively. The use of these "prototype" element values is standard in the literature, and it is for this reason that formulæ for *sections* of different types are not given.

The charts for the constant-*k* elements are in two parts. The range of values of impedance and frequency required is very great. An approximate solution is therefore obtained by joining the point corresponding to the actual impedance to the cut-off frequency required. The values of L_k and C_k can then be read off. These scales are cramped, and a better approximation is obtained by moving to the upper half of the chart, when the correct order of values has been found. Here, powers of ten are ignored, as they normally are in work on the slide-rule.

When the values of L_k and C_k have been determined, the choice between T- and π-sections is made; the necessary division of the values L_k or C_k by 2 is left to the user.

Example 1.

A low-pass filter is required to have an impedance of 600 ohms and a cut-off frequency of 5,000 c/s. A π-section will be used.

On the lower charts we join 600 ohms on the impedance scales to 5 kc/s on the frequency scales. The ruler cuts the L_k scale at 35 mH and the C_k scale at 0.1 μF. Transferring to the top scales, we join 6.0 on the impedance scales to 5.0 on the frequency scales. The ruler cuts the L_k scale at 0.38 and the C_k scale at 1.01. The values of L_k and C_k are therefore 38 mH and 0.101 μF for a π-section; we shall therefore use an inductance of 38 mH and capacitances of 0.05 μF.

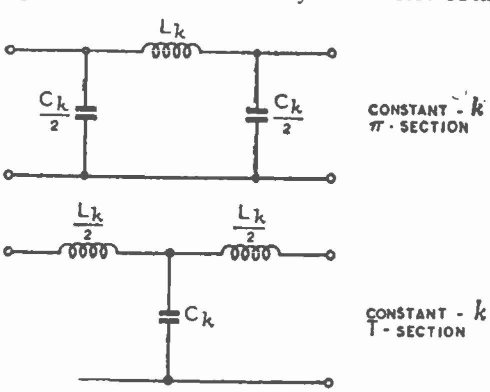


Fig. 2. Low-pass filter sections.

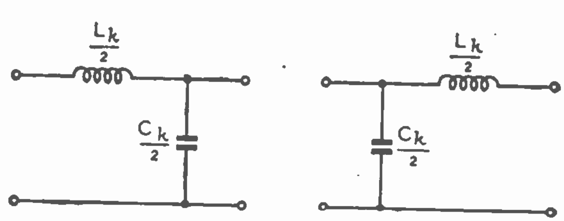
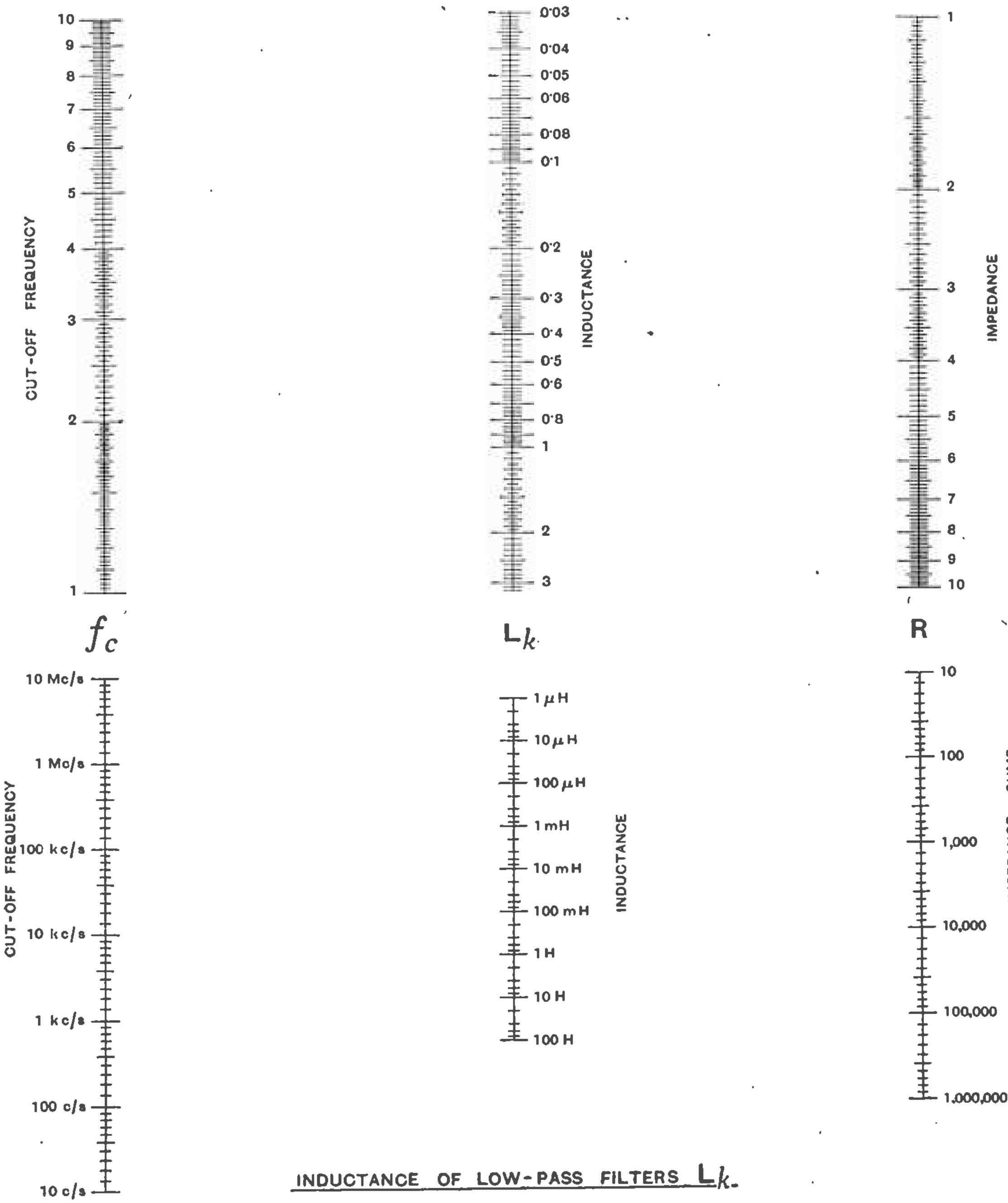


Fig. 3. Low-pass half-sections.



INDUCTANCE OF LOW-PASS FILTERS L_k

Wireless World
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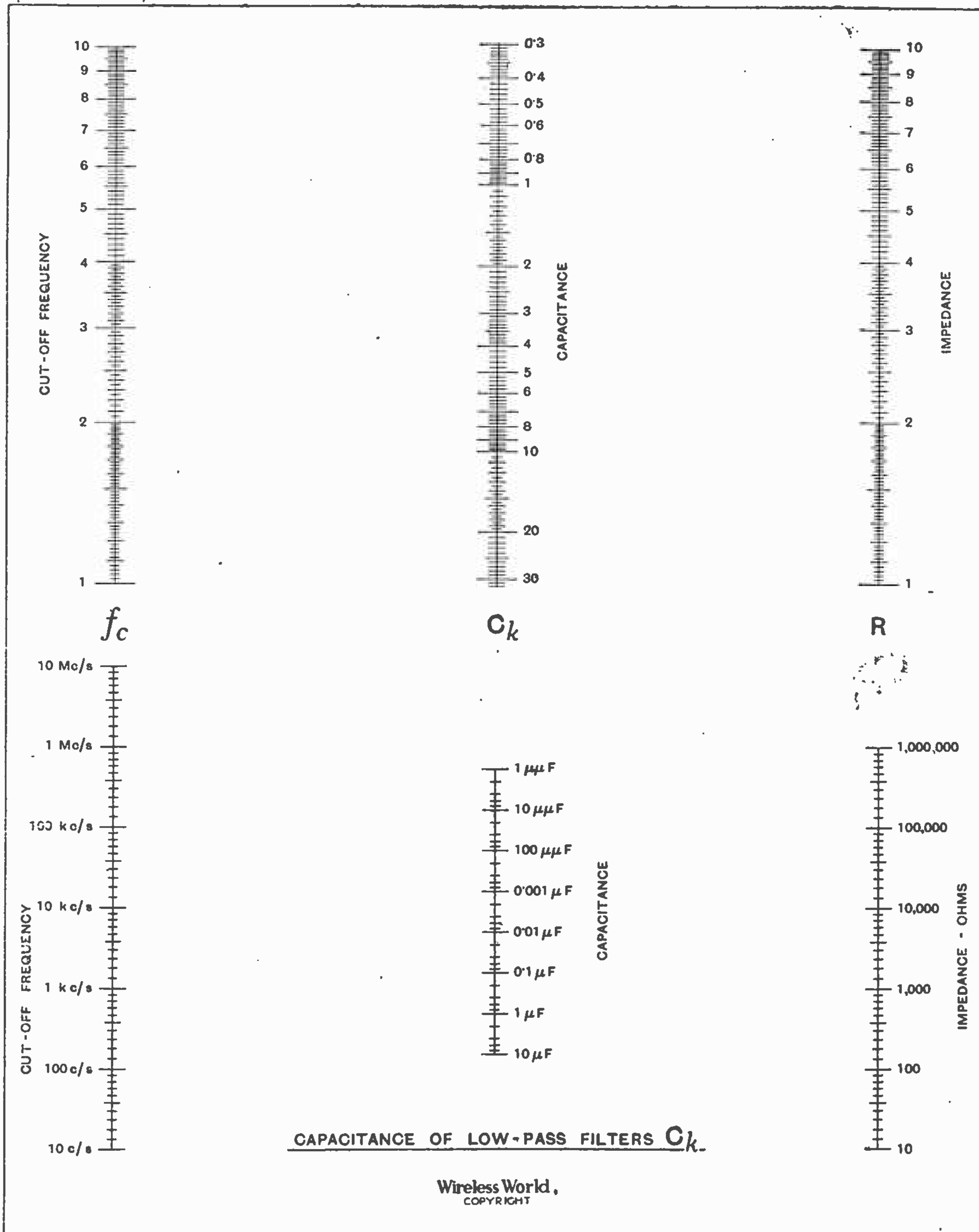
Abacs for Filter Design—



CAPACITANCE OF LOW-PASS FILTERS C_k.

WORLD OF WIRELESS

TELEVISION RESTARTING

IT was announced in the House of Commons on October 9th that the Government had given general approval to the recommendations of the Hankey Television Committee and "the necessary action had been set in train." These recommendations called for a resumption of the television service on pre-war standards (405 lines) rather than await the development of a new system. Nothing specific has been said about the various recommendations regarding licences and the suppression of electrical interference.

On the same day the B.B.C. announced that it is hoped that before the end of the year test transmissions of still patterns will be radiated. The date for the restarting of the public service will be settled in consultation with the advisory committee, the appointment of which, it will be remembered, was recommended by the Television Committee. The suggested date is next spring.

The extension of the service to the provinces will, it is stated, "be pressed on as staffing and materials allow." The Committee expressed the hope that the first extension—to Birmingham—may be in operation within about a year after the London transmitter restarts.

No further details are at present available. Senior appointments, it is known, will be announced shortly.

EUROPEAN BROADCASTING ALLIANCE

IT will be recalled that a plan for a co-ordinated international broadcasting system, to be run as an auxiliary to national networks, was described in our issue of August, 1944.

The plan, devised by A. V. L. Hubert, P. P. Ekersley and B. Tenenbaum, has now been in the hands of various national authorities, including the G.P.O., for many months. It is understood that although technically the scheme has been widely accepted as sound, there is, so far, no indication that it has been officially accepted by any nation or authority as the basis for a working international broadcasting system for Europe.

SILVER JUBILEE

IT will be twenty-five years on November 2nd since KDKA, the pioneer broadcasting station, operated by the Westinghouse Electric Corporation at Pittsburgh, started the world's first regular broadcasting service.

In those pioneering days a small shack acted as studio and transmitter room in which the staff of five was accommodated.

Although the late Dr. Frank Conrad, then chief engineer at Westinghouse, was a prime mover in the project, he was not present at the inaugural transmission. He was standing by at his experimental station 8XK in case of a breakdown at KDKA.

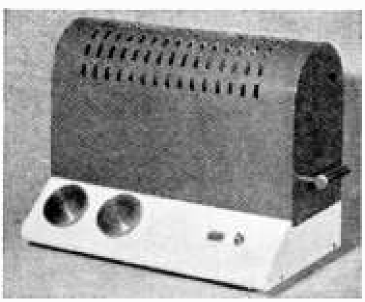
Bulletins giving the results of the Harding-Cox Presidential election constituted a large part of the first day's programme, which lasted from 6 p.m. until noon the following day.

MERCHANT-SHIP RADAR

AS a result of a conference called to reconsider the use of radar in merchant ships, a performance specification of a general purpose radiolocation set has been prepared.

The Ministry of War Transport has sent this specification to manufacturers and is arranging to make available to them advice on the technical aspects of the specification. It is also planned to establish a system for the issue of certificates of approval of designs of radar sets.

Sets manufactured for the Admiralty which are suitable for use in merchant ships carrying officers trained in their use and maintenance are, in the meantime, to be made available to shipowners.



SPECIALLY DESIGNED instrument cases such as this were seen at a recent exhibition arranged by Imhof's. This amplifier case is constructed of sheet steel with solid brass knobs. A pleasing feature of this design is the accessibility of the controls. In addition to the production of such specially designed cases Imhof's have a series of ten standard cases which are available from stock.

"RADIO" OR "WIRELESS"

WHO originated the term "radio"? In answer to this question the following was recently published in Washington, D.C.: "There has been some controversy over the origin of the word. It appears to have been first used in the United States by Donald McNicol in the title of a series of articles in *Western Electrician* during 1906-1907."

Donald McNicol, who is technical consultant of *Telegraph and Telephone Age*, writing in that journal, states: "I did not originate the term. The word was first used at the 1903 protocol in Berlin when the Germans pushed it forward because the British and Americans had adopted 'wireless.' What connection I had in the matter was in using the word 'radio' first in an American treatise of book-length on the subject."

WHAT THEY SAY

EMPIRE COMMUNICATIONS.—It is as important for British people to be able to communicate easily and cheaply between London and Sydney and between any other two places in British territories as it is for American people to communicate easily and cheaply between New York and San Francisco. If we make full use of up-to-date knowledge in radio science and engineering we can have services which will operate 24 hours a day. . . . It is to be hoped this will be one of the major considerations in British post-war development.—*Sir Ernest Fisk, writing to the Editor of "The Times."*

MANPOWER.—At one time during the war the ground radar stations of the Royal Air Force in the United Kingdom alone required the full-time employment of sixteen hundred officers and twenty thousand other ranks.—*Air Vice-Marshal Sir Victor Tait, K.B.E., C.B., Director-General of Signals, Air Ministry, addressing the Annual General Meeting of the British Institution of Radio Engineers.*

THE FUTURE.—FM contains in itself almost the whole future of audio broadcasting.—*Paul W. Kesten, Columbia Broadcasting System, executive vice-president.*

WE LED THE WORLD in television in 1939 and we have only weeks left in which to act if we are ever to get this lead back. The Government's attention to television . . . is called for now if this great industry is to be saved from disruption. . . . Television is the best export salesman we have.—*Sir Thomas Polson, K.B.E., C.M.G., Chairman of Pye, Ltd.*

PIT OR STALLS?—I anticipate that in time you will be offered two standards of B.B.C. television transmission, the utility 405-line picture, giving you a seat in the pit, and the luxury 1,000-line definition, putting you in the front row of the television stalls.—*Howard Thomas in "Sunday Graphic and Sunday News."*

PERSONALITIES

Carleton Dyer has been appointed Controller of Communication Equipment in the Ministry of Aircraft Production in succession to Sir Robert Renwick, who has resigned on his return to industry.

Roy Innes is the new General Secretary of the Association of Scientific Workers, the membership of which has now reached 17,000.

G. J. Redfern has joined Banks (London), Ltd., as Chief Electronic Engineer and will handle the technical side of the Company's business.

Dr. J. M. DODDS, head of the radio research section of Metropolitan Vickers, who were responsible for the transmitters of the original "CH" radar stations. He, and L. H. Bedford (see col. 3) of Cossor's, were the first industrial engineers to be taken fully into the confidence of the Government on radar.

IN BRIEF

Servicing Exam.—The results of the second examination for the Radio Servicing Certificate, held in London, Manchester and Glasgow on June 2nd under the auspices of the Radio Trades Examination Board, have been announced. Of the 56 entrants 24 passed both the written and practical parts of the examination. Twelve candidates passed only the written examination, of whom six re-entered for the practical test; four passed.

Dr. Partridge Memorial.—Just prior to his death, as a result of enemy action last year, Dr. Norman Partridge offered to finance, by a Trust, the award of an annual premium for the most outstanding paper on "Improvements in the Quality of Sound Reproduction" read before the British Institution of Radio Engineers in any one year. It has now been decided to establish a Dr. Norman Partridge Memorial Fund for this purpose and the first premium will be awarded in 1946. The Fund has already been well supported by Institution members.

Antarctic Radar.—The fitting of radar on the first of the large whale-factory ships, *Southern Venture*, for protection against icebergs on her voyage to the Antarctic is a revival of the earliest maritime application of radiolocation.

Television in Argentina.—An order has been placed for the erection of the first television transmitter in South America. The installation is to be carried out by Allen B. DuMont Laboratories, New York, and the site is expected to be in or near Buenos Aires.

Electronic Astronomy.—Some interesting applications of electronic technique to astronomy are given in a paper in the *Journal of the British Astronomical Association*, communicated by Arthur C. Clarke, who wrote recently in this journal on "Extra-Terrestrial Relays." Among the subjects dealt with are the use of photo-cell circuits to provide automatic following for stellar photography, television scanning methods of star counting and the possibility of using radar technique for the precise measurement of interplanetary distances.

Romford Radio Society has been re-formed and regular meetings have commenced. A fitted workshop is planned in the new headquarters to which they will shortly be moving. Particulars are obtainable from the Hon. Sec., R. C. E. Beardow (G3FT), 3, Geneva Gardens, Whalebone Lane North, Chadwell Heath, Essex.

"EI" Amateurs.—Ireland's fifty-three pre-war amateur transmitters are now permitted to operate. The Minister of Defence has revoked the Order, which has been operating since 1939, prohibiting transmission.

Scientific Films.—A revised catalogue of scientific films showing the suitability of films for various types of audience is now available from the Association of Scientific Workers, Hanover House, 73, High Holborn, London, W.C.1, price 2s. 6d.

Uruguay Broadcasting.—Marconi's W.T. Co. is to erect a 5-kW medium-wave transmitter at Montevideo for "Radio Rural." It will operate on a wavelength of 492 metres.

Gauge and Toolmakers' Exhibition.—An exhibition has been arranged by the Gauge and Tool Makers' Association to be held in the New Hall, Vincent Square, London, S.W.1, from January 7th to 19th, 1946.

More Radio Receivers.—A large factory at Crewe Toll, Edinburgh, has been allocated to Ferranti by the Board of Trade for the production of civilian radio receivers.

Change of Address.—The new address of the Import Licensing Department of the Board of Trade is 189, Regent Street, London, W.1. (Tel.: Regent 4090.)

A New Factory at Birtley, Co. Durham, has been acquired by W. T. Henley's Telegraph Works Company, for cable manufacture. This is in addition to their existing factories at Gravesend and Woolwich.

Plastics. — The manufacture of "Traffolyte" laminated plastics, formerly a product of Metropolitan Vickers, has been taken over by De La Rue Insulation, Ltd.

L. H. BEDFORD, Director of Research, of Cossor's, makers of the receiving equipment for the pre-war radar "chain." He also evolved the "Bedford attachment" for early gun-laying radar.

MEETINGS

Institution of Electrical Engineers

Radio Section. — "Radio Measurements in the Decimetre and Centimetre Wavebands" by R. J. Claydon, M.A.; J. E. Houldin, Ph.D., B.Eng.; H. R. L. Lamont, M.A., Ph.D.; and W. E. Willshaw, M.Sc.Tech., on November 7th.

"A Method of Increasing the Range of VHF Communication Systems by Multi-Carrier Amplitude Modulation," by J. R. Brinkley, on November 21st.

Both meetings will commence at 5.30 and will be held at the I.E.E., Savoy Place, London, W.C.2.

London Students' Section. — A "Brains Trust" Meeting will be held at 7.0 on November 6th at the I.E.E., London.

Cambridge Radio Group. — "Notes on the Stabilities of LC Oscillators" by N. Lea, B.Sc., on October 29th.

"Frequency Modulation," by K. R. Sturley, Ph.D., on November 20th.

Both meetings will be held at 6.0 in the Technical College, Collier Road, Cambridge.

British Institution of Radio Engineers

"UHF Aerial Technique," by S. Button, on November 21st at 6.0 at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

Radio Society of Great Britain

"Aerial Systems for the Radio Amateur," by F. Charman (G6CJ), at 6.30 on November 16th at the I.E.E., Savoy Place, London, W.C.2.

The

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NOW that the story of RADAR is known, Standard Telephones and Cables Limited is proud that it was the originator of the Grounded Grid Triode Valve for RADAR reception. The use of this valve at very short wave-lengths resulted in amplification of the echo signals and made possible a considerable increase in the range of many types of RADAR. This invention, shared freely with other companies, contributed greatly to winning the battle of the Atlantic.

Standard

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BRIMAR

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BIOLOGICAL AMPLIFIERS

1. Early Development : Neutralising Interference

By D. H. PARNUM,
B.Sc., A.R.C.S., Ph.D.

DURING the past ten years or so the use of valve amplifiers has become increasingly important in biological research. Their value lies in the measurement of the small varying voltages which occur in the tissues of any living organism.

Perhaps one of the most striking of these measurements is that of brain potentials. If two electrodes are placed at two points on the human skull, a voltage is produced between them; for a normal healthy person it varies pretty regularly at a frequency of 10 c/s, and has an average value of about 50μV. Certain types of brain abnormalities produce a quite different rhythm, usually of much lower frequency; brain tumours give a frequency of about 3 c/s, and the position of the tumour can often be found with considerable accuracy by placing the electrodes at different points.

This example has been given to show the importance of valve amplifiers in biological work. It is obvious that a voltage of 50 μV and frequency 10 c/s cannot be faithfully observed or recorded without amplification, and in fact no conclusive evidence about brain potentials was obtained until a valve amplifier was used. Another example is that of nerve fibre potentials. These occur as single impulses, corresponding to the passage of a signal along the nerve; typical figures are a peak value of 1 mV and duration of 1 millisec. To record such an impulse a system is needed with a frequency response flat up to at least 10 kc/s.

Yet another example is that of cardiography—the measurement of voltages associated with the action of the heart. The voltages in this case consist of impulses repeated at the frequency of the heart beat, i.e. about 1 c/s, and reaching a peak value of about 2 mV. Owing to the low frequency and comparatively high voltage, it is possible to measure these voltages with a fast-period galvanometer, but by using a tube with an afterglow screen, the slowly repeated voltage pattern can be observed visually and at once, by the patient's bedside; the galvanometer method involves photographic recording. The frequency range required here for faithful reproduction is 0.1 c/s to 50 c/s.

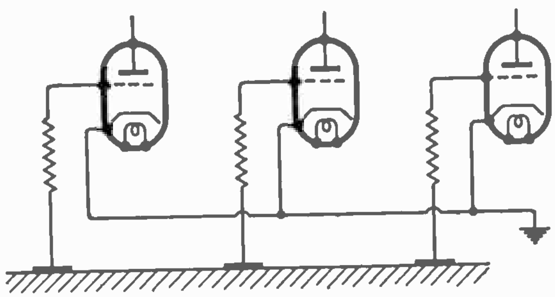

Fig. 1. Mutual coupling is possible between electrode input circuits.

This very brief account shows that the requirements of biological amplifiers vary somewhat with the problem, but are nearly always different from those of AF amplifiers. In general, the low-frequency response must be very low, so that sometimes a ZF (zero-frequency) amplifier must be used; the gain must be high, often over 1 million; and the input circuit must be of a special type. It is hoped that this article, which examines a few design problems in some detail, will be of interest to biologists and radio workers alike.

The Input Circuit

The input circuit of a biological amplifier is perhaps its most important feature. There are two chief difficulties: the first is due to interference, i.e. unwanted pick-up in the subject; the second is interaction between several amplifiers connected to one subject.

The first difficulty is familiar to everyone who has ever checked the action of an AF amplifier by touching a grid pin with the finger; a 50 c/s hum is generally the result. This is really exactly what happens if an input stage, with one side earthed, is connected to a subject. The "live" electrode will pick up considerable interference, mainly 50 c/s, but often higher frequencies, depending on the type of machinery and electric equipment operating in the neighbourhood. This voltage is usually several mV at least, and in general will completely mask the biological voltage. Screening of the subject, especially if human, is obviously

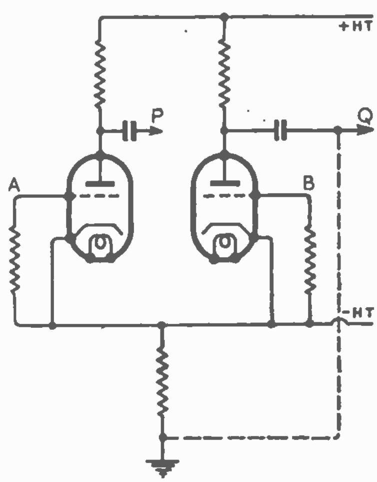

Fig. 2. Balanced input circuit.

Biological Amplifiers

difficult and clumsy, and in any case may not be effective. Hence the trouble must be cured in the amplifier.

The second difficulty is illustrated by Fig. 1, which shows three amplifiers connected to one subject. A voltage impulse occurring between grid and cathode of any amplifier will produce a small voltage in the common lead, and so inject a false signal into both the other amplifiers.

One of the earliest attempts at interference elimination was made by Robertson[1] in his electrocardiograph; the method was to introduce into the live amplifier lead a 50 c/s, voltage adjustable in amplititude and phase. This was adjusted to neutralise 50 c/s pick-up. Robertson reported good results, but the method is obviously not of wide application. It assumes that the interference is all 50 c/s, which is not always the case; even where 50 c/s is the basic frequency, the interference waveform is seldom pure, and the best cancellation would leave harmonic residuals. The method would probably not be successful for really small signals such as brain potentials; moreover it does nothing to overcome the interaction difficulty.

Both problems are fundamentally solved by the balanced input stage.

Balanced Input Stages

The first use of this type of circuit seems to have been by Matthews.[2] His circuit is shown in Fig. 2; for the moment, the earth connection at Q and the resistance between cathode and earth will be disregarded. The subject electrodes are connected to A and B and are balanced about earth. A signal voltage is a difference in voltage between A and B; it is split by the grid resistors to give (say) a positive voltage at A and an equal negative voltage at B. These voltages are amplified by their respective valves and the amplified difference appears at P and Q. Interference voltages, however, are not produced directly across A and B, but between A and earth, and B and earth; moreover, the interference at A and B will obviously be practically equal, since the two electrodes are connected to the same subject. These equal voltages are also amplified by their respective valves; if the valves are matched they will be amplified equally, and the difference between P and Q due to interference will be zero, or at least very small. The circuit is a discriminator between inphase voltages, such as interference, and antiphase voltages, such as a signal.

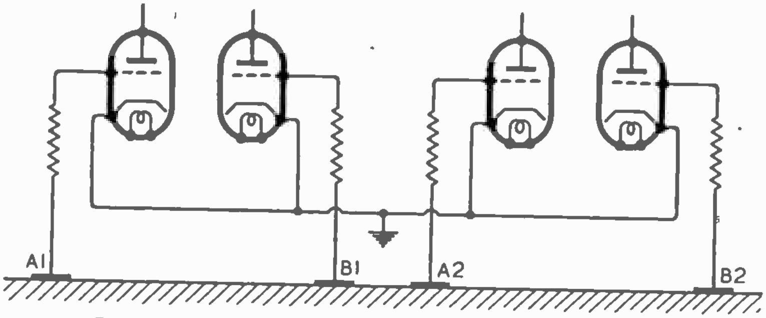

Fig. 3. Two balanced amplifiers connected to one subject.

Elimination of interaction is illustrated by Fig. 3, which shows two balanced amplifiers connected to one subject. If a voltage impulse occurs between A1 and B1, it operates the first amplifier, but as no current flows in the earth lead no spurious signal is injected into the second amplifier. It is even possible to replace electrodes B1 and A2 by a single electrode, and to continue this for a number of electrodes; so that to four electrodes, for example, three amplifiers can be connected to record the voltages between four successive points on the subject.

It may be remarked here that a high input impedance is very necessary with biological amplifiers, because the subject plus electrodes has inherently poor regulation. A balanced stage doubles the permissible input impedance, since this is equal to the two grid resistors in series. Grid resistors of 1 MΩ are common, giving an input impedance of 2 MΩ. This is much higher than that obtainable with any other indicating system such as a galvanometer.

We may also note here that a balanced input stage can be regarded as a differential amplifier; it will only transmit the difference of voltage between the two input grids. It is immaterial whether this voltage difference is applied actually between the two grids, as is normally the case, or is applied between one grid and earth, the other grid being tied to earth. In both cases there is a voltage difference between the grids. Hence a balanced input stage can always be used, when desired, as a single-ended one, and there is no loss of flexibility in standardising its use.

Push-pull Amplifiers

The circuit of Fig. 2 gives a push-pull output, neither side of which is earthed; without special

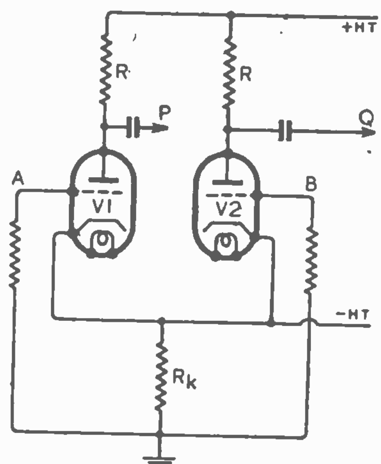

Fig. 4. Balanced input circuit with negative feedback.

circuits, a push-pull stage must follow, then another, and so on. Hence the simplest amplifier is push-pull throughout. Although this is bulkier than a single-ended amplifier, it has many advantages and has been largely used in America.

Owing to the low frequencies which must be passed, transformer coupling is impossible in biological amplifiers. It is therefore impossible to pass on merely the difference in voltage between P and Q (Fig. 2) to the next push-pull stage; the full voltage at each anode must be passed on to the corresponding half of the next stage, and this is repeated all the way down the amplifier. The resulting amplified interference, even if it is not enough to overload the final stage completely, is certain to make it badly non-linear and so cause modulation of the signal. Apart from this very serious defect, Fig. 2 does not possess high discriminating powers unless the valves are matched very carefully.

Both these difficulties can be overcome by using discriminating feedback. Fig. 4 shows the simplest circuit; R_k is a large common cathode resistance. (In this and in several succeeding circuits, the method of obtaining correct grid bias is not shown.) For an antiphase signal, suppose that A is positive and B negative. The anode current of V1 rises and that of V2 falls by an equal amount; the changes cancel in R_k and there is no cathode feedback. The stage therefore gives full gain.

For inphase signals the anode currents rise and fall together; the combined effect in R_k is equivalent to one of the currents in a resistance of $2R_k$. Thus each valve amplifies its own interference input as if it had a cathode resistance of $2R_k$, and the effective gain cannot exceed $R/2R_k$ even if the internal gain is infinite. Since it is quite easy to make $2R_k = R$, the inphase gain can be reduced to 1. The input interference is never enough to overload any stage (it is usually a few mV), so the output cannot be enough to overload the next stage. This principle can obviously be used right through the amplifier.

The balancing property is also greatly improved. In considering this aspect, two definitions are useful. The inphase/antiphase *gain* ration will be called simply the gain ratio, and will be denoted by r. The inphase/antiphase *output* ratio will be called the output ratio and will be denoted by r'; it is not the same as the gain ratio for a push-pull stage, because the output is the difference between two points such as P and Q. Generally r' is some small fraction of r; if the two halves are exactly matched it will be zero whatever the value of r.

In Fig. 2, r is 1 and r' depends only on valve matching. In Fig. 4, the inphase gain is about 1 and the antiphase gain (for triodes) may be 30; thus r is about 1/30.

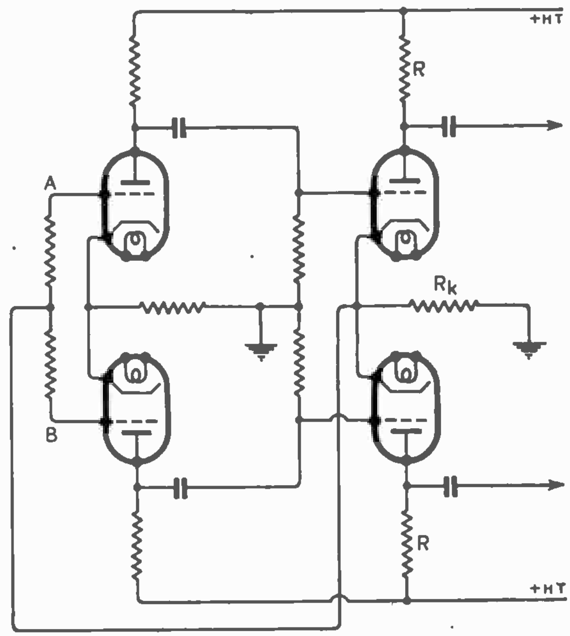

Fig. 5. Circuit with amplified feedback.

If the two halves are matched to within 10 per cent., analysis shows that r' will be very roughly 10 per cent. of r, or 1/300. Suppose we say that the output signal must be at least 3 times the interference; then to measure a signal of 10μV the interference must not exceed about 1 mV.

The output ratio can be improved by better valve matching, but it is quite easy to obtain a vast reduction in the gain ratio by amplifying the feedback. Fig. 5 shows Offner's method.[2] The junction of the input grid resistors, instead of returning to earth, is returned to the cathodes of the second stage, which has a large common cathode resistance R_k. This produces negative feedback for inphase signals as before; the inphase gain cannot exceed $R/2R_k$ and is usually about 1. The antiphase gain is now that of two stages, which can be set conservatively at 3,000 (using pentodes in the second stage), so that r = 1/3,000. If the two halves of the whole system match to within 10 per cent., r' is roughly 1/30,000, and a signal of 10μV can be measured in the presence of interference of about 100 mV. In practice an r' of this order is of little value, because interference inputs of 100 mV are most unlikely to balance within 3 μV.

Fig. 5 shows that no portion of the input circuit must be earthed, or the feedback path will be shunted; hence, the subject must be well insulated from earth. This is obviously not easy to achieve, especially with human subjects, and is a serious practical disadvantage of the circuit.

Fig. 6 shows the complete circuit of Goodwin's amplifier,[4] which does not require high subject insulation. This is a ZF amplifier and will be dealt with later in this connection. For the moment it is only necessary to note that the amplified feedback is taken from the anodes of the second stage to the cathodes of the first. For inphase voltages there is no potential difference between the cathodes of the first stage, and the feedback is independent of the setting of the variable resistor R3. The resistors R1, R2 form a potential divider feeding back 1/25 of the output voltage, and the inphase gain cannot exceed the inverse of this fraction, or 25. With R3 set at zero, each stage has a common cathode resistance and the antiphase gain is the full two-stage gain. To obtain a fair comparison with Offner's method we will take this as 3,000; r is then 1/120. Fig. 6 actually gives

Biological Amplifiers

a much lower value of r because pentodes are used in both stages. The circuit can be made more discriminating by increasing the feedback ratio.

The gain control of Fig. 6 is interesting. When R3 is set at zero the signal gain is a maximum. When R3 is set at its full value, it is virtually open-circuit; there is then complete negative feedback for antiphase as well as inphase inputs, and the gain becomes 25. The gain can obviously be varied between these limits by varying R3. Thus gain control in a push-pull amplifier is achieved by a single control. There is a disadvantage, however; the signal/interference ratio *in the output* is fixed whatever the signal, so that the improvement which would naturally occur with a large signal is lost.

So far the interference inputs have been assumed equal. What happens when they are not is the same for all balanced input stages, and is worth looking into at this point. Suppose the interference inputs are e and $e + \Delta e$. As explained earlier, this amounts to an antiphase signal Δe and equal inphase signals e. Δe will be transmitted with the full gain, e with the inphase gain. Thus the total interference output will be proportional to $\Delta e + r'e$, or $e\,(r' + \Delta e/e)$. Now $\Delta e/e$ is the fractional difference between the two inputs; suppose it is 1 per cent. Then $r' + \Delta e/e$ cannot be less than 1 per cent. and there is no point in reducing r' below about $\frac{1}{8}$ per cent. A very small value of r' is often of no value, and the simple circuit of Fig. 4 is good enough for many purposes.

This reasoning also shows that to reduce the interference output to zero, r' must equal $-\Delta e/e$. This means that r' must be adjustable within a region of about $\pm$ 1 per cent. The circuits so far described are basically unadapted to this, because they aim at a very low value of r, and r' must be less than r.

This question of balancing out unequal interference has received little attention in the literature, which suggests that it is not a serious problem; nevertheless an interference control would probably be welcomed by biologists. The interference *inputs* can obviously be adjusted to equality by making one of the input grid resistors a variable potential divider, but a variable component at such a low voltage level is obviously a bad idea. A possible way of varying r' is shown in Fig. 7. The control is not at the point of lowest voltage level; it has hardly any effect on the signal gain; contact resistance has no effect on the ratio of the two anode loads. The inphase gain is considerable, since the cathode resistor provides bias only and is quite small; but the inphase output will never be enough to overload the next stage, which should either be push-pull with discriminating feedback or a "compressor" stage, which will be dealt with in the succeeding part of this article.

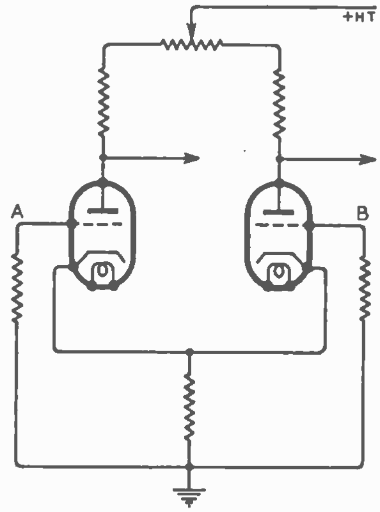

Fig. 7. Suggested circuit for balancing input.

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[1] Robertson, *Journal I.E.E.*, 1937, 81, p. 497.

[2] Matthews, *J. Physiol.*, 1934, 81, p. 29P.

[3] Offner, *Rev. Sci. Inst.*, 1937, 8, p. 20.

[4] Goodwin, *Yale J. Biol. Med.*, 1941-1942. 14, p. 101.

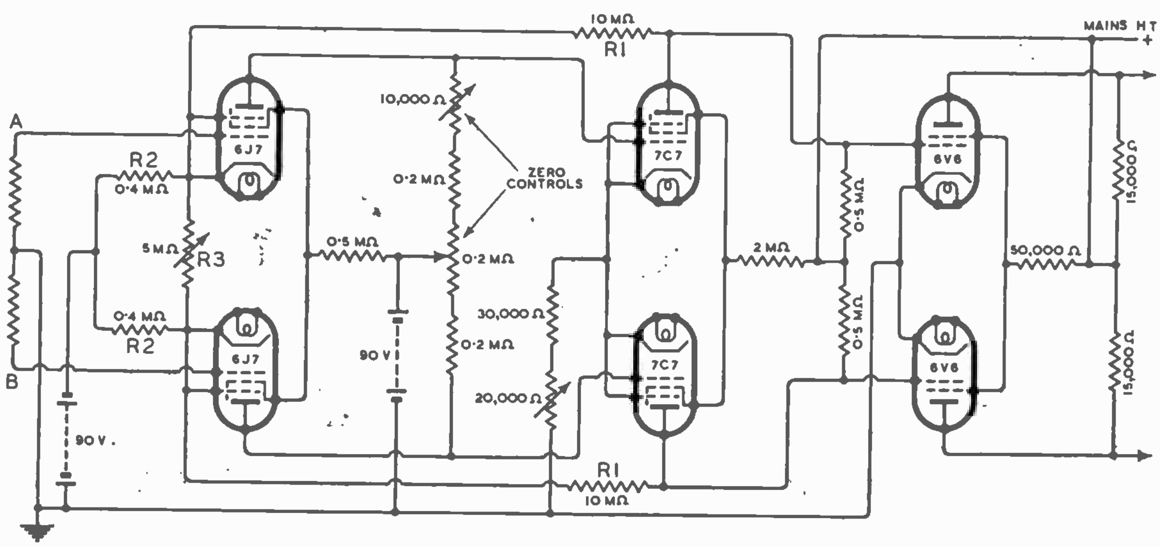


Fig. 6. Complete circuit of amplifier, due to Goodwin, which does not require high insulation of the subject.

LONG-WAVE CONVERTER

Extending the Range of the Wartime Civilian Receiver to Cover 1,500 Metres

By H. B. DENT

THE idea of using an add-on unit for reception on wavebands not covered by a receiver is very old, and is generally associated with the reception of the short and ultra-short waves. Thus the description "short-wave converter" is quite familiar, but the expression "long-wave converter" probably strikes a new note.

Theoretically there is no reason why a converter should not be employed for the reception of wavelengths longer than the longest allowed for in the receiver; but, so far, there has been no real demand for an attachment of this kind.

Now that long-wave broadcasting has returned, it is natural that owners of single-range sets, such as the Wartime Civilian Receiver, should be anxious to know if anything can be done to extend the waverange. The solution is a long-wave converter.

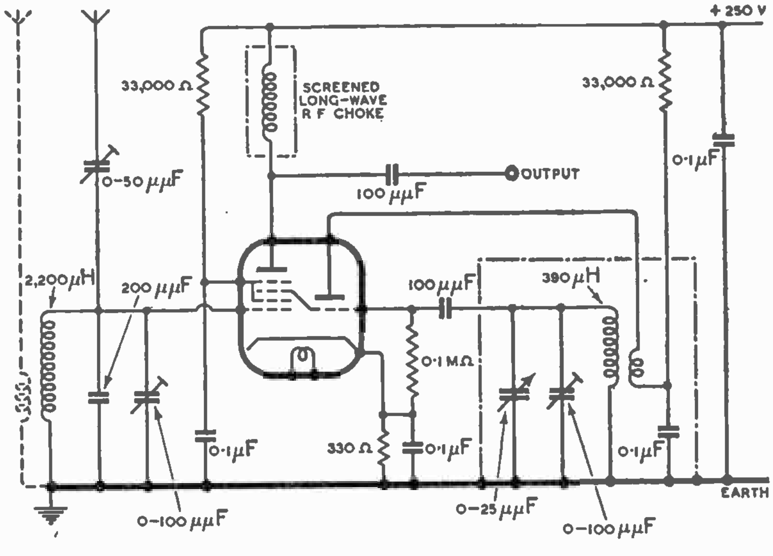
In principle the operation of a long-wave converter is identical with that of a short-wave converter except that instead of converting all signals to a lower frequency they are converted to a higher frequency. This process takes place, of course, in any ordinary two-band broadcast superhet., since all such sets have an IF of nominal 465 kc/s, which is lower than the medium waveband frequencies and higher than the long-wave frequencies, so that nothing very extraordinary is required of the suggested long-wave converter. It only remains to be seen how the requirements can be translated into a practical form in an economical manner.

There may be several ways of achieving this, but for the present purpose we will assume that a single-valve frequency changing unit, the circuit diagram of which is given in the figure, will be used. In the form shown, it presupposes that reception on one wavelength only will suffice, and no attempt is to be made to cover the whole of the long-wave band. If variable tuning must be provided, then a two-gang condenser must replace the two 100 μμF pre-set condensers, and, in addition, the usual parallel and series padding condensers must be included in the signal and oscillator circuits in order to ensure correct tracking. It will also be necessary to calculate the inductance needed in the oscillator grid circuit coil to suit the intermediate frequency to be used.

By foregoing what are, at present, the doubtful advantages of a full coverage of the long-wave band, all this tedious work is avoided, and, moreover, the unit becomes far easier to construct. Most of the parts required can be found in the spare parts box; furthermore, they are quite common standard values of the widest tolerance, so that even to-day little difficulty should be experienced in obtaining them.

The aerial coil is a standard long-wave tuning coil. It can be connected in the normal way, or, alternatively, the separate winding usually included in aerial coils may be employed as shown in dotted lines in the circuit. Likewise the oscillator coil is a standard long-wave coil as used in superhets having an IF of 465 kc/s, but any inductance capable of being tuned to 800 kc/s, and having a reaction winding, would serve equally well. For example, a medium-wave coil of 180 μH could be used and tuned by a combination of fixed and pre-set condensers having a total capacity of just over 200 μμF. This improvisation would not be possible if ganged tuning were adopted.

It will be seen that a small variable condenser, with a sug-



Theoretical circuit diagram of a converter to enable long-wave reception to be effected on sets such as the Wartime Civilian Receiver. Values of the components are chosen to suit an X65 valve. An alternative aerial connection is shown in dotted lines.

Long-wave Converter—
gested value of 0-25 $\mu\mu F$, is included in the oscillator circuit. This is to provide a means of compensating for drift in the oscillator frequency. The control for this should be brought out to the panel for easy access.

Mention of 800 kc/s for the oscillator frequency to tune a station operating on 1,500 metres, which is 200 kc/s, reveals that the chosen IF is 600 kc/s (500 m), and the receiver must accordingly be tuned to this frequency whenever the converter is in use.

The terminal marked "output" on the circuit diagram will be joined to the aerial terminal of the broadcast set and the aerial lead transferred to the converter. This change could, of course, be made by switches, but as they are difficult to obtain no provision is made for them in this case.

Now it only remains to find the necessary operating voltages for the long-wave unit. It is hardly worth while providing a separate power supply, as the consumption is only about 10 mA at 250 volts, in addition to a filament supply, and both of these could be obtained from the broadcast set. But it will necessitate making a few simple modifications to that set. A socket consisting of a five-pin valveholder can be fitted at any convenient place at the back of the set and leads taken to the HT and LT supply points. The base of a discarded valve is a good substitute for a cable-plug.

The values of the four resistors given in the circuit diagram were chosen to suit an X65 frequency changer valve, but any other type can be used if these values are adjusted, where necessary, to give the required operating voltages.

T.C.C. ELECTROLYTICS

"All Aluminium" Types for Servicing

SUPPLIES are now available of 8 μF, 450 V peak working, 550 V surge condensers for radio servicing. These dry electrolytic capacitors are of the plain foil variety. The construction is similar to that of the "Micropack" series and they are contained in an aluminium tube 2¼in. long and 1in. diameter protected by transparent insulating sleeving. The price is 4s. 6d. each.

A complete range of capacitors is in preparation and will be available shortly.

Letters to the Editor

Amplifier Noise • Capacity of W/T Channels • Army Communication Set • Adaptability of the Deaf

Biological Amplifiers

I AM interested in the remarks made about noise in biological amplifiers by G. D. Dawson and W. Grey Walter in your September issue. They say that the cause of low-frequency valve noise is not apparently known to electronic engineers. A number of subsidiary causes of noise are dealt with in E. B. Moullin's book, "Spontaneous Fluctuations of Voltage," namely, positive ion effects, secondary emission, collision ionisation and flicker effect. Quite apart from any question of magnitude, the first two of these effects show no variation with frequency, and the third shows none at the pressures used in modern valves. Flicker effect, however, does show a remarkable increase as the frequency becomes smaller. It is supposed, though the evidence is by no means complete, that the cause is variations in cathode emissivity, due, for example, to the momentary lodgment of a positive ion on the cathode surface. Such lodgments are supposed to be occurring continually at many different parts of the surface. Each ion will spend a certain length of time on the surface, and the average time of sojourn will thus provide a natural period associated with the effect. This natural period must give rise to a selective frequency variation; in the case of resistance and shot noise, the effect is purely random in time, and all frequency components have the same value.

Existing studies on flicker effect have all been made with valves in which the grid, if any, was connected to the anode. Hence the suggestion quoted by your correspondents—that the low-frequency noise is due to close grid-cathode spacing producing random grid emission—could not have held in these experiments; i.e., there is certainly a selective low-frequency effect due to the cathode alone. I do not know how good the correlation between high-valve slope and low-frequency noise is; but, assuming it is good, the linking factor is not necessarily the close grid-cathode spacing. Valve slope is also raised by increasing the cathode emissivity, and anything that does this will tend to increase the variations of cathode emission.

If the cause of the trouble is true flicker effect, one important point emerges from the existing work: that flicker effect is immensely greater with oxide-coated cathodes than with pure tungsten emitters. For example, Johnson (*Phys. Rev.*, 26, July, 1925) found that flicker effect did not set in with tungsten cathodes until the frequency was below about 100 c/s. For a coated cathode the value at 100 c/s is so large that it is not shown in the curve.

This suggests that the first stage of a biological amplifier should use tungsten-cathode valves. Even with specially designed valves, this would probably lead to low valve slope and consequent increase in shot noise, but the reduction in flicker effect would certainly more than offset this increase in noise.

Your correspondent's letter confirms my opinion that far too little is known about the low-frequency components of valve noise; the existing work on valve noise has largely been done at high frequencies precisely in order to avoid interference by flicker effect. A new study of the low-frequency end, culminating, if necessary, in the design of special low-noise valves, is definitely needed, and would be welcomed by biologists and all others using amplifiers for the measurement of very small voltages.

D. H. PARNUM.

Helensburgh.

High-speed Radio-Telegraphy

IN your September issue, Thomas Roddam has expressed the opinion that the Romac high-speed radio-telegraphy system will not be satisfactory for long-distance communication because of "fading" conditions. He further gives as his belief that such high speeds as 3,000 w.p.m. would not provide an overall economical system and that it would be preferable to employ 10 separate channels of 300 w.p.m. each instead of the one high-speed channel.

I have had many discussions on this subject with the inventor, Lt. S. Lalewicz, and the facts are that this system has already operated satisfactorily over considerable distances and further that in addition to its high speed the reception and recording of the signals has been effected satisfactorily in spite of fading and/or large noises. Further, the band width employed for the transmission was not excessive.

The theoretical considerations, introduced by Mr. Roddam, need much closer investigation. He raises two features of fading:—

(a) The fact that allowance must be made for a maximum path difference of 30 km., and

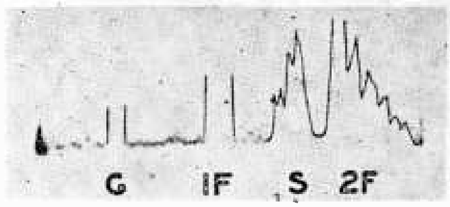
(b) That of selective "fading."

He points out, quite correctly, that such a path difference would mean that waves may arrive at a time displacement of 0.1 milliseconds, which is an appreciable percentage (25 per cent.) of the duration of a dot for signalling speeds of 3,000 w.p.m.

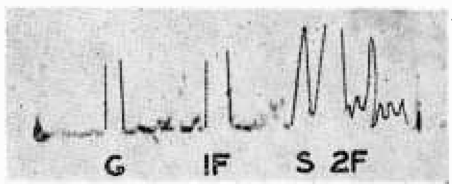
Mr. Roddam is very bold in his statement that clear reception of telegraphic symbols under such conditions would not be possible. In fact, Lt. Lalewicz informs me that he took this point into account before deciding to construct equipment for high-speed working, and that by using simultaneous records satisfactory results are obtained.

In other high-speed systems it has been found advisable to employ modulated CW, and then the effects of selective fading are not so serious. However, this result is obtained at the expense of the use of wider frequency bands.

It is usually necessary to pay a price for any technical improvement, and as it is of great importance to operate under bad conditions of fading and of noise the Romac system is based on the assumption that it is highly advisable to avoid any increase in the frequency band. In fact, it relies on features already described in *Wireless World*, making use, when necessary, of the synchronisation of independent records.



(a)



(b)

Recording (inked in) on 6 millisec. time-base, showing distant-scattered groups starting 100km. before 2F echo. (From "Jour. I.E.E.," June, 1940.)

Thus the question of overcoming fading is one of economics where the word is used in its broadest sense, to include even economy of frequency bands.

Mr. Roddam believes that it would be preferable to employ 10 separate channels of 300 w.p.m. each instead of a single channel of 3,000 w.p.m. Even if the modulated CW carrier is dispensed with in this case it is necessary to leave some clearance between the channels, and thus 10 channels would absorb a wider band than the single channel for the same intelligence.

The whole economic question is, naturally, one for users to decide and it is sufficient at present that the Romac system has shown that high-speed telegraphy can be operated with advantage during bad periods of "fading" and noise, and that it employs the minimum frequency band. All of this is quite apart from the fact that the Romac equipment can also offer advantages for slower signalling speeds.

J. ROBINSON.
London, N.W.7.

Thomas Roddam replies:—

Dr. Robinson has taken me to task for not sharing his complete faith in the Romac system.

I would ask whether the system has been used over a distance and at a frequency which would give multipath transmission: that is the crux of the matter when we consider it dispassionately. What was the distance, what was the frequency and what were the E and F layer critical frequencies?

I agree that a 30-km path difference would be workable, but suggest that anything more would not. What will the Romac system make of the dots in the accompanying Figure? In the six milliseconds shown, several letters must be distinguished (three-tenths of a word).

I do not wish to deprecate the use of the Romac system for suitable applications: it is only the first paragraph of the article in the July *Wireless World* which sticks in my gullet.

I hope to have an opportunity later to discuss at length the general problem of intelligence transmission.

Army Set R107

I READ with interest the descriptive article in your August issue and thought that as I was responsible for the design of the R107, the following comments would be appropriate.

In particular, the balance of aerial circuit, RF amplifier, and frequency changer noise is such

Letters to the Editor—

that the limit of sensitivity is set largely by the thermal agitation noise in the first circuit at all frequencies up to some 15 Mc/s. Accordingly on CW a signal of about 1 microvolt at the 80-ohm aerial input will be heard some 20 db. above the total receiver noise at the phone output, when the bandwidth of 3 kc/s is in use. (Note: *not* ±3kc/s.)

When the AF note filter is brought into use, then about 0.4 microvolt suffices for the same signal/noise ratio. This is a limit at which a good operator, using all facilities, can read as small a signal as 0.1 microvolt.

Such a performance in 1940, when the set was designed, was not to be found in any British communications receiver normally marketed. The American HRO was then the comparable performer, although not for selectivity. For the same pass-band width (3 kc/s) the HRO had an IF cut-off slope down to −60 db. at 6 db./kc/s, while the R107 achieved 14 db./kc/s.

In achieving this performance it should be noted that to ease the spares problem only two valve types were used, excluding the rectifier valves. Further, this set, primarily for use in vehicles, was and had to be very robust

It should be remembered that the R107 was designed in 1940, and that since then new receiver designs have been completed, developed, and put into production. Information on these will probably become available at a later date.

E. FORSTER.
Signals Research and Development Establishment,
Somerford, Hants.

Adaptability of the Deaf

I HAVE used a hearing aid for 10 years which I have continually modified to my increasing needs. There is no doubt that by the continual use of an aid the patient's ears are to some extent "educated." W. T. Smith's theory, set out in your October issue, implies that an approximate restoration of normal hearing is usual. I am sure that in most cases the limited frequency response of the combined aid and defective ears induces a medley of unnatural sounds. This is due to resonances which cause over-stimulation on certain frequencies. The patient correctly complains that the reproduction is poor, but puts up with the irritation because of the balance of advantage. In the course of years, however, nature dulls the over-stimulated nerves and permits the aid to be used without discomfort and with apparently greater benefit.

I suggest that this far from ideal state of affairs is a material factor in the difficulty, which the severely deaf experience when any fundamental change is made in their apparatus, and explains some of their disappointing reactions to "improvements" in the response of their instruments. In short, I think the adaptability of the deaf is as much due to physical changes as to subjective education.

I think Mr. Smith's theory presumes a degree of assistance which is rarely possible of achievement, certainly not with the *portable* aids at present available.

JOHN A. HAMILTON.
Glasgow, S.3.

"Schwingtöpfe"

THIS German word should be translated as "cavity resonators." Your reviewer, in the August *Wireless World* and also in *Wireless Engineer*, uses Klystron. The Klystron is a valve, with a velocity-modulated electron stream, working on the "buncher-catcher" principle.*

H. MORGAN.
London, S.E.

* See *Proc. I.R.E.*, April, 1945, and *Journal of Applied Physics*, May, 1939.

[Our reviewer replies as follows: —Ed.]

The following definitions from the "British Standard Glossary of Terms used in Telecommunication" show that Mr. Morgan's criticism is well founded. They also indicate how the confusion has arisen.

No. 1743, *Klystron.*—A velocity modulated valve in which the electrodes of the output circuit (and also possibly of the input circuit) are combined in the circuit to form a rhumbatron. (See 4526.)

No. 4526, *Rhumbatron.*—A resonant circuit characterised by an electromagnetic field bounded by a substantially closed conducting surface, energy being transferred to or from the electromagnetic field by inductive loops or capacitive elements in the field or by radiation through an opening in the conducting surface or by a beam of electrons projected through the field.

Hence, although the Rhumbatron (or Schwingtopf) forms an essential part of the Klystron, I was certainly not justified in referring to it as a Klystron. The book under review was not concerned with the velocity modulated valve, but solely with the Rhumbatron or cavity resonator.

G. W. O. H.

Radar

THE description of the front cover illustration of your September issue, given on page 265 of that issue, refers to the straight line from the centre as a "rotating scanner beam"; that, if not a mistake, is definitely misleading.

The line is in fact called the "Heading Line" and represents the direction dead ahead in the line of flight. It is obtained by the aerial scanning mechanism closing a contact which causes a brightening pulse to be applied to the CR tube every time the aerial points straight ahead.

G. T. CLACK.
Staines, Middx.

SERVICES-INDUSTRY CO-OPERATION

IN our last issue we stressed the unprecedented extent to which co-operation between Government Departments, the Services and the radio industry has taken place in the development of radar. There would now appear to be some prospect of this co-operation continuing in peace. Air Vice-Marshal Sir Victor Tait, Director-General of Signals, Air Ministry, addressing the Brit.I.R.E., stated that a plan was being formulated by the Services for a long-term contract with the industry for the conduct of development work. Sir Victor had previously stressed the dependence of the Services on "a large and healthy development section of the radio industry working for and with them."

PIEZO-ELECTRIC MICROPHONES

Effect of the Case on Performance

THE technician to-day is too often apt to concentrate on what he considers to be the essentials of a component and to dismiss its container as a frill of doubtful necessity. This attitude has doubtless arisen as a result of two things—the prevalence at one time of components of questionable quality in beautiful cases on the one hand and the widespread abandonment of cases of any sort in the interests of economy on the other.

With electro-acoustic apparatus, however, the case is more than a protective cover of good appearance. It is part of the device itself, and its materials, dimensions and shape affect the performance. This has been widely recognised with loudspeakers, and everyone realises that box resonance affects the performance to a marked degree. It is not, however, so generally realised with other devices, such as the microphone, and there is a prevailing idea that any case is good enough.

This was brought home forcibly to the writer when he recently needed a small microphone of fairly high quality. The need for quality, low background noise and sensitivity to weak sounds ruled out the carbon type, while the lack of a high degree of amplification made moving coil and condenser microphones impracticable. The piezo-electric crystal microphone was, therefore, the only type considered, but the high-quality commercial types were unsuitable because of their size and weight.

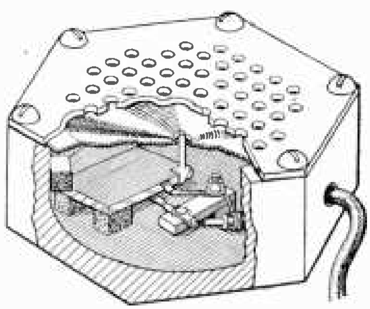
Crystal Mounting

Some tests were made, therefore, with a crystal unit fitted to a light case about the size of a telephone earpiece. The results were nothing less than appalling! All that could be said in its favour was that it was highly sensitive, but a terrific resonance around 1,000 c/s concentrated this sensitivity at the one point. In addition, the slightest touch on the case overloaded the amplifier with noise!

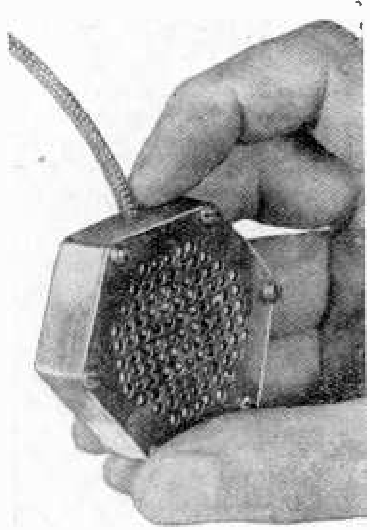
It was at first thought that the resonance was caused by the cone and one of much smaller dimensions was tried without effect. It was then observed that the microphone worked nearly as well without a cone at all, and this gave a clue to the trouble. The case was vibrating and its vibrations were affecting the crystal directly.

The internal construction of a microphone is shown in the sketch. The crystal is stuck to the case at three of its four corners, being spaced from it and partially shock-insulated by three small rubber blocks. The fourth corner is attached to the cone and metal plates on either side of the crystal form the electrodes. Any mechanical distortion of the crystal produces by virtue of its piezo-electric property a potential difference between the plates, and this forms the electrical output.

The three fixed corners of the crystal are supposed to remain fixed and the vibration of the cone under the influence of the sound



In this cut-away sketch of the microphone the crystal mounting is clearly shown. It is evident that flexure of the case will stress the crystal and so produce an output.



A view of the finished microphone described in the text.

waves moves the fourth corner and so tends to twist the crystal. However, if the case is itself vibrating, the three fixed points are no longer fixed.

There are many possible modes of case vibration. The back of the case may move more or less as a whole and carry with it the crystal. The result will be the same as if the back were fixed and the cone moved, so far as the crystal is concerned, but the effect will tend to be appreciable only at one frequency—the natural resonance of the case in this mode.

In more complex modes of vibration one part of the case may move towards the crystal while another part is moving away from it. If these two parts coincide with two of the crystal mountings the movement will tend to twist the crystal and produce an electrical output.

It is well known that such containers do resonate in complex modes and exhibit quite sharp resonances. Their unsuitability for microphones is, therefore, obvious.

Effect of Heavy Case

In order to prove that the bad performance of the microphone was really caused by the case, it was rebuilt, using a heavy brass plate for the rear of the case. This

Piezo-Electric Microphones—
plate was soldered to a heavy brass ring which formed the walls and cone support. This ring was actually a large nut from which the thread and the usual corner bevels were removed. It is this which accounts for the hexagonal shape shown in the photograph and it gives the microphone quite a pleasing appearance.

The new case was a great success. The terrific resonance of the light one disappeared and the response generally was greatly extended. The sensitivity was somewhat lower because of the absence of marked resonances, but compared well with a high-quality commercial diaphragm type crystal microphone of much larger dimensions.

Unfortunately, it was not possible to measure the performance, but the results obtained were a very striking demonstration of the advantage of a heavy rigid case and the uselessness of a light one.

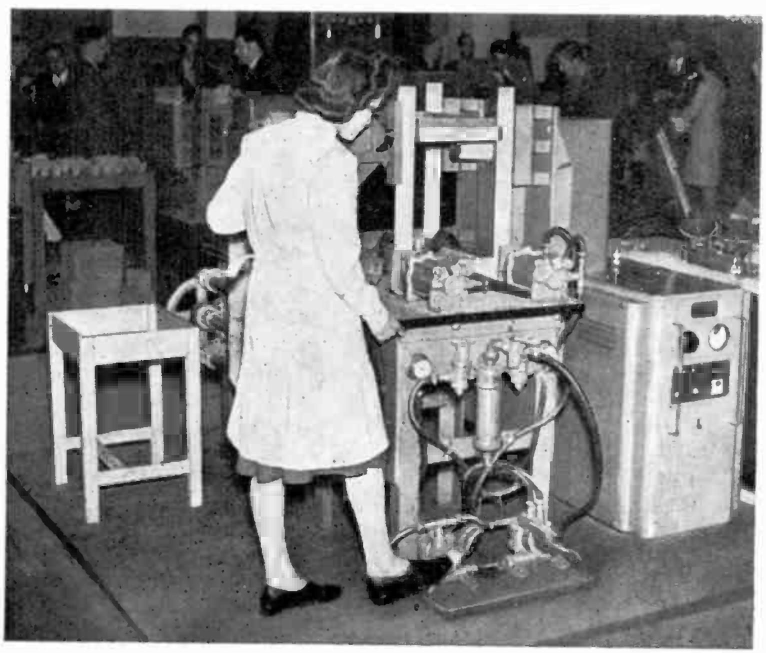
In addition to having a good frequency response, the new microphone was relatively insensitive to handling. It was possible to finger the case without swamping everything in noise. Handling produced some noise, it is true, but the level was something like 30 db. below that with the light case.—W. T. C.

RADIO-HEATING DEVELOPMENTS

Industrial Applications Demonstrated by Rediffusion, Ltd.

SOME indication of the extent to which radio heating has established itself in industry was given by an exhibition recently organised by Rediffusion, Ltd., in London.

The range of "Redifon" heaters now comprises four models. The RH2 (250-300 watts at 25-32 Mc/s) has already been described in this journal. The next size, RH7 (2-2.5 kW at 16-18 Mc/s) is a useful general purpose generator for eddy current or dielectric heating, and an excellent medium for gaining experience of radio heating technique in all its branches. Model RH31 (5.5 kW at 10 Mc/s) is suitable for plasticising moulding powder for large mouldings such as radio receiver cabinets, motor fascia boards, etc., and will deal with 3 lb. of standard moulding powder per minute. Model RH4 (25-30 kW at 1.7-3.4 Mc/s or 5-9 Mc/s) is suitable for heat treatment of steels or for setting glues in wood assemblies.



Typical applications of the Redifon RH7, 2-kW radio heater. (Left) Gluing sixteen joints simultaneously in 3 minutes in a hydraulically operated jig and (above) conveyor for drying textiles and similar materials.

Considerable progress has been made in the design of electrode systems and heating chambers, which now have the appearance of machinery rather than experimental wireless transmitting apparatus. This aspect was well exemplified in the demonstration of radio heating equipment for the plastic moulding industry, for glue setting and for the hardening of small steel parts—all applications in which radio heating has had time to prove its worth and for which there is now a steady demand for equipment.

Another sphere in which there is scope for future development is the drying of commodities such as wool, tobacco, chemical powders, etc., which have low thermal conductivity and must not be overheated. Here radio heating is capable of effecting economies in the drying time. An interesting example shown was a continuous drying conveyor for thick fabrics, paper board, etc. In this machine the material is carried between two sets of transverse electrodes which are staggered to give a longitudinal rather than a transverse field. The spacing of the electrodes is graded to vary the field intensity according to the condition of the material as it passes through the chamber and its moisture content is reduced.

In the section devoted to glue setting a RH2 generator was shown working a jig for gluing together the shaft and blade of rescue dinghy paddles. This particular assembly has turned out 1,000 paddles per week for many months. Another cabinetmaking jig shown in operation was for setting 16 joints simultaneously in the body of a desk. Power is supplied by a RH7, 2-kW unit and the electrode system is adjustable for several sizes of desk.

Demonstrations were also given of the rapid concentration of heat-sensitive chemical liquids in vacuo, the welding of PVC by the so-called electronic sewing machine and the curing of rubber samples.

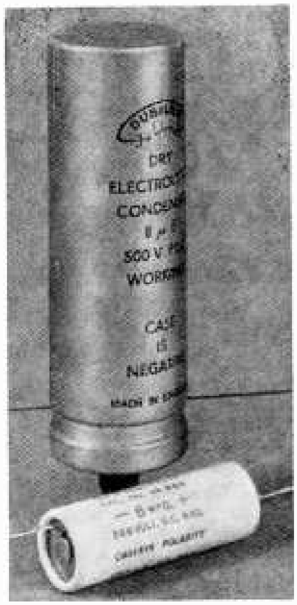
DUBILIER DRILITIC CONDENSERS

THE first of a new series of dry electrolytic condensers made by the Dubilier Condenser Co. (1925), Ltd., Ducon Works, Victoria Road, North Acton, London, W.3, for general post-war use are now available. At present the range includes but two models, one an 8-μF 500-volt DC type and the other 50-μF, 50-volts.

The first is a general-purpose HT smoothing and by-pass condenser and it can be used wherever an 8-μF electrolytic of the same working voltage was used hitherto. The only limitation imposed is that the AC ripple current passing through it must not exceed 100 mA.

Only in one position of the average radio receiver would the ripple voltage be of sufficient magnitude to produce a current in the condenser approaching this value and that is the reservoir condenser immediately following the AC rectifying valve. Only under certain conditions of operation, such as when the DC output is large or the AC waveform is exceptionally bad, would the limiting value be reached, or exceeded.

The main application of the 50-μF size is for by-passing cathode bias resistors, but it will serve equally well in any position where a capacitance of 50μF is required, providing the potential across the condenser does not exceed 50 volts peak.



This comparison between an old-style 8μF 500-volt dry electrolytic condenser and a new Dubilier Drilitic model of the same capacity and working voltage well illustrate the big reduction in size that has been effected.

In appearance both these condensers resemble the familiar tubular paper type, as they are enclosed in cardboard tubes which completely insulate the metal container. This is a seamless drawn aluminium can of ¾in. diameter and 2in. long, hermetically sealed at the open end by a rubber-faced laminated bakelite disc.

Small physical size, long working life, improved RF and AF characteristics, low leakage current and tropical finish, briefly sum up the outstanding features of these new condensers.

They are described as the Drilitic range; the 8-μF 500-volt model has the Dubilier type number BR.850 and costs 4s., while the 50-μF 50-volt size is listed as BR.505 and costs 3s. 6d.

LOOK AT IT THIS WAY!

Take as an example six executives with a combined yearly salary of, say, £6,000, or £2-18-2¼d. per hour.

Let's work it out—

The average time taken to locate an executive the old way is

5 MINUTES

With an average of 4 times per day each, the location of six executives in one year would take

550 HOURS!

The TANNOY will locate an executive in

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on any part of the premises! With the same average of 4 times per day each, the location of six executives in one year would take

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RANDOM RADIATIONS

By "DIALLIST"

Thank You!

IT was with great pleasure that I heard the tribute to the radar work of L. H. Bedford, of Cossors, paid by General Sir F. A. Pile in the course of his "Ack-Ack" broadcast. For some unknown reason very little has been said by the Powers-That-Be about Bedford's contributions to radar, outstanding though some of them were. Certainly the man in the street does not realise how much the defence of his country against both enemy raiders and "doodlebugs" owed to Bedford's genius and to the vast amount of hard, slogging work that he put in. An instance mentioned by the General was the evolution of a means of measuring the vertical angle to the target, or angle of sight, for use with AA radar equipments. The original AA gear, known as GL1, was not designed as a fire-control instrument: it supplied the range along the line of sight (slant range) and the bearing of the target, but nothing more; hence the target could not be accurately located in space, nor could its course be plotted on a map. The idea was, I suppose, that GL1 would give warning of the approach of raiders and that all the data necessary for AA engagement would subsequently be supplied by visual instruments. Unfortunately, it didn't work out quite like that. The *Luftwaffe* had a way of making use of cloud cover by day and at night the searchlights, not then controlled by "Elsie," were seldom able to find and hold their targets. The only hope of using the guns successfully lay in radar, and that could not be done unless radar was made able to measure the angle of sight.

Great Work

The problem was put up to Bedford, who produced a practical, working solution in almost incredibly short time. This was the "EF" (elevation-finding) attachment, a most ingenious and satisfactory device. The name, like so many of those given to technical equipment, was a misnomer; the idea was that such names should not give away too much. Actually EF did far more than provide a method of measuring the angle of sight, for it enabled the target to be followed continuously in both elevation and bearing as well as in range; reasonable accurate plotting on a map thus became possible. EF converted GL1 at the critical moment—towards the end of the Battle of Britain and just as the heavy night raids were starting—from a purely defensive warning instrument into a weapon of offence, by means of which raiders could be engaged in all conditions of weather and light. That was a magnificent achievement, but it was only a small part of Bedford's work.

The Mats

General Pile also mentioned the large wire-netting mats, erected from 1941 onwards round AA radar receivers, which so much puzzled many of those not in the know. Both GL1 and GL2 measure angle of sight by means of the phase relationship between the waves which reach the aerials direct and those which are reflected to them from the ground. For good results, the reflecting surface must be flat, level and homogeneous. As it happened seldom that we could site equipment on cricket grounds or polo fields, the natural surface of the soil was usually far from fulfilling these requirements. Some queer results were obtained at times before mats were devised and installed. The mats were the source of an unexpected headache for officers in charge of gun sites, owing to the way in which tall grasses, docks, nettles and so on grew up right through them. Where the mat was four feet or more above the ground these could be tidied up by crawlers armed with sickles. But often there were large areas where the clearance was a matter of only a foot or two; sometimes it was only inches. Sheep, goats, geese and rabbits were used by the ingenious, the choice of animal depending on the available headroom. Geese, as may be imagined, were popular in the later part of the year.

□ □ □

A Queer Fault

CURIOUS how some faults develop in wireless sets! Here's a rather puzzling instance that occurred to me last month. I drove to a place some nine miles from my home to pick up a receiver that I was going to try out. Arrived there, I found the set at work and giving a very good account of itself. It was switched off, disconnected and carried out to the car, on the back seat of which it was tenderly placed. The homeward drive was over an excellent road surface and there weren't any bumps, bounces or sudden stops. The set was carried into my wireless room, connected up and switched on. Not a sausage! Examination showed that there was no glow from one of the valves and the heater of this was found to be "dis." Then I spotted something else: there was a crack in the bulb of the valve, starting inside the base-cap and extending upwards for over an inch. That accounted for the burning out of the heater; but how had the glass become cracked and allowed air to enter? It must, I suppose have been due to the vibration during the journey by car; but the valve had previously made a very much longer journey by post without suffering, for it had been in use for some weeks before I took the set away. I have known bulbs crack near a metal top-cap that has been too tight a fit, but I have never before seen one that has given way like that at the bottom.

□ □ □

The New Sets

A FEW new broadcast sets are gradually making their appearance and the coming of more is announced. The majority of them don't appear to be very ambitious; not a few manufacturers, no doubt, are turning out now the models originally scheduled for the autumn of 1939. There's nothing wrong about that; in fact, it is highly desirable that they should do so if in that way they can get quickly into production. The need for new sets is now so big and so urgent that it is of real importance to get good, sound apparatus on to the market as quickly as possible and it doesn't matter enormously if much of it is small, simple and devoid of frills. But there is also a demand for really high-grade sets, containing every modern improvement. That demand, I believe, is likely to grow rather than to decrease, and I earnestly hope that it will be met adequately. Of one thing I'm sure and that is that manufacturers need have little fear that higher-priced sets will not sell. I've seen staggering prices fetched recently at auction sales by good-quality pre-war sets. There is plenty of money knocking about, for John Citizen and Jane his wife have had little chance of spending much in the last six years. They have done their bit in the savings campaigns, but they still have something in the stocking that they'd like to splash. They feel that now the old set is on its very last legs it would be pleasant to replace it with something really good.

□ □ □

On the Short Waves Now

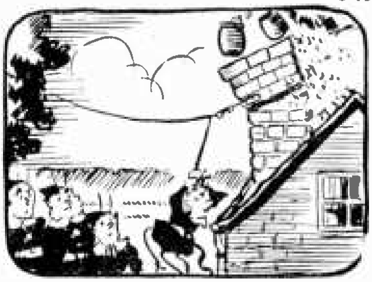
THERE are many interesting transmissions from far-away places to be picked up on the short waves just now with any reasonably efficient receiver. Exploring them is in fact something like the adventure that it was in days long ago, for now that we have no published lists of short-wave stations and the frequencies that they use you never know what you are going to find when you try round. In the 10-megacycle band the All-India Radio station at Delhi has been coming in very strongly and with little fading or distortion during the afternoons, and a few days before this was written I picked up in the same neighbourhood a good signal from the Allied Military Government Station in Burma. A Chinese station has been heard more than once, though I have not so far discovered its location. Melbourne has been very good once or twice. I have not yet heard any of the Dutch East Indies stations; it is quite likely that they were badly knocked about and have not yet got going again. Several U.S.A. stations are to be heard on various bands at different times of the day and night and once or twice I have had strong reception from South America. One morning recently I stumbled by accident on quite a strong transmission of music at a frequency a little under 30 megacycles. I have no idea what it was, for though I waited for some time no call sign came. Nor have I been able to find it since. I don't remember ever hearing a broadcast transmission on such a frequency before.

□ □ □

A New Tool

WHAT I believe to be something new in small tools has come my way lately. Some reader is sure to write to tell me that it's as old as the hills, but I certainly haven't seen it in the tool-shops until a month or two ago—I only wish I had! The thing is known as a tension file. It consists of a file of circular section, about ⅛ inch in diameter and with a "blob" at either end. By means of the blobs it is held fast in two special clips, which can be slipped on to the studs of an ordinary hacksaw frame. You then tighten it up just like a hacksaw blade and there you are. So far I have acquired tension files of fine and medium cut, but I believe that other kinds are to be obtained. You will see at once what a useful tool it is. For one thing it makes a kind of metal fretsaw which, unlike the hacksaw, will go round corners and cut pieces of any shape from sheet metal.

"But I want one with radar, so I can keep track of my husband!"
Courtesy "Broadcasting," Washington, D.C.



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With FLUXITE, now just you watch me,
Pull as hard as you may,
It won't come away......"
"But here comes the chimney" yelled EE.

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RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

PERMEABILITY TUNING

THE axial length of the tuning coil in a typical broadcast receiver is about an inch and a half, so that the maximum useful movement of the sliding core is limited to the same distance. Some form of step-up gear is therefore required between the tuning control knob and the station indicator in order to allow the various markings on the scale to be clearly spaced apart. Such gearing adds to the cost of the set, and is a common source of back-lash and similar troubles.

According to the invention, the tuning core is tapered or stepped, or is otherwise magnetically graded, so that its overall length can be made at least twice that of the coil. The increased tuning "stroke" thus made available is sufficient to cover the whole of the indicator scale without the use of any form of intermediate gearing.

Marconi's Wireless Telegraph Co., Ltd. (assignees of W. L. Carlson) Convention date (U.S.A.) Sept. 30th, 1942. No. 568436.

VALVE EMISSION INDICATOR

A SMALL aperture is made in the anode of a valve, or in both the anodes of a double-diode rectifier, and is covered with fluorescent material, so as to give a visual indication of the flow of the discharge stream from the cathode. A clear spot or "window" is made to allow the fluorescent glow to be seen through the metallised bulb of a screen-grid or similar type of discharge tube.

T. Williams. Application date Nov. 22nd, 1943. No. 568494.

CATHODES

THE emission from a cathode of pure metal such as tungsten and tantalum is not seriously affected by the presence of residual gas, or by the products of "gettering," but the cathode must be operated at a high temperature. On the other hand, low-temperature emitters, whether of the oxide-coated or thoriated-tungsten type, are peculiarly sensitive to "emission poisoning" and certain other forms of deterioration in an imperfect vacuum.

According to the invention, a thin layer consisting of a mixture of powdered metallic tungsten and thorium oxide is sintered on to a core of molybdenum or tantalum. Or the powdered tungsten may first be sintered on to the wire core, and then coated with thorium-oxide particles, the two being welded together by heating. The resulting cathode will give the same emission when operated at 2,000 deg. K. as pure tungsten at 2,900 deg. K. and is comparatively insensitive to contamination.

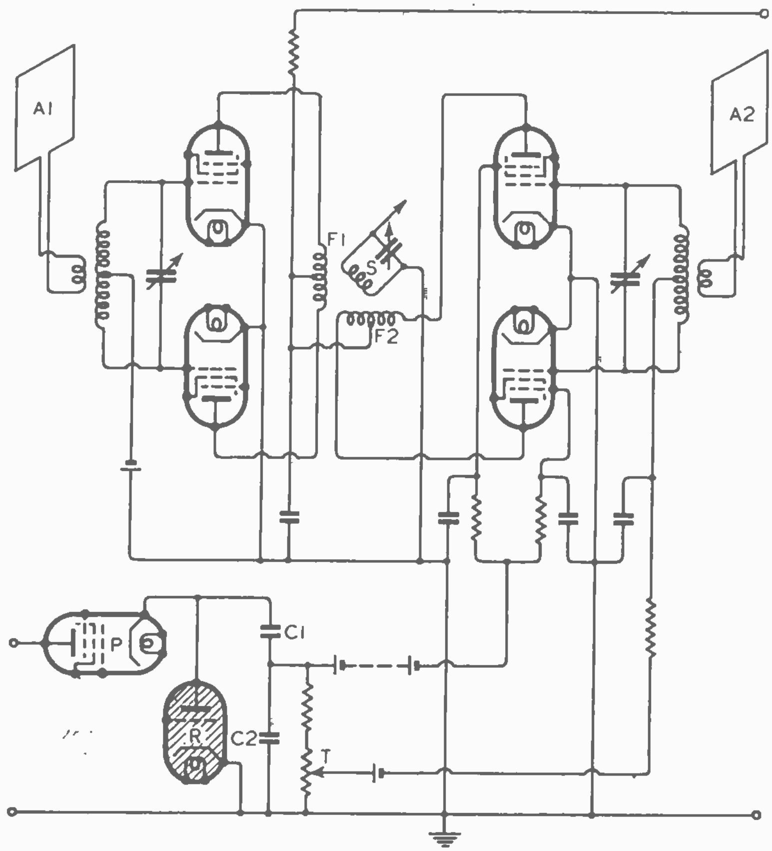
Marconi's Wireless Telegraph Co., Ltd. (assignees of L. P. Garner). Convention date (U.S.A.) Oct. 6th, 1942. No. 568962.

DF SYSTEMS

TWO spaced aerials A1, A2 are coupled through tuned input circuits to push-pull amplifiers feeding the fixed coils F1, F2 of a radiogoniometer. To take a bearing in the ordinary way, the incoming signal is reduced to zero by adjusting the phasing condensers of the input circuits and rotating the tuned search coil S to the null position.

According to the invention, these manual adjustments are simplified by passing the output from the search coil through a standard receiver (not shown) to one pair of the deflecting plates of a CR indicator tube (also not shown). The other pair of deflecting plates of the tube are supplied with a circular time-base voltage from two condensers C1, C2, which are charged through a constant-current valve P and discharged through a gas-filled relay R. A part of the time-base voltage is also fed through a tapping T to the control grids of one of the push-pull amplifiers, say the one coupled to the aerial A2; this imparts a cyclic variation to the gain of that amplifier, so that the signals from the two aerials must appear equal at least once in each cycle.

The signal from each aerial produces a radial deflection on the indicator, the two combining to form a "vee," when the phasing condensers are correctly set. The apex of the "vee" marks the moment of zero signal, but its actual position on the dial has no significance beyond indicating the times at which the most reliable bearings are likely to be obtained. The installation is particularly useful for analysing scattered waves, where the direction of arrival is liable to sudden changes.



Circuit for cathode-ray DF display.

Marconi's Wireless Telegraph Co., Ltd.; F. T. Farmer, and L. W. Whitaker. Application date June 12th, 1940. No. 568119.

TELEVISION

PICTURE-SIGNALS generated on a photosensitive screen of the mosaic type are liable, in reception, to show random "dark spots" which are usually preceded and followed, in the scanning direction by white "streaks." This is attributed, at least in part, to the effects of secondary electrons which are released from the mosaic screen, during scanning, and fall upon the mica rim surrounding it. Here they set up a negative charge, the field from which adversely affects the sensitivity of the screen.

According to the invention, the mica rim (which lies outside the sweep of the scanning beam) is coated with photosensitive material, and is illuminated, from the rear, by an auxiliary lamp, so that any negative charge is relieved by the release of photo-electrons. On the other hand, any tendency to develop a positive charge is offset by projecting a regulated amount of light from the auxiliary lamp on to a nearby coating of photosensitive material, on the inner surface of the tube. This releases a sufficient supply of fresh electrons to maintain the mica rim at the same "average" potential as the mosaic screen. At the same time, the arrangement allows a certain desirable "local" difference of potential to exist between the two edges of the rim which coincide with the start and finish of each scanning sweep.

Marconi's Wireless Telegraph Co., Ltd. (assignees of O. H. Schade). Convention date (U.S.A.) Aug. 21st, 1942. No. 569436.

TRANSMISSION LINES

THE ordinary two-wire type of line has a higher radiation-resistance for very short wavelengths, and a larger surge impedance, than that of a coaxial cable, but owing to their geometry the two conductors of the latter cannot be effectively balanced to earth.

By using two parallel copper strips, instead of wires, the surge impedance of the resulting line can be made as low as that of a concentric cable, whilst both conductors are still easily balanced to earth. In addition, the radiation and ohmic resistances are considerably reduced. For a frequency of say 600 Mc/s, two copper half-wave strips, each one and a half inches wide and one-eighth of an inch thick, are set one-eighth of an inch apart. The strips can be short-circuited at selected points by large-capacity condenser bridges, which have negligible impedance, and are easily and cheaply made.

Ferranti Ltd.; R. G. B. Gwyer; and J. G. Heaps. Application date May 3rd, 1940. No. 568378.

SUPERHET RECEIVERS

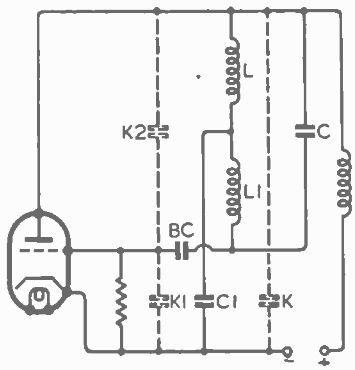
MOST of the "noise" produced in the mixing valve is stated to be due to transient currents produced by the random distribution of electrons which occurs when the main discharge stream is partitioned between the two output electrodes, usually the screen and the anode. According to the invention, the discharge stream is swung sharply from one output electrode to the other, *i.e.* in a small fraction of the operating cycle, so that the intervening period of partition noise is reduced.

The mixer valve is preferably of the beam type, in which the electron stream passes from the signal-input grid through focusing and accelerating electrodes, and between a pair of deflecting plates to two pairs of output electrodes which are separated by a gap. Local oscillations, generated across one pair of output electrodes, are applied in push-pull to the deflecting plates, which thus sweep the electron stream swiftly across the gap separating the oscillator electrodes from the other or main pair of anodes. The latter are connected in push-pull to a tuned circuit which is coupled to the first IF stage.

A. C. Cossor Ltd., and D. A. Bell. Application date Oct. 11th, 1943. No. 568684.

TRIODE OSCILLATORS

THE object is to overcome the limiting effect of the interelectrode capacities, so as to allow a three-electrode valve to be used for generating ultra-high frequencies. Two positive reactances L, L1 are connected in series across the anode and grid; both are bridged by a negative reactance C, and their common point is connected to the cathode by another negative reactance C1. In practice L and L1 may be simple leads or suitable lengths of coaxial line.



VHF oscillator circuit.

The circuit is distinguished from the well-known Colpitts' oscillator by the presence of the reactance C1, which provides sufficient feedback to maintain self-oscillation in spite of the various electrode capacities. These are indicated in dotted lines at K, K1, and K2. Ignoring the effect of the blocking condenser BC at very high frequencies, it will be seen that K and K1 are in parallel with the reactance C1 but shunt the outside ends of the reactances L L1 to the cathode, whilst K2 is in parallel with the reactance C.

Standard Telephones and Cables Ltd. (assignees of M. Dishal; W. Hotine and J. S. Le Grand). Convention date (U.S.A.) Nov. 30th, 1942. No. 569517.

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.

VORTEXION

"SUPER FIFTY WATT" AMPLIFIER

30 cps. to 15,000 cps. within ½ db. under 2 per cent. distortion at 40 watts and 1 per cent. at 15 watts.

Electronic mixing for microphone and gramophone of either high or low impedance with top and bass controls. Output for 15/250 ohms with generous voice coil feedback to minimise speaker distortion. New style easy access steel case gives recessed controls, making transport safe and easy. Exceedingly well ventilated for long life.

Amplifier complete in steel case as illustrated with built-in 15 ohm mu-metal shielded microphone transformer tropical finish. - - - Price 29½ gns.

Chassis only with valves - - 25½ gns.

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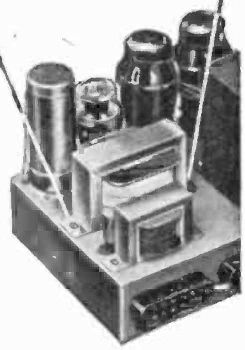

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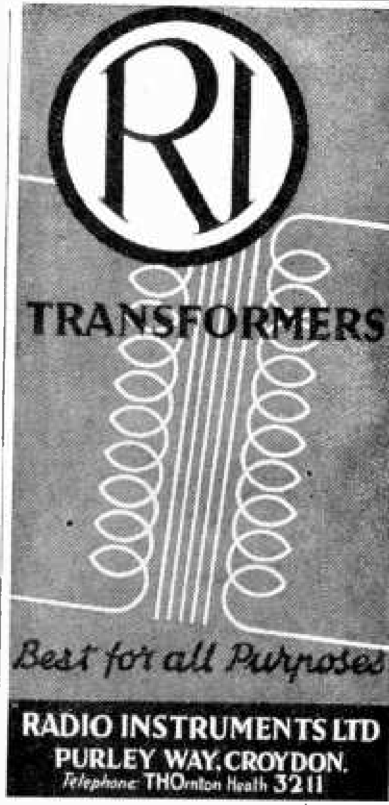

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ENAMELLED copper wire, 10 tons, slight salvage, for sale to bulk purchasers.—Apply H. Leston, Ltd. (Government contractors), 5, Charles Lane, London, N.W.8. [4175

ELECTROLYTICS, 8mfd 500v, 3/6; 8mfd 350v, 2/3; 50mfd 12v, 1/11; Grampian moving coil microphones, £3/18/6; matching transformer, 15/-; 8in pm speakers, 20/3.—O. White, 17, Upland Rd., London, S.E.22.

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CHOKES 8H. 300 ohms, 40 m/a., 4/6; 30H. 400 ohms, 60 m/a., 9/6; 30H, 100 m/a., 400 ohms, 15/-; 30H, 185 ohms 150 m/a., 25/-. 25H, 250 m/a., 120 ohms, 39/6.

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IN stock photo-cells, optical systems, S.O.F. amplifiers and all components and parts for making your own sound-on-film projector; latest list 4d.—Southern Film Services, Ltd., 5, Mackenzie St., Slough, Bucks. [4205

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COTTON-COVERED copper instrument wire, ¼lb reels, 18, 20, 22, 24 gauges, 1/6; 26, 28 gauges, 1/9; 30, 32g, 2/-; 34g, 2/3; enamelled ditto, same prices; silk-covered ditto, 2oz reels, 24, 26, 28g, 1/6; 30, 32, 34, 36g, 1/9; 42g, 2/-; 16g double silk, 1lb, 5/-; B.A. thread screws, 1 gross useful sizes, 2/6; ditto, nuts, 2/6 gross; assorted gross screws and nuts, 2/6; ditto, brass washers, 1/6 gross; fibre washers, 1/6 gr; assorted solder tags, 2/- gr; assorted small eyelets and rivets, 1/3 gr; rubber-covered stranded copper wire, 1d. yard; heavier quality, 1½d. yd; very heavy quality, 2½d. yd; tinned copper connecting wire, 20ft coil, 6d.; ditto, rubber covered, 10ft 6d.; finest quality push-back wire, 12 yards, 2/3; postage extra.—Post Radio Supplies, 33, Bourne Gardens, London, E.4. [4199

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THE Simplex Four, complete constructional details of this most successful midget ac-dc receiver (total cost of construction £9), including theoretical and full-scale layout, wiring diagrams, with instructions, per copy, 4/6; midget cabinets, handsome design, in red or brown, 25/-; midget high gain m. wave, t.r.f. coils, 7/6 pair; midget m. and l. wave, t.r.f. iron cored coils, adjustable cores, 12/6 pair; with circuit, aerial and oscillator coils, all-wave, s.m.l. wave, for use with i.f. 465kc/s, with circuit, 15/- pair; midget i.f. transformers, 465kc/s, 15/- pair; standard size ditto transformers, 12/6 pair; midget 2-gang 0.0005mfd variable condenser, with trimmers, 13/6. We may have it, the chances are we have, consult monthly comprehensive lists, 2½d. stamp with enq.; postage all orders.—O. Greenlick, 34, Bancroft Rd., Cambridge Heath Rd., London, E.1. Ste. 1334.

COULPHONE RADIO, Station Rd., New Longton, nr. Preston.—New goods only of the highest quality; all orders attended to same day as received; note price reductions on many lines, and remember that all orders over 5/- are post free; goods now sent c.o.d.; electrolytics, 8×450v 5/6, 8×8 450 8/6, 2×350 3/6, 25×25 and 50×12 2/6, 25×50 3/-, 50×50 3/3; Rola, Plessey, Goodmans and Celestion speakers, p.m., less transf., 3½in 27/6, 5in 19/6, 6½in 20/-, 8in 21/-, 10in 30/-; with transf., 6½in 24/-, 8in 25/-, 10in 42/6; Vitavox super quality, 12in p.m. K12/10, £7; Rothermel Senior de luxe crystal pick-ups, £3/18/9; mains transformers, screened primary, 200-250v, 350-0-350, 100ma, with 4v or 6v l.t.s, 24/-, bobbins only, 15/6; 420-0-425, 200ma, 4v 8a, 4v 4a, 4v 4a or 6.3v 4a, 6.3v 4a, 5v 3a, 47/6; 20hy 200ma chokes, heavy duty, 21/-; speaker transformers, push pull universal types, 4watt 7/6, 8w 12/6, 15w 21/-, 30w 37/6; Midget pen, 5/-; dropper resistors, 800Ω 0.3a, with feet and two sliders, 4/6; push-back wire (Henleys), 50ft 2/9, 100ft 4/9; Delaflex 2mm sleeving, 2/- dozen; valve-holders, 5-, 7-, 9-pin English, Mazda octal 4-, 5-, 6-, 7-pin UX and Int. octal, all types 6d. each; resin cored solder, 4/- lb.; 3-way cable, 6d. yd, 5-way 10d.; s.a.e. for comprehensive list.

Above space is dedicated to our Advertising Manager's lack of imagination this month—besides he was so busy helping with the numerous orders, being the result of last month's advertisement.

10,000 Popular and Rare Radio VALVES, exact type or suitable Replacement, otherwise valve and adaptor. ACHLDD, ACP, AC2HL, ACpen, AC2pen, AC5pen, AC5penDD, AC6GVM, ACTP, ACVP1, ACVP2, ACO44, AZ1, AZ31, CCH35, CY1, CY1C, CY31, D63, DA30, DD207, DDT, DH63, DH73M, DL, DL63, DO24, DW2, DW4/350, DW4/500, EB34, EBC3, EBC, EBL1, EBL31, ECC31, ECH3, ECH35, ECR30, EF5, EF6, EF8, EF9, EF39, EL2, EL3, EL32, EL33, EL35, FC4, FC13, FC13C, H141D, HD24, HL2, HL130, HL21DD, HL23, HL23DD, HL41DD, HL133DD, HL1320, HL1320DD, IW4/350, KT2, KT24, KT61, KT63, KT66, KTW61, KTW63, KTZ41, KTZ63, L2, MH4, MHD4, MHL4, ML4, MS4B, MSP4, MSpen, MSpenB, MU14, OM4, P2, PA20, PM2A, PM2B, PM2HL, PM22A, PM22D, PM24A, PM24M, PM256, PP3521, PT41, PX4, PX25, Pen4DD, Pen4VA, Pen25, Pen45, Pen45DD, Pen46, Pen428, PenA4, PenB4, PenDD4020, QP22B, QP25, QP230, S4VB, S215VM, SP2, SP4, SP4B, SP1304, SP41, SP42, SP2220, TDD2A, TDD4, TDD130, TH2, TH4B, TH210, TH300, TH41, TH433, TH2321, TP25, TP26, TSP4, U5, U10, U14, U16, U18, U21, U31, U50, U52, U4020, UR1C, UR30, UU5, UU6, UU7, UY31, V914, VHT4, VMP4G, VMS4B, VP2, VP2B, VP4, VP4A, VP13A, VP130, VP23, VP41, VP133, VP1322, VS2, W21, X8G, XH, XD, XP, XL, XLO, X24, X41, X61M, X63, X65, Y63, Z22.—01A, 1A4, 1A5, 1A6, 1B4, 1B5, 1C5, 1C6, 1C7, 1D5, 1D6, 1D7, 1E5, 1E7, 1F4, 1F5, 1F6, 1F7, 1G4, 1G5, 1G6, 1H4, 1H5, 1H6, 1J5, 1J6, 1LA4, 1Q5, 1P5, 1T5, 2A7, 2B7, 2D4A, 2D130, 2P, 3Q5, 5U4, 5V4, 5Y3, 5Z3, 5Z4, 6A4, 6A7, 6A8, 6AB7, 6B5, 6B7, 6B8, 6C5, 6C6, 6C8, 6D5, 6D6, 6F6, 6F8, 6H6, 6J5, 6J7, 6J8, 6K6, 6K7, 6K8, 6L5, 6L6, 6L7, 6N6, 6N7, 6P5, 6Q7, 6R7, 6SF7, 6SK7, 6T7, 6U7, 6V6, 6X5, 7A7, 7A8, 7B5, 7B6, 7B7, 7B8, 7C5, 7C6, 7D3, 7D5, 8D2, 10, 10D1, 11D5, 12A, 12A5, 12E5, 12J5, 12Q7, 12SJ7, 12SK7, 12SL7, 12SQ7, 12Z3, 13SPA, 14, 15, 18, 19, 20, 20D2, 22, 24, 25A6, 25L6, 25Y5, 25Z4, 25Z5, 25Z6, 26, 27, 29, 31, 32, 35, 35L6, 35Z4, 35Z5, 36, 37, 38, 39/44, 40, 41MTL, 41STH, 42, 42MPpen, 43, 45, 46, 47, 48, 50, 50L6, 53, 55, 57, 59, 71A, 74, 75, 76, 79, 80, 81, 82, 83, 85, 89, 99, 164v, 210DDT, 210VPA, 220B, 220TH, 354v, 954, 955, 956, 1821, 1853.

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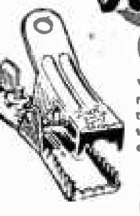

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ERIE ½watt resistances, 330, 450, 10,000, 22,000, 33,000, 220,000, 470,000, 2meg, insulated type except 33,000, 3/9 per dozen; Erie 2watt resistances, 680, 6,800, 140,000, 150,000, 220,000, 470,000, 820,000, 2 for 1/-, 5/- per dozen; Morganite resistances, carbon, 500, 1,000, 50,000, 2meg, 3/6 dozen; Erie 680, 3watt, 1/3 each; T.C.C. mica condensers, 0.0001×0.0001, bakelite cased, five (ten condensers) for 1/3, or 12/6 per 100; valve holders, chassis types, British 5 and 7-pin, American UX, 4, 5, 6-pin and international Octal, all 4/- dozen or 29/- 100; set 5 Cyldon ceramic trimmers, 30mm, on metal base, 1/6 each, per dozen 12/-.

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LATEST model broadcast pm loudspeakers standard model, 12in, 15watt, £7/10; Hi-Fi model, 12in, 15watt, £8/15; 15in and 18in models to follow shortly; Ticonal magnets, detachable diaphragms, die-cast chassis; early deliveries; spec upon request.—Broadcast and Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich 26970. [4027

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GOODMAN 12in P.M. high-fidelity twin cone "Auditorium," no trans; offers.—Telling, "Tolverne," Felstead Rd., Orpington, Kent. [4279

HARTLEY TURNER Standard 2,500Ω, £5, Hartley Turner 18in box baffle, £2/5; Tobie Ham Band Super and speaker, offers.—Box 3780. [4190

B.T.H. R.K. speaker, 230v field, £4; rectifier for same, £3; Sifam Multimeter, 7.5v to 300v, 3m.a. to 7.5a, £5.—Gibbs, 106, Boscombe Rd., Southend-on-Sea. [4209

SPEAKERS, 10in, R.K., 1,000 ohms field, 15 ohms speech coils, as new, £5; Bakers' 12in p.m., £3/10; AF5, £1.—Cook, 104, Raglan Av., Waltham Cross, Herts. [4167

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PA. 1, 2/6	PHF. 1, 2/3	PO. 1, 2/3
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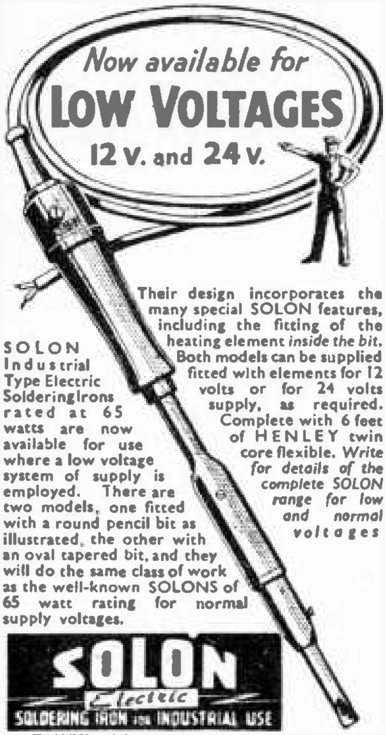

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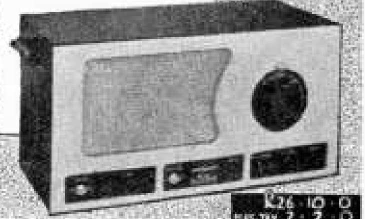

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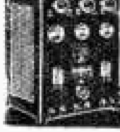

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REWINDS, mains transformers, field coils, chokes, high-grade workmanship, 7-day delivery; new transformers constructed to customers' specification, singly or in quantities.—Metropolitan Radio Service Co., 1021, Finchley Rd., N.W.11. Speedwell 3000. [3719

24-HOUR service.—6 months' guarantee, any transformer rewind, mains, outputs and i.f.s, etc.; all types of new equipment supplied to specification; business heading or service card for trade prices.—Majestic Winding Co., 180, Windham Rd., Bournemouth. [3592

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WANTED, EXCHANGE, ETC.

WANTED, No. 47 American 5-pin valve.—Box 3869. [4231

WTD., Wheatstone tape transmitter & hand perforator.—79, Allesley Old Rd., Coventry.

WTD., new Mullard DK1, DF1, DAC1, DL2 valves; also 6v car radio.—Box 3877.

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WTD., Goodman's infinite baffle speaker, auto-changer, good condition.—Particulars to Box 3946. [4277

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WANTED, "W.W.," Sept., '45, good condition.—G. Mobbs, 20, Perrymead St., Fulham, S.W.6. [4244

WTD, communication receiver, R.M.E., H.R.O. or Hallicrafter; must be in good condition.—Box 3787. [4204

COMMUNICATION type receiver wanted; good price paid for first-class make.—204, Nell Gwynn House, Sloane Ave., S.W.3.

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WANTED, one each following numbers "Wireless Engineer," in good condition: January, 1942; April and May, 1943; July, 1945.—Offers to Box 3944. [4274

WTD., battery receivers, any condition, covering at least 100 to 200 metres; also rotary convertors or motor generators, input 12-24v dc, output from 300v 70ma to 500v 170 ma dc.—Matheson, Fishmarket, Aberdeen.

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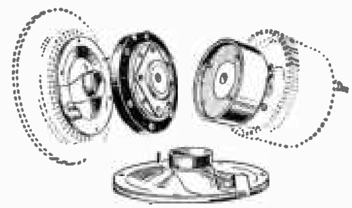

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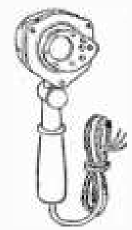

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None of the vacancies in these columns relates to a man between the ages of 18 and 50 inclusive or a woman between the ages of 18 and 40 inclusive unless he or she is excepted from the provisions of the Control of Engagement Order, 1945, or the vacancy is for employment excepted from the provisions of that Order.

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RADIO designer-engineer wanted by firm about to manufacture luxury radiogram for export; only first-class men with modern ideas and suitable for good salaried position.—Write Box 3788. [4207

RADIO testers conversant with superhetrodyne receivers and audio amplifiers.—Apply personally to the British Capehart Corporation, Ackmar Works, Ackmar Rd., Parsons Green, S.W.6. [4238

WANTED, energetic young man with knowledge of wireless relay service (maintenance, etc.) to take charge; good prospects and permanency for right man.—State experience to Whitworth, 9, Southgate, Elland. [4178

NATIONALLY known radio manufacturer has vacancy for chief buyer; must have previous experience in this capacity; only men of proved capabilities considered; own employees have been informed.—Box 3785.

NATIONALLY known radio manufacturer has vacancy for chief engineer designer; must have commercial experience and be capable of original thought; only men of proved capabilities considered; own employees have been informed.—Box 3598. [4173

PRODUCTION manager required by North Country radio and component manufacturers, modern factory, expanding business; previous experience similar post and sound technical qualifications essential; fine prospects first-class man; commencing salary £600-£700.—Box 3943. [4273

AMPLIVOX, Ltd., thank all those who replied to their advertisement for a service manager for valve deaf aids under Box No. 1130; so many letters were received that it has not been possible to reply personally; a suitable man has been chosen, and we hope that the unsuccessful applicants will soon be happily settled elsewhere. [4176

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WANTED, radio engineer with thorough production experience plus knowledge of design and current practice; able to handle staff and capable of supervising the production of high-grade radio and amplifiers.—Reply, by letter only, stating age, salary required, etc., to Managing Director, Sound Sales, Ltd., West St., Farnham, Surrey. [4194

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ARTIST-DESIGNER, specialised in modern cabinet design, seeks contact with radio manufacturer.—Write Box 1135. [3972

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RADIO and acoustic engineer, good education, seeks responsible post on technical staff, or take charge and develop new dept.—Box 3933. [4252

RADIO service engineer, 15 years' experience, 4 years' senior N.C.O. in R.E.M.E., demobilised November, seeks position as service manager or any position with good prospects.—Box 3876. [4243

SQUADRON Leader, R.A.F. Regular, technical signals branch, age 36, requires position, administrative and executive experience, and staff control; release expected January, 1946.—Box 3871. [4236

TECHNICAL representative, 31, experienced in communications, V.H.F., television development, Government technical officer, wide connections with industry, good appearance, personality.—Box 3868. [4224

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ADVERTISER, just released Forces, 10 years sales and service manager radio and electrical trade, 5 years radar engineer R.A.F., seeks position as representative or radio sales and service manager; South-West England area.—Box 3935. [4256

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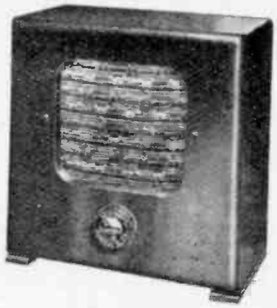

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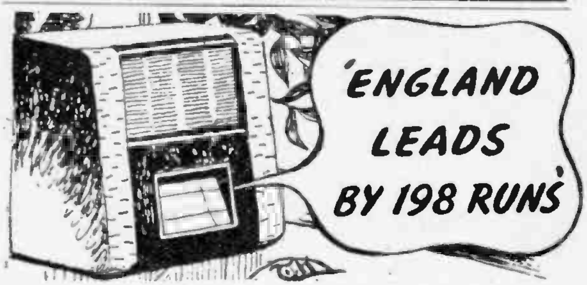

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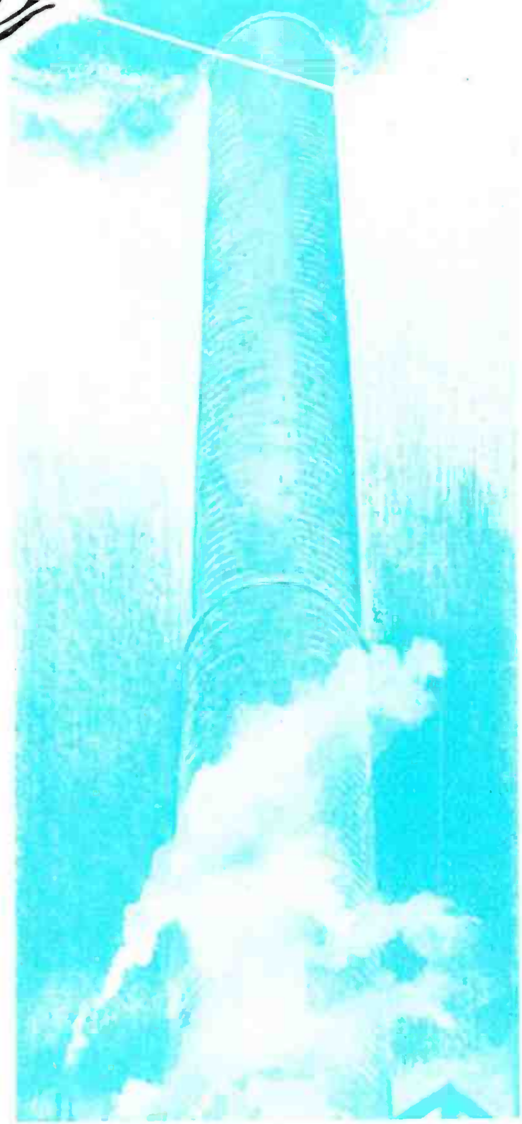

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