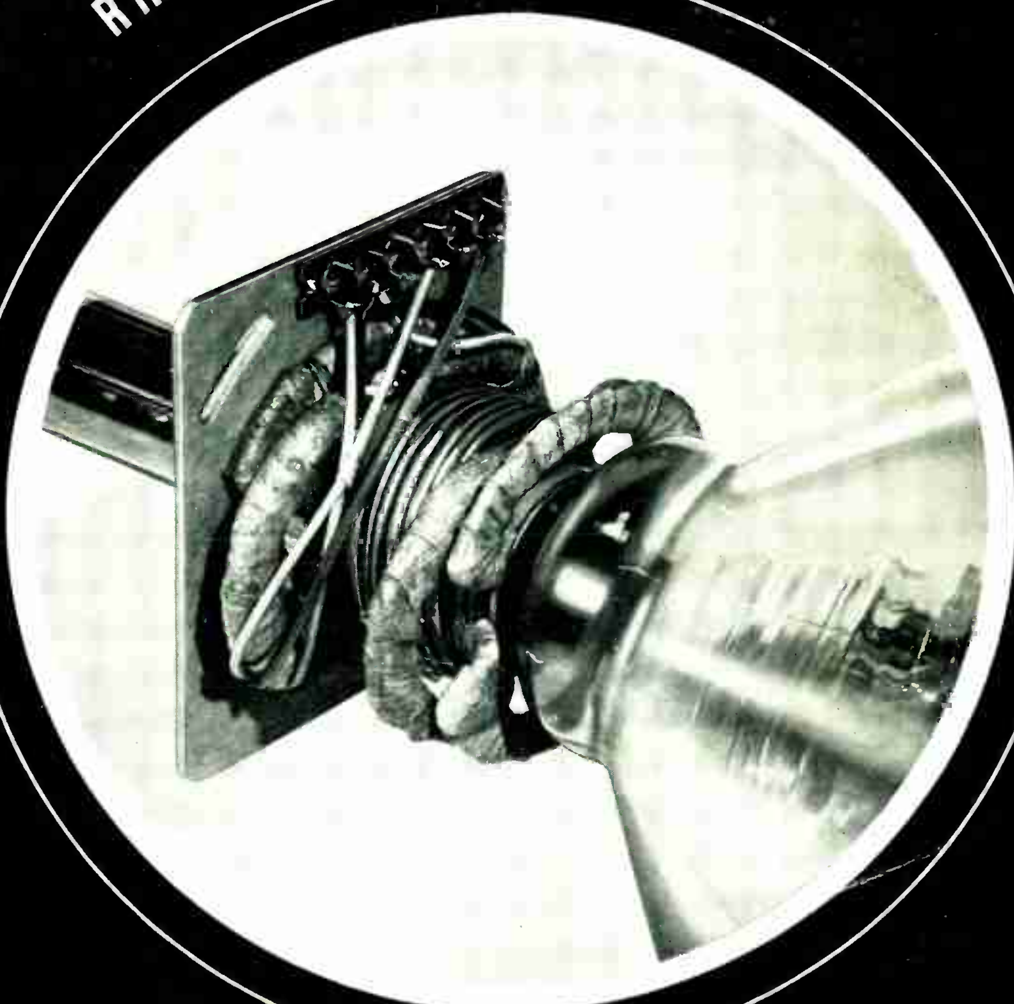
Wireless World

RADIO AND ELECTRONICS



FEB. 1947

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Vol. LIII. No. 2

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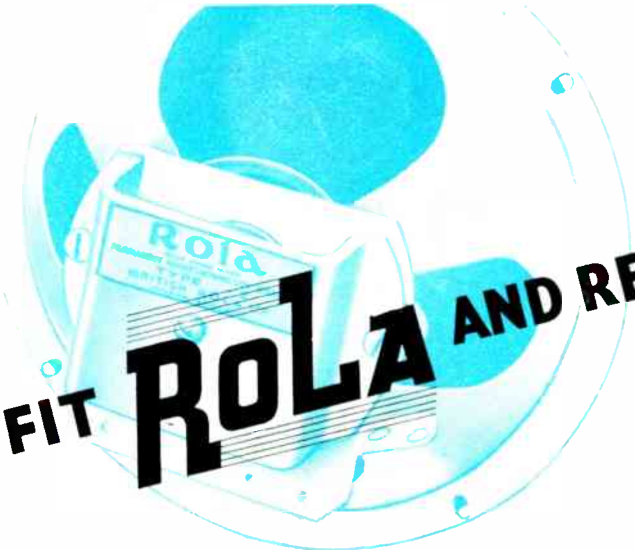

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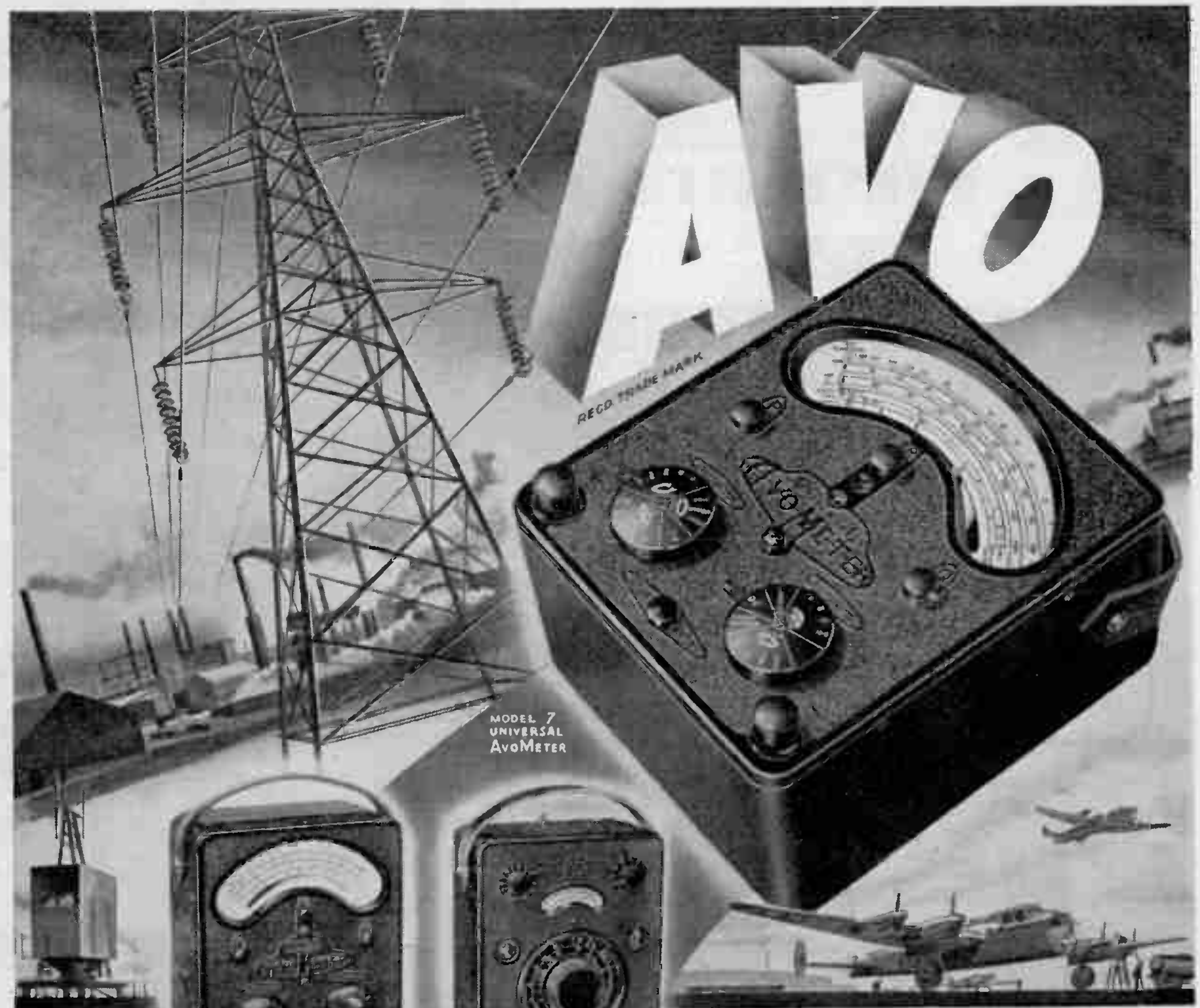

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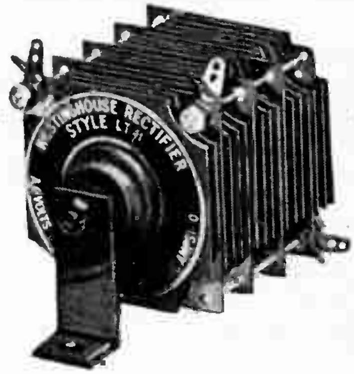

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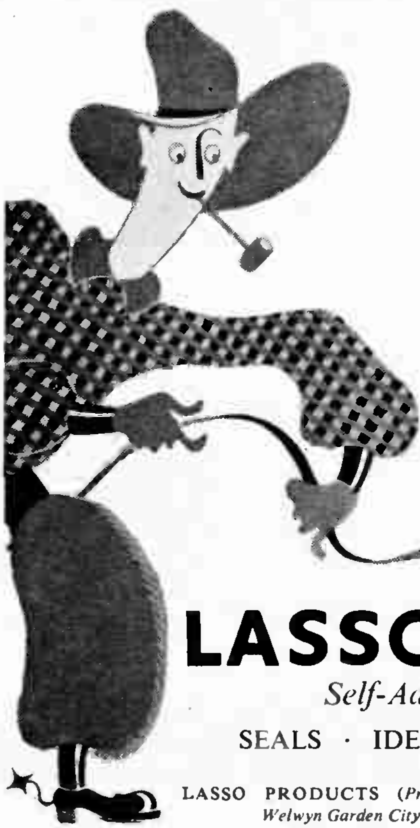

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These resistors comprise a ceramic former on which a winding of high grade alloy resistance wire is firmly held in position by a coating of durable vitreous enamel. The units are impervious to moisture, and type approval has been given for their use in the most severe tropical conditions.

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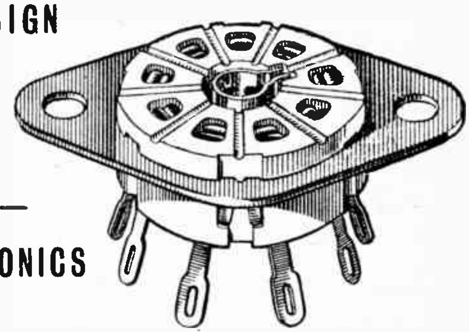

CLIX B9G valveholder for use with EF50, etc.
Cat. No. VH359/9, Polystyrene Body.
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. . . ARE USED BY ALL THE LEADING SET MANUFACTURERS

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2½"	P2V	3.0	7/16"	8,500	8,000	25W
3½"	P3C	3.0	¾"	7,700	24,000	1W
5" 5"	P5Q P5T	3.0 3.0	¾"	8,500 10,500	26,000 32,000	3W 3W
6½" 6½"	P6Q P6T	3.0 3.0	¾"	8,500 10,500	26,000 32,000	4W 4W
8" 8" 8"	P8D P8M P8G	2.3 2.3 2.3	1"	6,200 8,000 10,000	24,000 31,000 39,000	5W 5W 6W
10" 10"	P10M P10G	2.3 2.3	1"	8,000 10,000	31,000 39,000	6W 8W
12"	P64	12.0	1¾"	12,500	140,000	15W
18"	P84	10.0	2½"	13,500	350,000	40W

From the range of Celestion Loudspeakers most manufacturers are able to meet their requirements. The smallest model, a midget weighing 3½ oz. is intended for small personal radios and the largest, capable of handling 40 watts, for public address purposes. Between these extremes, the range is balanced and well considered.

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6.	30— 60 ,,	50 pf	
7.	50— 90 ,,	50 pf	
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Each range available in 4 types :

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Specify range and colour code when ordering Denco.

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435 PF ...	10 per cent.	800 PF ...	1 per cent.
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100 ohms ...	1 per cent.	100,000 ohms...	5 per cent.
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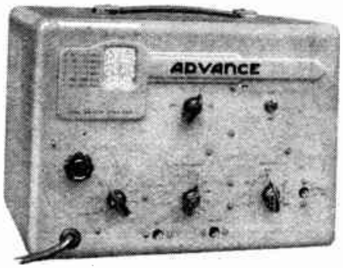

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Scientific G12

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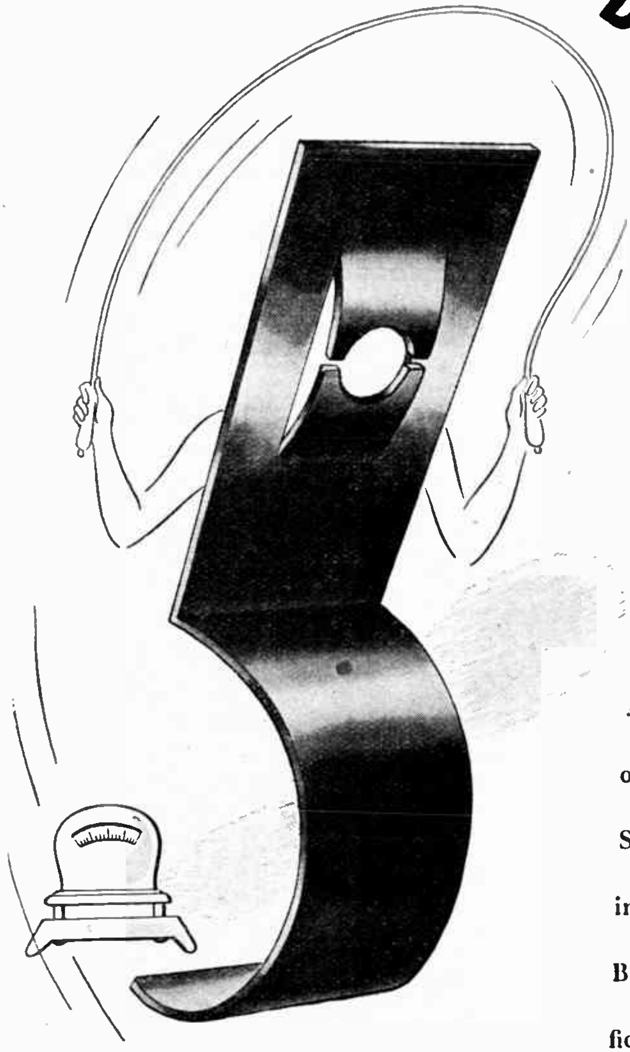

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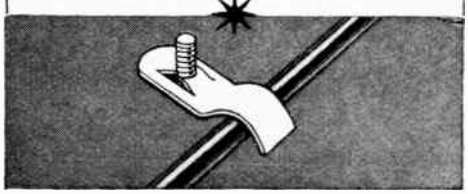

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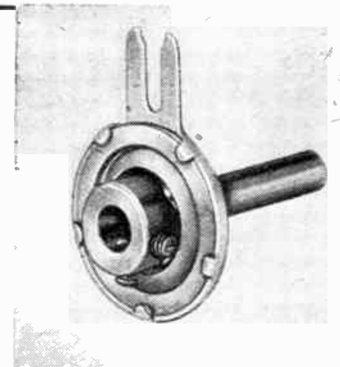

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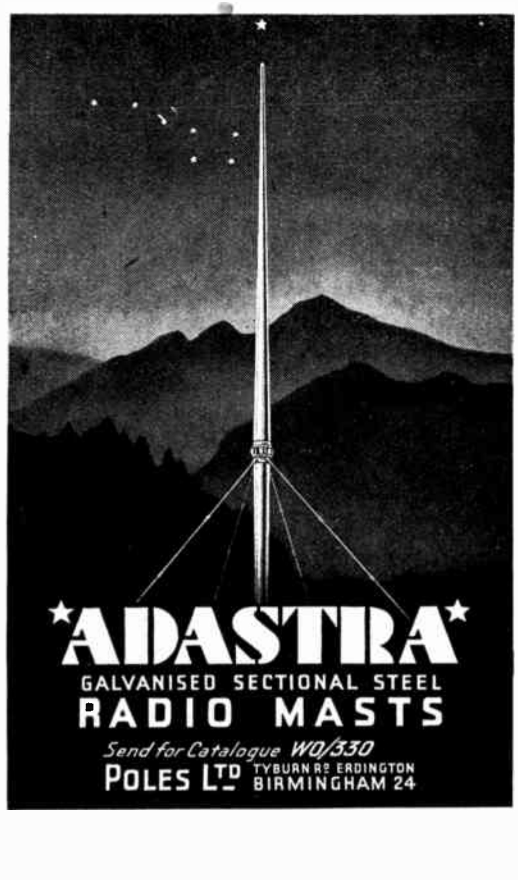

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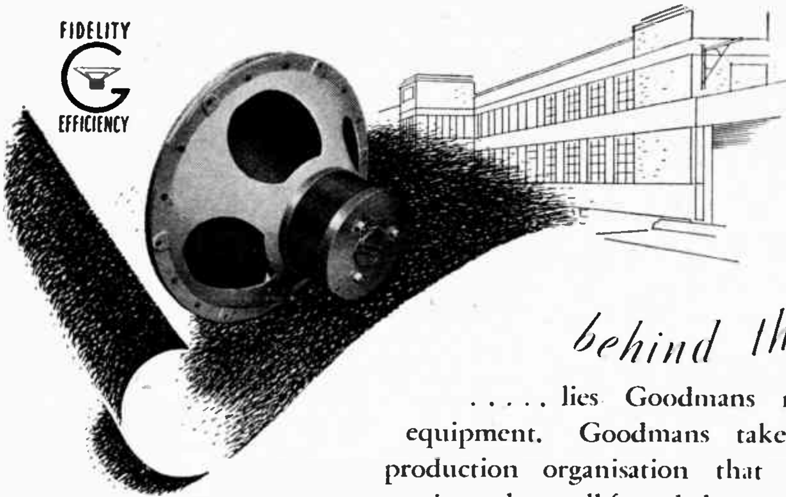

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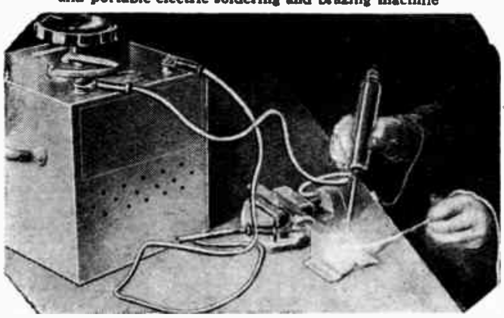

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- **EXCEPTIONALLY HIGH IMAGE RATIO**
- **ADAPTOR TO ALLOW FOR LOW VOLTAGE OPERATION**

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STRATTON & Co., LTD

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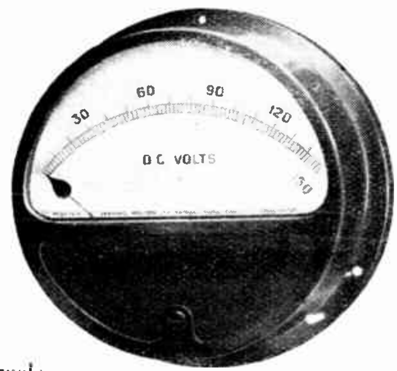
NEW WESTON DEVELOPMENTS



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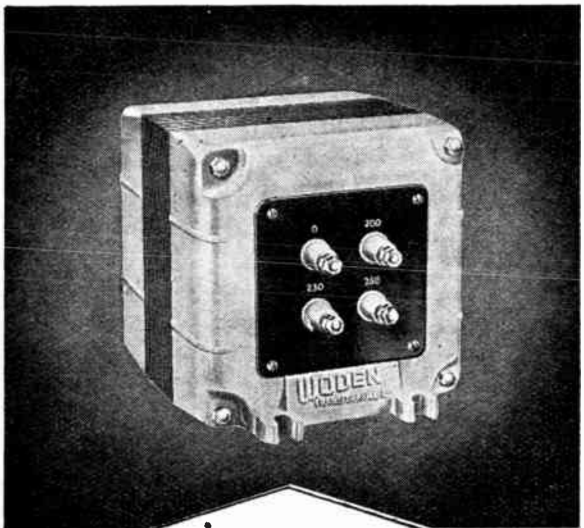

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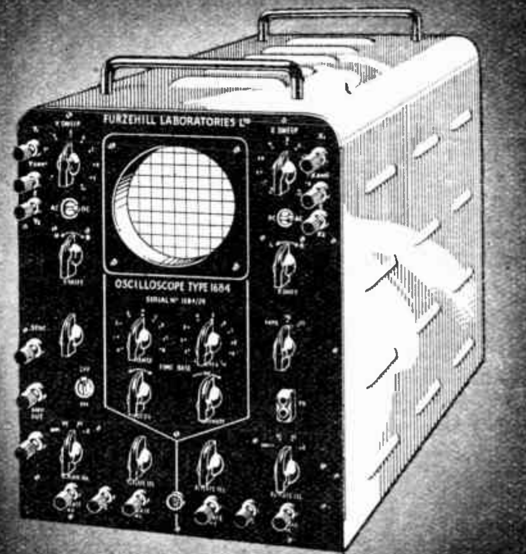

TYPE 1684B

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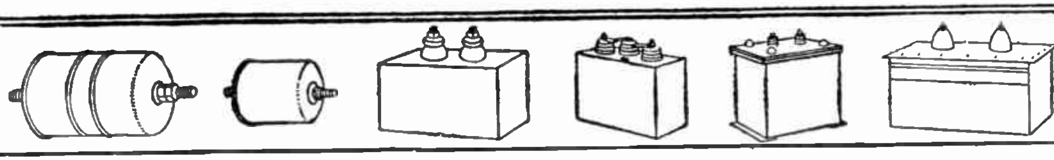

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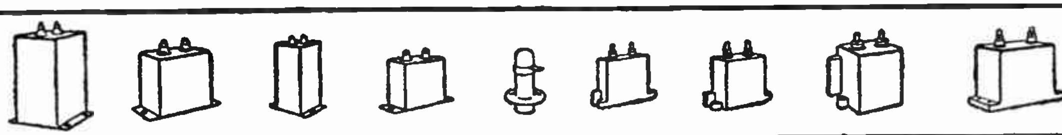

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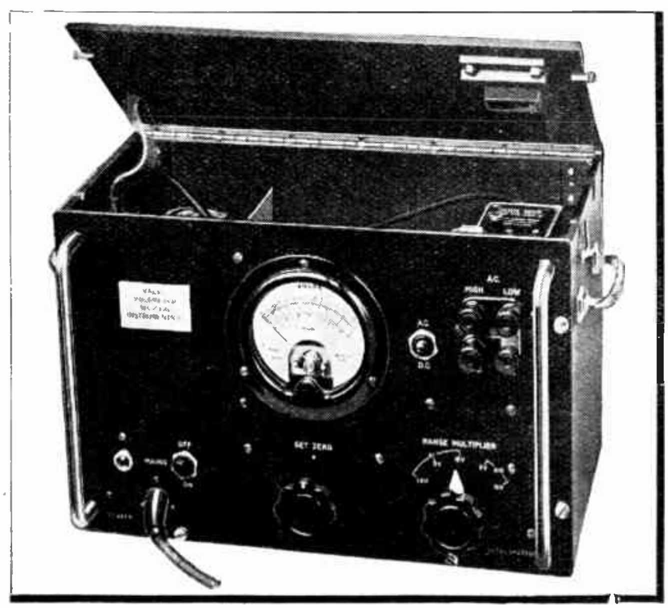

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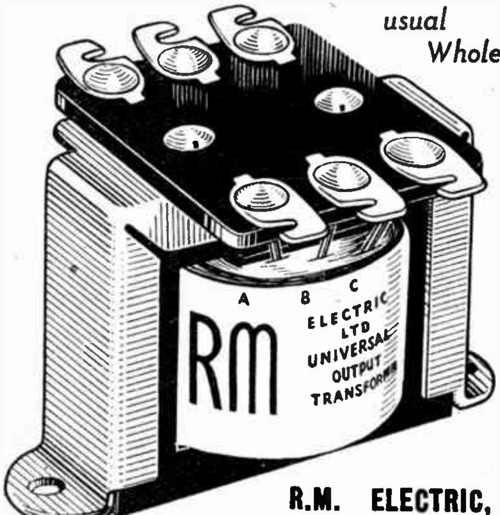

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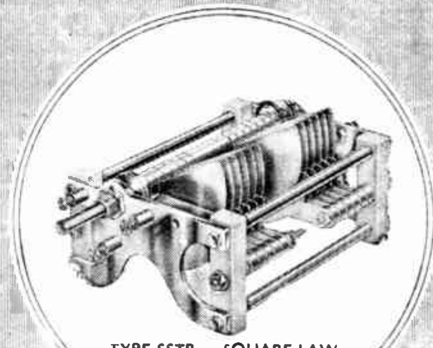

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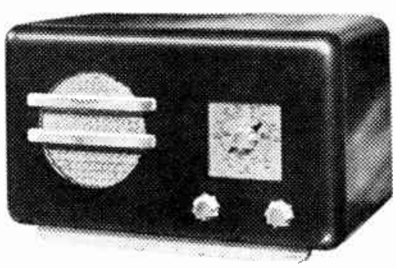

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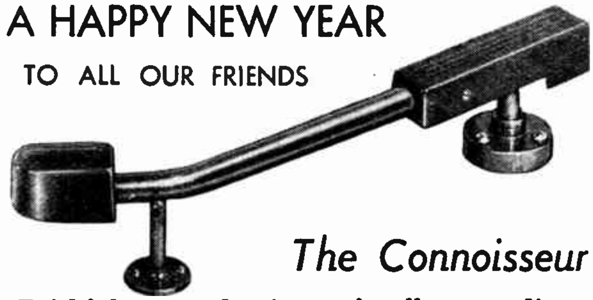

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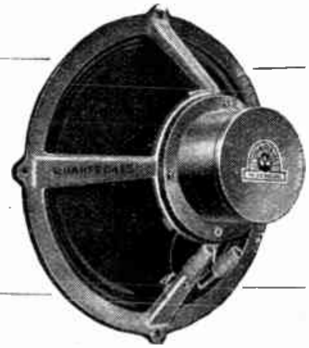

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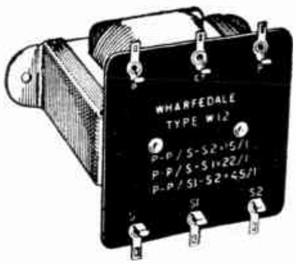

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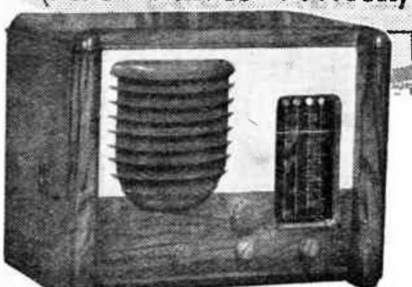
Wireless World *July, 1946*

Test Report

SOBELL Type 615

A.C. Table Model Superhet (Five Valves + Rectifier)



The following are brief extracts from a report which appeared in the July 1946 issue of "Wireless World" on the Sobell 615 6-valve A.C. Table Model Superhet :—

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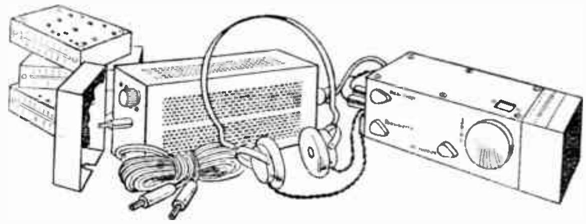

5-valve Superhet, using Midget valves (4, 1T4s, 1, 1R5) for A.C. or D.C. mains, 97—250 volts input. These sets are complete with aerial and earth equipment, lightweight headphones, mains lead, etc. Dimensions: Receiver, 7½ × 3½ × 2½. Power Pack approx. same size. Range 100 kc/s-20 mc/s in four ranges. These sets are brand new, ex-Govt., and sealed in metal containers complete with operating instructions **10 Gns.**

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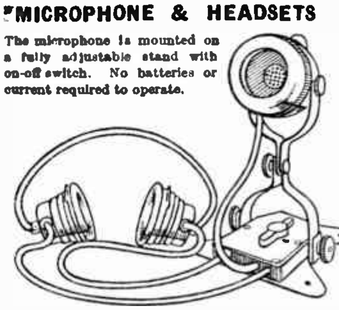

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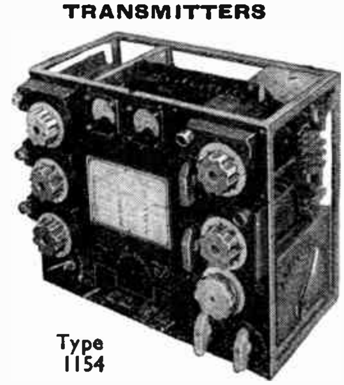

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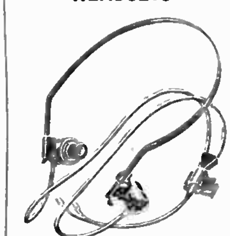

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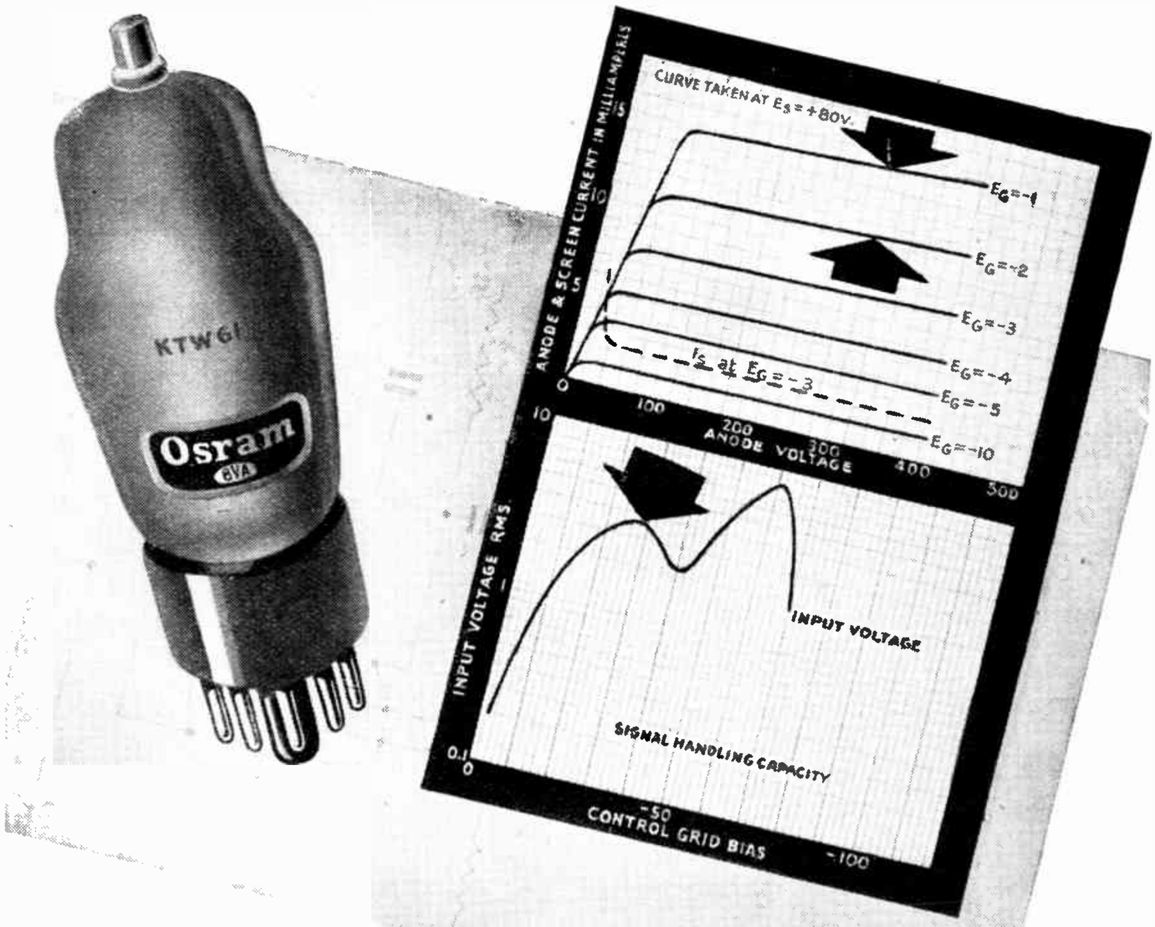

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Wireless World

Radio and Electronics

36th YEAR OF PUBLICATION

FEBRUARY 1947

Proprietors:
ILIFFE & SONS LTD.

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

Editor:
H. F. SMITH

Editorial, Advertising and Publishing Offices:
DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

Telephone: Waterloo 3333 (50 lines).
Telegrams: "Ethaworld, Sedist, London."

PUBLISHED MONTHLY

Price: 1/6

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Subscription Rate: Home and Abroad 20/- per annum.

Branch Offices:

COVENTRY: 8-10, Corporation Street. Telephone: Coventry 5210. Telegrams: "Autocar, Coventry."

BIRMINGHAM: King Edward House, New Street. Telephone: Midland 7191 (7 lines). Telegrams: "Autopress, Birmingham."

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VALVES AND THEIR APPLICATIONS

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

No. 2: Mullard SINGLE ENDED SHORT WAVE PENTODE EF54

WHEN, not long before the War, the EF50 was introduced, it shook a commonly-accepted belief that really useful VHF amplification was impossible without a complete departure from the conventional form of valve. The scale on which the EF50 was used during the War must have settled any doubts as to its practicability. Although the details of its construction were in fact considerably unusual, it plugged in like any ordinary valve, even to the extent of having all its connections at one end.

The EF54 is an EF50 with improvements. By reducing the grid-to-cathode clearance to the minimum capable of mass production, it has been possible to increase the slope to 7.7 mA/V. And the inductance of the cathode lead has been reduced by making parallel connections to four of the pins. Both of these changes are important in extending the useful range of frequency. Also, because the suppressor grid has not been designed, as in the EF50, to fit into a slope-controlling scheme, it has been wound with optimum pitch. This, and an adjustment of the screen grid pitch, have reduced the screen current, a result that does more than merely economize supply — it improves the signal/noise ratio, which is the essential matter. Useful amplification is obtainable at a frequency of 300Mc/s or even more.

Such results used to be thought possible only with acorn valves, which are so much more fragile and expensive. In some respects—notably signal/noise ratio — the performance of the EF54 is even better. The larger size of the electrodes and leads does mean, however, that a greater proportion of the tuning circuits is inside the valve. So it is necessary to design the external circuits accordingly. Radar mechanics may have been intrigued, perhaps, by the circuits of 200Mc/s pre-amplifiers using the EF54, with tuning coils and condensers apparently in series instead of in the more orthodox parallel positions. These circuits make sense if they are redrawn, showing the valve internal reactances.

One of the difficulties with all valves at VHF, of course, is their very low input resistance, which damps the tuned circuits heavily. A useful thing to know is that the gain can be increased several-fold by positive feedback, conveniently obtainable by connecting a small pre-set condenser across the cathode bias resistor. This is generally more convenient than the alternative method, of putting inductance in the screen grid lead.

This is the second of a series — written by M. G. Scroggie, B.Sc., A.M.I.E.E., the well-known Consulting Radio Engineer. Reprints for schools and technical colleges may be obtained free of charge from :

THE MULLARD WIRELESS SERVICE CO., LTD., TECHNICAL PUBLICATIONS DEPARTMENT, CENTURY HOUSE, SHAFTESBURY AVE., W.C.2

Wireless World

Radio and Electronics

Vol. LIII. No. 2 | FEBRUARY, 1947 | Price 1s. 6d.

Monthly Commentary

Symmetry or Circuitry?

ONE of the results of the recent "Britain Can Make It" exhibition has been to focus attention on the outward form of broadcast receivers. We comment on such matters of aesthetics with the greatest diffidence, but think that few will disagree with our opinion that manufacturers generally have shown great skill in producing acceptable cabinet designs in the face of severe shortages. Even better, in several cases a virtue has been made of necessity, and technical advantages have been secured by ingenious layouts using smaller quantities of our precious materials than in conventional practice.

Although efforts to improve the looks of broadcast sets are entirely praiseworthy, we believe there is some danger in placing too much emphasis on externals—if only because it amounts to following the line of least resistance, which is proverbially beset with perils. Everyone knows that a large section of the public now regards a receiver almost as an article of furniture, and certainly as something to be selected primarily on its external appearance. Taking the long view, this is an idea that should not be fostered too assiduously, or a state will be reached where the public loses all interest in performance or technical development.

Quite naturally and not unreasonably, the average citizen refuses to install in his living-room something that "looks like a scientific instrument." But—and this is the root of the problem—the broadcast receiver *is* a scientific instrument. In some of the latest models, with short-wave band-spreading and other refinements, it becomes increasingly difficult to camouflage this fact and at the same time to provide the user with a control system that enables him to obtain the full benefit of the facilities provided. Control knobs with no indication of function and (except for tuning) with no kind of indicating scale, are almost universal. Presumably for the sake of appearance, knobs of the wrong size and shape are fitted, often in the wrong places.

There is no slick and easy answer to all the questions implicit in external design. Compromises are needed at every point, but it is perhaps worth while pointing out that the public attitude as to what is and is not appropriate to the home is changing. This is, of course, due partly to a general tendency towards mechanization and electrification, but still more to the upheaval of war, which has brought untold thousands of men and—more important—women into close association with scientific instruments. As to how far we can go in meeting this change is a matter for careful consideration, but it would be a bad day for the future of radio if symmetry were allowed entirely to overshadow circuitry, or aesthetics to predominate over acoustics.

Variable-Mu

THE idea held by most of us that the term "variable-mu," as applied to an R.F. amplifying valve, stands for "variable mutual conductance" is finally disposed of by a letter from an American correspondent, published elsewhere in this issue. It now seems clear that the originators of this type of valve decided to call it a variable amplification factor valve, using the Greek letter μ as a symbol in its accepted sense.

What are we to do now? Respect for etymology requires that the term be spelled with a μ, but to do so would be confusing and unhelpful, as μ is rarely used or measured with such valves. Circuit design is carried out and the characteristics of valves are measured in terms of mutual conductance.

Whether we spell it μ or mu, the term is a particularly unhappy example of wireless jargon. Even at this late hour, and in the face of well-established usage, we venture to suggest the simple name of "variable-gain valve" as an alternative,

TELEVISION RECEIVER CONSTRUCTION

2.—*Line Deflector Coils: Winding Data*

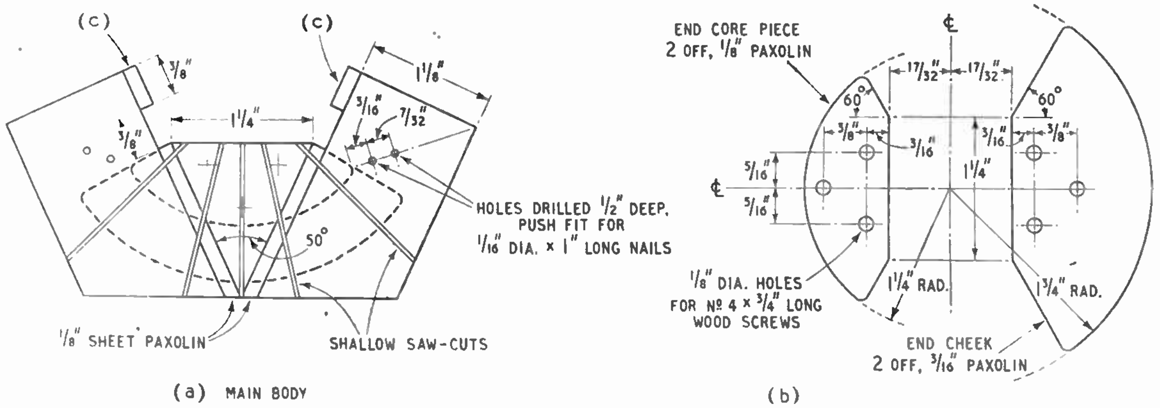
IT was shown in Part I that the most suitable form of deflector-coil assembly consists of a pair of former-wound low-inductance coils for the line scan and a pair of bent high-inductance coils for the frame. The choice of high-inductance coils for the frame is dictated largely by the desirability of economizing in wire and laminations.

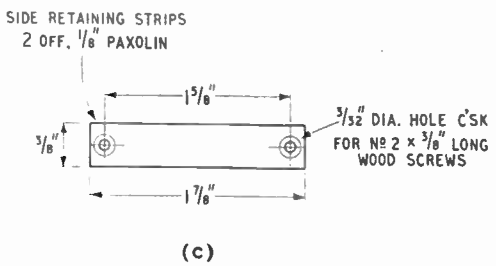
The construction of the coils is carefully. The line and frame coils are of quite different construction and the latter will be treated in the next article.

Full details of the individual parts of the former for the line coils are given in Fig. 1 (a) and (d). The main body can be cut from a solid block of wood, but it is easier to fabricate it from two side members, two $\frac{1}{8}$-in spacers and one V-block as shown. They $\frac{3}{16}$-in sheet. This material has been chosen on account of its strength and the ease with which it is worked, but is by no means essential. Brass is just as suitable, but more difficult to work.

The end cheeks and core pieces are most easily made by cutting circular discs with a tank-cutter and then cutting off the appropriate segments.

The edges of the end cheeks





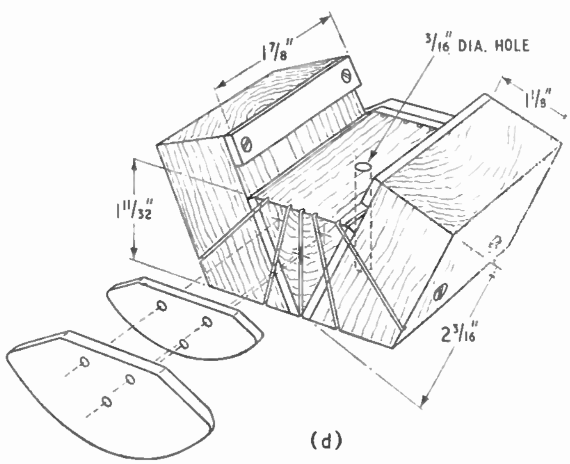
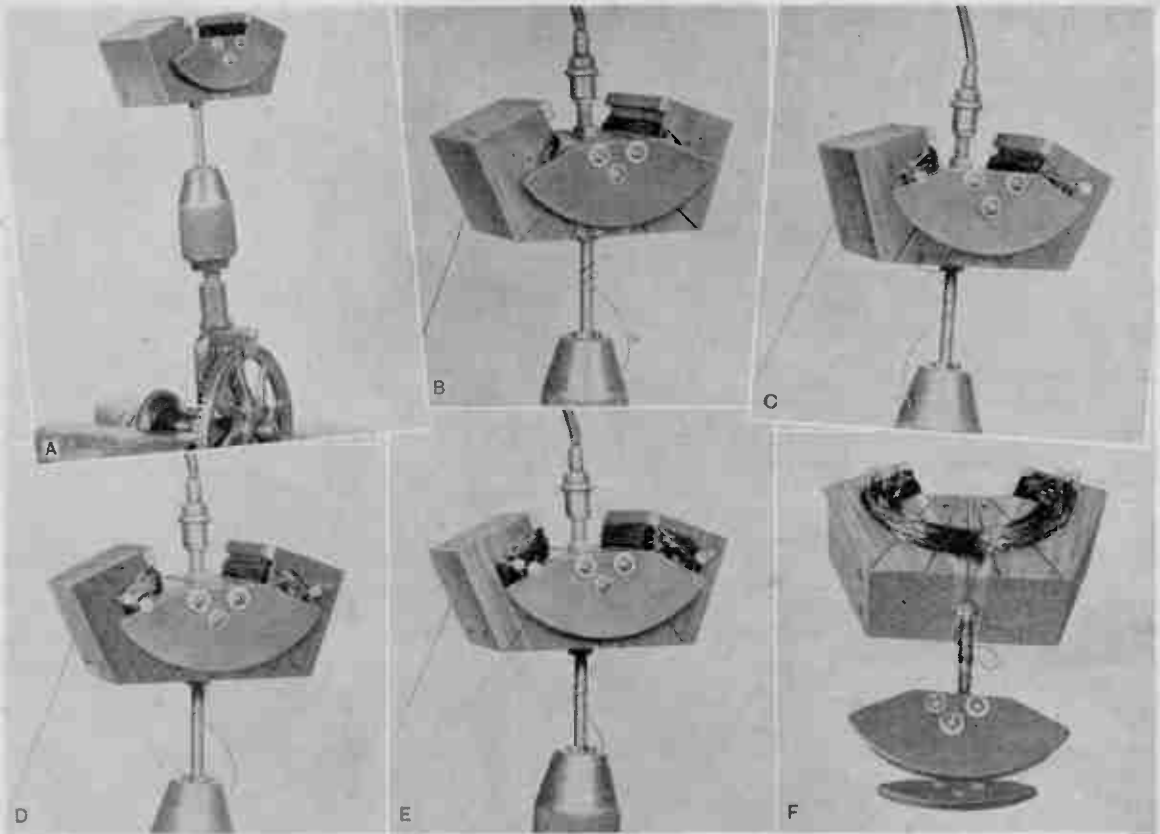
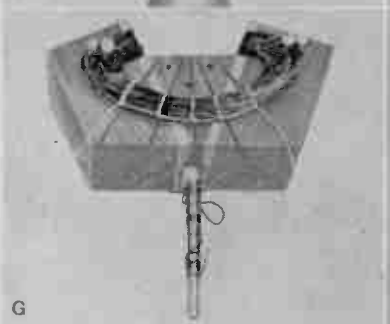


Fig. 1. These drawings show the construction of the winding former for the line-deflector coils. As shown in (a) and (d) $\frac{1}{8}$-in Paxolin sheet is used to separate the wooden side members from the V-block. This material is also employed for the side-retaining strips (c) and end cheeks and core pieces (b). Shallow saw-cuts across the face of the main body assist the binding of the coil before removing it from the former

by no means difficult but it is necessary to make certain formers and a jig and to adopt a definite procedure. No difficulty should be experienced if the instructions given in this article are followed are held together by four long screws passing into the V-block.

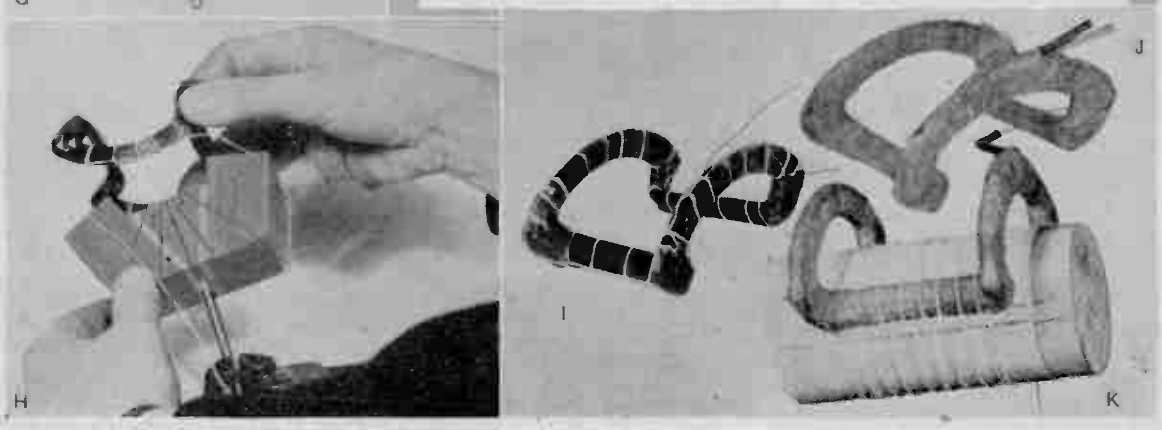
The two side-retaining strips (c) and the two end core-pieces (b) are cut from $\frac{1}{8}$-in Paxolin sheet and the two end cheeks (b) from must be carefully rounded and smoothed, to avoid damaging the enamel of the wire should it be allowed to scrape along an edge. If a buffing pad is available, the edges should be polished.





THE CONSTRUCTION STEP BY STEP

Fig. 2. (a) The former mounted ready for winding; (b) the first few turns in place; (c) after fitting the first pins; (d) with the second pins; (e) the fully-wound coil; (f) end-cheek and core pieces removed; (g) the end of the coil bound; (h) taking the coil off the former; (i) the bound coil; (j) the taped coil; (k) the finished coil tied to a mandrel to dry.



C

Television Receiver Construction—

Assemble the side-retaining strips, end cheeks and core pieces on the main body, and mount it on a spindle so that it can be turned easily by hand. One simple way of arranging this is to pass a length of 2BA rod through the centre of the main body and to clamp it with a nut on each side. The rod can be held in the chuck of a hand-drill, which is itself clamped vertically in a vice,

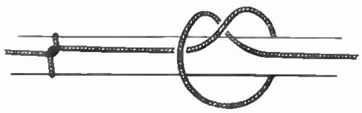


Fig. 3. This sketch shows the correct way of looping the binding thread.

as shown in Fig. 2 (a). While winding, the former is held in the left hand and rotated by it while the right hand guides the wire and maintains the tension.

The winding must start at one curved end, pass round it in the slot formed between the main body and the end cheek, up and into the straight side. Then down into the slot at the other end and so on. The winding finishes on the same end as the start and the coil has a total of 150 turns of No. 28 enamelled wire and requires some 2½oz of wire.

Care must be taken about the disposition of the wire along the straight sides. The first turns will naturally lie at the bottom of the slot, but after a time it will be found that there is a tendency for them to build up along the bottom of the slot (the ⅜-in side) instead of to pile up to the full depth (⅛in). This must be resisted as far as possible and the aim should be to build up the winding to the full ⅛-in depth as soon as possible so that the winding grows gradually at its full depth along the width.

It is not possible fully to achieve this, but if the winding is kept in triangular section an adequate approach to it can be secured, Fig. 2 (b). After some 50 turns have been wound it will be found that the wire starts to bunch at the corners. At this stage, insert a pin (1-in nail) at each corner, and continue winding, passing the wire over the pins, Fig. 2 (c). After a further 50 turns bunching again starts, so a second pin, Fig. 2 (d), is inserted at each corner and the winding continued.

It is at this stage that difficulty will be experienced if the winding has not been kept to the full depth of the slot as it has progressed. The turns passing over the second pins can only lie naturally in the end third of the sides, and if this has already been partly filled by the earlier turns there will not be room for them here. Some adjustment is quite possible, but not a great deal.

When the winding is complete, Fig. 2 (e), give the coil a coat of shellac varnish* and leave it until the varnish is only just tacky but not hard. Remove one end cheek and core piece (the latter will have to be gently prised out), as shown in Fig. 2 (f). Then tie up the end with thread, using a needle to pass the thread between the turns and the former in the saw-cuts provided, Fig. 2 (g). The correct method of binding is illustrated in the sketch of Fig. 3.

Do the same thing at the other end and then take off the side-retaining strips and remove the whole coil from the former, Fig. 2 (h). It will spring to a slightly greater size when doing this, but this is unimportant, as it is corrected later. Now tie up the sides, taking care not to bind too tightly and so pull them out of their rectangular shape, Fig. 2 (i).

Sleeve the end wires in 5-in lengths of sleeving of distinctive colours, noting which is start and finish, and bind the sleeving to the top of the rounded end. Then tape the coil with 1-in linen tape and give the whole a coat of shellac varnish. The coil then has the appearance shown in Fig. 2 (j).

Take a piece of round wood of 1$\frac{1}{16}$-in diameter as a dummy former, wrap a piece of paper round it and mark off lines parallel to the axis and 180° apart. Draw lines parallel to these and $\frac{3}{16}$in away on the same side so that the angle between them is less than 180°.

* Shellac varnish consists of shellac dissolved in methylated spirit. Ordinary methylated spirit is not very suitable, however, since it contains substances which may affect the enamel of the wire. Commercial spirit should be used, but is not obtainable. The way out is to use french polish. The high-grade uncoloured variety is just shellac in commercial methylated spirit and is eminently suitable.

Take the coil while it is still soft and place it on the cylinder so that the outside of each straight side coincides with the lines and bind it firmly in place, Fig. 2 (k). Slight final adjustment can be done after the binding. The sides must be parallel and the curved ends at right angles to them.

The coil is then left to dry. If heat is not applied this will take 48hrs or more, but can be accelerated to some 6hrs or so by drying in front of a hot fire, or even less in an oven.

Two coils of identical construction are required.

Details of the frame coils and of the assembly of the coils to form the deflection yoke will be given in the next issue.

"RADIO NAVIGATION"

DETAILED information on radio aids to marine navigation, unobtainable elsewhere in a single volume, is provided in the second of two books prepared by the Ministry of Transport covering the proceedings of the International Meeting on Radio Aids to Marine Navigation held in London last May.

This book, "Radio Navigation: Radar and Position Fixing Systems for use in Marine Navigation" published by H.M. Stationery Office, price 5s, is based on the technical papers presented at the meeting and deals very fully with existing radio navigational aids and, too, with those being developed.

The introductory chapters deal with "the navigational problem" and wave propagation as it affects radio aids to navigation. The second part deals with D.F. systems, including Consol. In the third section hyperbolic systems of navigation, including Loran, Gee, Decca and P.O.P.I. are reviewed.

By far the largest section of this 200-page book is devoted to marine radar systems. This section, which occupies nearly 100 pages, includes a specification for a merchant ship's radar set revised last November after meetings between the Government departments concerned and the radio industry.

The concluding section of this useful textbook and work of reference gives tabulated summaries of the principal characteristics of the various marine radio navigational aids which are based on the report of a technical committee representing the various Government scientific research establishments. A comprehensive index is also included.

IS "ELECTRONICS" OVERWORKED?

A Useful Word, But....

By "CATHODE RAY"

AT any given moment the lay Press has one or more favourite words. Enthusiasm for them is capable of overruling almost any absurdity or lack of fitness in their use. Familiar examples in recent years are "streamline," "pattern," "wonder" (as an adjective), and "bottleneck." ("Bottlenecks must be ironed out," as one leading article put it). In pre-*Wireless World* days, to call a thing "electric" was enough to raise it at once to the level of the mysterious and magical. Nowadays electric appliances are so common that nobody can get much of a kick out of the mere word, though the same cannot always be said for the equipment itself. So something a little more recondite is needed to take the place of "electric," and "electronics" seems to be doing it.

There is, of course, the usual time-lag before the popular journals discover words such as this. I have been unable to find out who first used the term "electronics," and when; it was certainly in use in America by 1930, when the monthly journal of that name began publication. Although the electron itself was not clearly recognized before J. J. Thomson did so in 1897, it was actually named as long ago as 1891, by Johnston Stoney, who more than hinted at its existence in 1874. Crookes had been playing about with electrons in 1870, and was certainly one of the founders of electronics.

But it still sounds "modern" and mysterious to the man in the street. Even in the technical Press the word is used more often than strict sense would seem to require; at least, if I have the correct idea of what electronics is. There are not many definitions to choose from, but this one by the American Institute of Electrical Engineers seems about right:—

"Electronics is that branch of science and technology which relates to the conduction of electricity through gases or *in vacuo*."

Less precisely, it is the glassware department of electrical engineering.

In my poetic youth (*Wireless World*, 29th Nov., 1935) I likened the sort of electricity that is bound by hard metallic conductors to Caliban, a slave suited to hauling trams along streets and other labour of a menial and unimaginative kind. Released from this bondage into free space, he is transformed into the fleet and dainty Ariel—electronics.

"Magnetrons . . . and other trons are really distinct groups of electronic devices." The heater and cathode of a magnetron being assembled in the valve laboratory of Marconi's W. T. Co.

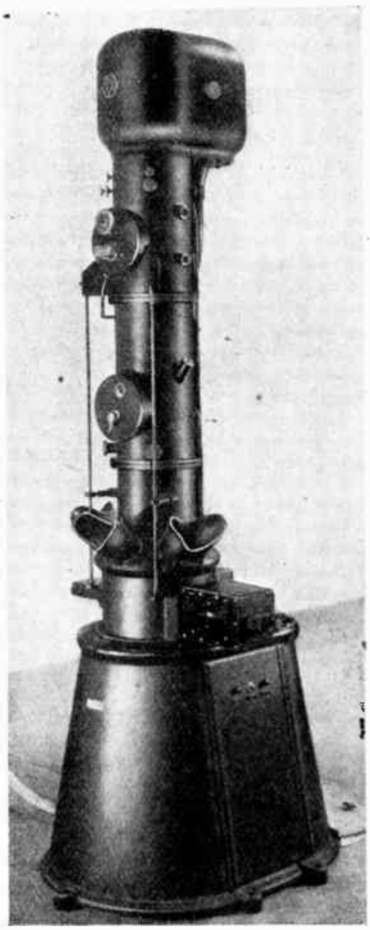
The earliest examples of this transformation were accompanied by an undesirable display of brute force. The electrons were torn from their material conductors by the irresistible tension of many thousands of volts. This was what was done in the first practical application of any importance—the X-ray tube. While the doctors were amusing themselves with this, other people were finding the secret of a more gentle spell—heat. Once released by it, the electrons needed only quite small voltages to control them. In fact, the first use made of thermal emission, by Ambrose Fleming in 1904, was as a detector of the very small radio-frequency voltages that could be received in those days of weak transmitters and no amplifiers. The idea was developed so fruitfully in the interests of radio communication that we radio people came to assume that we had almost a monopoly of electronic devices, and outsiders were only entitled to use them on sufferance and after making due acknowledgment. But the non-radio applications have gradually increased so far beyond the frontiers of the most imperialistic radio engineer that even the lay journalist couldn't keep on calling all of it "radio." Hence "electronics."

Looking under "Electronic Applications" in the *Wireless Engineer* Abstracts and References Index for 1945 I found the following diverse samples: area calculator; detonation indicator; electrometric titration; flame cutter; hopper control for ore crusher; paint spraying; petroleum plants; precision gauges for the blind; survey; temperature control in aircraft; water-in-petrol indicator; vulcanization; and—a lovely one this—thermal behaviour of houses. So it is a good idea to have a word for it all.

But would there be much sense in describing, say, boots as Metallurgical Applications, on the ground that they were protected with "tackets," which were the products of metallurgical processes? Some of the so-called electronic devices seem to me of this order. Take "electronic heating." A power oscillator valve is indisputably an electronic device. The people who design and manufacture it are workers in electronics. But does that

Electronics—

apply to the people who make R.F. oscillators incorporating such valves? Perhaps it does, because they may have to know something about valve technique in order to apply the valve effectively. But the stage having been reached at which a range of oscillators capable of delivering *n* kilowatts of R.F. is available, it seems to me to be stretching the meaning of "electronics" rather far to apply it to all of the uses that may be made of such R.F. oscillators, just because they incorporate an electronic device, to wit, a thermionic valve. Is it really any business of electronics whether the R.F. power so obtained is used to melt an alloy, or warm up a patient's thorax, or transmit a picture of Winifred Shotter? If it is, then at least it must be a somewhat remoter order of electronics than the production of distinctly new and different ways of usefully controlling electrons in bottles. After all, the essential features of this sort of heating result from the application of R.F. fields, irrespective of the precise means adopted for maintaining those fields

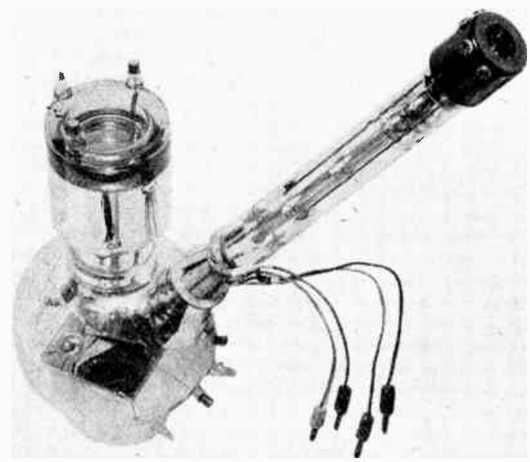


"The new science of electron optics." This Metropolitan-Vickers electron microscope is used for metallurgical research by Firth-Brown of Sheffield.

Then, of course, any hearing aid becomes an electronic aid immediately someone spots a valve somewhere inside it. (Admittedly this is a step in the right direction from the practice of calling it "radio"). And there is electronic music. Soon we shall have the electronic museum, so called because its chief treasure is guarded by an "invisible-ray" burglar alarm. And the electronic fried-fish shop, because it has an extension loudspeaker in it, and loudspeakers are generally worked by valves, which are electronic devices.

Even using the term fairly strictly, electronics has become a pretty extensive technology, of which the radio part (including radar and television) is only a fraction. Valves, in which the electrons are separated from matter by heat and controlled with ingenious complexity by a variety of grids, screens and anodes, are of course applied in millions to line communication, biology, industrial processes, calculating machines, and thousands of other non-radio purposes.

Although commonly called valves, magnetrons and klystrons and other trons are really distinct groups of electronic devices. The cathode-ray tube, with brute-force emission, was a much earlier invention than the valve, appearing in rudimentary form around the 1870s, due to Crookes. Now it has a hot emitter, and very refined focusing and deflection, and



A combination of electron optics and the photo-electric effect is the basis of television cameras. The Super-Emitron tube as used in the latest E.M.I. television cameras.

has become almost as ubiquitous as the valve. The X-ray tube, too has adopted a heated cathode; and surgeons are only some of the people who use it. For instance, it has been one of the chief tools in the progress of atomic theory, and is used industrially on quite a large scale for detecting flaws, to say nothing of showing you what the pair of shoes you propose to buy does to your toes.

The control of electron beams, especially in cathode-ray tubes, is closely analogous to the control of light by lenses, and as a result the new science of electron optics has arisen. One of its most spectacular applications is the electron microscope, giving actual magnification far exceeding the utmost theoretical limit with light or even with ultra-violet rays.

In the foregoing electronic devices, heat is applied to the cathode merely for the purpose of turning out a working-party of electrons for duty. What chiefly matters is how they are manipulated after having been assembled. The releasing of electrons by light, noticed in 1888, is far less effective for assembling purposes, but does provide one of the most useful methods of detecting and measuring light. Simple photo-electric cells, which are really diodes with light-sensitive instead of heat-sensitive cathodes, are used for making films talk, apprehending burglars, matching colours, detecting smoke, opening doors as they are approached, turning on lights when it gets dark, counting bales of newspapers or visitors to an exhibition, and a few hundred other purposes. In more complex form, combined with electron optics, the photo-electric effect is the basis of television cameras.

In these devices, a third method of releasing electrons is sometimes used along with the other two. The electrons are brought out by the peaceful picketing of their fellows; a process commonly referred to as secondary emission. If an electron hits anything hard enough it may knock out a dozen others. It is rather like the first stroke in snooker. The oldest application of this sort of emission is the dynatron. But more often it is suppressed, as in the pentode. The obvious amplifying possibilities are a little difficult to control, but the electron multiplier is one successful device, though not widely used. I shouldn't be surprised if we hear a lot more about secondary emission.

Two-colour stereoscopic television reception is provided by this cathode-ray tube used by the late J. L. Baird in his Telechrome system. With this tube the picture is visible on both sides of the screen.

Lastly, there is a very large and varied group of devices that come within the scope of the A.I.E.E. definition of electronics, and exemplify the principle that it is better to put 100 people to work than to try to do the work of 100 people. For the former is the role of the emitted electrons in such things as mercury-arc rectifiers, thyratrons, and fluorescent and vapour lighting. In these the function of the small initial working party of electrons is to dash in among the gas or vapour molecules and knock other electrons out of them. What is left of the molecule is an ion, and the process is ionization. Minus negative being positive, these robbed molecules are positive ions. Nothing succeeds like success, and each electron knocked out joins the crowd of beaters-up, until the space inside the tube is alive with a vast crowd of them.

Such a crowd would need an enormous cathode to yield it by thermal emission alone; and, when formed, would tend to defeat its own purpose by constituting a negative charge so great that a very high positive anode voltage would be needed to overcome it. But the ions, being positive, and relatively so heavy that they take a long time to reach the attracting cathode, neutralize the electron space charge so that an enormous space current can be set up by very little anode voltage (and hence very little loss of power) and very little cathode heating power. On the other hand, like all mobs, this one very soon gets out of control. So gas-filled tubes are the thing to use when heavy current, rather than fine control, is wanted.

The expression "gas-filled" sounds as if gas were pumped in under pressure, as indeed it is in ordinary electric lamps of that description. But in gas-discharge or ionization tubes the gas filling differs from a perfect vacuum by much less than 1 per cent. of atmospheric pressure. Nevertheless, it is enough to provide I don't know how many trillions of ions (and not American or short trillions either). Besides them, many electrons, though not detached, get such a shake-up that they are jerked into different atomic orbits and give out radiant energy. If the wavelength happens to come within the tuning range of the eye, the radiation can be used for lighting, as with the mercury and sodium street lamps. Radiation too short in wavelength to be seen can be used to excite visible radiation in fluorescent substances, as in the tubular lights coming into popular use.

Electronics, in the form of the mercury-vapour rectifier, invades even "heavy" electrical engineering, by providing A.C.-to-D.C. plant capable of handling thousands of amps with very high efficiency.

So the main fields of electronics activity are: communications; measurement and control; lighting; power. Yes, it did need a word for it.

MANUFACTURERS' LITERATURE

THE first of a new series of booklets —"Electrons" has been issued by the Edison Swan Co., 155, Charing Cross Road, London, W.C.2. It deals with "Electrons in Diodes" and is intended for elementary educational purposes. Applications from education establishments should be made to the Technical Service Dept.

The Mazda Valve Equivalents List has been produced in pocket form printed on glossy plastic material and is for general distribution.

An illustrated catalogue of components has been issued by M.O.S. (Mail Order Supply Co.) 24, New Road, London, E.1, price 1d.

Pending the production of a new illustrated catalogue, the Trix Electrical Co. have issued a duplicated list of their amplifiers and sound equipment in conjunction with a booklet of photographic reproductions.

A comprehensive sound recording service, with five studios giving the accoustic conditions necessary for every type of recording from talks to full orchestra is described in a brochure issued by Star Sound Studios, 17, Cavendish Square, London, W.1.

A.V.C. CALCULATIONS

Graphical Methods of Estimating the Performance of Circuits

By S. W. AMOS, B.Sc., (Hons.), Grad. I.E.E., A.M.Brit.I.R.E.
(*Engineering Training Department, B.B.C.*)

THE aim of this article is to show that it is possible to prepare a family of curves for any particular sequence of variable-mu valves, and that from this it is possible to deduce the A.V.C. characteristic of the receiver (i.e., the curve of aerial input volts plotted against detector input volts). The method is reasonably quick and is applicable to almost any type of A.V.C. circuit, with or without delay or amplification. It enables the performance of the A.V.C. circuit of the receiver to be assessed at the design stage. Although the author developed this method independently, it had something in common with work by Cocking[1] and an article by James and Biggs,[2] to which his attention was drawn subsequently. James and Biggs discuss in detail the calculation of the amount of harmonic distortion introduced by variable-mu valves which are controlled from the A.V.C. line—a point which is not dealt with here.

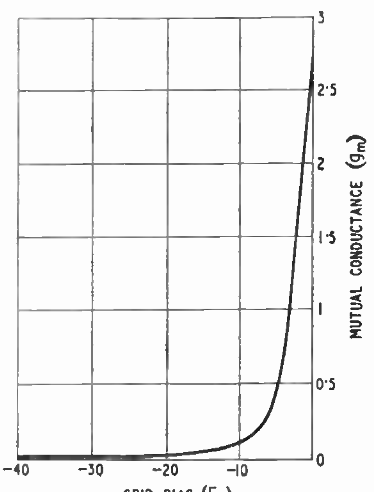


Fig. 1. Variation of mutual conductance with grid bias (g_m-E_g curve) for a variable-mu R.F. pentode.

This article is based on a knowledge of the shape of the $g_m - E_g$ curves of the controlled valves. To illustrate the method we will first consider a very simple case, that of applying A.V.C. to a T.R.F. receiver having only one controlled valve, namely, a variable-mu pentode preceding a diode detector. There is, of course, very little to commend the use of such a circuit in practice, but this example is chosen as a convenient means of introducing the method of deducing the form of the A.V.C. characteristic.

Suppose the $g_m - E_g$ curve of the particular R.F. pentode it is intended to use, for the particular screen potential planned, is as given in Fig. 1. This shows that, as the grid bias is increased negatively from -1 volts to -30 volts, g_m falls from 2.3 mA/volt to 0.0035 mA/volt. As it is very inconvenient to represent such a large variation in g_m accurately on a linear scale as in Fig. 1, this curve is repeated in Fig. 2 with a logarithmic scale for both g_m and E_g. This curve is interesting, for the long, almost straight portion shows that over a wide range of values of E_g the relationship between E_g and g_m is approximately exponential. As R.F. pentodes are generally used with anode loads the value of which is small compared with their value of R_a the stage gain M obtained from them is given by $M = g_m R_L$ approximately, where R_L is the value of the anode load. M, then, is proportional to g_m for a given value of load resistance and so Fig. 2 may be taken as representing the relationship between M and E_g (with a suitable readjustment of the vertical scale, of course). We can carry this argument further, for it is possible to include the voltage step-up of the aerial coupling circuit in the vertical readings also, so that they represent the overall gain from aerial terminal to the anode of the diode detector. If, for example, the effective value of the load of the R.F. pentode is 20,000 ohms, then the gain of the valve when $E_g = -1$ volt is $2.3/1{,}000 \times 20{,}000 = 46$. The gain of the aerial input circuit we will take as 10, giving an overall gain, at $E_g = -1$, of 460.

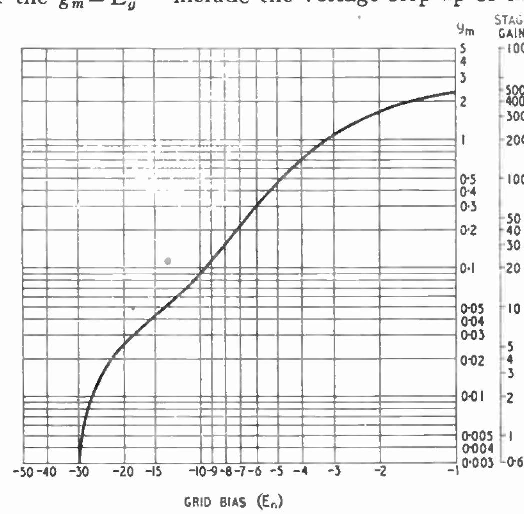


Fig. 2. Curve of Fig. 1 re-drawn with logarithmic scales for g_m and E_g.

A second vertical scale giving the value of overall voltage gain is indicated in Fig. 2. Now the overall gain is equal to the number of volts obtained at the diode anode for one volt input at the aerial terminal. This would, in

[1] "The Design of A.V.C. Systems," by W. T. Cocking, *Wireless Engineer*, Aug., Sept., Oct., 1934.
[2] "A.V.C. Characteristics and Distortion," by E. C. James and A. J. Biggs, *Wireless Engineer*, Sept., 1939, p. 435.

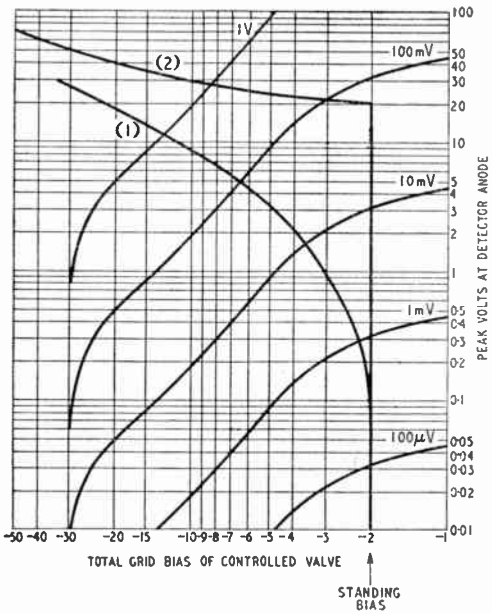


Fig. 3. Diagram for estimating the performance of an A.V.C. system with one controlled valve.

practice, overload the R.F. valve for all but the largest values of grid bias, but neglect this for the moment. So the second vertical scale of Fig. 2 may also be taken as giving the number of volts at the detector anode for one volt applied between the aerial-earth terminals. This curve is repeated in Fig. 3 in this new form and is labelled "1V." Obviously if the input to the aerial-earth terminals were reduced to 0.1 volt then we should get 1/10th of the number of output volts obtained previously; i.e., 46 volts at a bias of −1 volt. This is indicated by the curve labelled "100 mV" in Fig. 3. This process can be continued further and a nest of curves prepared for various input voltages. Because of the vertical logarithmic scale all the curves so obtained are of exactly the same shape, being merely displaced from each other vertically. This is a convenient feature for it considerably simplifies the preparation of such diagrams as Fig. 3.

Fig. 2 showed that there was little improvement in gain to be had by reducing the grid bias to less than −2 volts. This fact is usually made use of in receiver design by including self bias circuits in the cathode leads of valves to give a standing bias of approximately this value. Even in the absence of A.V.C. bias the grids of the controlled valves are 2 volts negative with respect to their cathodes and there is hence no possibility of grid current. A vertical line is drawn in Fig. 3 at a bias of −2 volts as a reminder of the fact that the bias never becomes less negative than this value.

Now consider a simple A.V.C. system, such as that given in the circuit diagram in Fig. 4, in which there is no delay and no amplification of the A.V.C. bias. The negative bias given by this system is directly proportional to the amplitude of the R.F. carrier applied to the diode anode, and, in fact, if the detection is 100 per cent efficient, is equal to it.[3] We shall assume that the A.V.C. voltage equals the peak value of the applied R.F. signal. Then a 1-volt signal gives −1 volt A.V.C. bias, which, together with the −2 volts standing bias on the controlled valve, gives a total bias of −3 volts. Similarly a 10-volt signal gives −12 volts bias, 20 volts give −22 volts and so on.

The relationship between the signal on the detector anode and the total bias voltage of the controlled valve is indicated by curve (1) in Fig. 3 and the intersections between this and the nest of curves previously drawn illustrates the performance of the A.V.C. circuit of Fig. 4. The intersections show, for example, that an input signal of 10 mV gives 1.7 volts at the detector anode and −3.7 volts total bias on the controlled valve, whereas a 1-volt input signal gives an output of 11 volts and a bias of −13 volts.

These and the data from other intersections are best represented on another diagram as in Fig. 5. From this we can see that there is no A.V.C. action for inputs smaller than about 1 mV: in other words this system is of little use in combating fading. For inputs exceeding 1 mV the A.V.C. system compresses a 1,000:1 variation in signal strength to a 40:1 variation in the signal applied to the detector anode.

The performance of circuits giving delayed A.V.C. can be deduced just as easily. Suppose, for example, in Fig. 4, that the anode

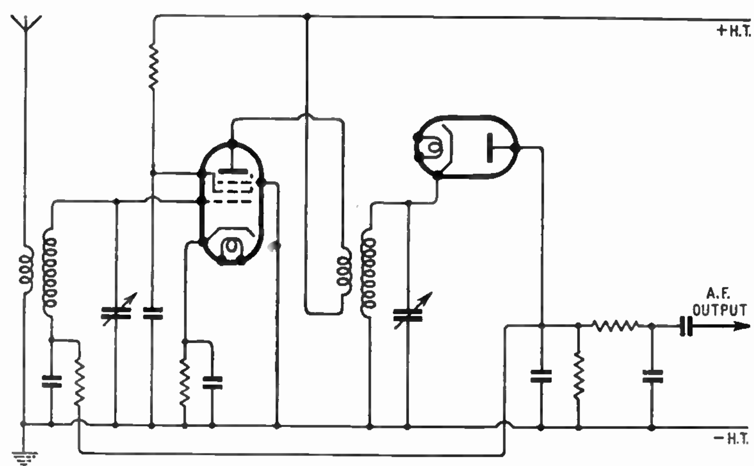


Fig. 4. Simple A.V.C. system with one controlled valve, giving the performance predicted by Fig. 3.

[3] This is only approximately true for small inputs to the detector, but is more justified for large inputs. We shall neglect the non-linearity of the diode, however, for the sake of simplicity in the preparation of these A.V.C. curves. We shall also neglect the fact that the anode current of a diode usually begins even when its anode is slightly negative.

A.V.C. Calculations—

of the A.V.C. diode is made 20 volts negative with respect to —H.T., and that the cathode is returned as shown, via the tuned circuit, to $-$H.T. This gives a delay of 20 volts and no conduction (and hence no A.V.C. volts) will occur until the R.F. signal applied to the diode anode exceeds 20 volts in peak value. A 21-volt signal will give -1 volt on the A.V.C. line and hence a total bias on the controlled valve of -3 volts. A 30-volt signal will give -12 volts, and so on. Curve (2) in Fig. 3 shows the relationship between the detector input and the total bias on the controlled valve, and the performance of such an A.V.C. circuit, deduced from the intersections of curve (2) with the nest of valve characteristics, is given in Fig. 5. The chief difference between the two types of A.V.C. represented in Fig. 5 is that the control voltage does not appear, with delayed A.V.C., until the signal at the detector is large, and so there is no limiting of the sensitivity of the receiver.

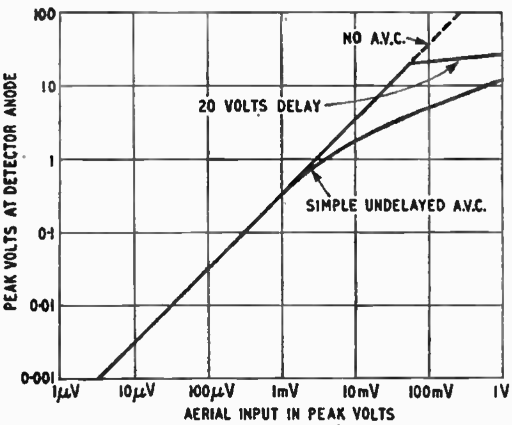


Fig. 5. Performance of a simple A.V.C. system such as that of Fig. 4, with and without delay.

Now consider a receiver having two valves controlled from the A.V.C. line such as the usual broadcast superheterodyne type, in which the frequency changer and the I.F. valve are controlled. The curve of the conversion conductance, g_c, plotted against control grid bias for a frequency changer with a variable-mu characteristic has the same shape as that given in Fig. 1, except that the value of the conversion conductance for any particular value of E_g is smaller, usually about one-quarter, of the value of g_m of an R.F. pentode for the same value of bias. For example, the maximum value of g_c (at $E_g=0$) is generally about 0.75 mA/volt compared with 3 mA/volt for an R.F. pentode at $E_g=0$. This means that when the g_c-E_g curve for a frequency changer is plotted using a logarithmic scale for g_c the resulting curve is of exactly the same shape and size as that given in Fig. 2, but the readings of the vertical scale are always one-quarter of those given in Fig. 2.

For convenience this curve is given in Fig. 6. As before, the vertical scale may be taken to represent the stage gain of the valve. Hence the way in which the gain varies with the total bias in a receiver with a frequency changer and an R.F. pentode, both controlled from the A.V.C. line, is obtained by multiplying the ordinates of Fig. 2 by the corresponding ones of Fig. 6, it being assumed that both vertical scales have been adjusted to give the stage gain of each valve and its associated coupling circuits. As both vertical scales are logarithmic. this multiplication merely means that the distances between the ordinates are added. From the resulting curve we can deduce a nest of curves for various input voltages, corresponding to those of Fig. 3.

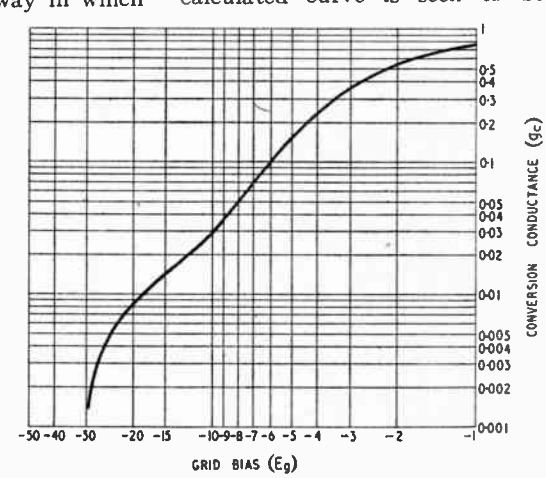


Fig. 6. Variation of conversion conductance (g_c) with grid bias (E_g) for a frequency changer valve.

Fig. 7 gives a set of curves deduced in this way. A strange feature of this diagram is that the nest of curves given there does not appear to have been produced by repeating the same shape over and over again at different positions, but such is indeed the case. The overall amplification here (at $E_g= -2$ for both valves) was assumed to be 30,000, made up of 100 from the I.F. valve, 30 from the frequency changer, and 10 from the aerial input circuit, all of which are quite reasonable values. Curve (1) in Fig. 7 is for simple undelayed and unamplified A.V.C. and curve (2) for A.V.C. delayed by 2 volts, the type of circuit commonly used in broadcast superhets, in which the bias voltage of the A.F. amplifying triode is used as the delay voltage.

In Fig. 8 the performance of these two types of A.V.C. system is exhibited graphically and on this graph are also plotted some points determined experimentally with a domestic superhet, the amplification of which (up to the diode) was known to be about 30,000. The agreement with the calculated curve is seen to be quite good, such divergencies as do occur, being probably due to the standing biases not being equal to each other and equal to -2 volts, to the loss of standing bias when A.V.C. bias increases negatively, to the fact that the delay voltage was not known accurately, and finally—though probably most important—due to the shape of the g_m-E_g and g_c-E_g curves of the valves not being precisely those postulated at the beginning of this article.

Evidently the many simplifying assumptions made in this graphical method do not affect the accuracy of the final result unduly.

A number of other A.V.C. curves—numbers (3), (4) and (5)—have been included in Figs. 7 and 8. Curve (4) illustrates a system with 20 volts delay, and should be compared with curve (2) of Fig. 3, where the same system controls a single valve.

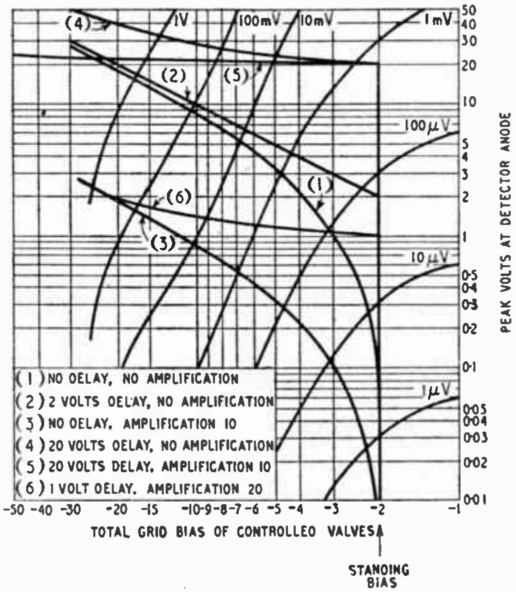


Fig. 7. Curves for determining performance of A.V.C. systems with two controlled valves.

Curves (3) and (5) show the effect of amplifying the A.V.C. voltage. Suppose, for example, the A.V.C. voltage is amplified 10 times, but is not delayed. Thus a signal input of 1 volt peak value to a diode will produce 10 volts negative bias, which, together with -2 from the standing bias system, gives a total negative voltage of 12 volts. Curve (3) shows how total bias depends on detector input for such a system and its intersections with the nest of characteristics is shown by curve (3) of Fig. 8. This system possesses the defect of the simple undelayed form of A.V.C. in an aggravated form in that it seriously limits the amplification of the receiver for small input signals, since even a small voltage at the diode anode produced a large control bias. In curve (5) we have assumed 20 volts delay and an amplification of 10 times. Here a 20-volt signal (or a smaller one) at the diode produced no A.V.C. bias, so only the standing bias is applied to the pre-detector stages and no limiting of sensitivity occurs. A 21-volt signal, however, gives -10 volts bias, making -12 volts in all. The performance of this system, given by curve (5) in Fig. 8 is very good. For inputs exceeding about 700 µV the output remains constant no matter how the input increases. An ingenious circuit providing amplified and delayed A.V.C. is described in Paragraph 38, Section N of Volume II of the *Admiralty Handbook of Wireless Telegraphy*, and the performance given by the constants mentioned there, namely, a delay of 1 volt and an amplification of 20 times, is illustrated by curves (6) in Figs. 7 and 8.

The method just described of deducing A.V.C. characteristic is capable of general application to all receivers, no matter what the number of controlled valves, provided that they all have the same standing bias and that the full A.V.C. voltage is applied to all of them. For receivers in which the controlled valves do have different standing biases and where only part of the full A.V.C. voltage is used for control purposes for some of them, it is still possible to deduce the A.V.C. characteristics provided that a nest of $g_m - E_g$ curves is drawn out for each controlled valve.

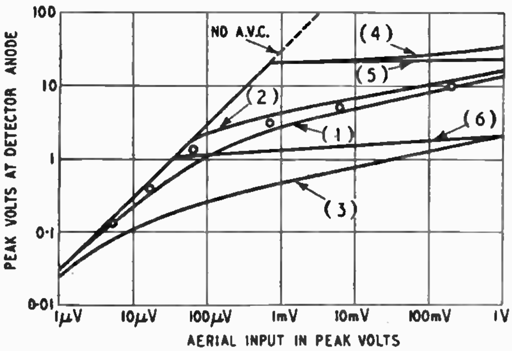


Fig. 8. Calculated performance curves of various types of A.V.C. systems (see Fig. 7) with two controlled valves. The points represent measurements from an actual receiver.

To conclude, an account will be given of the general method of preparing a single nest of curves for a receiver with any number of controlled valves. From this the deduction of the A.V.C. characteristic is a simple matter.

(1) It is assumed that all the controlled valves possess the same shape of $g_m - E_g$ (or $g_c - E_g$) curve when this is constructed with a logarithmic scale for g_m (or g_c). Plot this curve, making it occupy a fairly large overall height. The vertical height of the final nest of curves will be equal to one-half of the height of this $g_m - E_g$ curve for a system employing two controlled valves, to one-third of it for three controlled valves, and so on. So if the final diagram is required to be 4in high, and if there are three controlled valves, then the original $g_m - E_g$ curve should be about 12in high. This statement assumes that the original $g_m - E_g$ curve occupies three complete cycles of the vertical logarithmic scale. The curve now obtained is similar to Fig. 2, and should occupy about three complete cycles of the vertical scale (for a bias range of 0-30 volts). This simply means that the maximum value of g_m is one thousand (10^3) times the minimum.

(2) Suppose the receiver is to have four controlled valves. On a sheet of tracing paper construct another vertical logarithmic scale with the length of each cycle equal to one-quarter that of the existing scale of the $g_m - E_g$ curve. (For three controlled valves each cycle of the new scale should be one-third of the scale of the $g_m - E_g$ curve—and so on). Only about three cycles of this new logarith-

A.V.C. Calculations—

mic scale need be constructed, and the values 0.05 volts to 50 volts can be marked in. This will give the value of the detector input signal. The horizontal (E_g) scale of this new graph on the tracing paper should be the same as that of the original $g_m - E_g$ curve.

(3) Estimate the total gain, from aerial input to diode anode, expected from the controlled valves at their standing bias. Choose a value of input signal, say 1 μV, and trace the original $g_m - E_g$ curve on to the tracing paper so that the grid bias scales agree and so that the output voltages as indicated on the new logarithmic vertical scale are correct. Choose a new input (10 μV) and repeat the process. All that is necessary in order to do this, is to move the original $g_m - E_g$ curve underneath the tracing paper up a vertical distance of one cycle on the new logarithmic scale. Repeat again for inputs up to one volt, drawing in only these parts of the original $g_m - E_g$ curve which give outputs between 0.05 and 50 volts.

(4) Draw in the curve for the A.V.C. system it is intended to use and from the intersection of this with the nest of curves obtained by (3) deduce the A.V.C. characteristic as explained above.

Where a number of theoretical determinations of A.V.C. characteristics are wanted it would seem a good plan to have a number of frameworks similar to that of Fig. 7, in which the diode input signal—total bias volts curves for various A.V.C. systems are already plotted. These curves could preferably be the results of experiments on diode detectors, for, by this means, any errors due to the non-linearity of the diode for small inputs would be eliminated. The $g_m - E_g$ curves could be drawn on the framework as described above, with the exception that in this case the vertical scale of the $g_m - E_g$ curve will have to be "expanded" according to the number of controlled valves before the curves are copied, whereas in the previous method the framework is reduced to accommodate the $g_m - E_g$ curves.

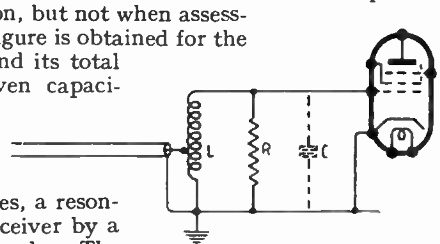
OUR COVER

A complete deflector coil assembly on the neck of a television C.R. tube is illustrated on the cover. Coil winding data for one pair of the coils included in it is given elsewhere in this issue and details of the other pair will be given next month.

Design Data (11)

AERIAL COUPLING IN WIDE-BAND AMPLIFIERS

INTERSTAGE couplings for wide-band amplifiers have been dealt with in Design Data (2), (3), (4) and (10). It was shown in the last that the aerial-to-first-grid coupling must be included as a stage in bandwidth computation, but not when assessing gain. As a result of this a figure is obtained for the inductance L of the circuit and its total shunt resistance R for a given capacitance C and bandwidth requirement.



Since wide-band transmissions are nearly always on V.H.F. or higher frequencies, a resonant aerial connected to the receiver by a feeder is invariably employed. The problem then becomes that of matching the feeder to the first circuit.

Most feeders have an impedance of about 75Ω and it is substantially resistive. Maximum power transfer occurs when it is so coupled to the circuit that the circuit shunt resistance is halved by the presence of the feeder.

If the total resistance set by the bandwidth requirement is R, then the circuit must be built for a resistance of 2R in the absence of the feeder and the feeder must be so coupled that it reflects a resistance of 2R into the circuit.

If the effective voltage ratio of tuned-secondary/primary is n, and R_f is the feeder impedance, the maximum transfer occurs when $n^2 = 2R/R_f$ and, by definition, the ratio of voltages at the grid of the valve to the feeder is n. In the ideal case, n would also be the turns ratio of the transformer; that is, if the coil L between grid and earth has N turns, the feeder would be tapped on at N/n turns from earth, or a separate coupling winding would have N/n turns. In practice, at high frequencies the coupling is very far from 100%, and the feeder connection must be at rather more than N/n turns. It is hardly practicable to calculate the right number, and N/n should be taken as giving only a rough approximation to it.

As an example, suppose L is found to need 9 turns and R is 2kΩ with $R_f = 75\Omega$. Then $n = \sqrt{(4{,}000/75)} = 7.3$ and the tapping is at about 1.23 turns above earth. In practice, it would probably be at about 1.5-1.7 turns. The artificial damping, apart from the feeder, must be arranged to be 4kΩ; it includes coil resistance losses, valve input resistance, and any additional damping resistor. The circuit is shown in the figure and the resistance R is thus rather more than 4kΩ.

The overall amplification from the feeder is then n times the amplification measured from the first grid. It will be seen that the step-up in the coupling is considerable and of the same order of magnitude as the gain of a valve stage.

It should be pointed out that it is sometimes possible to improve the signal/noise ratio by using somewhat tighter coupling than is indicated here. The improvement is small, however.

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MAINS TRANSFORMER PROTECTION

Fuses Designed to Withstand Initial Switching Surges

By
F. R. W. STRAFFORD, A.M.I.E.E.
(Belling & Lee, Ltd.)

It is a significant fact that the great majority of radio sets and electronic instruments embodying a mains transformer do not include fuse protection in series with the primary winding. The socket connection to the mains is generally backed by a fuse in the electric wiring of the building, but these fuses are invariably of 5 amp. or 15 amp. rating, and any defect in the apparatus giving rise to abnormal loads on the transformer would burn out the transformer long before the 5- or 15-amp. fuse cleared.

Since the cost of a small cartridge fuse and its holder is quite small compared with the cost of a mains transformer there do not appear to be economic grounds for its omission, particularly in high-grade laboratory equipment.

The reason for its omission is not difficult to establish. The simple type of cartridge fuse (Fig. 1 (*a*)) consisting of a filament of wire enclosed in a glass tube is not capable of withstanding the switching surge if its rating is equal, or near to, the rated current consumption of the equipment. This leads to the inclusion of a fuse of higher rating which will not clear on the switching surge. Unfortunately, the rating now becomes so high that the fuse will sustain overloads capable of burning out the mains transformer before the fuse clears.

At this stage it will be of interest to discuss the mechanism by which these switching surges are produced. An investigation was undertaken in which a number of pieces of laboratory apparatus were individually connected to the mains via a suitable recording device, to trace the amplitude and waveform of the primary current from the moment of switching on. It was observed that quite a large number of switchings could be made in which no surge occurred. This indicated that the moment of switching relative to the cycle of the applied E.M.F. is important.

The exact moment of switching, to provide the desired test surge is in the neighbourhood of that part of the applied E.M.F. wave where it is falling through zero amplitude and is also partly dependent upon the effective R/L ratio of the transformer referred to the primary circuit. The phenomenon has been analysed for an air cored inductance, and it is found that if an inductance of low R/L ratio (high Q) is connected to a source of alternating E.M.F. at the instant it rises through zero amplitude, the current which flows will rise to exactly twice the steady-state peak amplitude during the first half-cycle, rapidly falling thereafter to steady-state equilibrium conditions. The presence of the iron circuit, however, will increase the amplitude of the surge to more than twice the steady state if the iron is being worked near the bend of its B–H curve under steady-state conditions.

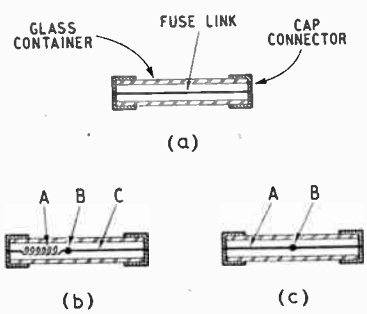


Fig. 1. (a) Simple cartridge fuse. (b) Spring-loaded fuse with low melting-point connection. (c) Magnesium-loaded nickel fuse.

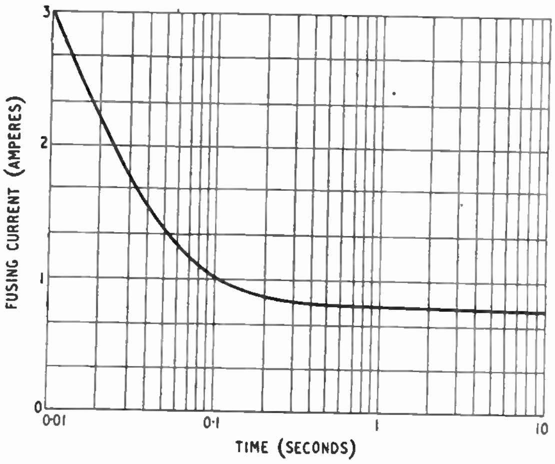
For reasons of economy, it is usual to select a cross-section of iron that gives this condition, so that any current over and above the rated current for the transformer will reduce the inductance. But this reduction in inductance will tend to cause the current to rise to an even higher value, and it is easy to visualise that this will tend to give a cumulative effect which comes into equilibrium by somewhat complicated energy transfer processes. For the types of transformers we are discussing, the surge can attain amplitudes some twenty times greater than the steady-state peak values of input current.

In examining the results of the tests carried out on a number of representative transformers two important characteristics were noticed. First, the duration of the surge never exceeded one half-period of the frequency of the applied E.M.F. The experiments were conducted using the 240-V, 50-c/s mains supply so that the surge never lasted longer than 0.01 sec. Secondly, the amplitude of the surge was not materially changed by "hot" or "cold" switching; i.e., whether the switching operation took place when the apparatus had been previously operated or not.

At this stage we will neglect the question of these surges and consider whether the simple type of fuse, as previously described, is likely to protect the average mains transformer of the type we have in mind, when faults arise causing excessive secondary loads.

Now, in accordance with British Standard Specification 646, a "B" category fuse (60 mA to 5 A) shall rupture within 1 minute where the current is 1.75 times the rated current. Starting on this basis transformers were first loaded on their secondaries until their design rating was attained, and a fuse of appropriate rating was included in series with the mains supply. The transformer was allowed to run for at least one hour under these conditions to attain temperature equilibrium. Inciden-

Mains Transformer Protection—
tally, the transformers tested were of the conventional type employing two valve heater secondaries and a 350–0–350-V H.T. secondary.



By short-circuiting any one of these three windings the fuse cleared instantly. It was noted, by separate measurement without a fuse in circuit, that short-circuiting a 4-volt winding caused the primary current to rise by 140 per cent. Short-circuiting the 6.3 volt winding caused a 300 per cent increase, and short circuiting the 350–0–350-V winding a 700 per cent rise. Fuses designed to B.S. 646 (category "B") will clear instantly on 100 per cent or greater overloads, a result verified by the foregoing short-circuit tests.

Reverting to the previous set-up (where the transformer was correctly loaded) each secondary winding was individually loaded until the primary current was 1.75 times the rated current. As would be expected the fuses cleared within 1 minute in each test. During the period prior to fuse clearance the average temperature of the windings was checked by noting the rise in winding resistance and employing the formula $R_T = R_0 [1 + \alpha T]$, from which one obtains $T = \frac{R_T - R_0}{\alpha}$, where R_0 is the resistance at 0° C, and α is the temperature coefficient of resistance. Most of the fuses cleared within 15 secs. and it was difficult to determine the temperature rise because of the lack of time to make observations. It was decided, therefore, to remove the fuses and maintain the 75 per cent overload for exactly 1 min, which is the top limit of the specification. Under these conditions the average temperature of the windings did not rise by more than 10° C. By holding the overload for 3 mins the temperature rose by 20° C.

It is clear that these temperature rises are not dangerous for a well-designed transformer, so that in the event of a fault causing the primary current to rise by a factor of 75 per cent or greater, a simple cartridge fuse designed in accordance with B.S.646 (category "B") would undoubtedly protect the mains transformer from breakdown.

Fig. 2. Time taken to blow fuse at various currents for a 0.5 amp fuse to specification B.S.646.

Thus the only deterrent to the wider use of B.S. 646 cartridge fuses for the class of application we have been discussing is their inability to withstand large current surges for a period of up to about 0.01 sec.

It was previously pointed out that these surges (for the type of transformer with which the radio and electronic industry are concerned) appear to reach, in the worst cases, some twenty times the normal rated peak current.

The simple type of cartridge fuse, covering ratings from 100 mA to 3 A, appears to possess a surge factor from 5 to 10 times the peak rated current. In a large majority of cases, therefore, such fuses will be blown by switching surges if their current rating is matched to the transformer rating.

The problem of protecting a transformer is thus one of designing a fuse which will meet the B.S. 646 specification in regard to the 1 min. overload test, but which will carry *at least thirty times its rated current for a period of* 0.1 *sec.*

In Germany a popular method of meeting this surge-resisting requirement is obtained in the manner indicated in Fig. 1(b). A coil of springy wire, A, is soldered by means of a blob, B, of low-temperature solder (e.g. Woods' Metal) to a fine manganin resistance wire C. The assembly is mounted under the spring tension in a glass tube and capped as in the familiar fuse construction. Under a prolonged overload of, say, two minutes, sufficient heat is generated by the resistance wire to melt the solder blob and the spring thus snatches the junction of A and C apart and clears the fuse. The temperature rise to cause disruption need only be of the order of 100° C, whereas for the filament-type fuse this may be 900° C or more according to the metal or alloy employed. Very sudden surges of large amplitude will not generate sufficient heat in the blob to cause it

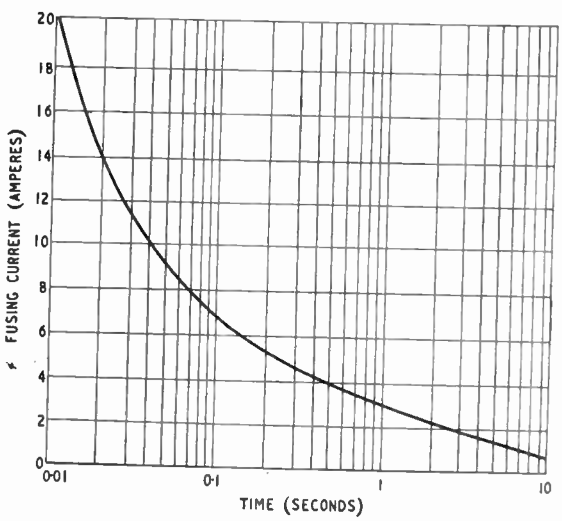


Fig. 3. Fusing current/time curve for magnesium - nickel fuse rated at 0.5 amp.

to melt, due, of course, to its large diameter relative to that of the wire, and its consequent high thermal inertia. The limit to the surge-handling capacity is set where the heat produced by the current is sufficient to raise the fine manganin wire to its melting point.

Naturally the greater skill and time taken to manufacture this type of fuse is reflected in its greater cost of production as compared with the single-filament conventional fuse. Fuses constructed in this manner will, however, protect transformers, and themselves, by virtue of their complete ability to withstand switching surges.

Another method* has been developed which permits of a construction whose difficulty lies about midway between the German fuse and the conventional type. The physics of its operation is quite different, however, and is as follows. A high melting point nickel wire A in Fig. 1(c) is made up into a conventional type fuse with the exception that it carries a small blob B of magnesium powder held together by a suitable binding varnish.

Now magnesium has a very great affinity for oxygen when its temperature is elevated, and at about 500° C it burns spontaneously, generating an intense heat. By careful manufacturing control of the diameter of the magnesium blob it is possible to manufacture fuses which will satisfy B.S. 646 long-time blowing requirements, but which will possess, in addition, a surge factor of approximately 40 times the rated current, thereby removing completely the disadvantage of the simple fuse.

Fig. 2 depicts the relationship between the fusing current and time for a 0.5 amp. rating fuse of the conventional type. This should be compared with Fig. 3 which represents the short time performance of a delay fuse embodying the magnesium nickel principle and designed also for 0.5 amp. rating.

While both fuses clear in about 10 seconds at 0.875 amps. (75 per cent overload) the delay fuse requires 20.0 amps. to clear it in 0.01 secs. as compared with 3.0 amps. for the simple fuse.

In practice it is usual to employ two blobs of magnesium per fuse, and these are respectively at about $\frac{1}{3}$ and $\frac{2}{3}$ of the length of the nickel element. The reason for this is to provide insurance in the event of one blob failing. The reason blobs are not placed in the centre is because, where the wire heats and expands, this region is obviously the more liable to touch the glass walls of the fuse container and inhibit blowing.

* Patent No. 473,335.

SHORT-WAVE CONDITIONS

Expectations for February

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

MAXIMUM usable frequencies for this latitude during December followed the expected triend, i.e., they decreased during both day and night-time. Whilst the daytime decrease was, however, only slight, the night-time M.U.F.s were quite considerably lower than during the previous month. Despite the slight decrease in daytime M.U.F.s, conditions were such that on most days high-frequency communication to most parts of the world was good for considerable periods. At night frequencies as low as 7 Mc/s were the highest that could efficiently have been used over many circuits.

There was very little ionosphere storminess during the month and only one disturbance of even moderate intensity occurred—during the period 19th-20th. Disturbances of minor intensity occurred on 3rd-4th, 11th-12th, 22nd and 25th-27th.

Forecast.—During February there should be a considerable increase in the daytime M.U.F.s and an appreciable increase in the night-time M.U.F.s, as compared with those for January. Both the seasonal and the sunspot cycle effects are such as to produce these increases. Communication on very high frequencies should therefore be good for considerable periods over most long-distance circuits, though the change in frequency as between daytime and night-time working frequencies will still be relatively great. Night-time M.U.F.s should however be such that frequencies lower than about 9 Mc/s will only be necessary over circuits traversing relatively high northern latitudes, and then only for limited periods.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during February for four long-distance circuits running in different directions from this country. In addition a figure in brackets is given for the use of those whose primary interest is in the exploitation of certain frequency bands, and this indicates the highest frequency likely to be usable for about 25 per cent of the time during the month for communication by way of the regular layers:—

Montreal:	0000	9 Mc/s		(14 Mc/s)
	0500	7 ,,		(12 ,,)
	0800	9 ,,	or 11 Mc/s	(13 ,,)
	1000	15 ,,	or 17 Mc/s	(19 ,,)
	1200	21 ,,		(29 ,,)
	1300	26 ,,		(36 ,,)
	1800	21 ,,		(30 ,,)
	2000	17 ,,	or 15 Mc/s	(21 ,,)
	2200	11 ,,		(16 ,,)
Buenos Aires:	0000	11 Mc/s		(16 Mc/s)
	0200	9 ,,		(14 ,,)
	0700	11 ,,	or 15 Mc/s	(16 ,,)
	0900	17 ,,	or 21 Mc/s	(26 ,,)
	1100	26 ,,		(37 ,,)
	1900	21 ,,	or 17 Mc/s	(26 ,,)
	2100	15 ,,		(21 ,,)
	2200	11 ,,		(17 ,,)
Cape Town:	0000	11 Mc/s		(16 Mc/s)
	0200	9 ,,		(14 ,,)
	0600	11 ,,		(18 ,,)
	0700	21 ,,		(29 ,,)
	0800	26 ,,		(38 ,,)
	1700	21 ,,		(31 ,,)
	1800	17 ,,	or 15 Mc/s	(21 ,,)
	2100	11 ,,		(17 ,,)
Chungking:	0000	7 Mc/s		(12 Mc/s)
	0500	11 ,,		(17 ,,)
	0600	17 ,,	or 21 Mc/s	(26 ,,)
	0900	26 ,,		(35 ,,)
	1100	21 ,,	or 17 Mc/s	(28 ,,)
	1300	15 ,,	or 11 Mc/s	(16 ,,)
	1600	9 ,,		(14 ,,)
	2100	7 ,,		(12 ,,)

Though February is not usually a particularly disturbed month the effects of any ionosphere storms which do occur are still likely to be troublesome over dark transmission paths, especially those which traverse high latitudes. At the time of writing it would appear that storms are more likely to occur during the periods 3rd-5th, 11th-13th, 18th-19th, and 22nd-23rd than on the other days of the month.

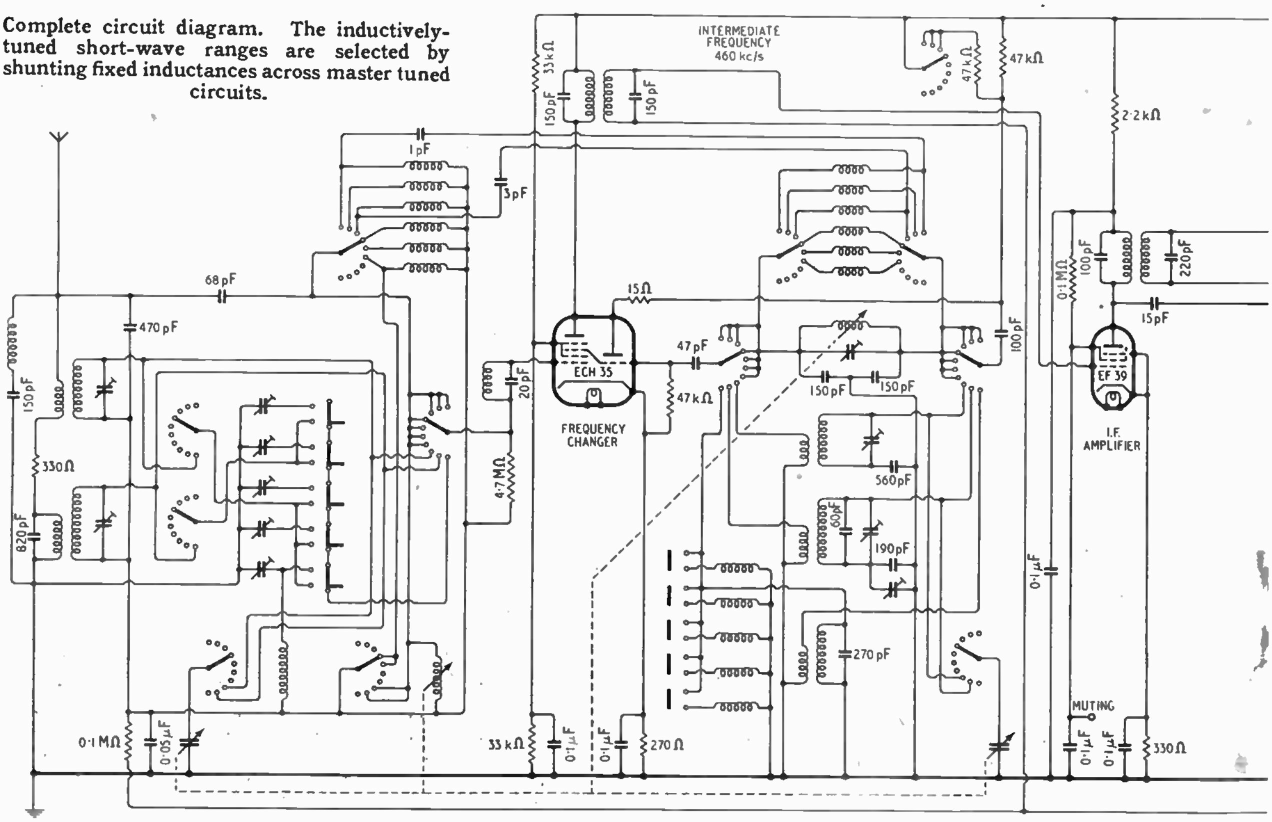
TEST REPORT

EKCO MODEL A28

Table Model Receiver for A.C. Mains

(Four Valves + Rectifier and Tuning Indicator)

THIS is a receiver which caters for every class of listener. Push-button tuning is provided for five stations, three on medium and two on long waves, so that the main programmes are instantly available without knob twiddling. Inveterate "ether-combers" will find the system of bandspread tuning very much to their liking, for it enables long-distance short-wave stations to be tuned-in with the facility of medium-wave stations. Quality enthusiasts have been provided with a tone control of unusual design, negative feedback in the output stage and a 10-inch loudspeaker.



Complete circuit diagram. The inductively-tuned short-wave ranges are selected by shunting fixed inductances across master tuned circuits.

Circuit.—On medium and long waves the circuit follows normal superheterodyne practice with ganged condenser tuning and magnetic coupling in the oscillator circuits. On short waves the gang condenser is disconnected and the oscillator is converted to the Colpitts type of circuit. Tuning is effected by "master" variable inductances in aerial and oscillator circuits with cores ganged to the main tuning drive, and inductances are connected in parallel to bring the frequency to the required ranges. A similar parallel arrangement is used for the push-button settings on medium and long waves. The aerial circuit is tuned by capacitance trimmers for the push-button stations and a parallel inductance is used to reduce the wavelength for the lowest range on the medium-wave band.

Television sound is received by the second harmonic of the oscillator when working on the 13-metre band. A fixed tuned circuit connected next to the grid of the frequency changer and working in conjunction with the valve input capacitance serves to tune the aerial input to the sound channel.

The intermediate frequency amplifier operates at 460 kc/s and together with the frequency changer is controlled by A.V.C. from the double-diode-triode valve. A muting terminal is provided for earthing the screen grid of the I.F. valve when using the set for gramophone reproduction. A Mullard EM34 is used as tuning indicator and provides two degrees of sensitivity.

WAVERANGES :

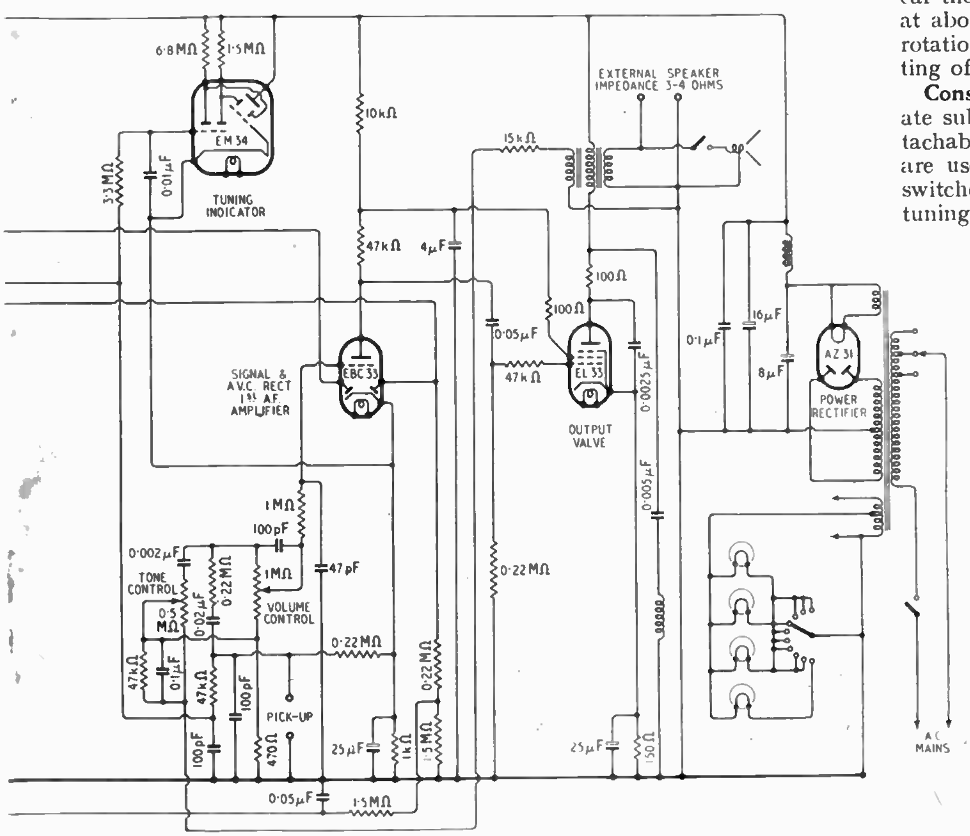
Short : 13.8-14 m. ; 16.6-16.98 m. ; 19.4-20.0 5. ; 24.6-25.9 m. ; 30.2-32.4 m. ; 38.4-43.0 m. ; 44.5-52 m. Medium : 200-550 m. Long : 900-2,000 m.

Price: £31 10s. plus £6 15s. 6d. tax.

The output stage has a 9-kc/s whistle filter permanently connected between anode and earth. Negative feedback is applied over two stages from a third winding on the output transformer. The feedback circuit is divided into two branches containing continuously variable R-C filters for bass and top boost. Simultaneous control is effected by a single potential divider. The volume control includes a simple form of tone compensation.

Performance.—The outstanding feature of this receiver is undoubtedly its short-wave performance. Freedom from frequency drift and the unusually wide degree of bandspreading on each of the principal broadcast bands make tuning easier, if anything, than on the medium-wave band. The automatic volume control is particularly effective and gives a steady audio-frequency output from signals which show very wide fluctuations on the cathode-ray tuning indicator. During the course of our test the programme from the Australian station VLB8 on 13.89 metres was received steadily for over two hours during the late morning—not a particularly favourable time for signals from the Antipodes.

Sensitivity and selectivity on the medium- and long-wave bands are up to the standard one expects from a modern four-valve super-heterodyne. Self-generated whistles were few and far between.



The loudspeaker delivers ample volume from the 2½-watt output stage and the tone control gives a wide choice of tonal balance. In the extreme clockwise position the "top lift" was considerable and seemed to be accompanied by an appreciable loss of bass. To our ear the best balance was obtained at about threequarters of the full rotation from the "bass lift" setting of the control.

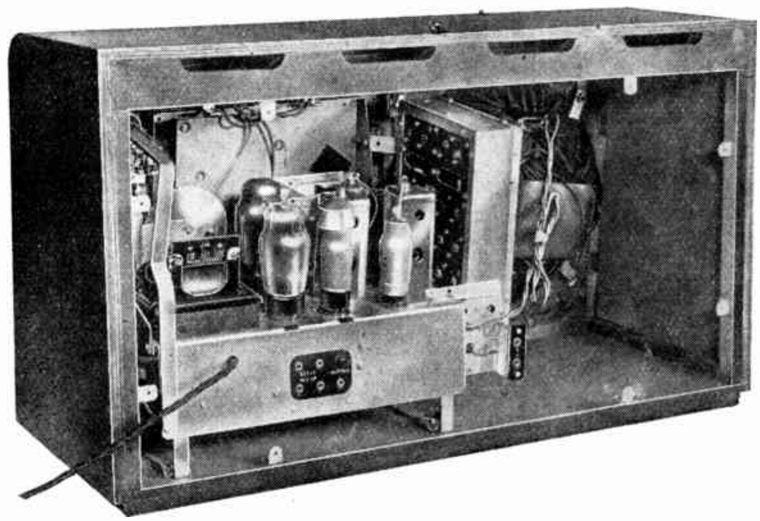
Constructional Details.—Separate sub-assemblies, which are detachable from the main chassis, are used for (1) the press-button switches and coils, (2) the gang tuning condenser, bandspread mechanism, drive and scale, (3) the aerial and oscillator coils and the waverange switch.

The indirectly illuminated Perspex tuning scale is provided with a series of pointers operating simultaneously on the vertical waverange scales. The range in use is indicated by a bar of light at the bottom of the scale. A neat cumulative stop mechanism is fitted to the tuning control spindle so that it is impossible to strain the tuning mechanism through the slow-motion reduction gear.

Instructions are given for fitting an external switch for muting the radio side when reproducing gramophone records. Alternatively, the user can search for a dead spot on one of the waveranges, or disconnect his aerial. We feel that in a receiver in this price category, the makers might

Ekco Model A28—
have found a tidier solution to the problem.

When the external loudspeaker is in use the internal speaker can be silenced by unscrewing slightly a small black terminal screw at the back of the set. Care should be used in making use of this facility for damage may result if the receiver is switched on without a load in the anode circuit of the pentode used in the output stage.



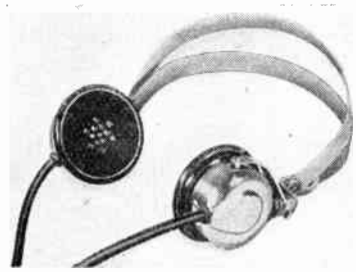
A separate screening box to the right of the chassis contains the tuning coils and waverange switch. The inductive tuning mechanism and gang condenser are mounted with the slow-motion drive on a detachable plate.

Makers.—E. K. Cole, Southend-on-Sea.

Moving Coil Headphones

THE design of the Type K headphones now being produced by S. G. Brown, Victoria Road, North Acton, London, W.3, is based on that of the moving coil microphones and head sets used by the fighting forces during the war. The response of the Services instruments was given a rising characteristic to ensure good intelligibility through extraneous noise, but in the Type K headphones the average response with constant input voltage is, according to the maker's curve, level within ±6 db from 200 to 5,000 c/s and tails off 10 db between 5,000 and 8,000 c/s and about 20 db between 200 and 50 c/s. There is a sharp cut-off at 8,500 c/s.

Modification of the response has been effected by a perforated cover plate shaped to fit the contours of the diaphragm. A thin plastic film prevents the ingress of moisture without interfering with the output.



S. G. Brown moving coil headphones, Type K.

The impedance at 1,000 c/s is 104 ohms per pair and a matching transformer will generally be required. We understand that transformers will be available for matching to 5,000, 7,000 and 10,000 ohms or 2, 6 and 15 ohms. The price of the Type K headphones without transformer is £5 5s.

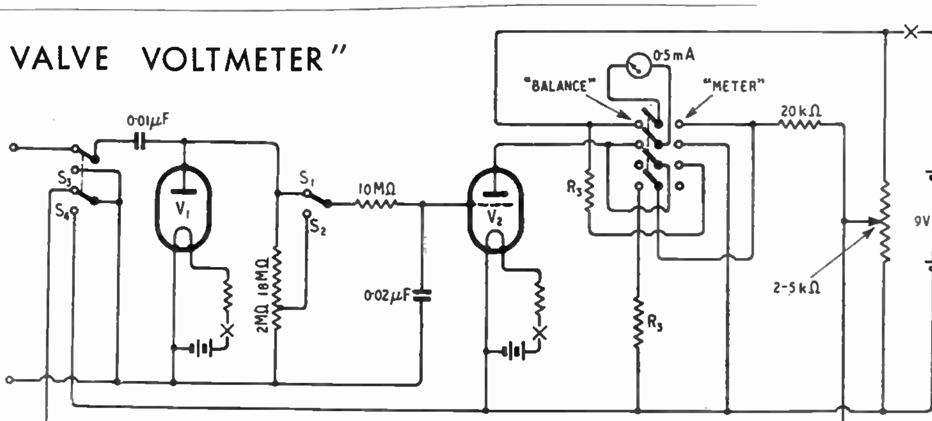
Industrial News

An Electronics Section has been formed by fourteen member firms of the Scientific Instrument Manufacturers' Association with Capt. A. G. D. West, director of Cinema-Television, Ltd., as chairman. The companies forming the Section are: Baird & Tatlock; Baldwin Instrument; Cinema-Television; Adam Hilger; Henry Hughes; Kelvin, Bottomley & Baird; Marconi Instruments; Mullard; Scophony; Short & Mason; Sperry Gyroscope; Sunvic Controls; Taylor Electrical Instruments; and Taylor, Taylor & Hobson.

E.M.A.—A revised schedule of subscription rates for membership of the Electronic Manufacturers' Association was recommended at the Annual General Meeting of the Association on January 22nd, this provides for a reduced subscription for smaller firms. Details are available from the Secretary, H. MacDougall, Vernon House, Sicilian Avenue, London, W.C.

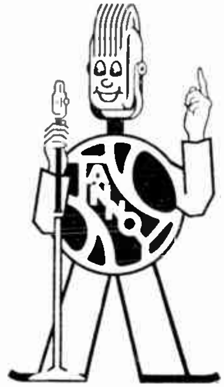
"SIMPLE VALVE VOLTMETER"

In Fig. 2 of the article which appeared on page 9 of the January issue, one or two errors occurred in the connections of the switches. The corrected circuit diagram is given here.



Ribbon Microphone, Type MR/415, freq. range 40-10,000 c.p.s. A high quality microphone suitable for relaying music or speech with excellent fidelity.

A 'SOUND'



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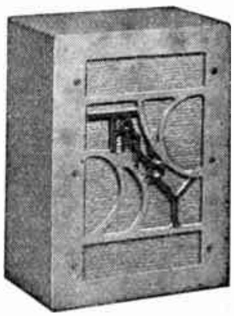

Wide Range Dual Unit Loudspeaker, Type LS/HF/5c, ideal for low level distribution systems.

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GUY R. FOUNTAIN LTD.,

" TANNOY " is the registered Trade Mark of equipment manufactured by

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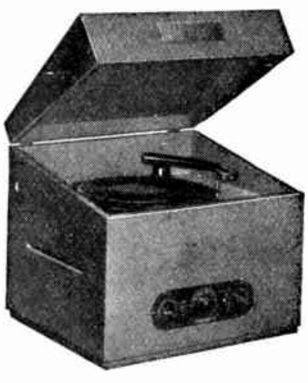


Radiogram, A.C. mains, Type RGG/AC/ML, Medium and Long waves, low output.

25 Watt Universal Transportable Amplifier, Type AUH/25, A.C. or D.C. supply of 200 to 250 volts.

gramophone milestones

Three dates stand out as important milestones in the history of the gramophone, the making of records and their reproduction.

In 1925 electrical recording was introduced, and Brunswick announced the "Panatrope," the world's first electric record reproducer.

The second milestone came twenty years later in 1945 when Decca announced ffrr—*full frequency range recording*. Twelve months later came the Decola, the world's first electric record reproducer having a frequency response range of thirty to fourteen thousand cycles per second.

Thought by some people to be a stunt, ffrr records had been made and marketed nearly twelve months before the announcement was made. Both critics and "man-in-the-street" music lovers had noticed a difference, and letters of appreciation showed that even when played on ordinary reproducers the outstanding qualities of ffrr definition and frequency coverage were immediately apparent.

Alongside the making of the new records a reproducer, equally revolutionary was taking shape, the desired characteristic being the distortionless reproduction of the full range of ffrr frequencies.

The result was the Decola, the coming of the gramophone into its own; a record reproducer ranking in musical qualities with the highest grade of pianoforte, bringing to the home and enriching family life with a range and variety of music impossible to obtain by means other than the Decola and Decca ffrr records.

There need be no secret about all this. It is the total sum of vision, enterprise, the ability to turn advanced theories into practical facts, and the co-ordiuation of the thinking and benchwork of a small team of enthusiasts. All of this will be explained clearly by word and diagram in this journal as soon as space permits . . . information which will enable you to bring your own reproducer as close to the Decola ideal as your resources permit.

ffrr

General ffrr recording technique, record groove shape, frequency characteristics, correction and bass compensation methods will all be explained, together with design details of the patented *Decca needle armature pick-up, amplifier and acoustical system*. This is the information you will be given to enable you to reproduce the living music of the concert hall from your Decca ffrr records . . . the music of the concert hall brought to your own home, just as the composer intended you to hear it, and true to the playing and singing of Decca international artists.

The Decca Record Company, Limited, 1-3 Brixton Road, London, S.W.9

HUM IN HIGH-GAIN AMPLIFIERS

Reducing Pick-up in the First Stage

By P. J. BAXANDALL
B.Sc. (Hons)

Typical microphone pre-amplifier and (right) experimental ribbon microphone.

WITH sufficient care, it is possible to make an A.C. mains-operated audio amplifier in which the hum level is quite negligible in comparison with the thermal-agitation or Johnson noise generated in the impedance of the input grid circuit, assuming the latter to be of the order of 50kΩ.

The Johnson noise itself is, unfortunately, just a fundamental fact of nature, and nothing can be done to reduce it, short of operating the whole equipment at a very low temperature![1] To give an idea of the order of magnitude of Johnson noise in an amplifier, the R.M.S. noise voltage across a 50kΩ resistance at ordinary temperatures is about 0.003 millivolt, the component frequencies being distributed throughout the audio spectrum. Now, 0.003mV is about the output obtained from a ribbon microphone transformer secondary, assuming an impedance of about 50kΩ, for a very quiet whisper at several feet from the microphone, so that if it is desired to be able to reproduce sound intensities down to this very low level, it is essential to ensure that hum is inaudible, or nearly so, compared with the Johnson noise.

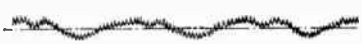


Fig. 1. Hum and noise output from microphone pre-amplifier, using SP41 valve with 100kΩ resistor between grid and earth.

One helpful fact is that due to the relative insensitivity of the human ear at low frequencies, an amount of hum which looks serious in comparison with the Johnson noise when displayed on a cathode-ray tube, may be almost completely inaudible on a loudspeaker. Fig. 1 is a reproduction of the output waveform of a microphone pre-amplifier made by the writer, using an SP41 valve, with a 100kΩ resistor across the input terminals. The hum was then just comfortably audible in a loudspeaker, but was quite faint compared with the "mush" due to Johnson effect.

It is not always necessary in practice to secure this degree of freedom from hum, since in many applications, such as P.A., the minimum sound intensity is high, but there are obviously occasions when it is desired to reduce all background noises to the absolute minimum. The writer has found that the factors requiring careful attention if this result is to be achieved do not seem to be very widely known by those who build audio amplifiers, and it is the aim of this article to give some practical information on the subject.

Some of the causes of hum, when an A.C. heater supply is used, are due to effects occurring within the valve itself.[2] Care must be taken to choose a suitable type, and further information on this will be given later in the article. It is also essential, however, to adopt the right layout of the internal circuit if serious hum is to be avoided.

In general, assuming that the obvious requirement of adequate smoothing of the H.T. supply has been attended to, there are two ways in which hum can arise in the external circuit, i.e.:—

(a) Pick-up of hum voltages by unscreened leads in the grid-cathode circuit, due to stray capacity between these leads and parts of the circuit carrying mains alternating potentials. This is often called "electrostatic hum"—though the ending "static" is rather a misnomer.

(b) Induction of hum voltages into wiring "loops" in the grid-cathode circuit, due to the presence of stray A.C. magnetic flux from mains transformers, chokes, heater wiring, etc. This is often called "magnetic hum."

Obviously these effects can also occur in screen and anode circuits, but owing to the much higher signal level the result is often negligible.

The cure for electrostatic hum is simply to provide screening for all high-impedance parts of the grid-cathode circuit, together with adequate values of by-pass condenser for cathode and screen. (There is also the matter of using a "hum-dinger" across the valve heater, but this is dealt with later). The main part of this electrostatic

[1] "Valve and Circuit Noises." *Wireless World*, May, 1940.

[2] "Valve Hum," by C. E. Cooper. *Electronic Engineering*, July, 1944.

Hum in High-Gain Amplifiers— screening is provided by using a screened lead between the grid of the valve and the amplifier input connection, and a screened top-cap connection if the valve has the grid connection on top. A complete valve-screen is also essential if the valve is unmetallized.

With regard to the signal input

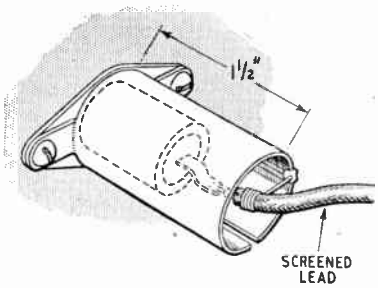


Fig. 2. Home-made sheet-metal screen for input terminal.

connection to the amplifier, the writer strongly recommends the use of a coaxial plug and socket. If ordinary screw terminals or a socket-strip are used, then part of the high-impedance input circuit becomes unscreened and may give rise to hum, especially if the whole equipment is not connected to a good earth. (Though it is always desirable to earth a high-gain amplifier system, there may be occasions when it is not practicable to do so, and if all precautions have been taken, freedom from hum should still be obtained.) The use of a coaxial system also avoids the forming of a "magnetic loop," as explained below. A short length of unscreened lead can be treated by the use of a small sheet-metal shield. See Fig. 2.

Wiring Loops

We now come to "magnetic hum" and its prevention. First, it should be realized that ordinary screened leads, valve screens, etc., give very little, if any, reduction.

Fig. 3 is intended to represent a bad layout from the magnetic hum point of view; screening has been omitted, since, for the moment, we are not concerned with the prevention of electrostatic hum.

It will be seen that the connection from the earthy input terminal to the valve cathode is via the chassis, whereas the connection from the other input terminal to the grid follows a very different path. Now if stray magnetic flux is present, some of it will probably pass through the loop, or "one-turn coil," *abcd*, labelled L_1. Similarly, there will be flux linking with loops L_2 and L_3. Since alternating magnetic flux passing through a coil causes an alternating E.M.F. to be induced in it, L_1, L_2 and L_3 will all have induced E.M.F.s in them; this state of affairs has been represented diagrammatically in Fig. 3 (b), where e_1, e_2 and e_3 are the induced E.M.F.s.

Whether the hum voltages e_1, e_2 and e_3 will be in phase cannot readily be prophesied, for the exact distribution of the stray flux is unknown, but if we take the worst possible case, then a total hum voltage of $e_1 + e_2 + e_3$ will appear between the grid and cathode of the valve.

That a voltage of any consequence could be induced in so small a loop by the weak and comparatively slowly changing stray magnetic flux may at first be surprising; but calculation shows that an E.M.F. of 0.01mV R.M.S. (about 10db up on the Johnson noise level in a 50 kΩ resistance) is induced in a loop of area 10 sq cm by a 50 c/s magnetic flux, at right angles to the plane of the loop, of peak density only about 0.5 lines-per-square-centimetre; and this is small enough to be caused by a mains transformer a considerable distance away, for the usual peak flux-density in a mains transformer is about 10,000 lines/sq cm.

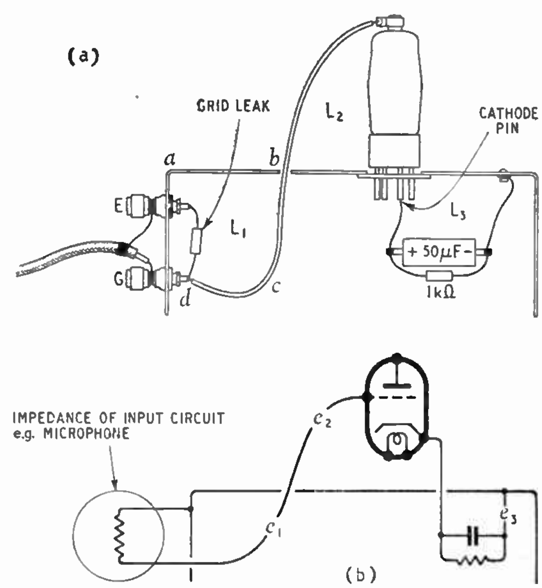


Fig. 3. (a) Shows a poor layout from the point of view of magnetic hum. (b) E.M.F.s induced by stray magnetic flux into loops L_1, L_2 and L_3 act in series between grid and cathode.

From the above it will be clear that magnetic hum can be prevented, or at least greatly reduced, in the following two ways:—

(a) By arranging the wiring of the input grid-cathode circuit so that loops are reduced to the absolute minimum area.

(b) By arranging the equipment so that the stray field from mains transformers and chokes is kept away from the highly sensitive input circuits.

The most completely satisfactory layout known to the writer is that shown in Fig. 4. By using the metallizing of the valve as a connection from the screening of the input lead to the bias resistance and condenser the system is made coaxial all the way, thus almost completely avoiding loops and at the same time providing good electrostatic screening.

It will be noticed that there is only *one* connection between the earthy side of the input and the chassis, i.e., at "E." It may be tempting to "make doubly sure" and put a second earthing point, say, at "P," but it is almost certain that this will cause a considerable increase in magnetic hum, because there will then be two paths in parallel from the earthy side of the input to the cathode—one via the input lead screening and the other through the chassis. That through the chassis will probably be of much lower resistance than the other, and will "take charge," so to speak, so that one will really have reverted to an arrangement almost as bad as that in Fig. 3.

Fig. 5 shows a layout which, though not quite as good as that in Fig. 4 from a theoretical point of view, is often quite adequate in practice, especially when the mains transformer is a considerable distance from the input circuit. The screened lead should be kept as near to the valve as possible to reduce the area of the loop formed with the cathode lead in the valve.

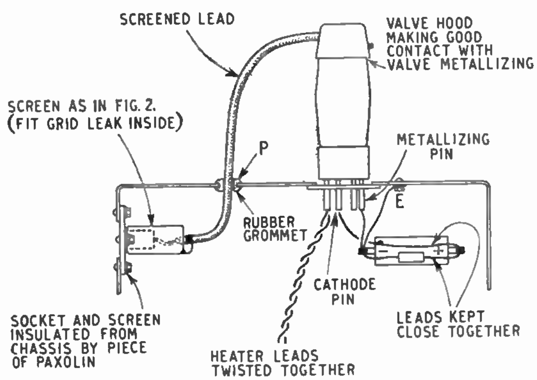


Fig. 4. Recommended layout. If valve metallizing is joined internally to cathode, the hood must be insulated from the metallizing and earthed via an insulated wire running close to valve.

Another point is that it is preferable to use a non-magnetic metal for the chassis of the low-level part of the amplifier; this is specially the case when the mains components are near, or in equipment mounted on a steel rack, in which case the uprights of the rack may provide easy paths for magnetic flux from transformers in other units of the rack assembly.

We now come to causes of hum associated with the valve itself. The main effects are:—

(a) Stray capacity coupling between grid and heater leads.

(b) Leakage between heater and cathode, and/or electron emission from heater to cathode.

(c) Direct influence of the electron stream by magnetic fields, either from the heater or from external sources.

Factor (a) may be reduced by using a valve with a top-cap grid connection. For grid impedances of about 50 kΩ and below, it is usually possible to obtain quite satisfactory results with valves having the grid brought out to a base-pin; but for high-impedance microphones, such as crystal microphones, it is essential for good results to use the top-grid type of valve.

The common practice of earthing one end of the heater winding is quite inadequate in low-level microphone amplifiers, and will usually give rise to serious electrostatic hum. The correct procedure is to connect a potentiometer of 50 to 500 Ω across the heater, and take the slider either to earth, or in some cases to a point about 6 volts positive to earth. (This is explained later.) If the potentiometer ("hum-dinger") is carefully adjusted, the electrostatic hum, due to stray capacity coupling between the grid and heater circuits, can be made to balance out almost perfectly, leaving only a trace of hum, mostly magnetic in origin.

Fig. 6 shows how the hum in an amplifier built by the writer, using an SP41 valve, varied with the setting of the "hum-dinger"; each curve being for a different grid circuit impedance. It will be noticed that the setting for minimum hum is not necessarily exactly at the centre of the element, and in fact it was found to vary by about 20% for different valve samples. It will also be noticed that the setting is much more critical for high grid impedances than for low ones; it may therefore sometimes be reasonable to replace the potentiometer by a couple of fixed resistors of equal

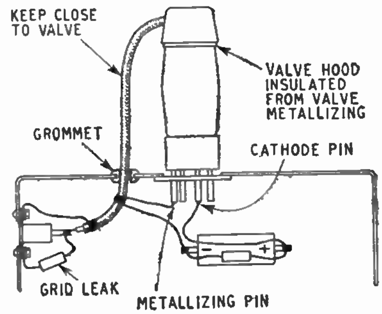


Fig. 5. A good practical layout —often quite adequate.

value, or use a centre-tapped transformer winding, if the grid circuit impedance is fairly low.

The purpose of taking the slider of the "hum-dinger" to a point positive to earth is to prevent electron emission from the heater to the cathode. Fig. 7 shows the improvement produced by doing this in the SP41 amplifier mentioned above. Different valves, even of the same type, vary greatly in the degree to which they produce this effect. Another way of curing the trouble, which is sometimes equally effective, is to reduce the heater voltage slightly, say to 3.7 volts for a 4-volt valve.

Serious leakage between heater and cathode can naturally be cured only by substituting a better valve!

Direct influence of the electron stream by the magnetic field from the heater is largely dependent on the type of heater employed, the best type being the "non-inductive helix." However, the writer's experience is that the amount of hum due to this effect in a carefully selected SP41, which has a "triple-hairpin" heater, is negligibly small if the grid impedance is greater than about 50 kΩ.

If it is unavoidable to have mains transformers, etc., fairly near to the first amplifier stage, then it is sometimes possible to remove most of the resultant magnetic hum by wrapping pieces of Mumetal (e.g., cut from transformer laminations) round the valve.

Coming now to the choice of specific valves, the writer has

Hum in High-Gain Amplifiers—
found that the best readily available valve is the Mazda SP41. However, it seems that the earlier SP41s, having green markings, are on the whole better for this purpose than the more recent sort with black markings; but in either case it is usually necessary to select from several valves that give the lowest hum. If a 6.3-volt heater is preferred, the SP61 or the R.A.F. VR65, now obtainable from surplus stores, are to be recommended; these are in other respects the same as an SP41. Of American valves, the metal 6J7, or preferably the 1620, are very good, the latter being usually less microphonic than an SP41. For low-impedance grid circuits (i.e., 50 kΩ or less) the 6AC7, with a base grid connection, is satisfactory.

The best valve of all, if it can be obtained, is probably the Mazda ACSP3. This was designed with a special view to low hum and microphony, and is widely used by the B.B.C. for microphone amplifiers. Even with this valve it is found that individual specimens vary in their hum properties, and selection is again desirable.

Other things being equal, valves with high-voltage low-current heaters give less magnetic hum than low-voltage high-current types. The Osram H30 triode, with a 13 volt 0.3 amp heater, is *very* good as a first-stage microphone amplifier and is still used to some extent.

However, the writer believes that a pentode is almost always the best choice for this purpose, for the following reasons:—

(a) Much higher stage-gain can be obtained.

(b) There is no appreciable Miller effect, and therefore the input impedance is high enough to suit any type of microphone.

(c) Owing to the relatively high signal level in the anode circuit when a high-slope pentode is used, an ordinary type of carbon resistor can be used for the anode load without trouble from the "carbon noise" generated by the passage of the anode current through it.

In connection with (c), experiments have shown that the amount of noise from a carbon resistor of say 100 kΩ with 1 mA current, is many times greater for a small ¼-watt type than for a 1 or 2-watt resistor, the noise voltage becoming progressively less as the physical size of the resistor is increased.[3]

The general order of noise voltage is 0.1 mV for a ¼-watt resistor of 100 kΩ with a voltage drop of 100 volts, falling to under 0.01 mV for a 2-watt resistor under the same conditions. The Johnson noise voltage across a 100 kΩ resistance is about 0.004 mV R.M.S. Thus if the stage gain is 100 to 200 times, and the grid impedance not much less than about 50 kΩ, one is quite safe in using a ½-watt anode load resistor of the ordinary carbon type.

The circuit diagram of the single-stage pre-amplifier used by the writer is given in Fig. 8. The gain is slightly over 200 when feeding into a following stage having a 250 kΩ input potentiometer, and the response flat to within 1 db from 30 c/s to 220,000 c/s, provided the input capacity of the next stage does not exceed about 40 μμF.

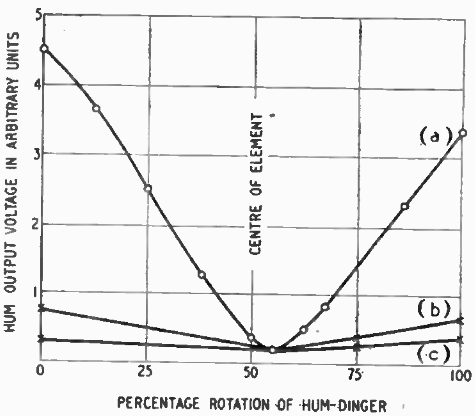


Fig. 6. Reduction of electro static hum by use of potentiometer across heater (a) with 1MΩ grid leak, (b) with 47kΩ grid leak, (c) with input short-circuited.

It will be noticed that a paper decoupling condenser is used for the second stage of decoupling. This is not really essential, but is the best practice, since electrolytic condensers sometimes give rise to "frying" noises, particularly if not new. Trouble from electrolytic cathode by-pass condensers seems to be rare, but naturally only the best quality new condensers should be used.

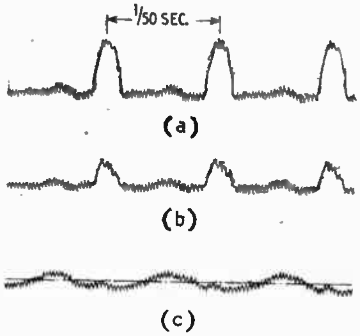


Fig. 7. Oscillograms of hum and noise with and without positive bias on heater. (a) Slider of hum-dinger earthed, (b) slider of hum-dinger at +1.5V to earth, (c) slider of hum-dinger at +4.5V to earth

Another very prevalent cause of hum is the induction of hum voltages into the microphone coupling transformer, due to stray magnetic hum fields.[4] When a ribbon microphone is used under conditions of maximum gain, it will be found essential, if an unscreened input transformer is used, to have the transformer at a distance of at least 12 feet from the power-pack; and even then it may have to be carefully orientated for minimum hum.

In cases where the microphone never has to be used at very great distances from the amplifier, an economical and very satisfactory arrangement is to use only one transformer, inside the microphone casing, wound to give a secondary impedance of about 20 kΩ. Up to 20 feet of cable can then be used between the microphone and the amplifier, without losing more than a decibel or two of response at 10,000 c/s. This is assuming a low-capacity cable is used, of about 20 μμF per foot. Some of the recent polythene-insulated R.F. coaxial cables are quite suitable.

A useful reduction in hum

[3] "Carbon Resistors," by R. H. W. Burkett, *Wireless World*, January, 1944.

[4] "Pick-Up Coupling Transformer," by J. Brierley, *Wireless World*, July, 1943.

pick-up can be obtained by using the "astatic" type of transformer construction. The improvement may amount to about 30 db in practice.[5] The core of the transformer must be earthed to avoid electrostatic hum, and, unless the transformer has an internal electrostatic screen, the primary winding may in some cases be earthed with advantage.

A further trouble often experienced with low-level audio amplifiers is valve microphony. If the loudspeaker is used near to the amplifier, then the presence of microphony may cause a howl to build up, due to acoustic feedback from the loudspeaker to the input valve. Individual valves vary greatly in this respect, and occasional samples are very bad indeed.

However, even with good valves, it is always advisable to adopt some sort of anti-vibration mounting, and the best system is probably to mount the input valve, together with its decoupling condensers, etc., on a small sub-chassis, and suspend this by means of rubber cords attached to some convenient part of the main amplifier structure.

In conclusion, the writer would like to thank C. G. Mayo, D. O. Roe, and A. Tutchings, as a result of discussions with whom some of the points mentioned above were first fully appreciated.

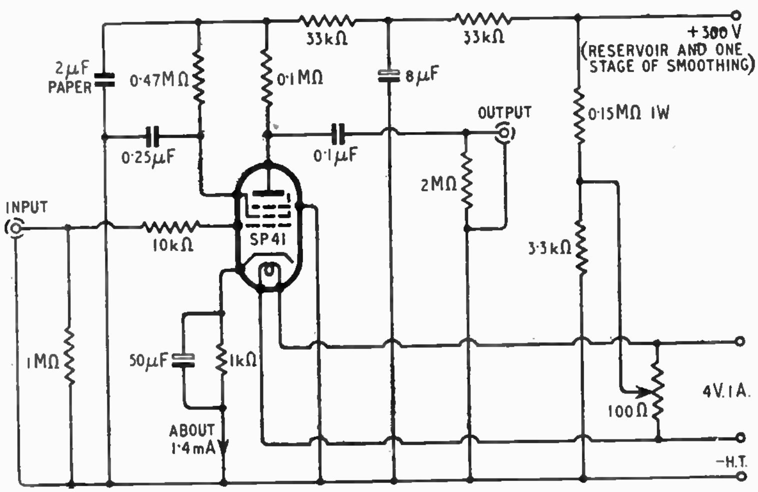


Fig. 8. Circuit diagram of the writer's microphone amplifier. All resistors ½ watt except where otherwise stated.

[5] "Notes on Transformer Design," by E. B. Harrison. *Electronics*, February, 1944.

TELEGRAPH KEY DESIGN

Scientific Analysis of Fundamental Requirements

Of all the component parts of the earliest wireless stations of fifty years ago, the morse key is the only one that has survived to the present day in unchanged, or at least in recognizably similar, form. So it would seem a fair assumption that keys are not susceptible to any great improvement; also that we know all that need be known about them.

Faith in the correctness of these assumptions is rudely shaken by an article in the *Marconi Review* (July-September, 1946) by H. J. H. Wassell. The author makes a detailed analysis of the factors involved in the manipulation of a telegraph key, and concludes that the desirable features are: (1) a moving arm of small mass and of "dead" metal; (2) arm length not less than 2½in, but not greater than is necessary to keep down the amplitude of transverse vibration; (3) a small gap, consistent with electrical loading; (4) contacts at or about the centre of percussion.

The need for a low moment of inertia is obvious if fatigue over long periods of working is to be avoided. Aluminium meets this requirement and also has the requisite "deadness," as measured by the inverse of the specific acoustic resistance. Transverse vibrations of the arm which might confuse the operator are thus quickly damped out. It has been found that in some older keys the natural period of vibration is comparable with the transit time of the key at the highest keying speeds (say 35 words per minute).

New Marconi telegraph key with calibrated adjustment of spring tension and contact gap.

The minimum arm length of 2½ inches is dictated by the divergence of the circular movements of the key arm and the hand of the operator, pivoting on the wrist. With an arm radius of more than 2½ inches and small contact clearances, the divergence from vertical motion is negligible and does not induce unnatural movement of the hand and consequent fatigue.

Contacts should be mounted close to the knob so that the pivots are relieved of resultant forces and there is less risk of setting up complex vibration in the arm.

All these factors have been taken into account in designing the latest Marconi key, the leading dimensions of which are compared with a representative older key ("A") in the table below.

Knife-edge pivot bearings loaded by the tension spring are used, as it is found that ball races show a tendency to dent with long use. The spring tension is adjustable by a knurled knob at the side of the key, and the gap is varied by rotating the skirt of the operating knob.

TABLE

	"A" Key.	New Key.
Weight ...	3 lb 2 oz	1 lb 3 oz
Volume (Overall cuboid) ...	158 cub in	23.5 cub in
Plan (Overall) ...	49 sq in	19 sq in
(Body) ...	40 sq in	14 sq in
Mass of Moving Arm (less pivot bar) ...	4½ oz	2 oz
Length between Knob and Pivot ...	3 13/16 in	3¼ in
Height of knob skirt above Bench...	2½ in.	1 1/16 in
Nat. period of transverse vibrations ...	470 cps	4,200 cps
Amplitude of transverse vibration for given impact ...	1 unit	1/8 units
Nat. period of bar as pendulum ...	0.72 sec	0.57 sec

NAVAL RADIO GEAR

Communication Equipment of British Warships

By G. M. BENNETT

A WHOLE book could be written on the British Navy's radio communication system: The world-wide network of big shore stations linking the Admiralty with every Command; the chains of shore stations within each Command linking the naval bases and providing communication with ships at sea; and, finally, the radio organization required within each fleet. The latter needs many channels for inter-ship operational and administrative traffic, for manoeuvring signals, for radar reporting, for gunnery control, for the direction of aircraft and many other purposes.

Aircraft carrier *Vengeance*. The masts on the side of the flight deck can be swung outboard to a horizontal position to avoid their being fouled by aircraft. V.H.F. direction-finding aerial is carried on the short mast forward.

In practice the equipment to be fitted in ships must necessarily be a compromise, for the amount which can be installed in the smaller vessels is restricted by their size. But then, for example, a destroyer screening the fleet is not required to man the large number of channels needed in a battleship carrying the admiral-in-command or an aircraft carrier which, in addition to maintaining communication with other ships, must also be able to work with aircraft.

Transmitting and Receiving Rooms

There is little difference between the equipment fitted in battleships and cruisers, the majority of which is arranged in five compartments. In the forward superstructure, conveniently adjacent to the Command, is the Bridge Receiving Room (B.R.R.). This contains nearly a dozen receivers covering the low-, medium-, high-, and very-high-frequency bands; i.e., from the 16 kc/s, used by Rugby for the Admiralty's simultaneous morse transmissions to the whole fleet, up to the 100-150 Mc/s band used for radio-telephone communication with aircraft. There is also the medium-frequency direction-finding set used for navigational purposes and a 50-watt emergency transmitter and associated receiver which can be operated off batteries in event of a failure of the ship's normal power supplies.

Also fitted high up in the bridge structure, in order to reduce to a minimum the length of the aerial feeders, is a small compartment containing the V.H.F. radio-telephone transmitters used for communication with aircraft and on the short-distance inter-ship manoeuvring wave.

The majority of the ship's

Bridge Receiving Room of an aircraft carrier. All-wave receivers are mounted in a row above the operators' bench on the right. The larger set in the left foreground is the medium-frequency D.F. outfit.

transmitters covering the medium- and high-frequency bands, are, however, divided, on the principle of not putting all one's eggs in one basket, between two transmitter rooms aft below the mainmast. The Lower Transmitter Room (L.T.R.) is well below armour for protection against bomb hits and shell-fire. It contains a 400-watt medium-wave W/T transmitter, a H.F. set of similar power for either W/T or R/T and two 50-watt sets. There is also a crystal wavemeter of high accuracy.

Whilst the L.T.R. is protected by armour, it is liable to damage by torpedo, mine or other underwater explosion. Furthermore, the efficiency of its transmitters suffers from the lengths of the trunks needed to carry the aerial leads to the upper deck. A second transmitter room (the Upper T.R.) is, therefore, sited in the after superstructure. Here are fitted a 5-kW medium-wave W/T transmitter, a 2-kW H.F. set for W/T or R/T, a similar set with an output of 400 watts and two 50-watt sets.

Finally, and chiefly as a stand-by for the B.R.R., a second receiving room (the Lower R.R.) is sited below armour adjacent to the L.T.R. Apart from receivers, this contains the perforators, undulators and relays needed for high-speed morse transmission.

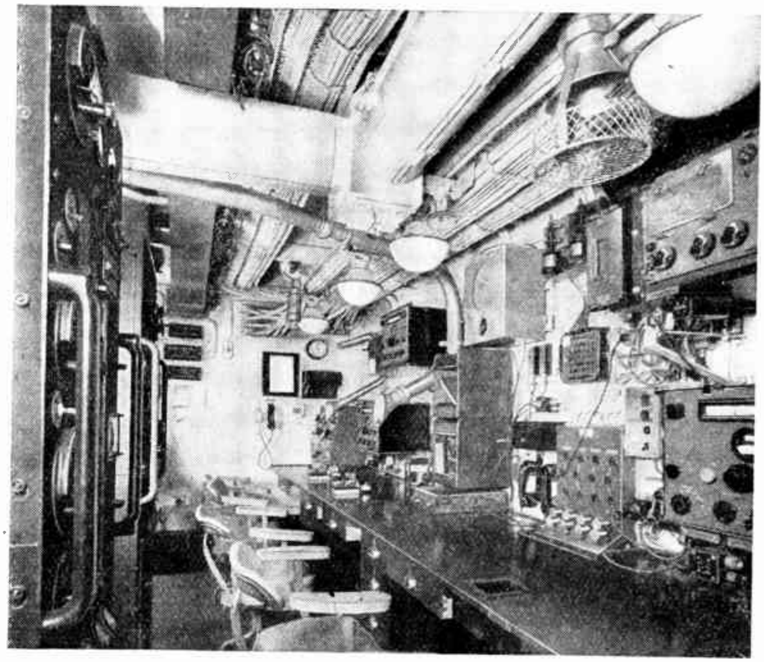
An extensive remote control system is provided to allow the sets in the three transmitter rooms to be controlled from any receiving position in either the B.R.R. or the L.R.R. and from such points as the bridge for manoeuvring purposes and the operations room for the direction of aircraft.

Power for all the equipment is supplied by three 40-kW motor alternators widely spaced in the ship providing a 50-cycle three-phase 400-volt A.C. supply.

Aerial Arrays

It will be appreciated that with so much equipment installed within the limited space of a warship, not to mention the radar equipment which does not fall within the scope of this article, special measures are necessary to avoid interference. This is the reason for fitting all the medium- and high-frequency transmitters in two compartments aft. For, thereby, the aerials can be concentrated on the mainmast and separated from the receiving aerials on the foremast which feed direct to the B.R.R. forward, and via feeder lines to the L.R.R. aft.

Unfortunately the arrangements of a ship's masts, the necessity to avoid fouling the arcs of gunfire and the obvious fact that, with a ship which may at any time be altering course, directional transmissions are impossible, only the simple types of aerial are possible. Furthermore, owing to the wide range of frequencies which the medium- and high-frequency sets are required to cover these aerials cannot be cut to their optimum length for any particular frequency. In consequence the medium-frequency transmitters are provided with roof aerials run between the two masts but terminating at such a distance short of the foremast as will obviate interference with the single wire, vertical receiving aerials rigged thereon for the B.R.R. The high-frequency transmitters all use single wire, vertical aerials grouped on the mainmast. In the case of the V.H.F. sets, however, dipoles are practicable and, since here the interference problem is not so acute, these are arranged at the foremasthead and at the extremities of the forward yards. Other measures necessary to obviate interference with a ship's receivers include elaborate aerial filters and special circuits designed to eliminate the shock impulse received from radar pulse transmissions.



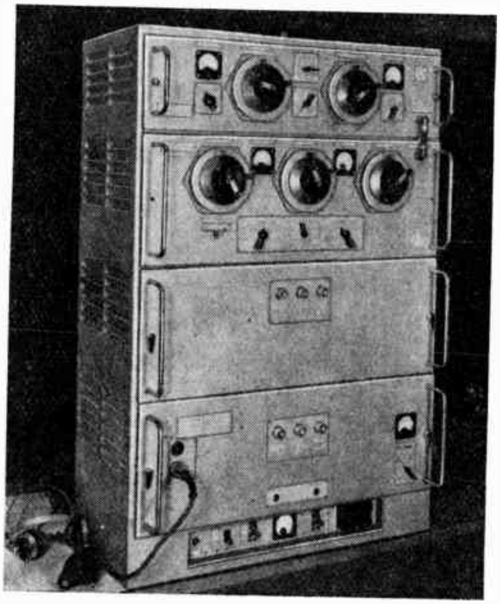
Main W/T office of a modern destroyer. The transmitters are on the left. Mounted above the bench on the right are the medium-frequency D.F. equipment, a number of all-wave receivers and the aerial and control circuit exchanges.

Aircraft Carriers

In aircraft carriers the amount of equipment installed, particularly for working on the 100-150 Mc/s band, is more extensive to meet the needs of aircraft operations. The peculiar structure of these ships necessitates a slightly different arrangement of the offices. The B.R.R. is sited in the island on the starboard side of the flight-deck just below the bridge. The three transmitter rooms are below the flight-deck separated as widely as possible in order to avoid more than one being put out of action by the same bomb or shell hit. And the stand-by receiving room is sited

Naval Radio Gear—
adjacent to one of these. Three masts on each side of the flight-deck, which fold outboard down to a horizontal position when aircraft are either landing on or flying off the deck, carry the medium- and high-frequency transmitting aerials. Single wire, vertical receiving aerials on the tripod mast mounted before the funnel on the island feed the B.R.R. Others rigged horizontally from booms jutting out each side of the flight-deck feed the stand-by receiving room. The extensive V.H.F. equipment requires a large number of dipole aerials erected on the many yards and spurs provided on the island's tripod mast.

D.F. sets working on the high- and very-high-frequency bands are also installed to give bearings to aircraft. And there is an automatic wireless beacon working in the V.H.F. band which enables the pilots of planes to determine instantaneously at any time the bearing of their parent ship.



The Navy's new compact 50-watt H.F. transmitter. Each of the four units can be easily withdrawn from the front for maintenance. When a 400-watt output is required an additional power amplifier is provided.

In destroyers the amount of radio communication equipment is on a smaller scale. With the exception of a small office aft containing a battery-fed, low-power transmitter and associated receiver for emergency use, the whole of the equipment is fitted in the main W/T office normally sited below the bridge on the level of the upper deck. The installation includes a 400-watt transmitter, which can be used for either medium- or high-frequency work, two 50-watt high-frequency sets, three V.H.F. sets, four all-wave receivers plus three for V.H.F., a medium-frequency D.F. set for navigational purposes and a high-frequency D.F. outfit for locating U-boat transmissions.

It is impossible to describe in one article the arrangement of the equipment in the many other types of warship now in service. But it may be mentioned in brief that these include depot ships, which carry the necessary high-power transmitters to enable them to perform the duties of a shore station at an advanced base, and headquarters ships for amphibious operations which carry the extensive equipment required to communicate not only with all the craft which take part in landings on a hostile shore, but also with R.A.F. planes operating over the beaches.

Then there are frigates and corvettes which are equipped on a similar scale to a destroyer, and submarines for which all equipment has to be especially designed in order to be fitted within the restricted space of the rounded hull.

Developing Communication Gear

The majority of the radio communication equipment installed in warships is designed by the staff of the Admiralty Signal Establishment, Haslemere, and manufactured by commercial companies. A proportion is, however, designed by the commercial companies themselves by development contract to meet specific Admiralty requirements.

Space will not permit any detailed description of modern naval radio communication equipment but a few of the more interesting developments may be mentioned in conclusion.

Since considerable difficulty was experienced in finding suitable mast sites for the large number of V.H.F. sets now required in the larger warships, the Admiralty Signal Establishment has developed a method of operating up to four such transmitters of 200 watts output simultaneously on a single rod dipole aerial without appreciable detriment to performance. Similarly, to relieve the position as regards H.F. aerials and to provide aerials which are not susceptible to breakage due to mast-whip when a ship is struck by bomb or shell, vertical "whip" aerials (in the form of a thin flexible rod supported at one end only) are now being used. These can be mounted in suitable positions on the superstructure or, to gain height, on the funnels.

The Navy's latest M.F. and H.F. transmitters are designed on the unit system. The basic units—50-watt sets covering, respectively, the M.F. and H.F. bands—are used where low-power sets are sufficient. Where higher power is needed, additional units in the form of power amplifiers are added.

MINIATURE SUPERHETERODYNE

An interesting range of multi-purpose valves is employed in the Philips Model 209U superhet for A.C./D.C. mains. The Mullard UCH21 is used in the frequency changer stage and also for I.F. and A.F. amplification. A Mullard UBL21 serves as double-diode rectifier and output pentode, and the power rectifier is a UY21.

The receiver is housed in a neat plastic cabinet with rounded corners and the indirectly-illuminated tuning scale (which is removable) projects from the top. The dimensions excluding dial are only 11in × 7in × 6in and there are three waveranges, including short waves from 16.5 to 51 metres. The price is £12, plus £2 11s 7d purchase tax, and the makers are Philips Lamps, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

BELLING-LEE QUIZ (No. 8)

Answers to questions we are continually being asked by letter and telephone

1* *The* **Belling-Lee** *twin unscreened feeder when sold in bulk is known as* **L.336.** *Price* **7½d.** *per yard. When supplied with 65ft. on reel the list number becomes* **L.344.** *Price* **13/6.**

Q. 33. *Is it preferable to use co-axial or balanced feeder with a television dipole ?*

A. 33. This was covered briefly in question 3, to amplify the answer we can do no better than extract part of an article by F. R. W. Strafford, A.M.I.E.E., from the current Technical Bulletin published by the Radio Component Manufacturers Federation, entitled "The Choice of Transmission Lines for Connecting Television Receiving Aerials to Receivers."

"At 45 mc/s the radiation losses of a *1 twin unscreened line of 75 ohms impedance are very small compared with the transmission loss, and for this reason, assuming a balanced termination, the screening efficiency against local electromagnetically propagated interference is high.

"The screening efficiency of the co-axial line is greater, but it is important to realise that this only obtains when the line is balanced with respect to earth and dipole and, in my opinion, herein lies the most serious charge against its economic adoption for television reception purposes.

"The dipole aerial possesses electrical symmetry, so that coupling such a symmetrical system to a co-axial cable (which is asymmetrical in its properties when placed in an electro-magnetic field) calls for two features to be introduced. Firstly, the line must be connected symmetrically to the dipole. This can be achieved by the use of a folded back element which corrects the impedance termination of the outer conductor. The introduction of such a folded portion will increase considerably the cost of the aerial structure. Secondly, the receiver input must be balanced with respect to earth to maintain electrical symmetry at its terminals. While it is not very difficult to balance a symmetrical type of feeder to an input tuned circuit, there appear to be considerable difficulties in balancing any asymmetric line such as the co-axial line, due to the high radiation losses of the outer conductor as compared with the inner conductor.

"If the balancing features are not introduced in the co-axial line the effect of electro-magnetic interference concentrated in the vicinity of the line will be to set up unequal currents in the inner and outer conductors respectively. This will give rise to a potential difference at the receiver input, thus vitiating to some extent the screening properties of the line, and so decreasing the signal-to-interference ratio in practice.

"If a balanced twin transmission line is employed on the other hand, the termination at the dipole end is inherently correct. It is necessary, however, that the receiver input curcuit shall be balanced in order to maintain the highest possible signal-to-interference ratio. Because the twin transmission line is inherently symmetrical electrically, it does not appear to be very difficult to match this to a conventional type of tuned input circuit and at the same time maintain balance with respect to ground.

"Supposing one neglects completely the matter of balancing at the dipole and receiver. Then for equal line loss there is nothing to choose between the two methods on the score of signal-to-interference ratio, with one possible exception. This exception occurs when the twin unshielded line is in close proximity to various metal objects and in different degrees of proximity throughout its route from the aerial to the receiver.

"Theoretically there will be small changes in the characteristic impedance at various points along the line, and these will give rise to reflections and subsequent attenuation. Measurements at 45 mc/s however, do not substantiate this prediction, not because they do not exist but because the magnitude of the subsequent attenuation due to reflection effects are small, and are masked by reading errors and small inconsistencies in measurements. If one were working with a twin balanced line whose characteristic impedance was of the order 400 ohms, and typified by a spacing of a few inches between the conductors, undoubtedly the close proximity of other conductors would show measurable attenuation, but the very close spacing necessitated by a 70 ohms line is probably the best reason for the immeasurable effect of proximate conductors. The same applies to the preservation of balance in the line, where it is not difficult to see that the close proximity of a twin 70 ohms feeder to another conductor would not effect much change in the balance of the line until the distance of the proximate conductor was at least comparable with the spacing between the wires of the line itself."

Q. 34. *Does an *2 anti-interference aerial suppress unwanted noises caused by H.F. interference ?*

A. 34. No.—no aerial can suppress interference. But with a well-designed anti-interference aerial it is possible to "run away" from the cause of trouble by erecting the collector outside the field of interference, or at any rate, to get it in such a location that the interference is so attenuated as to be negligible.

. . . To be continued

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This **AMPLIFIER** has a response of 30 cps. to 25,000 cps., within ½ db, under 2 per cent. distortion at 40 watts and 1 per cent. at 15 watts, including noise and distortion of pre-amplifier and microphone transformer. 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 feed-back 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, with built-in 15 ohm mu-metal shielded microphone transformer, tropical finish.

As illustrated. Price **36½ Gns.**

A.C.20 AMPLIFIER CHASSIS.—This well-known model has been retained, and has a response 30—15,000 cps., mixing arranged for crystal pick-up and microphone, large output transformer for 4—7.5 and 15 ohms to deliver 15 watts at less than 5 per cent. total harmonic distortion to the speakers. Metal Cabinet for above, if required, **£3 6 0.** Price **£21 0 0.**

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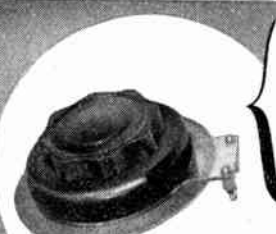

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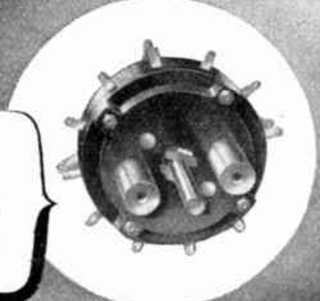

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H_2S TRAINER

Use of Ultrasonic Reflections from Submerged Relief Maps

By G. W. A. DUMMER, M.B.E., M.I.E.E. (Telecommunications Research Est.)

ONE of the most important of the radar navigation devices designed during the war was H_2S. This system was used by R.A.F. Bomber Command for "blind" navigation over Germany and made possible the accurate and heavy bombing of Berlin and other targets beyond the effective range of "Gee" and "Oboe." To use this device training was necessary, and navigator/operators could be trained either by flying training aircraft equipped with H_2S or by using a synthetic training device on the ground.

The first method was obviously expensive in petrol consumption, etc., and meant the use of a number of four-engined bombers which could not, at that time, be spared. In addition, extra maintenance and wear and tear of aircraft on non-operational flights was undesirable. It was obvious, therefore, that the use of a satisfactory synthetic trainer would save the country an enormous amount of training time and expense.

It had been the practice at TRE to design synthetic trainers in conjunction with the design of the radar equipment, so that when the equipment was ready to be introduced into the Services a training device was also ready to train operators. The H_2S training device, originated in Feb., 1943, was the first to use the new principle of a "miniature" radar system using ultrasonic waves propagated through water in place of electro-magnetic waves propagated through air. The long delay time of transmission of ultrasonic waves through a liquid was used to represent the radar delay times normally encountered in the operation of H_2S. The velocity of ultrasonic waves in water is 1.5×10^5 cm/sec, and as that of electro-magnetic waves in air is 3×10^{10} cm/sec, the scale on which the trainer operated was

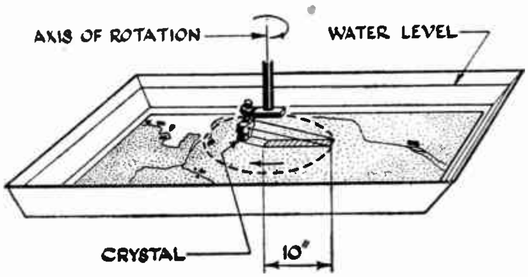


Fig. 1. Basic form of H_2S trainer

$$\frac{1.5 \times 10^5}{3 \times 10^{10}} = \frac{1}{200,000}\text{th}$$

of the radar scale. This meant that one "ultrasonic" mile = 0.315in, and a radar range of fifty miles could be simulated in a physical distance not exceeding 15 inches approximately.

The requirements for the training device were that a narrow beam of energy should illuminate an area of the ground as shown in Fig. 1, and that the beam should also be rotated at the same scanner rotation frequency as H_2S; the reflected signals were to be picked up as though from land, town or sea and fed as intensity modulation to the Navigator's Plan Position Indicator. The whole synthetic picture should be capable of movement in any direction at any aircraft speed so that navigation training could be carried out. These requirements were achieved in the trainer by using this new principle as described below.

If an X-cut quartz crystal is pulsed at its resonant frequency under water and a reflecting object is placed in the path of the transmitted wave, an echo will be re-radiated from the object in the same way as in radar and picked up on the crystal.

The intermediate frequency of H_2S was 13.5 Mc/s, and a crystal of that frequency was chosen for ultrasonic propagation so that the existing H_2S I.F. amplifier could be used. At a frequency of 13.5 Mc/s and with a velocity of 1.5×10^5 cm/sec the wavelength is of the order of 0.1 mm.

The crystal was made long and narrow to simulate the aerial coverage of H_2S and with $\lambda = 0.1$ mm and the crystal 5 mm $\times$ 25 mm, this was equivalent to an aerial array of $50\lambda \times 250\lambda$. The beam was thus quite sharp and rectangular.

The crystal beam was projected on to a glass relief map so that the projection covered a range of 0-30 miles (0-10in approximately), the crystal being used for both transmission and reception. The crystal was set back 1.25in from the axis of rotation to simulate "ground returns," and picture as seen from an aircraft flying at 20,000ft. On the glass map was

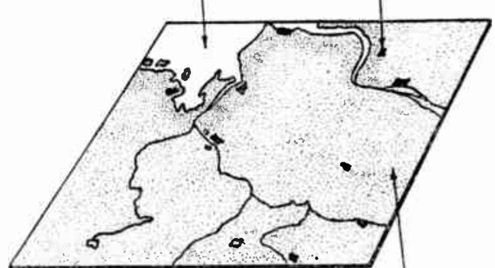


Fig. 2. Etched-glass map used in trainer

H_2S Trainer—

reproduced (to a scale of 1:200,000) a simulation of the area in Germany over which training was to be effected. (See Fig. 2). The amount of reflection of the radiated energy was proportional to the "roughness" of the glass surface, and the map was sand-blasted or etched to represent land masses. Towns were built up of granules of carborundum glued to the glass and the sea areas were left as plain glass. The map was placed at the bottom of a tank of water. The pulsed crystal was then rotated at 60 r.p.m. synchronously with the radial time base, and the signals received from the map were fed from the crystal to the input stage of the IF amplifier in the H_2S receiver and thence to the PPI.

The display produced was an excellent simulation of the actual H_2S picture seen in the air when flying over Germany. The rotating crystal was mounted on a gantry and made to travel over the surface of the synthetic map at controlled speeds and directions on the trainee's instructions, so that full navigation training could be given. A duplicate plotting map (not relief), with frosted underside and suitably illuminated, was mounted above the crystal assembly and a recording pen was arranged to mark the underside to record the track of the "aircraft."

A record of the bombing run on any chosen target was achieved as follows:— When the bomb release was pressed, the recording pen was magnetically pulled away from the underside of the plotting map. For a period corresponding to the time of fall of the bomb the pen continued to move and at the instant of bomb impact the pen snapped back on to the map. Points of bomb release and impact could easily be seen in relation to the target and errors in bombing procedure could be assessed.

Complete crew training was achieved by the pilot flying a Link Trainer (coupled to the H_2S trainer) under the operator's or navigator's instructions. The operator saw a continuous change of radar "picture" as the synthetic aircraft flew over the target area. It is estimated that the majority of the H_2S navigators in R.A.F. Bomber Command received training on these devices, which were manufactured by two of the leading radio firms in this country on "top" priority. Slight modifications and the use of a "sea" map and synthetic "ship" targets enabled the trainer to be used for "ASV."

The scheme was widely adopted in the U.S.A. and used for American versions of H_2S. There is little doubt that without a device of this type the quality and quantity of H_2S-trained operators in R.A.F. Bomber Command could not have been maintained during the war.

VARIABLE-RESISTANCE PICK-UP

Applying the Principle of the Strain Gauge

THE principle of the strain gauge, in which deformation of a conductor and its consequent change in resistance is used as a measure of the applied strain, has been used in a pickup which is described by K. J. Germeshausen and R. S. John in the November, 1946, issue of *Electronic Industries.*

A horizontal polystyrene bar of

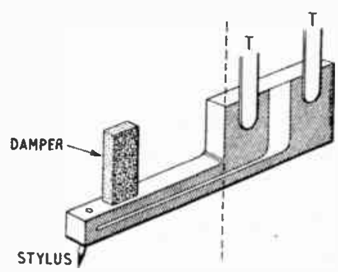


Fig. 1. Resistance element shaped to give "go and return" paths for the current. Fixed terminal connections are provided where the beam is clamped to the tone arm.

$\frac{1}{16}$-inch square section and $\frac{1}{2}$-inch long is clamped to the tone arm at one end and provided with a short stylus at the other (Fig. 1). The vertical faces of the bar are coated with a film of carbon powder in a plastic medium, and lateral bending causes alternate increase and decrease of resistance depending on whether the film is in tension or compression. Over the range of deflections resulting from the playing of a record the relationship between strain and resistance is stated to be linear. Push-pull connections between the resistance elements is used and a pre-amplifier circuit incorporating negative-feedback frequency compensation is reproduced in Fig. 2.

It will be appreciated that output is proportional to displacement; like the piezo-crystal pickup it is a constant-amplitude rather than a constant-velocity device, and its uncorrected response curve will be flat from the lowest frequencies up to the cross-over point (say 250 c/s) on a standard frequency record, and above this frequency the output will fall at 6db per octave. Compensation calls for a judicious mixture of electrical and mechanical correction—the latter in the form of a rubber or plastic damping block which can be applied in a variety of ways to give the desired frequency response.

Figures for voltage output are not given, but it is stated that a stage of pre-amplification is required before the input terminals of the usual two-stage audio section of a radio receiver.

Recommended values for the resistance elements are 75,000 to 100,000 ohms per side. The applied voltage should be as high as possible, but will generally be limited to 100 V by the current-carrying capacity of the carbon film. It is stated that carbon layers have been prepared which are

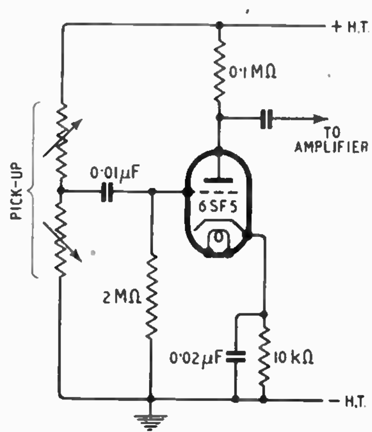


Fig. 2. Suggested pre-amplifier stage with frequency correction negative feedback.

free from the background hiss usually associated with carbon elements.

World of Wireless

RADIO INTERFERENCE

DELEGATES from eleven countries recently met in London at the invitation of the British Standards Institution to discuss the problem of radio interference suppression.

The work undertaken by the various countries represented—Austria, Belgium, Canada, Czechoslovakia, France, Netherlands, Switzerland, South Africa, Sweden, U.K. and U.S.A.—since the last meeting the International Special Committee on Radio Interference (C.I.S.P.R.) in Paris in July, 1939, was reviewed.

The measurement of interference at frequencies from 1,500 kc/s to 30 Mc/s, which are not covered by the C.I.S.P.R. standard measuring set, was discussed and it was agreed that at the next meeting consideration should be given to the best method of making measurements on each type of equipment giving rise directly to interfering fields.

DECCA NAVIGATOR

THE Decca Navigator has been approved by the Ministry of Transport for the purposes of general marine navigation, exclusive of pilotage, in specified areas, which extend up to 275 statute miles from London. This decision has been made after extensive trials, directed by the Ministry of Transport, with equipment fitted in thirty-five merchant ships. A new marine receiver is being produced and will be available to shipping companies on a hire-maintenance basis.

Consideration is now being given to the erection of a Scottish chain of stations which will, in conjnnction with the present English chain, provide a navigational service in all the waters of the British Isles.

A chain for Iceland is being considered by the Icelandic Government, and a New York chain has been sited and an application made to the F.C.C. for the required frequencies.

GOVERNMENT SURPLUS

REFERRING to the disposal of Government radio components a Ministry of Supply announcement states: "The Ministry's policy is to satisfy public demand. But where the surplus is very heavy in relation to current production and requirements, it may be against the national interest to release the whole of the surplus stocks, especially if they could be sold only at such low prices as would cause serious harm to the industry concerned and lead to unemployment. Unfortunately it is not a proposition to hold surpluses for any long period, because of shortage of accommodation and, sometimes, the risk of deterioration in store. For those reasons it is occasionally necessary to scrap goods in serviceable condition, although this seldom happens.

"Certain types of fixed condenser, such as paper tubular, are a case in point. The stocks represent many months' normal production. It has been decided after full enquiry to release for sale another twelve million of these types. The balance will be disposed of by dumping in disused mineshafts, as it is impracticable and uneconomical to break the condensers down to recover raw materials."

E.M.I. DEVELOPMENTS

ARRANGEMENTS have now been concluded with Major Edwin Armstrong, the F.M. pioneer, whereby Electric and Musical Industries, Ltd., and its subsidiary companies throughout the Empire, may manufacture and supply F.M. transmitting and receiving equipment under Armstrong patents.

Another invention for which the company has secured patent rights is a noise suppression system for gramophone reproduction due to H. H. Scott in which the audio-frequency bandwidth of the amplifier is controlled automatically by the volume level. At high levels noise is generally masked, and the full frequency range may be used, but at low levels surface scratch and low-frequency motor rumble obtrude. Reduction of bandwidth to eliminate these noises does not seriously affect the aural impression, since the response of the ear to both high- and low-frequency components in the original sound is progressively reduced as the volume decreases.

A new method of televising motion picture films has been developed in E.M.I. laboratories and was recently demonstrated to the B.B.C. and members of the Television Advisory Committee.

R.S.G.B. GROWTH

A FOURFOLD increase in the membership of the Radio Society of Great Britain since 1939 is recorded in the Society's Report for the year ended September 30th, 1946. The year's increase of 2,924, compared with 1,900 in the previous year, brought the total to 12,570, of which 380 are overseas members and 675 associates and junior associates.

CONSOL

AFTER extensive tests, conducted by the R.A.F., the first Consol D.F. station, at Bush Mills, Co. Antrim, Northern Ireland, now provides a 24-hour service. It was taken over by the Ministry of Civil Aviation on January 1st and is now operating under the call sign 7H7 on a frequency of 263 kc/s. There is a break in transmission from 1500-1515 daily for routine maintenance.

The keying cycle of 60 dots and dashes—lasting 30 seconds—is followed by the transmission of a continuous note—interrupted by the call sign—for 28 seconds. Transmission cycles are spaced by a 1.5-second break.

A description of the system was given in our issue of July last year.

B.R.E.M.A. AND F.M.

"THE ultimate employment of F.M. transmissions is inevitable." This statement is included in the technical section of the recent report of the British Radio Equipment Manufacturers' Association, where it is also stated that "development of the F.M. system should be supported." Two provisos are, however, made:—

(1) That it is used as an addition to, and not in replacement of, existing transmissions;

(2) That inter-regional and international broadcasts in, or from, this country are not curtailed in consequence.

An expenditure of £2,000 was authorized by the Council of B.R.E.M.A. on an F.M.-A.M. investigation.

PERSONALITIES

G. M. Garro-Jones, who is chairman of the Television Advisory Committee, received a Knighthood in the New Year Honours. He was also chairman of the Production Planning and Personnel Radio Committee, one of the two main working committees of the Radio Board when it was set up by the Government in 1943.

H. Townsend, G.P.O., Director of Telecommunications, who is also a member of the Television Advisory Committee, is created a C.B.

S. L. Hulme, Deputy Director of Telecommunications, Ministry of Civil Aviation, is created an O.B.E.

Among those appointed Members of the Order of the British Empire in the Honours List are:—

A. D. Kent, chief of the Testing Department of Marconi's W.T. Co. He has been a member of the company's engineering staff for 35 years; **R. N. Fox,** wireless officer with the British

World of Wireless—

Mission in Lhasa, Tibet; **F. S. Sellek**, regional radio controller in the Civil Aviation Department of the Government of India.

Sir Robert Watson Watt has relinquished his appointment as Vice-Controller of Communications Equipment, Ministry of Aircraft Production, which he has held since 1942, and that of Scientific Adviser on Telecommunications to the Air Ministry and is forming a private company of technical consultants to be known as Sir Robert Watson Watt & Partners, Ltd. It is understood he will continue to act as scientific adviser on telecommunications to the Ministries of Supply, Civil Aviation, Transport and Air.

Col. Sir A. Stanley Angwin, K.B.E., D.S.O., who has been Engineer-in-Chief G.P.O. since 1939, has resigned on his appointment as chairman of the new Board of Directors of Cable and Wireless. He joined the Post Office Engineering Department in 1906. On his return to civilian life after the 1914-18 war he took a large part in the design and construction of the Leafield, Cairo and Rugby stations. Sir Stanley, who was President of the I.E.E. in 1943, was created a Knight Bachelor in 1941 and a K.B.E. in 1945.

A. J. Gill, B.Sc (Eng.), who has been Deputy Engineer-in-Chief of the G.P.O. since 1944, has succeeded Col. Sir Stanley Angwin as Engineer-in-Chief. He entered the Post Office Engineering Department as an assistant engineer in 1913 and in 1925 was appointed executive engineer in charge of the Radio Experimental Section at Dollis Hill. He became Staff Engineer of the Radio Branch in 1932. A. J. Gill was chairman of the Wireless Section of the I.E.E. in 1938 and was elected a vice-president of the Institution in 1945.

J. Innes, C.B., B.Sc.(Eng.), has been appointed managing director of the Board of Cable & Wireless and has therefore resigned his directorship of the G.P.O. Telecommunications Department.

G. W. Entwisle has been appointed Engineer-in-Chief of Cable and Wireless following the vacation of the post by

G. H. Entwisle.

W. G. R. Jacob, O.B.E., on the Government's acquisition of the company. Mr. Entwisle has been joint deputy engineer-in-chief since the merger of the cable and wireless companies in 1929. He joined the Marconi Co. in 1910 and became chief communications engineer, a post which he held until the merger.

Dr. C. F. Bareford, M.Sc., Ph.D., has been appointed manager and head of the new Mullard Electronics Research Laboratory at Salfords, near Horley, Surrey. In 1934 Dr. Bareford joined the B.T.H. Company as a vacuum physicist. Two years later he went to, what is now known as, the Admiralty Signal Establishment, where he has been engaged on radar and telecommunications research.

Dr. C. F. Bareford, M.Sc., Ph.D.

Charles R. Denny, who has been acting chairman of the U.S. Federal Communications Commission since the resignation of Paul Porter last March, has been appointed chairman. His term of office is until June, 1951.

E. J. Bell, of Belling & Lee, has gone to South Africa to supervise the final stages of the work of fitting suppressors to the Royal train and the pilot train.

Louis Gerard Pacent, American pioneer radio engineer and one-time contributor to this journal, has received the U.S. War Department's Certificate of Appreciation for services to the Signal Corps.

W. E. Warrilow, who has been associated with the radio and electrical industries for many years has retired on reaching the age of 70. Since 1925 he has been special electrical commissioner for Odhams Press.

OBITUARY

We regret to record the death of **R. N. Vyvyan**, formerly Engineer-in-chief of the Marconi Company, at the age of 70, at Falmouth, where he has been in retirement for the past ten years. One of the pioneers of trans-oceanic radio-communications, he joined the Wireless Telegraph and Signal Company (later to become Marconi's W.T. Co.) in March, 1900, and was one of a band of seventeen technical assistants that Marconi gathered around him for the purpose of putting his inventions on a commercial basis. He was responsible for the building of the stations at Poldhu, Cornwall, Cape Cod, America and Glace Bay, Canada (1900-1902). His book "Wireless over Thirty Years," published in 1933, recalls the experiences of those early days.

It is with regret we record the death of **E. F. (Frank) Heaver**, after a long illness, at Bideford, Devon, where he had been conducting his business as agent for many well-known American manufacturers since he moved from his Bush House office, London, during the war. Prior to starting the company of Frank Heaver, Ltd., he was for many years sales manager of R. A. Rothermel, Ltd.

IN BRIEF

Air Radio.—The three State-owned British air-line corporations, B.O.A.C., B.E.A. and B.S.A.A., have formed a non-profit-making company—International Aeradio, Ltd.—with the object of installing and operating in this and other countries radio navigational aids and telecommunications equipment.

Television Tests.—The B.B.C.'s television test transmissions are now made between 10 and 11 a.m., instead of the half-hourly periods before and after the afternoon transmissions. The transmission of the demonstration film continues from 11.0-12.10.

Television Production.—A sharp rise in the production curve for television receivers during August, September and October is shown in the latest Board of Trade figures. The monthly output was 235, 754 and 1,334, respectively.

"This Year, Next Year . . ."—The Postmaster-General recently stated in the House of Commons that no forecast of the date of the opening of the Birmingham television station could be given, but it was unlikely to be earlier than two years hence.

Standard Telephones and Cables is to provide two major wireless stations for the Turkish Government at Ankara and Istanbul, respectively. The £400,000 order is for long-distance radio-telephone and telegraph equipment.

Radio Launching.—Radio as an aid to the launching of ships was successfully tried out at the Clydeholm shipyard of Barclay Curle & Co., Glasgow, when the 9,430-ton *Sangola* was launched for the British India Steam Navigation Co.

"F.B.I. Register."—The first post-war issue of the "F.B.I. Register"—the official directory of manufacturer members of the Federation of British Industries—will appear this summer. Our Publishers, Iliffe & Sons Ltd., and Kelly's Directories, Ltd., will be jointly responsible for the compilation, production and sale.

Consultants Wanted.—J. Mort, B.Sc., A.M.I.E.E., proposes to start a Technical Advisory Bureau, and would like to hear from specialists in various radio branches who are willing to act as part-time consultants. Address: 42, Barn Lane, Golborne, near Warrington.

Shore Radar.—Plans have been prepared by the Mersey Docks and Harbour Board for the Port of Liverpool to be equipped with radar. The P.P.I. will provide dock officials with a continuous picture of the movement of shipping in the 15-mile channel.

Acoustics.—A meeting has been arranged by the Physical Society for February 19th at the Royal Institute of British Architects, 66, Portland Place, W.1, to discuss the formation of an Acoustics Group of the Society. H. L. Kirke, head of the B.B.C. Research Department, will be in the chair. It is proposed that membership of the Group will be open to members of other societies at a nominal fee. Provision is also planned for group membership by firms. The acting secretaries are A. T. Pickles and W. A. Allen, 1, Lowther Gardens, Prince Consort Road, London, S.W.7.

Eire's S.W. Station.—The new high-power short-wave broadcasting station being erected by the Irish Government to replace the present low-power transmitter is expected to be ready to begin transmission by the end of April.

Institute of Physics.—The address of the Institute and of its *Journal of Scientific Instruments* is now 47, Belgrave Square, London, S.W.1. Tel.: SLO 9806.

CLUBS

Bromley.—The Hon. Editor of the *R.S.G.B. Bulletin*, A. O. Milne, G2MI, will give a demonstrated lecture on frequency measurement at the meeting of the North-West Kent Amateur Radio Society on February 28th at 8.0 at the Aylesbury Road School, Bromley. Secretary, L. Gregory, G2AVI, 18, Upper Park Road, Bromley, Kent.

Glasgow.—In the list of clubs published in the January issue the Hi-Q Club, Giffnock, was indicated in error as being affiliated to the R.S.G.B. It is a private club with a limited membership of licensed amateurs. The Glasgow Amateur Radio Club, formed about two years ago, which was affiliated to the R.S.G.B., is defunct. There is, however, a need for such a club in Glasgow, and J. D. Gillies, GM2FZT, Hi-Q Club secretary, is therefore compiling a register of interested Glaswegians. His address is 3, Berridale Avenue, Glasgow, S.4.

Grimsby.—Regular meetings of the Association of Grimsby and District Radio Engineers, which was formed in 1937 under the presidency of Sir Walter Womersley, have recommenced. The secretary, H. Crampin, 268, Victoria Street, Grimsby, will be glad to hear from manufacturers willing to send a lecturer to address the association.

Ilford.—At the next meeting of the Ilford and District Radio Society on January 30th, F. H. Haynes (Haynes Radio, Ltd.), president of the Society, will lecture on "The 100-watt Transmitter." Meetings are held every Thursday at 8.0 at St. Alban's Church Room, Albert Road, Ilford. Secretary, C. E. Largen, 44, Trelawney Road, Barkingside, Ilford, Essex.

Manchester.—At a meeting in Manchester on December 21st the Radio-Controlled Models Society was formed. Officers are to be elected at the next meeting (January 25th). Correspondence regarding the Society should be sent to R. Lawton, 10, Dalton Avenue, Whitefield, nr. Manchester.

Southall.—The next two meetings of the West Middlesex Amateur Radio Club will be held on Feb. 12th and 26th at 7.0 at the Labour Hall Rooms, Southall. At the first meeting A. Gott, a committee member, will speak on radar and at the second F. Charman, G6CJ, will give a demonstrated lecture on aerials. Secretary, N. S. C. Priest, 7, Grange Road, Hayes End, Middlesex.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"The Calculation of Field Strength over a Spherical Earth," by C. Domb, M.A., and M. H. L. Pryce, M.A., Ph.D., on February 5th.

"The Design of High-Fidelity Disc Recording Equipment," by H. Davies, M.Eng., on February 19th.

"The Economics of Transmitting Station Design," informal lecture by B. N. MacLarty, O.B.E.

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

Alexander Graham Bell Centenary Lecture, by Col. Sir A. Stanley Angwin, K.B.E., D.S.O., on March 3rd at 5.15 at the Central Hall, Westminster. This meeting will be open to the public.

Cambridge Radio Section.—"The Use of Electronics in Nuclear Physics," by E. S. Shire, M.A., on February 25th at 6.30 at the Cavendish Laboratory.

Students Section.—"Radio Modulation Methods—Amplitude, Phase, Frequency and Pulse," discussion to be opened by G. Dawson, R. F. Howard and D. Deacon on February 18th, at 7 p.m., at Savoy Place, London, W.C.2.

British Institution of Radio Engineers

North-Eastern Section.—"Deaf Aid Systems," by Dr. R. T. Craig, on February 12th at 6.0 at Neville Hall, Westgate Road, Newcastle-on-Tyne.

Scottish Section. — "Electronics in Nuclear Research," by J. M. A. Lenihan, M.Sc., on February 13th at 6.45 at the Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow, C.2.

London Section.—"A. C. Behaviour of the Barrier-Layer Photo Cell," by J. A. Sargrove, on February 20th at 6.0 at the London School of Hygiene, Keppel Street, London, W.C.1.

North-Western Section. — "D.C. Amplifiers," by R. A. Lampitt, on February 21st at 6.30 at the College of Technology, Manchester, 1.

Physical Society

Acoustics Group. — "The Contribution of Acoustical Science to Allied Studies," by Dr. Alex Wood on February 19th at 3.0 in the Jarvis Hall of the Royal Institute of British Architects, 66, Portland Place, London, W.1.

Television Society

"The Film in Relation to Television," by Marcus F. Cooper on February 12th at 7.15 at Film House, Wardour Street, London, W.1. Joint meeting with the British Kinematograph Society.

"The Television Outside Broadcast Service," by T. H. Bridgewater, on February 28th at 6.0 at the I.E.E., Savoy Place, London, W.C.2.

Radio Society of Great Britain

"Noise Limiters," by R. H. Hammans (G2IG) on February 14th at 6.30 at the I.E.E., Savoy Place, London, W.C.2.

British Sound Recording Association

"Problems of Sound Reproduction," by L. E. C. Hughes, Ph.D., President of the Association, on February 28th at 7.0 at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

BROADCASTING AT V.H.F.

Is F.M. the Answer ?

By THOMAS RODDAM

IT seems that we are going to have V.H.F. broadcasting fairly soon. On July 16, 1946, Mr. Herbert Morrison told the House of Commons that "within a year or so" there would be "detailed plans for the establishment of frequency-modulation stations in various parts of the country."[1] A long series of tests has been carried out by the B.B.C. and some of the results have been published.[2]

There are, of course, many people like the writer who do not believe that V.H.F. will be a good thing. It is a bit too much like a wire-broadcasting system from a political point of view. The only redeeming feature may be that when most of the stations have left the medium waveband for the ultra-short waves, we shall be able to find a dozen really good channels in the medium waveband for the old-fashioned listeners who can't afford new sets. Like air travel and dehydrated potatoes V.H.F. broadcasting is to be with us in the near future; is frequency modulation the best answer ?

There can be no doubt that, considered purely from a technical standpoint, F.M. has considerable advantages. For radio links, in which accurate tuning and stable circuits are incorporated the noise-suppression feature of requency modulation pays its way. The cheap broadcast receiver may not be so satisfactory, for even with magic-eye tuning many people, and women especially, seem incapable of tuning a set properly, and an F.M. set is more difficult to tune and yet demands closer tuning than an ordinary A.M. receiver. The cost of an F.M. receiver will normally be rather higher than that of a normal broadcast receiver, and it is possible that attempts to keep the price down will result in skimping of the features that would permit the full advantages of F.M. to be realized.

The alternative of pulse modulation deserves, in the writer's opinion, a full series of tests. This system of working was first adopted by the British Army in the Number Ten set, and the basic principles have already been described in *Wireless World*. The transmitter, which in the army set operated on a frequency of about 3,000 Mc/s, is modulated with a train of pulses. These pulses are not quite regularly spaced in time, but depart from regular spacing according to the audio-frequency modulation to be transmitted. It is quite feasible to use this system for what is known as multiplex working, in which, say, four separate programmes are applied to one transmitter, and the pulses corresponding to the four programmes are interlaced. The Number Ten set actually carried eight telephone channels, but for broadcasting we need a wider audio-frequency band, and a choice of four programmes should satisfy anybody. Pulse modulation, like frequency modulation, is wasteful in bandwidth, for to transmit audio frequencies up to 15 kc/s we must use a bandwidth running into hundreds of kilocycles (per second). Consequently it is only possible at V.H.F.

Multipath Distortion

The chief technical advantage of pulse modulation is that it does not seem to be so liable to what is called multipath distortion. Television viewers in outlying suburbs may know what the effect is: a double or multiple image of the picture. In America it has been found that the most appalling distortion can be caused to an F.M. signal when the energy reaches the receiver both directly and by a reflected path either from the lower atmospheric levels or from the local gasworks or other large reflector. This effect did not cause much trouble in the B.B.C. tests.

Another defect of F.M. is the possibility of occasional "capture" by a distant station when propagation conditions are abnormal: this is probably not very serious, although on the rare occasions when it happened it would be very irritating, because there does not seem to be anything the listener can do about it.

Pulse modulation has, however, one very great advantage, and it is for this feature that the writer hopes that it will be very carefully examined, and that a decision will be postponed until after a detailed series of tests has been carried out. The advantage is in multiplexing. If we are to have, say, four programmes in any area, we shall need, with F.M., four transmitters and four aerial systems. These aerial systems may consist of up to eight stacks at a height of up to 1,000 feet. It is most unlikely that all four aerial systems can be mounted on the same mast, so that four large masts will be needed. As the range of V.H.F. broadcasting is limited, these masts must be planted down in the middle of the densely populated areas to be served. If they are all close together, this makes a rather cumbersome set-up: if they are widely separated, we shall not be able to use directional receiving aerials unless we twist them round when we change from one programme to another. Directional arrays, however, will help a great deal in avoiding multipath distortion and "bursts."

With pulse modulation, on the other hand, only one transmitter and one aerial system is used. We can, if we wish, put up a ten-element Yagi aerial, although in my Pimlico garret I shall continue to use a piece of wire laid along the floor. The possibility of getting up to an extra six decibels at the receiver by the use of a directional aerial must be seriously considered.

The other great advantage is in this question of tuning. With pulse modulation, programme selection is made by circuits which

[1] *Hansard*, Vol. 427, No. 177, Col. 1099.
[2] See *Wireless World* October 1946 p. 316.

Broadcasting at V.H.F.—
choose one or other of the interlaced trains of pulses. The radio-frequency circuits can be pre-set, and they are not critical in tuning, so that there is no real reason why the receiver should not have completely fixed tuning with trimmers only. There is no way of making a set of this type give poor quality by maladjustment by the user. This seems to be a most desirable feature, for it is the people who don't tune in properly who also grumble the loudest; the less chance they have of ruining their reception the more hope there is of evolving a satisfactory permanent scheme.

It is possible, of course, to have multiplex transmission with F.M., using "frequency multiplex" instead of "time-division multiplex." This involves rather a lot of complication, and is only suitable for radio links such as may be used in colonial telephone services and the like. It need not be considered as a possibility in ordinary broadcasting.

This discussion of V.H.F. broadcasting is intended to act as an antidote to an attitude which has been fostered by the lay press, of which the following quotation is typical.

"Frequency modulation offers not only virtually unlimited wavelengths, but infinitely superior reception."[3]

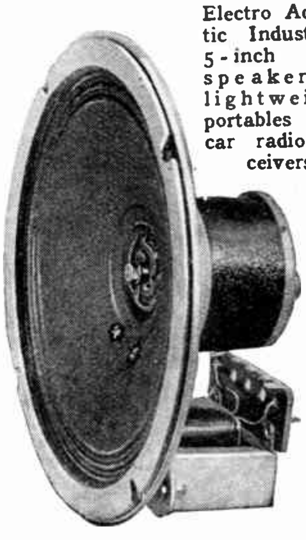
It is true that frequency modulation has a lot of advantages, but it is only one possibility. Once a service is started it will be very difficult to make a change: the present status of disc recording and of television give us a guide as to what happens once a system is generally adopted by the public. It took the B.B.C. a long time to escape from the idea that the average listener used a crystal set. We must be absolutely sure before we settle down to V.H.F. that we have found the best answer from all points of view, and that it will not be too easy for either the unskilled listener or the shoddy set manufacturer to give the new service a bad name. The writer confesses freely that he is doubtful about F.M. for this reason; only large-scale tests will reassure him.

[3] *The Spectator*, July 26, 1946.

FOR ALL-DRY PORTABLES

Light-weight P.M. Speaker of High Efficiency

DESIGNED with the object of making the most of the 200-odd milliwatts which represents the maximum undistorted power available from 1.4-volt output pentodes, this new 5-inch loudspeaker also has the virtues of small size and low weight. From back to front the depth is 2¼in and the weight (without transformer) is only 12½oz.



Electro Acoustic Industries' 5-inch P.M. speaker for lightweight portables and car radio receivers.

Special attention has been given to the economical use of Ticonal alloy in the magnet, in which the average flux is 9,500 gauss. The centre pole is tapered and the profile is designed to minimize leakage flux.

The shallow-angle cone is centred by the well-tried "front" spider which is found to give reliable service under conditions of high humidity. Damp-proof adhesives are used throughout and the cone is impregnated with a chemical which inhibits the growth of fungus. Metal parts are either cadmium plated or stove enamelled.

On test the unit gave a well-balanced response with a surprisingly full bass, and the electro-acoustic efficiency was definitely higher than that of several 6-in and 8-in standard P.M. speakers with which it was compared.

The price is 25s, or 32s 6d with transformer, and the makers are Electro Acoustic Industries, Stamford Works, Broad Lane, Tottenham, London, N.15.

UNBIASED

By FREE GRID

Quizologists Forward Please

I WONDER if any of you "scolards" can help in tracing the origin of the suffix "tron" which seems to have become as much a disease as our old friend "dyne." In my innocence I have

American Publicity Wallah

always supposed "tron" to have been started on its career by the publicity wallah of an American radio firm who simply chopped off the final syllable of the Hellenogenic (copyright reserved) word electron and used it as a synonym for the word valve or tube. If such be the case it has long since shed its commercial and arbitrary origin and has for many years been used in very exalted circles to describe atom-investigating apparatus like the cyclotron.

In this respect its history has been the very opposite to "dyne" which started life in the aristocratic and rarefied atmosphere of the research laboratory as the final syllable of words like homodyne and heterodyne, but rapidly sank in the social scale until it was freely used by any and every type of "inventor" to describe some allegedly new circuit which he had thought of in his bath.

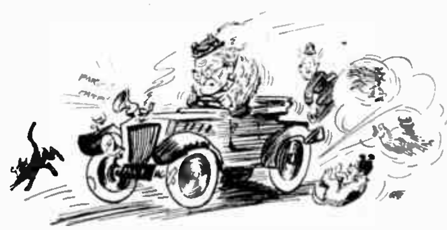
In spite of the perversion of its true meaning, "dyne" is at least a dignified adaptation of "dynamis" (δυναμις). It is not merely the back legs of the horse like "tron," unless, as I have recently been told, my fondly cherished etymological beliefs concerning "tron" are quite erroneous and that it has no connection at all with electron or any other word of Greek origin. If so, matters are even worse than I thought, for, since it is always allied with a Greek word to form names like thyratron, it seems that we have a whole host of horrible hybrids in our midst, which have the effrontery to defy the canons of decent society and shamelessly flaunt their mixed parentage in our faces.

I am even told that "tron" is far older than the science of wireless and was used in the heyday of Crookes and Röntgen and their like; in fact, one correspondent even asserts that it is merely a rearrangement of the first four letters of Röntgen's name.

If we can get the true parentage of this word settled I should be much happier as I have nothing but admiration for the sheer ingenuity and hard thinking which has been put into certain words in which "tron" is used. The most outstanding example is undoubtedly the word klystron. This word so exactly and yet so poetically describes the functioning of the device, the man who evolved it must have put as much research work into it as the inventor of the tube itself; in fact, his effort can only be described as Homeric.

Peccavi

IT was with very serious misgivings that I received confirmation from the Editor's pen in a recent issue of *Wireless World* of an uneasy suspicion which I have long held concerning my broadcast receiving licence. It undoubtedly confers no authority upon me to receive such things as telegraphic transmissions even though they may be addressed to "CQ," nor apparently am I permitted to receive broadcast telephony from any but an authorized station. It is true that the law as expounded on the back of the licence form does not say explicitly that I mustn't do certain things, but it obviously implies it.



Public Enemy No. 1.

None of these things worries me personally, however, as I have always endeavoured to be a law-abiding citizen, even to the extent of eschewing the temptation to use fuel by switching over to a battery set when Mr. Shinwell switches off the current in the middle of my favourite programme. Even during the war, owing to my suspicions of what the Editor now confirms, I endeavoured, although without much success, to check the disregard for law and order displayed by the local Home-Guard Commander who used the C.W. morse transmissions picked up on his home broadcast receiver to give code practice to a signals unit. I did, however, persuade him to communicate with the P.M.G. admitting his offence and asking for a plenary indulgence and a retrospective permit. The matter is, I am glad to say, receiving attention and there is every hope of the permit forthcoming in the near future, thus enabling him once again to go about among his fellow citizens without the hang-dog "I dun it" expression.

The thing which does trouble me is that, after diligently studying the licence conditions, I find no authority whatever is conferred on me to receive any form of atmospheric disturbance no matter whether man-made or otherwise.

Everytime, therefore, I hear the noise of the next-door vacuum cleaner or a passing car creates a snowstorm on my television screen I realize that I am no less a law breaker than the most hardened malefactor whose waxen torso is exposed to view in a building not very far from Sherlock Holmes' old flat in Baker Street which any London guide worthy of his salt will point out to you.

Worse still, I have even used my radio set for the conveyance of messages to me, thus infringing the P.M.G.'s monopoly, for every time I hear a racket some ten times worse than usual emanating from my L.S., or see a blizzard of more than Arctic severity on my viewing screen, I know that Mrs. Free Grid's mother is approaching in the decrepit equipage which has more notches on its bumpers than a Chicago gangster has on his gun stock.

KEYING MONITORS

Radio Oscillator Triggered by the Transmitter

By W. A. ROBERTS

A RELIABLE keying monitor is a most useful aid to good operating as it enables the amateur, and especially the beginner, to maintain a constant check on his morse transmissions.

There are many varieties of monitors but most of those in general use can be grouped into one of two main categories (a) R.F. oscillators beating with the radiated signals and (b) A.F. oscillators keyed simultaneously with the transmitter.

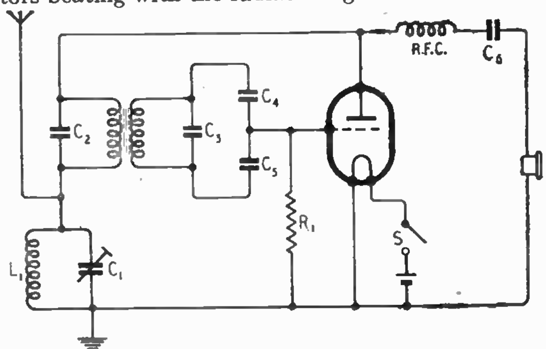
The former serve as a check on both the operator and the transmitter, but in order to serve a really useful purpose in the dual role they must possess a very high degree of frequency stability.

Whilst the latter do not demand such care in design, the type generally used gives no warning of a breakdown in the transmitter, and so they act merely as a check on the operating style.

A particularly attractive keying monitor, which differs from those in general use since it combines some of the attributes of the A.F. and the R.F. pattern, is shown in the circuit diagram.

It is, in effect, an A.F. oscillator with the H.T. obtained by self-rectification of the signals radiated from the transmitting aerial and picked up by the monitor. This is effected by the tuned circuit L_1C_1 which must, therefore, be tuned to the same frequency as the transmitter. High accuracy of tuning, or circuit stability, is, however, unnecessary as the pick-up can be controlled by the length of the short vertical rod aerial.

Best results have been obtained with the grid artificially tapped down the audio oscillator coil, this tapping being effected by a condenser potentiometer C_4 and C_5. With an average intervalve transformer C_5 can be made 0.05μF and C_4 some value from 0.0005μF upwards. It should be chosen to give reliable, but not too fierce, oscillation; an average value is about 0.002μF. With this method of adjustment it does not seem important whether the transformer is connected to step up from the anode to the grid or to step down.



Audio-type keying monitor with H.T. obtained by rectifying the signals picked up by the self-contained aerial.

The resistor R_1 is the usual grid leak and a value of about 50kΩ is suggested, but it may have to be lowered if there is a tendency to squegger.

The capacitance of C_3 will have to be found experimentally as both C_4 and C_5, as well as the inductance of the grid winding, combine to determine the frequency of the audio signal generated. Capacitor C_2 is merely an R.F. by-pass condenser and may or may not be needed. If used about 100pF should suffice.

With this form of oscillator the output load should be of reasonably high impedance and this can conveniently be achieved by using a comparatively small capacitance at C_6, for example, 0.001μF. The R.F. choke must be effective at the radio frequency of the transmitter.

A telephone ear piece secured to the monitor is preferred by the writer to plug and socket connections for external headphones, as it helps to render the unit more self-contained. No electrical connection is needed to the transmitter so that the monitor might quite well include its own dry cell L.T. battery.

LETTERS TO THE EDITOR

Variable-mu *v.* Variable-μ : Result ♦ Standard Valves Criticized ♦ What Are "Technical Assistants"?

μ-Confusion

MAY I add one further point to the delightful article on "μ" by "Cathode Ray"? Precisely what he anticipated has happened to the American "micromho." In valve data sheets it is frequently given as "μmho." However, these sheets are typewritten and mimeographed, and few typewriters talk Greek; so it is often typed "umho," a stroke being added later to make the "u" into μ. This stroke is now as often as not omitted. If the result is pronounced "Um! Ho!" some eyebrows may be raised, but there can be no misunderstanding.

Dublin. G. F. DALTON.

THE significance of "variable-mu" (which was touched on by "Cathode Ray" in your November issue) was discussed in *Wireless Engineer* in May and June, 1944. The conclusion there reached was that "the significance of the 'mu' appears to have undergone a change on crossing the Atlantic."

"The Electronics Dictionary" (by Cooke and Marcus, published in U.S.A. in 1945) contains the following definitions:—

mu—Greek letter μ used as symbol for *amplification factor*, for micron (a unit of length) and for the prefix micro-;

high-mu tube—A vacuum tube having a high *amplification factor*.

These definitions confirm the opinion that "mu" means "amplification factor" (at least in U.S.A.).

Some confusion is apparently introduced by the definition of "variable-mu" which reads:—

Variable-mu tube—A type of thermionic tube having a grid so designed that the amplification factor and mutual conductance can be varied by adjusting the grid-bias-voltage value.

A diagram in the dictionary shows "Close spacing for High-Mu Action—Wide Spacing for Low-Mu Action." It is suggested that the use of the term High-Mu in the illustration shows that the words "amplification factor" are more important than "mutual conductance" and, further, that the last part of this definition was inspired by B.S.204:1943, definition No. 1782—"A valve the mutual conductance of which can be altered smoothly over a wide range by variation of grid bias."

The "vastly sillier and more confusing" name (see "Cathode Ray's" article) was given to the valve by the inventors (Ballantine and Snow)—*Proc. I.R.E.*, Vol. 18, 1930—in describing their types 550 and 551 tubes.

L. BAINBRIDGE BELL.
Witley, Surrey.

IN your November, 1946, issue, "Cathode Ray" offers interesting criticisms of the use of μ to represent, among other things, variable-mu, which, he concludes, stands for variable mutual conductance. As one of the original sinners I wish to make the following explanation in the nature of a feeble defence. In 1931, at a conference with the late Stuart Ballantine, we were discussing the then new Type 551 tetrode, the first variable-mu tube made. Mr. Ballantine, Mr. Snow and myself designated the tube as a variable-mu (or μ if your typewriter had Greek letters) tetrode. The reasoning was as follows. The tube depended for its action on the irregular spacing of the control grid wires, this spacing determining what was then as now called mu or amplification factor, and this construction led to the amplification constant varying with grid bias when the tube was tested as a triode in a Miller bridge with the plate and screen connected together. This was the customary way to read amplification factor for the purpose of standardizing the tubes, although admittedly the tube was never operated in that way. The term variable-mu (or μ) *never* meant mutual conductance, a term which was anathema to Mr. Ballantine since he said that there was nothing mutual about it and he was instrumental in having it changed to transconductance after a long struggle with the I.R.E.

Incidentally there was a battle of μ versus *k* in the early 20's. General Electric and Bell Telephone Laboratories used μ (or mu) for amplification factor while Westinghouse would have none of it and used *k*. Many hours of argument were required to settle the issue and to this day one can spot a Westinghouse-trained man by his use of *k* whenever possible.

I would like to make a suggestion here that all technical people learn the Russian alphabet as they have learned the Greek, since a dozen or more new symbols, easily printable, could be had and perhaps the first six or seven could be used to relieve the burden of μ without treading on some otherwise preserved ground. The use of the *modern* Japanese alphabet has been suggested also and seems to have some merit as upwards of twenty new symbols could be used. German Gothic is too hard to print and read.

W. R. FERRIS.
Washington, D.C., U.S.A.

Standard Valves

AFTER several weeks of trepidation concerning the latest B.V.A. moves at valve standardization, I was greatly encouraged by J. Sparrow's letter in your January issue. I share his views on yet another awkward and irritating addition to an engineer's troubles.

"Standard" seems a very optimistic word to use for the new valve base, especially when it has to be divided into two types to accommodate the normal range of valves.

Surely a very convenient and practical base type has been evolved for us by the widespread success of the international octal base. Such a base will accommodate a large variety of valves without requiring different sizes of holders. The new standard, using a bayonet-type valve holder, on the other hand, limits the diameter of the base within close limits unless recourse is had to the use of different size holders.

The point that seems to be most difficult to understand is the necessity for placing the locating boss on the side of the shell, instead of on the spigot; and thus having to use a bayonet-type base.

With the very lengthy spigot and the bayonet-type base, more headroom will be required above the valve for the removal and replacement than need be. This does not seem helpful when considering the compact apparatus designers promise in the future.

The international octal base has been very successful, and the "international" quality ought to be an important point in these post-war days of high exports. The vast majority of service equipment uses the international octal, and this base is also appearing in many new sets.

Why not adopt that which experience has shown to be acceptable, simplify all our present valve types into a standard range, and make an important step towards progress?

As it is, wireless dealers will have to add yet another shelf for their valve stocks, *Wireless World* another page to its "Valve Data," and the enthusiast will have a still larger collection of oddities to choose from!

London, W.5. R. G. PARR.

Protecting Pilot Lamps

IN the "Random Radiations" columns of the September issue of your journal, "Diallist" mentions, under the cross-heading "Pilot Lamps," a need for a protective device for pilot lamps.

It may be of interest if I point out that such a device already exists in the form of Thermistors, a product of my company. In suitable circumstances Thermistors give adequate protection against surges to pilot lamps and the like.

B. J. AXTEN.

Standard Telephones and Cables, Ltd., London, W.C.2.

B.B.C. Quality

SOME very interesting points regarding the quality of present-day B.B.C. transmissions are raised by H. A. Hartley in your January issue. I should like to endorse his remarks regarding the frequency discrimination and harmonic distortion present in most broadcasts. I have conducted similar experiments to Mr. Hartley's and can vouch for the accuracy of his figures. It is noteworthy that the B.B.C. programmes of *commercial* discs show a consistently higher fidelity than many of their live studio broadcasts, which shows that there is something radically wrong with either studio or studio equipment.

Whilst admiring Mr. Hartley's curt dismissal of B.B.C. recordings, it must be realized that approximately 50 per cent of programme material during peak listening hours is recorded. Incidentally, not all recorded features are announced as such in the *Radio Times* and over the air.

Some of the "top" shows are *never* presented "live" nowadays; i.e., Music Hall, Navy Mixture, Have a Go, Robinson Family, etc. As all these recordings are usually of an extremely low standard, action of some sort is long overdue. In any case, the only legitimate use of a recording is for a repeat performance of some popular item: only then if the quality is sufficiently good. A defect which Mr. Hartley omitted to mention, but which he must have noticed, is hum. Most B.B.C. transmissions are marred to some extent by this form of distortion, particularly recordings, despite the fact that they are usually weak in the lower end of the frequency spectrum.

The B.B.C. has consistently neglected its duty to the public in respect of transmission quality, and it would appear that a real improvement can only be secured by appointing some outside body like the American F.C.C. to lay down standards to which the B.B.C. must be forced to conform.

HARRY TEMPLE.

Bedlingtonshire, Northumberland.

Technical Assistants

THE "technical assistant" is a comparatively new form of radio life. He is so far the product, not of special training or even necessarily of special aptitude, but of erratic selection from the upper fringe. of the mechanic-serviceman band of ability. That, and the very poor financial inducements offered, are the reasons why Thomas Roddam (your December issue) finds a shortage of these strange creatures in research and development spheres. Nevertheless, they are likely to increase in numbers, since their work is most attractive to the keener and more intelligent of non-degreed (surely "unqualified" is a little harsh?) technicians; it is time that they began to be officially recognized and classified as a special genus, and some sort of specialized training provided to ensure an adequate supply of them in industry. For they can be most useful when they know their work properly—which can be assured by suitable tests, both written and manual, and certification on the lines of other recognized professionals.

Ideally, the "technical assistant (radio)" would be a mongrel (or perhaps "hybrid" is the less offensive term). He would be partly pukka engineer, capable of grasping what his Head Wizard was driving at with "cos and tan and all that" and translating it into workshop English; partly draughtsman, able to play with ideas on paper and prepare working diagrams; and quite 50% skilled mechanic and tester, since he must be able to handle materials to make models and prototypes and to find out by measurements what their performance was. Altogether, a man of considerable parts, and invaluable to the highly trained academic specialist who did not want to come out of the clouds to tell somebody how many turns to put on or how to dispose of valve holders. W. H. CAZALY.

London.

RANDOM RADIATIONS

By "DIALLIST"

A Lifer?

THE French wireless magazine, *Toute la Radio*, asks: "Are we to be sentenced to the 4+1 receiver for ever and ever?" From which you will no doubt gather that the French radio industry is at the moment suffering from much the same lack of vision as our own. Somehow I don't think that our sentence will be a lifer, for our manufacturers are even now slowly beginning to realize that putting a conventional 4+1 combination into an unprepossessing box and labelling the confection "The World's Best Set, £15 15s," is not going to produce that post-war money for jam which so many of them had expected. That realization is being brought about by the failure of Mr. and Mrs. Broadcast Listener to queue up for the 4+1s—unless they're something very special in the way of 4+1s. The only really ready market, in fact, that such sets are finding is amongst people who are setting up home for the first time and have never owned wireless sets before. On the other hand, there is a big demand for high-priced receivers of good performance, which can't be turned out fast enough to meet it. I am sure that I'd have no difficulty, if I feel like it, in buying to-morrow a dozen assorted 4+1s off the shelves of the three radio shops of the little town in which I live; but if I wanted a more elaborate set I'd have to put my name down on a waiting list.

The Reason Why

There are over ten million owners of wireless sets here. The great majority of the receivers in use must be six years old or more, since supplies have been short from the autumn of 1939 until quite recently. There should therefore be a pretty considerable demand for replacements, one would think. Then why the rather sticky sales? Simply because, so long as the old set continues to work, people are not going to spend good money on a replacement which shows no very striking improvements in design or performance. Manufacturers possibly forgot that during the war the servicemen who remained in civvy street became adepts at fettling up elderly receivers. And, after all, is there so much that can wear out in a year or two in a reasonably well-made receiver? Replace the valves, the volume control (almost certainly required), the wave-change switch (nearly as likely), one or two resistors and capacitors, clean up and re-align, and the set will probably be nearly, if not quite, as good as ever it was. Its owner is hardly likely to discard it in favour of a new one unless that new one is obviously a much better thing. The price, I am sure, does not matter very much, so long as the receiver offered is good value. Wages have never been so high as they are today, and there is a pent-up urge resulting from the years of austerity to spend money on worth-while things—if they are available.

□ □ □

What *is* Radar?

THIS question does need to be settled and I was glad to see "Cathode Ray" raising it again in the December issue. As things are now almost any new-fangled system of direction or position finding or course indication is loosely classed as radar by folk who ought to know better. In the days when it was called R.D.F. and the term radar hadn't been invented echoes returning from the target to a receiver on the same site were an essential part. That is basically what radar should mean to-day. Radar should include such systems as H_2S and A.S.V.: it should certainly not include Gee, Loran and Decca. The beginning of the confusion came when I.F.F. made its bow. I.F.F. was part and parcel of every radar station, or at any rate of every gun-control and fighter-control radar station. It was developed by research folk concerned with radar, operated by radar teams and serviced by radar mechanics. Hence it was rather naturally lumped in with radar. Also it operated on exactly the same principle as many of the radar training devices—the triggering of a transmitter at the target by the outgoing pulse. And naturally again, these trainers were classed with radar.

The Slippery Path

Thus I.F.F., like the trainers, was not itself a radar device in the true sense, though it was part of many radar equipments. Once feet had been set on the slippery path towards inaccuracy by the classification of I.F.F. and training devices with radar, progress in this undesirable direction was rapid. Before long anything evolved by T.R.E. or A.D.R.D.E. (now R.R.D.E.) which used pulses and was concerned with position-finding or aircraft control from the ground became almost automatically an acknowledged, though illegitimate, member of the radar family. The next step was to dispense with echoes, whether primary or induced, as a criterion. Then the pulse was dropped as a birthmark proving radar legitimacy. Finally, systems using no pulses and no echoes and operating on the long waves claimed family rights to the name radar, and few save "Cathode Ray" and my humble self called attention to the triple bar sinister in their ancestry. Genuine radar is indisputably concerned with the out-and-home journeys of radio pulses. It is thus limited to systems operating on the ultra-short waves and the micro-waves in which the received pulse is an echo of the transmitted pulse.

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Programme Quality

MY sympathies are entirely with those who inveigh against the quality of reproduction obtainable from the B.B.C. transmissions to-day. Occasionally an item is pretty well transmitted and one can make the most of it with a receiver designed for high-quality reproduction. But how often does this happen? The answer, I am afraid, must be that it happens distressingly seldom. In common with most members of the male sex I maintain (though it is far from easy at times to make one's nearest and dearest believe it!) that I do a good day's work. The bulk of home listening is therefore done from about 9 p.m. onwards. Many of the directly transmitted items are not too bad, though harmonic distortion is far too prevalent. But what rouses me to wrath is the average recording, of which we have many more than should come the way of those paying a hundred-per-cent post-war increase in the cost of their receiving licences. Not to put too fine a point upon it, the generality of recordings are just foul!

Need They Be?

Often I ask myself why recordings should be so entirely bad; why they should scratch and/or crackle; why they should make speech sound like no human speech; why they should turn music into a travesty of its real self. I don't know the answers; I just go on wondering. The B.B.C. knows all about the magnetophon and possesses at least one working instrument. The magnetophon, we have been told, eliminates all surface noises and deals faithfully with all frequencies from about 25 to 10,000 cycles a second. Then if the magnetophon is there and is all that good, why on earth isn't it used regularly? It is reported to have been used lately for experimental transmissions. Anyway, it is no credit to the B.B.C. that we should have so many recorded items, for one of the great appeals of wireless is that is enables sounds to be broadcast as they occur. It is even more of a slur that the quality of the recordings should be at so low a general level.

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French-English Terms

WHEN I read the letter from M. Aisberg which appeared in the last issue I made a note to break a lance with him next time I set pen to paper. I can't and won't agree that *"un self"* is nothing more than technicians' slang in French for an inductor. I'll admit that it ought to be, since there are correct French terms for the same thing. But I've come across *"self d'antenne"* or *"self de 200μH,"* or *"self de 50H"* scores of times in reputable French text books and in circuit diagrams. I should hate to arouse the enmity of M. Aisberg, who took a very active part in the resistance movement and spent much time in devising methods intended (as he put it to me) *"pour enquiquiner le Boche"*—if you can translate that one, your colloquial French isn't too bad—and pretty effective methods they were. Still, I'm not going to let him get away unchallenged with his claim that *"un self"* is just slang and nothing more.

ALL-DRY PORTABLE

A NEW battery portable with 1.4V valves has been introduced by the Rees Mace Manufacturing Co., 40, Welbeck Street, London, W.1. Known as the "Cameo" Model AD70 the set employs a 4-valve superheterodyne circuit and has two waveranges. The price will be £15 plus £3 5s purchase tax.

"NOISE FACTOR": A Correction

It is regretted that in formula (1) on page 393 of the December, 1946, issue the denominator of the third term was given inadvertently as G_2 instead of G_1G_2.

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

TELEVISION IN THREE DIMENSIONS

TELEVISED scenes are reproduced in three dimensions, as distinct from the known stereoscopic effects derived from pictures that are projected on to a flat screen.

At the transmitter, the scanning system includes a "range-finding" device. This introduces an auxiliary current, which varies in intensity with the distance of each point being scanned, and is added to the ordinary signal.

At the receiver, the auxiliary signal-current is applied to deflect the scanning stream of a cathode-ray tube in a direction at right-angles to its normal sweep. The image of each spot is then projected on to the surface of a spiral drum, which takes the place of a viewing screen. The drum rotates once per frame, so as to produce a succession of contour lines, which vary in depth to an extent determined by the pitch of the spiral, thus presenting to an observer when viewed through a suitable lens system the impression of a luminous solid object.

Several forms of "range-finding" device are described. One consists of a pair of photoelectric cells, which are placed at different distances from the object being scanned, and are so inter-coupled that the output from one cell is divided by the output from the other to give the control current for the third dimension.

J. L. Baird. Application dates: August 26th, September 27th, October 7th, 11th, and November 26th, 1943; and February 9th, 1944. No. 573008.

RADAR

EXPLORING pulses are fed through a forked wave guide to two aerials which radiate in diverging directions, the resulting echo-signals being picked up on a corresponding pair of aerials which are similarly coupled to a common receiver.

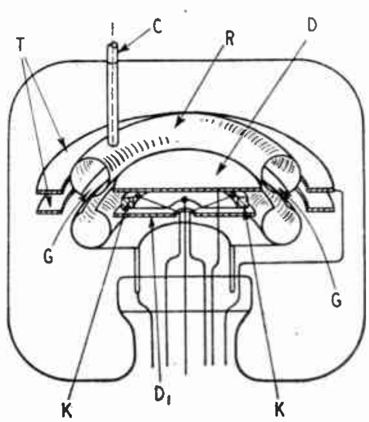
To ensure the desired sequence of operation, and to protect the receiving circuits from shock excitation when the transmitter is in action, a constantly rotating metal disc is used as an obturating switch.

Each of the wave guide feeders is fitted with a flange at odd number of quarter wavelengths distant from its forking point. Similar flanges, fitted to the ends of continuation feeders, are held in close alignment with the first set, but with sufficient separation to allow the metal disc to rotate between them. When both the flanges of a given wave guide coincide with an aperture in the disc, energy can flow freely to or from the corresponding aerial. On the other hand, any wave guide that is short-circuited by the disc will present a very high impedance to the operating circuit to which it is coupled.

Marconi's Wireless Telegraph Co., Ltd. (assignees of G. W. Leck). Convention date (U.S.A.) May 25th, 1943. No. 577269.

VELOCITY MODULATION

THE electrons emitted from a ring-shaped cathode K are first compressed into a thin sheet by the field from a pair of discs D, D1 and are then forced to pass radially through



Velocity-modulated valve generator.

the central gap G in an annular resonator R of dumb-bell cross-section. In their passage they are velocity-modulated by the internal fields, and at the far end are reflected back as a "bunched" in-phase stream, by a pair of biased electrodes T. The oscillations so built up are drawn off from the resonator by a coupling-loop (not shown) at the end of a concentric line C.

Owing to the thinness of the initial electron stream, the entrance to the gap G can be made comparatively narrow, thereby reducing radiation-losses from the resonator. At the opposite end of the gap, where the spread is greater, there is a corresponding reduction of the space-charge effect that normally tends to prevent efficient "bunching." If the electrodes T are biased so as to collect all the electrons having more than a given velocity, the device can be used as a mixer in a superhet receiver.

L. F. Broadway. Application date January 14th, 1941. No. 577037.

DIRECTIVE AERIALS

A KNOWN form of short-wave aerial consists of a length of wire which is wound into a continuous open spiral, according to the formula $L \pm S = \lambda$, where L is the length of wire in each complete turn (as measured by the velocity of the wave in the wire) and S is the spacing between successive turns (as measured by the velocity of the wave in space). The aerial is fed from one end, the other end being either left free, or terminated by an earthed resistance.

The directivity of the aerial is along the axis of the helix, the sense being determined by the plus or minus sign in the above formula, whilst the sharpness of the polar diagram increases with the number of complete turns. It is found, when a plain wire is used, that most of the radiation occurs from the first few turns, thereby limiting the directional effect.

To overcome this difficulty the wire is first coiled into a primary helix of small diameter before being wound into the helix of the master formula. The new value to be given to the term L is best found experimentally, but it is shorter for the close-spiralled wire, and shows a lower decrement due to radiation, so that the new aerial can include a greater number of useful turns than would otherwise be available.

Marconi's Wireless Telegraph Co., Ltd., and C. S. Franklin. (Addition to 573896.) Application date, December 4th, 1942. No. 576159.

TIME OR SPEED CONVERTERS

IT is sometimes desirable to slow down the timing of a recorded event, either to allow of a more detailed examination, or to permit the observation to be transmitted over a channel not well adapted for high-frequency working, as, for instance, when using land lines to relay the "spotting" of aircraft by radar equipment.

The necessary conversion is effected by means of a cathode-ray tube arranged to generate two separate electron beams, each of which scans a common screen, alternately, and at different speeds.

The screen carries a sensitized mosaic on the side facing the two guns, and is silvered at the back. It is first scanned by the beam which is modulated by the signal to be recorded. The resulting secondary emission produces static charges, which are then discharged, to reproduce the original signal, by the second beam, which is unmodulated and moves at a lower speed than the first. The first beam is cut out when the second beam is operating, and vice versa. The same device can be adapted to speed-up the original record.

Marconi's Wireless Telegraph Co., Ltd., and S. W. H. W. Falloon. Application date October 5th, 1939. No. 577068.

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.

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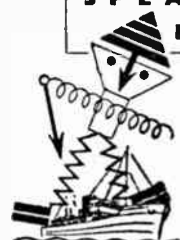

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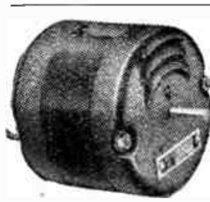

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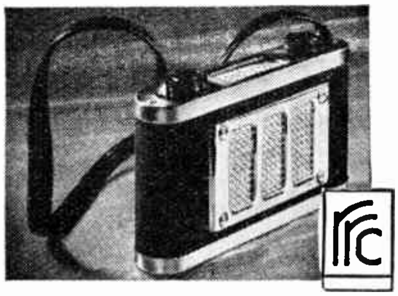

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Readers are warned that Government surplus components which may be offered for sale through our columns carry no manufacturer's guarantee. Many of these components will have been designed for special purposes making them unsuitable for civilian use,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

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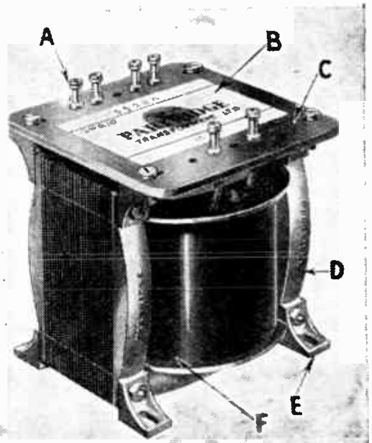

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FOR sale, 13 valve Stromberg Carlson super radio receiver, large console cabinet in excellent condition, size—height 43in, width 29in, depth 15in, 15-20 watts output from two 616's in push-pull feeding Auditorium loudspeaker and acoustical labyrinth, 5 wavebands; a real bargain for the connoisseur; cost approximately £120 in 1939.—Best offers to A. J. Harvey, Raleigh House, Newbegin, Hornsea, E. Yorks. [6850

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R.C.A. Volt Ohmyst Junior (electronic meter), A.C.-D.C. 0-3-1,000v. 0-1,000mΩ. new, with spare tubes; £22.—Box 5706. [6797

WESTON analyzer, new, 20,000 o.p.v., £20; R.C.A. Junior Voltohmyst, electronic voltohmmeter, new, £20.—Box 5629.

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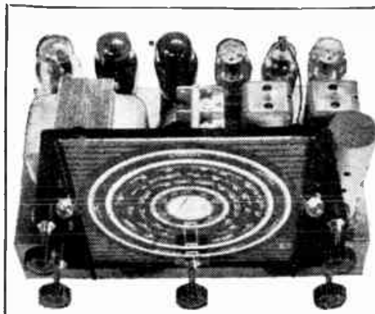

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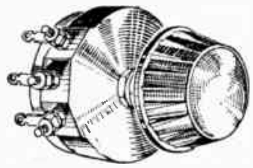

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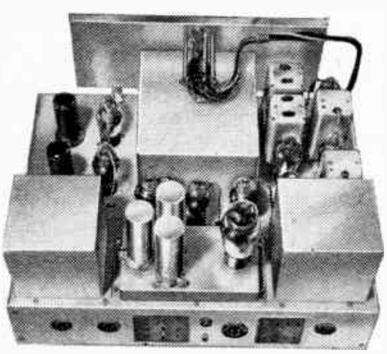

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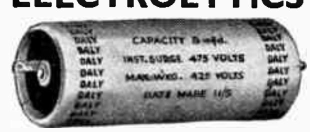

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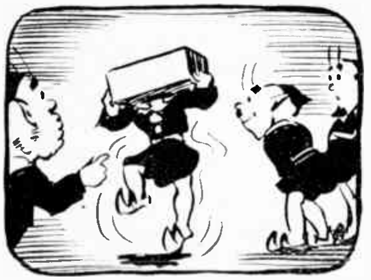

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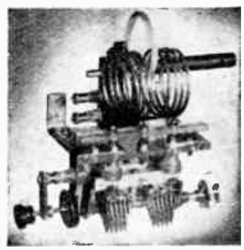

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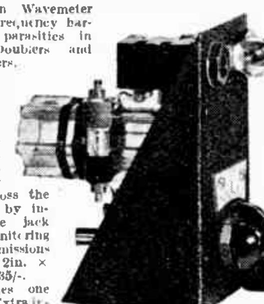

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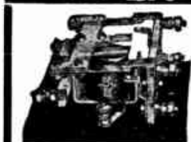

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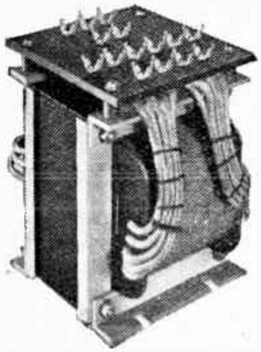

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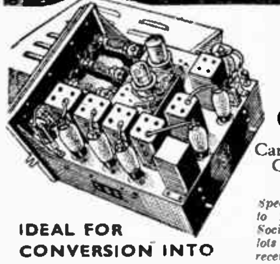

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RADIO production testers required for 12-valve advanced radiogram, first-class men only, 5-day week.—Apply Dynatron Radio, Ltd., Ray Lea Rd., Maidenhead. [6691

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A MAN age 25 may draw pay at £310, £347 or £420 a year on entry, according to qualifications and experience. In addition to pay single men receive free furnished accommodation and married men receive married allowance of £228; in both cases rations are provided in kind or a ration allowance of £57 a year paid in lieu.

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DYNATRON RADIO, Ltd., Ray Lea Rd., Maidenhead, have vacancies for the following technicians: Senior inspector, production testers, junior designing draughtsman, production wiring foreman; only first-class men required for exceptionally advanced radio work, excellent prospects, good pay and amenities.—Apply Personnel Manager. [6693

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RADIO instructors required to teach circuit theory and servicing of radio and radar apparatus, theoretical knowledge equivalent to City and Guilds intermediate standard with preferably some Radar and instructional experience; salary £275-£300, depending on age and experience, plus consolidated bonus at present £78 per annum.—Write, giving age and full details of education, qualifications and experience, to the Captain, H.M.S. Collingwood, Fareham, Hants. [6823

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"WESTON" Moving Coil Meters, edge type, 2½in. scale, 0 to .3 amps, **30/-**; 0 to 2 amps., **27/6**; 0 to 60 volts, **27/6**; 0 to 150 volts, **27/6**; all have F.S.D. of 2 m/amps.; 0 to 1 volt, 1 m/a. F.S.D., **35/-**; another 3½in. scale reading decibels 50 microamps., F.S.D., **70/-**, another 301 model 0 to 3 m/a., **40/-**; 0 to 50 m/a., **35/-**; 0 to 200 m/a., **35/-**.

EX-G.P.O. REPEATERS, CARRIER TELEPHONE TYPE No. 2. These are complete with valves and power pack for A.C. mains or battery working, consisting of 2 6v6's, 2 EF50, 12-volt Mallory Vibrator with necessary smoothing. New and unused, size 14 x 16½ x 20in., weight 127 lbs. **£7/10/-** each. Carriage 10/-.

ERNEST TURNER, moving coil m/amp. meters, 2in. scale, 0 to 10 m/a., 0 to 20 m/a., 0 to 50 m/a., **27/6** each; all fully guaranteed. Standard Telephone 3in. scale m/coil meters, calibrated to read 0 to 25, 100 volts movement, 1 m/a., incorporating metal rectifier, **45/-** each.

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SHORT WAVE H.F. CHOKES, 1/6; H.F. chokes, **1/-**; .01 condensers, **4/-** per doz. R.1.3 to 1 L.F. transformers, **6/-**; condensers, 1 M.F., 1/3; 2 M.F., **2/-**; 4 M.F., **3/6**; 10 M.F., **5/6** each; smoothing chokes, 20/30 henrys, 80/100 m/amps., **8/6**; electrolytic condensers, 80 M.F. 350 v. wkg., **7/6**; 500 M.F. 50 v. wkg., **8/6**.

USEFUL PANELS, consisting of chokes, resistances, mod. transformers, condensers, calibrated to decibels, and various other components, all mounted on metal baseplate, size 19 x 5 x 5, **10/-** each, post 2/6; 19 x 8 x 5, **15/-** each, post 2/6; 19 x 12 x 5, **20/-** each, carriage 3/6. All components as new. Makers Standard Telephone.

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INDUCTION MOTORS, approx. 1/16th h.p. 100 volt A.C. mains only. Can be used with a series resistance of approx. 50 ohms to work off 200/230 volts A.C., price **25/-** each. Carriage 1/6.

ROTARY CONVERTERS, D.C. to A.C., 20 volts D.C. to 75 volts A.C. at 250 m/amps., large size, weight 45 lbs., well-known makers, make useful rewinds, **45/-** each. 5/- carriage.

X-RAY TRANSFORMERS, 100/250 volts 50 cy. 1 ph. input, 90 kv. at 2½ kW. output, with Coolidge winding, small size, in oil, **£25** each Carriage forward.

D.C. MOTORS, approx. ⅛ h.p., either 110 v. or 230 volt, D.C. mains, series wound, **20/-** each. Post 1/6. Mostly with laminated fields.

EX-G.P.O. 2-TONE CONTROL UNITS. Consisting of 3 6v6's in Class AB—2 6v5G's, 8 WX6 Westectors, power pack, consists of Mallory 12-volt rectifier with all the necessary smoothing gear, numerous condensers and resistances, all in new condition, **£5/10/-** each C/P.

STEEL RACKS. Useful as transmitter racks, size 40in. x 24in. x 16in., **30/-**. Ditto, 58in. x 33in. x 18in., **70/-**. Carriage on all types, **7/6**.

ELECTRIC DESK FANS. Large type, 220 volts D.C., with a 15in. blade, **50/-** each, carriage 5/-. Ditto, 100 volt, induction type, for A.C. only, 12in. blade, **35/-**, carriage 3/6.

MOVING COIL HORN SPEAKER UNITS, by well-known makers, 15 ohm. speech coil, permanent magnet type, **12/6** each, post 1/6. Smoothing chokes, 20 henry, 40/60 m/a., **4/-** each Bakelite Valve Holders, 4-pin type, in lots of 50 only, **12/6**. Post 1/-.

EVERETT EDGCUMBE 3 READING VOLTMETERS, 0 to 5, 25, and 250 volts, 4in. scale, complete in teak wooden carrying case, **50/-** each. One only, Ship's Sextant (Makers, H. Hughes). condition as new, **£8/10/-**.

ROTARY CONVERTERS. Ex-Govt. 80 volts at 16 amps. D.C. input, 80 volts at 8 amps. 2,000 cycles output, **£5** each, carriage **10/-**. Another 460 volts D.C. input, output 300 volts 50 cycles 1 phase at 4 kilowatts, constant rating, condition as new, **£20**, C/F.

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EVERETT EDGCUMBE 2½in. METERS, 0 to 5 volts AC/DC, incorporating Westinghouse Rectifier, **47/6**. Ditto, calibrated in decibels +3—10, with rectifier, **65/-**. Another reading 15-0-15 m/amps., **35/-**. Ditto, 30-0-30 m/amps., **35/-**. These meters are all first grade moving coil instruments.

VARIABLE RESISTANCES, worm wheel drive, 2,000 ohms, to carry 250 m/amps, **35/-** each. Electrolytic Condensers, 2,500 mf., 25 w. wkg., **25/-** each; 250 mf. 250 v. wkg., **15/-** each.

MAINS TRANSFORMER, 200/250 v. Primary, 500/0/500 v. at 150 m/a., 4 v. 4 a., 5 v. 3 a. and 6 v. 5 amps., **55/-**. Ditto, 350/0/350 volts at 100/120 m/amps, 4 v. 4 a., 5 v. 2, 6.3 v. 4 amps., **32/6**. Ditto, 6 and 12 volts at 3/4 amps., **30/-** each.

MALLORY 12-VOLT VIBRATORS. New and unused, **7/6** each. Twin gang, .0001 mf. Variable Condensers, **10/-** each. Ditto, .00015, **12/6** each (well-known makers).

Other items in stock, for which please let us quote. 250 watt Transmitter Valves, Battery Valves, Switchboard Volt and Ampmeters, Dynamos Regulators, Transformers to your requirements, complete X-Ray Apparatus, etc., etc.

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THE Civil Service Commissioners announce that a special competition will be held for appointments as Assistant Engineer (new-style)—male—in the Post Office Engineering Department and Assistant Traffic Superintendent in the Telephone Department of the General Post Office. Approximately 100 vacancies in each grade will be filled by examinations spread over a period of two or three years.

CANDIDATES must have been born on or after the 2nd August, 1915, and have attained the age of 18 by the 1st January of the year in which they compete. Allowance will be made for service in H.M. Forces prior to 3rd September, 1939.

MEN only are eligible to compete for appointment as assistant engineer (new style).

THE salary scales are as follows:—

ASSISTANT engineer (new style): London, £280, rising by annual increments of £20 to £580; Provinces, £265, rising by annual increments of £20 to £560 (including consolidation addition).

ASSISTANT Traffic Superintendent:—Men: London, £190, rising by annual increments of £18 to £465; Provinces, £180, rising by annual increments of £18 to £435. Women, London, £190, rising by annual increments of £12 to £375; Provinces, £180, rising by annual increments of £12 to 345, to which is added a consolidation addition ranging from £78 at the minimum to £90 at the maximum for men over 21, with corresponding addition from £63 to £72 for women over 21. For men and women below the age of 21 the additions are as follows:—Age 18, men £47, women £47; age 19, men £55, women £55; age 20, men £63, women £59.

MALE candidates may apply to compete for appointment as assistant engineer (new style) and assistant traffic superintendent at the same examination.

THERE will be prospects of promotion to higher grades.

CANDIDATES now serving in H.M. Forces must send in their application forms in time to reach the Civil Service Commission not later than six months after the completion of their service. All other candidates must send them in by 1st April, 1947, except that for candidates who are under 18 years old on the 1st April, 1947, the latest date for sending in the form is the 1st January following their 18th birthday.

COPIES of the regulations and forms of application may be obtained from the Secretary, Civil Service Commission, Burlington Gardens, London, W.1, or from the Chief Officer, Civil Service Commission, at the following addresses, quoting No. 1679:—
(INDIA): 10, Underhill Lane, Delhi.
(EGYPT): 8, Sharia Tolumbat, Garden City Cairo.
(ITALY): C/o G.H.Q., C.M.F.
(GERMANY): C/o 2nd Echelon, G.H.Q., B.A.O.R. [6723

ENGINEERS with experience of design of electronic test equipment required by large London firm, previous experience in the design of test equipment for radio or radio components industry is essential.—Reply, stating full details of technical qualifications, experience, age, salary required, to Box 5579.

MODEL shop foreman required for large manufacturing group; tool room and press shop experience essential and at least five years' experience in development of small electro-mechanical devices; applicant must have initiative and be able to take charge; position offers interesting work and good prospects for the successful applicant.—Box 5666.

BRITISH OVERSEAS AIRWAYS CORPORATION require radio and radar mechanics overseas. Grade 1 City and Guilds standard essential, starting basic salary £215/16, plus overseas pay £104 per annum, and substantial station allowances which approximate to a further £300 a year.—Write, with details of experience and equipment serviced, to Staff Appointments Superintendent, Stratton House, Piccadilly, W.1, marking envelopes "Radio" and enclosing stamped addressed envelope [6730

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SIGNALS officer (R.A.F.), 26 yrs., married, requires remunerative and progressive post, ex-app. (R.A.F.), 10 yrs.' experience all R.A.F. radio comms., C. & G. Final standard, first-class administrator and organiser, available March.—Box 4901. [6570

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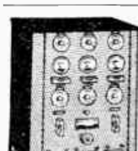

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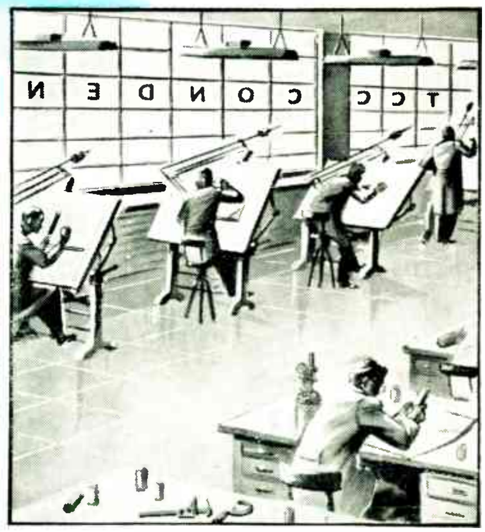

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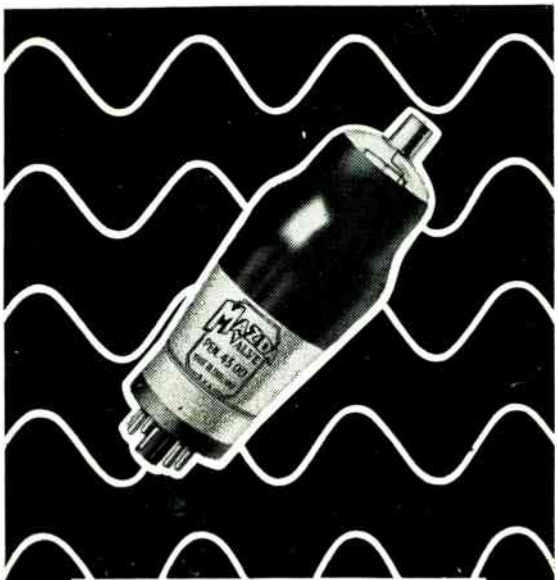
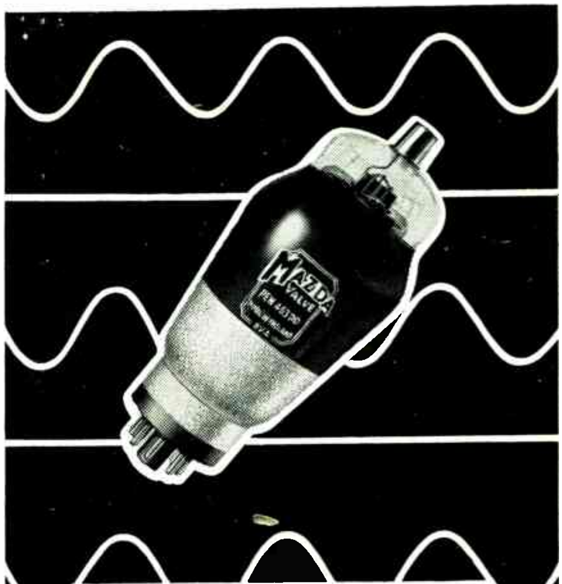


Pen. 45. DD

Filament Voltage	4.0V
Filament Current	2.0A
Maximum Anode Voltage	250V
Maximum Screen Voltage	250V
Mutual Conductance	9.0mA/V



Pen. 453. DD

Filament Voltage	45.0V
Filament Current	0.2A
Maximum Anode Voltage	200V
Maximum Screen Voltage	200V
Mutual Conductance	12.0mA/V

The Pen.45.DD, designed for use in A.C. Mains Receivers, and the Pen.453.DD, in AC/DC Receivers, are Double-diode Beam Power Amplifiers.

In either valve the double-diode section is completely screened within the valve from the tetrode section, so that the two sections may be treated as two separate valves as far as circuit considerations are concerned. They are designed to combine the functions of Detector, A.V.C., and Output Valve.

Under normal operating conditions the Pen.45.DD will give a Power Output of 4.85 watts and the Pen.453.DD of 4.3 watts for 5% Third Harmonic Content and with the Second Harmonic not exceeding 5%.

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