Radio SIR!

1930-1931

6D

William K. O'Brien

SHORT WAVE *or* BROADCAST—

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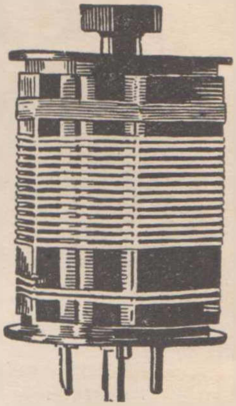

"Lewcos" Short Wave Coils

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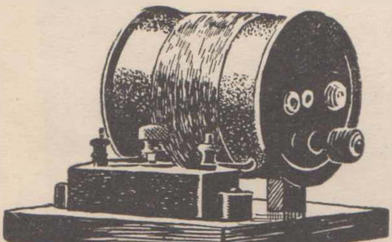

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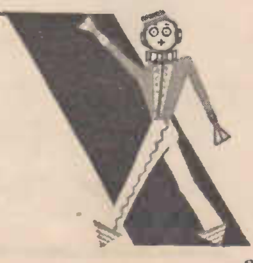
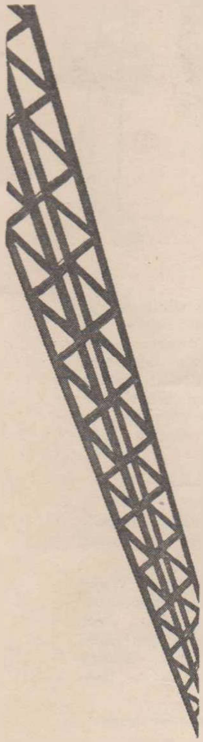


INTRODUCTION

Introductions are usually uninteresting sort of things, so we are assuming that you have left this page among the last to be perused, and have now at least a fairly good idea of the matter contained in this book.

Acting on this presumption we think you will believe us when we say that "Radio Sir" is the product of six months' solid work. Further, we think you will agree that, as a whole, whether the reader be the veriest novice, the home constructor or the most advanced amateur, these pages will have materially benefited him —and perhaps in some cases—her.

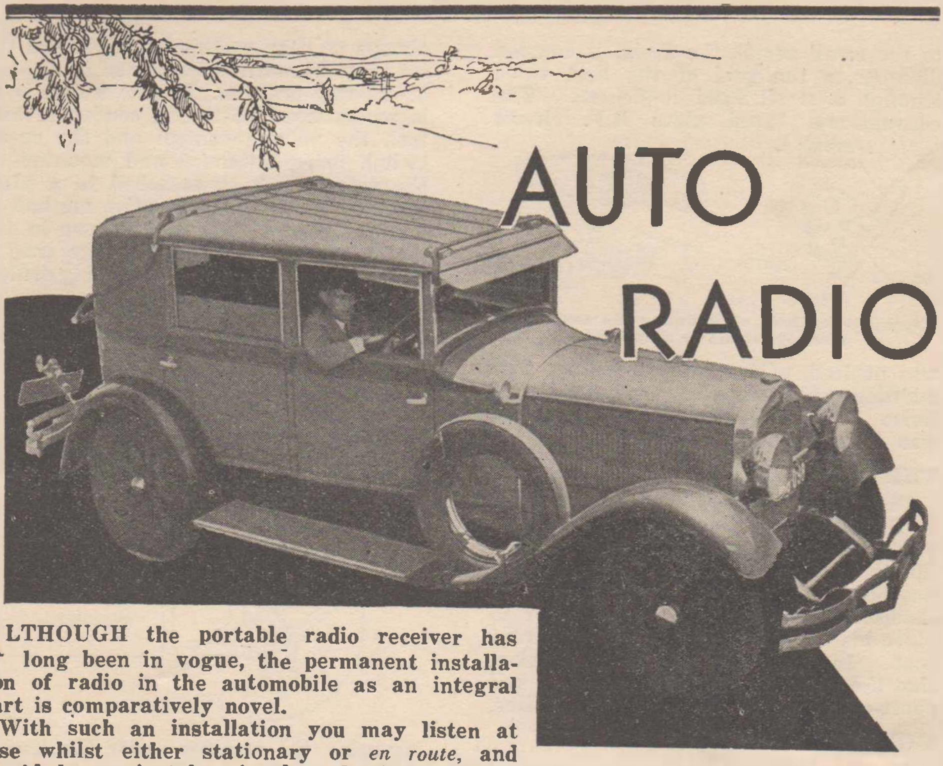


The receivers and amplifiers described in the first section, were designed and constructed in Philips Australian Laboratories and completed early in December.

The time that elapsed between then and now has been occupied by intensive testing and the alteration of details which testing showed to be desirable.

You paid 6d. for this copy of "Radio Sir"; if it had been possible to let you have it free we would have done so but, as it is, we think you will agree you have received a bargain for a price considerably less than the cost to produce.

In conclusion, if you have any queries arising out of the matter contained in the sheets that follow, please do not hesitate to write to your nearest Philips Office, who will help you to the best of their ability.



AUTO RADIO

ALTHOUGH the portable radio receiver has long been in vogue, the permanent installation of radio in the automobile as an integral part is comparatively novel.

With such an installation you may listen at ease whilst either stationary or *en route*, and provided care is taken in the selection of parts and in the construction of the receiver it will be almost as satisfactory as a home radio.

On long night drives and whilst waiting on punts and in queues, the Dashboard Radio is an entertaining and invaluable companion—its use for picnics, etc., needs no expansion.

THE VALVES:

IN the receiver around which this article is written, A.C. tubes were used due to the robustness of their filaments and the fact that the voltage fluctuations of the current drawn from a car's battery would not seriously affect their life. An additional advantage of the A.C. tubes used is the suppressing of microphonic noises.

Showing the "battery-box" which is made to contain three Ever-Ready batteries and is bolted under the floorboard.

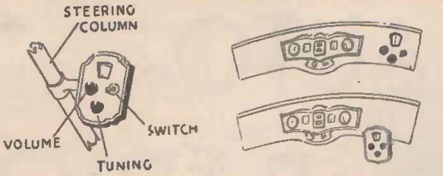
Four valves in all are utilised. The two R.F. stages employ the E442, whilst in the detector stage an E442S is used. These valves have an enormous R.F. amplification factor, enabling the amateur constructor to build a compact and efficient receiver capable of operating with limited aerial pick-up and with a low first cost and upkeep. This latter is, of course, important, as dry batteries must be used for plate supply.

Single lift audio amplification with the C443 penthode ensures excellence of reproduction. The C443 is designed to operate at 300 volts and has been incorporated in lieu of a B443 (150 volts) on account of the former's resistance to shocks and jolts.

The detector valve is coupled to the penthode by means of a Philips Resistance Capacity Coupling Unit. A 400 ohm potentiometer serves to vary the bias of the first R.F. valve and thus acts as a volume control. Selectivity not being particularly important owing

AUTO-RADIO—CONTINUED

to the small aerial, the aerial is coupled directly to the grid of the first valve through a small fixed condenser. The conventional tuned plate R.F. circuit



Alternative methods of mounting the controls on steering column or dashboard.

was utilised, with careful shielding. The addition of de-coupling resistors minimise R.F. feed-back. Grid detection was found to be most effective.

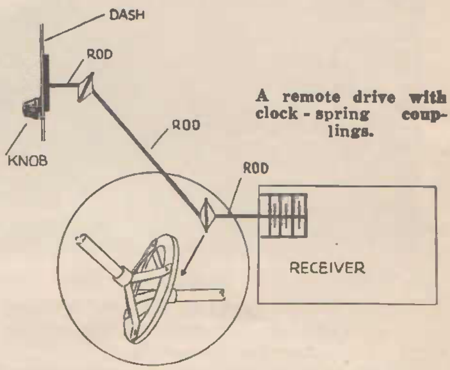
THE "B" BATTERY:

The accommodation for the three 45-volt Heavy Duty Ever-Readies was provided by the special sheet iron container illustrated, which bolted beneath the floorboards. In some cases it may be thought desirable by the constructor to place his "B" batteries beneath the front seat. In this case care should be taken that the batteries cannot move about and short-circuit or set up disturbing rattles.

MOUNTING:

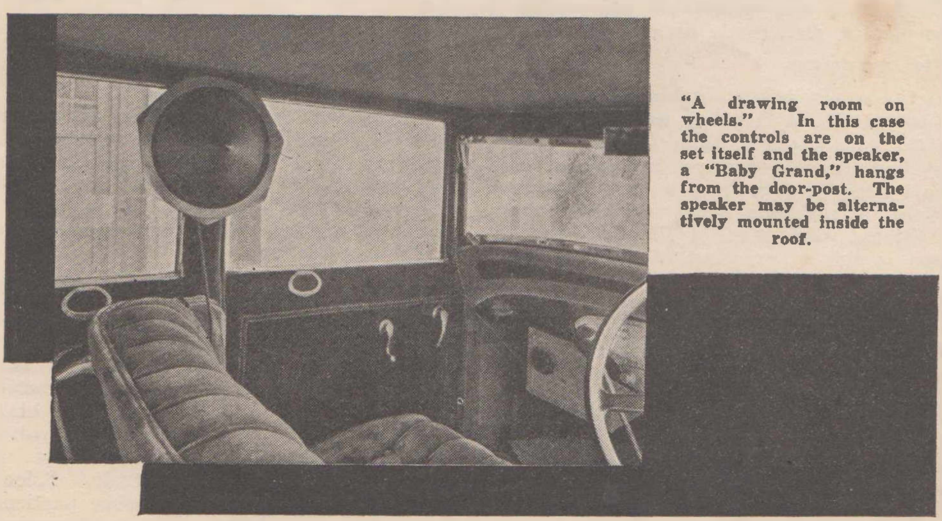
The receiver in question was mounted in a Hudson Six Sedan, underneath the dash on the driving side and, owing to the two inch shafts on all controls, put the dials at the finger tips. It is not always as easy as this however, and the set must sometimes be placed in an out-of-the-way position. Whenever this is so it necessitates the tuning condenser control, the volume control and the on-off switch being extended and mounted on the actual dash or attached to a plate screwed to it. An alternative method of mounting these controls is shown in (b) fig. 2, which has the advantage that it does not necessitate the dash being drilled.

A study of the radio journals reveals the fact that many of them recommend



A remote drive with clock-spring couplings.

mounting the receiver under the bonnet of the car and over the engine. This makes the elimination of ignition interference a heart-breaking job, and for this reason we do not recommend its consideration.



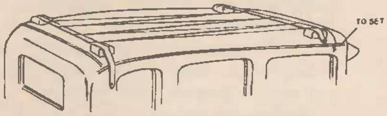
"A drawing room on wheels." In this case the controls are on the set itself and the speaker, a "Baby Grand," hangs from the door-post. The speaker may be alternatively mounted inside the roof.

AUTO-RADIO—CONTINUED

In cases when the receiver is not mounted right in front of the driver, long leads (which cause no trouble) are taken to the volume control and the switch which are mounted on the dash or the special plate. The condenser control gives a little more trouble, it being necessary to construct, a special flexible drive of the type shown in fig. 3. The constructor will usually be wise in avoiding any speedometer type drives, as a considerable amount of back lash is usually inevitable.

IGNITION INTERFERENCE:

In most cars, particularly where a common battery is used for filament and ignition supply, the ignition noises cause



One method of mounting the aerial with straps and blocks.

a considerable amount of trouble and unless eliminated make listening whilst the engine is running, impossible.

In the vast majority of cars all interference (or all that need be worried about) may be eliminated by placing 20,000 ohm wire-wound resistors in the spark plug leads, as shown below.

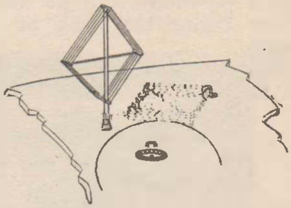
Carbon resistors are as a rule quite useless, although we believe a type especially designed for this purpose has been marketed in America. If these are available by the time this book is printed they will presumably be quite satisfactory; if they are not available we would once again stress that only wire-wound jobs should be employed.

If the generator is causing interference, this will usually be eliminated by placing a 2 m.f. condenser across its output.

AERIAL:

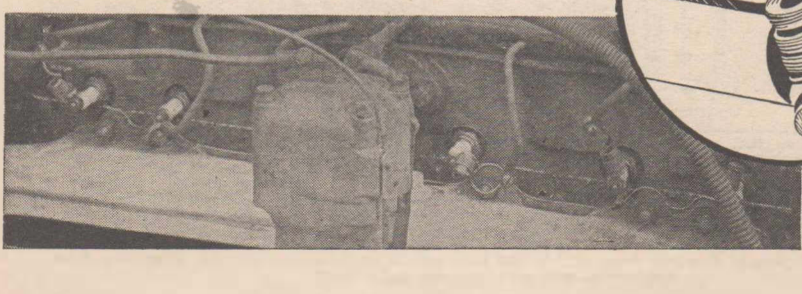
As with most points associated with the dashboard radio it is impossible to lay down any definite rules for the aerial system, as these vary according to the car, etc. An indoor aerial was tried with the Hudson, but owing to the steel body-work, results were practically nil. When this was transferred to the outside roof, signals came in at uncomfortable strength.

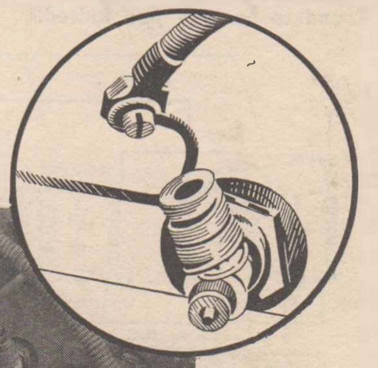
A suggestion for a frame aerial adjustable from inside.



Owing to the fact that one side of the accumulator of a car is always connected to "earth" (the chassis) no ground lead need be taken. In some automobiles the negative of the accumulator is earthed, and in others the positive. Owing to the provision of blocking condensers this point need not trouble the constructor. The "A" battery connection can usually be taken from underneath the dash from one side of the ammeter and chassis, and the circuit has been designed so that no harm can come if the set cabinet is in contact with the car frame.

Suppressors to eliminate ignition noise. These consist of wire-wound resistors of approximately 20,000 ohms.

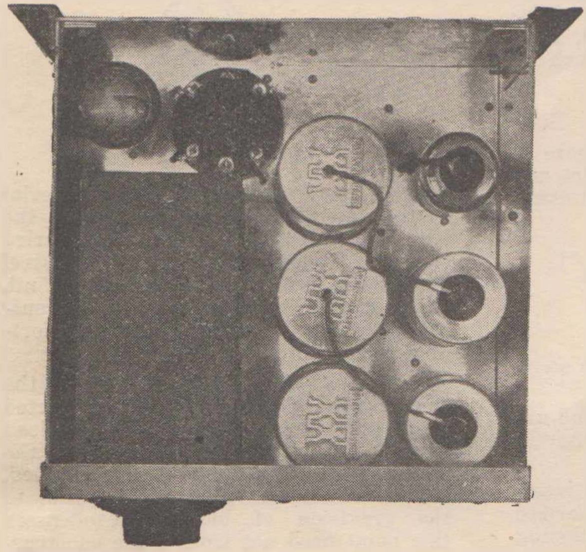




AUTO-RADIO—CONTINUED

THE SPEAKER:

It is recommended that a Philips 2020 "Baby Grand" be used and it will be found that the hanging device at the rear makes mounting to the door-post a moment's work. In the case of an open car, a position could no doubt be found either under the dash or alternatively under the hood. Owing to the natural damping of a sedan, the tone switch on the "Baby Grand" speaker should be placed so that the high frequencies are accentuated. Reproduction will then be found to be very fine indeed.



Overhead view of the auto set. All wiring, resistors, and condensers are mounted underneath the base.

GENERAL:

The set cabinet is fashioned from sheet aluminium and ⅜in. angle of the same material and by virtue of its compactness, will be found to combine the necessary stability with lightness. The gang condenser is shielded both between sections and in its entirety, and the coils and valves are provided with individual shields.

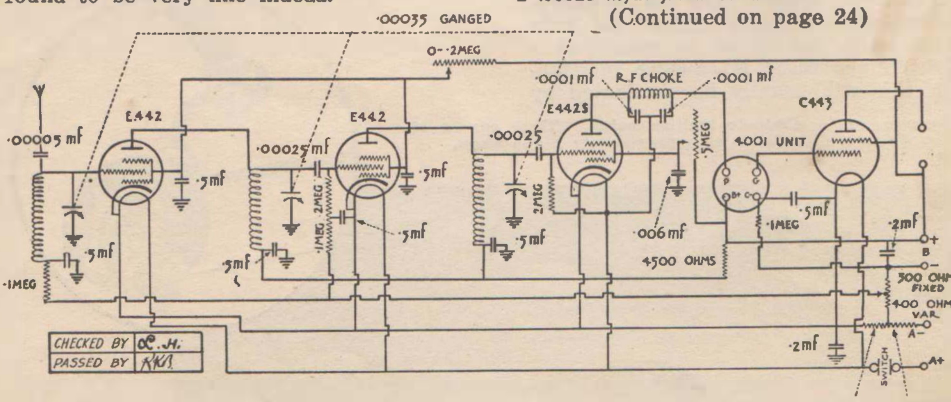
A sub-panel of aluminium is supported on the sub-panel brackets, and in turn supports the assembly and wiring. Point to point wiring may be adopted either with the convenient insulated hook up wire or spaghetti covered bus wire. That locknuts or spring washers be fitted to all mounting bolts, etc. is an absolute necessity, as otherwise the vibration will speedily loosen everything.

External wiring can be concealed under the car mats and in the upholstery and where exposed to possible damage or water, covered with flexible metal tubing.

PARTS REQUIRED:

2 *Philips E442 valves.*
1 *Philips E442S valve.*
1 *Philips C443 valve.*
1 *Philips 4001 unit.*
1 *Three gang .00035 mfd. condenser.*
7 *.5 mfd. fixed condensers.*
2 *2mfd. fixed condensers.*
1 *.006 mfd. fixed condenser.*
1 *.00005 mfd. fixed condenser.*
2 *.00025 mfd. fixed condensers.*

(Continued on page 24)



The theoretical circuit diagram from which the best positions for mounting the numerous fixed condensers and resistors can be gauged.

The "PCJ-FIVE"

—A SHORT WAVE RECEIVER CAPABLE OF TUNING IN THE WORLD'S MOST SCATTERED STATIONS

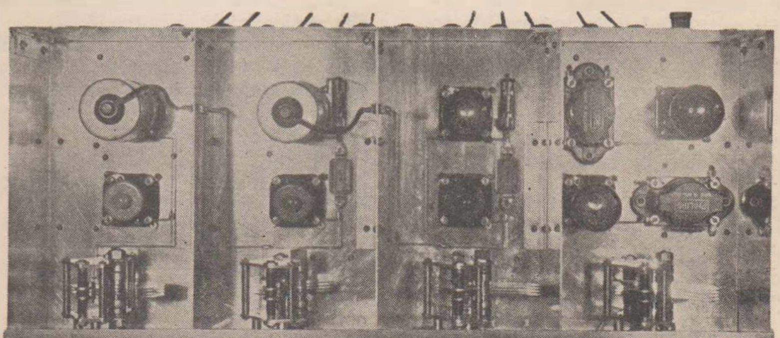
TO the ordinary listener there is probably no thrill in radio to equal that given by the reception of broadcast speech and music from a station in a far distant country. This is an experience which the short-wave listener, who is equipped with a good set, is constantly enjoying.

THE average broadcast listener is usually somewhat bewildered when he first operates a short-wave receiver, due to the fact that he is totally unaccustomed to wondering whether the music which is being received with such clarity is perhaps from Germany or America. The short-waves can truthfully be said to absolutely annihilate distance as we know it.

The construction of a modern short-wave set, thanks to the screen grid valve, is simple and, although conditions for the reception of various countries vary considerably in respect to the time of the year and even the time of the day, nevertheless there is nearly always something of interest to be picked up.

The PCJ-5 is a practical set of extremely high efficiency, which has been designed so that the amount of wiring has been reduced to a minimum, and providing the original layout is approximately adhered to, good results are bound to ensue.

An inspection of the theoretical dia-



Overhead view of the PCJ-Five showing the disposition of components.

THE PCJ-FIVE—CONTINUED

gram shows that the circuit consists of two tuned R.F. stages employing the A442 screen grid tubes, a regenerative detector with potentiometer control of grid potential, transformer coupled to two stages of audio.

The layout and wiring with the aid of the theoretical sketch and the very clear photographs, should present no difficulty whatever.

It should be noted that the potentiometer must be completely insulated from the panel.

The tops of the three valve holders, which carry the coils, should each be painted a distinguishing colour; the top of the aerial coil socket—yellow, the first R.F.—red, and detector—black. If the tops of all the coils are now painted in similar colours, changing of coils becomes very easy, and it is impossible to plug the wrong coil in any socket by mistake. Coil data is given at the end of this article.

The tuning of this receiver may be found somewhat difficult, the most important point being to keep the reaction control well back.

When a station has been located and the screen grid stages brought into resonance, it will possibly be necessary to again reduce reaction. If the reaction is not kept well back at the commencement of tuning, it will probably be found that, when bringing the screen grid stages into resonance, the receiver will break violently into oscillation until the peak tuning is reached, when it will stop oscillating altogether and another search will have to be made for the station.

For those who find the three stages too difficult to tune, the aerial coil can be replaced by a 3,000 ohm wire wound resistance, making this stage aperiodic. Probably the easiest method of accomplishing this is to mount the resistance on top of a valve base, the two filament pins being connected together, and the grid and plate pins connected, the resistance being then connected between the grid and filament pins.

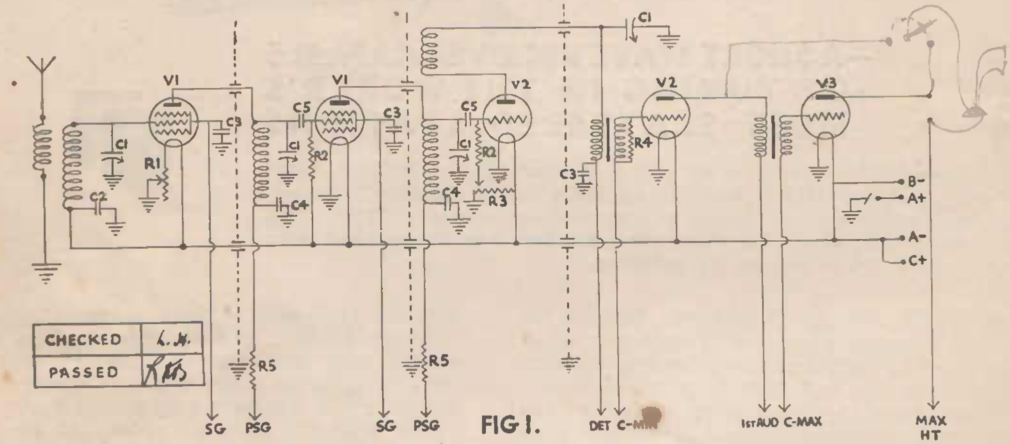


FIG 1.

The theoretical circuit diagram.

Before this unit is plugged into the valve holder in the set, the earth connection must be removed from the aerial coil altogether, so that the aerial is only earthed through the condenser "C2." This new arrangement is shown theoretically in Figure 2.

The potentiometer control on the bottom of the grid leak will be found of great assistance in obtaining smooth reaction and bringing the receiver to its most sensitive state.

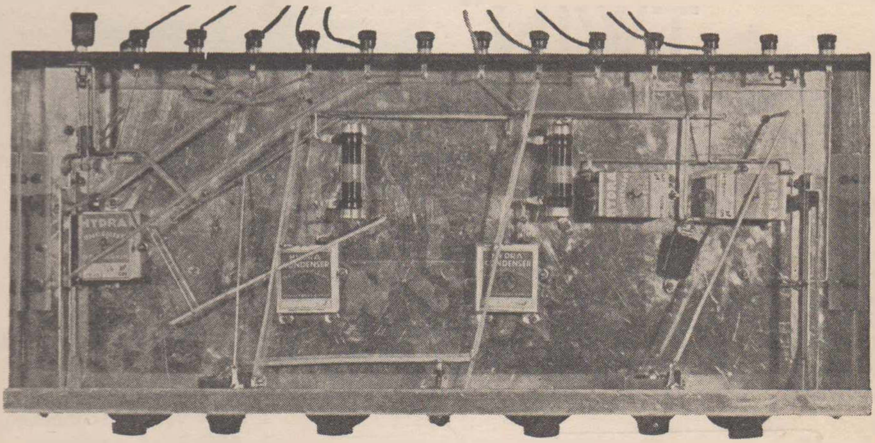
One of the main drawbacks to smooth reaction in short-wave sets (fringe howl) has been overcome by means of the resistor "R4" placed across the secondary of the first transformer.

This receiver can be worked efficiently from a Philips "B and C" power unit or, alternatively, 135 to 160 volts of "B" battery. In either case a 4-volt accumulator should be used. If a Philips Trickle Charger is employed, this accumulator can be of low capacity.

THE PCJ-FIVE—CONTINUED

In conclusion, this set, during the extensive tests which were carried out with it, gave results which were better than those given by any other home-built, short-wave set, with the exception of one of the Supersonic Hetrodyne type.

With the aperiodic aerial the results were excellent and control very easy.



Under-panel view of the receiver showing wiring.

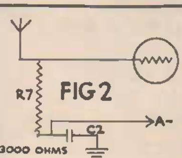
COIL PARTICULARS:

Coil Set	Wavelength	Yellow 1st coil turns		Red 2nd coil turns	Black Det. coil turns	
		Antennae	Secondary	Secondary	Reaction	Secondary
1	14 to 25.75	5	3½	3	4	3
2	23.25 to 43.75	6	6	6	6	6
3	41 to 83	10	16	14	7	13

All coils wound with 26 D.S.C. The turns given for SG coils are only approximate and vary for every receiver.

PARTS REQUIRED:

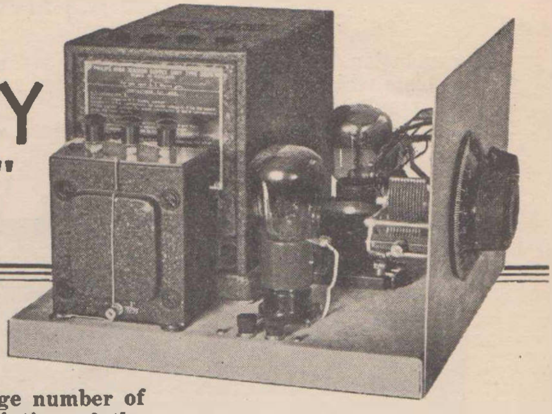
*V*1. 2 *Philips A442, Cap G.*
*V*2. 2 *Philips A415, Cap G.*
*V*3. 1 *Philips B405, Cap G.*
*C*1. 4 .00015 *variable condensers (Igranic).*
4 *Vernier dials.*
*C*2. 1 .006 *fixed condenser (Igranic).*
*C*3. 3 .5 *fixed condensers.*
*C*4. 2 .25 *fixed condensers.*
*C*5. 2 .0001 *fixed condensers.*
8 *UX valve sockets.*
1 *Filament switch.*
13 *Terminals.*
1 *Jack, S.C.*
1 *Jack plug.*
2 *Grid leak clips.*
*R*2. 2 6 *meg. leaks.*
*R*5. 2 5,000 *ohm fixed resistors (wire wound)*
*R*4. 1 .1 *meg. leak.*
*R*3. 1 400 *ohm potentiometer.*
*R*1. 1 30 *ohm rheostat.*
1 *piece Bakelite* 23⅞ *x* 2.
2 *Screening cans.*
2 *Philips* 4003 *audio transformers.*
9 *Valve bases (G or UX).*
¼-*lb. nr26 D.S.C.*
1-*lb* 16 *gauge tinned copper.*
4 *lengths spaghetti covering.*
1 *Ten cord battery cable.*
5 *doz.* ¼*in. x* ⅛*in. metal screws and nuts.*
2 *doz.* 1*in. x* ⅛*in. metal screws and nuts.*
1 *Pair sub-panel brackets (2in. high).*



Showing how aerial is earthed through the condenser C2.

(Continued on page 16)

The "ECONOMY TWIN"



A MODERN TWO-VALVE ALL-ELECTRIC RECEIVER

WHILST most radio hobbyists aspire to something more ambitious than a two-valve local receiver we feel that there will be a large number of readers who would appreciate a description of the Economy Twin—designed by Philips for home construction. As many interested readers will not be technically conversant with set-building, fullest details are given, whereas with the more complicated sets much is left to the constructor owing to space limitation.

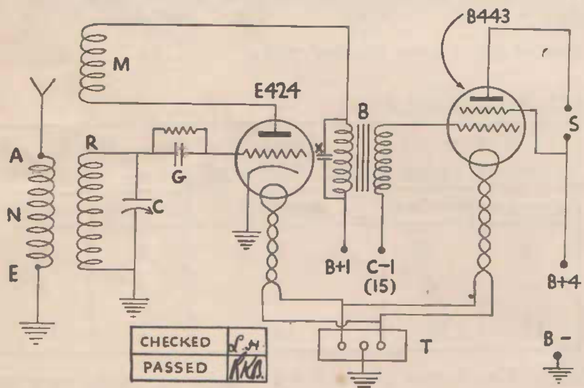


FIG. 1. The circuit diagram.

THE illustration of the finished set, which may be built into a new or existing cabinet if desired, shows that the main features are undoubtedly its compactness and simplicity. Power is derived from a Philips 3009 "B and C" power unit and a 4009 filament transformer. These are mounted at the rear whilst the radio components occupy the space immediately behind the panel.

The parts required are as follows:—

1 Philips 3009 "B" and "C" power unit
1 Philips 4009 filament transformer
1 Philips 4003 audio transformer (B)
1 Philips E424 valve
1 Philips B443 valve
1 Radiokes 3-coil tuner with swinging coil reaction (M.R.N.)
1 .0005 variable condenser (C)
1 .001 fixed condenser (X)
1 .00025 fixed condenser (G)
1 2 megohm grid leak
1 piece 16 gauge aluminium, 12in. x 8in.
1 piece 16 gauge aluminium 13in. x 14in.
1 Pilot UY valve socket
1 Pilot UX valve socket
4 Terminals
2 Ebonite strips
Nuts and bolts.

CONSTRUCTION:

The large sheet of aluminium should first be bent to a

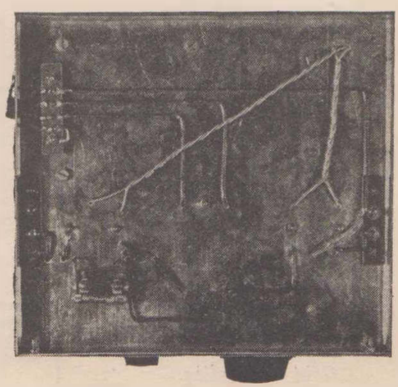


FIG. 2. Under-panel view.

THE "ECONOMY TWIN"—CONTINUED

platform formation as shown in the finished photograph with a side flange of 1 inch. The components may then be mounted as shown in the overhead photo (fig. 4) and the layout plan (fig. 3). The layout plan shows how the wiring is next accomplished and it will be seen that the dotted lines represent "underbase" wiring. Several holes are necessary in the base to bring the wiring out on top, and the ebonite strip for mounting the speaker terminals must keep the terminals from making contact with the base which is used as the common earth connection. The aerial terminal must also be insulated from the base but the earth terminal, of course, should make good contact with it.

The connection "C" on the five pin UY socket should be connected directly to a screw which holds this socket on to the aluminium panel. If there is any doubt as to whether this screw makes good contact with the aluminium a short lead should be taken directly from "C" to the bottom of the terminal "E."

Filament wiring, which should be of twisted flex, should be kept well away from the rest of the wiring. Note that the connection from filament transformer to earth terminal should be continued to one of the base screws to ensure contact.

The selectivity of this set is adjustable by means of the aerial coil "N," and is greatest when this coil is at right angles with respect to coil "R." When in this position volume is natur-

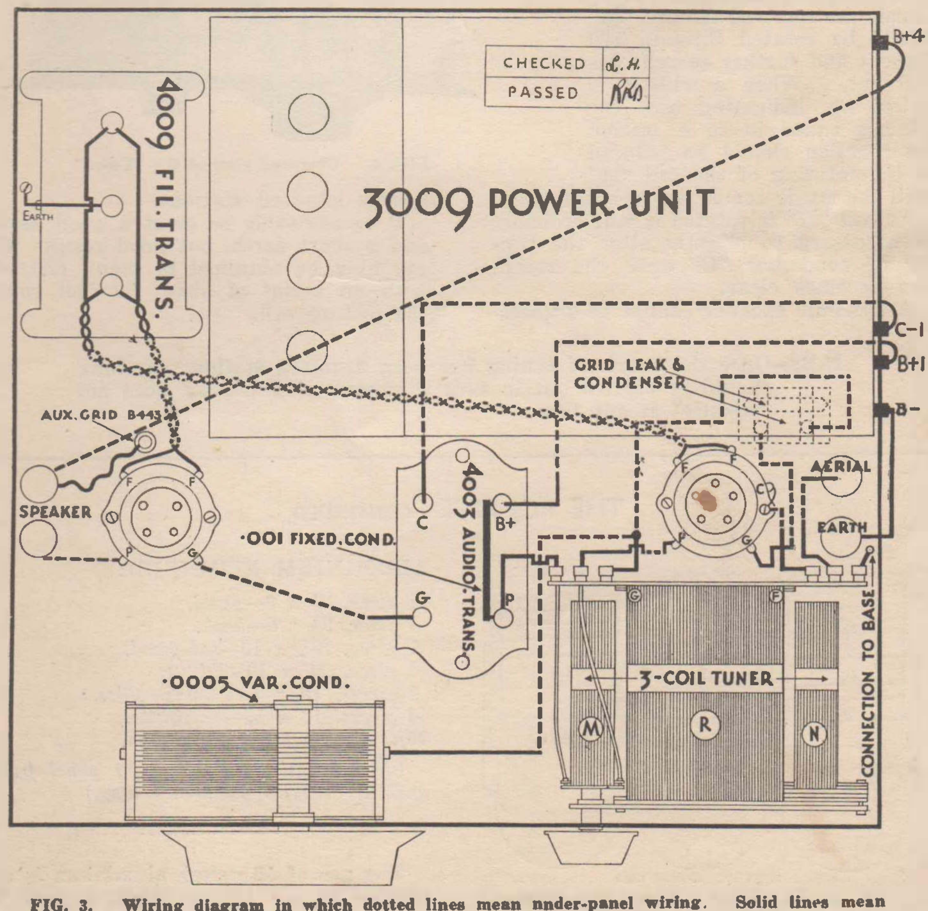


FIG. 3. Wiring diagram in which dotted lines mean under-panel wiring. Solid lines mean top panel wiring. Grid leak and condenser are mounted under panel.

THE "ECONOMY TWIN"—CONTINUED

ally not nearly so great as when it is parallel.

When the wiring has been completed, the E424 should be placed in the five-pin N (UY) socket, and the B443 in the four-pin G (UX) socket.

The spring plug in the "C" bias portion of the power pack should be No. 15 along the top row.

Upon switching on for a test the coil "N" should first be brought as close as possible to "R" and the swinging coil "M" adjusted so that it also is parallel to the coil "R."

The tuning condenser "C" should then be slowly rotated until a station is heard. If no signals are received the coil "M" should be rotated through 180 degrees and further search carried out. When a whistle is picked up, indicating that the set has tuned in to a station the reaction should be reduced by the rotating of the coil "M" until the music comes through naturally.

As coil "M" is rotated it will probably be necessary to slightly alter the tuning of condenser "C" until the reception becomes clear.

A dynamic speaker cannot be successfully used with this receiver but a Philips magnetic model such as the "Peter Pan" or "Baby Grand" will give all the volume which could be desired when receiving locally situated stations.

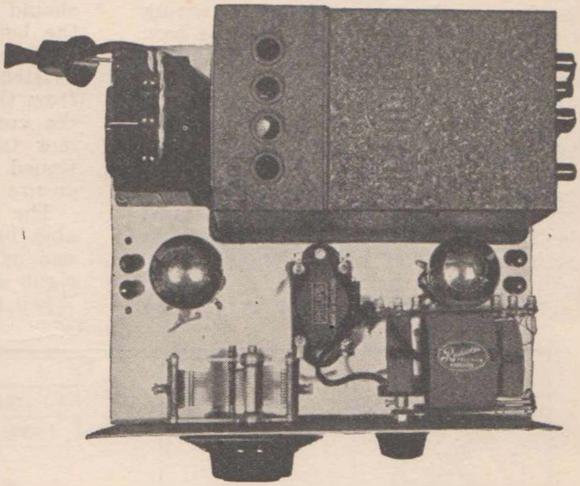


FIG. 4. Overhead view of the "Twin."

It is advisable to erect a good aerial and a short earth, but good results will probably be obtained in many districts with an aerial of about 30 feet round the picture rail.

N.B.—Once the knack of tuning has been acquired station searching should be carried out in such a manner that the set does not "whistle" at any time.

THE PCJ-FIVE—CONTINUED

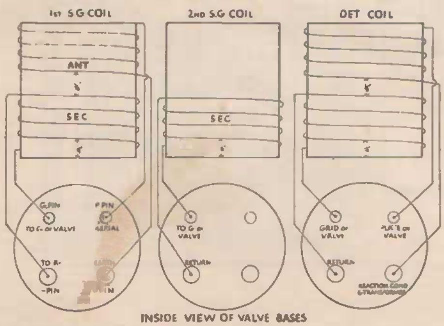


FIG. 3. Details of coil connections for yellow-red, and black sockets.

ALUMINIUM REQUIRED:

1 piece, 24 x 8—panel.
1 piece, 24 x 6—back.
1 piece, 23⅞ x 10—sub-panel.
1 piece, 24 x 10—lid.
2 pieces, 10 x 7 15/16ths—sides.
3 pieces, 10 x 5⅞—partitions.
10ft. of ¾in. angle aluminium.

(This quantity will allow for panel frame and 12 brackets 4½ inches long.)

The use of 16 gauge aluminium is advisable as the job is heavy enough to warrant it.

The IMPROVED AC333

INTRODUCING THE SCREEN-GRID DETECTOR

WHEN the now famous A.C. 333 was introduced in 1929, it incorporated principles of advanced design, and leapt immediately into popular favour.

The circuit was featured in "Popular Hobbies," "Wireless Weekly," etc., and back copies of these papers should be referred to for that circuit.

In introducing the improved A.C. 333 the band pass filter system, which proved so effective in the original model, has been retained.

AN inspection of the circuit shows that it still incorporates the well-known E442 screen grid. This is band-pass coupled to the detector, which is a new type of screen grid tube, E442S. This, in turn, is resistance coupled to a B443 penthode, the whole combination giving a very high overall gain together with genuinely phenomenal reproduction. In the previous modél transformer coupling was utilised.

The following method of construction will be found the easiest.

First, screw the screening box firmly to the wooden baseboard in the position shown in the layout. The position will be easily found because the front section of this screening box is permanently attached to the front panel of the case.

Next, mount the following components:—

The Toroid coil, .01 condenser, 1 M.F. condenser and the horizontal E442 valve socket.

The R.F. choke N (UY) socket for the E442S and the two other 1 M.F. condensers inside the screening box.

The Philips 4001 resistance capacity unit and G (UX) socket for the B443.

A considerable amount of wiring can now be carried out, according to the theoretical circuit diagram. The grid condenser can also be screwed to the base-board and connected.

The band pass coil should then be wired into the circuit and the panel units mounted. These are:—

9 plate midget condenser (reaction).

The ganged condenser, which consists of two Pilot condensers coupled by means of a set of Pilot links.

Volume control resistance, and

Aerial tuning condenser.

The front panel, with these components, being attached firmly to the front of the set, more wiring can then be completed.

The A.C. filament leads should consist of twisted flex in lengths of 8, 14 and 20 inches for the E442, E442S and power tube respectively.

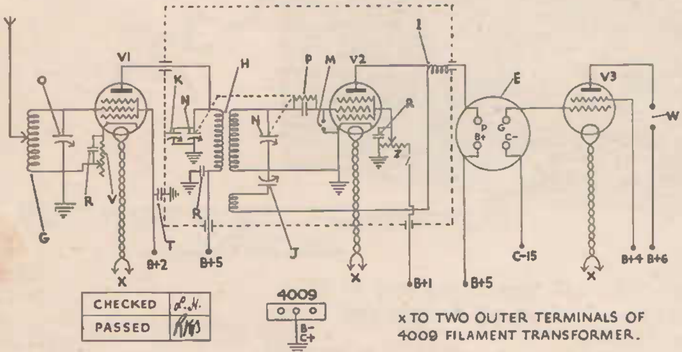
Next the small balancing condenser and the potentiometer, for adjusting the voltage on the screen grid of the detector, should be mounted.

The other three sides of the screening box can then be dropped into place and the wiring completed.

The power pack should now be

THE IMPROVED A.C.333—CONTINUED

mounted. The screw in the base of this corresponds to the hole in the base-board and this should be removed from the power pack and inserted through the hole in the base-board.



Circuit diagram.

The power pack should now be connected up, the rest of the cabinet assembled, and the set made ready for test.

Insert the valves in the order shown and connect the three flexible leads to the respective terminals of the screen grid and penthode tubes.

For a first test, the plates of the reaction condenser should be placed approximately half way in, and the moving contact of the potentiometer "X" controlling the screen grid voltage, also half way. The volume control should be turned as far as possible in a clockwise direction. Both the main tuning condensers should then be rotated very slowly.

Having tuned in a station the potentiometer "X" should be carefully adjusted for maximum volume. It is probable that when a station is found the reaction will have to be considerably reduced.

When everything else is correctly adjusted for that broadcaster, the small balancing condenser should be rotated very slowly until the best results are obtained.

Once the best positions for the potentiometer "X" and the small balancing condenser "K" are found, these two components can be left permanently adjusted.

The combination of the E442S and the 4001 unit results in a constant amplification between 100 and 5,000 cycles, whereas at 10,000 and at 50 the amplification will be 70% and 85% respectively of that obtained at 100 cycles.

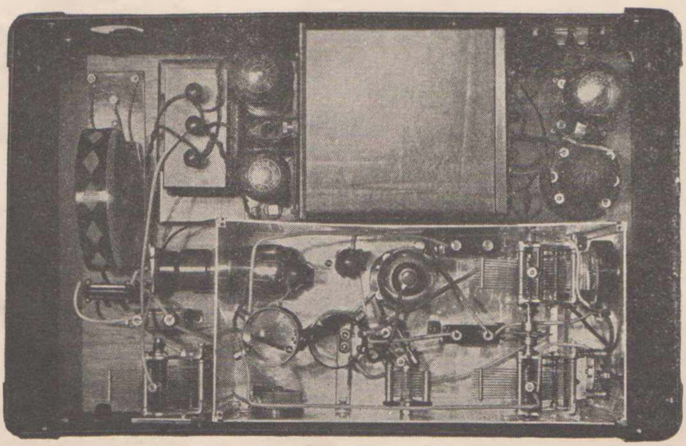
On test this set gave very remarkable results. The quality was excellent and the selectivity was extremely good.

Throughout the tests an energised Philips moving coil speaker and a Philips "Sevenette" were used, the volume being sufficient to fill a large room on either.

Parts required:

A 1 *Philips power pack.*
V1. 1 *Philips E442 Cap N.*
V2. 1 *Philips E442S Cap N.*
V3. 1 *Philips B443 Cap G.*
E. 1 4001 *Philips R.C. unit.*

(Continued on page 20)



Overhead view showing layout of parts.

The IMPROVED DC 333

INTRODUCING THE SCREEN-GRID DETECTOR

THE original D.C. 333 receiver, which was designed by Philips Radio as an answer to the demand for a Direct Current version of the A.C. 333, was at the time of introduction one of the most advanced of three tube receivers.

The improved model is now presented with the same confidence and, like its predecessor, it is for use where A.C. mains are not available.

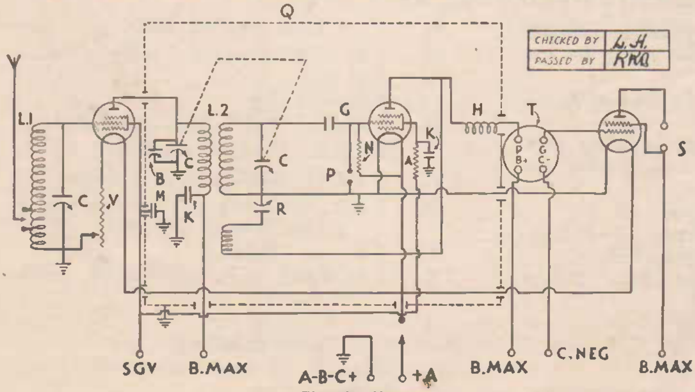
THE new improved D.C. 333 is equipped with a screen grid detector and is thus designed along the most modern lines. The incorporation of this detector system increases the gain from this stage, while the original purity of tone has been retained. We thus believe that this receiver satisfies every requirement for a simple, highly efficient and economical, modern set; light in both "A" and "B" battery consumption and capable of good "distance" results together with excellent tonal quality.

The theoretical diagram shows that the receiver employs three tubes; these consisting of two screen grids, type A442, and one penthode, type B443.

The radio and detector stages are coupled by means of a "band pass filter," this method giving maximum gain together with full retention of all side bands, while the selectivity is of a high order.

The screen grid detector is then coupled to the penthode by means of a Philips 4001 resistance capacity unit; the combination of screen grid and 4001 giving a gain of 78 in this stage.

The two tuning controls have been retained. The two dials will usually be found nearly in step and tuning is simple. Although one dial control has certain definite advantages in easy tuning, the additional complexity and cost is not justified in a receiver of this type, particularly where the greatest efficiency per stage is aimed at.



Circuit diagram.

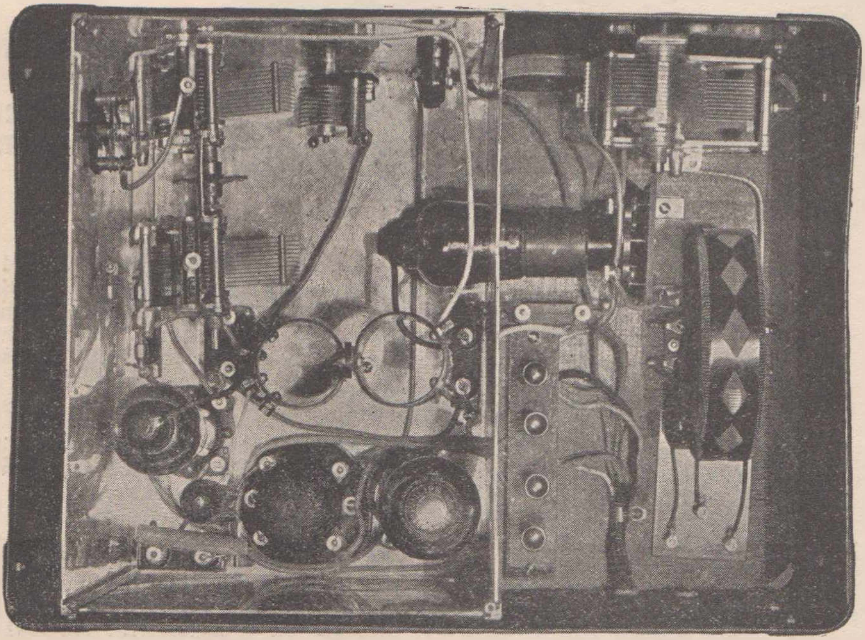
The parts required to build the receiver are:—

- 1 *Philips valve B443.*
- 2 *Philips valves A442.*
- 1 *Radiokes metal cabinet ready drilled.*
- Q. 1 *Radiokes box shield*
- L1. 1 *Radiokes special circloid coil.*
- L2. 1 *Radiokes band pass coupling unit*
- R. 1 *Radiokes 19 plate midget condenser.*

THE IMPROVED D.C.333—CONTINUED

B. 1 *Radiokes 5 plate midget condenser.*
H. 1 *Lewcos R.F. choke.*
1 *Radiokes vertical valve holder.*
C. 3 *Pilot 1623 centraline variable condensers.*
K. 2 1 *M.F. Philips fixed condensers.*
G. 1 *.00025 T.C.C. condenser.*
M. 1 *.01 T.C.C. condenser.*

To complete the set a 4-volt accumu-



Overhead view showing parts layout.

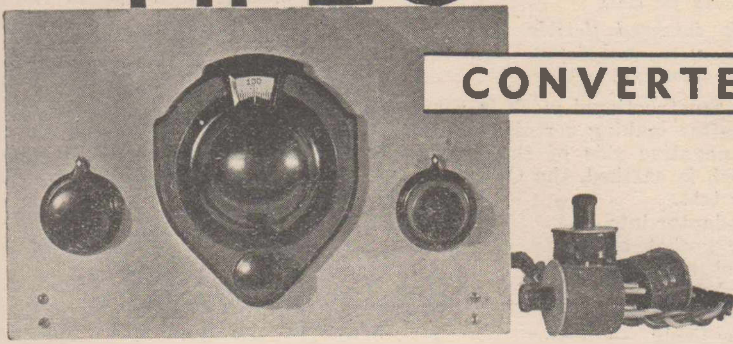
1 *Set Pilot coupling links.*
2 *(G) UX valve sockets (Pilot).*
V. 1 *30 ohm rheostat.*
N. 1 *2 megohm grid leak type resistor.*
A. 1 *.03 megohm grid leak.*
T. 1 *Philips 4001 unit.*

lator is required, and at least 135 volts "B," together with 12 volts "C." A magnetic type speaker is advised, and a Philips Baby Grand, or Sevenette speaker would be ideal, and would complete the "matched" combination.

THE IMPROVED A.C.333—CONTINUED

F. 1 *Moire finished collapsible containing Cabinet drilled ready for use (Radiokes).*
G. 1 *Special Radiokes Circloid with terminal base.*
H. 1 *Radiokes band pass coupling unit.*
B. 1 *Horizontal socket and bracket for E442 tube.*
I. 1 *Radiokes R.F. choke*
J. 1 *100 M.M.F. condenser (Radiokes).*
K. 1 *5-plate condenser (Radiokes).*
1 *Radiokes screening box, drilled ready for use.*
1 *Baseboard.*
W. 2 *Phone tip jacks.*
M. 1 *Single circuit jack.*
N & O. 3 *Pilot 1623 centraline condensers.*
Q. 1 *Set Pilot coupling links.*
D. 1 *G (UX) baseboard valve socket.*
1 *N (UY) socket.*
2 *Vernier dials.*
R. 3 *Philips 4012 1 M.F. condensers.*
T. 1 *T.C.C. .01 M.F. condenser.*
U. 1 *T.C.C. .00025 with leak clips.*
V. 1 *400 ohm single hole mounting wire-wound Emmco resistance.*
U. 1 *2 meg. grid leak.*
X. 1 *0-100,000 ohm wire-wound potentiometer.*
10-ft. Celatsite flex.
10-ft. Spaghetti tubing.
10-ft. No. 20 tinned copper wire.
Screws.

The "HI-LO" CONVERTER



THOSE who possess a broadcast receiver are not debarred from experiencing the thrills of short-wave reception, as the Converter which must be added to their present set is neither complicated in design or operation, and is not expensive.

A description of an extremely efficient type of battery operated Converter is given below, and it will be noted that it employs an A442 Screen Grid tube in the Radio Frequency stage coupled to one of the A415 Detectors which have proved so extraordinarily efficient for short-wave work.

THE wiring should be quite clear from the circuit diagram and under-panel photo whilst the layout is clearly shown in the rear view.

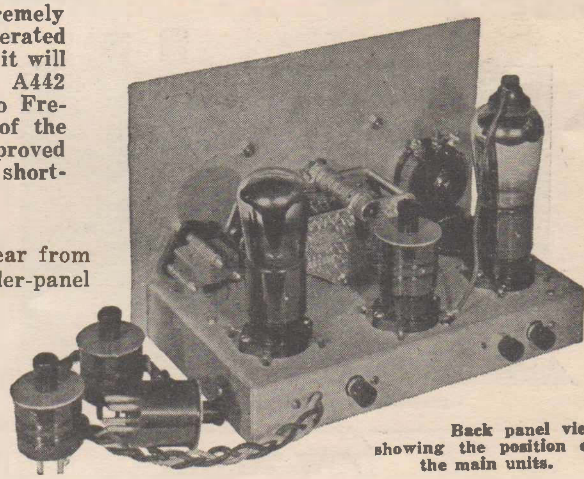
The three connections marked "X" on the theoretical diagram are taken to the corresponding connections on a valve base. The detector valve is removed from the socket in the broadcast set to accommodate this valve base.

Great care must be taken in seeing that the "A" negative connection in the broadcast set is the one which is taken to earth.

Apart from this plug-in valve base, only one other connection is required to furnish power to this Converter. This is a "B" positive tapping, which should be taken to a potential of approximately 135 to 150 volts on the "B" battery or power unit supplying the broadcast set with power.

The parts required are:—

3 *UX valve sockets (pilot).*
R1. 1 3,000 *ohm fixed resistance (Radiokes L3)*
R2. 1 30 *ohm rheostat*



Back panel view showing the position of the main units.

C1. 2 .01 *fixed condensers (T.C.C.)*
C2. 1 .00015 *variable condenser (Igranic)*
1 *Slow motion dial (Igranic)*
C3. 1 .0001 *variable condenser (Radiokes Midget)*
C4. 1 .0001 *fixed condenser (T.C.C.)*
V1. 1 *Philips A442, Cap G.*
V2. 1 *Philips A415, Cap G.*
R3. 1 0 *to* 200,000 *ohm variable resistance*
RFC. 1 *R.F. choke (Lewcos)*
1 *UX (G) valve base for adaptor plug*
1 *piece of aluminium,* 10*in. x* 6½*in.,* 16 *gauge*

THE "HI-LO" CONVERTER—CONTINUED

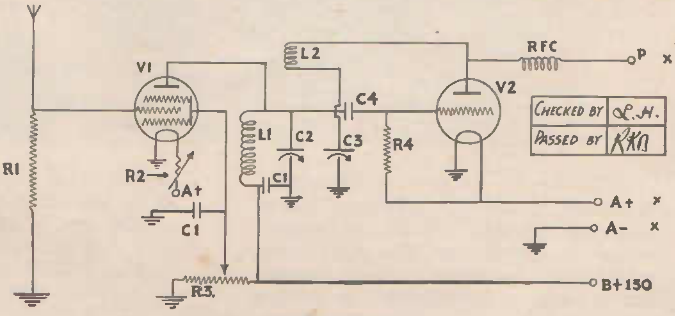
1 piece of aluminium, 7in. x 11½in., 16 gauge

UX valve bases for coils.

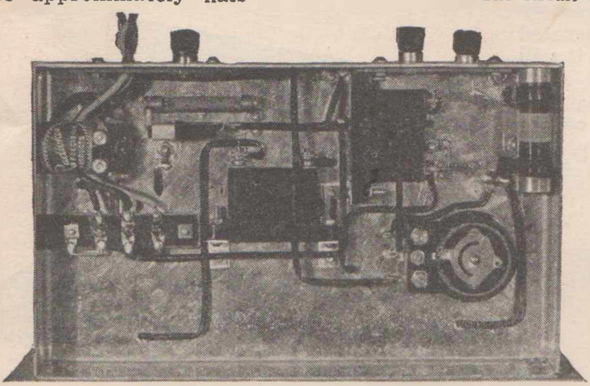
Approx. 6ft. insulated flexible wire, sufficient to reach detector socket in broadcast set.

When the constructional work is completed, and after making certain that it is the "A" negative side of the broadcast set which is earthed, the Converter is ready for test.

Plug the adaptor into the detector socket of the broadcast set—the detector valve from this socket is, of course, removed entirely — connect the additional "B" lead as previously described, and plug one of the coils into the centre valve socket on the Converter. The resistance "R3" should be approximately half way in, "R2" should be also about half way. The vernier dial should now be rotated very slowly, until the carrier wave of a station is heard. Whilst this tuning is taking place the set must be kept just breathing in oscillation by means of the reaction condenser. When the carrier is received this reaction must be loosened until the speech or music becomes intelligible. Adjustments can then be made to "R2" and "R3" until the best positions for these are found.



The circuit diagram.



Under-panel view of the converter.

In conclusion, we would again emphasise that the "A" negative lead of the broadcast set must be earthed and not the "A" positive, and secondly a 4-volt accumulator must be used by the set. If a 6-volt accumulator is employed the valves required for the converter will be:—

1 A642, Cap G and

1 A615, Cap G.

HOW TO OBTAIN "FREE" BIAS

In A.C. sets "free" grid bias may be obtained by means of a fixed wire-wound resistor, placed, in the case of indirectly heated valves, between cathode and earth.

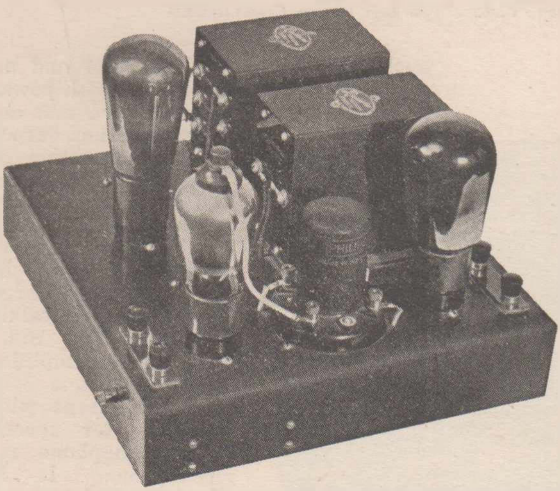
In the case of a last stage directly heated power valve, this resistor is placed between the centre tap of the filament transformer and earth.

$$\text{Value of Resistor} = \frac{1000 \times \text{bias required}}{\text{Plate current in M/a}} \text{ ohms}$$

Example—

An E415 requires a bias of 6 volts at 150 volts B. and passes a plate current of 6 M/a.

$$\text{Value of cathode resistor} = \frac{1000 \times 6}{6} = 1000 \text{ ohms}$$



The 443 TWO-STAGE AMPLIFIER

IN the following brief description we deal with an unique amplifier in which the use of screen grid and penthode tubes has been made with the object of obtaining, with resistance capacity coupling, a quality of reproduction as near perfect as possible.

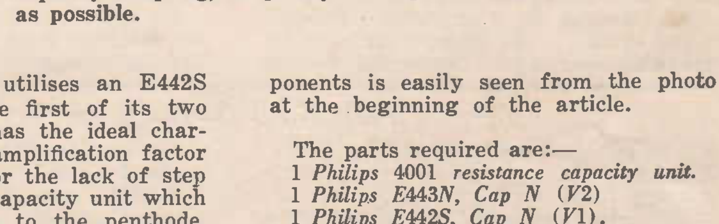
THE 443 amplifier utilises an E442S screen grid in the first of its two stages. This tube has the ideal characteristic of a high amplification factor which compensates for the lack of step up in the resistance capacity unit which is used for coupling to the penthode. The penthode used is a Philips E443N which requires 400 volts for plate operation. This is supplied by a special Radiokes Power Pack using a Philips 505 rectifier. Filament supply is in both cases A.C. at 4 volts.

The reproduction is of a standard only made possible by the use of a penthode. High notes are retained and the response between 100 and 5000 cycles is quite even, with only 10% and 15% variations at 50 and 10,000 cycles respectively. The output is sufficient for supplying dance music in average ballrooms and the unit will be found equally suitable for radio or phonograph amplification in the home.

From the circuit diagram the wiring can be easily followed whilst the position of the components is easily seen from the photo at the beginning of the article.

The parts required are:—

1 *Philips* 4001 *resistance capacity unit.*
1 *Philips E443N, Cap N (V2)*
1 *Philips E442S, Cap N (V1).*
1 *Philips* 505 *rectifier (V3).*
1 *Radiokes power transformer, type special "P" (T).*
1. *Radiokes filter choke, type 30M (CH).*
2 *Radiokes potential dividers, type SD129 (R3) (to be wired in series).*
1 *Radiokes 900 ohm resistor, type H9 (R4).*
1 *Radiokes 5000 ohm resistor, type L5 (R2).*
2 1 *m.f. Philips 4012 condensers (C1).*
2 4 *m.f. Hydra condensers (C3).*
2 2 *m.f. Hydra condensers (C2).*



The circuit diagram.

THE 443 TWO-STAGE AMPLIFIER—CONTINUED

1 2 *m.f. Philips* 4013 (*C4*).
1 .5 *meg. grid leak* (*R*1).
2 *UY valve sockets.*
16 *gauge aluminium.*

The maximum voltage obtainable from the pack (400) is applied to the plate of the E443N, 175 volts being required for the auxiliary grid. Approximately 250 volts should be applied to the B plus terminal of the resistance capacity unit.

Many people who do not wish to build their own audio amplifier will be interested in the Philips 2754 W.S. 10-watt amplifier. This is a two-stage unit compactly housed in a crystalline finished metal casing. An illustration is to be found on this page. The valves utilised in the 2754 W.S. are an E424 and an E443 penthode. It is complete with power pack, output transformer, etc., and delivers sufficient output for full operation of a moving coil speaker.


The Philips 2754 W.S. Amplifier.

There are many other amplifiers made by Philips, from phonograph amplifiers up to large equipment for talkie work. "Big Bill," the super amplifier on wheels, is a 500-watt equipment with facilities for speech and gramophone reproduction. It is mounted on a Ford truck and visits most of the important public functions which happen in Sydney.

Details of small or large amplifiers can be obtained from your nearest Philips branch or agent.

AUTO-RADIO—CONTINUED

2 .0001 *m.f. fixed condensers.*
3 .1 *meg. leaks.*
2 2 *meg. leaks.*
1 4500 *ohm wire-wound resistor* (2 *Pilot* 2250 *ohms in series*).
1 400 *ohm potentiometer.*
1 300 ohm *fixed resistor.*
1 0-200,000 *ohm resistor* (*variable*) *Royalty type.*
1 0-500,000 *ohm resistor* (*variable*) *Royalty type.*
1 *R.F. choke.*
1 .6 *ohm centre-tapped wire-wound resistor* (*to carry at least* 5 *amps*).
4 *UY valve sockets.*
3 *Coil screen cans.*
2 *Valve screen cans.*
1 *Jack, S.C. and plug.*
2 *Terminals.*
2 *doz.* $\frac{1}{4}$*in. x* $\frac{1}{8}$*in. metal screws and nuts.*
2 *doz.* $\frac{1}{2}$*in. x* $\frac{1}{8}$*in. metal screws and nuts.*
1 *pair Airzone sub-panel brackets.*
Several yards flex.

Aluminium required, 16 gauge

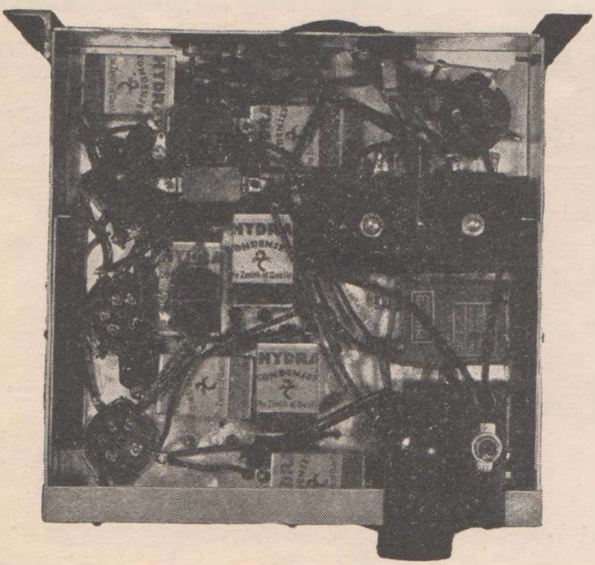
2 *pieces* 10 *x* 7$\frac{1}{2}$ *inches.*
1 *piece* 10 *x* 10 *inches.*
2 *pieces* 9$\frac{7}{8}$ *x* 7$\frac{1}{2}$ *inches.*
1 *piece* 9$\frac{7}{8}$ *x* 9$\frac{7}{8}$ *inches.*
4*ft.* 6*ins. of* $\frac{3}{4}$*in. angle aluminium.*

Coils

95 *turns nr30 on* 1$\frac{1}{4}$*in. former.*

Batteries

3 *Ever-Ready H.D.* 45.



Under-panel view of the auto set.

CONVERTING D.C. RECEIVERS FOR A.C. OPERATION

BY converting battery receivers for operation from the electric mains, the same trouble-free service usually associated with electric irons, toasters, radiators, etc., is obtained Receivers operating from the mains will give consistent performance, and the results so far as amplification and sensitivity are concerned, are greatly improved. This is brought about by the superior characteristics of the indirectly heated A.C. tubes, which are most generally used.

THE indirectly heated Miniwatt types E415, E424, E438, and E442, are all examples of the very best practice in A.C. valve construction. When using the E424 as an audio amplifier in conjunction with the 4003 transformer, a stage gain of 72 is possible. For resistance capacity coupled circuits, the E438 is an improvement over the D.C. valve types A425 and A630, on account of the higher amplification factor. Radio frequency amplifier design has been raised to a very high standard of efficiency since the introduction of the E442 and E442S screen grid valves.

When converting existing receivers for mains operation, new components must be installed in place of the batteries. For plate current and grid bias voltages, a power unit is required. The Philips units 3003 and 3009 are both suitable types, where ordinary valves requiring not more than 150 volts plate potential are to be employed. If special power tubes requiring 30 to 50 M/a or more for the plate current are to be installed, a special power pack must be obtained that will supply the larger output necessary for these valves.

Indirectly heated valves should be used in all sockets except the last audio stage. Alternating current may be applied to any of the ordinary power tubes without introducing hum, provided the usual precautions are taken. To reduce the mains voltage for filament lighting purposes, a step-down transformer is required. A transformer, having a centre tapped secondary, and encased within a metal casing, is to be preferred. The 4009 is recommended where a filament voltage of 4 volts is required.

Since the valves in the receiver are indirectly heated, alternating current hum will be practically eliminated. In the tubes, the filament is mounted within the Cathode, which is usually of tubular design. When the filament voltage is applied, the Cathode becomes heated and the electrons are liberated from this electrode. Indirectly heated valves have four elements, and are fitted with special sockets to accommodate a contact for the extra element. The tubes are supplied with two types of bases, one being the five-pin style, and the other the American UY five-prong base. Special sockets are available for these bases, and must be substituted for the ordinary sockets when changing to mains operation.

FILAMENT WIRING:

The most important changes are in the wiring of the filament circuits. UY five-pin sockets must first be substituted in place of the existing UX type—except for the power stage. All filaments are connected in parallel, as in D.C. receivers, **but the filament wiring must be carried out with twisted flex so that the alternating current hum will not cause interference. The wiring should be twisted from the terminals on the filament transformer to each valve socket.** As the indirectly heated valves draw .9 amps each, wire of sufficient diameter to carry this current must be used. It should be noted that all filament "via chassis" return wiring has been eliminated in the A.C. versions, and this is essential when A.C. is used. In this way the A.C. is isolated, and troublesome hum is eliminated. The centre tap terminal from the filament transformer must be grounded.

All standard receivers may be converted successfully for A.C. operation. As a large number of listeners are using Reinartz and Marco four circuits, special

CONVERTING D.C. RECEIVERS FOR A.C. OPERATION—CONTINUED

consideration will be given to the changes which will apply to these popular receivers. The diagrams show how these receivers should be wired for A.C. operation, and we have also shown how to modify a five valve receiver which includes two stages of tuned radio frequency amplification.

THE 3 VALVE REINARTZ:

Apart from the changes in the filament wiring, the circuit shown resembles the ordinary battery operated set, with a few minor modifications. It should be noted that the grid return from the detector tube is taken to the Cathode, and also to earth. The Cathode in the first audio stage is connected directly to earth when the bias is obtained from a high tension unit. The "C" positive and "B" minus connections are earthed at convenient points in the receiver.

At the point marked "X" a radio frequency choke may be inserted, and is beneficial in some cases. The .1 meg. grid leak type resistors R1 Fig. 3, may be inserted to obviate audio feed-back. The other components, such as coils, condensers, and audio transformers, are not changed. For this receiver we recommend the E415 as detector and first audio amplifier, with the B405 in the output socket.

THE MARCO 4 RECEIVER:

The remarks concerning the Reinartz apply also to this receiver. In addition special precautions must be taken in the radio frequency stage. For A.C. operation, it is essential to use grid bias on the radio frequency amplifiers. To eliminate the tendency towards back coupling, it is best to use a voltage-dropping resistor connected in the Cathode, instead of taking a tapping to our power unit. In most cases the E415 tube is used as a radio frequency amplifier, and the bias resistor for this tube should equal 1000 ohms. The condenser which is bridged across this resistance, may have a maximum capacity of 1 M.F. The grid return is direct to earth.

As the tubes are fed from a power unit, it is essential that a small fixed condenser of at least .006 M.F. be connected from the "B" positive terminal of the plate coil to earth. This provides a path for the radio frequency currents, and prevents them from entering the high resistance circuits of the power unit. This explains why some receivers will function on batteries and refuse to function when any form of power unit is substituted. Trouble of this description will invariably be traced to this source.

TUNED RADIO FREQUENCY RECEIVERS:

A circuit is given of a five valve receiver adapted for A.C. operation. The remarks given relating to the other two receivers apply also in this ease. Voltage-dropping resistors are used for grid bias purposes in both radio frequency stages. A separate resistance is used, and connected in each Cathode lead. Each resistance should have a value of 1,000 ohms, to provide the correct bias for the E415 valve. The value of these resistors does not vary with alteration in plate voltage. A by-pass condenser must be inserted in the plate circuit of each stage, and should be mounted as close as possible to the "B" positive terminal of the plate coils.

On account of the high amplification factor and mutual conductance of the E415 tubes, both radio frequency amplifiers must be carefully stabilised to prevent oscillation. If oscillation takes place, bad hum will be apparent in the reproduction. This can be prevented by inserting grid suppressor resistances at the points marked "X" on the grid circuits of the radio frequency tubes. These resistances should be adjustable, and a resistance which may be varied between 0 and 1000 ohms will be satisfactory in both positions. Neutralisation is, however, a better method.

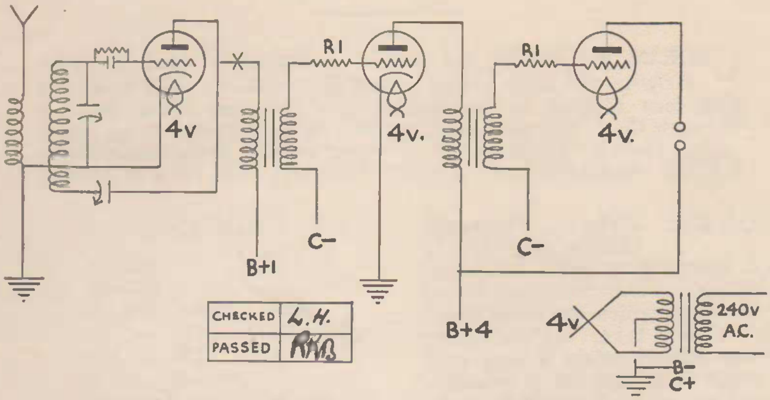
The use of shielding is an additional safeguard against undesirable feed-back effects. For best results the radio frequency stages should be independently shielded, and it is also an advantage to have both audio stages shielded from the detector circuit.

GENERAL REMARKS:

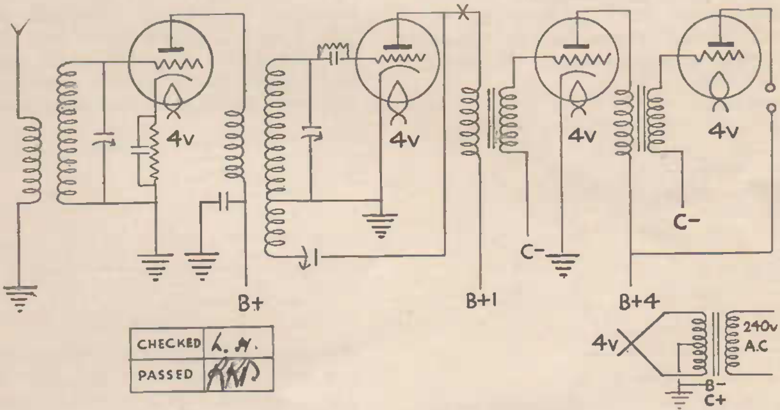
In A.C. receivers, precautions should be taken to see that the filament wiring does not run near or parallel to any plate or grid leads. The earth connections are most important, and the follow-

(Continued on page 71)

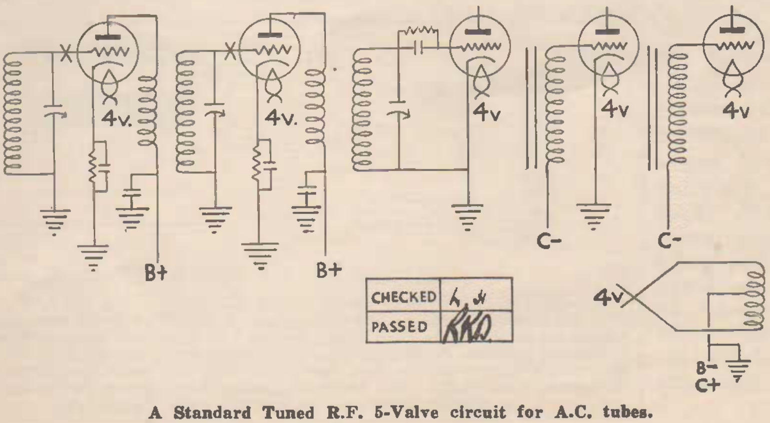
CONVERTING D.C. RECEIVERS FOR A.C. OPERATION—CONTINUED



A 3-valve Reinartz circuit modified for A.C. operation.



The Marco-4 for use with A.C. tubes.



A Standard Tuned R.F. 5-Valve circuit for A.C. tubes.

CHOKES

CHOKES are one of the smaller components used in radio circuits and their action is best described by their name, as they are utilised to prevent certain impulses from passing through them, the unwanted impulses being diverted to an alternative circuit. There are three types used in radio, these being RADIO FREQUENCY, AUDIO FREQUENCY, and FILTER.

R.F. CHOKES:

Radio Frequency Chokes are used to choke back impulses of radio frequency from one circuit, so that they are forçed to follow the path which the constructor desires they should take. As a capacity (or condenser effect) offers a very easy path for radio frequency, it is essential that the self-capacity of the R.F. choke should be kept low. This form of choke nearly always consists of a solonoid of wire, wound upon an air-cored former. Good commercial chokes such as the Lewcos or Radiokes are nearly always used by modern constructors. A simple R. F. choke may be made, however, by winding 200 turns of 30 or 40 gauge wire on to a cotton reel.

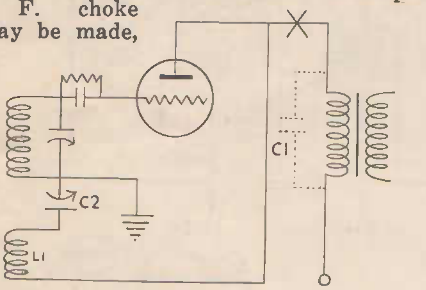


FIG. 1.

Fig. 1 shows an ordinary Reinartz detector circuit. It is desired that a portion of the R.F. component should be fed back via L_1 C_2 in order to provide increased sensitivity by means of regeneration. Insertion of any R.F. choke at "X" will assist this. If the audio transformer primary be by-passed by means of condenser C_1 this choke becomes absolutely essential.

A.F. CHOKES:

Audio Frequency chokes act as a barrier to audio frequencies in the same way as an R.F. choke does to the radio frequencies. As it deals with low frequencies, the wire can be wound over an iron core in order to get an increased inductance without the loss which would follow were this done with R.F. chokes. Its most usual application is to choke filter output circuits (fig. 2) and in this case it is connected so that the plate current of the power tube does not flow through the speaker windings. The audio currents, however, are blocked by the choke and find an easy path via the large condenser, and hence through the speaker. (Continued on page 71)

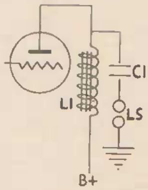


FIG. 2.

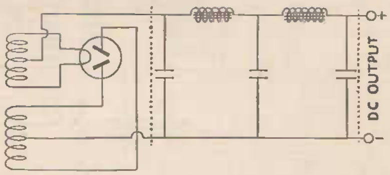
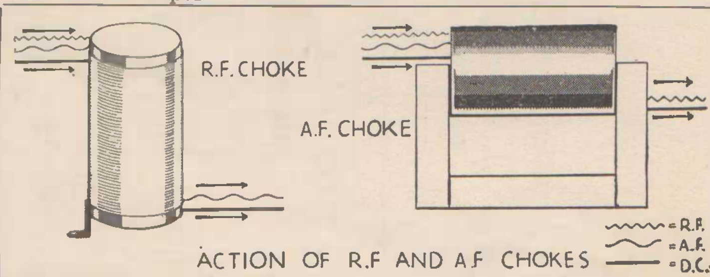


FIG. 3.



The Radio Frequency Choke shown on the left consists of a coil of wire wound over an air-cored former. When impulses of High Frequency are applied the impedance of the choke rises tremendously, and effectively compels these Radio Frequency impulses to take the alternative path, which the designer desires that they should follow, at the same time permitting the Audio Frequency impulses to flow through freely. The Audio Frequency choke shown on the right offers a similar impedance to low or Audio Frequencies.

VALVES

THE name "Valve" is a misnomer which is applied to vacuum tubes used for radio reception. The whole thing originated with Doctor Fleming, the designer of the original tube, a two electrode type using an anode and cathode, or as they are more familiarly known, plate and filament. This tube had a very limited application and could only be used for rectification. It was later improved by Dr. Lee de Forrest, who added the grid, thus making three elements.

The modern receiving valve is used for two purposes, amplification and rectification. The amplifiers may be divided into two general groups, which are Radio Frequency (R.F.) and Audio Frequency (A.F.). The last mentioned can be further sub-divided into first-stage audio amplifying and output stages or power tubes. Rectifiers may also be divided into two classes: (1) Detectors used for rectifying radio signals and making them audible, and (2) Rectifiers which are used for converting the alternating current obtained from the mains, into direct current for plate and grid supply. This type is used in both power units and power packs, and consists of either one or two plates and a filament, whereas the Detector used for rectifying radio signals may be any one of the modern triode or screen grid types.

VALVE CHARACTERISTICS:

WHEN describing a valve there are three all-important characteristics, other than the operating voltages, which must be taken into consideration. These are mutual conductance (or slope) amplification factor and plate impedance. To appreciate these characteristics it is first of all necessary to understand the working of a valve.

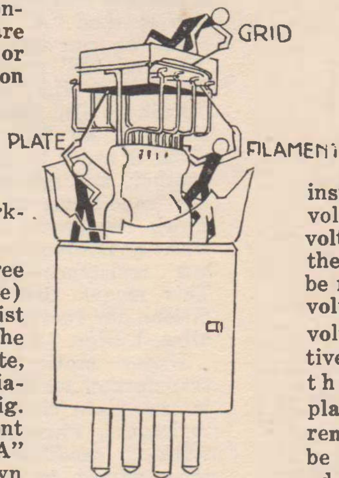


FIG. 1.
The elements of the triode.

In the standard three element type (triode) the elements consist of the filament, the grid, and the plate, which are shown diagrammatically in Fig. 1. When the filament is heated, by an "A" battery or step-down transformer, electrons are emitted, and upon the application of a positive potential to the plate (from a "B" battery, power pack or "B" eliminator) these electrons are attracted to it, forming a current through the valve. The grid is placed between the filament and the plate, and as the electronic filament/plate current passes through its meshes this current can be controlled by variations of grid potential.

As the grid is made more negative with respect to the filament, so the plate current decreases and vice versa; and it is the ratio of changing grid volts to plate milliamps which denotes the mutual conductance. Thus in the curve of the A415 (fig. 2) it will be seen an alteration of 1v. grid potential alters the plate current by 2 mA, which denotes a mutual conductance of 2 mA/V.

Amplification factor is the ratio of effect of grid and plate voltage on plate current. As an instance, with the A415 at zero grid volts (see fig. 2) an increase in plate voltage from 100 to 150 volts increases the plate current by 6.6 mA. It will be noted that when working on the 150 volt curve, moving the grid bias, 3.3 volts negative means that the plate current will be decreased by 6.6 mA. to 4.3 mA. Therefore, the effect of 3.3 grid volts and 50 plate volts is the same, making the amplification factor—

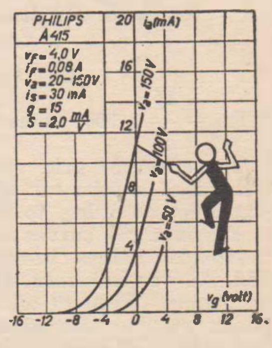
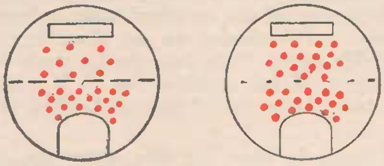


FIG. 2.

VALVES—CONTINUED

$\frac{50}{3.3} = 15$. The impedance is ascertained by Ohm's law—

$\frac{E}{I} = R$ or $\frac{\text{volts} \times 1000}{\text{mA.}}$ = ohms, but only applies to changing currents.



Showing the effect of negative grid bias. Left, low emission due to high negative bias. Right, high emission due to low negative grid bias.

Referring again to the A415 curve it will be noted that at zero grid volts an increase of 50 volts (from 100 to 150) plate potential produces an increase of 6.6 mA. from which by rewriting our formula we get—

$$\frac{50 \times 1{,}000}{6.6} = 7{,}500 \text{ Ohms.}$$

Now as the three factors mentioned, i.e., mutual conductance, amplification factor and impedance, have been derived from the relation of grid voltage, plate voltage and plate current, it is reasonable to suppose that they assume a direct relationship to each other. This is quite correct and the formula is—

$$Rp = \frac{G}{S} \times 1000 \text{ ohms}$$

Where Rp = impedance; G = amplification factor, and S = mutual conductance. Therefore, for the A415 we have—

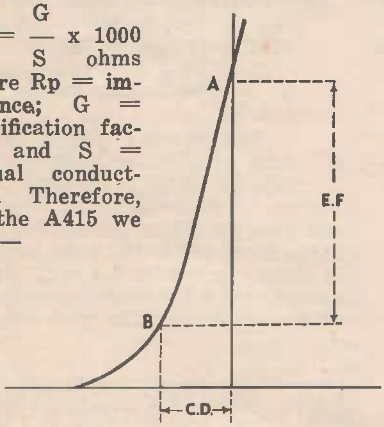


FIG. 3

$$Rp = \frac{15}{2} \times 1000 \text{ ohms} = 7{,}500 \text{ ohms}$$

The effect of grid volts on the plate current of a tube can be readily understood by referring to fig. 2. In this is shown three curves of the A415, the horizontal values being grid voltages, and the vertical ones, plate currents in milliamps. First of all imagine a point which will be referred to as the operating point. If this is placed on the 150 volt curve immediately above minus 4 grid volts, the plate current indicated will be 3 milliamps. If the operating point is moved to the left thereby making the grid more negative, the plate current will be decreased; the reverse action takes place when the operating point is moved to the right, i.e., further up the slope of the curve. Therefore, on referring to fig. 3, it will be quite plain that an A.C. voltage applied to the grid will be reproduced in the plate circuit, but at a larger amplitude. It will only be an exact replica of it when the straight portion of the valve curve is used. In order to ensure that the straight portion only is employed we must fix our operating point. When no input is given to the tube, or in other words when the tube is at rest, it is midway in the straight portion of the curve. In order to ensure that the straight portion only is used, we must limit the input or grid swing. Taking a position mid-way in the straight portion marked "A" and "B" as operating point we can apply a voltage equal to "C" and "D" and the resultant amplified voltage E.F. is created in the plate circuit. On returning to the curve, however, we find that these are only given in order to compare one valve with another, and are not taken under working conditions, as all the data from which the curve is drawn, is obtained with a milliameter—which is of very low resistance—in the plate circuit. This means that under working conditions our curves in figs. 2 and 3 will be altered. Figs. 2 and 3 are "static" curves.

Under static conditions the audio transformer which is usually to be found in the plate circuit behaves as a pure resistance, whereas under "dynamic" or working conditions the operations are too complex to be correctly shown by means of simple curves.

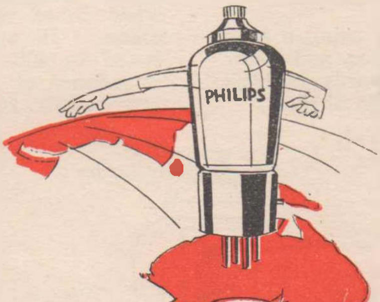
CHOOSING A VALVE:

Having dealt briefly with the main characteristics of a valve it is necessary now to detail the various points which have to be considered when one has to be chosen. First of all there is the filament voltage, and this of course depends wholly on the voltage available from the "A" battery or filament trans-

VALVES—CONTINUED

former. Next is the filament current which in D.C. valves is a very important consideration, because the lower the current taken by the valve, the longer the accumulator may be used without recharging. The user is well catered for owing to the fact that tubes of excellent characteristics are available in .06 amp. types in both 4 and 6 volt classes.

The next consideration is plate voltage and this again is governed by the voltage available. Then there are the characteristics which have been already briefly described, but for a proper appreciation of their actual practical value, it is necessary to go rather more deeply into these characteristics.



Screen Grid reaches out for 'em.

Taking first the amplification factor, this may be imagined as the actual amplification which takes place in the tube, but to transfer the whole of this gain the plate load would have to satisfy certain conditions which are impossible in practice; however it is quite possible by using a step-up device, i.e., a transformer, as a plate load, to obtain much more gain in one stage than is denoted by the amplification factor. The formula denoting the gain per stage is—

$$\frac{\text{amplification factor}}{1 + \dfrac{\text{valve impedance}}{\text{effective resistance of plate load}}}$$

or—

$$\frac{G}{1 + \dfrac{RP}{RO}}$$

where G equals amplification factor, RP equals valve impedance and RO equals effective plate load.

Where a step-up device is used the formula is—

$$\frac{GN}{1 + \dfrac{RP}{RO}}$$

Where N = the turns ratio of the coupling transformer.

It has been shown that impedance is really the internal resistance of the tube and it is absolutely essential, in order to obtain the maximum transfer of power from tube to load, that their impedances be matched. Matched is a broad term and according to circumstances it may necessitate that the load be of either a higher or lower impedance than the tube. As an instance, using an A415 as an audio amplifier it will be seen on analysing the formula given (1) that the higher the plate load and the lower the valve impedance the better the gain per stage. On all frequencies higher than 1,000 cycles, the impedance of the 4003 transformer is much higher than that of the A415. At this point the ratio of impedance is 23:1 and,

$$g = \frac{15 \times 3}{1 + \dfrac{7{,}500}{175{,}000}} = \frac{45}{1.04} = 43.3$$

This gain will increase slightly as the frequency is increased, until the capacity between turns of the transformer windings begin to bypass the very high frequencies, and conversely it will slowly decrease until the impedance of the transformer primary approaches that of the tube, as the frequency decreases below this point the loss of gain will be accelerated.

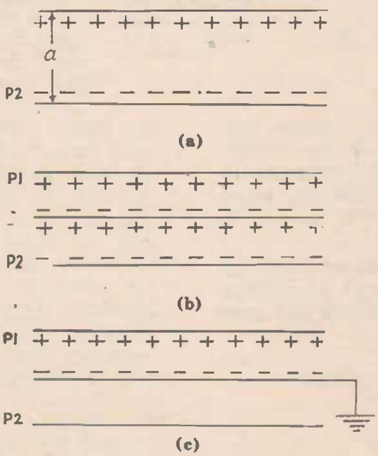


FIG. 4.
Showing principle of screen grid valve.

The impedances are equal at 44 cycles, and at this point the gain is exactly half that of the product of the amplification factor multiplied by turns ratio. This is quite obviously seen when the values are substituted, i.e.

$$g = \frac{15 \times 3}{1 + \dfrac{7{,}500}{7{,}500}} = \frac{45}{2} = 22.5$$

VALVES—CONTINUED

If the impedance of the A415 was twice the present value the gain on low frequencies would be reduced by one-third, and for 44 cycles would be—

$$g = \frac{15 \times 3}{1 + \dfrac{15,000}{7,500}} = 15$$

therefore the advantage of using a tube of a high amplification factor, and a low impedance or in other words a high mutual conductance, is quite obvious.

When using a screen grid tube, as either radio or audio frequency amplifier the position is reversed, then the impedance of the load is always lower than that of the tube.

Using a tuned plate circuit as an example, with an average type of coil tuned to resonate at 400 metres, and having a resistance of 17.4 ohms the dynamic resistance would be approximately 50,000 ohms, and with an impedance of 1,000,000 ohms and an amplification factor of 1000 in the E442, we get the following equation:—

$$g = \frac{1000}{1 + \dfrac{1,000,000}{50,000}} = 47$$

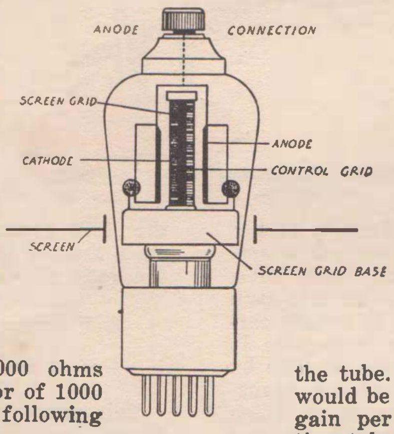
It will be seen that the 1, which was an all important factor when the impedance of the tube and the load were nearly equal is now of little consequence, when the ratio between these two factors is 20:1.

Now if we could improve our coil by reducing the resistance and increasing the impedance to 100,000 ohms our gain would be—

$$g = \frac{1000}{1 + \dfrac{1,000,000}{100,000}} = 91$$

therefore by doubling the load impedance we have nearly doubled the gain obtainable. From this it is quite clear that low loss circuits should be used in conjunction with screen grid tubes.

By increasing the gain we would also increase the selectivity—the lack of selectivity in tuned plate circuits is due to the fact that the load impedance off resonance is too high compared to that on resonance. As an instance, take the coil on which was calculated the gain above, which, by the way, was only of very average design. The impedance when tuned to 400 metres was 50,000 ohms. If we leave this circuit still tuned to 400 metres we find that the impedance at 411 metres, which is approximately 20 kilocycles off resonance, is still so high that quite a considerable amount of amplification would still take place on this unwanted frequency. We can however reduce off resonance impedance by considerably reducing the resistance of the coil. Bearing in mind that the impedance of the screen grid tube is largely dependent on the screen grid voltage, we could decrease this potential and thereby increase the impedance of the tube. By doing so selectivity would be greatly improved, but the gain per stage would be proportionately reduced.



Sectional view of an A.C. screen grid valve.

The screen grid tube derives its name from the additional element which is used, i.e., the screen grid. The placing of the elements will be seen from the illustration of the E442. First of all there is the vertical cathode which contains the heating element in the shape of a filament. Around the cathode is wound the grid, and enclosing this grid and between it and the plate is the screen grid.

Let us imagine two plates, P1, and P2, which are charged respectively positive and negative (Fig. 4a). If a third plate or screen S is inserted mid-way between these two (fig. 4b) one side of this third electrode will become positively charged and the other negatively. But the addition of the third plate has not altered the capacity between P1 and P2, as its addition has put two condensers P1s and P2s, each of double the capacity of P1, P2 (because of the small space in between the electrodes) in series, therefore there is no change in the total capacity. However, if we earth this additional electrode "s" (fig. 4c), the capacity

VALVES—CONTINUED

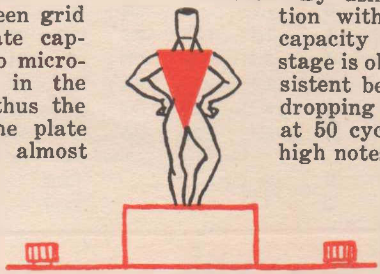
between P1 and P2 becomes negligible. This is the basis upon which the screen grid tube depends. P1 and P2 represent the control grid and anode or plate, whilst "s" represents the screen grid which is earthed, so far as radio frequency potentials are concerned, by reason of its being connected to the positive power supply.

The insertion of this screen grid reduced the grid and plate capacity from the 2 to 4 micro microfarads which was usual in the triode type, to .01 mmf., thus the feed-back by means of the plate to grid capacity becomes almost negligible. The addition of this fourth electrode, resulted in an entirely new technique in R.F. amplifier design. Formerly general purpose tubes with an impedance of approximately 8,000 ohms were coupled to the succeeding tube by means of a radio frequency transformer which had a step-up ratio in the neighbourhood of 1-5. This procedure was never satisfactory, some means had to be used to neutralise the feed-back from plate to grid and resultant oscillation.

The introduction of the screen grid, besides reducing the inter-electrode capacity had the effect of enormously increasing both the amplification factor and the impedance, whilst allowing the same relationship between the two (slope) to be maintained.

The impedance of modern screen grid tubes varies from 200,000 to 1,000,000 ohms according to type. However this value is largely dependent on both the screen grid voltage and the control grid voltage, but the effect of these will not be dealt with here as the optimum values for best operating conditions are always supplied by the makers of the tubes, but it must be remembered when adjusting screen grid voltages, that too high voltages will improve amplification but will also increase the tendency towards instability, or at too low voltage will decrease the amplification but improve selectivity. The control grid should of course be adjusted at the correct value, but may, in some cases, be used in conjunction with the volume control, and by increasing the negative potential and thereby the impedance of the tube, so the volume will be decreased with a proportionate increase in selectivity.

The lower impedance type of screen grid tube will give excellent results when used as detectors and audio amplifiers. The coupling device in each case should be a resistance capacity combination. By using an E442S in conjunction with a type 4001 resistance capacity unit, a gain of 70 per stage is obtainable. This gain is consistent between 100 to 5,000 cycles dropping to 70% at 10,000 and 85% at 50 cycles. As the loss on the high notes only represents 30% and that on the low notes 15%, the decrease will be barely audible, and for all practical purposes the resultant amplification is "straight line."



In the last stage—POWER.

POWER VALVES:

The term "Power Valve" is self-explanatory; the object of the tube is to handle "power," whereas other types previously described act practically always as voltage amplifiers. The audio voltage fluctuations in the plate circuit of the detector are fed either directly or through an intermediate audio amplifying stage into the power tube, and it is the function of this tube to convert the audio voltages applied to its grid, into variations of current in the plate circuit, of sufficient strength to work satisfactorily the type of speaker connected to it.

Where the output from the detector is insufficient to adequately load the power tube, a stage of audio must be introduced in order to increase the audio voltage applied to the grid, so that the desired output may be obtained.

The performance of which a power tube is capable is indicated by its rating in "Watts." Two power ratings are applied to a power tube—"plate input," being the product of the plate voltage and the plate current in amperes, and "undistorted output"; undistorted in this instance meaning that distortion, composed of undesirable harmonics, does not exceed 5% of the total power output.

When choosing a power tube the necessary undistorted output must be ascertained. For an average room a modern dynamic speaker needs an input

CHARACTERISTICS OF

AMERICAN REPLICAS

Philips Type	Replica of	Purpose	Directly or Indirectly Heated	Filament Volts	Filament Current	Plate Volts	Plate Current	Neg. Grid Bias at Max. Plate Volts	Max. Aux. Grid Volts	Mut. Cond.	Amp. Factor	Impedance
F109A	226	Amplifier	D	1.5	1	200	9	12	—	1.5	9	6,000
F209A	227	Gen. Purp.	I	2.5	1.75	200	8.8	12	—	1.5	9	6,000
F242	224	Screen Grid	I	2.5	1.75	180	4	1.5	100	1.1	—	—
F203	245	Power	D	2.5	1.5	250	35	50	—	3	3.5	1,170
C603	171A	Power	D	6	.25	180	18	40	—	2	3	1,500
F704	250	Power	D	7.5	1.25	450	55	84	—	2.1	3.8	1,800
						Max. A.C. Input			Max. Output			
1560	280	F.W. Rect.	D	5	2	300 V			125mA			
1562	281	H.W. Rect.	D	7.5	1.25	750V			110mA			

STANDARD A.C. TYPES

Philips Type	Purpose	Directly or Indirectly Heated	Filament Volts	Filament Current	Plate Volts	Plate Current	Neg. Grid Bias at Max. Plate Volts	Max. Aux. Grid. Volts	Mut. Cond.	Amp. Factor	Impedance
E409	Amplifier	I	4	.9	150	12	9	—	3	9	3,000
E415	Detector	I	4	.9	150	6	6	—	2	15	7,500
E424	Spec. Det.	I	4	.9	150	3	4.5	—	3	24	8,000
E435	R.F. & R.C.	I	4	.9	200	3	1.5	—	1	35	35,000
E438	R.F. & R.C.	I	4	.9	200	2.5	3	—	1.5	38	25,300
E442	Screen Grid	I	4	.9	200	1.5	1.25	100	1.2	—	—
E442S	Screen Grid	I	4	.9	200	3	3	60	1	—	—

STANDARD D.C. TYPES

Philips Type	Purpose	Filament Volts	Filament Current	Plate Volts	Plate Current	Neg. Grid Bias at Max. Plate Volts	Max. Aux. Grid Volts	Mut. Cond.	Amp. Factor	Impedance
A109	Gen. Purp.	1.3	.06	150	2	9	—	.45	9	20,000
A209	Detector	2	.08	150	4	9	—	1	9	9,000
A225	R.F.	2	.08	150	1	3	—	1	25	25,000
A409	Gen. Purp.	4	.06	150	3.5	9	—	1.2	9	7,500
A415	Detector	4	.08	150	3	4.5	—	2	15	7,500
A425	R.F. & R.C.	4	.06	150	.8	3	—	1.2	25	20,800
A435	R.F.	4	.06	150	1.4	—	—	.5	35	70,000
A442	Screen Grid	4	.06	150	2.8	—	75	.8	—	—
A609	Gen. Purp.	6	.06	150	4	9	—	1.5	9	6,000
A615	Detector	6	.08	150	4	4.5	—	2.4	15	6,250
A630	R.F.	6	.06	150	.7	1.5	—	1.5	30	20,000
A635	R.F.	6	.06	150	1.2	—	—	1.5	35	23,300
A642	Screen Grid	6	.06	200	4	—	100	.7	—	—

PHILIPS A.C. AND D.C. VALVES

POWER (A.C. OR D.C.)

Philips Type	Filament		Plate		Neg. Grid Bias at Max. Plate Volts	Mut. Cond.	Amp. Factor	Impedance
	Volts	Current	Volts	Current				
B105	1.3	.15	150	8	18	1	5	5,000
B203	2	.19	150	12	30	1.5	3	2,000
B205	2	.15	150	7	18	1.2	5	4,200
F203	2.5	1.5	250	35	50	3.3	3.5	1170
B403	4	.15	150	15	30	1.5	3	2,000
D404	4	.65	200	30	30	3.5	3.5	1,000
B405	4	.15	150	8	18	2	5	2,500
B406	4	.1	150	7.5	15	1.4	6	4,300
E408	4	.9	400	26	30	2	8	4,000
B409	4	.15	150	6.5	9	2	9	4,500
E406	4	1.0	250	48	24	6	6	1,000
B605	6	.12	150	9	18	1.8	5	2,800
C603	6	.25	180	18	40	2	3	1,500
C606	6	.25	250	24	25	3.35	6	1,850
F704	7.5	1.25	450	55	84	2.1	3.8	1,800

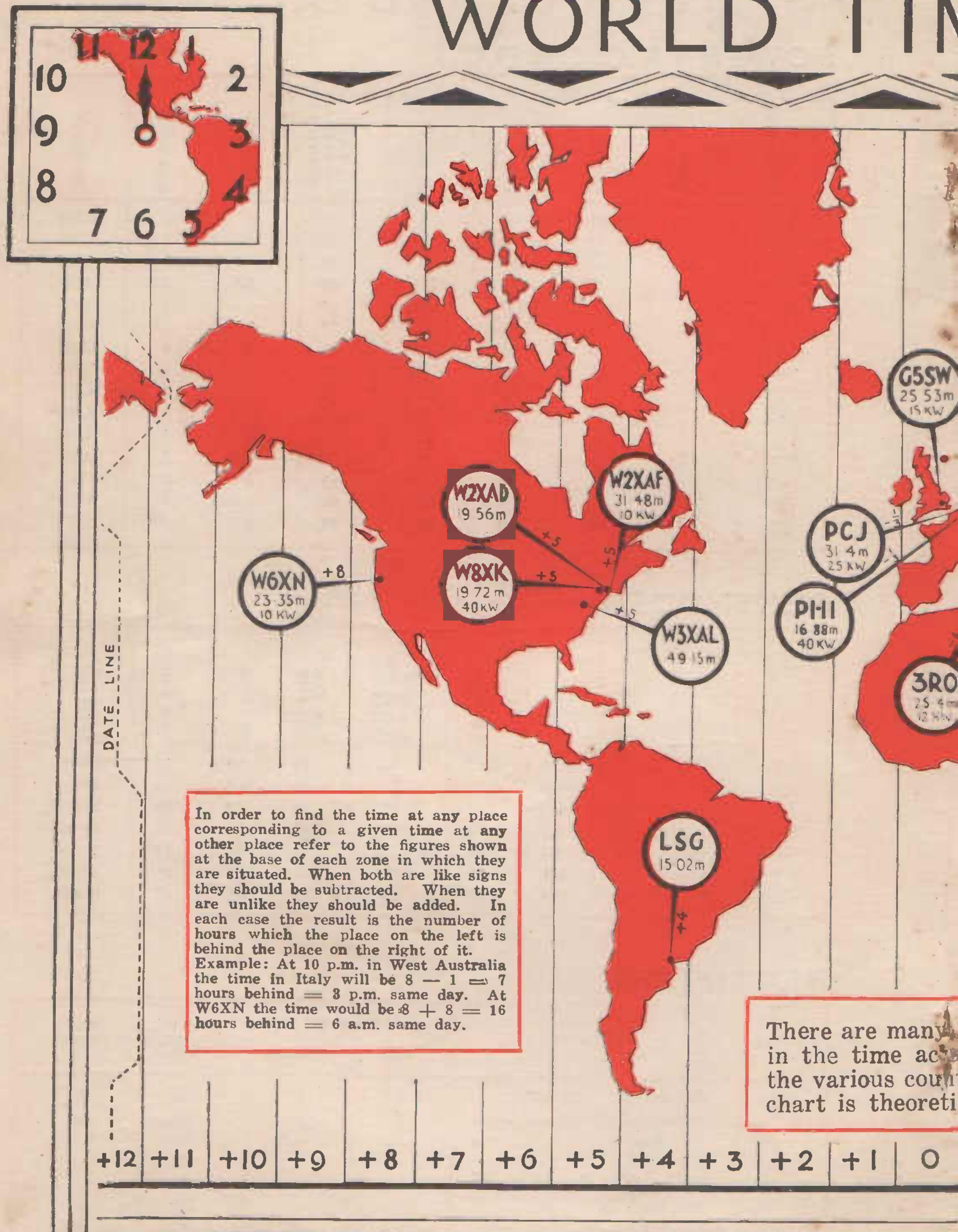
PENTHODES

Philips Type	Filament		Plate		Neg. Grid Bias at Max. Plate Volts	Max. Aux. Grid Volts	Mut. Cond.	Amp. Factor	Impedance
	Volts	Current	Volts	Current					
C243	2	.27	150	17	15	150	1.5	60	40,000
D243	2.5	.6	300	25	20	200	1.5	80	40,000
B443	4	.15	150	12	15	150	1.2	80	50,000
C443	4	.25	300	22	22	200	1.5	80	40,000
E443N	4	1.0	400	30	37	200	3.0	60	20,000
F443	4	2.	550	45	39	200	4	60	15,000
C643	6	.25	300	21	20	200	1.5	60	40,000

RECTIFIERS

Type	Rectification	Filament		Max. A.C. Input Volts	Max. Output m/A.
		Volts	Current		
1561	Full Wave	4	2	500	125
1560	Full Wave	5	2	300	125
1562	Half Wave	7.5	1.25	750	110
505	Half Wave	4	1	400	60
506	Full Wave	4	1	300	75
373	Half Wave	4	1	220	40
1201	Full Wave	2.5	1.5	300	[illegible]

WORLD TIM



In order to find the time at any place corresponding to a given time at any other place refer to the figures shown at the base of each zone in which they are situated. When both are like signs they should be subtracted. When they are unlike they should be added. In each case the result is the number of hours which the place on the left is behind the place on the right of it. Example: At 10 p.m. in West Australia the time in Italy will be 8 — 1 = 7 hours behind = 3 p.m. same day. At W6XN the time would be 8 + 8 = 16 hours behind = 6 a.m. same day.

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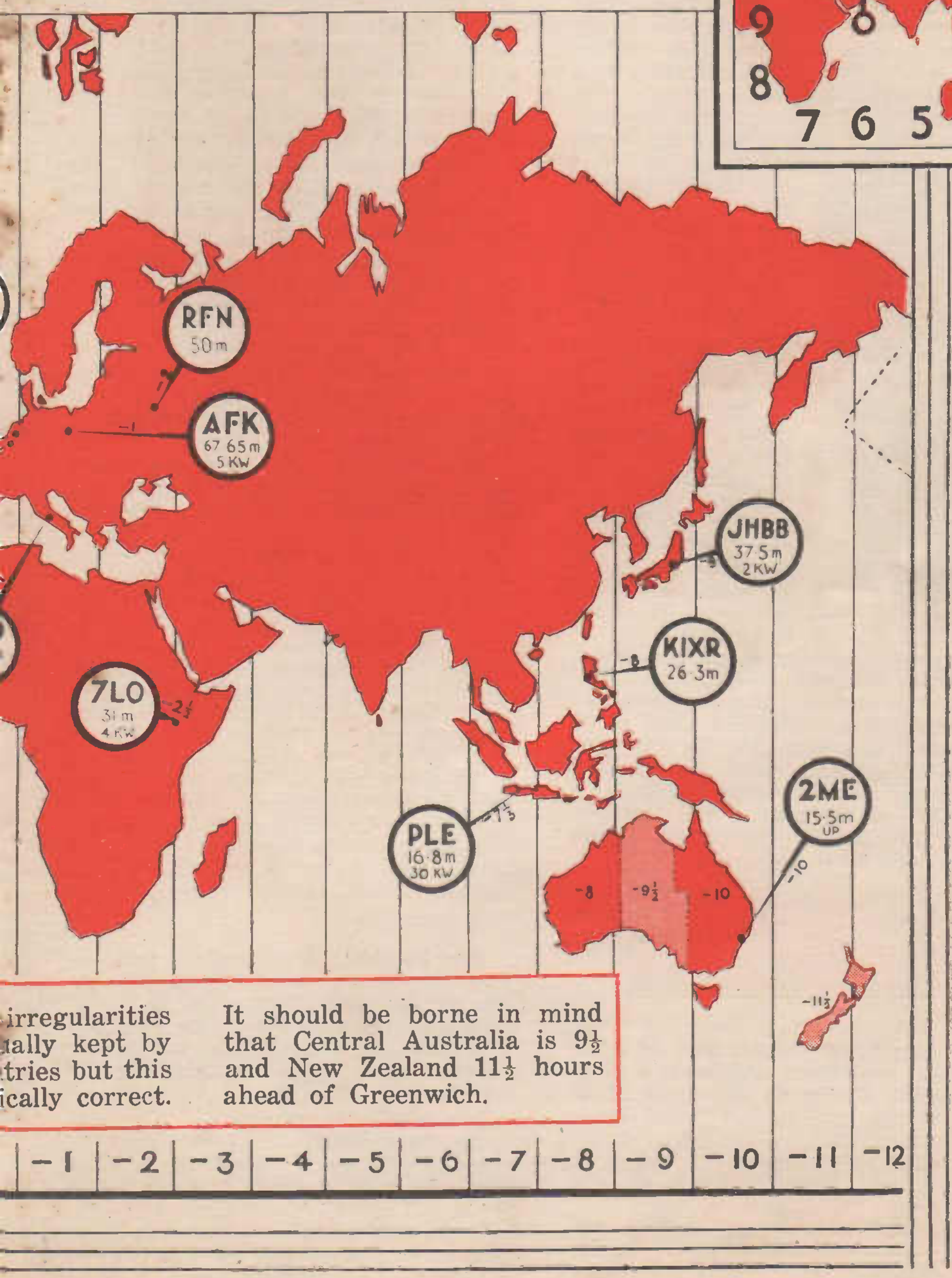


irregularities ually kept by tries but this ically correct.

It should be borne in mind that Central Australia is 9½ and New Zealand 11½ hours ahead of Greenwich.

VALVES—CONTINUED

of approximately 1 watt. Taking 20-25% as being the percentage of undistorted output to plate input, we find that a tube having a plate input of 5.0 watts will be needed. Providing a plate voltage of 200 is available, our power tube must have a normal plate current of 25 mA. This would indicate a tube of the new D404 type.

Supposing a larger output is required, for instance 2 watts, the plate input must be at least 10 watts; this necessitates a plate voltage of at least 250, giving a value of 40 mA. which condition is admirably fulfilled by the E406.

The next problem is the transferring of the power from valve to speaker. For maximum power transfer the impedance of the speaker should be about twice that of the tube—the speaker impedance being measured at about 200 cycles.

Where the speaker impedance is incorrect for the tube, then a "matching" output transformer must be incorporated, the primary of which must be of the correct impedance for the tube, and the secondary must match the speaker. This transformer is always required for a speaker of the moving coil type.

The formula for the output transformer ratio is:—

$$\sqrt{\frac{\text{A.C. Resistance of tube}}{\text{Impedance of Speaker}}} : 1$$

For an ordinary power tube of 2,500 ohms A.C. resistance, coupled to a movcoil speaker having an impedance of 30 ohms at 200 cycles, this would be:—

$$\sqrt{\frac{2500}{30}} : 1 = 9 : 1 \text{ approx.}$$

Although most speakers and transformers are designed for tubes of higher plate impedance than that associated with the most modern power tubes of the 1,000 ohms A.C. resistance type, this is no disadvantage because the tonal effect of "unmatching," even to the extent of 20%, is undistinguishable to the average ear, therefore the only noticeable effect will be an increase in power which is a decided advantage.

This increase will be greatest in the lower register, which will help to minimise the deficiencies in gramophone records and broadcasting.

On investigation of the grid circuit of the E406 we find that the normal bias is 24 volts, which, allowing for A.C. heating, gives us a grid swing of 22 volts. This value can be obtained from an E415 and 4003 transformer combination when the tube is either used as a grid detector or an amplifier for gramophone pick-up.

From the above it is apparent why a power tube should have a steep slope. If the E406 was an ordinary power tube with a slope, for example, of 3 (that is half the existing plate current change per grid volt), a grid bias of 48 volts would be necessary, giving a grid swing of 46 volts, in order to get the same power in the plate circuit, therefore an intermediate stage of audio would be needed to provide the required audio input voltage. This is not the case, however, and we find that by using a steep slope tube we are able to eliminate one audio stage with its consequent distortion, hum and expense. Furthermore, with one audio stage, most of the back coupling problems, associated with two stages, are eliminated, and the receiver becomes much simpler in construction.

PENTHODES:

The Penthode is a modern development of the power tube, designed and brought to perfection in Philips Radio Research Laboratories. Its function is similar to that of a normal power tube, but its operation is strikingly different.

The penthode contains five elements—the three normal ones found in the three-element power tube, and, in addition, two extra elements in the form of grids. The addition of these grids results in a tube having a high amplification factor and capable of delivering a

VALVES—CONTINUED

constant output to the speaker, irrespective of audio frequency changes in the signal being handled. This latter is perhaps the most important advantage possessed by the penthode.

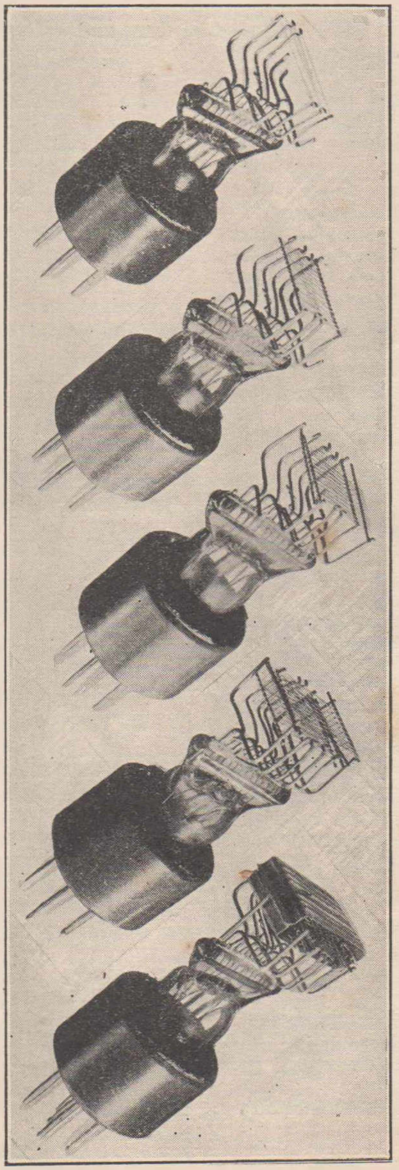
The grid, called "screening" or "auxiliary" grid, is placed between the normal grid and the plate, and a positive potential is applied to it.

In the preceding article on Power Tubes the matter of matching the load, which in this case is the speaker, to the tube has already been explained, but, unfortunately it is impossible to obtain this matched condition for all audio frequencies.

This is due to the fact that the speaker is not a resistive load but is inductive and its resistance to A.C. current varies with changes in frequency. Realising this, it is easily understood that, if the speaker is matched to the tube at say 200 cycles, then it will be seriously "unmatched" at 5,000 cycles.

In addition to this, owing to the low amplification factor of the average power tube, the plate voltage applied to it has a very serious influence on the plate current and this greatly decreases the output obtainable from the valve.

Therefore, in using an ordinary power tube we have two influences which tend to reduce the actual output from the speaker. One which is apparent at high frequencies only, and another which is apparent at all frequencies.



The five elements of the penthode. Showing the mounting of filament, three grids, and plate.

In order to overcome these two deficiencies the engineers of Philips Laboratories have designed and produced the new type of power tube, termed the **penthode.**

In the first place the A.C. resistance of a penthode is many times higher than that of an ordinary power tube. This brings about a condition whereby the A.C. resistance of the load is much smaller than that of the tube at all times and allows for practically constant transfer of energy from the tube to the load at all audio frequencies, and has the result of giving the reproduction a brilliance and definition which is not generally apparent when using a **triode** power tube.

As the slope of a penthode does not vary greatly from that of a power valve and as the A.C. resistance is much higher, the penthode naturally has a much greater amplification factor, and this considerably reduces the effect of plate voltage on plate current, thus making the penthode far more efficient than a comparable triode.

The improved efficiency is even greater than may be at first imagined, and applies both to the ratio of audio input to audio output and to the ratio of undistorted audio output to anode input (or dissipation).

(Continued on page 71)

POWER SUPPLY APPARATUS

WHILST batteries still have very many definite radio uses, such as in portable receivers and sets for which power supply is not available, they are not being used to the same extent as of yore. This, of course, is due to the introduction of power units for both "B," and "B" and "C" supply.

THE D.C. set must still have an accumulator, to be sure, but even in this regard modernisation has also set in, the accepted method being to use a trickle charger for the continuous replacement of current drawn from the storage battery.

In pictorial form we show in Fig. 1 how "all-electric" operation is obtained with a trickle charger and power unit. In this case the charger is a

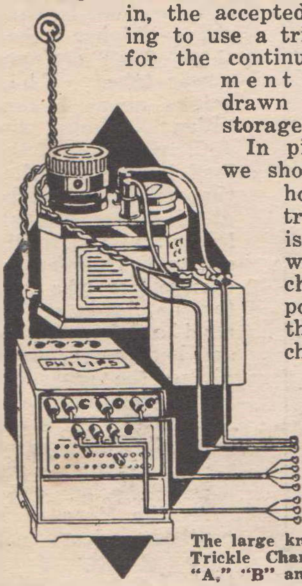


FIG. 1.

The large knurled switch on the Trickle Charger (top) controls "A," "B" and "C" power to the receiver.

Philips type 1017 which has a special two position switch on the top as a control for all power to the receiver. In one position the accumulator is charging; in the other the accumulator and power unit are both connected to the receiver.

In the next few pages we will deal separately with Power Units, Battery Chargers (Rectifiers), and Filament Transformers.

POWER UNITS: Power Units have been devised as a means of using the ordinary electricity supply for obtaining the "B" and "C" voltages for radio receivers. They consist of four main parts, these being the power transformer, rectifier (valve), filter, and voltage dividing resistors.

Fig. 2 shows the action of a Power Unit in pictorial form, demonstrating how the A.C. voltage flows through the primary of the power transformer being transferred by induction to the secondary winding and increased in voltage by the ratio of the windings. The boosted A.C. next reaches the rectifying valve, and undergoes the change termed rectification. The voltage is now slightly reduced and emerges as rectified A.C., which is equivalent to pulsating D.C.

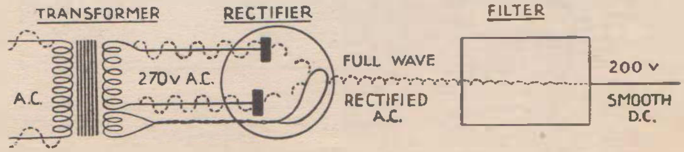
The pulsating unidirectional current is then passed through the filter which has the action of smoothing the fluctuations until it becomes Direct Current, such as that obtained from dry batteries.

The Home Constructor is strongly advised against endeavouring to build his own Power Unit, as in the vast majority of cases he is doomed to partial, if not complete failure before he starts.

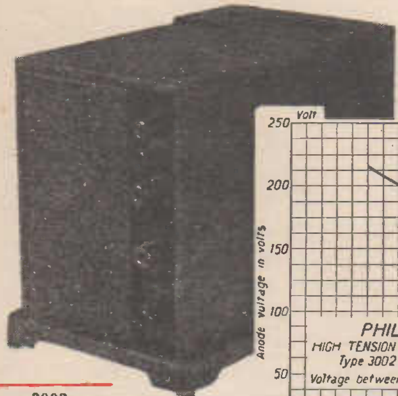
Philips Power Units are available in five types, one being specially for D.C. mains and the other four for A.C. The latter possess the following features:—

1. Full-wave rectification.
2. Simple installation.
3. Voltages may be readily adjusted by plugs to suit different valves.
4. Economical.
5. No high voltage terminals exposed.
6. Output steady and absolutely free from hum, even on short waves.
7. Enclosed in attractive metal casings.
8. High output.
9. Series resistors in each B+ lead, each by-passed by means of a large condenser. This system obviates troublesome feed-back.
10. Voltages given by each tap may be simply calculated by graph and formula.

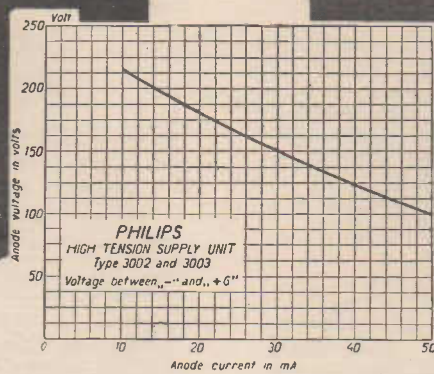
FIG. 2.
Showing how a power unit operates in supplying D.C. from A.C. mains.

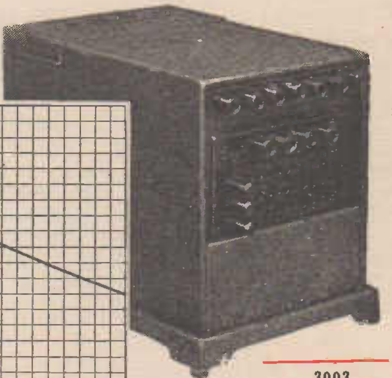


POWER SUPPLY APPARATUS—CONTINUED

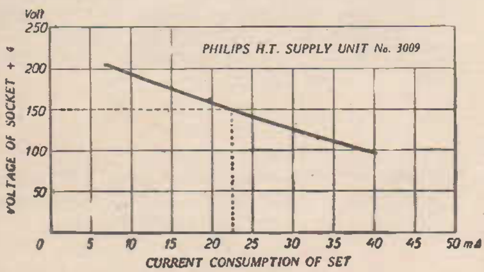


3002
"B" Unit

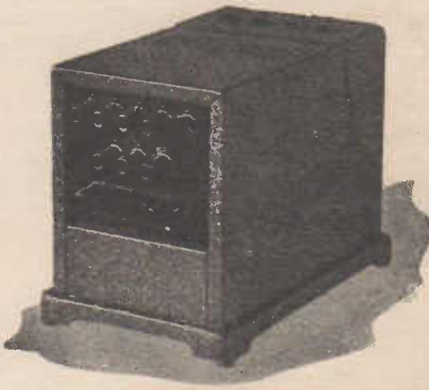




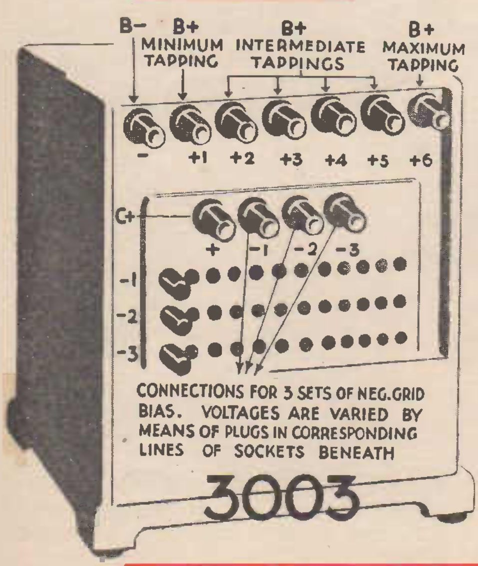
3003
"B & C" Unit

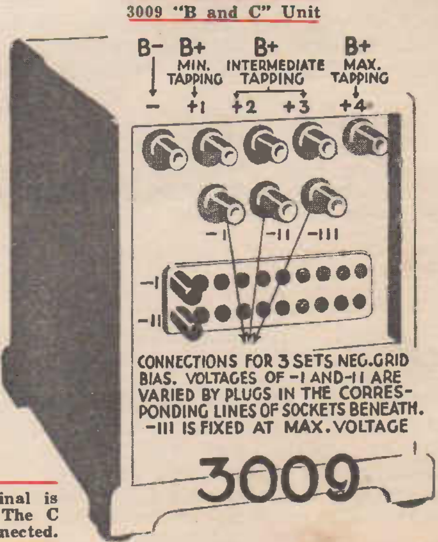


Voltage curve of 3009.



3009 "B and C" Unit





Note that with the 3009 no C plus terminal is provided as the connection is internal. The C plus from the receiver can be left disconnected.

POWER SUPPLY APPARATUS—CONTINUED

The types of power units are briefly described as follows:—

3002 (A.C.)

This is a "B" Power Unit which has facilities for various "B" voltage taps enabling each stage of the receiver to be correctly supplied. The maximum voltage depends upon the current draw required as also do the intermediate tappings. The 3002 will give 210 volts at 12 milliamps and 150 volts at 30 milliamps from the maximum tapping.

3003 (A.C.)

A "B" and "C" unit which, as far as "B" voltages are concerned, is identical with the 3002. The "C" bias voltages are available in three different groups for three separate stages. Each group can be varied by means of a "wander-plug" between 0 and 40 volts negative.

P.P.P. (A.C.)

The Philips Power Pack, which consists of a 3003 unit plus a filament transformer. It is thus a complete pack for "A," "B" and "C" supply for A.C. tubes.

3009 (A.C.)

This is a "B" and "C" Power Unit for the smaller type of receiver. It has a maximum of 150 volts at 22½ milliamps, and therefore, gives sufficient voltage for small A.C. sets. Three sets of grid bias are available, one of which is fixed at 20 volts and the other two adjustable between 1 and 20 volts.

3005 (D.C.)

An improved "B" Power Unit for operation from D.C. mains with three voltage taps. Voltage adjustment is by means of knob-controlled resistors.

CALCULATING VOLTAGES:

Types 3002, 3003 and P.P.P.

On each of the models, 3002, 3003 and P.P.P. the socket "—" is for the negative lead. Socket +1 is the lowest voltage, and +6 the highest. When the unit is in operation, a milliammeter in the negative lead will indicate the total current being drawn from the apparatus. It can be seen from the curve that if the total current is 30 m/A the voltage from +6 will be 150 volts. If the current is decreased, the voltages will increase, and vice versa. The voltages V_1, to V_5 for the sockets +1 to +5 may be calculated when voltage at +6 is known, by the following formula:—

V_1 = Voltage at socket 1, etc.,

$$V_1 = 0.6V.—(4 \times i_1)$$
$$V_2 = V_6—(40 \times i_2)$$
$$V_3 = V_6—(15 \times i_3)$$
$$V_4 = V_6—(8 \times i_4)$$
$$V_5 = V_6—(3 \times i_5)$$

Where i_1 to i_5 are the current readings in milliamperes for the various sockets as measured under working conditions.

Assuming that the total current draw is 30 m/A, then socket +6 is delivering 150 volts. If from socket +4 we are drawing 5 m/A, then the voltage between negative and socket +4 will be:

$$V_4 = V_6—(8 \times i_4)$$
$$= 150 —(8 \times 5)$$
$$= 150—40$$
$$= 110 \text{ volts}$$

The "C" bias values on the 3003 and P.P.P. are fixed and marked with the voltages on each sub panel socket.

Type 3009.

A formula is used for calculating the "B" voltages obtained from tapping +1 to +3. First the current from +4 must be measured by means of a milliammeter, and the voltage calculated from the curve on page 41. The current from each individual socket must be measured so that we can satisfy the following formula—

$$V_1 = 0.4 \times V_4—(25 \times i_1)$$
$$V_2 = 0.75 \times V_4—(12 \times i_2)$$
$$V_3 = V_4—(8 \times i_3)$$

Where—

V_1 = Voltage of socket +1
i_1 = Current from socket +1
V_2 = Voltage from socket +2
i_2 = Current from socket +2
V_3 = Voltage from socket +3
i_3 = Current from socket +3

With this unit the "C" bias socket —3 is fixed and will give 20 volts when the total current is 20 m/A. The two adjustable taps may be varied over the following values under the same condition.

1, 2, 3, 4, 6, 8, 10, 12, 15, and 20 volts, as marked.

POWER SUPPLY APPARATUS—CONTINUED

If the total current draw is different, the value of the bias may be calculated by multiplying the marked voltage by the figure representing the total current, and dividing the answer by 20. For instance, if the total current is 22 m/A. the 15 volt tap will deliver—

$$\frac{22 \times 15}{20} = 16.5 \text{ volts}$$

BATTERY CHARGERS:

Battery Chargers (or Rectifiers) are of three types—thermionic, electrolytic, and mechanical. Both mechanical and

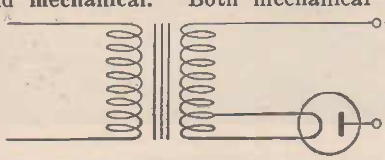
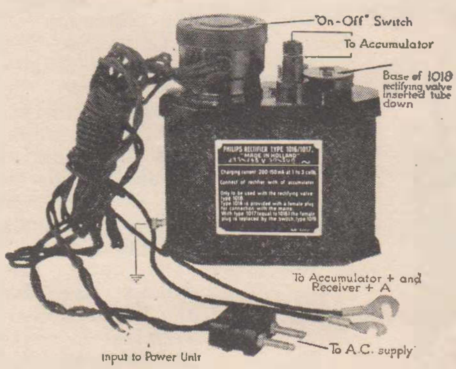


Fig. 3.

electrolytic types are now rarely used, the former on account of its noise and the latter because it utilises acid solutions. We need therefore, only concern ourselves with the thermionic (or valve) rectifier.

The thermionic rectifier employs a power transformer with an appreciable step-down and a rectifying valve. Its similarity to the power unit is so far obvious, but no filter or voltage dividing devices are required as the pulsating D.C. is suitable for accumulator charging and the output voltage is fixed.



Philips 1017 Trickle Charger showing features and connections.

Rectifying valves have two electrodes—cathode and anode and an essential feature is that the cathode has a high emission at comparatively low temperature. Philips rectifying tubes, used in the smallest of trickle chargers to the largest of A.C. rectifiers, have nickel coil filaments, coated with Barium Oxide. This makes a most efficient cathode which gives the necessary emission at a filament temperature low enough to ensure long life. Fig. 3 shows the connections for half-wave rectification. The rectifying valves for small chargers are fitted with the standard English four-pin base.

Types:

There are really three sections into which chargers may be divided. These are trickle, normal, and heavy duty. The two former are the only ones we meet in radio, and we will therefore, deal with them first.

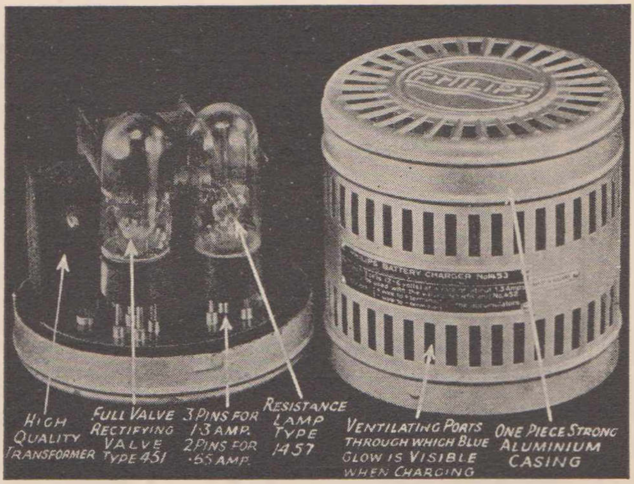
Trickle Chargers:

A trickle charger is a unit which has a very low charging rate, and which is therefore suitable for the continuous recharging of accumulators when not in use. Its application to radio "A" batteries is best demonstrated by the Philips Trickle Charger type 1017. This unit is permanently wired to the accumulator and the switch on top ensures that, when the radio receiver is not being used, the accumulator gets a small continuous charge from the mains. The charging rate of the 1017 is about .075 amp. which, in twenty hours, will obviously put 1½ amp. hours in the battery. With four hours use of the set, and twenty hours charging each day the accumulator is kept right up to the mark all the time. Should the charging rate be too high it can be reduced to the correct figure by means of a variable resistance placed in series with one of the leads to the accumulator.

Normal "boost" Chargers:

These types are for the comparatively rapid charging of accumulators. The two types of Philips units which come under this classification are the 1453, usually used for radio battery charging, and the 366, most commonly used for car batteries. The 1453 is actually a dual rate unit which charges at either 1.3 or .5 amps. the rate being changed by means of a switch in the output leads. The former rate will charge the average radio accumulator in 36 hours whilst the lower rate is really a heavy trickle suitable for the trickle charging of large accumulators.

The 366 is a larger unit capable of charging a radio and car battery at the same time at 3 amps, or a single 6-volt car battery at 6 amps.

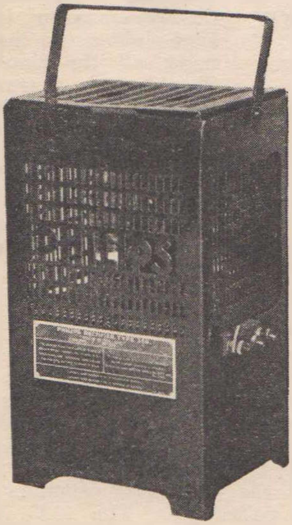


The 1453 Dual Rate Charger with casing removed.

Heavy Duty Chargers:

In this range there are a large number of types which it would be impossible to describe separately. These are for use by service stations where large numbers of batteries are to be charged, by process engravers, electroplaters, and many others who require low or medium voltage D.C. at high amperage.

Of the Philips multibattery charging units, the 1370 is most popular. This unit will charge from 3-20 2-volt cells at various rates up to 6 amps. Type 1371 will charge 30 cells at 15 amps.



Philips "366" Charger suitable for charging both car and radio accumulators at the same time.

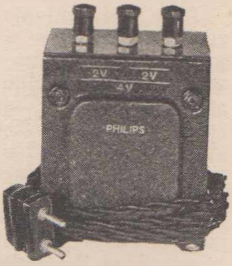
FILAMENT TRANSFORMERS:

Filament transformers are utilised for stepping down the domestic power supply voltage to the value required for filaments of A.C. tubes.

Philips have two types available—

Type 4009:

For heating the filaments of A.C. valves. The potential obtainable from the secondary winding is 4 volts, and is maintained under loads up to 5 Amperes. Three terminals are provided. The two outer terminals are for the filament connections, and the middle terminal is connected to the centre tap in the 4 volt winding. This should be connected to earth.



4009 Filament Transformer.

The windings are accommodated in a metal casing of blue crystalline finish. The 4009 is robust and neat in appearance, and is supplied with a cord and plug for attaching to the A.C. mains.

Type 4008.

This transformer is similar in size and construction to the other type, but is designed for the 2.5 volt Miniwatts, types D243, F203, F242, and F209A. In addition a 1 volt winding is provided.

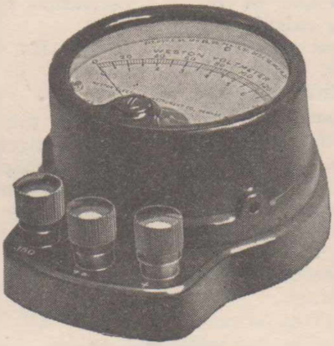
MEASURING INSTRUMENTS

FEW standard receivers incorporate any type of measuring instruments as their readings to the average man would convey little. For he who possesses a fair technical knowledge of things radio, meters are most valuable—if not essential.

IN radio work the following meters are most generally used:—

The voltmeter.
The milliammeter.
The ammeter.

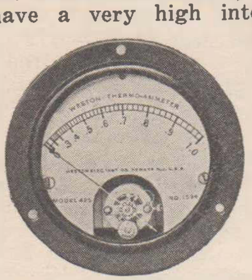
All types may be obtained in panel mounting styles or built into special cases.



A typical voltmeter.

VOLTMETERS:

These are made for measuring both A.C. and D.C. voltages. The A.C. types may be used to read D.C. voltages, but the D.C. type will be destroyed if connected in an A.C. circuit. A voltmeter is a high resistance device and to register, it must be connected across points of different potential. To give a true reading in circuits where the current is limited, the meter must have a very high internal resistance.



An ammeter reading 0-1 amp.

For checking the voltage tappings on power units, the internal resistance should not be less than 800 ohms per volt.

The internal resistance is always shown on high grade instruments. A quality voltmeter with a full scale deflection of 150 volts will cost about £3/15/- and a 300 volt type about £5.

A multi-range meter is very useful and will usually have three ranges. One Weston model may be used to read from 0-10, 0-250, and 0-750. This meter is listed at about £7.

Especially in receivers using high voltage tubes, a voltmeter is most desirable. Apart from the satisfaction of knowing just what voltage is on the plate of each tube, it is essential if grid biassing is to be taken out of the "trial and error" class.

MILLIAMMETERS:

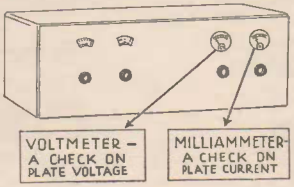
For radio work we do not often encounter currents over 1 amp., and for current measurements the milliammeter will suit our requirements. In appearance and construction they resemble voltmeters. **The milliammeter however, is a low resistance device, and is connected in series between supply and load to obtain readings.**

In radio they are principally used for reading the plate current of valves, and a meter with a full scale deflection of 0-50 m.a. will be suitable for the majority of experimenters. A meter of this type will cost about £2/10/- if quality is given preference. Ammeters are useful for battery charging work where larger currents are common.

AMMETERS:

This instrument is, of course, the same basically as the milliammeter, except that it reads in units (amperes) instead of thousandths.

The ammeter is useful for battery charging and for filament circuit measurements more especially with high-consumption A.C. tubes. This meter is rarely used by the average receiving experimenter.



Showing how voltmeters and milliammeters are utilised for large receivers.

Thermo Coupled Ammeters are used by transmitting stations to measure high frequency current, such as is present in the aerial circuit. They may be graduated in amps or m/A, and indicate the value of high frequency current present. Special types are manufactured for

MEASURING INSTRUMENTS—CONTINUED

registering low frequency currents, and may be used for comparing the output of various receivers when tuned to a modulated signal.

MAKING A MULTI-PURPOSE INSTRUMENT OUT OF A MILLIAMMETER

It does not appear to be generally known that a milliammeter may be used for several purposes by means of resistances and a little simple calculation. This is nevertheless so and the constructor may, if he wishes, build this one instrument into a container together with the necessary resistances which can be placed in and out of circuit by switches mounted alongside the meter.

The instrument with which we are concerned is a sensitive milliammeter. It may be used for reading currents as indicated on the scale, or for heavier currents if we first add a predetermined resistance in shunt, or parallel. We can also use the same instrument to read various ranges of voltage, and in this case, must add certain values of resistance in series.

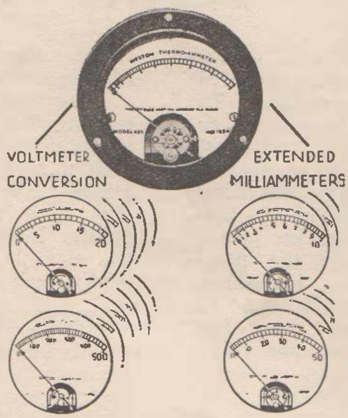
We have already stated that the meter has a low value of internal resistance. Let us assume that we have a milliammeter with a full scale deflection of 5 m/A. The internal resistance we will consider to equal 20 ohms. Then by using ohms law the voltage across the terminals of the meter will be—

$$\frac{5 \times 20}{1000} = .1 \text{ v.}$$

This means that our meter is also acting as a low reading voltmeter, and will register voltages up to .1 volt. To extend the range to higher voltages we must add resistance in series, and the amount of resistance required (Rx) will depend upon the range desired, and may be found according to this formula—

$$Rx = R \left[\frac{V_2}{V_1} - 1 \right]$$

Where V_2 = Extended range.
V_1 = Normal range.
R = Internal resistance of meter
Rx = Value of series resistance.



How a milliammeter may be used for several purposes.

Suppose we wish to use our milliammeter to read 30 volts, then the series resistance will be—

$$Rx = 20 \left[\frac{30}{.1} - 1 \right]$$

$$= 5980 \text{ ohms.}$$

With this resistance in series, a full scale deflection indicates 30 volts.

To multiply the current range we can also calculate the necessary shunt resistance for various ranges.

$$SR = \frac{C_1 \, R}{C_2 - C_1}$$

Where SR = Shunt resistance.
C_1 = Normal range of meter.
C_2 = Value of extended range.
R = Internal Resistance.

Let us assume that we wish to double the range of the meter and the shunt resistance for this case will equal—

$$SR = \frac{5 \times 20}{10 - 5} = \frac{100}{5}$$

$$= 20 \text{ ohms}$$

It will be seen that for this particular example that the shunt resistance is equal to the meter resistance. Since we have doubled the current in our circuit we must halve the resistance. When two resistances are joined in parallel, the resultant resistance equals their product divided by their sum, or—

$$R = \frac{20 \times 20}{20 + 20} = \frac{400}{40} = 10 \text{ ohms}$$

This means that the path of the current will be evenly divided, half flowing through the shunt and half through the meter. Thus it will be clear that the current through the meter is still only 5 m/A. The extra current is carried by the shunt resistance.

PICK-UPS

ELECTRIC reproduction of phonograph records has increased tremendously in popularity during the last year or two. In the course of the following article we shall endeavour to make clear the reason for this, and also explain the elementary principles of the system.

FROM 1877 up to 1925, record manufacturers used the mechanical system for recording the sound waves they desired to impress upon the record. This system had many disadvantages, chief of which was the impossibility of recording a large number of performers satisfactorily, due to the fact that they had to be grouped near the recording system owing to the insensitivity of the latter. Another serious disadvantage lay in the fact that the diaphragm, horn, etc., used, introduced serious distortion.

The total range of frequencies covered was only from about 220 cycles up to about 3,500 cycles (i.e., just below middle C to about 3 octaves above) and even then the recording was very uneven as the response curve on an average recorder rose sharply from a low level at 220 cycles, to a much higher level at 500, then peaked at 1500 and dropped sharply down to 3000 cycles. Therefore the records themselves had only a very poor rendering of the original performance impressed upon them and this, it must be remembered, was due principally to the disabilities of the mechanical recording system.

Then in 1925 the record manufacturers adopted the system which had been developed by the engineers of the Bell Telephone Laboratories—that of electrical recording. The introduction of this method immediately swept away the two greatest disadvantages associated with gramophone record production—

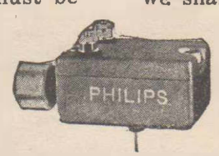
The "Forty-Forty" Pick-up Equipment packed in its plush-lined case.

(1) The response of the reproduction was extended down to 50 cycles and up to 5000, thus increasing the bass and bringing in many upper partials, which affect so vitally the brilliance of the reproduction.

(2) It became possible to record faithfully large bodies of performers.

Under the new system the sound waves are converted into electrical impulses by means of microphones and these impulses are taken through valve amplifiers and the fluctuating energy is fed into the field coils of a recording device.

The fluctuations in the field cause movement of an armature to which the cutting stylus is attached. The movement of this stylus is then used to cut the record. Now, if we take this electrically recorded disc and attempt to reproduce it mechanically, we immediately re-introduce some of the disadvantages of the old mechanical recording, but if in our reproducing system, we reverse the whole recording process, we shall obtain an output which will be a very faithful reproduction of the original. (See foot of next page.)



Philips 4005 Pick-up Unit for attachment to the phonograph tone-arm.

First, then, the mechanical vibrations imparted to the needle by the record, must be re-converted into electrical impulses. This is done by substituting an electrical pick-up for the ordinary gramophone sound box. The pick-up must convert the needle vibrations into voltage vibrations of exactly the same wave form.

PICK-UPS—CONTINUED

Electro-magnetic pick-ups may be divided into two general types—"single-acting" and "4-pole differential."

In the single acting type (fig. 1) the armature (A) is mounted upon one side only of the pole pieces NS. This type is not very efficient. The majority of good pick-ups use the 4-pole principle (fig. 2). In this system the armature (A) consists of a needle holder mounted on a reed which passes between the pole pieces P of the magnet system. Coil C is wound on a former through which the armature passes. The ends of the winding are taken to the terminals of the pick-up, rubber damping cushions R being placed at each side of the reed, to prevent it from sticking to the pole pieces. The bar magnet M magnetises the pole pieces. A fluctuating voltage is then generated in the pick-up as shown in fig. 3.

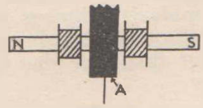


FIG. 1.
The "single acting" type pick-up.

When the armature A is at rest, the magnetic lines of force set up between the diagonal poles NS are in a state of balance and cancel out (a). When the armature is moved to one side by the action of the needle vibrating in the grooves of the record, the magnetic force will be greatest between the diagonal poles which are in line with the new position of the armature. As this position is continually changing, the magnetic field will also be continually varying and as the field cuts the coil C a varying voltage will be induced into this coil. It will vary exactly in accordance with the vibrations of the needle, and therefore the pick-up has converted the mechanical vibrations into electrical impulses of audio frequency. These are then fed into an amplifier and thence into a speaker, which converts the impulses into sound waves.

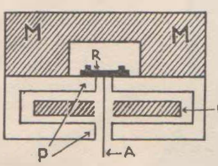


FIG. 2.
The "4-pole differential" pick-up.

The Philips 4005 and 4040 pick-ups are examples of the 4-pole differential type. In these pick-ups the output is extraordinarily high, averaging about 2 volts R.M.S. and rising in the bass to as much as 3.4 volts R.M.S. This high output means that fewer stages of amplification are needed to obtain any desired volume, and therefore the possibility of amplifier distortion is decreased. Normally these pick-ups should be inserted between grid and filament of the first audio stage.

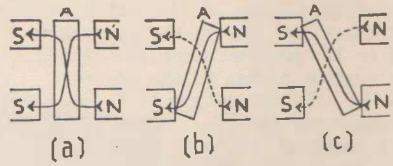
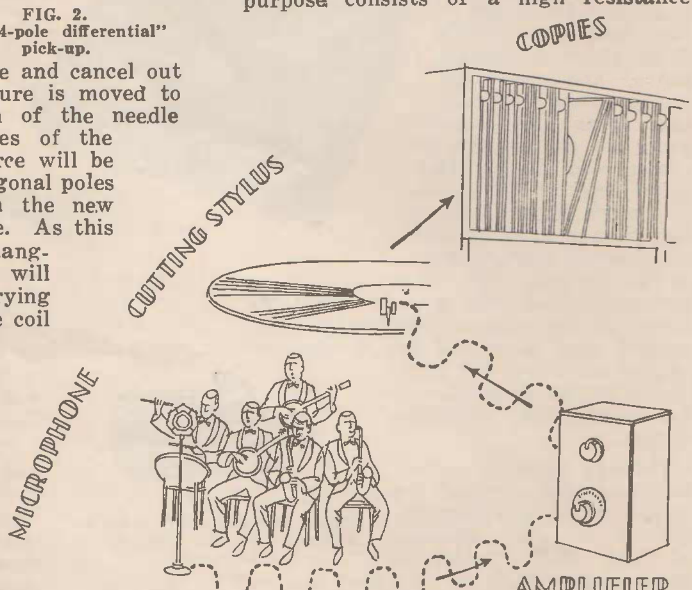


FIG. 3.
Showing how the pick-up generates a fluctuating voltage.

In order to avoid overloading of any of the valves in the amplifier, it is necessary to have some means of controlling the output from the pick-up.

An effective volume control for this purpose consists of a high resistance



RECORDING

Showing how electrical recording and electrical

PICK-UPS—CONTINUED

potentiometer having a value of at least 50,000 ohms (fig. 4).

This potentiometer should be connected directly across the pick-up and the slider connected to the grid of the first amplifying valve.

This method is much to be preferred to that of using a plain resistance, as, in this latter case, high note loss would be serious.

With a high resistance potentiometer, however, the pick-up is working into a constant high resistance load and however much the slider may be varied the pick-up always works into the full resistance, and the high note loss is negligible.

Where the pick-up is connected to the primary of an audio transformer this potentiometer should be connected directly across the secondary and the slider taken to the grid of the first audio valve.

The Philips 4040 pick-up equipment consists of the unit itself mounted on a nickel tone-arm, a weighted base for the arm to move from, a volume control, and flexible adaptors for connecting to sets having no provision for pick-up attachment. These are all neatly packed in a plush lined case and this makes the equipment conveniently suited to occasional use as well as for permanent connection if desired.

It is essential that a pick-up should be sufficiently heavy to avoid jumping the grooves of the record during heavy passages, about 4½ to 5 ozs. being the best weight, at the same time the damping must not be too heavy, or the needle will be unable to follow correctly the variations in the grooves, and cutting will result.

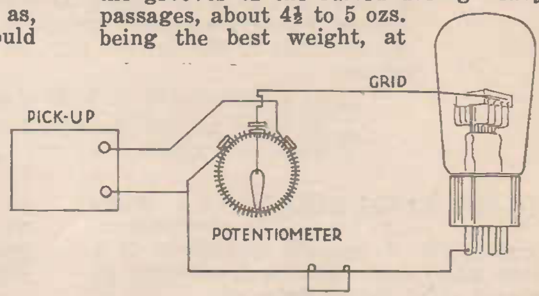


FIG. 4.
Connections for the volume control potentiometer

POSITION OF TONE-ARM FOR PICK-UP:

It is important that the tone-arm pivot should be at the correct distance from the centre of the record. This distance is easily found from the formula—

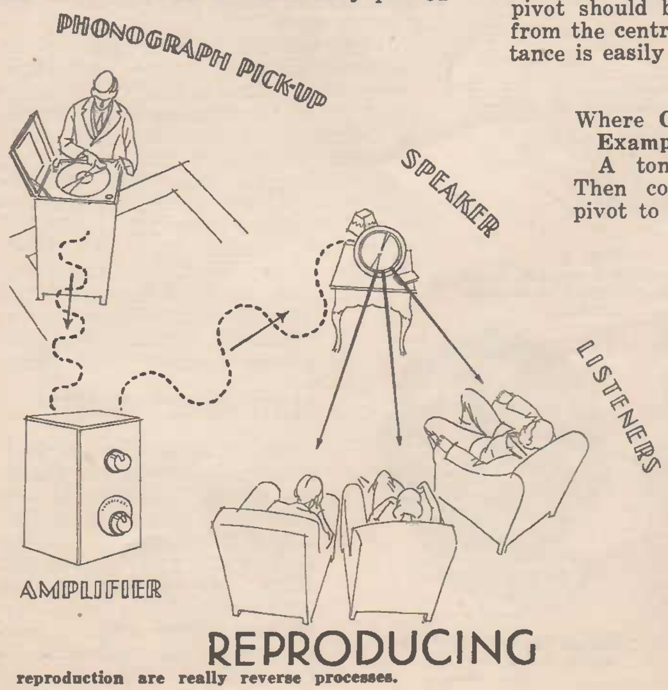
$$\sqrt{C^2 - 12}$$

Where C = Length of tone-arm.

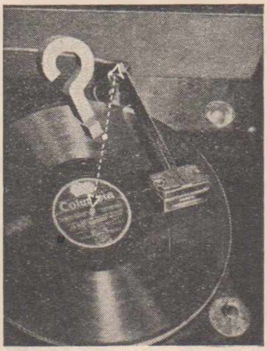
Example—

A tone-arm is 7 inches long. Then correct distance, centre of pivot to centre of record—

$$= \sqrt{7^2 - 12} = \sqrt{37}$$
$$= 6 \text{ inches approx.}$$



reproduction are really reverse processes.



SPEAKERS

THE function of the speaker is to convert plate current changes fluctuating at audio frequency in the plate circuit of the power tube, into sound vibrations (air waves). These vibrations must be as nearly as possible, replicas of those set up by the performers before the microphone, therefore the speaker must convert these plate current variations into mechanical movement in some part of the speaker unit, so that sound waves may be set up.

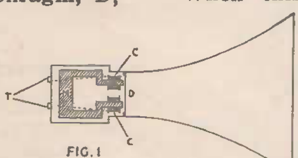
There are two main methods of accomplishing this—

(1) *by means of a diaphragm and horn*

(2) *the modern system of a cone; magnetic or moving coil.*

DIAPHRAGM-HORN:

The diaphragm-horn system Fig. 1, consists essentially of a thin metal disc, called a diaphragm, D, placed close to the poles of a magnet, M, over which are wound two small coils C, joined in series and connected to the two input terminals T. These coils are then connected in the plate circuit of the power tube, and plate current variations flowing in this circuit, pass through these coils, making the combination of M and C an electro-magnet. As the plate current fluctuates in these coils it has the effect of varying the pull which the magnet exerts upon the diaphragm D, causing it to fluctuate in accordance with the plate current changes. The varying air pressure caused by the small movements of the diaphragm D are intensified by means of the horn, so that an output of reasonable volume is obtained.



The defunct diaphragm-horn type speaker.

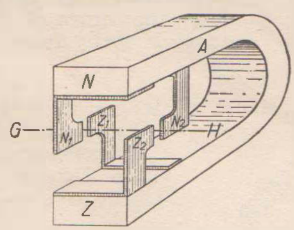


FIG. 2.
The horseshoe magnet, basis of the Balanced Armature motor.

This system has several inherent faults, sufficiently serious as to preclude the possibility of obtaining faithful reproduction.

Perhaps the most serious drawback lies in the fact that the diaphragm must be in very close proximity to the magnet, so as to obtain highest efficiency and consequently a powerful magnetic flux passes through it, causing saturation. When this saturation occurs the diaphragm becomes insensitive to all but strong intensity changes in the magnetic field, this of course causes distortion.

Further distortion occurs due to the fact that the magnetic field rapidly decreases in strength as the distance from the magnets is increased, therefore when the diaphragm moves away from the poles, the field exerts less influence upon it.

Distortion also occurs due to the natural frequency of the diaphragm, horn, etc. This means that when a note is to be reproduced which has a frequency approaching that of the natural resonance period of the horn or diaphragm, this note will be selected by these units for reproduction in greater strength. It will often be noticed that the whole speaker seems to vibrate when certain notes are reproduced. This diaphragm-horn type of magnetic speaker has now almost entirely disappeared.

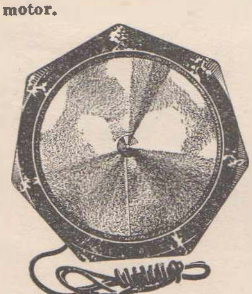


FIG. 3.
Philips "Baby Grand" speaker which is of the new magnetic type.

MAGNETIC, CONE:

Of the various methods employed in magnetic speakers, the best is probably that known as the "4-pole balanced armature," a Philips laboratory development. With this method all the drawbacks of the 2-pole diaphragm type have been overcome, as evidenced in the Philips "Baby Grand,"

SPEAKERS—CONTINUED

"Peter Pan," and "Sevenette" models.

This balanced system consists of a horseshoe magnet A (Fig. 2) to which the poles N1, Z1, and N2 and Z2 are attached, so that they are energised by this magnet. In this way two fields are formed, N1, Z1, and N2, Z2.

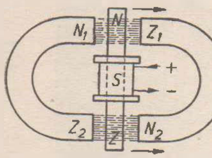


FIG. 3.

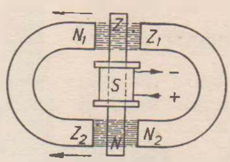


FIG. 4.

Showing how the armature is operated by the magnet system.

The poles N1 and Z1 and N2 and Z2, together form horseshoe magnets so that the two pairs of magnets are opposite each other (fig. 3 and 4) forming a completely closed magnetic circuit. The armature is suspended between the two magnets as in accordance with G-H, fig. 2, and due to the placing of the poles, no magnetic current will flow through it. Therefore, it may be of very light construction, with resultant improvement in reproduction. In fig. 5 the method of suspension is shown.

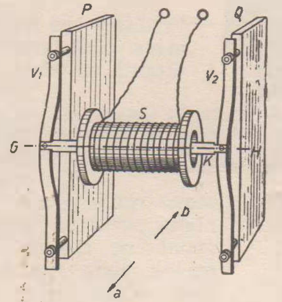


FIG. 5.
The armature K is suspended on springs V1 and V2. K may oscillate freely in the centre of the coil S which is actually fixed rigidly to the chassis of the speaker.

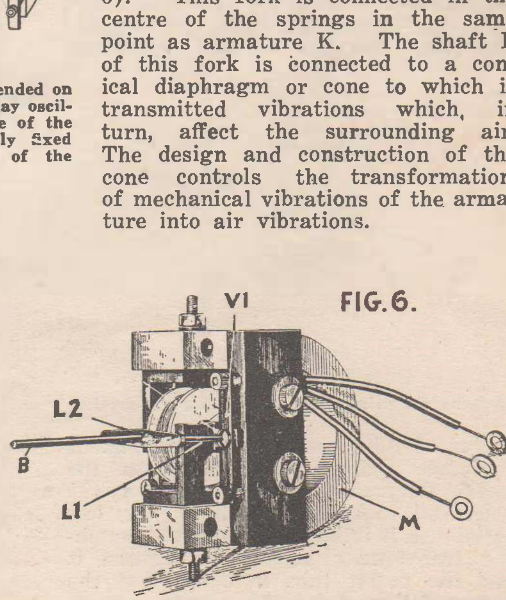
Over armature K (fig. 5) is a coil S which is fixed rigidly to the chassis of the speaker, and through which passes the plate current of the last stage valve. Armature K can oscillate freely in the cylindrical space in the centre of the coil S, and is connected at both ends to the centres of the flat springs V1 and V2. The ends of these springs are fixed to strips P and Q by bolts, and these strips in turn are fixed to the magnet M as shown in fig. 6.

The working of this magnet system on the armature can be seen in figs. 3 and 4. If the current direction in the coil is such that the armature is polarized, as indicated in fig. 3, the armature will move to the right with force which is directly dependent on the force of the current variation in the windings of the coil S. Fig. 4 shows that this movement is opposite when the current direction is reversed. Such a change of current direction has apparently no influence on the polarity of magnet A (fig. 2) and reversing the polarity of the iron armature does not constitute a drawback.

The magnetic field between the magnet system is not constant throughout, but is strongest in the region of the poles. When the armature is moving towards the poles it moves in a magnetic field which becomes gradually stronger. In order to eliminate strain on the armature, the springs V1 and V2, fig. 5 are of material whose tension increases when bending, so that the increase of the field density round the armature is neutralised when this armature moves toward the poles.

The movements of the springs V1 and V2 are transmitted to the fork by means of the bars L1 and L2 (fig. 6). This fork is connected in the centre of the springs in the same point as armature K. The shaft B of this fork is connected to a conical diaphragm or cone to which is transmitted vibrations which, in turn, affect the surrounding air. The design and construction of the cone controls the transformation of mechanical vibrations of the armature into air vibrations.

FIG. 6.



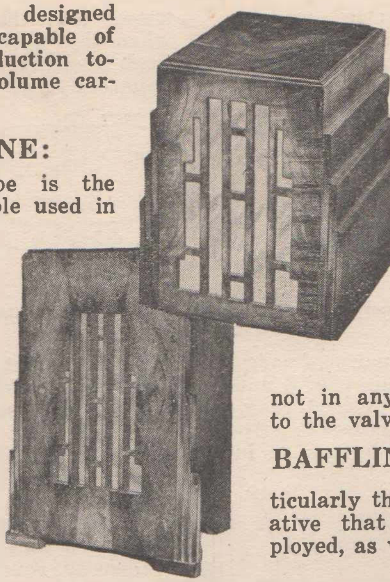
The complete unit ready for mounting to the speaker frame. The driving rod B is affixed to the peak of the cone.

SPEAKERS—CONTINUED

Speakers carefully designed along these lines are capable of giving very fine reproduction together with excellent volume carrying capacity.

MOVING COIL, CONE:

Another modern type is the moving coil, the principle used in Philips "Campanilla" and "Permagnetic" models (fig. 7). In this case the coil A carrying the signal current, i.e., the voice coil, is attached directly to the cone B, this coil is placed within a powerful magnetic field, set up by an electro or permanent magnet C. The current variations in the coil A (which is connected through a transformer to the plate circuit of the power tube) set up interaction with the permanent magnetic field, causing movement of the cone to which the coil is attached. The whole moving section is extremely light in weight, and also has no natural resonance



Philips "Campanilla" Cabinets, splendid examples of moving coil speakers requiring no external power to operate, due to the special permanent magnets employed.

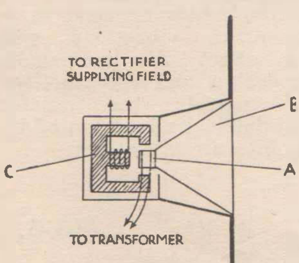


FIG.7

Showing the principle of the moving coil speaker.

period of its own. The movement therefore follows very faithfully the audio fluctuations of current in the voice coil. As this coil is of very low resistance it is imperative that a matching transformer be placed between it and the power tube in order that the power delivered by the power tube is developed fully across the speaker.

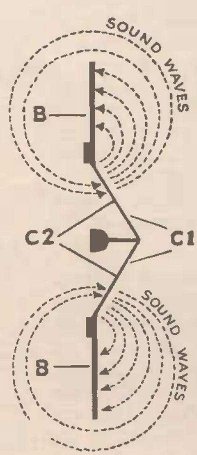
This matching is also frequently employed with the ordinary magnetic speakers. A transformer or filter circuit also serves the useful purpose of keeping the direct plate current out of the windings of the speaker.

A filter unit is described elsewhere, but it should be noted that a 1-1 transformer or a filter, merely serves the purpose of keeping this direct current from the speaker, and does not in any way match the speaker to the valve.

BAFFLING: With all types of open cone, and particularly the moving coil, it is imperative that correct baffling be employed, as when the cone is in motion there is a difference in air pressure between the front and the back of the cone. Low frequencies will tend to move round the cone from a point of high pressure to that of low, thus equalising the pressure, this of course means that the low notes would be lost. This effect can be sufficiently overcome by placing the speaker on a baffle board, thus providing a much longer path for these low frequency air waves, with the result that they are, as it were, projected into the room.

This baffle may be of various shapes, from a plain board to an ornate cabinet. For general use with an open cone, such as a Philips "Baby Grand," or a moving coil unit, the baffle should be of 5-ply and have a total length of at least 18 inches from the edge of the cone to the other edge of the baffle.

(Continued on page 71)



Showing how a baffle tends to prevent bass notes from reaching the back of the cone where they become suppressed by their corresponding vibrations.

CONDENSERS

ON the subject of Condensers there is much to say, as Condensers mean capacity, and capacity is a most important factor in every radio receiver and transmitter.

Condensers may be broadly divided into two types—fixed and variable. In this article we will touch lightly on their theory, explaining the application of the unit of capacity, show their various uses in radio work, and give some simple mathematical calculations and deal generally with variable types.

GENERAL

CONDENSERS are rated in capacity, and the unit is known as the Farad. This is much too large for practical work, and has been divided by a million, and the result termed the Micro Farad. The letters M.F. are invariably used to express this unit. Some people find the term Micro Farad too difficult for expressing small capacity values, and have further divided the Micro Farad by a million, and termed the resulting unit a Micro Micro Farad, which is expressed M.M.F. This term is used largely by American writers when dealing with the capacity of small condensers. It is a simple matter to convert a value expressed in M.F. to M.M.F. To do this, simply multiply the M.F. value by 10_6 which, is equivalent to shifting the decimal point six places towards the right. Examples will make this clear. If the capacity of a condenser is .0005 M.F. then the capacity in M.M.F. will be:

$$.0005 \times 10_6 = 500 \text{ M.M.F.}$$

and for a capacity of .005 M.F. we have

$$.005 \times 10_6 = 5000 \text{ M.M.F.}$$

The capacity of a condenser depends on several points, the most important being:—

1. Area of plates.
2. Number of plates.
3. Dielectric used between plates.
4. Distance between plates.

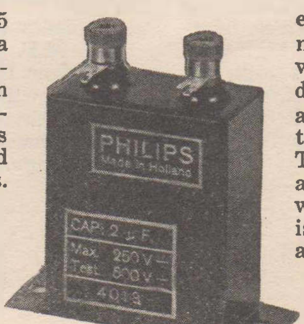
Of the four points enumerated, the third is the only one requiring further information. By the dielectric we mean the insulating material between the plates. First of all it must be realised that all condensers consist of two sets of plates. When connected in a circuit, each set will carry a charge of electricity opposite in potential. That is, one set of plates will be positively charged while the other set is negative. The importance of insulation is now apparent. For small fixed condensers of less than .5 M.F. capacity, mica is most generally used as the dielectric material. Variable condensers almost invariably use air as the dielectric. All insulating materials possess a dielectric constant or permativity factor which represents the ratio increase when compared with air. The permativity of mica is 6, so that a condenser having mica dielectric and similar in size to one having an air dielectric, would possess six times the capacity of the air condenser.

FIXED CONDENSERS

When capacities over .5 M.F. are manufactured, mica is discarded as a dielectric except in cases where a high breakdown voltage is important. The Philips condensers are made in four sizes, and bear individual type numbers.

Type	Capacity in M.F.
4012	1
4013	2
4014	3
4015	4

These condensers are intended for use in circuits where the potential does not exceed 250 volts, which is the maximum safe continuous working voltage. Each condenser is actually subjected to a potential of 500V. during tests after manufacture. These condensers are made up around a specially prepared waxed paper dielectric. This is in the form of a long strip, and each side is coated with a metallic paint leaving a clear margin along the edges of the paper. Connections are made to each metal painting and the paper is then rolled.



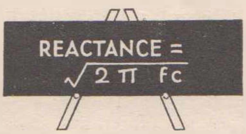
Philips 4013 fixed condenser (2-mf.).

CONDENSERS—CONTINUED

Next it is compressed and dipped in wax to exclude the air which would be detrimental to the efficiency of the unit if given free access to the elements of the condenser.

For protection, and to further exclude the atmosphere, the waxed component is sealed in a metal container which makes the finished article very pleasing in appearance. Screw terminals and lugs are provided to facilitate the wiring.

BY-PASSING: A condenser placed in a direct current circuit will not pass any current. This does not hold good for circuits carrying alternating currents, as the reactance of a condenser is influenced by frequency and is expressed:—



This means that the higher the frequency the greater the current that will flow across the condenser plates. These properties are most important and are utilised to great advantage in most receivers. A most striking example is the by-pass condenser which should be connected from B plus to A minus in all radio frequency amplifiers, as shown in Fig. 1.

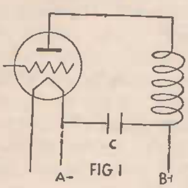


FIG 1

Here the condenser marked "C" provides a by-pass for the high frequency currents, preventing them from wandering through the leads to the high tension unit which would offer a high resistance path and result in weaker signals and perhaps serious back coupling with other stages of the receiver. As high frequencies are being dealt with, a small capacity may be used. 6000 M.M.F. is usual for this position. Although the condenser is bridged from B plus to A minus, no direct current will flow.

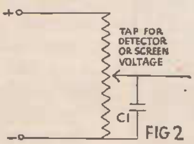


FIG 2

Users of the ordinary battery operated sets should insert a fixed condenser of the Philips 4013 type across the radio B plus terminal to A minus and also a

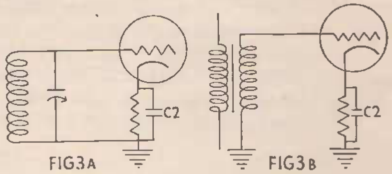


FIG3A FIG3B

4015 condenser from the B plus max. terminal to A minus. These condensers will serve to prevent back coupling between the stages of the receiver, and will also reduce foreign sounds such as invariably arise when using "B" batteries.

These condensers are most useful for by-passing resistors in anode feed systems, and also for bridging grid bias resistors. When dealing with bias resistors a 1 M.F. is ample for radio frequency and first audio stages. Better reproduction follows if a large capacity is shunted across the resistor supplying bias for the output tube.

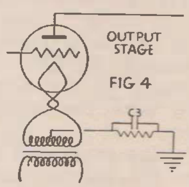


FIG 4

In Fig. 2 we have a potentiometer connected across the output terminals of a rectifier unit so that the slider may be used to provide a voltage for a detector tube or the screen of a screen grid amplifier tube. In this case the by-pass condenser "C," should equal 2 M.F.

Figures 3a, and 3b show the connections for bridging bias resistors in radio frequency and first audio circuits. Again a 1 M.F. job is recommended for the positions C2 in both cases.

The wiring for an output stage is shown in Fig. 4 and here a 3 or 4 M.F. condenser may be employed to advantage. These condensers may be used even if high power output tubes are used, as the potential across the condenser equals the grid bias, and a 250 volt continuous rating leaves more than a safe margin.

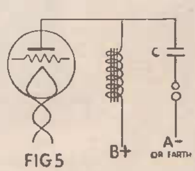


FIG5

CONDENSERS—CONTINUED

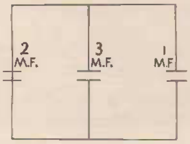
In a choke output circuit, a 4 M.F. should be used. The connections are shown in Fig. 5. The plate voltage should not exceed 250 volts when the 4015 condenser is employed. All the Philips fixed condensers are guaranteed within 10% plus or minus of the marked value.

PARALLEL & SERIES WIRING:

When two or more condensers are joined together in series or parallel, the resultant capacity can be readily calculated. If we connect condensers in parallel, the resultant capacity is equal to the sum of each capacity, and may be written:

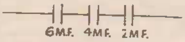
$$C = C_1 + C_2 + C_3$$

We will take the case of three specific condensers connected in parallel.



In this case the total capacity will be:
$C = 2 + 3 + 1 = 6$ M.F.

If capacities are joined in series, **the resultant capacity will be less than the value of the smallest capacity.**



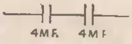
Here the resultant capacity is found by the following formula, which applies to three condensers or more in series—

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \text{thus}$$

$$\frac{1}{C} = \frac{1}{6} + \frac{1}{4} + \frac{1}{2} \text{ thus } \frac{1}{C} = \frac{11}{12}$$

therefore: $C = \frac{12}{11} = 1.09$ M.F.

Two condensers in series are calculated by dividing the product of their capacities by the sum of their capacities, which may be written:—



$$= C = \frac{C_1 \times C_2}{C_1 + C_2}$$

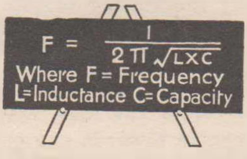
$$\text{thus } C = \frac{4 \times 4}{4 + 4} = \frac{16}{8} = 2$$

VARIABLE CONDENSERS

A variable condenser is a component possessing capacity, the value of which we may readily change. The condenser is made up of two sets of plates called the stator and rotor plates. When the rotor plates are fully meshed with the stator the capacity is at the maximum. By rotating the moving plates through 180° the capacity will fall from maximum to minimum. All condensers still have a capacity when in the minimum position. The lower the minimum capacity, the greater the capacity variation between the "All out" and "All in" positions.

When discussing fixed condensers we mentioned the relation between dielectric and capacity, and the same thing applies to variable types. Air dielectric condensers are invariably employed in radio receivers as only small capacities are used in our tuning circuits. Rarely do we find a variable condenser with a greater capacity than 500 M.M.F.

Variable condensers are universally used for tuning in radio receivers. It is important to remember that the resonant frequency of a tuned circuit depends on the values of inductance in the form of the coil, and the capacity in parallel. It may be expressed:—



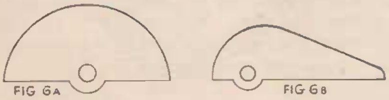
We can see from this expression that if "C" is variable the frequency will also be variable, which is the condition desired for receiving different transmitters each operating on a separate frequency or wave-length.

Mica condensers are utilised for special purposes, usually where a large

CONDENSERS—CONTINUED

proportion of capacity to inductance is required, and this condition arises in wave meter design. They are naturally more compact than the familiar variable condensers and are sometimes used in receivers where compactness is given first consideration.

SHAPE OF PLATES: Differently shaped plates are used by manufacturers, and this point is worth some special attention. We read in advertisements and on packing cartons that the condenser concerned is of the square law, straight line frequency, or logrithmic type, and such conditions are brought about by the shape of the plates. The moving plates are the ones specially shaped and in most cases the fixed plates may be considered as semi-circular.



Semi-circular and straight line frequency plates. The latter gives the advantage of even tuning over the band which it covers.

Fig. 6A illustrates an ordinary semi-circular plate. A condenser of this type will give a straight line capacity variation. This means that a change of 5° near the minimum position will correspond in capacity alteration to a change of 5° at the centre or towards the maximum position.

If inserted in a receiver, such a condenser will render tuning difficult, as the stations on the low dial readings will be bunched close together. It was with the object of reducing this trouble and thereby facilitating tuning, that the logrithmic and straight line frequency types were developed. A typical straight line frequency plate is shown in Fig. 6B. It should be noted that the point of rotation has been moved away from the centre towards one end. Also the plate has been cut away from the semi-circular style. Condensers of this type are to be preferred, as they spread the broadcast stations more evenly, and this is greatly appreciated when tuning in the "B" class stations.

The alignment of the plates is important. All plates should be evenly spaced and this spacing should be maintained for any position of the moving plates. The plates for both rotor and stator sections should be soldered together to minimise resistance losses. Preference should be given to condensers of the metal end-plate style. The advantage is that by earthing the end-plates, which by the way should be connected to the moving plates, an electro static shield is provided, thus eliminating hand capacity effects.

GANGING: Condensers are said to be "ganged" when two or more sets of moving plates are operated from a common shaft.

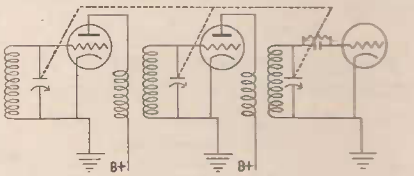


FIG. 7.

A typical circuit in which the 3 variable condensers are ganged for single control.

Fig. 7 represents a wiring diagram for a standard receiver showing the tuning circuits for two radio stages and a detector. In such an arrangement, each tuned stage consisting of a coil and condenser is identical. That is, the three coils are of the same size and shape, and the tuning capacities are equal.

In each stage one end of a coil and the moving plates of a condenser are earthed. Under these conditions ganged condensers may be employed. We shall require a condenser assembly with three rotors joined to a common shaft. The three sets of fixed plates are independent and isolated by insulators. Each section of the assembly is treated as a separate condenser. In this way we are able to tune three stages simultaneously from a single shaft, or in other words, we have realised single dial control. This form of tuning is incorporated in most manufactured receivers, and is popular with home constructors.

With a ganged condenser chassis each section should be fitted with a small variable capacity known as a "trimmer." By adjusting the trimmers each tuned stage may be properly balanced to compensate for any irregularities in the components or layout.

AUDIO FREQUENCY COUPLING

THE fact that the radio receiver has been taken out of the "bad gramophone" into the "musical instrument" class, is due, of course, to the tremendous improvements that have been made within the last three years in audio amplification and speaker design.

Everything appertaining to the audio or low frequency side of a receiver has come under this wave of progress—tubes, speakers, transformers or resistance coupling units, and even the gramophone pick-up. Modern reproduction, which may safely be said to be practically perfect, has been made possible not by any one of these things, but by a combination of them all, although an extra large bouquet must be handed to Pentodes and Power Valves generally.

There are two methods of audio frequency coupling in general use—Transformer and Resistance Capacity. Choke coupling is sometimes used, but has very few supporters and is not worthy of mention in this book.

THE function of an Audio Transformer is to take the audio impulses fluctuating in the plate circuit of one valve, amplify them, and pass them on to the grid of another valve so that they may be further amplified (fig. 1). At the same time it must do this without distorting the original impulses.

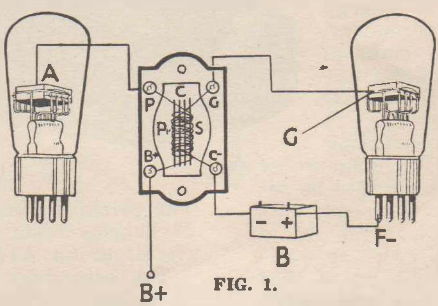
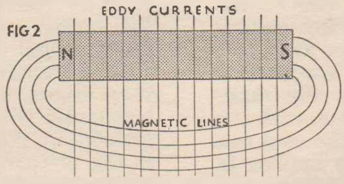


FIG. 1.

Showing the function of an audio transformer as a coupling device.

It consists essentially of a coil of wire (P) wound over an iron core (C) and connected in the plate circuit of the detector or first audio valve, with another coil (S) wound over it. This second coil being connected between grid and filament of the next valve, the fluctuating currents passing through the inner coil (primary) set up a fluctuating magnetic field, which cuts the second coil (secondary) inducing a voltage into it which fluctuates in accordance with the audio impulses flowing in the primary. The purpose of the core is to offer an easy path for the magnetic lines of force and thus increase their intensity.



The transformer core showing magnetic lines of force and eddy current.

An audio transformer is also usually designed to give a voltage step-up effect, and this is done by winding more turns on the secondary than there are on the primary, and the amplification is in accordance with the ratio of the number of turns. Thus a transformer having 1000 turns on the primary and 3000 on the secondary, would step-up the voltage so that the voltage across the secondary would be three times that across the primary. This step-up would only apply to the fluctuating component in the primary, and not to the steady "B" supply. It should be noted that, as a valve is a voltage operated device, it is a fluctuating voltage which is required in the secondary.

It may be asked why a transformer with a ratio of thirty, forty, or fifty is not made, but it must be remembered that this passing on of energy and stepping up must be accomplished without distortion. To start with, there is a limit to the number of turns that can be put on the primary. Maximum energy is given to the primary when its A.C. resistance is roughly twice that of the preceding valve, but if, to achieve this, it becomes necessary to

AUDIO FREQUENCY COUPLING—CONTINUED

wind a large number of turns on the primary, then to maintain our step-up ratio, we should have to wind a very large number of turns on the secondary —this would immediately give rise to undesirable self-capacity effects which would by-pass some of the high notes, and the resulting reproduction would lack brilliance. Another undesirable result of this large primary, would be a considerable increase in the D.C. resistance, necessitating an increased "B" voltage to maintain the required voltage at the plate of the valve.

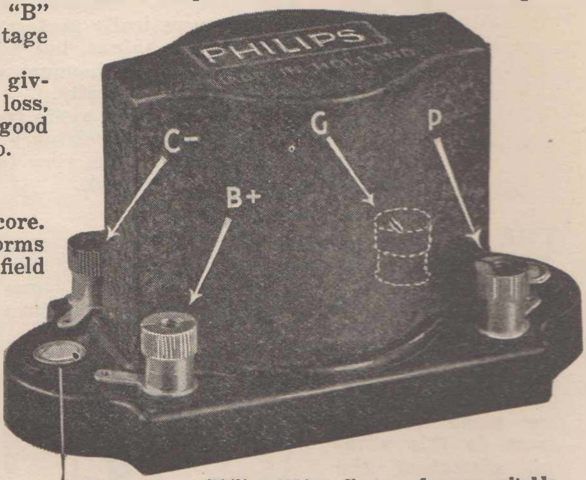
It has been found that the ratio giving the best step-up with the least loss, is approximately 3 to 1 and most good modern transformers have this ratio.

ACTION OF THE CORE

A point not yet considered is the core. As previously explained, this performs the function of intensifying the field thrown out by the fluctuations in the primary, so that a considerable amount of primary energy can be induced into the secondary. It does this because the material of which it is made, allows the magnetic lines of force to pass very easily through it—(Fig. 2) but, as it is made up of conducting material which is under the influence of a fluctuating field, currents would be set up in it. These are known as eddy currents, and their energy is given off in heat—a direct loss. In order to overcome this, the core is built up of thin sheets of the material, called laminations —each insulated from the other, thus increasing the resistance of the core and decreasing the strength of the eddy currents. These laminations do not affect the magnetic properties of the core in any way.

The older type transformers had cores of silicon and iron, the use of this substance resulting in large size cores and a large number of turns of wire on the primary to obtain the necessary inductance. Nowadays nickel alloys are used, which have a much greater concentrating effect (permeability) on the magnetic lines than the silicon cores, with the consequence that the size of the core can be greatly reduced. This also applies to the size of the primary winding, and because of the high permeability core, the inductance will still be greater than the average large silicon iron core transformer, and as the size of the primary can be reduced, so also can the secondary. The ratio of step-up is maintained and the high frequency loss reduced. The transformer then becomes a highly efficient component of small size.

The Philips 4003 audio transformer is an excellent example of this modern trend in design. It has a primary winding, giving absolute freedom from oxidisation. also it possesses a high tensile strength.



Philips 4003 audio transformer, suitable for coupling any audio stages.

The primary possesses an inductance of 28 henries when connected in the plate circuit of an A415 miniwatt.

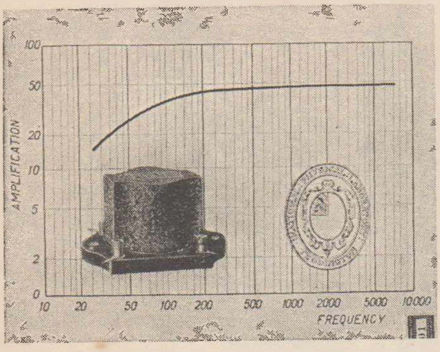
The secondary is wound with nickel wire, again giving mechanical strength and freedom from oxidisation. The core is composed of a special high permeability nickel alloy—the whole being highly impregnated with a moisture resisting preparation. Many transformers show a good response curve when the actual value of the audio currents remains at a certain definite intensity. When the energy passing through the primary varies from this figure, then the output no longer follows the true input/output ratio. Some of the notes will be transferred with greater strength than others, and furthermore, additional harmonics will be set up which were not present in the original audio component in the primary.

This form of distortion is called "amplitude" distortion, and its results are very distressing to the ear, in that the reproduction appears very uneven in strength, and therefore unbalanced.

AUDIO FREQUENCY COUPLING—CONTINUED

With the Philips audio transformer, due to its special core, audio currents are transferred faithfully over a very considerable range of plate current intensity, i.e., the transformer retains a certain definite inductance irrespective of the plate current flowing within very wide limits.

The transformer gives excellent results when preceded by an E415, A415, A409, or E409—at 60 cycles the A.C. resistance will be 10,000 ohms, and thus correct tube and transformer primary matching will be attained. When preceded by an A415 or E415, a stage gain of 45 is attained. When preceded by the new indirectly heated special detector E424, a stage gain of 72 is reached.



Curve of the 4003 transformer prepared by the National Physical Laboratories, England.

This compares very favourably with a modern screen grid type of detection circuit.

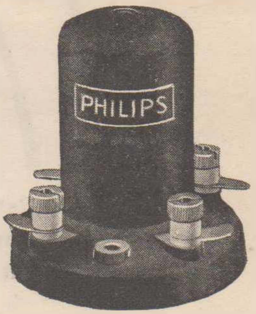
RESPONSE CURVE

In the first part of this article it was explained that the transformer had to transfer the audio fluctuations without distortion. Now consideration will be given to the actual range of frequencies which the transformer must handle faithfully.

In the first place the ear is able to detect sound vibrations fluctuating from 16 to 15,000 times per second, i.e., frequencies from 16 to 15,000 but it is not necessary for practical purposes to reproduce this entire range. The voice covers the frequency range from 60 to about 1300, the latter being a high soprano note. In music the range is from about 16 (4 octaves below middle C) to 4,224 (4 octaves above middle C), but besides these fundamental frequencies, both voice and musical instruments have overtones which go up to a frequency of 10,000 so that it is necessary for the transformer to transfer and amplify all the frequencies from approximately 50 to 10,000.

The middle section from 200 to 6,000 should be handled so that all frequencies are amplified and transferred evenly. The frequencies from 200 down to 50 give body to the reproduction, the upper frequencies give brilliance to the music and intelligibility to speech. This frequency response in a transformer is shown by means of a response curve, and by reference to this the capabilities of a transformer can be rapidly judged.

Reproduced is the curve of the 4003 transformer. From this it can be seen that the fundamental frequencies from 200 to 6,000 are amplified absolutely evenly. The important upper frequencies from 6,000 to 10,000 are still efficiently amplified so that no brilliance is lost, and down at 50 cycles as much as 56% of the maximum amplification is available, and this curve is constant over a very wide range of signal intensities. The curve was made by the National Physical Laboratories, and a standard circuit was used.



Philips 4001 resistance capacity coupling unit.

A comparison with Resistance Capacity Coupling shows that a good audio transformer has the following advantages:—

1. **Upper frequencies fully amplified, whereas the condenser used in resistance capacity attenuates these.**
2. **Considerably greater amplification, permitting the use of fewer audio stages to attain any desired volume.**
3. **Less "B" voltage required, due to the low resistance of the transformer primary compared with the high anode resistance in the Resistance Capacity method.**

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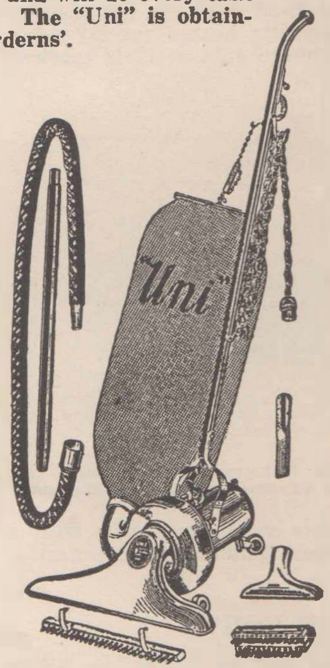

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AUDIO FREQUENCY COUPLING—CONTINUED

Advantages 1 and 2 also apply when comparing Transformer with Choke Coupling.

RESISTANCE CAPACITY

Some maintain that the amplification by this method is more faithful than through transformers, but this is a controversial point. The modern transformer has done much to influence the issue in favour of the latter method, but the resistance capacity system is again becoming of interest, and we are therefore devoting some space to it.

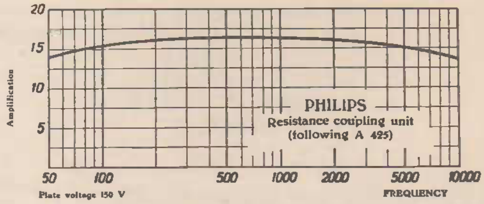
With resistance capacity coupling it is most important to match the plate resistances to the tubes. As there is no step-up in the resistances, it will be seen that it is necessary to employ tubes with a high amplification factor. If a low impedance tube is used, the value of the plate resistance must be reduced. A low impedance tube means greater plate current and consequently a greater voltage drop on the plate resistor.

The tubes A425, A442, A630 (D.C.), and E438, E442S (A.C.) will all perform splendidly in resistance coupled apparatus. The plate resistance should not be less than four times the impedance of the preceding tube. A resistance of 100,000 ohms will suit the three types mentioned. The impedance of the E438 is 25,300 ohms. The grid resistance is not critical and 2 Megohms is a good average value.

As the plate resistance is in series with the "B" supply to the preceding tube, a high voltage is essential on account of the inevitable voltage drop. Resistance Coupling may be applied with success to receivers embodying screen grid detector tubes, which are becoming more and more popular. A higher plate resistance is an advantage, as the impedance of the screen grid tubes is above normal.

Care must be taken to prevent back coupling, which may be particularly troublesome if several tubes of the amplifier are fed from a single high tension terminal.

For those who desire to use Resistance capacity coupling, Philips market the 4001 resistance unit, which may be simply installed, as it has four terminals marked in the same manner as on the 4003 transformer. This unit will match Philips tubes specified for Resistance Capacity work. A special feature incorporated in the unit, is a R.F. choke, to prevent high frequency currents from reaching the first audio stage.



Curve of 4001 Resistance Capacity Coupling Unit.

It must be remembered that if a resistance unit follows the detector stage, a high impedance tube must be inserted in the detector socket. This form of coupling should be utilized in receivers where plate detection (anode bend) is used, as generally speaking, a high impedance tube is invariably employed for this method of detection.

Connections for resistance couplings are shown in the diagram. It will be noted that it is necessary to use two amplifying stages to provide the requisite grid swing for the output tube. The resistors marked "R" are not part of the 4001 unit. These are extra resistors used in conjunction with the condensers marked "C" for decoupling purposes in order to eliminate "motor-boating." This form of interference may become very troublesome in an amplifier of this type. 10,000 ohms each, will be a suitable value for the decoupling resistors, and 2 M.F. for the condensers "C."

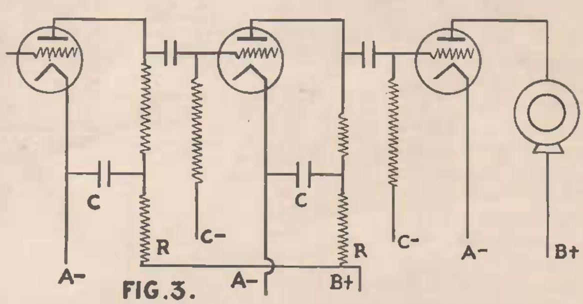


FIG. 3.

Typical circuit arranged for Resistance Capacity Unit.

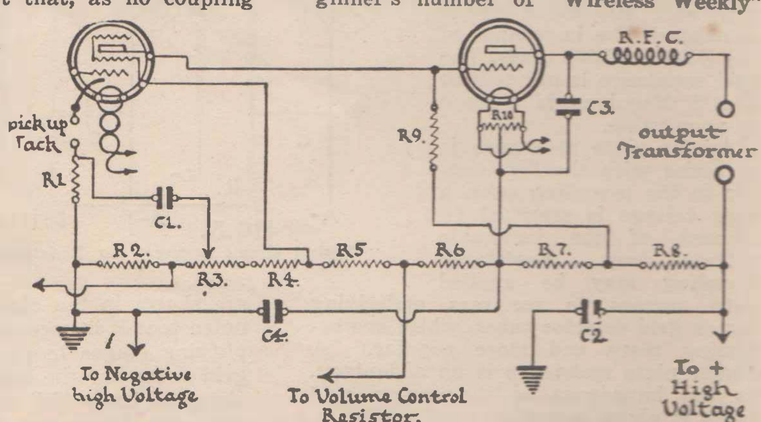
DIRECT-COUPLED RECEIVERS

LATEST DEVELOPMENT

THE most interesting feature of radio design in the past few months has been the advent of direct-coupled audio systems. The idea is really an old one, but it is only about twelve months ago since two American engineers, Loftin and White, succeeded in getting entirely satisfactory results from it. They obtained excellent results from the circuit when used as an amplifier, but claimed that the first valve could not be used as a detector in a radio circuit.

HOWEVER, shortly after the arrival of the first details from America, "Wireless Weekly" succeeded in perfecting a circuit which gave satisfactory results, both for radio and amplifier operation. The circuit proved immensely popular and has since been published in six different Australasian radio papers as well as one of the leading English papers. The circuit has been adopted by several Australian manufacturers and also by many of the manufacturers of midget sets in the United States.

The system is in some respects similar to a resistance-capacity coupling arrangement, except that, as no coupling condenser is necessary, the frequency response is considerably improved. When a valve such as the F242 is used in the detector socket, and an E443N in the output, terrific volume can be obtained. Owing to its ability to handle the high notes the penthode is particularly suitable for direct-coupled circuits and provides excellent reproduction.



A schematic diagram of the audio amplifier of a receiver using the direct-coupled system. It will be noticed that there is no coupling condenser employed between the plate of the detector and the grid of the output valve.

There are one or two points about the direct-coupled circuit, however, which are worth mentioning. In the first place the success of the job depends to a big extent upon the accuracy of the resistors used, and secondly upon the performance of the valves being exactly according to their rated characteristics. On this account, it is most important that only high-grade valves, such as Philips, be employed. When loud volume is not desired the F203 is a suitable valve for use in the direct-coupled circuit. Full details of the circuits and constructional details of the various sets using direct-coupling can be obtained from the "Wireless Weekly."

If you find any difficulty in mastering the interesting constructional data published in this booklet, a special beginner's number of "Wireless Weekly" dated February 6, will help you. In this you will find the explanations of circuit diagrams and many other fundamental points necessary to a knowledge of radio.

AERIALS

Types—Action of an Aerial—Losses—Protection—The "Aerial Cop"

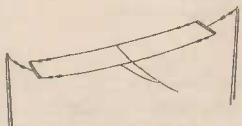
DUE to the introduction of supersensitive receivers, large outdoor aerials are becoming a relic of the past. This has been brought about chiefly by revolutionary changes in radio frequency amplifier design, and one of the most direct causes has been the introduction of the new SCREEN GRID TUBES. However, all listeners who are operating receivers which do not include radio frequency amplifiers, will find an efficient aerial system essential.

WHEN the broadcast stations first commenced the transmission of regular programmes, there were many types of aerials in vogue. It was not an uncommon sight to find four or five different aerial styles erected within a few hundred yards of each other. Due to enlightenment on the subject, the craze for something different in the way of an aerial has died out, leaving the single wire aerial the most popular form.

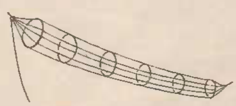
A single wire aerial is capable of picking up good signals from broadcast and short-wave stations. Indeed, many of the most powerful short-wave transmitters, including the famous PCJ station, use single wire aerial systems for their transmitters. Generally speaking we may consider it the best proposition for the average radio enthusiast.

THEORY:

To appreciate the action of a receiving aerial it is helpful and interesting to consider radio waves in general. The radio waves are generated by means of special apparatus which we will refer to as a transmitter. This machine possesses the property of converting ordinary electrical currents into high frequency oscillations. When the transmitter is connectel to a suitable aerial system, the high frequency oscillations are set up within the aerial, which results in powerful electro-magnetic waves being radiated. High frequencies are essential for transmission purposes, as the power radiated from an aerial is proportional to the square of the frequency. For broadcasting work the frequencies between 500 and 1500 kilocycles are generally employed.

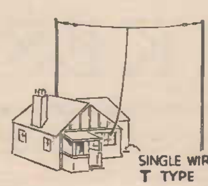

THE ONCE POPULAR TWIN WIRE


THE FOUR WIRE


THE CAGE OR SAUSAGE


THE COPPER BALL AERIAL-RECENTLY IN FASHION


SINGLE WIRE Γ TYPE


SINGLE WIRE T TYPE

Wave-length and frequency go hand in hand, and any figure quoted as wavelength may be converted to terms of frequency. As an example it may be remembered that a wavelength of 300 metres corresponds to a frequency of 1000 kilocycles. Suppose we wish to determine the frequency of the signals from 2FC. As 300 metres equals 1000 KC. we may write the frequency for 2FC which operates on a wavelength of 442 metres as:—

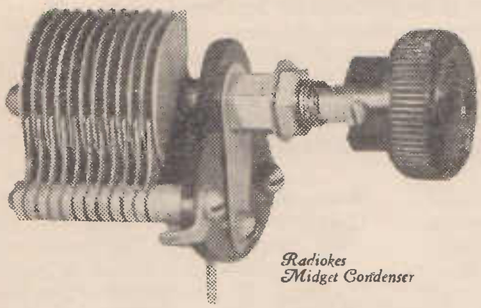
$$\frac{300}{442} \times 1000 = 678 \text{ Kilocycles}$$

Taking 40 metres as another example, we find—

$$\frac{300}{40} \times 1000 = 7500 \text{ Kilocycles}$$

Now the variations set up in the ether by the transmitter, are electro-magnetic waves, and these travel out from the aerial at a high velocity. The velocity is the same as that of light, and equals 186,000 miles per second. Actually, light consists of electro-magnetic waves, but of a much higher frequency than radio oscillations. This high velocity enables a signal to cross the

Your Set Can Only Operate as well as its Parts



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RADIOKES MIDGET CONDENSERS give permanently satisfactory performance and sharp tuning because they are substantially built by precision methods, and rustless throughout. The plates are spaced with minute accuracy, and the stationary plates permanently locked in position. Designed for low minimum capacity and high maximum capacity.

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RADIOKES R.F. CHOKES Accurately made and carefully tested. Designed to minimise distributed capacity. The special mounting bracket lifts the choke, and therefore its field, out of the wiring of the set.

Radiokes R.F. Choke

RADIOKES PRECISION PRODUCTS

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AERIALS—CONTINUED

space between England and Australia in one fourteenth part of a second.

Let us now consider what takes place round and about the aerial wire. Figure 1 shows a typical arrangement.

Here we have a horizontal aerial, and down lead joined to earth. All aerials will have a natural period of oscillation, usually referred to as the natural wavelength. That is, they may be considered to be in tune to one particular wavelength. This is because such an arrangement will naturally possess the three necessary factors. These are, resistance, capacity and iuductance.

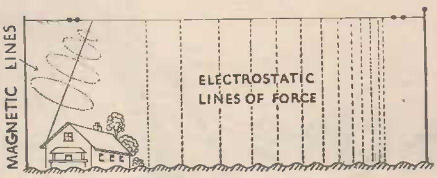

FIG. 1.

Showing a typical L-type aerial and the theoretical properties which affect it.

The resistance is found in the wire. A current through the aerial will produce a magnetic field, chiefly around the down lead, therefore inductance must be present. The third factor, capacity, may be accounted for as lines of electro static force which are set up between the wire and earth when the aerial is raised above earth potential. When dealing with the aerial as shown in Fig. 1, we find that the lines of force are widely spread, as the inductance and capacity is distributed throughout the length of the wire. The electromagnetic fields are greatest around the lead in, while the electro static forces become stronger as the free end is approached. It is the spreading and collapsing of these lines of forces that result in the radiation of electro - magnetic waves from the transmitting aerial. In the case of the receiving aerial the response to the incoming waves is partly governed by the fields set up by the lines of force.

The right and wrong way of connecting to insulators.

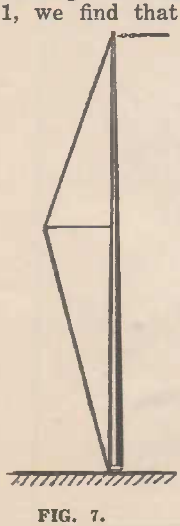

FIG. 7.

Method of staying a mast when space is limited.

NATURAL WAVELENGTH:

If it is desired to calculate the natural wavelength or frequency of an aerial, an approximate result may be obtained by multiplying the length in feet by 1.5. Suppose our aerial is 50 feet long measured from free end to earth connection. Then the natural wavelength will be—

50 x 1.5 = 75 metres

In most receivers we find an aerial coupling coil. This is invariably connected in series between the aerial lead and earth, and provides a means of introducing oscillating currents present in the aerial system to the receiving circuit. It also has the effect of increasing the natural wavelength of the aerial.

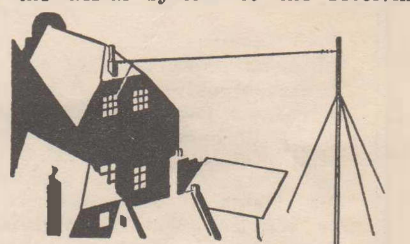

Fig 1

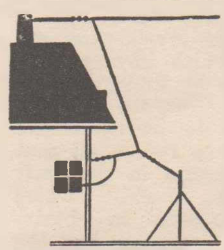

Fig 4

Above: Typical single wire aerial.
Left: Method of keeping lead-in clear of obstructions.

As we have found that a fifty foot aerial has a natural wavelength of only 75 metres, it will be realised that this loading by the aerial coil is desirable for reception on the broadcast waves.

WHAT CONSTITUTES A GOOD AERIAL SYSTEM?

The greatest current will flow in the aerial when it is in resonance or "in tune" with the transmitter, as then the aerial impedance is low. The current

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AERIALS—CONTINUED

in the aerial is directly proportional to the induced voltage, and inversely proportional to the aerial impedance. Thus

$$\text{aerial current} = \frac{E}{Z}$$

Where—E = induced voltage
Z = aerial impedance

At resonance the aerial impedance is cancelled, and only the ordinary resistance remains.

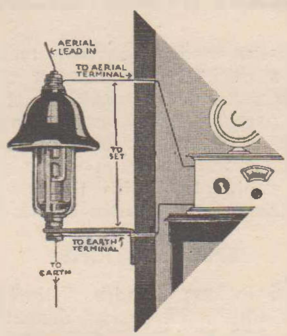
The induced voltage should be high for good reception. This depends largely on the efficiency of the aerial. A high signal voltage will be induced in the aerial if the resistance is kept low.

This may be accomplished by using heavy wire and making a thorough contact to earth. A bad earth connection is likely to introduce high resistance and large losses.

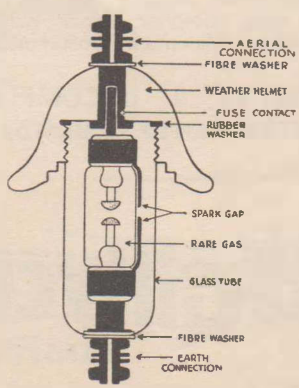
Clearance should be given plenty of consideration. It is most undesirable to have a large tree or building under the aerial wire. Such an object will greatly reduce the effective height and may introduce other troubles. Always avoid crossing electric power and telephone wires. Otherwise there is the possibility of the aerial fouling with these wires. In fact, keep your aerial as far away from them as possible to prevent interference from them.

The high frequency waves from the transmitter set up oscillating currents in the aerial of the same frequency as the original. These currents set up in the aerial are conveyed to the receiver, amplified, and the electrical impulses received are converted back to their original sound frequencies and become audible through our loudspeakers.

Elevation is an important factor, and the aerial wire should be raised as high as possible from the ground or building, depending upon location. For purposes of reception, the length is not critical. A single wire of say sixty feet, including lead-in, is a fair average. When erecting an aerial, the following points should be observed.



The "Aerial Cop."



Sectional view of Aerial Cop.

Good elevation.
Clearance.
Insulation.
Protection from lightning.
Reliable supports.

The efficiency of the aerial so far as picking up signals is concerned, is almost directly proportional to the height.

Only the highest grade insulators should be used. Two well-spaced at each end are sufficient. Pyrex glass insulators are considered the best, whilst glazed porcelain are also very satisfactory.

PROTECTION:

The question of protection is most important. An efficient lightning arrester is essential for any installation. The Philips "Aerial Cop" is a truly ingenious device for this purpose. This apparatus embodies a rare gas fuse in a special insulated holder. Two screw contacts are provided. The bottom contact is earthed, and the lead-in passes round the top contact. Both connections are permanent. No switching is necessary and the apparatus is always on duty. In addition to the fuse, an air gap is provided for heavy discharges. The great advantage of incorporating a rare gas fuse is that any small potentials which tend to build up by accumulation on the aerial may leak away to earth through the fuse. The cartridge will visibly glow at a potential of 120 volts, so there is no possibility of a dangerous potential developing on the aerial. Experimenters will no doubt often have noticed sparks jumping the plates of the aerial condenser. This is due to high voltages accumulating on the aerial and leaking to ground via the condenser.

The "Aerial Cop" is easily installed,

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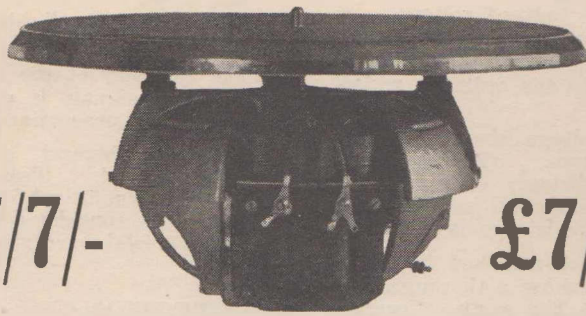

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SPECIFICATIONS:

Size: Height, 6 inches; Breadth, 7 inches; Turntable, Blue or Green Plush, 12 inches diameter. Motor is induction type, 200-250 Volts A.C., and guaranteed to run under heavy strain without "pull up." Main frame of cast iron, with phosphor bronze bearings. Motor cushion mounted. Maximum consumption 25 watts.

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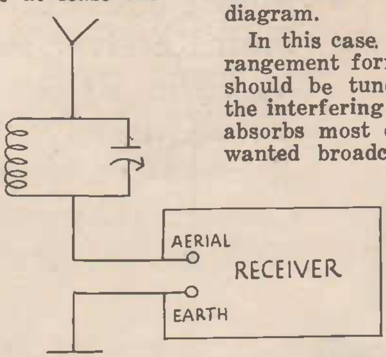
AERIALS—CONTINUED

and is supplied with a special metal angle bar for wall mounting. It may be mounted internally or externally, as desired. On account of the special construction it is not possible for the insulation to become impaired by bad weather.

Only reliable supports should be used to hold the aerial in place. A good mast is a great asset for at least one end. Use two masts if possible. It is not necessary for them to be equal in height. The aerial may be horizontal or erected at an angle. Do not use iron or steel wire. Copper wire will give the best results. Stranded 7/20 gauge copper wire plain or enamelled is the most popular. Take your lead-in either from dead centre or either end—never from any intermediate point.



Connections for wave-trap.

Listeners who are operating commercial receivers should carefully read the directions given, and modify their aerials to comply with the requirements of their sets. Particularly so on the point of length. A reduction in length will often give a useful increase in selectivity.

THE WAVE TRAP:

When bad interference is experienced from a broadcast station it may be reduced or eliminated by connecting a simple tuned circuit in series with the aerial lead. The idea is outlined on the diagram.

In this case the coil and condenser arrangement forms a rejector circuit, and, should be tuned to the wavelength of the interfering station. This circuit then absorbs most of the energy of the unwanted broadcaster and hardly affects the desired station.

For best results the coil should have low losses, and only the best types of variable condensers are worth while for the rejector circuit. Use heavy gauge wire and short leads. Solder all connections. When the wave trap condenser is changed, the tuning of the receiver should be readjusted to the transmission desired.

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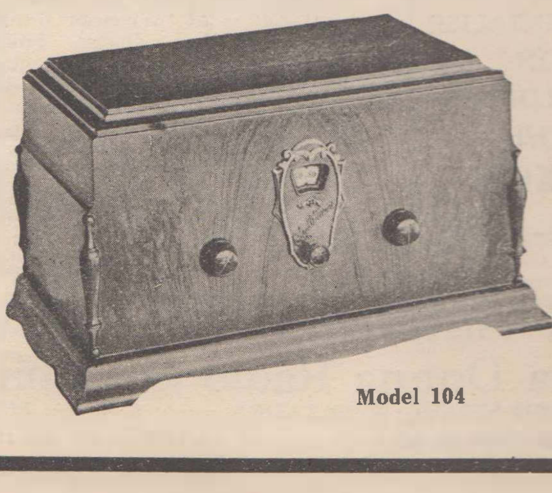


Model 104

CONVERTING D.C. RECEIVERS FOR A.C. OPERATION

(Continued from page 26)

ing points should always be grounded:—

(a) Centre tap of filament lighting transformer.
(b) "B" minus.
(c) "C" positive.
(d) Casing of high tension unit.
(e) Casing of filament heating transformer.
(f) All metal shielding.

When converting a battery receiver to A.C. it should be noted that all wiring connected to the D.C. filament wiring should be altered so that it is connected to earth. Nothing must be connected to the filament wiring in A.C. sets except the filaments of the valves.

Only the best quality valve sockets should be used. If a socket with a bad contact is wired in to a receiver, it will cause much trouble which will be very difficult to trace. All connections should be soldered to avoid trouble from faulty or loose connections. Always remember that A.C. receivers are no more difficult to operate than the ordinary types, and owing to the superior apparatus available in this field, better results are to be expected.

CHOKES

(Continued from page 28)

FILTER CHOKES: Filter chokes are used for smoothing in power supply circuits (fig. 3), so that working in conjunction with large condensers they smooth out ripples and help to give a hum-free output. They are similar to audio chokes in construction but the windings and core are made sufficiently heavy to deal effectively with the currents involved.

The wire should be of a heavy gauge so that the D.C. resistance is kept low, and the voltage drop across the choke, reduced to a minimum.

VALVES

(Continued from page 39)

This means that when a penthode is used correctly in the last stage, it is not necessary to use a preceding audio tube, and further, that for an equal consumption of plate current at a specified plate voltage, the undistorted output from a penthode will be larger than that of a triode.

Penthodes are made to fill the needs of every type of set user, and the incorporation in a receiver is well worthwhile, the main advantages being:—

1) Greater faithfulness and brilliance of reproduction.
(2) No necessity for an intermediate audio stage.
(3) Cheaper sets, easier to construct.
(4) High input-output ratio, which means that the greatest possible effect operates upon the speaker for any given signal input to the penthode.
(5) Small plate current required for equal or even greater undistorted output.

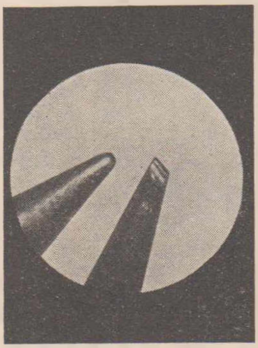
SPEAKERS

(Continued from page 52)

If made up in the form of a box, the back should be left open, or have several large holes cut in it; this will tend to prevent box resonance, which seriously muffles the reproducton. **An excellent baffle is provided by a wall or partition into which the speaker is built so that only the cone and cone support projects. The average cone speaker is moderately well loaded when receiving an input from the power tube of about 500 milliwatts. A moving coil type requires about 1500 milliwatts if it is to show to its best advantage.**

THE CARE OF RECORDS

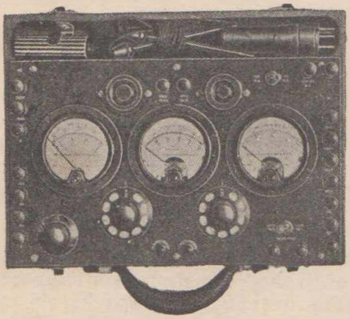
The fact that phonograph records last only a very short time at their best is entirely due to the misuse to which they are subjected. Firstly there is the matter of handling, which should always be by the edge of the record. This prevents grease from the hands clogging the grooves. It is of course essential to keep records in their sheaths.



On the subject of needle-changing it must be realised that this is no myth. The accompanying illustration shows (under a magnifier) an unused needle and a needle used twice. The used needle would practically ruin the loud portions of the next record it played.

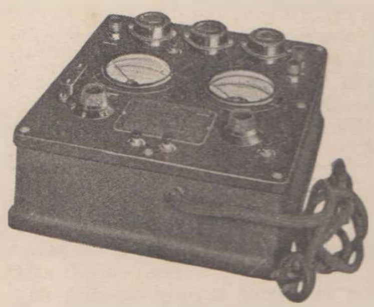
THREE OUTSTANDING SERVICE INSTRUMENTS

FORTY odd years of world-wide instrument supremacy is reflected in Weston Radio Test Equipment. When selecting your servicing and test instruments bear in mind the fact that throughout the whole electrical industry Weston quality and dependability are the standards by which all other instruments are judged.



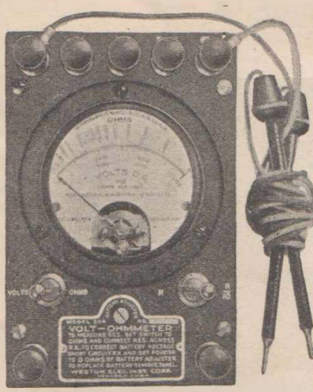
MODEL 547

A complete Test Set for all types of A.C. and D.C. Radio Receivers and Tubes. It is fast, convenient and reliable in operation. Extensively used by radio service men. Also suitable as a handy portable test set for general factory and laboratory purposes.



MODEL 555

Counter Tube Checker. Widely used by better radio dealers to test tubes at time of sale. Checks all type tubes, A.C., D.C. and Rectifiers (both plates). Speed and ease of operation have made it very popular.



MODEL 564

A Volt-ohmmeter, compact and completely self-contained. Valuable aid in radio service and in laboratory work. For checking continuity of circuits, voltages. Ranges 10,000/100,000 ohms and 3/30/300/600 volts.

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