THE AUSTRALASIAN

Radio World

1/6

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Vol. 14 ... No. 8

January 26, 1950

“Q-PLUS’s” No. 1. 1950 RELEASE

“Q PLUS”

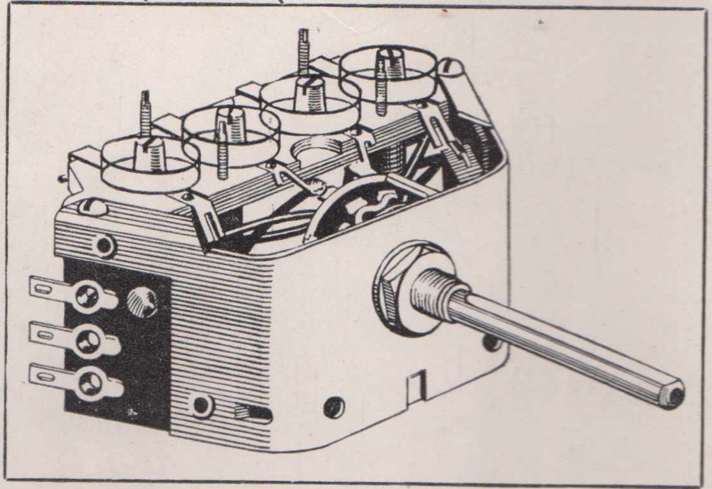
Australia’s Smallest Dual Wave Bracket

Available for 550-1630 KC B/C Band, 16-50 Metres, Short Wave Band, it comes in types to cover all popular converter valves, INCLUDING TYPE 6BE6.

It’s good value too, both SW & BC padder condensers being wired in.

Watch for other "Q-Plus" 1950 releases —Support Australia's progressive Radio Components firm—First with midget coils, etc, and first with all worth-while developments.

Specially shaped to fit into personal portables, portables, midget AC sets or just standard radios —nothing could be finer—**permeability tuned using special "SPHERICAL CARBONYL" Ferro- magnetic cores,** spherical for perfect high frequency insulation, Polystyrene insulated - trimmers mounted alongside cores for ease of alignment. Fully tropic - proofed —in short everything that a 1950 coil bracket demands.



Illustrated approximately life size—the new “Q-Plus” midget Dual Wave Bracket

Retail Price 49/6

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DW5 — ECH35,
33 or — X61M
DW6 — 1R5
DW7 — 6BE6

NB: This unit now replaces all earlier models.

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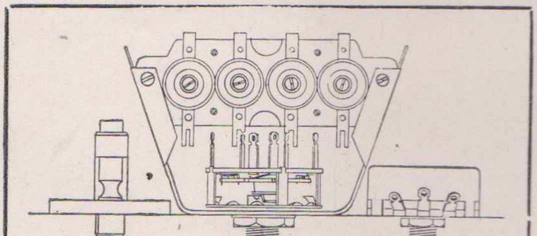

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THE AUSTRALASIAN

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and incorporating
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VOL. 14 JANUARY, 1950 No. 8

CONTENTS

EDITORIAL

AT this time of the year it is customary to look back over the past, then turn to the future.

Looking back: My first duty is to express my sincere appreciation for the loyal support which I have received from buyers and subscribers. Production problems have meant that many issues have not been as good as I would have liked them; increased production costs have made an increase in price inevitable. Yet I am happy to note that sales to-day are higher than ever before in the long history of the publication. The advertising position is not so happy. The manufacturers of component parts have their problems, and many of them are not able to support technical journals in the manner they deserve.

The future looks much brighter. Once clear of the holiday season, we expect to be able to get bigger and better issues out on time. For editorial matter the outlook is also brighter, as quite a few firms have mentioned to us that they intend to release new lines in the near future. One of the first is a new "Aegis" kit-set job for a four-valve mantel model, to use the latest high-gain valves. Next is a set to use a most compact dual-wave coil bracket which has been designed by the 'Q-Plus" engineers.

All we need is a little more revenue from advertising, and we will be able to turn out much better issues for 1950.

A. G. Hull

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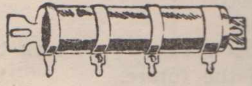

3

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VD25 15,000 ohms, 2 variable clips 5 6

VD28 25,000 ohms, 2 variable clips 5 6

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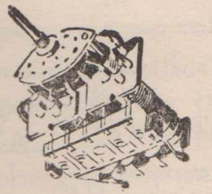


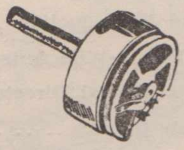
D.W. 37

Dual Wave Unit with R.F. Stage £6/10/-

D.W. 29 .... 4/5

Dual Wave Unit £1/14/-

POTENTIOMETERS AND RHEOSTATS 5



7/6 Retail

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PT 38	10 ohm 25 amp
PT 39	20 ohm 25 amp
PT 34	30 ohm 25 amp
PT 46	400 ohm 50 M/A
PT 47	1,000 ohm 35 M/A
PT 49	2,500 ohm 30 M/A
PT 51	5,000 ohm 30 M/A
PT 52	10,000 ohm 30 M/A

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OUR FEATURE ARTICLE.

V. T. V. M. MULTITESTER

For a few pounds you can build yourself this fine piece of test equipment. It can do a great many jobs on the service bench or in the laboratory.

THE instrument about to be described will be of particular use to radio enthusiasts as it is entirely self-contained and powered by internal batteries, the consumption being very low.

General Description:

Valves used—
  1- 1S5
  1- 1T4
Batteries—
  1- 67½v. Minimax
  3- 1.5v. Torch cells.
Meter—
  1 m.a. Moving Coil.
Ranges covered—
  AC. 0-1.5 volts.
    0-15 „
    0-150 „
  D.C. 0-1.5 „
    0-15 „
    0-150 „
  Mils 0-1.5 D.C.
    0-15 „
  Ohms × 10 ½ scale = 100 ohms
    × 100 ½ scale = 1,000 ohms
    × 1000 ½ scale = 100,000 ohms
    × Megs. ½ scale = 10 Megs.
  Sig. Tracer-Phone Jack output.
Controls—
  "Zero" Set
  "Max" Set
  Selector Sw. AC. DC-DC × Mils Ohms.
  Operation Sw. Off. Sig. Tracer, V.T.V.M.
  Range Sw. 6 position.

By
JESSE SMITH,
Pakenham Street,
Blackburn, Victoria.

In order to explain how the instrument functions it is first necessary to explain the fundamental operation after which will be explained the basic principal of operation on each type of measurement of volts, current and resistance.

Fundamental Operation Of VTVM.

Ref. Fig. A1. Referring to this diagram you will see that the tube is biased —1.5 volts, the filament being positive 1.5 volts with respect to earth and the grid being tied to earth through the 10 meg. resistor. A 0-1 ma. meter is in series with the HT supply to plate and a plate current of 1 ma. is flowing. (This is an assumed

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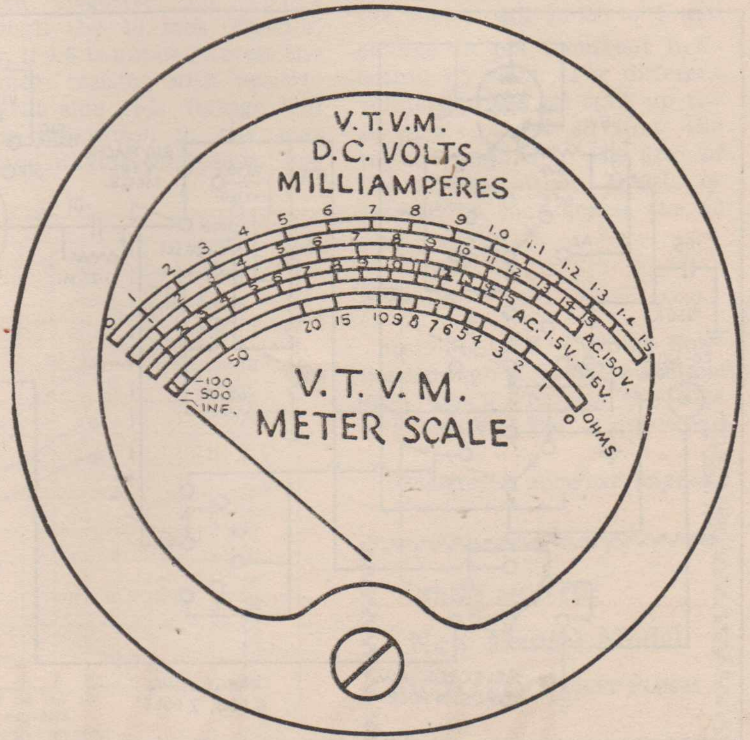

MULTITESTER

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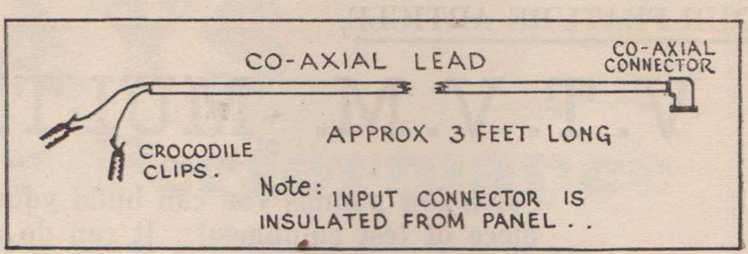
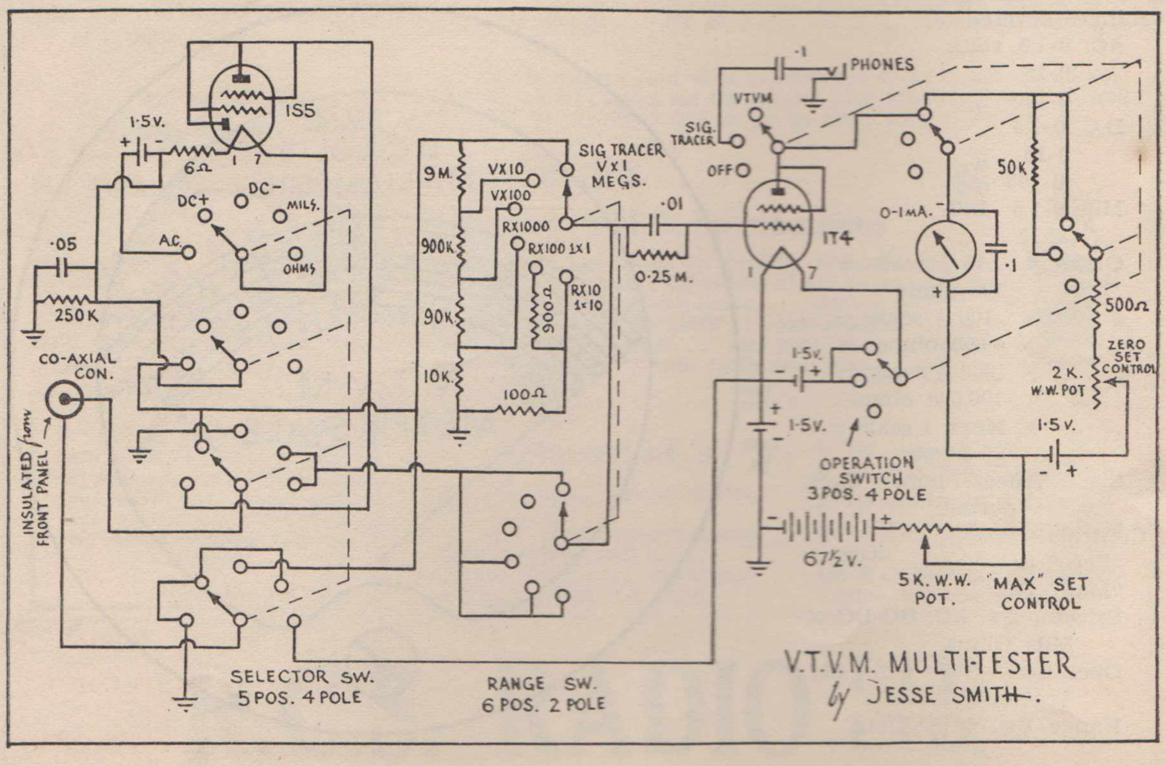


figure for purpose of explanation.) Now we only wish to read the change in plate current and for our purpose we desire to use a 1 ma. meter to indicate a voltage reading of 1.5 volts full scale, so to make the meter read zero when no DC voltage is applied to "X" we use an additional 1.5 volt cell to provide a flow of 1 ma. through the meter in the opposite direction to that flowing through the valve circuit. This is shewn in Fig. A2. The "Zero" adjustment pot adjusts this current flowing and therefore sets the meter now to zero. So, there is current flowing from the HT supply to the valve in one direction and current flowing from the 1.5 volt cell via potentiometer and through meter in the opposite direction which balance out making the meter read zero current.

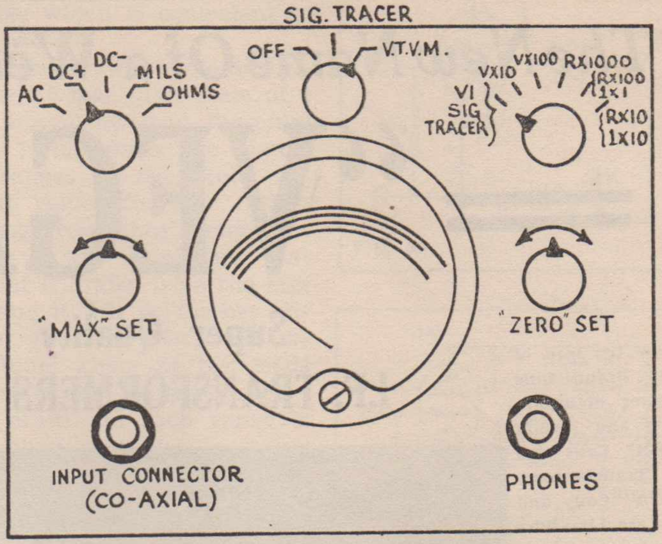
Maximum Set.

Now in Fig. A3 we apply an external source of 1.5 volts to terminals "X" Positive to grid and negative to earth. The bias to the valve is now effectively zero bias because the grid is positive 1.5 volts with respect to earth and the filament is positive 1.5 volts with respect to earth making the grid zero volts with respect to filament, in other words zero bias. Reducing the bias from negative 1.5 to zero causes an increase in plate current through the valve and the meter will indicate 1 ma. change in plate current. So with 1.5 volts applied the meter reads full scale (1 ma.). The exact adjustment at maximum position is taken care of by the Max set pot and with no external voltage applied the meter reads zero. Adjustment at zero being taken care of by the Zero set pot. It can be seen that with ageing of the



HT supply (when voltage drops after long use) that the Max set pot will take care of this as the pot is set at nearly maximum value of 5000 ohms with a new 67½ v. battery. A new battery should last at least a year as the current drain is in the order of 2-3 milliamperes. The same applies to the reflexing circuit cell, approximately same current as valve. The bias cell only draws current when used on resistance ranges (Ref. resistance measurements-further paragraph) and the max. being 15 ma. This cell should give a long service. Filament supply to 1T4 valve is 50 mils and fil. supply to 1S4 also 50 mils, this latter valve only drawing filament current when on AC range due to the filament being automatically switched on by selector switch.

Now I shall explain how the instrument is made to read Volts DC. Current, Resistance Measurements, AC Volts and Signal Tracer operation.



V.T.V.M. MULTITESTER PANEL LAYOUT

D.C. Volts.

Ref. Fig. B1. The tube is biased negative 1.5 volts through the 10 meg. resistor. Now, if 1.5 is applied across the 10 meg. resistor with positive to grid side this voltage will be in opposition to the bias voltage making the bias voltage equivalent to zero volts. With correct adjustment of Max set control and Zero set control the meter will indicate 1 ma. change in plate current indicating 1.5 volts. For different voltage ranges we split up the 10 meg. resistor so that the voltage applied to the grid of the 1T4 is either 1-10th or 1-100th of that across the 10 meg. resistor.

Milliamperes.

Ref. Fig. B2. Current flowing through R causes a voltage drop which changes the bias to the valve. For .5 mil range

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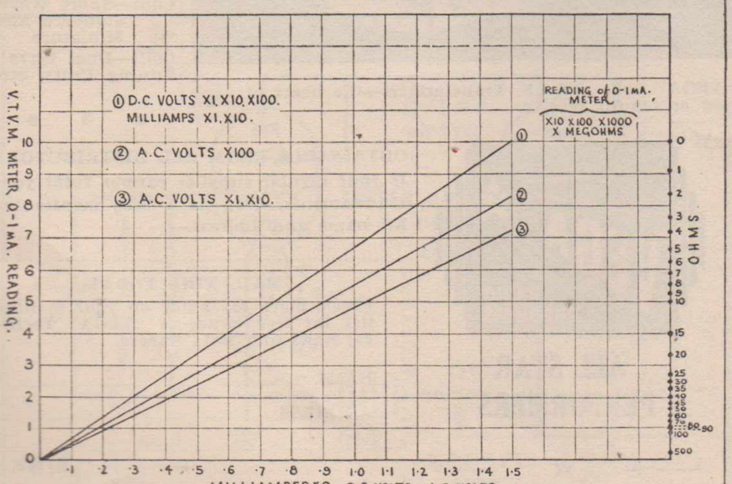

GRAPH for CALIBRATION of V.T.V.M. MULTI-TESTER ...

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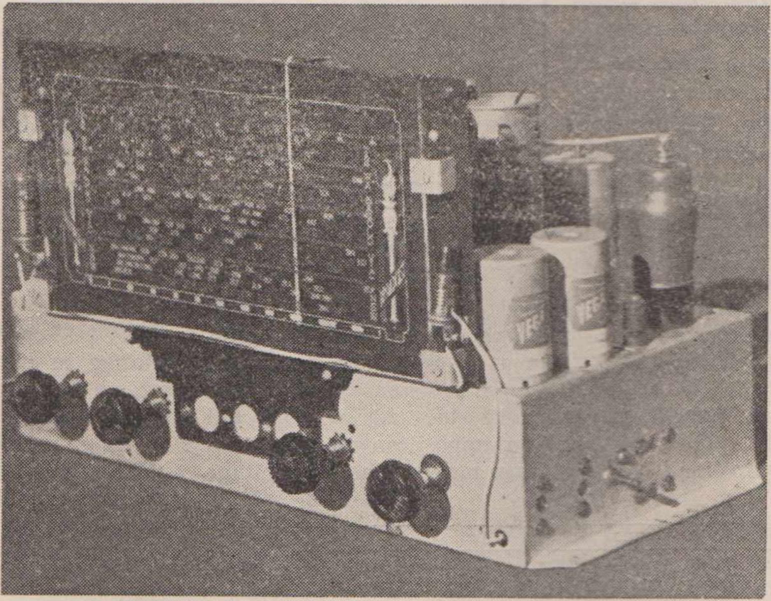

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R/W9.

MULTITESTER

(Continued)

we use a 1000 ohm resistor. $I = \frac{E}{R}$ so for 1.5 volts across

R = 1.5 and as R = 1000 ohms $= I = \frac{1.5}{1000} =$ .0015 ampres

= 1.5 ma full scale deflection.

For 15 millampere range we use a 100 ohm resistor which gives us

$I = \frac{E}{R} = \frac{1.5}{100} =$ 15 milliampre

Resistance Measurements

Refer to Fig. B3. The tube is biased through a 10 meg. resistor (Megohms Range) by 1.5 volts. By placing a resistor at points "X" the resistor will act as a voltage divider for the bias supply to the valve and the meter in the VTVM circuit will indicate a change in plate current corresponding to the new value of bias. As an example on Megohms range when a 10 megohms resistor is placed across points "X" it acts as a voltage divider and provides only one half the bias voltage which is equivalent to 0.75 volts.

The meter will therefore indicate 0.5 ma. (half scale of 1 ma. movement) and therefore reads 10 megohms. To change the ranges we substitute different values for R. When making resistance measurements it will be obvious that current is drawn from the bias cell and it will be further obvious that current will be maximum when the test leads are shorted. Maximum current drawn on each range is as follows:—

Megohms using 10 megs at R, 0.15 microamperes.

Ohms X 1,000 using 10,000 ohms at R, 150 microamperes.

Ohms X 100 using 1,000 ohms at R, 1.5 milliamperes.

Ohms X 10 using 100 ohms at R, 15.0 milliamperes, these figures being of course when the test leads are shorted.

It is possible to extend the range to read direct in ohms with a half scale reading of 10 ohms by using a 10 ohm resistor at R. The maximum current drawn from the bias cell when the test leads are shorted would be 150 milliamperes. An additional range would be required on the switch deck. It has, however, not been incorporated in the instrument described here.

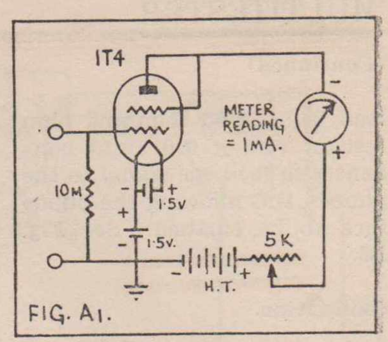


FIG. A1.

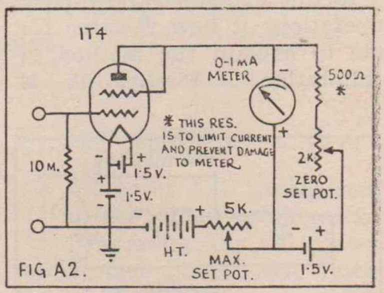


FIG A2.

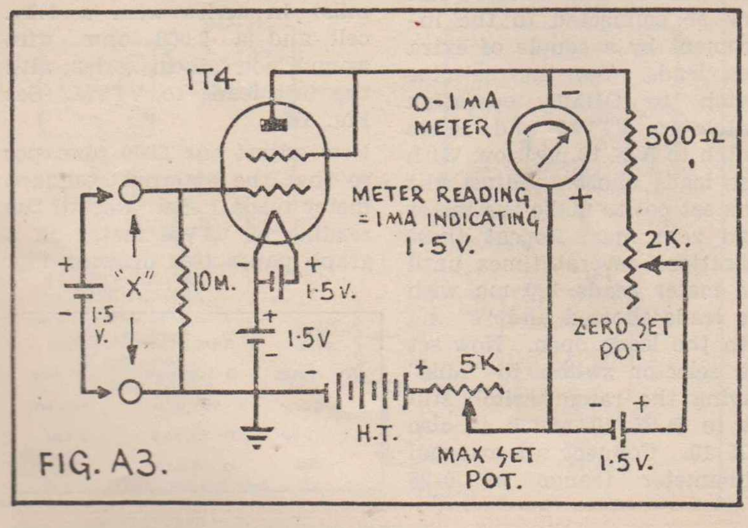


FIG. A3.

AC Volts.

Ref. fig. B4. The 1S5 valve has grid, screen and plate tied to the diode and is used as a diode to rectify A.C. current. The diode load is a resistor R2. A suitable DC path must be provided at test leads and this can be the winding of transformer or coil being measured. The current flowing through the diode load is applied in opposition to the normal bias to the 1T4 and so causes a meter reading in proportion to this bias voltage. The voltage ranges are adjusted the same as on DC volts operation.

Signal Tracer Operation

The tube is operated as a grid leak detector, the plate

(Continued on next page)

MULTITESTER

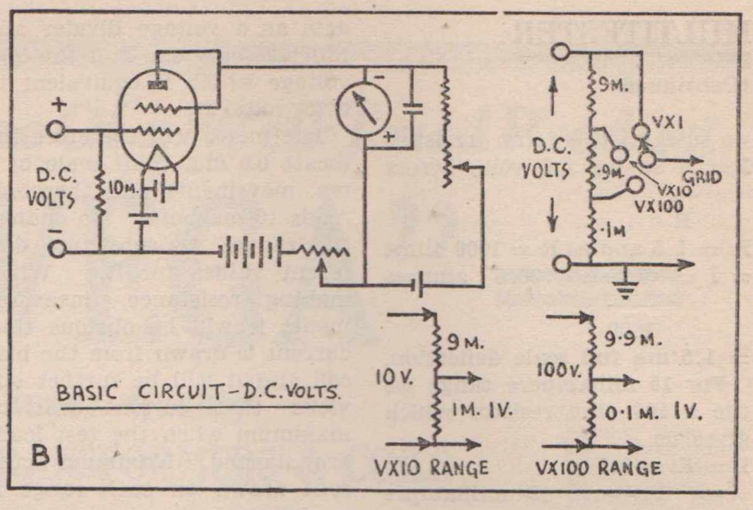
(Continued)

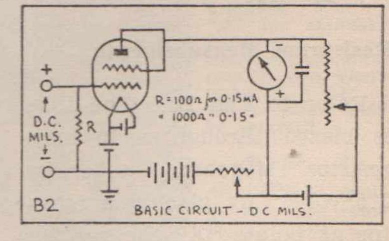
load being a 50 thousand ohm resistor and a 0.01 mfd condenser to feed the signal to the phones, this allowing the phone jack to be earthed. See Fig. B5.

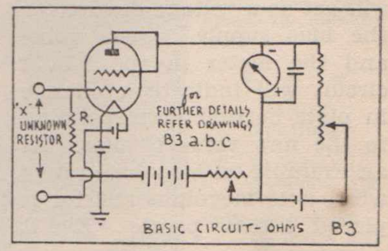
Calibration

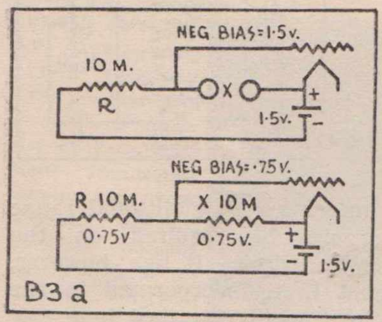
Having explained the various operations it now remains for me to explain the method of calibration. Firstly, it is necessary that the 0-1 ma. meter to be used in the instrument have a scale marked off from 1 to 10, i.e., 10 divisions. If the meter does not have such a scale this can be done by using a known 0-1 ma meter in series with a 1.5 volt cell, a 2000 ohm pot and the meter to be calibrated. Set the pot so that the standard meter reads 0.1 ma and mark the scale on the other meter. Set pot to read 0.2 ma on external meter and mark scale on meter. Continue until all points have been recorded up to 1.0 ma., including the zero point. The meter can now be connected to the instrument by a couple of extra long leads. Set the selector switch to OHMS, operation switch to VTVM and range switch to R X 10 position. With test leads shorted adjust the Max set pot to make the meter read zero ma. Repeat these operations several times until the meter reads 1.0 ma with the leads shorted and "0" ma with the leads open. Now set the selector switch to "Mils" leaving the range switch still set to R X 10 which is also I X 10. Connect an external milliameter (range of 0-25 mils) in series with a 1.5v. cell and a 2,000 ohm wire wound pot, all in series with the test leads to VTVM. (See Fig. B6.)

Now adjust the 2000 ohm pot so that the external standard meter reads 1 ma. Record the reading of VTVM meter on a graph paper (see drawing Fig.

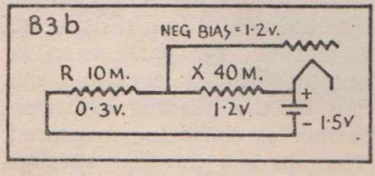




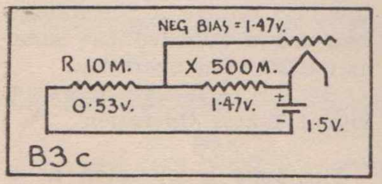




Grid is —1.5 volts with respect to filament. No current flowing through R with tests leads at X open. Meter in VTVM circuit reads infinity.
A 10 meg resistor is inserted at X (test lead connections). Grid is now 0.75 volts negative with respect to filament. Meter in VTVM circuit reads 0.5 ma, indicating 10 megohms.



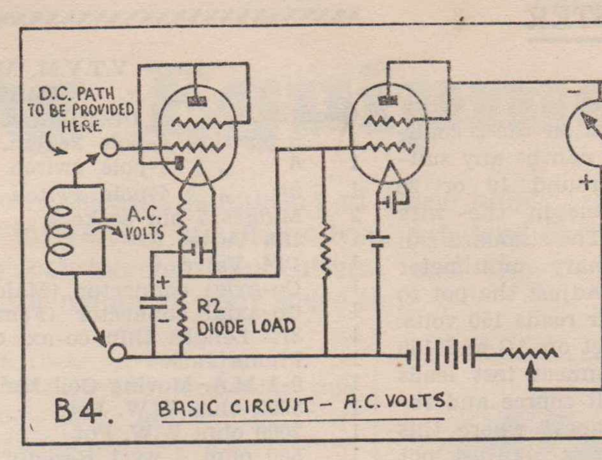
A 40 meg resistor is inserted at X. Grid is now —1.2 volts with respect to filament. Meter in VTVM circuit indicates 0.2 ma, indicating 40 megohms.



With a 500 meg resistor at X, the negative bias is increased to 1.47 volts, and meter in VTVM circuit reads 0.02 ma, indicating 500 megohms.

	RANGE	½ SCALE
R · 10 MEG.	0-500 MEG	10 MEG
" 10,000	0-500,000	100,000
" 1,000	0-50,000	1,000
" 100	0-5,000	100

B7). Set pot to read 2 ma on external meter and record reading of VTVM meter on graph. Repeat for 3, 4, 5, and up to 15 ma. The 15 ma mark should appear at the 1 ma mark on VTVM meter. This calibration will provide the calibration for the DC volts and DC mils ranges (all ranges).



B4. BASIC CIRCUIT – A.C. VOLTS.

Resistance Measurements—Calibrations.

I have already explained the basic principle of resistance measurement and on looking at the diagram, Fig. B3, you will see that the valve is biased through a 10 meg. resistor (on Megohm range). Now, if a further 10 meg. resistor is placed at "X," "X" being the test leads (see Fig. B3a) the bias to the valve will be reduced to 0.75 volts, as the two 10 meg. resistors now form a voltage divider network in the bias supply to the valve. The meter in the plate circuit would indicate .5 ma. Further example at Fig B3b shews that a 40 meg resistor would make the effective bias—1.2 volts and the meter would indicate 0.2 ma. If a 500 meg. resistor were placed at "X" (see Fig. B3c) the bias would be increased to 1.47 volts and the meter would rise only to 0.02 ma. From the formulae we can therefore calculate all the desired values and fill in the percentages of full scale deflection on the graph which, in turn, can be finally drawn upon the meter scale. It is suggested to fill in only the following: 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 40, 50, 75, 100, 500, and infinity. One resistance scale only is required as the ratio is the same on all ranges.

AC Volts Calibration.

A source of A.C. is required. Set up the circuit as shewn in Fig. B4a, using any old power transformer that will give

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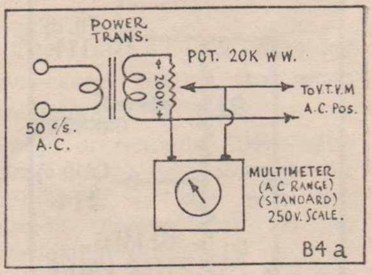
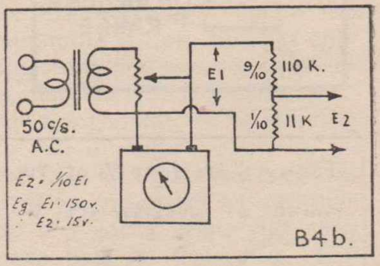
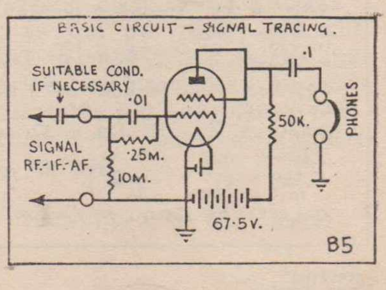


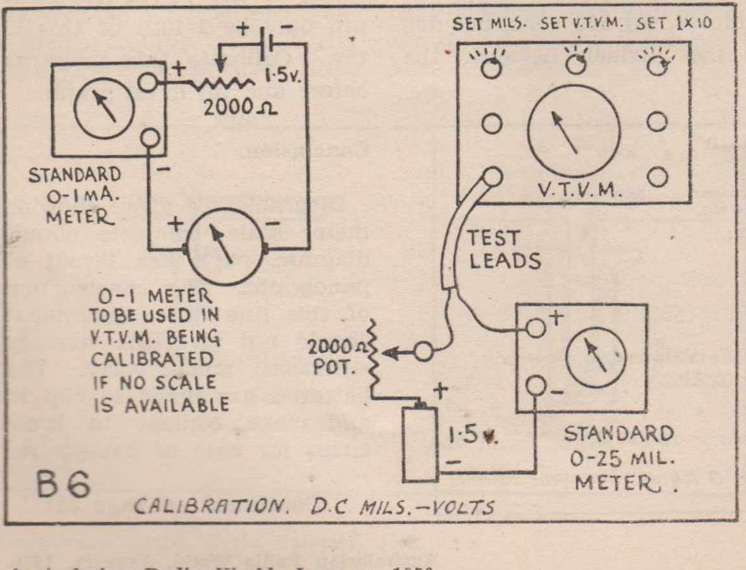
B4 a



B4b.



B5

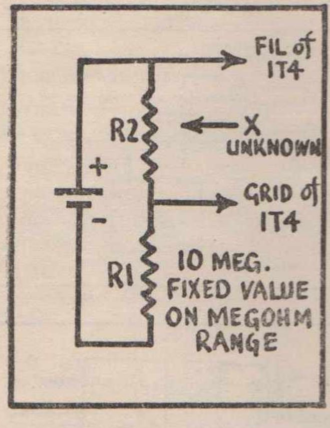


B6 CALIBRATION. D.C MILS.-VOLTS

MULTITESTER

(Continued)

about 200 volts on the secondary. The pot can be any suitable value around 10 or 20 thousands ohms in the wire wound type. The standard can be your ordinary multimeter (AC range). Adjust the pot so that the meter reads 150 volts. With VTVM set on AC and 150 volt range connect test leads to the 150 volt source and record on the chart where this meter reading is. Adjust pot to read 140 volts on standard meter, record reading as before. Repeat at each 10 volt step. Having completed this range set VTVM to 15 volt range and modify the test set up as shown in diagram Fig. B4b. The standard meter will indicate, say 150 volts, but due to the divider network the supply to the VTVM test leads will only be 1-10th of this = 15v. Calibrate this range as before and fill in on graph.



FORMULA TO FIND % OF FULL SCALE FOR ANY VALUE OF RESISTANCE :- $\frac{1}{\frac{R_1+R_2}{R_1}} \times \frac{100}{1}$

EXAMPLE 1 IF R_2 = 10 MEGS

$\frac{1}{\frac{10+10}{10}} \times \frac{100}{1} = \frac{1}{\frac{20}{10}} \times \frac{100}{1} = \frac{1}{2} \times \frac{100}{1} = 50\%$

50% OF FULL SCALE OF 1 ma. = ·5 ma. INDICATES 10 MEGS.

EXAMPLE 2. IF R_2 = 50 MEGS.

$\frac{1}{\frac{10+50}{10}} \times \frac{100}{1} = \frac{1}{\frac{60}{10}} \times \frac{100}{1} = .1666 \times 100 = 16.666\%$

16.666% OF F.S.D. OF 1 ma. METER – 0.166 MA. INDICATES 50 MEGS.

V.T.V.M. MULTITESTER.
PARTS LIST

Quantity.	Description.	Identification data, etc.
1	5 position 4-pole switch.	Selector switch.
1	6 „ 3-pole switch	Range switch
1	3 „ 4-pole switch	Operation switch.
2	Midget 7-pin sockets.	
1	1S5 Valve.	
1	1T4 Valve.	
1	Co-axial connector (Male).	
1	Co-axial connector (Female).	
1	3ft. Length thin co-ax. cable.	
1	Phone Jack.	
1	0-1 M.A. Moving Coil Meter.	
1	5000 ohm W.W. Pot.	Max Set Control.
1	2000 ohm W.W. Pot.	Zero Set Control.
1	500 ohm ½ watt Resistor.	Current limiting.
1	50,000 ohm ½ watt Resistor.	Sig. Tracer Plate Load.
2	0.1mfd. Paper 200v. Condensers.	
1	0.01 mica Condenser.	Grid Leak Condenser.
1	0.25 meg. ½ watt Resistor.	Grid Leak Resistor.
4	1.5 volt Torch Cells.	
1	67½ volt. Minimax or similar type Battery.	
1	6 ohm Resistor.	
3	3 meg. Resistors, ½ watt = 9 meg.	
1	400K Resistor, ½ watt	= 900K
1	500K „ ½ „	
1	40K „ ½ „	= 90K
1	50K „ ½ „	
1	10K „ ½ „	
1	400 ohm resistor, 1 watt	= 900 ohm
1	500 ohm resistor, 1 watt	
1	100 ohm resistor, 1 watt	
1	250K resistor, ½ watt	Diode Load Resistor
1	0.05mfd Paper Condenser.	Diode Load Condenser.
	Hardware, Panel, etc. to suit.	

Conclusion.

Diagrams are given showing meter scale, complete circuit diagram, parts list, layout of panel, etc. The construction of this fine little instrument should not give the average enthusiast much worry. The batteries are made to clip in and make contact to brass strips for ease of battery re-

(Continued on page 34)

Selecting Equipment

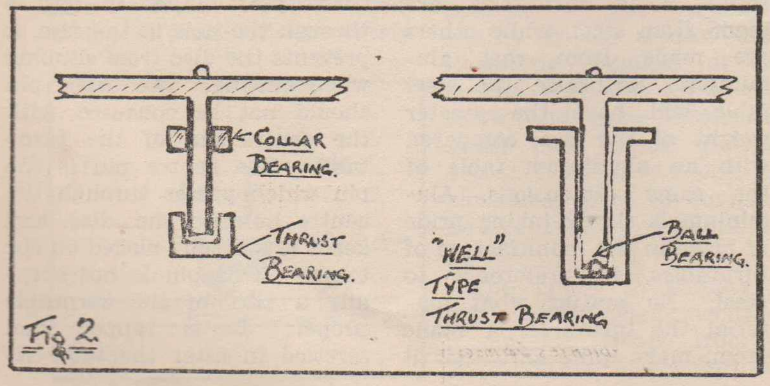
Making your own records is another of those hobbies that are interesting in themselves, yet lend themselves to commercial applications, and the making of money in your spare time.

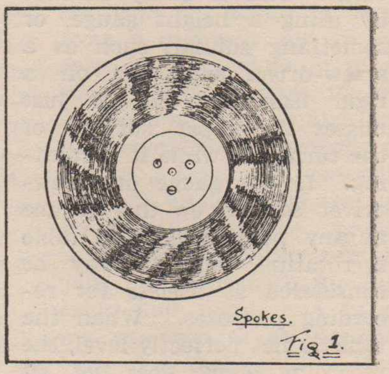
LAST month we dealt with home recording from the angle of the newcomer. The cost of mechanical equipment and amplifiers, etc. was gone into, and this was followed by a list of the terms most commonly used in recording circles. This month we go into the more technical side of things, namely, the difficulties encountered in the purchase and selection of the necessary gear.

By
JOHN McL. BENNETT

As was pointed out previously, the main piece of equipment in the recorder is the turntable. This turntable is the controlling factor in the quality of the finished disc. If there is any vibration or rattle in the turntable, this materially affects the disc, causing peculiar noises to be reproduced and also causing "patterns" to appear on the lacquer of the blank, as it is cut. Most of the vibration found in recording may be traced to the drive motor. Although you may be unable to feel any vibration, you will be able to detect its presence due to the patterns on the disc as it is cut. These vibration patterns usually take the form of "spokes" radiating from the centre of the disc.

The motor vibration may be caused by a variety of things, such as worn bearings, loose drive belt, overloaded motor or worn drive pulleys. The stylus cuts shallow and deep, as the vibration varies, thus the light and dark patches on the surface, giving the appearance of spokes.





There are obvious cures for each case, firstly, the worn bearings; these must be replaced or relined. Drive belts can easily be loosened or tightened, as the case demands. The matter of the overloaded motor is a little more difficult. When the motor is working outside its maximum rating, there is only one thing you can do, and that is, purchase another motor. If you are thinking of attempting to run a motor unable to do the task to which you have set it, then you might as well give up any ideas that you may have had on recording, and turning out first-class discs.

As you will realise, it will pay to consider the weight and drive requirements of the turntable you have before purchasing the motor with which to turn it.

(Continued on next page)

RECORDING

(Continued)

The choice of the turntable itself is more or less in the hands of the purchaser. However, there are certain points to be watched here also. The flat surface of the table should form a perfect right-angle with the centre-line of the spindle on which the table turns. This is easily checked by using a height gauge, or something similar, such as a screw-driver supported on a rigid base, so that it just misses the upper surface of the turntable while it is rotating. If the gauge or screw-driver scrapes on the surface at any point while the table is rotating, then it may be considered as useless for recording purposes. When the table is not perfectly level, the recording blank does not sit flat and thus the stylus does not cut evenly to the same depth.

Turntable Drive.

When it is desired to record at both 78 and 33 1/3 r.p.m., a twin cone pulley must be used when belt-rim-drive is employed to drive the turntable. A couple of small mathematical calculations involving motor speed, turntable speed and turntable diameter will give you the required diameter for the two cones on the motor pulley.

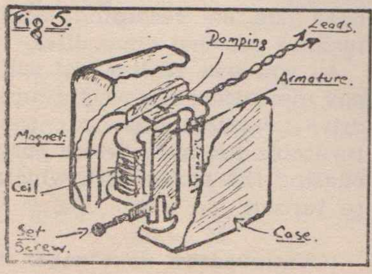


Fig 5.

Another important feature in the selection of the recording turntable is freeness and play in the mounting bearings. the supporting of a heavy turntable presents quite a number of problems, not the least of which is the bearing.

You will realise that it is nigh impossible to have a bearing both above and below the turntable. Consequently, one really substantial bearing beneath the table has to suffice. Unless this bearing is well made, you will run into trouble. Where there is any wobble, beware, choose a turntable with sturdy bearings and things will run smoothly in more than one way.

Weight also plays a big part in the suitability of the turntable, especially when you intend to record at 33 1/3 r.p.m. A turntable rotating at this speed has little inertia, and any pressure, no matter how small, tends to have a "braking" effect unless the turntable has sufficient weight to keep it turning at a steady rate. Some turntables are made from steel, while others are made from cast aluminium. Naturally, the steel table will have the greater weight of the two, compared with an aluminium table of the same dimensions. Aluminium is slowly taking pride of place in the manufacture of turntables, in preference to steel. No matter what material the turntable is made from, make quite sure that it has sufficient weight to keep it spinning for some time, when spun by hand. If it does so, then you will be safe in using it for slow sped recordings. Figure 2 shows two methods of bearing principles, commonly used in both commercial and home-made equipment.

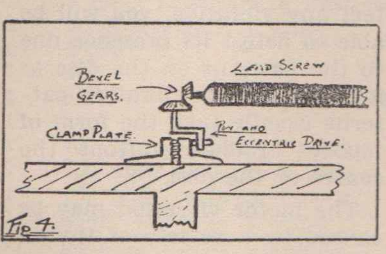


Fig 4.

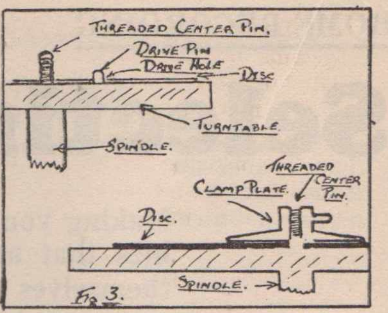


Fig 3.

So much for the underneath portion of the turntable, the top of the table does not, and should not present any real difficulty. The main considerations being, the method of "anchoring" the blank to the surface of the table, non-scratch surface covering for the table and, last but not least, the method of drive used to actuate the feed mechanism for cutting.

On examination of a blank you will find three small holes spaced evenly about the centre of the disc, and about one inch from it. These holes are called "drive holes," and are used to engage a small metal pin in the turntable, called a "drive pin." When the pin is through the hole in the disc, it prevents the disc from slipping when cutting. The drive pin should not be confused with the centre pin of the turntable. The centre pin is the pin which passes through the centre hole of the disc and keeps it centrally placed on the table. This pin is not actually a part of the turntable proper; it is tapped and screwed in after the table itself has been finished. Some systems use a clamp-plate to "anchor" the disc. This is a small metal plate which is screwed down the threaded centre pin, tightly on to the uncoated, centre portion of the blank. See Fig. 3.

The Table Top.

Normally, all turntables are covered with some soft material or thin rubber sheet to minimize scratches on the surface of the discs. This covering is also necessary to provide some friction to hold the disc under the clamp-plate. Most commercial type turntables use rubber surfacing, although felt and velvet are still popular.

Driving the Feed Screw.

Feed-screw drive mechanisms can be rather involved, and are most important as, upon the accuracy of the screw and the "half-nut" depends the accuracy of line spacing on the recorded disc, as well as the quality of reproduction. When you have play and wobble in the cutter carriage and other associated parts, you will run into more strife than if you had wobble and "wow" in the turntable. There should be no half-measures when selecting the feed mechanism. Cheap gear is usually to be avoided, as far as possible. Accurately ground square threads are usually the most popular, although there are many screws on the market which have smaller threads. The size of the thread is no gauge to accuracy, as the ultimate line spacing is dependent on both the reduction-gear ratio and the number of threads per inch on the lead screw. However, it can be said that it is advisable, when purchasing, to look for the product of a firm whose job it is to manufacture recording equipment, rather than to think of accepting a feed mechanism which you know to be home-made. This home-made job may be quite alright, yet again, it may not, and it is not worth taking the risk. You will find that it will pay in the long run to buy a reputable brand of screw. As was said before, and as you doubtless know, imported gear is more or less out of the question, but the Australian-made product is not lacking in quality by any means. Royce Recording Studios, of Melbourne, turn out an excellent screw and drive mechanism, under their name of Royce Senior Traversing Gear. This particular piece of equipment retails for approximately £12/10/-.

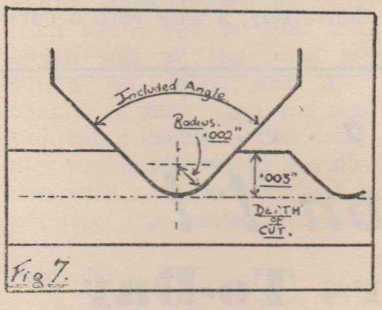


Fig 7.

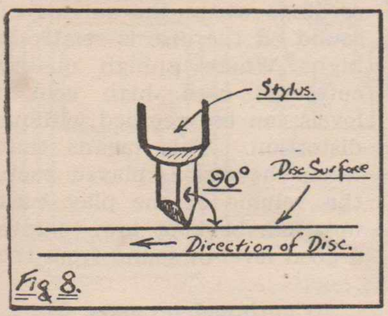


Fig 8.

The power to actuate the drive of the feed mechanism is obtained either from the centre or rim of the turntable.

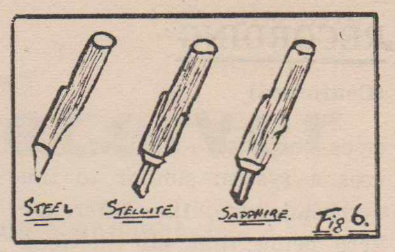


Fig 6.

Both systems are identical in principle, the main difference in mechanical construction being that the screw is turned from a different end in each case. Inside, centre drive employs gears, as does its rim-type counterpart. Centre drive is accomplished through the use of a small pin, extending at right angles from the centre clamp-plate, i.e., parallel to the surface of the turntable. This pin turns with the turntable and plate, and in doing so, engages an eccentric, vertical, pin which is connected to a right-angle-bevel gear, which in turn rotates the lead screw. This all seems somewhat involved on paper, in writing, but Figure 4 should clear up any difficulties.

Rim drive uses the same idea, the only change being the replacement of the eccentric and clamp pin by a small cog wheel, driven by teeth machined into the outer perimeter of the turntable. This type of drive is not often seen these days, but it detailed as a matter of interest.

The most common feed-screw drive system seen today is the centre-pin drive. There are, of course, several other systems of slowly feeding the cutter across the surface of the disc, the fan or sector type is occasionally used, the disadvantage with this system lies in the fact that the cutting angle alters as the stylus trav-

(Continued on next page)

RECORDING

(Continued)

erses the disc. Another type uses a system similar to the overhead type, the difference here being that all the feed mechanism is below the bed of the turntable. Both of the above systems are still in use.

Cutting Heads.

We pass from the mechanical details to a combination of mechanical and electrical, the cutting head. Upon the cutting head rests the whole of the burden of placing the sound on the disc, in the form of wavy grooves. The precision with which the cutter is made determines, to a large extent, the quality and purity of the sound impressed on the disc.

Although there are two types of cutting heads generally manufactured, crystal and magnetic, only one is normally available to the home recordist, that being the magnetic type. The magnetic type cutter is capable of excellent quality, and is used in all high-fidelity studio equipment. The cost of a magnetic cutter ranges from about £5 to about £50, according to its frequency range and power handling capabilities. Crystal cutters are relatively cheap, but are almost unobtainable here.

Working back from basic electrical fundamentals, we find that a conductor when moved in a magnetic field, so as to break the lines of force, has a current generated in it. Conversely, a wire with a current flowing in it has a magnetic field surrounding it, and will move a wire, in a fixed magnetic field. So also, current flowing in coils, placed in a magnetic field, can cause another piece of metal, within the magnetic field, to vibrate.

This is the theory surrounding the construction of a magnetic cutter. The electrical impulses from the amplifier flow through the coils in the cutter, and as they are alternating currents, they cause the metal cutting stylus to vibrate in accordance with the alternations. Thus electrical impulses from the amplifier become a physical movement of the cutting stylus. The vibration of the cutting stylus causes the wavyness of the grooves on the recording. Figure 5 shows the schematic construction of a magnetic cutting head, in section.

There are certain limits and qualities which control the overall operation of the cutter. The characteristic which limits the performance of all poor quality, cheap cutters is their inability to handle high volume levels without overloading, resulting in distorted sound being recorded on the disc. In poor magnetic cutters this overloading can be put down to magnetic saturation of the iron armature which carries the cutting stylus. A cutter which cannot handle high volume levels cannot make recordings where the volume of sound on the disc is relatively high. Where a high quality cutter is used, high volume levels can be recorded without distortion. This means that when the disc is played back, the volume of the play back unit can be kept low, to give a good level of sound from the

(Continued on page 28)

A NOVEL CIRCUIT

Two-Station Receiver

Here is an idea for a little set with some unusual features. It is designed to operate on only two selected stations with switch control.

By

W. S. LONDEY

A few weeks ago I made a small radio for a very old friend who is confined to her bed. As she resided fairly near a radio station I thought I would try a loop aerial, grid leak detector and output, job. As the rating for a 6V6 give one case using 100 volts on the screen and 250 volts on the plate I felt that this might be worth trying out, particularly when one manufacturer, at least, uses a similar arrangement without a filter choke. The low drain—less than 20 ma.—was also an advantage, as it allowed the use of a midget power transformer. The low power output would not matter in the circumstances.

The experimental set-up was a 6J7G, 6V6GT and 6X5GT operated from a 150/150v., 30 ma., power transformer and driving an 8in. speaker. The loop aerial was wound on a former of card about 1-32in. thick, cut about as shown in Fig. 1. About 35 turns were wound on, the number being unimportant as the whole band did not have to be covered. The coil was tuned by an air trimmer—10 to 80 mmfd. This covered the band from about 800 to 1600 k.c., which was all that was required as there was little chance of more than one station being usable. This trimmer was finally set to the station with a screwdriver and it left only one control—volume.

Controls.

This volume control was a switch type, allowing the set to be switched on and off at will. As mentioned earlier, no filter choke was used, the rectifier output, about 190 volts, being supplied direct to the output transformer primary, a 16 mfd. condenser being used. The screen was supplied through a 50,000 ohm resistance and another filter condenser, in this case a 10 mfd., 200v. one I had on hand. An 8 or 16 mfd would do. The plate from the h.t. supply resulted in too much hum, even when filtered by a 50,000 resistance and a .5 mfd cond. In any case the 6J7 can supply ample output to drive the 6V6 at the lower voltages as the 6V6 requires only 4½ volts peak when the screen voltage is 100. The rated load for a 6V6 when the plate and screen voltages are equal is about 5000 ohms but reduction of the screen voltage increases the load resistance required so a load of 7000 ohms was tried and worked very well. Possibly a higher value of about 10,000

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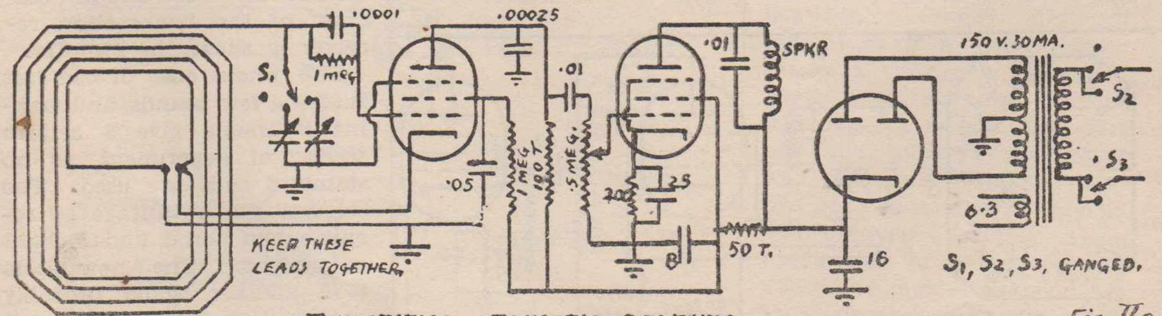


TWO STATION ELECTRIC RECEIVER.

Fig IIa.

(Continued)

may have been better but the tone and volume were all right on 7000 ohms. Hum was negligible, although a 24 mfd. condenser across the h.t. supply may have reduced it a little.

Taken all round the set was ideal for the job for which it was made and it had the advantage that it would cost very little to run as the total drain from the line was less than 20 watts, there was no tuning to worry about and the single control made the operation simple.

PARTS LIST

The parts required to make the set are as follows:—

- **1 Power transformer—150/150 v., 30 ma.**
- ***1 Triple pole three position switch.**
- **3 Valve sockets.**
- **1 6J7G or 6SJ7GT valve.**
- **1 6V6GT valve.**
- **1 6X5GT valve.**
- **1 Speaker—7,000 to 10,000 ohm input.**
- **1 50,000 ohm resistance.**
- **1 1,000,000 ohm resistance.**
- **2 1 megohm resistance.**
- **1 200 ohm resistance.**
- **1 500,000 ohm potentiometer.**
- ***2 P21 padders or other suitable.**
- **1 .001 mfd condenser.**
- **1 .00025 mfd condenser.**
- **2 .01 mfd condenser.**
- **1 .05 mfd condenser.**
- **1 25 mfd low voltage electrolytic condenser.**
- **1 16 or 24 mfd 350 volt electrolytic condenser.**
- **1 8 or 16 mfd 350 volt electrolytic condenser.**

If a condenser of the normal type be used for tuning the items marked * will not be required while controllable regeneration will require a 500,000 ohm resistance instead of one of the 1 meg. units, the circuit being as shown in Fig. IIb.

If the triple pole switch is not used a switch type pot. may be used.

Another Idea.

As this set was so effective it was decided to carry out a few more experiments along similar lines, this time to make a set to receive more than one station. As there are two stations here a similar arrangement was used, but two adjustable condensers were used—type P21 padders, one with all but two plates removed, and a switch to select the one required. The switch was a triple pole three position wafer job and two of the poles were used as a double pole line switch, and the third as a station selector. It was found that the 6in. speaker used in this case was appreciably less sensitive than the 8-20 of the previous job. (Rola give a difference of 3DB in the sensitivity of their 6H and 8K speakers.) To balance the loss in sensitivity it was decided to try the application of some regeneration to the 6J7. The cathode, therefore, was tapped to a point one turn from the earthed end of the coil. This was too much, the set oscillating over the whole band so the tap was shifted to ½ turn by by bringing the earth end of the coil across the centre, as shown in Fig. IIa. The increase in sensitivity was evident and effectively made up for the change in the speaker.

It may be possible to receive more distant stations by the use of the 1 turn tap and a potentiometer in the screen supply to the 6J7, as this would allow the regeneration to be controlled. The circuit diagram of the two station receiver is shown in Fig. IIa.

The whole cost of the set is only a few pounds, and making it should give a certain feeling of experiment, as no standard coils are used. The set has the advantage of requiring no aerial and is light in weight. The new Rola 6-9L speaker would probably be excellent for the set as it has a high sensitivity.

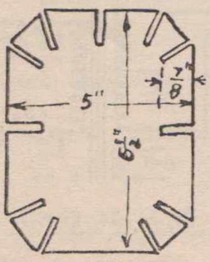


Fig. I

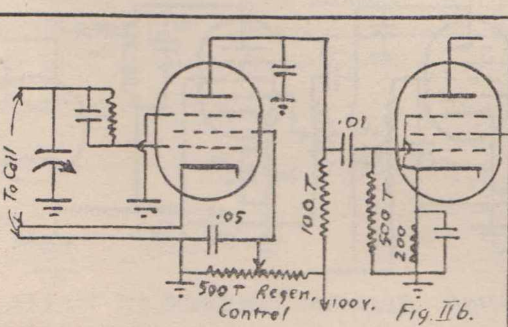


Fig. IIb.

RADIO THEORY COURSE—Part 7.

Sound Reproduction

In our series of theory we now come to the subject of reproducing sound waves from the receiver by means of headphones or loudspeaker.

By
W. S. LODNEY,
Barkly Street,
Sale, Vic.

THE earliest form of sound reproducer was the simple earphone developed for telephone purposes. The simple form has a bar magnet with a coil surrounding one end and a steel diaphragm (a thin steel sheet fixed at the edges) placed to just clear the pole and coil. The pull of the magnet causes the diaphragm to dish inwards slightly at the centre and any current in the coil will cause an increase or reduction of the magnet strength so that the attraction on the diaphragm will increase or decrease slightly. This will cause a variation in the amount the diaphragm is dished and the resulting movement will produce air movements to correspond with the current variations. These air movements, if rapid enough, will travel through the air as sound waves, and, in the case of the radio signal, will be similar to the sound waves reaching the microphone in the radio station or recording studio.

The Ear-phone.

There has been little change in this type of ear-phone over the years, the only refinements being the use of more effective magnet materials and using horse-shoe shaped magnets with a coil on each pole. This has increased the efficiency and power handling capacity of the unit. Fig. 1 illustrates the two types of phone. In general two units connected in series are used for radio work as this allows the use of both ears and helps to exclude outside sounds.

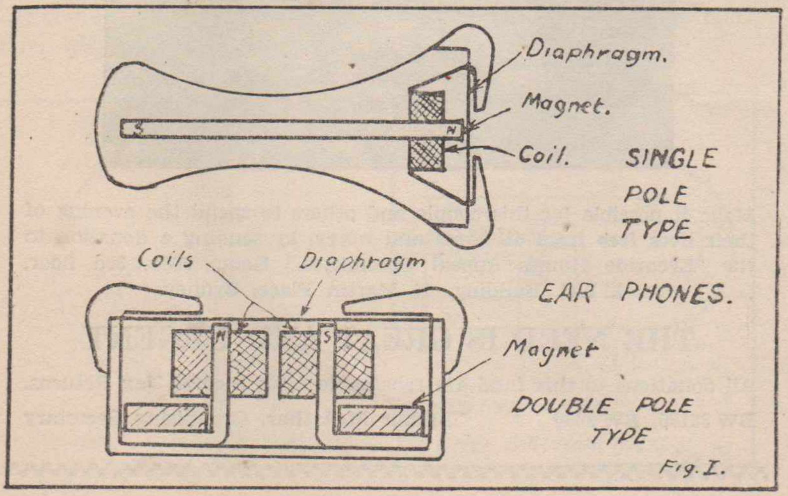


Fig. I.

Dynamic Ear-phones.

During the last war dynamic types were produced but little has been seen of them on the general market. Hearing aids, which must use ear-phones generally use very small units, both for reasons of appearance and lightness, and these generally are fitted into a moulded ear plug. Some of these are small examples of the simple magnet and coil type but many modern types are using crystal ear-pieces. These operate on the principle, common to many electrical laws, that if a given motion causes a voltage and current, then, a voltage and current will cause a motion. In part one the piezo-electric effect was mentioned—that is, flexure of a piezo-electric crystal will produce a voltage, then, application of a voltage will cause the crystal to bend (or twist, depending on the cut of the crystal) and this movement can cause air movement .

FOR TRANSMITTING

The Single - Wire Antenna

Much has been done about the design of compact aerial arrays, but there is much to be said for the long single-wire antenna, if you have the space in which to erect it.

By

JOHN McLEAN BENNETT

THE long single wire antenna does not receive particularly much attention in ham circles today. Although not highly publicised, the long wire is well worthy of consideration when you have the space to erect it. In the class of long wires, we have three specific types, all of which exist in both simple and complex forms.

We have the single wire, Vee and Rhomic. Of these three, we are concerned with the long single wire.

The actual gain from a small long wire, about two wave lengths long, is relatively low compared with stacked arrays, collinear arrays and similar systems. However, where plenty of space is available a long wire, four or more wavelengths long, is ideal for multiband operation, and has excellent directional characteristics. When the length of the antenna has reached the four wavelengths mark the gain is approximately three db., or equal to twice the transmitter power.

The main lobes on a long single wire are concentrated somewhat to the ends of the antenna. The small minor lobes in the pattern have a maximum radiation intensity approximately equal to that from a simple half-wave dipole. The nulls around the lobes are rather sharp, although sometimes slightly obscured, in practice, by irregularities in the pattern.

The long wire will be resonant so long as it is an integral number of half-waves long. Thus it will be obvious that the antenna can be used on harmonically related frequencies.

Orientation, Directivity and Length.

Figure 1 shows the conditions applying to **one** lobe. Actually, these are the conditions applying to half of one lobe, the other half being cut off by the ground.

Maximum radiation takes place in the broken-line semicircle. The angle between the wire direction and the line marked "wave direction" is controlled mainly by the length of the antena. From a half-wave to about four wavelengths long, the angle of maximum radiation with respect to the wire has a steep gradient ,that is, it has a sharp rise over a small range of length.

The angle is approximately 80 degrees with a half-wave antenna, falling to about 25 degrees when the antenna is four wavelengths long. From four to fifteen wavelengths the angle with respect to the wire only decreases from 25 to 15 degress. Thus it appears that the minimum practicable length for the long wire will be four wavelengths. The angle of maximum radiation with respect to the wire, labelled angle "B" in Fig. 1, has an average value of 15 degrees between six and ten wavelengths.

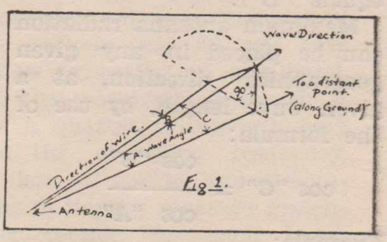


Fig 1.

Normally, in practice, there is some wave angle, "A," that will give the best results for the frequency in use and the distance to be travelled (for 14 mc/s. D.X., about 10-20 degrees).

For that wave angle, the wire direction and the best geographical direction are related by the angle marked "C." When the wave angle is very low, "B" and "C" will be almost equal. Also the higher the wave angle, the smaller the angle "C" becomes. That is, the higher the wave angle

(Continued on next page)

THEORY

(Continued)

The Loud-speaker.

Early radio receivers were used only with ear-phones, but, as the output strengths increased loud speaking sets were constructed. Early speakers were merely large phones, to which were attached horns of more or less exponential shape. Fig. II.

The horn speaker had many limitations for home listening. Firstly, the reproduction of bass notes was only fair, due to the limited power handling capacity of the driving unit and to the small horns on most speakers. A large horn is necessary for the reproduction of low notes. The sound output also was limited by the power handling capacity of the speaker; to produce a large amount of sound there must be considerable diaphragm movement, and the sensitivity under these conditions was, therefore, low, this in turn tended to reduce the sound for a given signal, or resulted in the overloading of the output valve with consequent distortion. Some types had an adjustment so that the distance between the poles and the diaphragm could be adjusted for the best compromise between fidelity and sensitivity.

Cone Speakers

To some extent the moving iron driving unit replaced the horn speaker as it could handle greater power and had a better low note response. Fig. III illustrates the principle of this unit which was usually attached to a large fabric diaphragm or to a stiffened paper cone in a suitable baffle.

Various other types of speaker were used at different times, probably the most interesting being the condenser speaker which consisted of a tightly stretched metal foil diaphragm separated by a small gap (and an insulating sheet) from a fixed perforated plate. A high potential was applied between the plate and foil so that the foil was attracted. This voltage was varied by the audio output of the receiver and, of course, the attraction varied similarly giving a similar effect to the variation of magnetic attraction in the headphones. These speakers were made up in large sizes—several feet square but were little used as the development of the dynamic speaker displaced most other types.

To understand the opera-

tion of the dynamic speaker one must bear in mind two important rules given in Part I.

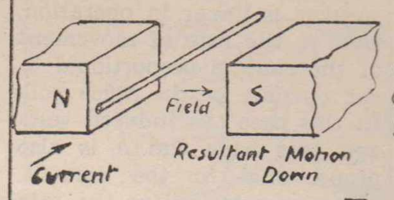
These are:—

(a) If a conductor moves in a magnetic field so that it cuts the lines of force of that field there will be a voltage induced in that conductor; the magnitude of that voltage being proportional to the rate at which the lines are cut, and the direction of the voltage is given by Fleming's right hand rule.

(b) If a conductor carry a current in a magnetic field then there will be a force on that conductor; the magnitude of the force being proportional to the current, the length of the conductor and the field strength, and the direction being given by Fleming's left hand rule.

Electro-mechanics.

Fig. IVa and b illustrate these rules showing a single conductor in a simple field. A study of these two diagrams will show that the motion is such that it will induce a voltage in the conductor in such a direction as to oppose the flow of current which caused the motion. These two effects combine in this manner —if the conductor were free to move without restriction and a potential of 1 volt was applied across its ends there would be a large current flow (the resistance of the conductor is very low). This would produce motion, and, if we assume no resistance to motion, the rate of movement would be such that there would be induced in the conductor an e.m.f. of 1 volt. This would oppose the applied e.m.f. and, in consequence reduce the current to zero. In practice there must be some resistance to motion and the conductor would then move more slowly so that the induced e.m.f. is less than that applied, the difference being such that it will send enough current through the resistance of the conductor to overcome the opposition to motion. The energy consumed being equal to the product of the current and the applied e.m.f.



IVa

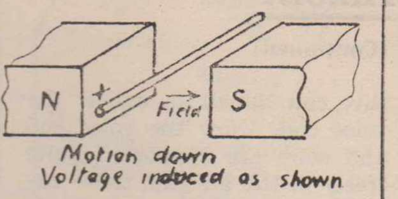


Fig. IV.b.

The energy equations being as follows:—

Energy put in = E I T

Work done by moving conductor = E'IT

Loss in resistance of conductor = (E-E') IT or = I^2RT.

The current is given by I = (E-E')/R

Where E = applied voltage
E' = induced voltage
T = time
I = current
R = resistance.

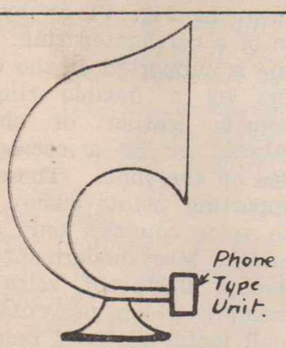
The voltage E' is generally termed the back e.m.f. and in any well designed electrical equipment is very nearly equal to the applied e.m.f.

Dynamic Speakers.

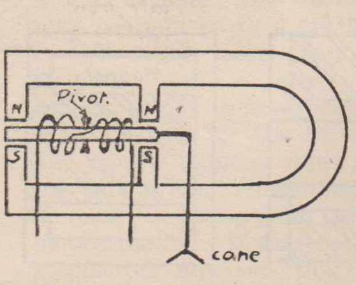
Instead of using a single straight conductor the dynamic speaker uses a coil of wire in a radial field, the radial field being obtained by the use of an annular air gap between the two poles of a magnet; some soft iron being used to make up the magnetic circuit between the poles of the magnet and the annular gap.

Fig. V shows three different magnet constructions used—(a) is an electromagnet; (b) and (c) are permanent magnet types; (c) using a hollow cylindrical magnet and (b) using a solid magnet and soft shell. The coil of the electromagnet can be used as a filter choke in A.C. sets.

A little consideration will show that the coil will tend to move bodily along the direction of the axis of the magnet if a current is passed through it and the cone is attached to



HORN SPEAKER Fig II



MOVING IRON CONE DRIVING UNIT. Fig III

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THEORY

(Continued)

this coil which is called the voice coil. Now the voice coil and cone are supported quite freely in the air gap, there being (theoretically at least) only sufficient stiffness to maintain the coil in the air gap so that any tendency to movement will only be resisted by the pressure of the cone on the air.

Cone Movement.

If an alternating, or speech frequency, voltage be applied to the voice coil it will move back and forth in the air gap in a manner to correspond to the variations in voltage and this will cause air movement, or sound waves to be emitted so that we can convert the electrical energy into sound waves, which is the principal requirement of a speaker.

There is, however, another important aspect of this coil, magnet, cone system which we must consider.

It will be realised that the speaker acts as a load on the valve which drives it, being supplied with power at various frequencies and in varying amounts.

We can assume that, within its power handling capacity, a speaker is linear in operation, that is, the rate of movement of the cone is proportional to the current in the voice coil. In this case the induced voltage (the back e.m.f.) is also proportional to the current, being proportional to the rate of motion.

Power Output.

Then the power output from the speaker is given by $W' = E'I$ W' being the sound output in watts, and the input is greater by the resistance loss $W = E'I + I^2R$ W being power input.

But $E' = KI^2$

then $W = I^2K + I^2R$

$= I^2(K+R)$

The term $K+R$ is generally termed the impedance of the speaker, being similar in nature to impedance in an alternating current circuit and to distinguish it from the resistance of the voice coil which should be much lower. This is distinguished by the symbol Z.

In practice the impedance of a speaker voice coil varies somewhat with frequency, the amount of variation being a function of the cone size and material, the baffling, which is most important at low frequencies as it controls the loading on the cone, and the general design of the speaker air gap, etc. In order to offset to some extent the loss of loading at low frequencies due to the use of small baffles many modern speakers have rather stiff suspensions, which have the effect of giving a pronounced resonance at some low frequency — dependent largely on the size of the speaker and its use. Small speakers such as 5in. units have a cone resonance at about 120 cycles per sec., 6in. about 105 c.p.s., 8in. about 90 c.p.s., and 12in. from 45 to 75 c.p.s.

Cone Construction.

The cone used on a dynamic speaker is, in modern practice, of felted flax, or some similar material, moulded to shape. Some of the older types used a cone which was cut from the flat and the join cemented, care being taken that the join was a curved line. The voice coil may be wound on a projecting cylindrical section of the cone centre, or, more usually, wound on a special former and cemented to the cone. As the voice coil must move freely in the magnet air gap some means of centreing must be provided. This is usually done by a spider, which is usually of bakelite cut as shown in Fig. VI or by the use of a corrugated ring. The cone is supported at the outer edge by a flexible ring of chamois leather or similar material or by a corrugated edge on the cone. These two supporting points ensure that the voice coil can only move axially,. Most modern speakers have a dustproof voice coil assembly which prevents any small metal particles reaching the air gap where they would

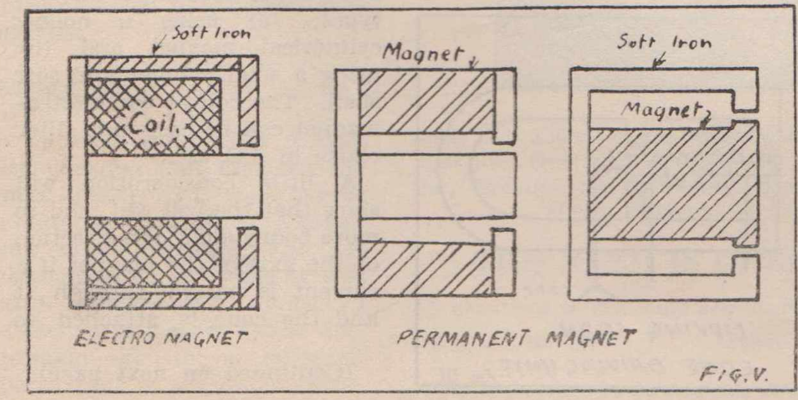

FIG. V.

stick and cause rattling and buzzing.

Baffling.

Much has been said about loudspeaker baffling, bass reflex enclosures, etc., but a good rule for all general cases is to make the path from the back to the front of the cone as long as possible, consistent with available space and the speaker characteristics. The reason for the baffle is that, at low frequencies, the compression wave from the front of the cone has a tendency to simply travel round the edge of the speaker and occupy the space just vacated by the cone in moving forward to make that compression.

Sound Waves.

As sound waves travel comparatively slowly, it is only necessary to make the path long enough for the cone to be moving back before the compression wave from the front of the cone reaches the back. This means that the distance from cone front to cone back should be half the wave length of the lowest frequency to be reproduced. This distance may be calculated from the rule—

$V = Lf.$

or $L = V/f.$

where V = the velocity of sound in air,
= 1100ft. per second.
L = the wavelength of of the sound in ft.
f = the frequency in c.p.s.

For example:—

To reproduce a frequency of 50 c.p.s. the speaker baffle would have to be large enough to make the distance from front to back of the cone 11 ft.

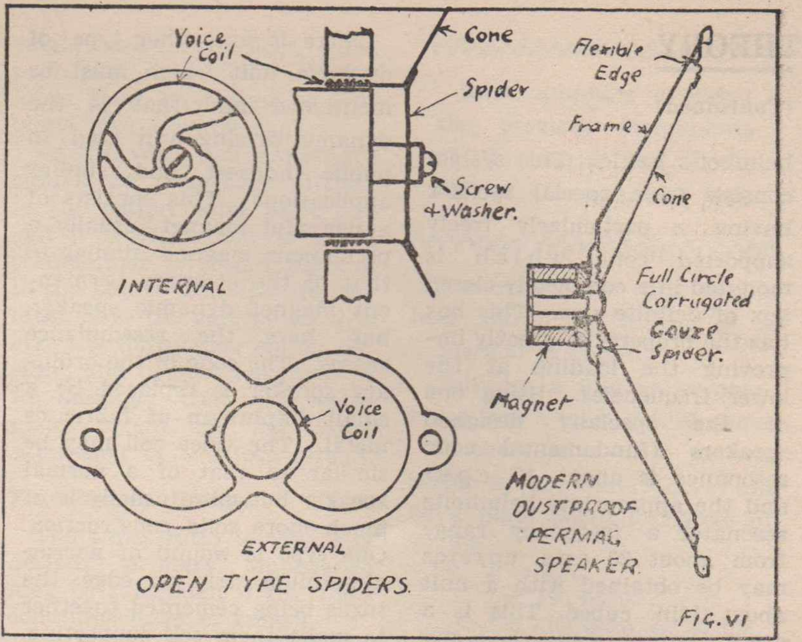

FIG. VI

$D = \frac{1}{2} L$

and $L = 1100/f.$

then $D = 1100/2f.$

$= 1100/2+50$

$= 11$ feet.

Then, assuming the speaker to be in the centre of the baffle the baffle would have to be 11ft. in diameter. Strictly the distance from the front to back should be measured from the cone edge and this would increase the baffle to 11ft. plus the cone dia. (not the speaker dia. as the cone is usually 1½in. to 2in. smaller than the nominal diam. of the speaker).

If the frequency limit is raised to 120 c.p.s. (for example a 5in. speaker) the distance may be reduced to 4.6ft. This is still much more than the distance used in small receivers using these speakers, even allowing for the increase due to the cabinet sides and the valves, etc., which tend to increase the sound path length by obstruction. It must be remembered, however, that the ear is not sensitive to very low (or very high) frequencies at low volume levels. In consequence a speaker on a baffle having an effective path length of about four feet is ample for general home listening. If you want to listen to very high, or very low frequencies you must operate at high volumes and have a very large baffle. Even then the neighbors might not like your music. If you are able to do so a speaker fitted into a wall between two rooms or in the ceiling will give a perfect baffle—provided the rooms have not any pronounced resonances.

Even a baffle as small as 4ft. diam. would be wasted on a speaker having a natural resonant frequency much above 120 c.p.s. as the speaker response falls off rapidly at frequencies below its cone resonance.

No discussion of speaker baffling would be complete without some mention of the

(Continued on next page)

THEORY

(Continued)

helmholtz baffle. This system consists of a special speaker having a particularly freely supported cone which is mounted in a completely closed box of definite size. This box has the property of greatly improving the loading at the lower frequencies. Using one of the specially designed speakers (fundamental cone resonance is about 17 c.p.s.) and the appropriate helmholtz resonator a frequency range from about 20 c.p.s. upwards may be obtained with a unit about 18in. cubed. This is a great improvement on any other system as regards size.

There is one other type of dynamic unit which must be mentioned and that is the dynamic driving unit used in public address and similar applications. This consists of a powerful magnet—usually a permanent magnet—similar to that of the ordinary permanent magnet dynamic speaker, but here the resemblance ceases. The cone of the ordinary speaker is replaced by a small diaphragm of fabric or metal. The voice coil may be similar to that of a normal speaker but more usually is of much more solid construction. One type is wound of narrow aluminium strip on edge, the turns being cemented together to make them self-supporting. The diphragm may be flat, but is generally corrugated in some manner to increase the edge flexibility and may be shaped to give better coupling to the horn which is necessary to load the unit in use. These horns are of exponential form and start with a quite small throat to suit the driving unit, increasing exponentially in cross section to the required flare diameter. These units, if properly constructed are much more efficient than an ordinary cone type dynamic with a baffle and, in addition to being able to handle considerable power, are directional in character. This diredtional property allows more efficient use of the power of the amplifier and reduces the tendency to feed back to the microphone.

Impedance Matching

The term voice coil impedance was referred to earlier in this article but no mention of values was made. A little thought will show that, as the coil can only have comparatively few turns, it can only have a small impedance. Practical values vary considerably ranging from about 1 ohm to 20 or so. Small speakers usually have voice coil impedances in the order of 3 ohms. (Rola 3in., 5in., and 6in. are 3.7 ohms —at 400 cycles per sec.) Larger speakers show more variation —8in. speakers range from 1 ohm to 8 ohms for different makes, 12in. speakers may have even higher impedances (Rola 12in., 2 or 8 ohms; Magnavox, 6.5 ohms; A.W.A., 12 ohms; and Goodmans, 15 ohms).

As the output valve of any receiver is designed to operate into some definite load impedance—a load differing greatly from the designed value will cause loss of sensitivity or will increase the distortion. Pentode valves are much more critical of the load impedance than are triodes. The actual value of impedance varies from 2500 ohms to 2500 ohms for single ended amplifiers, while push-pull amplifiers require loads from 3200 ohms to 3500 ohms with a centre-tap.

As the voice coil impedance cannot be connected directly in the output valve plate circuit it is convenient to use a transformer to couple the coil to the plate. This transformer must have the correct ratio to give the impedance match desired, and in addition must be so designed that the valve plate current will not cause saturation of the iron circuit.

Transformer Ratios.

The turns ratio to give any desired primary impedance may be calculated if the voice coil impedance is known.

$$Np/Ns = \sqrt{Zp/Zs}$$

Np = Pri. Turns
Ns = Sec. Turns.

For example: A speaker having a voice coil of 2 ohms impedance is to be matched to a valve requiring a load of 5000 ohms

$$\text{then } Np/Ns = \sqrt{5000/2} = \sqrt{2500} = 50 \text{ to } 1.$$

Then, if the primary was wound with 2800 turns, the secondary would have to have 2800/50 or 56 turns.

Back numbers contain the previous instalments of this series are available at 1/- each, post free.

The reason for this law is best shown by means of a numerical example—

Consider a 6V6 valve operating into a load of 5000 ohms.

If there is a plate voltage swing of 100 volts there will be a plate current change of 20 ma.

$$\text{i.e. } I = E/Z = 100/5000 = .02 \text{ amp. or } 20 \text{ ma.}$$

Peak instantaneous power will then be given by

$$W = EI = 100 \times .02 = 2 \text{ watts}$$

$$\text{or } W = E^2/Z = 100 \times 100/5000 = 10000/5000 = 2 \text{ watts.}$$

Now, if we assume that there is no power lost in the couplin transformer the same peak power would be dissipated in the speaker voice coil. If the

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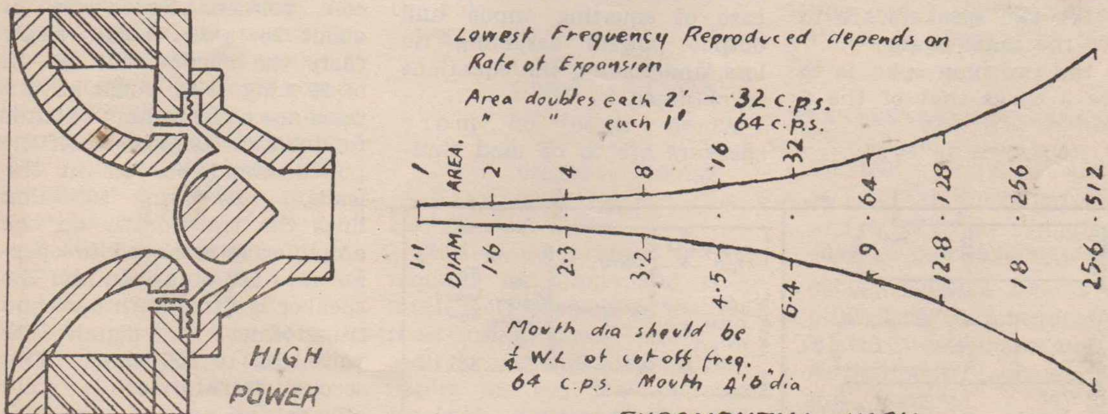


DYNAMIC HORN DRIVING UNIT.

EXPONENTIAL HORN.

FIG VII.

THEORY

(Continued)

coil has an impedance of 2 ohms then—

$W = e^2/z$ (e and z being secondary voltage and impedance)

then $2 = e^2/2$

or $e2 = 4$

and $e = 2$.

This gives a turns ratio of 100/2 or 50/1 as calculated before.

Alternatively—equating the equal powers we get

$W = E^2/Z$

and $W = e^2/z$

or $E^2/Z = e^2/z$

and $E^2/e^2 = Z/z$

$(E/e)^2 = Z/z$

therefore E/e = the sq. root of the impedance ratio.

Multiple Speakers.

This rule allows the determination of the ratio for cases where several speakers having similar, or different voice coil impedance may be operated off a single transformer singly or in combination yet the load remains constant.

For example: A transformer is required to match a 5000 ohm input to two speakers having v/c imps. of 2 and 6 ohms.

(a) the two speakers are to receive the same power;

(b) the two ohm spkr. is to receive 3 times that of the 6 ohm;

(a) $(e')^2/z' = (e'')^2/z''$

and $E^2/Z = (e')^2/z' + (e'')^2/z''$

substituting values we get—

$(e')^2/2 = (e'')^2/6$

or $e''/e' = \sqrt{3}$

$= 1.73$ to 1

and $E^2/5000 = 2)e'')^2/6$

$E/e'' = \sqrt{5000/3}$

$= \sqrt{1666}$

$= 41$ to -

Assuming a 2800 turn primary as before then the secondary will be—

2800/41 = 68 turns for 6 ohm spkr.

The tap will be at 1/1..73 of this or at 39 turns, for 2 ohm

(b) $(e')^2/2 = 3 \times (e'')^2/6$

and $E^2/5000 = 4(e'')^2/6$

$E^2/e''^2 = 5000 \times 4/6$

$E/e'' = 57.7$ to 1;

also as $e' = e''$ there will no tap.

The secondary will have 49 turns.

If the 6 ohm speaker were to receive the most power in case (b) the secondary will have 93 turns for the 6 ohm speaker and will be tapped at 10 turns for the 2 ohm speaker.

The voice coils singly would require 97 turns and 56 turns for the 6 and 2 ohm coils respectively.

Although the foregoing may appear complex a little study will show that it is simply a case of equating input and output powers assuming no loss, and solving the equations so obtained.

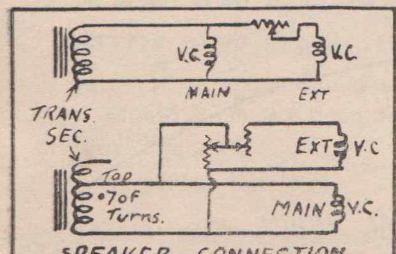
Where three or more speakers are to be used similar rules could be employed with, of course, more equations, but there is a simpler and more effective method which is also safer and more efficient where large powers or long leads are involved, that is, the use of a standard resistance line, usually 500 ohms.

The use of 500 ohm lines.

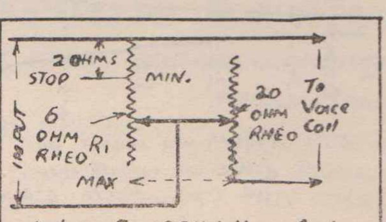
The use of some standard line impedance greatly simplifies calculations and has several other advantages, particularly where long lines are involved. 500 ohms has been accepted as an arbitrary standard, probably because the P.M.G. use lines of about this impedance. Any other value may be used if desired but transformers are available from stock for 500 ohm work. The advantage for long lines is seen if the voltages and currents are calculated for the ordinary 2 ohm voice coil.

Impedance of voice coil = 2 ohms. Power per speaker (say) = 5 watts. But $W = E^2/R$ or $= I^2R$. Substituting we get $E = 3.15$ volts and $I = 1.58$ amps.

If the speaker is to be 100 ft. from the amplifier the leads could not be run from the plates but must be at voice coil voltage. Now wire of about 20 s.w.g. could easily carry the current but 200 ft. of 20 s.w.g. wire would have a resitance of 1.57 ohms which is far too high as almost half the power would be lost in the leads. By using 500 ohm lines the transformer on the amplifier is arranged to operate into 500 ohm load and the speaker is fitted with a second transformer to match the voice coil to 500 ohms. This second transformer is quite efficient as no d.c. is present and the laminations can be interleaved to give best results.



SPEAKER CONNECTION.



Values For 2 OHM Voice Coil.

SIMPLE ATTENUATOR. FIG VIII

The voltage and current in the 500 ohm line would only be 50 volts and 1/10 amp. respectively, and the power loss in the line would be negligible. There is one point, however, which is important, the voltage, which, being over 3^2, makes it necessary to run the leads in vulcanised india rubber (V.I.R.) or tough rubber insulated wire.

As line to voice coil transformers are available in a variety of line impedance it is a comparatively simple matter to arrange for several speakers to be supplied from a 500 ohm line so that any desired power distribution is obtained.

If the speakers are each to have equal powers the transformers used on them will each be N times 500 ohms, where N is the number of speakers, and they are simply connected in parallel.

Alternatively, if 1, 2 or 4 speakers are to be used then transformers matched to 500 and 250 ohms could be used (tapped types are available and connected so that two 250 ohm units are in series when two transformers are used or the four (on 500 ohm taps) are connected in series paralel when all are used.

Unbalanced Power Distortion

When several speakers are required to supply power in unequal amounts, for example in a factory where some rooms are quieter than others, a solution is comparatively simple.

For example: An installation consists of 6 speakers to be driven as follows:

3 at 10 watts each,
2 at 7 watts each,
1 at 3 watts.

Total power = 3 x 10 + 2 x 7 + 1 x 3
= 47 watts.

Now line voltage E is given by—

$$E^2 = WZ$$
$$= 47 \times 500$$
$$= 23500 \text{ volts squared.}$$

This gives a value of 153 volts and the line must be insulated accordingly.

Now $W = E^2/Z$

then $Z^2 = E^2/W'$ where W' and Z' are speaker watts and impedances.

For 10 watt speaker—

$$Z = 23500/10 = 2350\text{ohms}$$

For 7 watt unit—

$$Z = 23500/7 = 3360\text{ohms}$$

For 3 watt unit—

$$Z = 23500/3 = 7800\text{ohms}$$

As these values are not standard the nearest even values can be substituted with little error.

Try 10 watt units 2500 ohm impedance.
7 watt units 3500 ohm impedance.
3 watt units 8000 ohm impedance (7500 would do).

These are all slightly higher than the calculated values so the distribution of power would be very nearly as required.

The total impedance of the paralleled units is given by the rule—

$$1/Z = 1/Z' + 1/Z'' + \text{etc.}$$
$$= 1/2500 + 1/2500 + 1/3500 + 1/3500 + 1/800$$
$$= 8 \times .0004 + 2 \times .000286 + .000125$$
$$= .001897$$

and Z = 527 ohms.

This is quite close to the required 500 ohms and is a much more economical method than using equal power to each speaker and fitting attenuators on the low powered speakers. This method would require a total amplifier power of 6 x 10 watts, the difference between the 47 watts used and the 60 being lost in the attenuators which are purely loss type controls.

When it is necessary to be able to vary the power to any speaker then an attenuator is the only solution. The best attenuators use several ganged variable resistors, the tapers being arranged so that the impedance presented to the line is constant. As these may have to dissipate considerable power they are wire wound units and are fairly expensive. A simple attenuator for low power use may be made up of two rheostats, one about three times and the other about ten times the impedance of the line (or voice coil, if the speaker is fed at voice coil level) connected as shown in Fig. VIII, a stop being arranged so that R_1 cannot be reduced below the line impedance. In practice the impedance to the line is slightly high at mid-volume but the attenuator is simple and gives a fair range—no off position, being useful where two speakers are being used with their voice coils in parallel across a tapped transformer designed for one or two speakers. If a second speaker is simply paralleled to the existing one a simple series resistance is enough, in fact is best.

RECORDING

(Continued from page 16)

recorded matter and at the same time keep the hum and needle scratch at a low level, where it is not troublesome.

Frequency range plays a big part in the characteristics of the cutter. High quality cutters usually have a wide range of frequency, while poor cutters have a restricted range. A good cutter will probably have a range from about 50 c.p.s. to about 8,000 c.p.s. Poor cutters often respond only to frequencies in the middle register, that is, from about 500 to 30,000 c.p.s. This makes the reproduced sound harsh to the ear. Where a cutter has a good, wide range, and is not particularly sensitive to any one or more bands of frequencies, it is said to have a **flat response.** Poor cutters may be sensitive to high frequencies, others to low frequencies and others to the middle notes of the musical register. None of these qualities are desirable, consequently a poor cutter should be avoided when good reproduction is being sought after from your recordings.

Coupled with the cutter is that all-important, although small, piece of equipment, the cutting stylus. Without the stylus the cutter is useless. Figure 6 shows the three most commonly used cutting styli, the steel, the stellite, and the sapphire. The actual usable cutting life of a steel stylus varies, but on the average, the steel stylus can be used for about 30 minutes of recording time. As the styli "age," the surface-noise level increases. A stellite stylus may be used for two hours or more cutting time. The sapphire is capable of cutting for anything up to seven hours, before the cut begins to go grey. Figure 7 shows the proper dimensions for a cutting stylus and groove depth. The cutting angle is extremely critical in cutting discs. The vertical cutting face of the stylus should make an angle of exactly 90 degrees with the un-cut surface of the blank. See Fig. 8. When this angle is more than 90 degrees it is referred to as the dig-in angle, when less than 90 degrees, as the drag-angle. The cutting angle can be adjusted in a variety of ways, by loosening the mounting and raising or lowering the head, by use of a screw adjustment, etc., this can only be ascertained by examining the particular piece of equipment you happen to have. The point remains, however, that the angle **must** be as near as possible to 90 degrees, to keep noise level down. When the angle has been determined, and fixed, it need not be altered.

Depth of cut is much more difficult to determine, although not so difficult to set. The only drawback being that it has to be altered for each stylus, each type of blank and for different applications. Proper and correct depth of cut can only be ascertained by making a few test cuts. The most simple method, and possibly the most accurate, except the use of a micrometer, is to use a microscope or powerful magnifying glass. On examination, the ratio of the groove width to the un-cut land, should be in the approximate ratio of 60 per cent. groove; 50 per cent. land.

When the groove is too shallow, poor tracking results, the pick-up failing to follow the grooves and jumping out. When the cut is too deep, over-cutting and cutting through give a lot of trouble. With the above mentioned ratio, the depth of cut is approximately 0.002in. This allows all normal sounds to be recorded at their normal level, without over-cutting. The method of adjusting the depth of cut also varies with individual machines, consequently we won't describe the process, suffice to say that it is usually accomplished through the use of screw adjustment, lowering or raising the head, or by use of counterweights on the back of the carriage.

Our next part will deal with amplifiers, recording levels, frequency response, and other angles on the electronic side of the recording.

ANTENNA

(Continued)

becomes, the nearer the best direction for transmission approaches the wire direction. They coincide when "C" is zero. That is, when the wave angle is equal to the angle of maximum radiation with respect to the wire (when "A" equals "B").

Maximum antenna radiation can be placed in any given geographical direction, at a given wave length, by use of the formula:

$$\cos \text{“C”} = \frac{\cos \text{“B”}}{\cos \text{“A”}}$$

Example:

Given: Angle of radiation. ("B") 10 degrees. Wave angle ("A") 15 degrees.

To find: "C," the angle between the wire direction and the actual geographical direction to the given point, compass bearing 75 degrees E. of N.

$$\cos \text{“C”} = \frac{\cos \text{“B”}}{\cos \text{“A”}}$$

i.e,

$$\cos \text{“C”} = \frac{\cos 15}{\cos 10}$$

$$\cos \text{“C”} = \frac{0.9659}{0.9848}$$

$$\cos \text{“C”} = 0..9806$$

i.e., "C" = arcos 0.9806. (arcos means angle whose cosine is) therefore angle "C" is 11 degrees 18 minutes.

Thus the antenna wire direction must be approximately 11 degrees either side of the actual compass direction given. That is to say, the antenna must point either 64 or 86 degrees E. of N., for best results.

However, it must be remembered that Fig. 1 only gives an idea of the conditions applying to the **maximum** point of the lobe. Radiation at higher or lower wave angles will be proportional to the actual variations in the field strength patterns, compared with the maximum point of the lobe.

The length of the half-wave sections in a long wire is not the same as the physical length of a ingle half-wave antenna in pace. Due to the abence of the end effects experienced with the single half wave. The end effect only enters into the matter at the termination points of the two extreme-end half-wave sections, possibly several wavelengths apart.

For the half-wave in space, the formula is:

$$\frac{492}{\text{Freq. (Mc/s)}}$$

Actually, this is considerably shortened in practice, especially when the antenna is supported by insulators at the ends, as it mostly is. The insulators add a capacity to the end, thus physically shortening the antenna. The formula then becomes:

$$\frac{492 \times 0.95}{\text{Freq. (Mc/s)}}$$

or

$$\frac{468}{\text{Freq. (Mc/s)}}$$

When considering the half-wave sections for a long wire, however, the shortening effect is negligible. The formula for calculation of the TOTAL LENGTH of a long wire is:

$$\text{Length} = \frac{492\ (N - 0.05)}{\text{Freq. (Mc/s)}}$$

where N equals the total number of half waves in the antenna. This equation gives the antenna length in feet.

When the antenna is cut for one band, the lowest frequency to be used, it may become unbalanced on twice the fundamental frequency, owing to the fact that the end effect is decreased when the antenna is more than one half wave long. Consequently radiation may take place from the feed-line. The feeder system becoming unbalanced also, especially when end-feed is employed. When the antenna is centre-fed no unbalance whatsoever takes place. Feedlines will only be perfectly falanced when operating on the band

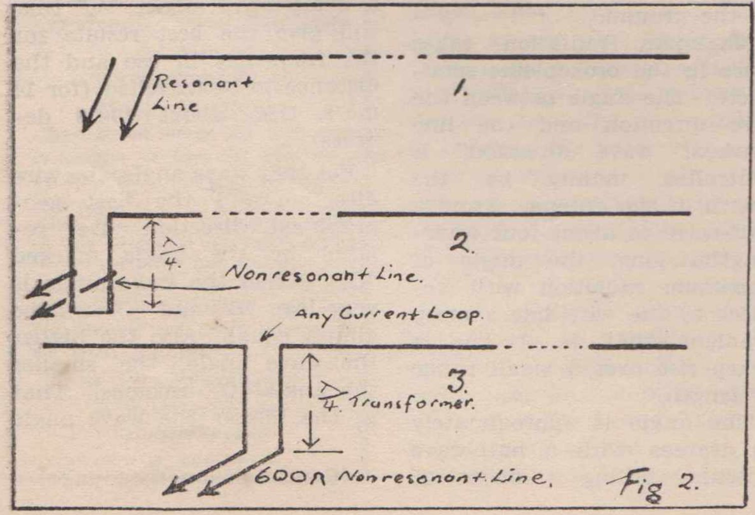


Fig 2.

for which the antenna was cut.

The directional properties of the long single wire, as was said before, are excellent, as is the gain, when the antenna is four or more wavelengths long. The long wire radiates more power in its favorable direction than does a normal half-wave antenna in its favourable direction. The considerable gain and directive properties of the long wire are made possible by a loss in radiation in other directions. The longer the wire, the more directional the antenna becomes.

With the long wire, you no longer have the doughnut pattern of the half-wave antenna, the pattern takes on the form of large lobes at the end of the wire, with smaller minor lobes along the centre of the antenna. As the length of the antenna is increased, the line of maximum radiation more closely approaches the axis of the antenna. Long wire antennas have an "end-on" characteristic when extremely long, even at low radiation angles.

The normal half-wave antenna has one "doughnut," a full-wave antenna has two, a one - and - one - halfwavelength antenna has three, a two-full-wavelength antenna has four, and so on. One "doughnut" for each half wave in the total length. These doughnuts gradually come to lobes at the ends, along the axis of the antenna, and although there are many smaller lobes at other various angles to the axis, they have little effect on the radiation. The horizontal radiation pattern depends largely on the vertical angle of radiation under consideration.

When the wire is more than four wavelengths long, vertical radiation at an angle of 15-20 degrees, best for 14 mc/s D.X., is in line with the axis of the antenna, being slightly greater a few degrees either side of it.

It is not a particularly sharp antenna, but combines good end-fire directly with the desirable ability of the small, intermediate, minor lobes to radiate a small amount of power, thus enabling you to work in all directions.

Directivity does not increase greatly after the antenna length exceeds fifteen wavelengths. Mainly because of the effect of the R.F. resistance of the wire, making current amplitude unequal in different loops along the length of the antenna.

Fig. 1 shows, diagramatically, that when the wave angle is equal to the angle which the maximum radiation intensity of the lobe makes with the wire, the best transmitting and receiving direction lies in the direction of the wire.

Feeding Power to the Long Single Wire.

The current in each adjacent half-wave section of a long wire antenna must be out-of-phase. To enable this state of affairs to exist, the antenna can only be fed at the end or at a **current loop.** If the antenna was fed at a **current node,** the current would be in-phase in each adjacent half-wave section. If the phase in one section could be reversed, then the currents in the feeders would be in phase, and thus feeder radiation would not be cancelled out. Thus all long-wire harmonic antennas must be fed, either at the end or at any **current loop.**

The most common method of feeding the long wire is shown in Fig. 2A. This is the only method of feed whereby the antenna operates as a true long wire. Because the current loop changes to a current node when the antenna is operated on any even multiple of the frequency for which it is cut. An open-wire, resonant line is used to end feed the long wire as in 2A. The antenna will operate down to the band at which it is only one half wave long.

Figures 2B and C show two methods of feeding with a non-resonant line. It should be obvious that 2B will only allow operation on one band, as the matching section must be a quarter wavelength long on the operating frequency. Unless, of course, you are going to have a separate matching section for each band. This method of feed is ideal for the man who intends to operate on one band only.

The Q-section transformer in 2C should be adjusted to match the impedance of the antenna to the line. This arrangement is usually used in conjunction with a 600 ohm line. As it is designed, it will only work one band, however, if the feeders are considered as a resonant line, feeders and transformer both, the antenna can be used on all other bands. As was said before, the antenna does not operate as a true long wire under these conditions.

The end-fed arrangement is by far the most convenient system for use with tuned feeders, but it has its disadvantages. Mainly because high antenna currents are liable to be set up on the line, another disadvantage lies in the fact that the reactance of the antenna changes rapidly with change in frequency. This means that when using an antenna several wavelengths long, a small change in fre-

(Continued on page 34)

SOMETHING NEW!

Our Technical Directory

For many months people have been writing to us wanting to know where they can have this done, or where they might be able to get that made for them.

It has long been our opinion that it would be of benefit to the readers, the suppliers, and to us, if we could make known the whereabouts of hard-to-get components and where to have those special jobs done for you.

This is the idea behind this directory. If you have any further suggestions as to what you want in the list, by all means let us know. It is intended to expand the list to several pages, so that everything will be covered, thus helping everyone along.

If you think you have something that will interest other readers, send us the information and we will follow it up.

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C.B. (Ashfield) queries the ability of the modern rectifiers, with their small envelopes, to stand up to overloads in the same way as the old type 80, which would operate on voltages up to 600 and even higher.

A.—There was no doubt about the remarkable way in which the old-type rectifiers would stand up to overloads, but we have not seen any proof that the modern valves won't stand up in the same way. There may be a smaller radiation surface with the smaller amount of glass, but we doubt if this is likely to be the limiting factor in the power which can be handled. The fact that you had trouble with one valve does not mean that the trouble was due entirely to the fact that you were running it on 400 volts at 125 ma. Often enough a faulty valve is discovered in sets which operate with a high tension of 275 volts. However, to save all further doubts, why not fit the type 5R4GY, which is now listed at 26/-. It has same base and socket connections, same heater ratings as the 5Y3, but is rated to take 800 volts on the plate with currents up to 150 ma.

* * *

H.F. (Hamilton, N.S.W.) is confused by the opposing views expressed by writers on the subject of cathode followed circuits for audio amplifiers.

A.—To sum up in a few words: the cathode follower requires so much signal voltage to drive it that it really amounts to making it necessary to have at least two extra valves and a number of components in order to get slightly better results. Whether the improvement is worth the extra cost will depend a great deal on individual preference. Some people feel that even the slightest improvement is worth battling for, others do not have the same musical appreciation, taste, etc. For ordinary people, the main thing seems to be to get plenty of noise as cheaply as possible.

* * *

R.E. (Richmond) is having trouble with a high-quality set which tunes in a hum on certain stations and is silent when not tuned in to a station.

A.—This is often a problem with high-quality sets. Some of the hum is simply due to bad transmission by certain stations and can't be cured at the set. In other cases the quickest cure is a couple of .1 mfd. condensers (600 volt rating) from each side of the power mains to earth.

ANTENNA

(Continued)

quency may necessitate a large change in the antenna coupling network to compensate for the change in impedance.

Thus it will be seen that the line becomes unbalanced at all frequencies between those at which the antenna is resonant. This means considerable radiation from the feed-lines.

On the average, the long single wire is most satisfactory when fed with 600 ohm line, through a Q-section transformer, for multi-band operation, or when fed through a quarter-wave matching section for single band operation.

If you have a fewhundred feet of space, in a reasonably useful direction, then we recommend that you try the long single wire antenna. The results will repay your energy, especially if the antenna can be more than four wavelengths long bearing in mind the fact that radiation resistance increases greatly with increase in length.

Any further data can be obtained from the latest A.R.R.L. Antenna Handbook, from whence some of our information came. This book is on a much greater scale than previous antenna books, and is a very necessary text-book for all those of you, whose hobby it is to play with antenna systems.

EVENTIDE HOMES APPEAL

Some two years ago the Loyal Orange Institution of Australia set out to provide homes for elderly people. To date a block of land at Padstow Park has been purchased, cleared, surveyed, partially fenced, and three cottages erected, and a number of ornamental trees planted. Three happy couples are installed in the three cottages, and a fourth cottage is being built.

Donations to this fund are tax free, and may be sent to the secretary, Room 306a, 3rd floor, M.L.C. Building, 44 Martin Place, Sydney.

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MULTITESTER

(Continued from page 12)

placement, wiring and assembly. Good luck to you.

SPECIAL NOTE.

Maintaining Calibration of VTVM Multitester.

Whenever using the instrument and before making measurements check for correct calibration as follows:

Set switches to OHMS, VTVM, MEGS.

Short test leads.

Adjust Zero set pot to Infinity ohms (Zero deflection of meter).

Open test leads.

Adjust Max set pot to Zero ohms. (Max. deflection of meter.)

Repeat above until meter reads Infinity with open test leads and Zero ohms with shorted test leads.

Meter is ready for use on all ranges.

Re-check as above when necessary.

Owing to the effect of the holidays, etc., the Shortwave Review does not appear in this issue.

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Containing Circuits of 257 Receivers manufactured by 44 Brand-Line Manufacturers during 1948

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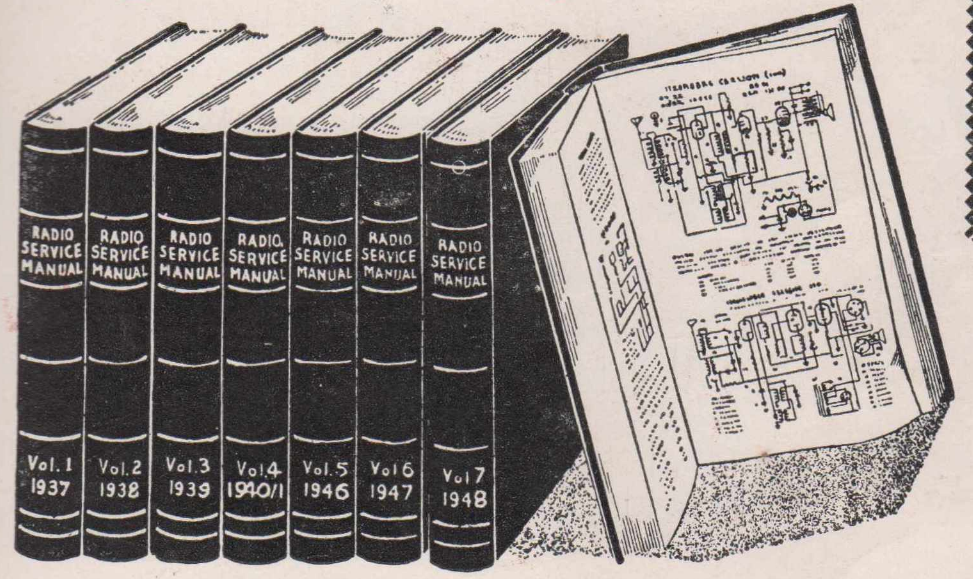

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