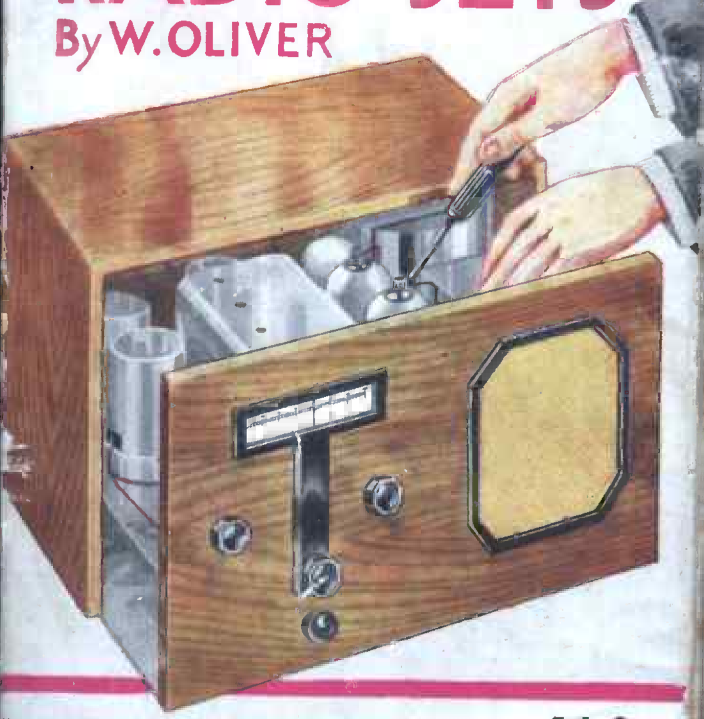
MAKING AND REPAIRING RADIO SETS

By W. OLIVER



How to do your own Repairs. How to make your own Battery or Mains Set. How to Charge Accumulators at home

1/-

EFERENCE BOOK FOR EVERY

FOULSHAM'S WIRELESS GUIDES

MAKING AND REPAIRING RADIO SETS

BY

W. OLIVER

Author of
SHORT-WAVE RADIO RECEPTION

FULLY ILLUSTRATED

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PREFACE

This handbook will help you in choosing radio apparatus, designing and building sets, making and decorating cabinets, preventing, tracing and curing faults, carrying out simple radio repair jobs, and maintaining batteries or mains apparatus in good order.

When you want to build a wireless set at home, you have the choice of two alternatives: (*a*) to follow exactly the specification in a published design; or (*b*) to design a set for yourself, taking as a basis one of the simple, fundamental circuits from which practically all sets are evolved and modifying it to suit your own needs.

If the second alternative (*b*) appeals to you, the principles outlined in Chapter V will help you to work out a design to meet your requirements. Whichever alternative you adopt, Chapter VI will help you to make a good job of the actual construction.

If the set goes wrong at any time after you have built it, the notes on set testing in Chapter VII, and on tracing faults in Chapter VIII will help you to track down the trouble quickly and easily. These will be equally helpful, of course, in dealing with troubles in any other existing set.

Having located the fault, if an actual repair is needed, the hints in Chapter IX will enable you to tackle the job of mending the components. This applies chiefly, of course, to home-built sets. In the case of factory-built sets, certain parts are often sealed, and the makers' guarantee is often conditional on the seals being left intact. The conditions of guarantee, if any, should therefore be ascertained before tackling repairs to factory-built sets.

W. O.

LIST OF ABBREVIATIONS

The following are the meanings of the various abbreviations used in this book.

A	Aerial or anode.
A.C.*	Alternating current.
Amp.*	Ampere.
A.V.C.*	Automatic volume control.
B.A.*	British Association (screw standard).
C.C.	Coupling condenser.
D.C.*	Direct current.
D.C.C.*	Double-cotton-covered (wire).
Det.	Detector (valve).
D.S.C.*	Double-silk-covered (wire).
E	Earth.
F	Fuse or filament.
G	Grid.
G.B.*	Grid-bias.
H.F.*	High-frequency.
H.F.C.	High-frequency choke.
H.T.*	High tension.
I.F.*	Intermediate frequency.
L.F.*	Low frequency.
L.F.C.	Low frequency choke.
L.S.*	Loud speaker.
L.T.*	Low tension.
M/a*	Milliampere.
M.C.*	Moving coil (loud speaker).
Milliamp.*	Milliampere.
Mfd.*	Microfarad.
MΩ	Megohm.
Ω	Ohm.
P	Power (valve).
Pen.	Pentode (valve).
Q.P.P.*	Quiescent Push-Pull (output system
R.	Resistance.
RC.	Reaction condenser.
S.G.*	Screened-grid (valve).
S.W.*	Short-wave.
V.C.	Variable condenser or volume-control.
Var.-mu	Variable-mu (valve).

Those marked with an asterisk (*) are more or less standardised abbreviations in general use.

CONTENTS

MAKING AND REPAIRING RADIO SETS

CHAPTER I

YOUR RADIO "SHOPPING LIST"

PARTS REQUIRED FOR SOME POPULAR CIRCUITS

In some respects building a wireless set is rather like building a house.

If you had built a house with your own hands, and any part of the structure subsequently developed some defect which needed repairing, you would know exactly how and where to get at it.

Similarly, if you have built a set with your own hands, you will know exactly what is in it, where certain faults are most likely to occur, how to take the whole set to pieces and how to "get at" any parts needing replacement, without wasting time or trouble.

Instead of becoming hopelessly lost in a "jungle" of wires and components when you delve into the set, you will know your way about the circuit and will be perfectly familiar with the construction of every part of the set.

That is usually more than half the battle in tackling a repair job. You must know a set thoroughly inside and out in order to adjust or repair it easily and well.

I would strongly advise you, therefore, even if you have bought your set ready-made and are merely interested in repairs and maintenance, to read the chapters on constructional work very carefully. This will enable you to follow the construction mentally, so that you will be thoroughly conversant with all parts of the set, even though you may not have actually built it with your own hands.

What components and accessories must be put on your radio "shopping list" when you go out to buy the materials and apparatus with which to build a set? That, of course, depends entirely on the type of circuit. But generally speaking, all sets may be said to have the following items in common:—

Chassis, or baseboard and panel assembly; cabinet; on-off switch; wave-change switch (unless one is incorporated in the tuner); fuse-holder(s); fuse(s); terminal blocks; terminals; plugs and jacks (if needed); connecting wire; screws, etc.

An aerial and, generally, some sort of earth connection are also needed, and for battery-operated sets you want:—

H.T. battery; L.T. accumulator; G.B. battery (*not needed usually for one-valve set*); flexible battery-leads; wander-plugs (for H.T. and G.B.) and spade-tags (for L.T.).

For a one-valve set, a small-capacity 60-volt H.T. battery is sufficient as a rule; for a two-valve set, a 120-volt battery, and for a three or four-valve set, a voltage of 120 to 150 is usually required, the cells preferably being of the super-capacity type for economical working when a big current is needed. The G.B. battery can be of 9 volts for ordinary L.F. and power valves, but at least 16 volts is usually necessary for variable-mu valves of the battery-operated type.

The parts needed for a simple one-valve circuit (detector valve with reaction) are:—

Aerial tuner with reaction winding; variable condenser (·0005 mfd.); reaction condenser; pre-set condenser (·0005 mfd. maximum); grid condenser (·0003 mfd.); potentiometer (300–400 ohms)—optional; grid-leak (2 Megohms); high-frequency choke; valve-holder; and perhaps a ·0003 mfd. fixed condenser as a by-pass for connection between the anode and filament negative terminals of the valve-holder.

If you wanted to add a power valve, so as to work a loud-speaker, you would need the following additional components:—

Low-frequency transformer (3–1 or 5–1

ratio); valve-holder; and perhaps certain "extras," namely: anode resistance and 2 mfd. fixed condenser for decoupling the detector circuit; output choke and 2 mfd. fixed condenser for an output filter circuit, or an output transformer—the filter unit or transformer being needed only if the loud-speaker to be used does not incorporate a matching transformer of its own.

If your low-frequency transformer was of the parallel-feed type, you would need an anode resistance and fixed condenser for the parallel-feed circuit; suitable values for these, and circuit diagrams, will generally be found on leaflets enclosed in the transformer carton.

If you wished to give your set greater range and selectivity by adding a stage of screen-grid or pentode H.F. amplification, you would need some more extra parts, namely:—

An extra tuner and variable condenser, or else a two-gang tuner and two-gang condenser, properly matched, for tuning both the H.F. and detector circuits; a fixed condenser for capacity-coupling between H.F. and detector valves (say ·0002 mfd.); a fixed condenser (1 mfd., *non-inductive*) for decoupling the screen-grid; an H.F. choke for S.G. anode circuit; and another valve-holder.

Should you decide on a variable-mu type of valve for the H.F. stage you will need a potentiometer for G.B. control (say, 25,000 ohms), a fixed condenser (1 mfd.) for the G.B. circuit, and either a three-point switch to break the potentiometer circuit as well as the L.T. circuit when the set is switched off, or a switch for the same purpose combined with the potentiometer.

The screening-grid voltage is usually rather critical, and if you cannot conveniently take a lead to a suitable tapping on the H.T. battery, you will need a high-resistance potentiometer (say, 50,000 ohms) to enable you to adjust this potential.

For a push-pull or "Class-B amplification" output circuit you will need special transformers, the intervalve one having a centre-tapped secondary, and the output one having a centre-tapped primary (unless your loud-speaker has a built-in transformer with provision for class-B connections); and you will also need a Class-B type of valve-holder.

From the lists I have given, you can easily deduce what extra components would be needed if you wanted to get extra amplification by duplicating either the H.F. or L.F. stages.

Mains versions of most of the foregoing circuits, too, can be designed without much alteration, except for changes in one or two minor components, such as valve-holders and switches, which will probably need to be of a different type from those used in a battery set; and the addition of the mains power unit which will take the place of the batteries.

The mains equipment needed includes a mains transformer and rectifier (in the case of A.C.), together with the necessary smoothing choke, large-capacity condensers of the electrolytic type, and resistances for potential dividing to apply the necessary voltages to the different valves.

All mains equipment must be of a type conforming with the regulations laid down by the electricity supply authorities, and proper precautions must be taken in its use; but I shall have more to say regarding that when dealing, later on, with charging accumulators and building mains sets.

For superheterodyne sets, various additional components are needed, including intermediate frequency (I.F.) transformers and sometimes special valves. It is best to adhere strictly to a published design in building superhets., at least until you become fully conversant with their working.

H.T. vibrators, or vibrator-rectifiers, are becoming increasingly popular, forming a good substitute for dry batteries as a source of H.T. supply. (See also page 38.)

CHAPTER II

CHOOSING COMPONENTS

When you walk into a wireless shop to buy the parts with which to build a set, you are faced with a bewildering choice. There are often many different types available in any one class of component or accessory. What are the pros and cons of each type and what are their particular uses? Those are the questions to be answered in this chapter and the next.

CHOKES

H.F. Chokes.—Available types include plain, sectionalised, and astatic or binocular windings. Screened models, having the windings enclosed in a metal "can" that may be connected to earth, help to prevent interaction between the H.F. choke and other components. Some of the modern H.F. chokes have "iron-dust" cores, similar to those of certain tuning coils.

Fig. 1 shows the commonest uses of H.F. chokes in an ordinary broadcast receiver. H.F.C.1 is a high-inductance, low-capacity choke designed for use in the anode circuit of a modern H.F. valve. For H.F.C.2, however, almost any good type is usually satisfactory.

A well-designed H.F. choke should function correctly over a waveband of at least 200–2,000 metres. For the short waveband (below 100 metres) a short-wave choke is usually necessary. In "all-wave" sets, an S.W. choke is sometimes joined in series with an ordinary one.

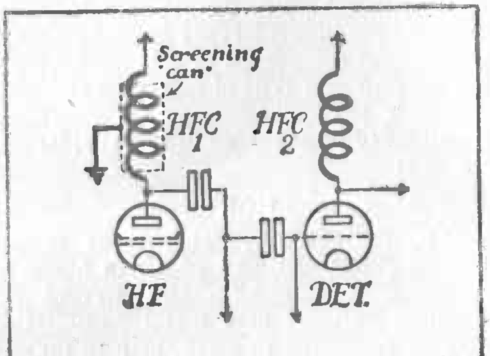


FIG. 1

WHERE TO USE H.F. CHOKES.

L.F. Chokes.—Chokes with a laminated iron (or iron substitute) core are used for L.F. work. Fig. 2 shows common uses of L.F. chokes. L.F.C.[1] needs to be of a very high-inductance type, but L.F.C.[2] can usually have an inductance of, say, 20 or 30 henries. L.F.C.[1] is used for parallel-feed coupling

instead of an anode resistance, to avoid the voltage-drop associated with the latter.

Tapped chokes can be had, and these are useful for the output circuit as they facilitate accurate matching between the output valve and the loud-speaker.

Suitable smoothing chokes are needed in

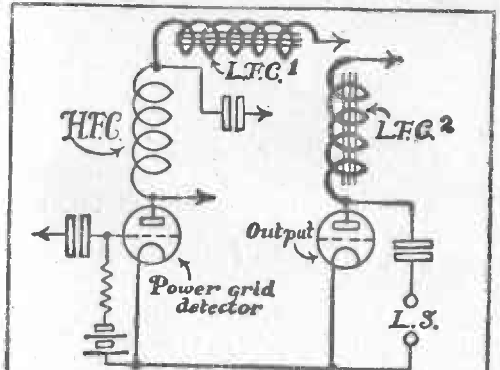


FIG. 2

WHERE TO USE L.F. CHOKES.

all mains sets for "smoothing" the H.T. current.

COILS

The choice of a tuning-coil depends on (*a*) the type of set, (*b*) the chief purpose for which the set is wanted and (*c*) the place in which it is to be used.

Clearly, if the set is installed within a few miles of a powerful Regional station, a very selective type of tuner is necessary. Similarly, if it is to be used a good deal for getting distant stations, it will need to be more selective than if it is required mainly for programmes from one or two semi-local B.B.C. stations.

All the following types, with the exception of plug-in coils, may be either plain or enclosed within earthed metal screening "cans":—

PLUG-IN COILS.—Although still used in a fair number of short-wave sets, these have been almost entirely superseded for ordinary broadcast reception by tuners with waveband switching which eliminates the trouble of changing coils.

DUAL-RANGE TUNERS, ETC.—Air-core tuners, with simple waveband switching, are inexpensive and are easily wound at home if desired. But they cannot be reduced below a certain physical size (for a given inductance value) without loss of efficiency; and they are not as selective as the iron-dust core type.

IRON-DUST CORE TUNERS.—The advantages of these coils are their selectivity and very compact construction. They take up a minimum of space in the receiver. But, of course, they cost more than air-core coils.

BAND-PASS TUNERS.—Band-pass tuners give good selectivity without cutting off the sidebands of the transmission, which causes a loss of high notes in the reproduction. But they tend to complicate the circuit and increase the initial cost of the set.

The variable condensers tuning a band-pass unit have to be "ganged" (i.e., coupled together mechanically) to allow of single-knob control.

PERMEABILITY TUNERS.—A permeability tuner dispenses with the need for a variable condenser. Tuning is effected by varying the effective inductance of the coil. At the time of writing, these tuners are not widely used.

• • • •

The sharpness of tuning needed for reasonably good selectivity with any simple type of tuner usually results in a loss of high notes, especially when using a good deal of reaction to bring in distant stations.

The tone can be re-balanced and the ratio of high to low notes corrected by means of a tone control device in the L.F. amplifier.

CONDENSERS

VARIABLE CONDENSERS.—Variable condensers are used mainly for tuning and for capacity control of reaction. You have a choice of two kinds: (*a*) with air-spaced plates and (*b*) interleaved with solid dielectric spacers. The air dielectric type is the more efficient, and more widely used than the kind with the solid dielectric sheets; but the latter enable the plates of the condenser to be much thinner and closer together, and therefore the solid-dielectric condenser is very small in proportion to its capacity. Hence, it is very useful where space is limited—in a portable set, for instance, or a "midget" receiver.

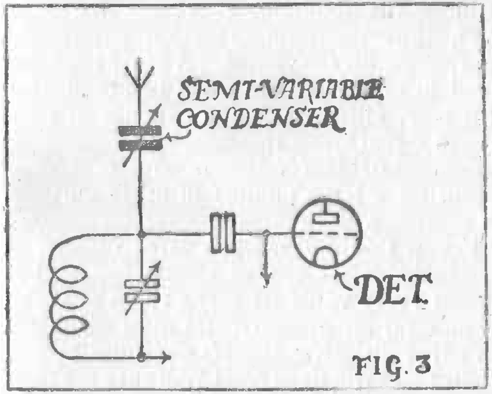
For tuning, ·0005 mfd. is the usual capacity. In the case of a set with two or more tuned circuits, if properly matched coils are available, single-knob tuning can be had by using a gang condenser, that is, a condenser with two or three separate sections, but with the moving plates mounted on a common spindle so that all sections are adjusted simultaneously by turning one knob or dial.

Reaction condensers frequently have a capacity of between ·0001 and ·0005 mfd. and specially designed ones which take up a minimum of space are available.

Although reaction condensers do not usually need to be screened, it is generally advisable to use screened variable condensers for tuning purposes, especially if there is more than one tuned circuit. Gang condensers are completely enclosed in metal screening cases provided with earthing terminals.

The sections of a gang condenser are fitted with "trimmers" which have to be adjusted to compensate for stray capacities, etc., in the different circuits.

In short-wave sets (for use below 100 metres) the tuning condenser should have a low capacity—say ·0001, ·00015, ·0002 or



A SIMPLE AID TO SELECTIVITY

·00025 mfd. Special types designed expressly for S.W. work are available.

SEMI-VARIABLE CONDENSERS.—These, sometimes known as pre-set condensers, can be fixed at any desired capacity, within a given maximum or minimum, by adjusting a small knob or screw which compresses springy metal plates interleaved with mica dielectric.

A compression condenser is most commonly used, perhaps, as a series coupling capacity between the aerial lead and the end of the aerial tuner, as shown in Fig. 3. This capacity, when suitably adjusted, reduces the damping effect of the aerial load, thus promoting reaction effects and sharpening up the tuning. A great improvement in selectivity can often be obtained in this way, although at the expense of some loss in signal strength.

Semi-variable condensers are, of course, useful for a large number of other purposes as well.

FIXED CONDENSERS.—A large number of fixed condensers are, or should be, used in almost every valve set. The types available include (*a*) air dielectric, (*b*) mica dielectric, (*c*) paper dielectric and (*d*) electrolytic.

Air dielectric fixed condensers are the most efficient, but so bulky in proportion to capacity that they are hardly ever used except perhaps for certain purposes in short-wave sets.

Mica dielectric types are commonly used in capacities up to, say, 0·1 mfd. In bigger capacities than this, paper dielectric types are used instead, chiefly in values between 1 and 8 mfds. When used in H.F. parts of

the circuit, they should be of the non-inductive type.

The electrolytic types (widely used in mains sets, especially where a very big capacity is needed) are very compact and small in proportion to their capacity comparatively inexpensive, and will stand a certain amount of overloading without sustaining permanent damage.

DIALS

A wide selection of tuning indicators—slow-motion dials, disc drives, etc.—is available nowadays. The most popular type, perhaps, is a "full-vision" scale with a thin pointer moving across it, either horizontally or through an arc, according to the shape of the scale.

In mains sets the dial is almost invariably of translucent material, and is fitted with a small pilot-lamp bulb that lights up when the set is switched on. This serves the dual purpose of indicating that the current supply is on and of illuminating the scale to facilitate accurate dial-reading.

One can obtain dials or tuning scales graduated in degrees, in wavelengths or in frequencies, or with the names of the various stations receivable printed on them in their correct order of wavelength. The drawback to this is that the scale needs altering if any station changes its wavelength materially.

In choosing a dial, the chief points to bear in mind are that the markings should be easily and accurately legible, and that the slow-motion drive mechanism should be perfectly smooth and free from any trace of slip or backlash.

RECTIFIERS

H.F. Metal Rectifiers.—Miniature metal rectifiers, specially designed for radio frequency work, are useful in several ways. One can be used, for instance, as a detector. It consumes no current, takes up little space, is inexpensive and long-lived. But, of course, it cannot be made to amplify, as well as rectify, the signals in the way that a detector valve can, and it must be preceded by an H.F. stage or stages to give adequate input.

Other uses of these miniature metal rectifiers are in connection with automatic volume - control arrangements and H.T. " economiser " units.

Care should be taken to select the right type of H.F. metal rectifier for the particular purpose it is to serve. Details of latest types and uses can be found in the manufacturers' catalogues.

Metal Rectifiers for A.C. Mains.—Various types of metal rectifiers are available

for changing A.C. current, from a mains transformer, into a direct current which, when " smoothed," is suitable for the H.T. supply to valves. A metal rectifier has a much longer life than a valve.

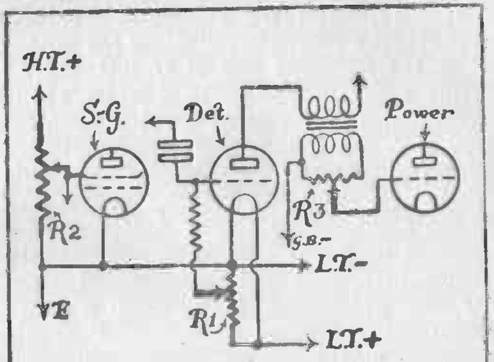


FIG. 4

SOME USES OF POTENTIOMETERS.

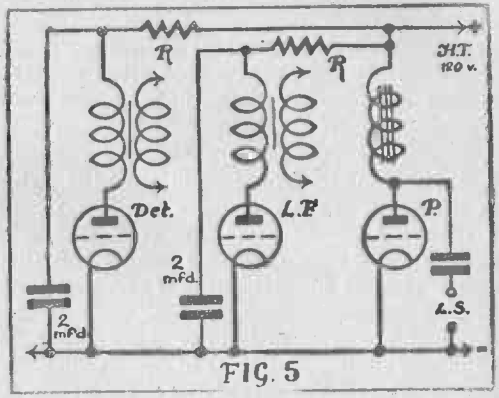
RESISTANCES

Variable Resistances and Potentiometers.—Rheostats for filament current control are very seldom used in modern sets, though one may usefully be employed in the negative filament lead of a battery-operated S.G., H.F. valve to reduce current consumption, control volume smoothly and, as an incidental effect, greatly improve selectivity.

Some of the uses of potentiometers are indicated in Fig. 4. R[1] (only applicable to a battery set) helps to make reaction smooth and easily controlled; 300–400 ohms is a suitable value for the resistance winding. R[2] provides a means of adjusting the potential on the screening grid of an S.G. valve; in this case the resistance can be about 50,000 ohms. R[3] acts as a volume-control (most so-called volume-controls are actually high-resistance potential dividers) and this may have a resistance between 50,000 and 500,000 ohms. As a general rule it is best to use as high a resistance as conveniently possible here, to avoid the effect of high-note loss which may occur when a lower resistance is connected across an L.F. transformer secondary or a gramophone pick-up.

As a volume-control is generally subjected to fairly constant wear, you should be careful to choose one that will not tend to cause scratching noises in reception after a period of a few months' use. Among the best types are those in which the wire winding is protected from wear by means of a spring disc or "squash plate" which is pressed into contact with the wire as the contact-arm is rotated; or those which have a very hard, composition resistance element that will not wear out prematurely.

Fixed Resistances.—Those available include flexible resistance links (commonly called "spaghetti" resistances), cartridge-type resistances, wire-ended resistors, tapped anode resistances, and so on. Some kinds are wire-wound, others are composed of a moulded resistance element.



DECOUPLING AND VOLTAGE-DROPPING ARRANGEMENTS.

Resistances in the anode circuit of a valve have the effect of reducing the H.T. potential applied to the anode. This voltage-dropping effect can be turned to good account, as shown by the example in Fig. 5, where voltage-dropping resistances are used to reduce the maximum available H.T. voltage of 120 to the lower values required for the anodes of the detector and L.F. valves. The resistances serve a dual purpose, not only dropping the voltage but also acting as decoupling resistances if used in conjunction with suitable fixed condensers (say, 2 mfd. each) as shown in the diagram.

In calculating the resistance required to drop a given voltage, divide the voltage to be dropped by the current in milliamperes, and multiply by 1,000. This gives you the answer in ohms. For example, if you have a 100-volt battery, and one of the valves in your set only needs 60 volts on its anode, you will want to drop 40 volts. If the valve in question passes an anode current of 2 milliamperes at 60 volts, then you will need a resistance of 20,000 ohms, because 40 (volts) ÷ 2 (milliamps) × 1,000 = 20,000 (ohms).

Grid-leaks are ordinarily obtainable in values ranging from 250,000 ohms to 5 megohms. For use before an ordinary detector valve, a 1, 2 or 3 megohm leak is usual, except in the case of a short-wave set when a 5 megohm grid-leak can often be used with advantage. (The associated grid condenser may be ·0003 mfd. with a 2 megohm and ·0001 with a 5 megohm grid-leak.)

In choosing fixed or variable resistances, take care that their current-rating is ample

for the current they will have to carry. The manufacturers generally indicate on the carton-labels the maximum current that can be carried safely without risk of overheating or burning-out.

SWITCHES

Every valve set requires an on-off switch. There is a wide choice of types, some merely for making and breaking the L.T. circuit, others for wavechanging or radio-gramophone change-over as well as for switching on and off. The types in common use are (*a*) push-pull switches, (*b*) toggle switches and (*c*) rotary switches.

For mains working, a switch must be properly insulated to render it shock-proof, it must be capable of handling the necessary power, and must have a quick make-and-break action. In the case of a battery set, quick make-and-break is not so important as good firm contact.

Wavechange switches are often incorporated in the bases of tuning coils; if there is more than one tuned circuit to be switched, the switches are ganged to enable them to be operated by moving a single knob.

In mains sets, thermal delay switches are often used. These allow a little time to elapse between the switching-on of the L.T. current and the application of the H.T. potential, thus permitting the valves to heat up and give their full emission before the H.T. comes on. This avoids peak voltages with risk of damage to certain components.

TRANSFORMERS

H.F. Transformers.—Although not very widely used nowadays, these provide one method of coupling between an H.F. valve and the next valve in the circuit.

I.F. Transformers.—These are used in superheterodyne circuits, and are fitted with metal screening covers to prevent unwanted couplings with other parts of the circuit.

L.F. Transformers. — These can be obtained in various ratios, 3 to 1 and 5 to 1 being the most popular ratios for ordinary use. The bigger the step-up ratio, the bigger the amplification obtainable, but it is not always practicable to use a high ratio.

Modern L.F. transformers with cores of special alloys instead of iron are very small and compact ; but it is usually necessary to connect them on the parallel-feed principle. This diverts the direct battery-current from the primary winding of the transformer, with the result that the effective inductance of the primary is much higher than it would be if several milliamps. of direct current were flowing through it.

Input Transformers.—An input transformer is sometimes needed with a gramophone pick-up. A transformer is an advantage, for instance, if the leads from the pick-up have to be rather long. A 1–1 ratio is suitable if the pick-up has a fairly big output, but if the output from the pick-up is not as powerful as you would wish, it can be " boosted up " by using a step-up transformer having a ratio of, say 3–1. An ordinary L.F. intervalve transformer of the parallel-feed type can be used for this purpose.

Output Transformers.—Output transformers are widely used in conjunction with moving-coil loud-speakers. As it is important that the transformer be such as will ensure correct matching, many types of M.C. speaker incorporate a transformer as an intergral part of the speaker assembly.

Mains Transformers.—A mains transformer usually has a primary winding with tappings for connection to A.C. mains of different voltages ; and one or more secondary windings, which are often centre-tapped. The secondaries supply H.T. current (which has to be rectified and smoothed into a suitable direct current) for the valve anodes, screening grids, etc. ; and L.T. current (4 volts A.C.) for the filaments of indirectly-heated A.C. valves, rectifier valve, etc.

The choice of a mains transformer depends chiefly on the rectifier that is to be used with it, and on the voltage and current required. Manufacturers issue pamphlets indicating the types of transformers and rectifiers suitable for use in conjunction with one another for given outputs and these should be consulted when making a choice. (See Chapters X and XI.)

VALVE HOLDERS

Apart from special types, valve holders may be divided into two classes: (*a*) baseboard mounting and (*b*) chassis mounting. The former class are intended to be screwed down on to the upper surface of a wooden or metallised wood baseboard, and the wiring to their terminals carried out above the baseboard. The latter class are bolted to a metal chassis, and the wiring carried out below the "deck."

The number of sockets or contacts varies, according to the type of valve the holder is to accommodate, from four up to seven or more.

Some types of valve holders are fitted with screw terminals for solderless connections; others have tags only, and to these the connecting wires have to be soldered.

CHAPTER III

CHOOSING ACCESSORIES

AERIALS

APART from "freak" aerials of various kinds, there are three different classes to choose from. These, ranged in order of general efficiency, are (*a*) outdoor aerials, (*b*) indoor aerials and (*c*) loop or frame aerials.

Practical tests will show which of these is best for use with a particular set in a given locality.

OUTDOOR AERIALS.—In buying wire for an outdoor aerial you have a choice of (*a*) bare copper, 7/22 stranded; (*b*) enamelled copper, 7/22 stranded, and (*c*) various patent kinds of stranded aerial wire with vulcanised or other insulating coverings.

Bare copper is very liable to rapid surface corrosion when exposed to the sooty air of large towns or the salt air of a seaside place. The enamelled or insulated kinds last much longer, and so save the expense of freqnent replacement.

INDOOR AERIALS.—For indoor aerials single D.C.C. or D.S.C. copper wire of 18 gauge, or even thinner, can be used.

Thin flex also gives satisfactory results. Among patent types of indoor aerials there are some good metallised tape aerials that can be put up very inconspicuously around the walls of a room

FRAME AERIALS.—Frame aerials can either be bought ready-made or constructed and wound at home, with D.S.C. copper wire of a suitable gauge, or special wire sold for the purpose.

BATTERIES

The three batteries needed for an ordinary valve set are (*a*) the low-tension, which heats the filaments of the valves; (*b*) the high-tension, which applies a positive potential to the anodes, screening grids, etc., of the valves and feeds them with current; and (*c*) the grid-bias, which applies, usually, a negative potential to the control grids of certain valves in the set. (See Fig. 6.)

L.T. ACCUMULATORS.—An accumulator (2 volts, as a rule, but occasionally 4 or 6) is the normal source of L.T. current for battery-driven receivers. In buying an accumulator you have the choice of (*a*) glass cells, which are efficient and leak-proof; (*b*) celluloid cells, which are lighter and smaller for a given capacity, but sometimes tend to leak after a time, and are, of course, rather inflammable; and (*c*) a "block" cell, enclosed in a bakelite case, which is

compact in size and relatively light in proportion to its capacity.

For portable sets, non-spillable models are available, and there are miniature types for "midget" sets.

In deciding what capacity accumulator to buy, add up the total L.T. current con-

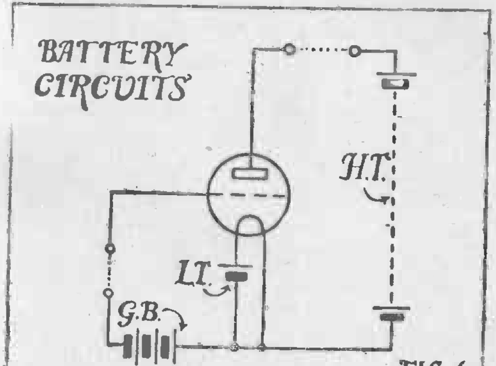


FIG. 6

SHOWING THE BATTERIES NEEDED FOR A SET.

sumed by your valves, and select an accumulator with a maximum discharge rate that will allow a margin of safety outside this total.

A convenient capacity for an accumulator is one that will work the set for about fifty hours on each charge. (This means that if you have the set on for three or four hours a day, the accumulator will need to be recharged about once a fortnight.)

To find the necessary capacity, simply multiply the total filament current of the valves by fifty and get a qualified dealer to show you a choice of cells having this capacity reckoned at a 50-hour rating or less.

H.T. ACCUMULATORS.—Some listeners like accumulators for H.T. supply as well as L.T. A capacity of 1,000 to 2,000 milliamp. hours is ample for an ordinary type of set.

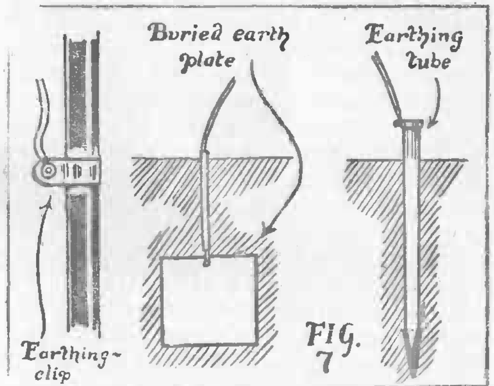
Accumulators provide a reliable source of H.T. current of unvarying voltage during the greater part of discharge. Unlike dry batteries, they can, of course, be recharged when run down, but are of higher initial cost, and of greater weight and size.

H.T. VIBRATORS.—These, in conjunction with other components, enable you to make up a power unit to give H.T. supply from an L.T. accumulator (4 or 6 volts).

EARTHING DEVICES

For an earth connection you can use (*a*) an earthing clip clamped tightly to a main water pipe (which should first be scraped clean and bright at the point of contact) preferably near the place at which it emerges from the ground ; (*b*) a metal plate at least a foot square (preferably larger) buried at a depth of at least two feet (preferably more)

in moist soil ; (*c*) an earthing tube, driven into moist soil ; or (*d*) one of the special chemical earthing devices on the market which help to keep the soil around the earth connection moist and thus ensure a low-resistance earth. (Types *a*, *b* and *c* are shown in Fig. 7.)



THREE POPULAR TYPES OF EARTH-CONNECTION.

Heavy stranded wire, vulcanised, should be used for the earth lead from the set to the buried or water-pipe contact.

FUSES

To protect your apparatus from damage in the event of a short-circuit or wrong connection, suitable fuses are needed.

The two chief types in general use are (*a*) bulb fuses, resembling flash-lamp bulbs, and (*b*) cartridge fuses, consisting of a fuse wire enclosed in a hermetically sealed glass tube with metal end-caps clipping into a holder.

Fuse-bulbs are usually sold in 60 or 100 milliamp. ratings; the cartridge type are available in ratings varying from 60 milliamps. to 1 amp.

In an ordinary battery set, a fuse-bulb in series with the H.T. negative lead will protect the valve filaments. It will also protect the H.T. battery, unless there is more than one H.T. positive lead. If there are H.T. positive leads going to intermediate tappings on the battery, it is advisable to fit a fuse in each of these leads if you want to ensure complete protection for the battery.

A convenient alternative to ordinary fuses is provided by special wander-plugs having suitable fuses incorporated as an integral part of the plug.

Twin fuses, preferably of the type with an insulating box-holder to eliminate risk of shock, should be used in mains leads.

GRAMOPHONE PICK-UPS

Pick-ups range in price from a few shillings up to several pounds. The output of the cheaper models is often as big as that of the more expensive types, but the frequency-

response and quality of reproduction of the former is naturally not so good.

Another point is that the more expensive models are usually designed to give more perfect "tracking," which reduces wear on records and gives better results.

Yet another little feature of convenience that you get in return for the bigger outlay is that the pick-up head is pivoted or rotatable to make needle-changing easier.

Some types of pick-up are made to fit on to the tone arms of existing gramophones; other types (which are in the vast majority) are complete with carrier-arms, and often incorporate a volume-control as an integral part of the assembly.

LOUD-SPEAKERS AND HEADPHONES

BALANCED - ARMATURE SPEAKERS. — The chief advantages of a moving-iron speaker, such as the balanced-armature type, are its cheapness and the ease with which the necessary diaphragm, etc., may be made at home. It is sensitive to small outputs, and if properly arranged with a cone diaphragm of adequate diameter and a large baffle or cabinet will give reasonably good reproduction. Its drawbacks are that it will not handle a really big output without serious overloading and it does not reproduce low or very high, notes properly (in other words, its frequency range is much smaller than that of a moving-coil speaker).

MOVING-COIL SPEAKERS.—M.C. speakers have a number of advantages over the moving-iron types which they have almost entirely superseded. They have a wide frequency-range, giving true value to low notes; and they can handle big volume without distortion or overloading.

The overall sizes of M.C. speakers vary considerably with different models; some are remarkably small, and are intended for use in "midget" receivers, portables, etc.

There are two classes of M.C. speakers: (*a*) the type employing a mains-energised (or occasionally battery-energised) magnet system, and (*b*) the permanent-magnet type. The latter is the more convenient of the two, and is, of course, the obvious choice in the case of battery-driven sets. The energised type is, however, a little more efficient, and may be a better choice for a mains set. Incidentally, it is often possible to use the field coil, which energises the magnet, for a dual purpose, allowing it to take the place of the smoothing choke in the H.T. supply circuit of a mains set.

There are other types of loud-speaker that offer interesting possibilities, but are not yet in general use among ordinary listeners.

HEADPHONES.—The only sets with which headphones are needed nowadays are crystal

sets (often regarded as obsolete, although they still have their uses in certain circumstances, and there must be thousands continuing to give good service in many districts); one-valve sets, unless of a special type using a multi-electrode valve that will give L.S. results within limited range of a station; and some of the smaller short-wave sets.

METERS

The cheapest meters for radio testing are small pocket voltmeters and milliammeters of the moving-iron type. At a slightly higher price you can get similar instruments combining L.T. and H.T. voltage readings with a milliamp. scale; the ranges may be, say, 0–6 and 0–120 volts and 0–30 milliamps.

If the meter is to be used much for checking the voltage of a 2-volt accumulator, it is important to choose a meter that gives sufficient deflection of the pointer on 2 volts to permit of reasonably accurate reading.

For higher accuracy than is obtainable with a moving-iron instrument, you need to use a moving-coil meter. Some very versatile combination meters testing volts, amps., milliamps. and ohms, are obtainable at a couple of guineas or so for the small types and about four times that price for highly accurate meters suitable for professional as well as amateur work.

These multi-range meters are extremely useful for all testing and fault-tracing in radio receivers or accessories.

VALVES

The enormous range of receiving valves now available can be divided at once into two chief categories: (*a*) battery-operated, and (*b*) mains-operated valves.

The different types include two-electrode (diode), three-electrode (triode), four-electrode (tetrode), five electrode (pentode) valves and types with an even larger number of electrodes, such as the heptode. Some kinds, again, consist virtually of two or more valves enclosed within one bulb—"Class-B" output valves and double-diode triodes, for example.

Screen-grid valves and H.F. pentodes have almost entirely superseded 3-electrode valves as H.F. amplifiers, and are also used fairly frequently as detectors. Three-electrode valves are used in L.F. stages, but in many cases they have been superseded by power pentodes for the output stage.

For A.C. mains, indirectly-heated valves, having a heating element in addition to the cathode (the actual electron-emitter), are generally used, except in the output stage, where it is possible to use a directly-heated valve without unduly increasing extraneous noise.

Some of the multi-electrode valves have special uses in superheterodyne circuits (one valve being made to do the work previously done by several) and in automatic volume control systems.

Certain types of valves can be obtained with metallised glass bulbs, which are earthed for screening purposes; and then, of course, there is a range of "catkin" valves having an unbreakable metal exterior.

For "midget" sets, tiny valves can be obtained, which consume a relatively small current and are, therefore, suitable for use in conjunction with the special miniature accumulators (mentioned on p. 37) and small H.T. batteries.

(For types of valves used in various positions in typical sets, see circuit diagrams later.)

CHAPTER IV

CHASSIS AND CABINET CONSTRUCTION

THE pleasing simplicity of modern design in furniture can easily be extended to radio cabinet-work without impairing technical qualifications in the least. There is no longer the slightest necessity for the exterior of a set to be rendered ugly and untidy by a heterogeneous collection of wires, terminals and numerous knobs!

The following hints will enable you to design and construct a chassis and cabinet suited to your own requirements, and to decorate the exterior in a way that will harmonise with the rest of the furnishing scheme of the room or rooms in which the set is to be used. I am assuming, of course, that you are conversant with the necessary tools and their use in simple cabinet making.

TYPES OF CHASSIS AND BASEBOARD ASSEMBLIES. — The kinds of chassis, etc., commonly used as the foundation, so to speak, of radio sets are (*a*) all-metal chassis; (*b*) wood and metal, comprising, for example, an aluminium panel and screen together with a plywood baseboard; (*c*) a baseboard and panel or chassis made of special

metallised wood which can be obtained ready prepared for this purpose; (*d*) an all-wood panel and baseboard; and (*e*) an ebonite or bakelite panel with a wooden baseboard.

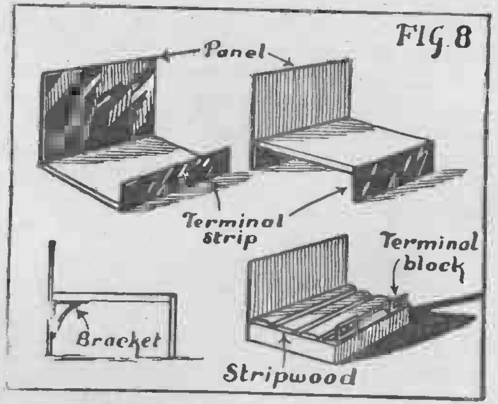
Which of these is most suitable for a home-built set depends very largely on the type of set. Where very complete screening is desirable, an all-metal chassis, such as is used in a great many factory-built receivers, is certainly the best choice. An incidental point of convenience is that the chassis can be used as a conductor to take the place of certain earthed leads, thus minimising the wiring required in connecting up the components.

If, however, the circuit is one that does not call for elaborate screening, the use of a metal chassis is hardly worth while, since it is not so easily worked with ordinary tools and is comparatively expensive if of good quality. Wood, either plain or metal-covered, is cheaper and much easier to deal with. The specially-prepared metal-covered kind offers some of the advantages of a metal chassis without its drawbacks.

The type of cabinet that is to be used to house the set must, of course, be taken into consideration when deciding on the design for the chassis, etc. The question of cabinets will be gone into later.

The simplest kind of " foundation " for a set is that consisting of a vertical panel screwed at its lower edge to a horizontal baseboard. Usually there is a terminal strip or a couple of terminal mounts at the back.

A more modern development of this simple scheme is arrived at by raising the baseboard on strips of wood so as to allow of

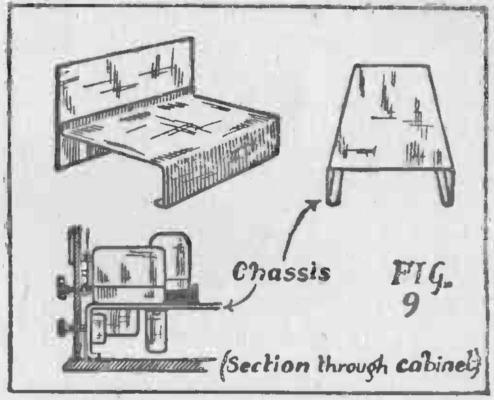


SIMPLE "FOUNDATIONS" FOR A SET.

small components, such as condensers and resistances, being mounted on the underside of the baseboard. This makes a much neater job.

It may even be worth while, in some cases, carrying the idea a step farther by securing the baseboard halfway up the front panel,

leaving room for comparatively large components either above or below the baseboard. This sometimes makes for very compact assembly. Moreover, with metallised wood, the different parts of the circuit which need to be well separated can be effectively screened off from one another.



METAL CHASSIS AND METHOD OF MOUNTING COMPONENTS.

A good idea for a simple set (especially a short-wave one, where you want to avoid having too much solid material close up to the coils and components) is to build up a baseboard of stripwood. This, incidentally, makes for easy wiring, as any leads that have to go through the baseboard can be taken between the narrow strips without any need for drilling holes.

Incidentally, when drilling holes for this purpose in a metallised baseboard, it is a good idea to cut away the metal for a radius of a quarter-inch or so around the hole, to avoid risk of shorting. This cutting can be done with a brace and half-inch bit.

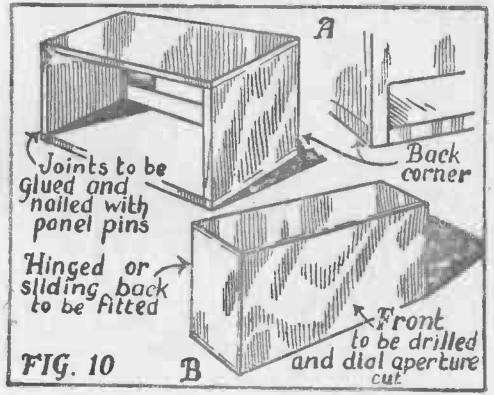
With certain types of cabinet (as will be explained later) no panel is necessary. The parts are assembled on a plain chassis, and holes are drilled in the front of the cabinet to take the spindles of variable controls, dial escutcheons, etc.

The construction of the various chassis assemblies will be obvious from the details given in Figs. 8 and 9. Aluminium sheets and panels can be obtained cut to size, and the necessary bending is facilitated by clamping the sheets of metal between thick strips of wood.

CABINET DESIGN AND CONSTRUCTION.—There is plenty of scope for originality in designing cabinets for sets, radiograms and loud-speakers. Of course, the design is limited to some extent by technical considerations, but apart from these there is no need to stick rigidly to conventional plans.

There are five general classes of cabinets: (*a*) those that house the set itself without any accessories, except perhaps the grid-

bias battery; (*b*) those that house the set and all batteries; (*c*) those that house the set, batteries (or mains apparatus, of course) and loud-speaker; (*d*) those that house a gramophone turntable, motor and pick-up in addition to the set, power supply apparatus and speaker; and (*e*) those that house a separate loud-speaker only.

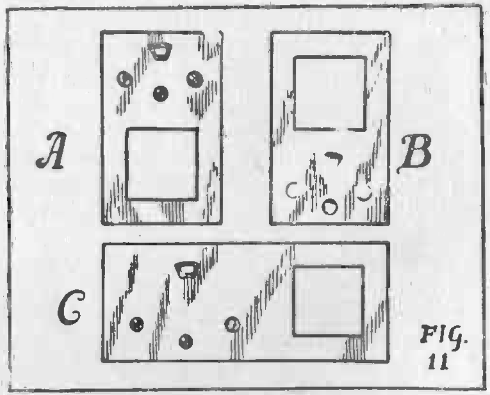


TWO SIMPLE TYPES OF CABINETS.

A very simple type of cabinet for a set alone is shown in Fig. 10 (*a*). This is suitable for a set having a vertical panel attached to a baseboard. The latter slides into the cabinet from the front.

A similar type of cabinet, but for a chassis-built set without panel, is shown in Fig. 10 (*b*).

Before inserting the set (which slides in from the back), the wooden front of the cabinet must be drilled at appropriate points to take the spindles of the variable controls and a suitable aperture must be cut for the dial escutcheon.

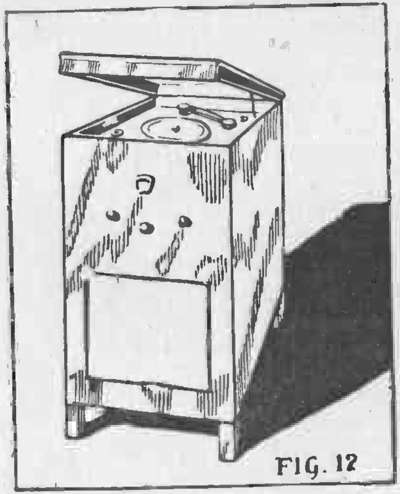


CABINETS FOR SELF-CONTAINED SETS.

As a natural development from this we get a similar design but on a larger scale with accommodation for a built-in loud-speaker. There are three convenient positions for the loud-speaker sound aperture; these are shown in Fig. 11 (*a*, *b* and *c*). It would not be advisable to have the speaker to the left of the set (as seen from the front) unless

the circuit was specially designed, for, in the case of a normal lay-out, this would bring the speaker close to the H.F or input end of the set and might cause howling.

In the design shown by Fig. 11 (*a*) it is necessary to fix a shelf, or at least a pair of



A RADIOGRAM CABINET.

stout wood strips forming bearers, to support the set. In the other two designs, of course, the set can rest on the "floor" of the cabinet.

With the addition of a gramophone

equipment, of course, a more elaborate type of cabinet becomes necessary. A typical conventional arrangement is shown in Fig. 12.

Taking these everyday designs as an elementary basis on which to exercise your ingenuity, it is a fairly easy and very interesting job to devise something out-of-the-ordinary that is more specifically adapted to your individual requirements.

There is a wide choice of suitable woods, including such obvious ones as oak, mahogany and walnut. If you decide on a cabinet of fairly conventional design and a standard size, your local wireless dealer or wood shop can get you a "kit" or parcel containing all the necessary wood, mouldings, etc., planed and cut to size ready for assembly.

If you prefer working out a cabinet to your own design, of a size exactly suited to the set and speaker you are going to use, it is worth while to take the fullest possible advantage of the various special mouldings (grooved and ornamental), stripwood, etc., which you can buy from a local dealer in cabinet woods and fretwork materials. Many of these mouldings, etc., greatly facilitate construction and improve appearance, especially in making a cabinet of plywood, the edges of which need to be concealed.

CABINET FINISHING AND DECORATING.—Apart from the usual methods of staining and polishing, there are other ways of finishing or decorating a wireless cabinet which give it a distinctive appearance appealing to those who like something out of the ordinary.

There are plenty of easily-applied and (more or less) quick-drying finishes of various kinds on the market. Most of them can be applied with an ordinary soft paint-brush.

One of the easiest finishes to apply is aluminium paint. This is certainly rather unconventional for a wireless cabinet, and if used on a big scale would look too "tinny." But on a small cabinet, with contrasting fittings of polished black bakelite, the effect is definitely pleasing and striking. The paint dries quickly, and if two or three coats are applied thinly and evenly with a very soft brush (after glass-papering the wood perfectly smooth and removing all dust), a good matt finish of satiny smoothness will be obtained.

For those who like a coloured cabinet, oriental lacquers are very pleasing. A fine, hard, glossy surface can be obtained if sufficient trouble is taken in applying successive coats and rubbing down thoroughly in between the coats. This process takes rather a long time to do properly, but the results make the time and trouble worth while.

Ordinary enamel, in appropriate dark colours, also makes an effective finish. After applying anything of a paint-like nature, it is necessary to place the cabinet in as dust-free an atmosphere as possible while drying. Any grit settling on the wet surface will spoil the appearance and be difficult to remove once the paint or enamel has dried hard.

There are various patent preparations of the combined stain-and-polish type, that form quite a good and easily-applied finish for wireless cabinets.

But perhaps the best finishes of all are the most obvious ones, namely, (*a*) stain and french polish, and (*b*) stain and white hard spirit varnish. French polishing, of course, is a job which calls for considerable skill and experience to get the best results, although there are available some excellent brands of special rapid french polishes (sometimes combined with suitable stains) which greatly facilitate the job for an amateur.

Before staining, the wood should be thoroughly smoothed with sandpaper, and the grain completely blocked with wood-filler to produce a hard, smooth surface. The final rubbing down should be done with very fine glasspaper, finishing with a worn piece.

You will find a variety of cabinet designs, with full instructions for their construction and finishing, in *Wireless and Gramophone Cabinet Making*, a 1s. volume in Messrs. Foulsham's Do It Yourself Series.

CHAPTER V

SET DESIGNING SIMPLIFIED

Designing one's own set is a fascinating job, and not as difficult as might be supposed, although it calls for a good deal of care and ingenuity if the receiver is of an ambitious type.

In tackling the work of designing a lay-out, you may feel that you do not know where to begin! Quite a good plan is to take the theoretical circuit diagram and, as a start, to arrange the parts as nearly as possible in the relative positions they occupy in the diagram. Then, gradually rearrange them as requisite to form a more compact, convenient and practical lay-out.

The simple two-valve circuit (detector and L.F.) in Fig. 13 will provide a typical illustration. From the arrangement in the circuit diagram, comparatively little re-shuffling is required to bring the parts into the more compact and convenient positions shown in Fig. 14. There is plenty of room towards the rear edge of the baseboard for the addition of a decoupling resistance and condenser if desired.

If you should wish to add a choke-capacity output filter, the necessary L.F. choke and

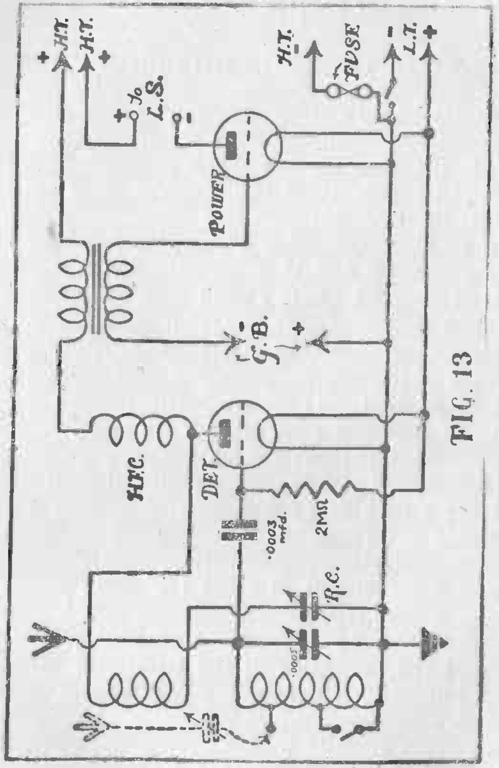


FIG. 13

A SIMPLE TWO-VALVE CIRCUIT.

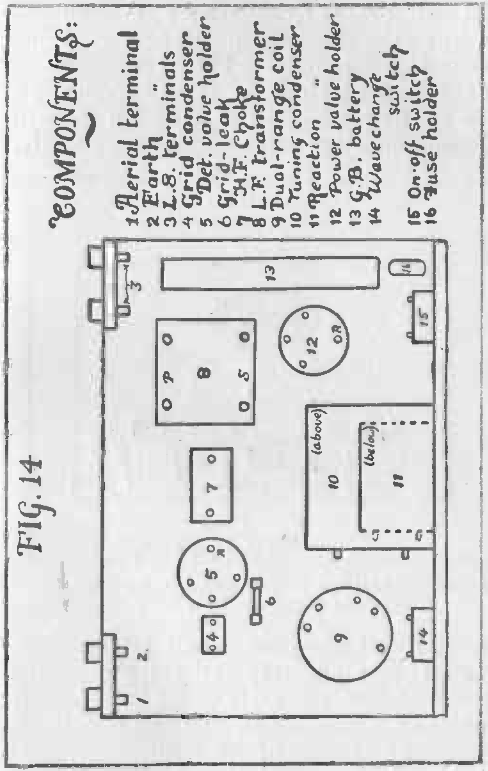


FIG. 14

SUGGESTED LAY-OUT FOR COMPONENTS IN THE FIG. 13 CIRCUIT.

condenser could be accommodated to the right of the G.B. battery's position in Fig. 14, the baseboard, of course, being enlarged accordingly. Fig. 14*a* shows a suitable panel lay-out for this two-valve set.

To the detector and L.F. circuit a stage of H.F. amplification can be added very easily.

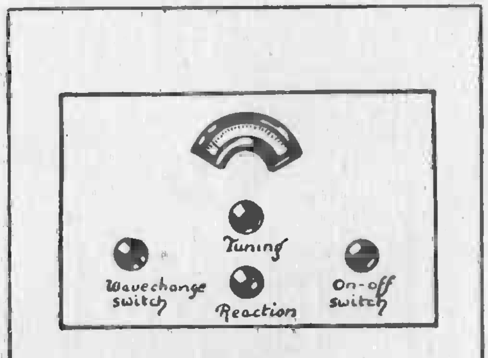


FIG. 14A

SUITABLE PANEL LAY-OUT FOR THE BASEBOARD ASSEMBLY SHOWN IN FIG. 14.

Fig. 15 shows a simple circuit arrangement for an H.F. stage employing a screen-grid valve, and how the parts could be arranged in practice, employing an ordinary metallised baseboard and a vertical screen.

The components associated with the grid circuit of the S.G. valve need to be screened

off from those in the anode circuit. A convenient way of doing this is to enclose the grid circuit components inside a metal (aluminium or copper) screening box. The S.G. valve should be of the metallised-bulb type to complete the screening effect.

With some small additions or modifica-

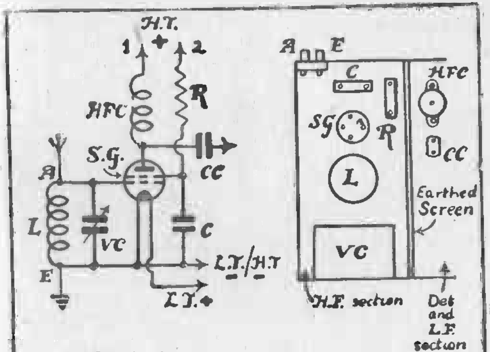


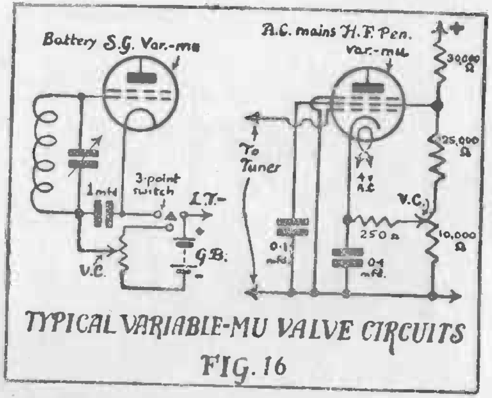
FIG. 15

AN H.F. STAGE IN THEORETICAL AND PRACTICAL FORM.

tions, these schemes are equally applicable to variable-mu valves (Fig. 16) or H.F. pentodes (Fig. 17).

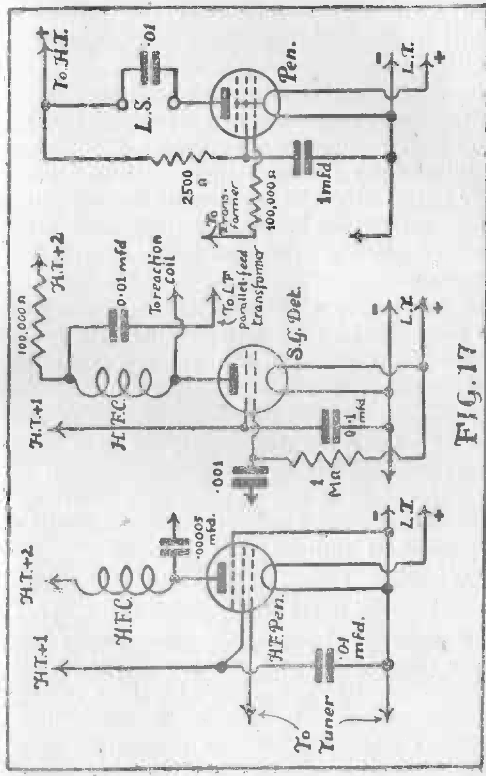
When two H.F. stages are required, very careful and complete screening and thorough decoupling in S.G. and anode circuits is usually necessary to ensure stability. With this proviso, the lay-out of the single stage might be duplicated for the most part.

Only slight modifications are necessary in order to use a screen-grid valve in the detector stage, or a power pentode in the output stage. (See Fig. 17.)



VOLUME-CONTROL ARRANGEMENTS, ETC., FOR VARIABLE-MU VALVES.

The suggested lay-outs shown in the diagrams are the most obvious arrangements, and taking these as a starting-point, you can vary and adapt the details to suit your own individual requirements and to take advantage of all the latest developments as they come along from time to time.



SUITABLE CIRCUIT ARRANGEMENTS FOR H.F. PENTODE, S.G. DETECTOR AND OUTPUT PENTODE.

In working out designs and lay-outs of your own, you should bear the following points in mind if you want to get the best results :—

(*a*) All inductive windings, such as tuning coils, chokes and transformers, should be so placed that there is no unwanted coupling or interaction between them. If two coils have to be fairly near to one another, coupling can be minimised by placing them with their axes at right angles, and, of course, by screening.

(*b*) Connections between tuning coils and the variable condensers in parallel with them should be short and direct, especially in short-wave sets.

(*c*) Generally speaking, components in the grid circuit of a valve should be kept well separated from those in the anode circuit of the valve. This also applies to the wiring. All connections in the grid circuits should be kept as short and direct as possible.

(*d*) Sufficient clearance should be allowed for all moving parts (such as the rotor vanes of non-screened variable condensers) to rotate freely throughout their arc of travel without fouling any other parts, scraping against wiring, or causing short-circuits. (There is less need for this precaution now than formerly, owing to the increased tendency for components with moving parts

to be totally enclosed in moulded covers or screening cases.)

Designing Portables. — Portable sets follow the same basic principles of design as ordinary receivers, but the lay-out has to be modified to attain the most compact assembly possible. The components, too, have to be selected with a view to keeping the weight and overall size of the set down to a minimum.

By exercising ingenuity and by careful screening at critical points, you can attain a very compact lay-out. But the overall dimensions of the outfit should not be reduced by undue crowding of the components. This not only tends to produce faults but also makes many of the parts so inaccessible, once the set is built, that the location of troubles and replacement of faulty components becomes a most awkward and tedious job.

As one is restricted in regard to batteries for a portable by considerations of size and weight, the valves chosen should be of types that take a relatively small current and do not require a very high H.T. voltage.

If a very small, light portable is required, special valves, components and batteries of the "midget" type can be used.

CHAPTER VI

SET BUILDING SIMPLIFIED

When you have decided on the type of set you propose to build, and have either worked out a design of your own or selected a suitable one from the wide choice of published specifications (appearing in most of the weekly or monthly wireless technical journals) a shopping expedition becomes necessary!

If you are going to build your own cabinet, you will need to get the wood, mouldings, and various fittings required; a local shop will probably be able to supply all you need, but failing that you can get supplies direct from one of the big firms that specialise in these goods.

Any sheet aluminium or copper, or metallised wood baseboards, can usually be obtained through your radio dealer or direct from a metal supply firm.

The actual components and accessories, of course, you will select from the fascinating assortment of gleaming gadgets displayed at the local radio shop.

When you have prepared the chassis or baseboard and panel, and laid out all the components and tools conveniently to hand

on a table or bench, arrange and mount the various components. Panel mounting parts are secured, in holes drilled to receive them, by means of their one-hole fixing-bushes. Baseboard-mounting parts are secured to the wood by means of suitable wood-screws; the latter should be of the round-headed type, unless the holes in the fixing lugs are countersunk. If a metal chassis is used, of course, the "baseboard mounting" parts are secured by means of bolts and nuts. The chassis has to be suitably drilled beforehand to take these fixing bolts, and holes must also be drilled in it to permit of wires passing through from the upper surface of the chassis to the under part, where necessary.

With some sets of very straightforward and "open" design, it does not matter in what order the components are assembled. In the case of a set having a very compact or complicated lay-out, however, it may be very necessary to mount the parts in a certain order, otherwise you may find that, after fixing certain components in position, you cannot "get at" the "sites" for the others.

Often it is best to work from the front panel backwards, mounting the variable condensers, switches and so on, first, and the baseboard - mounting or chassis - mounting components afterwards.

One-hole fixing nuts should be well

tightened to avoid any likelihood of the components twisting round or working loose. On a metal panel, they sometimes grip better if a slight burr is left around the drilled hole, instead of smoothing the edges after drilling.

In mounting valve-holders or any parts with metal contact-screws, etc., on the under surface, take great care that these screws do not make unintentional contact with the metal of a chassis or metallised baseboard. Sometimes it is best to slip washers under the fixing-lugs to raise the component off the surface of the metal and provide an air-space under it.

When all the components have been assembled and mounted correctly, all that remains is to wire up the set by making all necessary connections between terminals, etc.

There are two ways of wiring up a home-built set ; some people prefer one way, some prefer the other. One is to make solderless connections by forming the ends of the connecting-wires into "clockwise" loops (with the aid of round-nosed pliers) and clamping these loops under nuts or milled heads on the stems of the terminals ; the other way is to solder the wires either direct to the tips of the terminal-stems or to soldering-tags secured under the terminal-nuts. (For soldering see Chapter IX.)

To make efficient solderless connections, the wires and terminals must be clean and

bright at the points of contact, and the clamping-nuts must be screwed down firmly —but not, of course, so hard as to break the screw-thread !

Terminal-blocks, which can be obtained ready-made in bakelite, or made at home out of scrap ebonite, should be mounted at the back edge of the baseboard or chassis to accommodate the aerial and earth terminals or sockets, and also the loud-speaker terminals, unless a plug-and-jack connection is preferred for the speaker. In that case the jack can be mounted on the panel if desired.

There is more than one way of arranging the battery leads. A row of terminals can be mounted on an ebonite strip at the rear edge of the baseboard, the internal connections made to the stems of the terminals and external flex-leads used to link up with the batteries. Alternatively, flex-leads can be taken direct from the terminals of components such as transformers, chokes, etc., through holes in the back of the chassis, to the batteries. Or a third method is to make use of a multi-way battery cord.

CHAPTER VII

SET TESTING SIMPLIFIED

BEFORE explaining how to locate faults in a set, it might be as well to give a few hints on preventing them.

In general, one can guard against the development of a good many faults by keeping the whole of the apparatus protected as far as possible against dust, damp and undue heat.

Faults due to poor contact in the aerial and earth system can be minimised by avoiding joints as much as possible. It is best to keep the aerial wire in one continuous length and, in the case of an outdoor one, to bring it through a hollow lead-in tube direct to the aerial terminal of the set.

If there is an earthing switch, periodic attention to the contact-pieces and the insulation will help to ward off troubles in this direction. The contacts should be kept clean and bright, the connections to terminals sound, and the insulating surfaces free from grime.

Premature deterioration of dry batteries can be avoided by protecting them from heat and damp. They should not be placed too near a window, where direct sunlight

and moist air can get at them. They keep in best condition when so placed that cool, dry air can circulate freely all round them. It is a good plan, therefore, to place them on strips of wood raising them off the "floor" of the cabinet so as to allow an air-space underneath.

Flexible leads, especially those to batteries, should be examined periodically for signs of wear, breakage or corrosion. Plugs should be opened out with a penknife if necessary to ensure good contact in the battery sockets; and accumulator spade-tags should be kept free from corrosion. A light smear of vaseline helps. Care should be exercised when scraping off the sulphate that corrodes accumulator spade tags, as the dried acid is apt to be highly concentrated.

Correct charging is one of the most important factors in preventing accumulator trouble. In discharging, the cells should never be worked below the minimum voltage or specific gravity indicated on the labels or in the manufacturers' leaflets. It is especially harmful to let the cells stand for any considerable length of time in a discharged condition.

Breakdowns in chokes, coils, transformers and wire-wound resistances can be very largely prevented by avoiding any sudden surges of current liable to burn out the windings, by protecting them from damp, and by avoiding rough handling of any exposed windings. Coils of the iron-dust core type need especially careful handling, as any displacement of the core will alter the inductance, etc., of the winding.

WHEN A FUSE "BLOWS."—If the set suddenly ceases working, or seems absolutely "dead" when switched on, the fuse may have "blown" in protecting the rest of the apparatus against the effect of some fault or short-circuit that has occurred. This point should be checked up first of all.

A fuse of the bulb type can be tested by removing it from its holder and connecting it across a 2-volt accumulator or 1½-volt dry cell. If the filament glows it is intact, and you must seek elsewhere for the cause of the signal stoppage.

A cartridge-type fuse can be tested by means of a dry cell and a milliammeter. The meter needle will flick if the fuse is intact.

If you find that the fuse has "blown" (burnt out or fractured), you will need to discover the fault that caused it to "blow" and you will need to put matters right before inserting a new fuse, otherwise that will promptly "blow" too.

A high-resistance, high-reading voltmeter connected across the terminals of the fuse-holder will indicate whether there is a harmful short-circuit that caused the fuse to burn out. A milliammeter, of course,

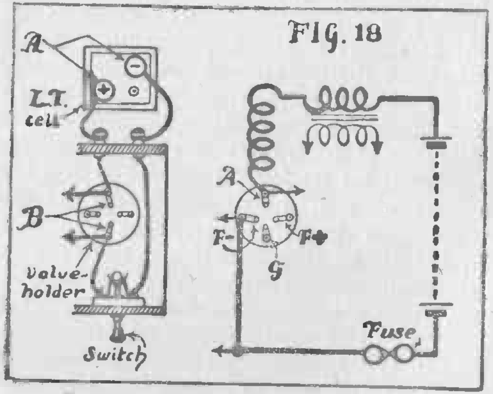
would indicate the fact equally well, but in the case of a serious short with a high voltage existing across the fuse-holder, there is a risk of passing an excessive current through the milliammeter if it will not read high enough for the test.

Do not attempt to make the set work by "shorting" the fuse-holder out of circuit, unless you are quite positive there is no fault in the H.T. and L.T. circuits. *Never* "short" a mains-set fuse.

FAULT-TRACING INSTRUMENTS.—A multi-range meter, as described in the chapter on the choice of accessories, is the most useful instrument for tracking down faults in a set and its associated batteries, etc. Other simple aids to trouble-tracing include a suitable dry battery, a pair of "test-prods" with flexible leads attached, a flash-lamp bulb, a pair of headphones, and a hydrometer for accumulator testing. Armed with these, you can test practically all the components and accessories used in an ordinary set.

"SHORT CUTS" IN SET-TESTING.—Fault-tracing can be done partly by inspection and partly by meter-tests, etc. Make a rapid inspection of the set and accessories to start with. Note whether all leads are correctly joined up to their respective terminals, whether all plugs are making good contact in their appropriate sockets, whether the valves are firmly inserted in their holders, whether switches and other moving parts are functioning correctly in response to the movement of control-knobs or levers, and so on.

If this preliminary search fails to reveal the fault by inspection, the next step is to test with instruments. A good deal of time



"SHORT CUTS" IN TRACING FAULTS.

and trouble can be saved by resorting to various "short cuts."

Suppose, for example, that you suspect an L.T. fault. A voltmeter test directly across the accumulator terminals will only reveal the condition of the cell itself, but if, instead of putting on the test-prods at this

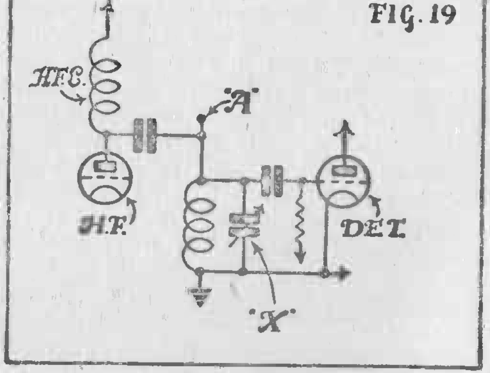
point (marked A on the left of Fig. 18), you put them on to the filament sockets of the valveholder marked B in Fig. 18, you will be able to ascertain whether the flexible leads from the cell, the internal L.T. wiring, the on-off switch and the valveholder filament sockets are in order, as well as ascertaining the state of the accumulator.

Again, a simple voltage test with a high-resistance meter connected between terminals "A" and "F +" of the detector valve-holder (on the right in Fig. 18) will show whether there is continuity through all the parts of the circuit shown by heavy black lines in the diagram, whereas a similar voltage test with the meter prods connected directly across the H.T. battery sockets would indicate nothing but the state of the battery itself. *Note that it is advisable to remove the valves from their holders before carrying out the test illustrated on the right in Fig.* 18.

NARROWING THE FIELD OF SEARCH.—Another short cut consists of narrowing down the field of search by isolating different sections of the circuit.

The H.F. stage can be cut right out of circuit straight away by connecting the aerial lead (preferably in series with a fixed or semi-variable condenser—especially in the case of a mains set) to the point marked "A" in Fig. 19. Tuning is then carried out on the variable condenser marked "X" only. If, on making this change, the set is found to be working correctly (making due allowance, of course, for the reduced strength and range resulting from loss of H.F. amplification), it is clear that the fault lies somewhere in the H.F. stage.

FIG. 19



CUTTING OUT H.F. STAGE

If, however, the set still refuses to work you can test the detector and output stages by a similar process of elimination. The detector stage can be tested separately by connecting a pair of headphones in the anode circuit of the detector valve. With

ordinary direct transformer coupling it will suffice to connect the 'phone leads across the primary winding of the L.F. transformer. With some circuits, it is preferable to connect the 'phones as shown in Fig. 20.

If a gramophone pick-up, known to be in correct working order, can be connected in the grid circuit of the L.F. or output valve,

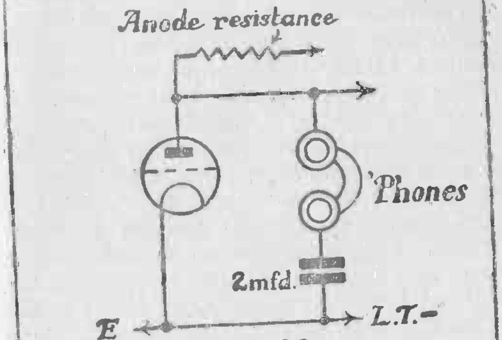


FIG. 20

TESTING WITH HEADPHONES.

and a record played over in the usual way with the set switched on and the loud-speaker connected up, this will indicate whether the fault lies in the L.F. stage or output circuit and loud-speaker. Alternatively, both the detector and the output stages could be checked in this way by connecting the pick-up in the grid circuit of the detector valve, that is to say, between grid and filament negative.

It should be clearly understood that testing with headphones and meters, while the set is working, with the power supplies switched on, is recommended for *battery-driven* sets *only*. It is wise to make a rule of never touching any part of the interior of a *mains*-driven set while the power supply is on; the set should be completely disconnected from the mains socket before you begin to test or examine the components inside the cabinet. Some mains sets, in fact, are so constructed that it is impossible to open the cabinet without first removing the mains plug. This is certainly a useful precaution, especially if the set is to be handled by non-technical listeners, as it eliminates any risk of direct shock from the mains; although there still remains the possibility of shock from charged-up fixed condensers of big capacity, unless these are short-circuited, *after* disconnecting the set from the mains, to discharge them.

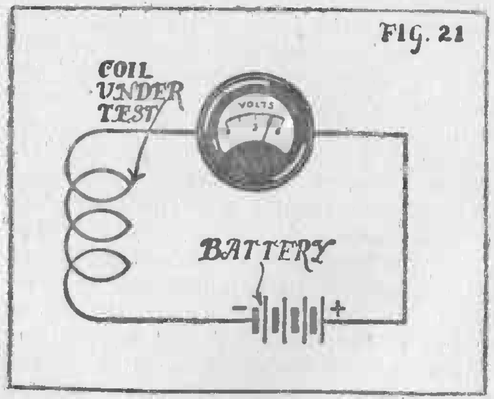
TESTING COMPONENTS.—With the aid of a multi-range meter, battery, test-prods and headphones, individual components can be tested, either as a precaution before building them into a new set, or as a means of locating faults in a set that has already been completely assembled.

Before carrying out any tests, make sure that your meter and battery are working correctly, for if the meter itself happens to be faulty, or the test battery is run down, you will get misleading results that may cause you to "scrap" a perfectly good component.

CONTINUITY TESTING.—You can find out whether there is a break in the winding of a coil, choke, transformer or wire-wound resistance by making a continuity test. For this you require a suitable battery and a test meter or, failing that, a flashlamp bulb or a pair of headphones.

The battery is connected in series with the suspected winding and the testing instrument—meter, lamp or 'phones. The voltage required for the test will depend on the resistance of the winding that is to be tested. To avoid any risk of damaging the winding you are testing, do not use a higher voltage than is necessary to give a conclusive indication. It is safest to start with a low voltage and increase it if necessary. You can get a suitable range of voltages by using an ordinary 9-volt or 16-volt grid-bias battery, tapped every 1½ volts, and an H.T. battery with the usual tappings at intermediate voltages.

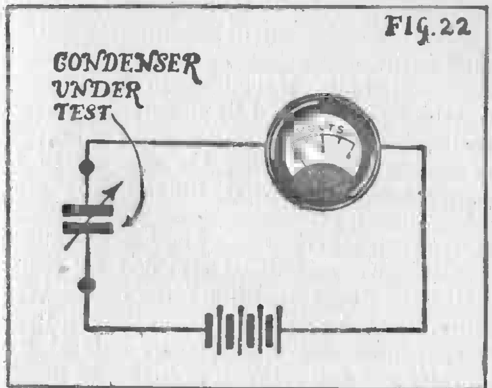
Fig. 21 shows how to test a coil-winding for continuity. If the wire is unbroken, the meter will show a reading when a suitable voltage is applied. Failure to obtain a reading indicates a break somewhere in the winding or connections to the terminals of the coil. In the case of a long winding of fine-gauge wire, if the winding is in order there should be a voltage drop, due to the resistance of the wire.



A CONTINUITY TEST.

An H.F. choke can be tested in this way, or by connecting a pair of headphones in place of the meter. If the choke is intact a click will be heard in the 'phones when you make or break the circuit. This test is also suitable for L.F. choke and transformer windings.

TESTING FOR SHORT-CIRCUITS.—Fig. 22 shows how you can test a variable condenser to see whether the moving plates are rubbing against the fixed ones and causing an intermittent short-circuit when they are rotated. If the condenser is working correctly, you should get no meter-reading. If, however,



TESTING FOR SHORT-CIRCUIT.

you find that the meter needle flickers or shows a reading as you rotate the moving vanes of the condenser through the full arc of their travel, this is an indication of a "short." It may be due to bent plates or bearings out of alignment.

A fixed condenser can be tested for short-circuit in a similar manner. In this case, if the condenser is of big capacity, the meter-needle will give a momentary flick on completing the circuit; this is due to the condenser charging up. But there should be no further meter reading; if there is, the condenser is faulty. Electrolytic condensers are an exception: they pass a fairly big momentary current on charging up, and a very small continuous current afterwards.

Short-circuits in coil-windings, etc., can usually be discovered by means of a battery and meter test which will reveal the presence of a short by showing the absence of the normal resistance that the winding offers when it is in order.

Testing Batteries.—The condition of an accumulator can be ascertained by testing with a voltmeter and hydrometer. When fully charged and before being put into use the accumulator should read a trifle over 2 volts per cell. When actually in use the voltage should remain steady at exactly 2 volts until the charge is nearly exhausted. When the voltage falls to 1·8 the cell should be recharged immediately.

Hydrometer readings show the specific gravity of the electrolyte (acid and distilled water) in the cell. This also gives a reliable indication of the state of the charge, as the S.G. falls during discharge. The label on the cells, or the manufacturers' pamphlets,

state the correct specific gravities for the cells when charged and when needing recharging. These figures vary with different makes of accumulator.

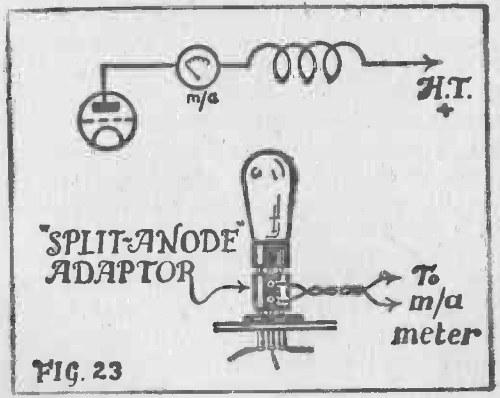
Many accumulators now are fitted with an indicator (working on the hydrometer principle) showing at a glance the state of the cells—whether "full," half-discharged or "empty." This type of indicator is very convenient for non-technical users. But, of course, a good hydrometer with graduated float gives the most accurate indication of the S.G.

In ascertaining the condition of an accumulator, the voltage reading and specific gravity should be considered in conjunction with one another. Either alone may be unreliable, in certain circumstances.

In testing a grid-bias battery with a voltmeter, it does not matter whether or not the battery is connected up to the set, or whether or not the set is switched on at the time. But in reading the voltage of an L.T. or H.T. accumulator or battery, it is important to take the reading when the cells are on load, which means that they should be connected up to the set and actually delivering current to the valves at the time the voltage is being measured.

Dry batteries and, to some extent, accumulators tend to recuperate lost voltage when they are standing idle. That is why a voltage reading taken when the cells are "off load" or "resting" may be very misleading.

As a matter of fact, the discrepancy between "on load" and "off load" readings is much greater in the case of a good, expensive, high-resistance voltmeter than it



USING A PLUG-IN ADAPTOR FOR METER CONNECTION.

is in the case of a cheap, comparatively low-resistance model, because the latter drains a fairly big current from the battery when connected across it, and this big current drain tends to make the voltage drop in the same way as it falls when supplying current to the valves in the set.

MEASURING ANODE CONSUMPTION.—Fig. 23 shows how the anode current consumed by a valve can be measured by means of a milliammeter. A "split-anode adaptor" (which can be bought for a few pence) affords an easy way of connecting the meter in circuit without disconnecting any of the ordinary wiring in the set.

A.C. HUM IN MAINS SETS.—A drawback to mains sets is the tendency to hum. In some cases the background hum may become sufficiently pronounced to mar reception, and then, of course, steps must be taken to get rid of the trouble. Fortunately a cure can often be effected quite easily when once the location or source of the hum has been traced.

A.C. mains hum may be picked up in a variety of ways. It may, for example, be "collected" by the aerial and earth system; or it may come direct from the mains, so to speak by way of the H.T. supply components; or, again, it may be induced by interaction between the transformers, chokes, etc., in the receiver and mains unit.

If the hum ceases or is greatly reduced on disconnecting the aerial and earth, it is probably picked up by one or other of these. See that the aerial does not run close to A.C. mains leads, either exposed or concealed in walls and floors. The use of special screened or shielded lead-in cable for an outdoor aerial should minimise pick-up of hum and other kinds of electrical interference.

Avoid overloading the H.F. valve or valves, as this sometimes tends to exaggerate any mains "ripple" picked up by the aerial.

Hum introduced directly through the H.T. supply is generally due to inadequate or faulty "smoothing"; a better smoothing choke and bigger reservoir condensers should effect a cure.

Other causes of hum include a poor earth connection; fracture of one filament in a full-wave rectifier valve; faults in decoupling arrangements; inadequate spacing between power leads and wiring; and interaction or coupling of some kind between components or wiring in the receiving circuit and components or wiring in the power "department" of the set.

The mains transformer, smoothing choke, etc., should be kept well away from other components if possible, and if excessive hum is troublesome it can be minimised by arranging the chokes and transformers in such a way that the coupling effect between them is reduced as much as possible. To find the best angle at which to mount them, it is usually necessary to experiment with different orientations.

CHAPTER VIII

A GUIDE TO FAULTS AND THEIR CAUSES

NOISES IN RECEPTION

Crackling Noises.—Crackling, grating and sizzling noises may be due to atmospherics, or to some fault in the set. Any doubt as to their cause can, however, be settled in most cases by simply disconnecting the aerial. If the crackles cease, or become greatly diminished in strength without the aerial, they are almost certainly due to atmospherics. And as atmospherics are a natural phenomenon, occurring chiefly in summer especially if the weather is thundery, they cannot be entirely eliminated, although their effect may be reduced by using a small indoor aerial instead of an outdoor one and by cutting down H.F. amplification.

Cessation of crackling on disconnecting the aerial might, of course, indicate a fault or breakage of some sort in the aerial wire, lead-in, etc., so that possibility should be taken into account before attributing the noise to natural causes.

If, however, the crackles continue quite unabated when the aerial is disconnected, they are clearly due to a fault somewhere in the set itself. The following is a list of possible causes (there may be others, but these are the most likely ones) :—

Run-down batteries ; faulty connections to accumulator ; badly-fitting wander-plugs ; broken wires ; break in stranded flex concealed under rubber or braided covering ; break in coil, choke or transformer windings ; loose terminal-nuts ; loose or displaced electrodes in valves ; faulty valve-holders ; faulty resistances (especially grid-leaks) ; intermittent shorting between fixed and moving plates of variable condensers ; faulty contact in moving parts, such as switches, variable resistances, volume controls, etc.

ELECTRICAL INTERFERENCE. — Various kinds of electrical apparatus and appliances when used in fairly close proximity to a wireless set often cause interference intermittently or continuously. The noises produced sometimes resemble atmospherics.

A typical example of electrical interference is the curious ticking noise heard in a set tuned to short waves (below 100 metres) when a motor-car passes near the aerial. This is caused by the magneto system of the car, and is more pronounced with some makes than others.

Some kinds of electrical machinery and appliances, especially if faulty or sparking

badly, cause very serious interference with wireless reception.

The trouble is best dealt with at its source, by correcting faults and, if possible, fitting suitable interference suppressors.

MECHANICAL VIBRATION. — Mechanical rattling, jarring or other unwanted vibratory noises sometimes occur in a loud-speaker when it is handling loud passages of music, etc. This trouble, if in a balanced-armature speaker, may be due to loosening of the nut on the chuck which secures the driving-rod to the centre of the cone diaphragm, or to a faulty joint between this rod and the armature itself, or merely to an accumulation of dust and grit between the armature and the pole-pieces.

In a moving-coil speaker, extraneous noises may be due to the moving coil having got slightly out of centre, or to dust and grit having found its way into the mechanism. (Many M.C. speakers are protected with a dust-proof bag ; this should not be removed, except when absolutely necessary for testing and adjustments to be carried out.) If delicate adjustments are needed, return the unit to the makers.

Any loose nuts, screws or fittings on the loud-speaker unit or cabinet, or a loose fret, or a fret-backing of tinsel fabric that is not stretched tightly enough and consequently vibrates in sympathy with the diaphragm on loud notes, may cause unpleasant rattling or vibrating noises.

CONTINUOUS OR INTERMITTENT HOWLING.—Whistles or howls may be due to oscillation through use of too much reaction on your own or a neighbour's set. If the howl varies in pitch as you alter the tuning, your own set is presumably the culprit.

Whistling or howling of constant pitch may be due to instability or feed-back of some sort in one of the amplifying stages.

A continuous whistle of constant pitch occurring on certain transmissions only is in all probability a heterodyne whistle due to insufficient frequency-separation between two transmissions on adjacent frequencies (wavelengths). The cause is obviously outside your control, but you can sometimes reduce the effect of the interference by adjusting the tone-control, if there is one on your set.

"MOTOR-BOATING."—This curious but appropriate name is given to the rapid "popping" noise, rather like the sound of a motor-boat engine, which sometimes occurs in sets as a result of inadequate decoupling arrangements or a run-down H.T. battery.

THRESHOLD HOWL.—This is a grunt, roar or howl which is heard when the reaction is increased until the set is just beginning to oscillate—i.e., on the "threshold" of oscillation. It is generally due to H.F. currents

finding their way into the L.F. part of the set, and can be cured by improving the H.F. choking and by-passing arrangements, and the decoupling in the anode circuit of the detector. A "grid-stopper" resistance may also help.

POOR QUALITY OR VOLUME

DISTORTION.—Among the causes of distortion, the commonest are :—

Incorrect grid-bias; run-down H.T. battery; run-down accumulator; worn-out valves; incorrectly-adjusted loud-speaker unit; too much reaction; instability in amplifier.

Overloading of the valves is perhaps *the* most frequent cause of distortion; it can usually be detected by violent flickering of the meter-pointer when a milliammeter is connected in the anode circuit of the valve that is being overloaded.

WEAKENED SIGNALS.—Loss of volume may be due to :—

Faults in aerial or earth system; run-down batteries; worn-out valves; incorrect adjustment of L.S. unit; incorrect reaction adjustment; incorrect grid-bias; faulty, corroded or high-resistance joints and connections in the set wiring; faulty contact in switches; break in reaction winding of tuning coil, etc.

BREAKDOWNS

NO SIGNALS, BUT SET "ALIVE."—If the set appears to be working but no signals are forthcoming (i.e., if there is the usual faint humming or "swishing" sound from the loud-speaker when the set is switched on, but no transmissions can be tuned in), the following are some likely causes :—

Break in aerial or earth system; break or "short" in tuning coils; faulty connection or "short" in tuning condensers; a faulty valve, probably in the H.F. or detector stages; a faulty valveholder; gramo.-radio switch accidentally left in "gramo." position; valves inserted in wrong order; incorrect H.T. battery connections; and breakdown in transformers, chokes or fixed condensers.

COMPLETE SILENCE—SET APPARENTLY UNWORKABLE.—If no sound at all can be heard (not even a click or faint hum) when the set is switched on and the various controls manipulated, the following causes may be suspected :—

Fuse "blown"; faulty switch; fault in loud-speaker or leads to it; break in battery leads; break in wiring of H.T. or L.T. circuits to output valve; run-down batteries; connections to H.T. battery accidentally reversed; fault in mains unit, or mains leads; and breakdown of mains supply.

CHAPTER IX

RADIO REPAIRS AND OVERHAULING

SKILL in soldering is a great asset when one comes to tackle radio repairs. A very neat job can be made of mending breakages, etc., with the aid of solder, where a clumsy and inefficient repair would result if one had to fall back on any other method.

Before dealing with repairs and overhauling, therefore, it might be well to give a few hints on radio soldering.

An electric soldering-iron, working off the mains, greatly facilitates the work and makes for efficient results.

Even with an ordinary type of soldering-iron, however, very good work can be done if the copper bit is heated in a clean flame, such as that from a blow-lamp or a gas-jet.

A clean, well-tinned bit, heated to just the right temperature, is half the battle. The bit should be tinned not merely at the extreme tip but for about an inch, at least, up from the tip. There are various methods of tinning, but the following everyday way gives quite satisfactory results :—

File the bit all over to get the surface clean, bright and free from dents, etc. Heat to the requisite temperature, then file the surface quickly again, apply soldering-fluid or flux, and tin all sides of the iron thoroughly with solder. Some solder can be melted into a tin lid, and the hot bit rubbed in the solder until it is evenly coated over all sides Or a blob of solder can be dropped on to each side of the bit in turn, and spread over the surface with a match stick or a piece of tinned copper wire thrust into an old file handle to form a tinning tool.

If the iron is heated in a gas flame, you will generally find that the bit is at about the right temperature for tinning when the colour of the flame around it changes from blue to a vivid green.

The iron will need re-heating at intervals as the work progresses. But it should not be overheated, as the solder will then " boil off " in beads and the copper will need re-tinning.

Scrupulous cleanliness is perhaps the greatest " secret " of success in radio soldering. All the metal surfaces to be soldered (soldering-tags or terminals, connecting wire, etc.) must be rubbed with a file, or emery, or sandpaper, until they are perfectly clean and bright, and then they must be well tinned.

Making a perfect joint between a well-tinned soldering-tag and a piece of tinned copper wire is delightfully easy with a well-tinned and properly heated iron. Just apply

a slight trace of flux (merely sufficient to make the solder flow freely) and run a tiny blob of solder on to the joint, leaving the hot iron in contact with the metal just long enough for the solder to flow neatly over the job. The finished joint can be cooled with a touch from a wet rag, and then all trace of flux should be cleaned off with a soft, dry rag.

If properly made, soldered connections should result in a low-resistance contact that is also mechanically strong, so that no ordinary amount of tugging with the fingers will break the joint.

The solder and flux used should be of a kind suitable for radio work. Different solders have different melting points, and some fluxes, too, make for much easier working than others. In general it is best to use a non-corrosive type of flux for radio and electrical work, but experience shows that an acid flux is not usually harmful provided that all traces of it are rubbed away on completing the joint.

When making soldered joints in a set, take care that no metal filings get deposited on insulating surfaces ; these might form a conducting path over the surface of an insulator, thus causing leakage of current. The results might be especially serious if the leakage occurred between, say, the sockets of a valveholder. " Spurklings " of melted flux, too, should be carefully removed from insulating surfaces as well as from metal. A camel-hair paint brush of a suitable size is handy for removing metal filings from inaccessible places in the set, and a clean, soft rag will remove spots of flux.

"UNMENDABLE" AND "MENDABLE" COMPONENTS.—The following components are usually difficult or impossible to repair, and need to be replaced when affected by the faults mentioned below :—

Valves with burnt-out or fractured filaments, lost emission, or faulty electrode-fixing.

Fuse-bulbs or cartridge fuses that have "blown."

Fixed condensers with punctured or broken-down dielectric (mica or paper).

Faulty composition resistances.

Broken or burnt-out windings in the following components, however, can usually be rewound either at home or on return to the manufacturer—although, of course, the high cost of repair or low cost of new component, in certain cases, may not warrant this being done :—

Tuning coils ; H.F. and L.F. chokes ; H.F., I.F., or L.F. transformers ; wire-wound resistances, potentiometers and volume-controls ; loud-speaker units ; and meters.

AERIAL AND EARTH REPAIRS.—For work that can only be done conveniently out-of-doors, such as any necessary repairs to broken aerial and earth leads, where ordinary soldering methods are difficult on account of rapid cooling of the iron, etc., some of the special paste solders now on the market are very useful. They enable you to dispense with a soldering-iron if desired, the joint being made by smearing on the paste, and then applying heat from a suitable source, such as a small blow-lamp or even a cigarette-lighter.

In overhauling an aerial system, it is advisable to clean the contacts of the earthing (anti-lightning) switch, if there is one, and also to remove any grime or sooty deposit from its insulating surfaces. This cleaning should be done periodically.

The tendency to corrosion and loss of efficiency through soot and grime being deposited on aerial wires and insulators is one of the great drawbacks to the use of outdoor aerials in town atmospheres. The aerial wire should be renewed when it shows signs of serious corrosion, and the aerial insulators should be cleaned from time to time.

COIL REPAIRS.—If you find a break in a tuning-coil winding (revealed by the continuity-test described in Chapter VII), you will need to unwind the wire and either re-wind the coil with fresh wire of the same kind and gauge, or else solder the broken ends together.

In the case of a sectionalised winding on a slotted former, there will probably be no need to unwind more of the wire than is actually necessary to get at the breakage; but with a plain, single-layer winding it is best to take it all off, otherwise the wire will probably spring out in a loose spiral and get tangled.

Clean and tin the ends of the wires, twist together, and run a thin film of solder over the twisted join. The absolute minimum of flux and solder should be used. Wipe away all trace of flux, and bind the join with silk to insulate it. Then rewind the wire on to the coil-former as before.

If the winding consists of enamelled wire, the soldered join can be painted over with suitable enamel instead of binding with silk. Quick-drying enamel is best, otherwise you will need to wait a long time for it to dry before rewinding the coil.

A break in an H.F. or L.F. choke could be repaired in a similar way, but some sort of coil-winding machine is needed to unwind and rewind the wire, as there are usually several thousand turns on a choke.

A coil-winding machine can be improvised from an ordinary hand-drill, secured in a horizontal position by, say, clamping it in a vice. A length of B.A. threaded rod is

gripped in the chuck, the bobbin or coil to be wound being slipped on to this B.A. spindle and secured with washers and nuts on either side of it.

In rewinding, care should be taken to keep the wire absolutely dry and clean, as any moisture may cause another breakdown later on. With very fine wire it is inadvisable even to allow it to run between the bare fingers when guiding it on to the former or bobbin, lest the slightest trace of moisture from the skin be left on the wire.

The number of turns put on can be counted approximately by counting the rotations of the drill handle and then working out the gear ratio to ascertain the number of revolutions made by the chuck.

Tuning-coils wound with cotton-covered wire sometimes deteriorate through the insulating sheathing absorbing moisture from the air. The moisture can be dried out quite easily by placing the coils in a very warm atmosphere for some little time—i.e., fairly near a fire, gas or electric radiator, or even in a cool oven. But, of course, the heat applied must *not* be enough to scorch the cotton covering or damage the coil-former in any way.

Dial Adjustments.—Tuning-dials, disc-drives, etc., often develop slight mechanical defects which need attention.

In the case of a friction drive, slip or backlash can usually be taken up by tightening any adjusting-screw or slightly bending any pressure-spring there may be.

Jerkiness or stiffness in the movement of any dial mechanism can, of course, be obviated by a little judicious oiling; but you should take care not to get much oil on the friction discs, etc., as the drive may then start slipping badly.

In the case of a cord drive, if the cord needs renewing, a length of good flax fishing-line of suitable size can be used.

SWITCH REPAIRS.—When switches give trouble, the question of whether to repair or replace depends mostly on the type and cost of the switch. Some kinds are very easily repaired, others are rather awkward and fiddling to deal with, and are not easily assembled again once they have been taken to pieces.

In a faulty switch, the contacts may need cleaning, springs tightening up or bending to exert greater pressure, and possibly broken parts may need replacing with home-made substitutes fashioned out of odds and ends of metal.

If a built-in wavechange switch in a tuning-coil gets out of order and cannot be repaired easily, the possibility of cutting it out of circuit and connecting an external switch in its place is worth considering. Whether this is practicable or not will depend on the type of coil, arrangement of switching and general lay-out of the set; but if a suitable switch is handy you can soon tell by practical experiment.

RIVETING BREAKAGES.—Broken ebonite or bakelite panels, bases, etc., can often be repaired by riveting small metal repair-plates across the crack on the back of the panel or underside of the base.

HINTS ON REPLACEMENTS.—When overhauling a set, the following hints on the subject of replacements should be borne in mind :—

Fixed condenser replacements, if subjected to high voltage when in the set, must be of a type rated at the same, or a higher, working voltage than that of the condensers they are replacing. Careful "matching" may be necessary when replacing one valve of a pair arranged in "push-pull" or Q.P.P.

See that fixed resistance replacements are rated to carry the necessary current.

When replacing old valves with up-to-date types of higher efficiency, the latter sometimes makes the circuit unstable, so that better screening and more thorough decoupling become necessary.

If an ordinary L.F. inter-valve transformer needs replacement, it is often preferable to replace it with a tone-control transformer and potentiometer. This will enable the tone to be adjusted by simply turning the potentiometer knob. In a set that is used a good deal for reception of talks, news, plays and other speech items, tone control is very useful in improving high-note response and removing any tendency to boominess or gruffness in the loud-speaker reproduction. Again, if the set is required to provide music for dancing, tone-control is equally useful in "boosting-up" the bass-response and emphasising the rhythm which is so essential for dancing purposes.

USEFUL REPAIR ACCESSORY.—If you do much repair work on radio components with a lot of small parts such as screws, nuts, and so on, you will find the following hint saves time and trouble :—

Get a shallow metal tray, such as an old tea-tray, and give it a coat of aluminium paint on the inside. Place this tray on the table or bench where you are working, and when dismantling components, put each screw, nut or other part down in proper order on the tray. This will prevent these essential oddments getting lost or muddled up—which is otherwise very liable to happen. The aluminium-painted background makes the smallest nut or screw easy to see. This idea facilitates re-assembling the parts quickly in proper order.

CHAPTER X

ACCUMULATOR CHARGING AT HOME

AT least an elementary knowledge of electrical theory and practice is essential to safety in building and using any apparatus that is to be connected directly or indirectly to electric supply mains. In dealing with the dangerously high voltages frequently used, you must know enough about the principles of insulation and other relevant matters, to protect yourself against risk of electric shocks and to protect your apparatus against dangerous short-circuits and other damage.

No matter whether you are working a complete receiving set directly off the supply, or whether you are merely using the mains indirectly as a source of current for recharging secondary cells (accumulators), all the apparatus connected to the mains must comply with the regulations laid down by the authorities concerned with the supply of electricity, and must be used in a way which complies with those regulations. Detailed regulations are published by the Institution of Electrical Engineers, Victoria Embankment, London, W.C.2, from whom copies can be obtained.

For the safety of yourself and your apparatus you should see that all insulation is sound; that adequate fuses are included in circuit wherever necessary; that all wiring is properly carried out and that all "live" parts of the apparatus, or parts which are liable to become "alive" in event of a breakdown, are suitably protected to avoid risk of accidental contact with any part of one's body.

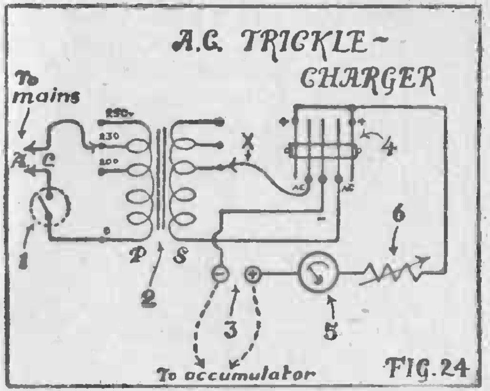
Accumulators have to be charged with direct current. If, therefore, the supply mains in your house are of the alternating current type, the charger must include a rectifier for changing the A.C. into a direct or "one-way" current. A transformer is also needed, in the case of L.T. accumulator charging, to step down the high mains voltage to a much lower value.

With D.C. mains, no transformer or rectifier is used, only a resistance to cut down the charging rate to a suitable value; but there are various "snags" in charging from D.C. mains that may easily outweigh the apparent advantage of this simplicity.

Making and Using a Trickle Charger (A.C. Type).—Where A.C. mains are available, a trickle charger affords a simple means of keeping L.T. accumulators charged up. A charger of this kind can either be bought ready-made or easily built at home. It will be safe to use if properly constructed

with good quality components and correctly handled. There is very little likelihood of anything going wrong with it, once it has been correctly fixed up.

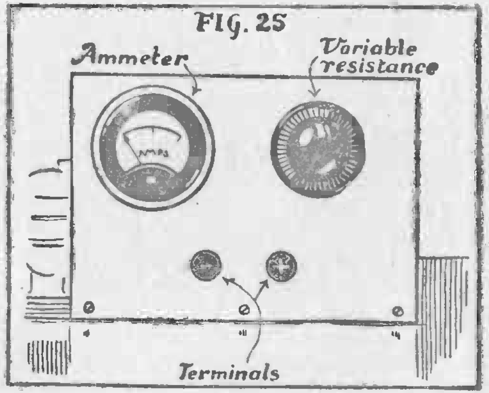
Fig. 24 shows the circuit of a simple trickle charger, and the actual lay-out of the parts can follow this diagram—*i.e.*, similar relative



A SIMPLE TRICKLE-CHARGING CIRCUIT.

positions can be adopted in practice when mounting the components.

The essential parts, reading the diagram from left to right, are: (1) a mains switch; (2) a mains transformer, with tapped primary for A.C. voltages between 200 and 250, and tapped secondary suitable for charging 2, 4 or 6 volt accumulators; (3) a pair of insulated terminals; (4) a suitable metal rectifier of the L.T. type; (5) an ammeter reading 0–1 ampere; and (6) a resistance, which may be a variable one of, say, 0–4 ohms. Some twin flex connected to a mains plug or adaptor (for linking up the



PANEL LAY-OUT FOR TRICKLE-CHARGER.

charger with the supply mains), and some insulated connecting wire for joining up the parts, are also needed.

The components can be mounted on a small wooden baseboard (say, 5 in. × 10 in.) and a miniature ebonite panel (say, 5 in. × 4 in.); the switch, transformer and rectifier

are mounted direct on the baseboard, and the terminals, ammeter and variable resistance are mounted on the ebonite panel (as shown in Fig. 25) which is screwed to the front edge of the baseboard.

For trickle charging, a charging rate of half an amp. is sufficient. You can get this by adjusting the variable resistance so that the ammeter reads 0·5 amp. with the accumulator connected up to the terminals and the flex lead "X" in Fig. 24 connected to the appropriate secondary tapping for the voltage of the cell or cells on charge.

The secondary voltage must be greater than the "back voltage" of the accumulator being charged, and it must be such as will enable the desired charging rate of 0·5 amp. to be obtained within the range of adjustment afforded by the variable resistance.

The transformer and rectifier should be chosen in conjunction with one another; suitable types are mutually recommended by the respective makers in their catalogues.

There are several methods of connecting up a metal rectifier to give full-wave rectification, but the one shown in the diagram, known as the "bridge" circuit, is best suited to an L.T. trickle charger.

With an A.C. trickle charger and proper switching, it is not necessary to disconnect the accumulator from the set while charging is in progress.

The accumulator can be put on trickle charge for a few hours each day, to replace the current taken from the cells by the use of the receiving set. If, as will probably be the case with the average battery-driven set, the total current consumed by the valve filaments is about half an ampere, the accumulator can be kept "up to the mark" by putting it on charge (at half an amp.) for about the same number of hours daily as the set is used. Serious over-charging should of course be avoided, as a general rule; although an occasional slight over-charge at the low rate in question is not likely to do any harm. It is, however, important that the cells shall be charged adequately for the work they have to do.

Ample ventilation is necessary to keep the parts cool when the charger is working. The cover for the charger had best be of perforated metal to allow air-circulation.

CHARGING ACCUMULATORS FROM D.C. MAINS. — Charging an accumulator from direct-current supply is a fairly easy and reasonably safe job in the hands of an experienced electrician. It is not, however, one to be recommended to an amateur who has had little or no experience of battery and electrical work.

Any amateur who has a D.C. supply in the house, and wishes to charge accumulators direct from it, would be well advised, therefore, to consult a qualified local electrician and get him to rig up a safe and convenient arrangement for charging the cells, that will fulfil the regulations laid down by the authorities.

No transformer or rectifier, of course, is used in charging from a D.C. supply; the simplest method of D.C. charging makes use merely of a suitable resistance (lamps are often used) to "drop" the difference in voltage between that of the mains and that of the accumulator to be charged.

GENERAL HINTS ON ACCUMULATOR CHARGING.—Before charging an accumulator, top-up the electrolyte by adding distilled water (if necessary) to bring the liquid up to the acid-level marked on the glass or celluloid case.

A cell is fully charged when the voltage reaches 2·6 volts, and the specific gravity readings remain constant for some considerable time. The positive plate in a fully-charged cell is a rich chocolate-brown colour, and the negative plate a clear grey.

Overcharging is indicated by excessive gassing and rise of temperature above 100° Fahrenheit. This must be avoided.

Accumulators on charge should be kept away from naked lights, as the cells give off inflammable gases when charging.

In the instructions placed on each cell, a charging rate is given. If this is exceeded, damage to the plates will probably result. As a rule, the 0·5 amp. rate of a trickle-charger is below that given by the manufacturer, and is quite safe in this respect.

Detailed hints on charging any particular type of accumulator can, of course, be had from the manufacturers.

CHAPTER XI

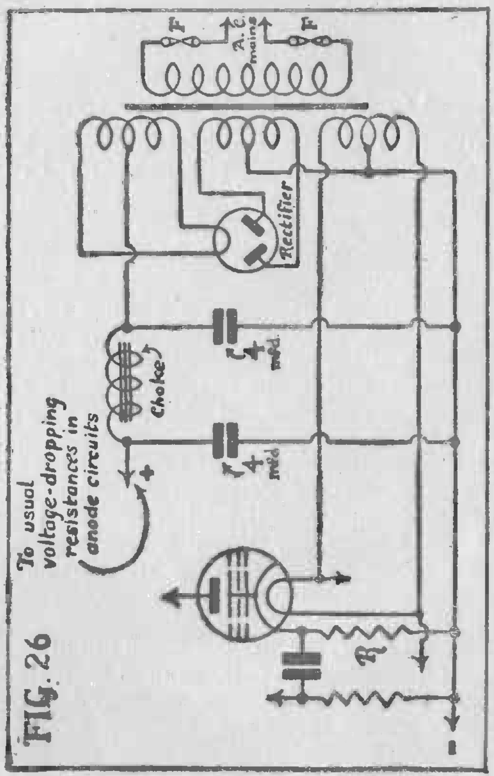
A.C. AND D.C. MAINS SETS

MAINS-DRIVEN circuits in general use can be divided into three broad classes: (1) A.C. mains sets; (2) D.C. mains sets; and (3) A.C./D.C sets using valves of the special "universal" type suitable for either A.C. or D.C. mains.

In describing the design of a mains set, it is hardly necessary to go into details about the parts of the circuit which have already been dealt with in the chapters devoted to general principles of set design and construction. So we will concentrate on the features which are peculiar to a mains set; and these, naturally, appertain chiefly to the power supplies—H.T., L.T. and G.B.

In an A.C. set, the current from the mains needs to be passed through transforming, rectifying and smoothing devices before it can be used for H.T. supply.

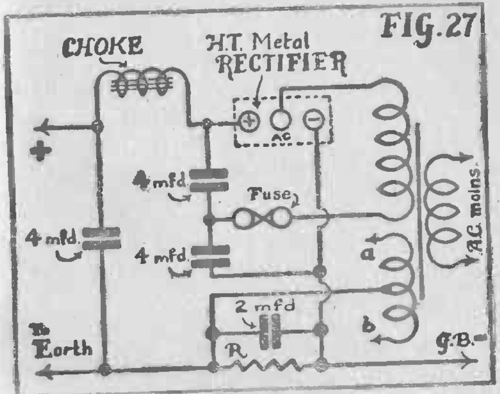
Fig. 26 shows the usual method of obtaining H.T., L.T. and G.B. from A.C. mains when a valve rectifier is employed, and Fig. 27 gives a typical arrangement suitable for use with a Westinghouse metal rectifier. In choosing the mains transformer and rectifier, care must be taken to see that these



TYPICAL POWER SUPPLY CIRCUIT FOR A.C. MAINS SET (USING DOUBLE-WAVE VALVE RECTIFIER).

are of types suitable for the voltage and frequency of the mains and for the voltages and currents required by the valves. Full particulars of suitable types will be found in the makers' catalogues.

Automatic grid-bias can be obtained, at the expense of the H.T. voltage, so to speak,



POWER SUPPLY CIRCUIT FOR A.C. MAINS SET (USING WESTINGHOUSE METAL RECTIFIER).

by means of the resistances marked "R" in Figs. 26 and 27. As the grid-bias voltage is deducted from the H.T. voltage available, the rectifier output must equal the sum of the maximum anode voltage and maximum grid-bias voltage required.

You will notice that the mains transformer in Fig. 26 has three centre-tapped secondary windings. The top one supplies L.T. current at 4 volts to the filament of the full-wave rectifying valve ; the centre one supplies H.T. current which, after rectification, is at the voltage and amperage required by the valves ; and the bottom one supplies L.T. current at 4 volts to the heaters of the indirectly-heated A.C. valves. (If a directly-heated valve is used in the output stage, an additional L.T. secondary winding will be needed on the transformer.)

In all cases (whether shown in the diagrams or not) suitable switching and fusing arrangements must be included in the leads from the mains.

The valve rectifier shown in Fig. 26 is of the directly-heated type. If you are using indirectly-heated valves in conjunction with a directly-heated rectifier, it is advisable to insert a thermal-delay switch (not shown in the diagram) to prevent the occurrence of high peak voltages when switching on.

If, however, you use an indirectly-heated type of rectifying valve, you may not need the thermal-delay switch, as the cathodes of both rectifying and receiving valves will take about the same time to heat up.

At least one suitable smoothing choke, associated with fixed condensers, is needed in a mains set or eliminator, whether of the A.C. or D.C. type. About 30–40 henries is

the usual value for smoothing chokes, the inductance being reckoned at the maximum D.C. current. If a loud-speaker of the mains-energised type is employed, the field winding can sometimes be utilised as a substitute for the smoothing choke, thus reducing initial cost and saving space.

The fixed condensers on either side of the smoothing choke can be 4 to 8 mfd. each and the electrolytic type are convenient.

The smoothing arrangements are followed,

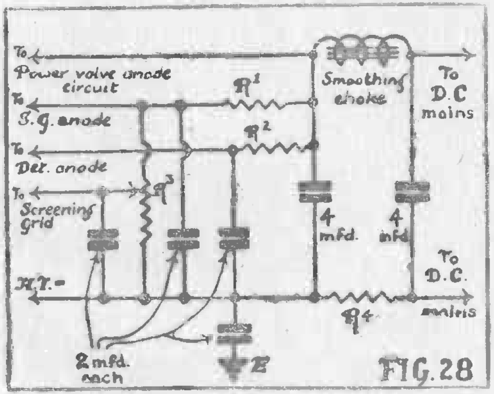


FIG. 28

H.T. ELIMINATOR CIRCUIT FOR D.C. MAINS (NOTE : R^1, R^2 AND R^3, WITH ASSOCIATED 2 MFD. CONDENSERS, FORM A RESISTANCE-CAPACITY ARRANGEMENT SUITABLE FOR VOLTAGE-DROPPING AND DECOUPLING IN ANY MAINS-OPERATED CIRCUIT.)

in any type of mains set, by a network of voltage-dropping, decoupling resistances and by-pass condensers. The method of arranging these is shown in the next diagram, Fig. 28. This gives the circuit for a D.C. mains eliminator; but the same method of voltage-dropping and decoupling is suitable for A.C. circuits, so the details have been omitted from the previous diagrams to avoid needless repetition.

In Fig. 28, only one smoothing choke is shown. This will probably be sufficient; but if excessive hum is experienced it may be necessary to employ additional smoothing chokes (in conjunction with suitable by-pass condensers) in the individual anode leads, on the high-potential side of the voltage-dropping resistances.

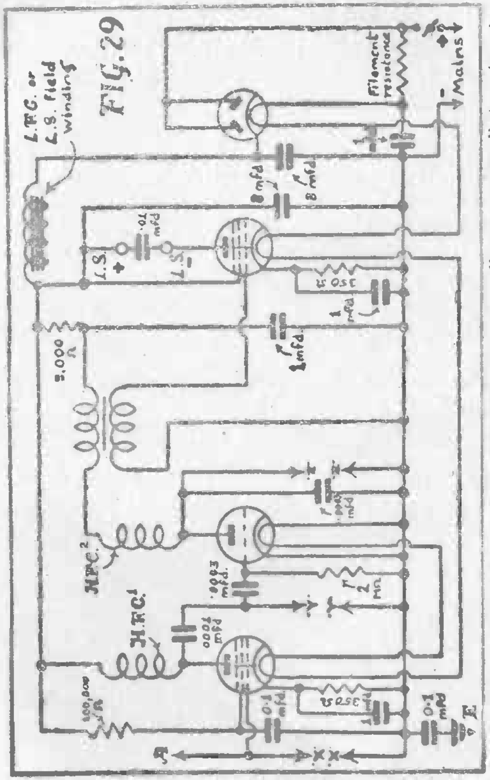
Air-core chokes may be needed in series with each of the D.C. mains leads as a further precaution against hum.

Note that the reservoir condenser across the mains leads has to stand up to the full voltage of the mains; it is very important, therefore, to select a type with a sufficiently high working voltage rating. The other fixed condenser associated with the smoothing choke has to withstand nearly as high a voltage, but the by-pass condensers in the network of anode voltage-dropping resistances need not have such a high working voltage rating.

In any "universal" or D.C. set, or eliminator, the fixed condenser in series with the earth lead is very important, and it must be rated at a working voltage at least equal to that of the mains. As an additional precaution, it is advisable to connect a fixed or semi-variable condenser in series with the aerial, when using a set on D.C. mains.

In Fig. 28, the resistance R4 is a mains resistance, dropping the voltage of the supply to the maximum anode voltage required. In calculating the value required for this resistance, it is necessary to allow for a voltage drop through the smoothing choke due to the ohmic resistance of the winding—which is not, however, likely to be very high. "R4" must, of course, be capable of carrying with safety the total anode current of all the valves plus the current taken by any potentiometer across the H.T. circuit.

Fig. 29 shows a typical circuit for a three-valve set with "universal" A.C./D.C. valves. This circuit is shown in a simplified form, the tuning arrangements being omitted to avoid complication in the diagram. The lead marked "A" goes to aerial via a series condenser (fixed or semi-variable); the leads marked "X" "X" go to the aerial tuning circuit, those marked "Y" "Y" to the detector grid tuning circuit and those marked "Z" "Z" to the reaction coil and condenser. Naturally, the choice of tuning



A TYPICAL CIRCUIT SHOWING ARRANGEMENT OF "UNIVERSAL" (A.C./D.C.) VALVES.

arrangements will depend on the degree of selectivity required, and so on.

Typical values for the necessary resistances and capacities are shown, but these will depend somewhat, in actual practice, on the other components and the valves used, etc.

The chief features of interest special to this circuit are the L.T. and H.T. supply arrangements. The rectifier valve, an indirectly-heated type operating on the half-wave principle, rectifies the H.T. current when the set is used on A.C. mains.

As regards the L.T. circuit, you will notice that the valve filaments (including that of the rectifier) are wired in series, and a series filament resistance is interposed between them and the positive mains lead, to cut down the voltage to a suitable value.

This resistance must be of a type properly designed for this particular purpose, and must be mounted in such a way that air can circulate freely around it, in view of it, tendency to get heated up by the passage of current.

In many sets of the universal or D.C. type (with indirectly-heated valves) a barretter is used in series with the valve heater wiring, either in place of, or in addition to, the series filament resistance. The barretter is a kind of lamp (with a standard valve base, but only the filament contacts actually used), and its function is to keep the heater current at a reasonably uniform value, even when the voltage varies. The resistance of the barretter varies in response to variations of applied voltage, and thus maintains a practically unvarying current.

The barretter must be of a type suited to the valves in use, and must be mounted in such a way that the heat radiated from it will not have a detrimental effect on near-by components.

As you will see from the diagram, the most striking feature of a circuit employing "universal" valves is that it can dispense with the need for a mains transformer.

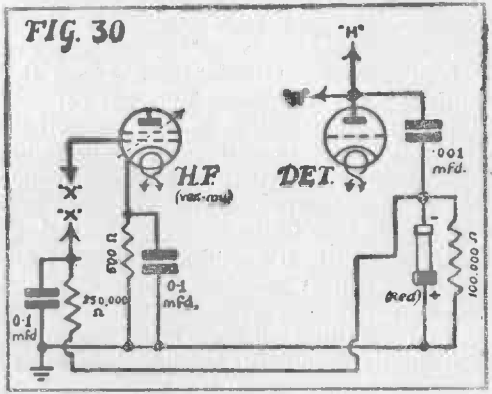
AUTOMATIC VOLUME CONTROL

A large number of modern sets are fitted with some sort of automatic or self-adjusting volume control (usually abbreviated to "A.V.C.").

There are several different methods of arranging an A.V.C. circuit, some relatively simple, others rather complicated. The more elaborate arrangements are only used in sets of an ambitious type, and it is felt that a detailed description of these methods would be rather outside the scope of the present book.

A typical example of one of the simplest methods, however, is shown in Fig. 30. The diagram is in skeletonised form for the sake of simplicity, all unessential details

being omitted. The leads marked "X" "X" go to the grid tuning circuit of the variable-mu S.G. valve (or H.F. pentode); the lead marked "H" goes to the H.F. choke in the anode circuit of the detector valve; and that marked "R" goes to the reaction coil.



A SIMPLE METHOD OF AUTOMATIC VOLUME CONTROL.

The automatic volume control voltage is developed across a suitable "Westector" (H.F. metal rectifier) connected as shown, and this applies a bias to the H.F. valve's control grid. The bias varies in a certain proportion to the strength of the signals applied to the detector valve, and thus the overall volume of the output is maintained at a fairly constant level, more or less irrespective of the strength of the incoming signal.

The chief object of A.V.C., of course, is to minimise the effects of fading.

MAINS APPARATUS

Important Note

It cannot be too strongly emphasised that mains sets are in a quite different category from any others—that is, they constitute apparatus which is connected to the public supply of electricity, and in consequence they must conform in every detail of construction and use to the regulations laid down by the local Electric Supply Authority and to the statutory conditions under which that authority operates. You can ascertain these regulations from the local office. Incidentally, your fire insurance may be conditional upon your complying with all such regulations.

Most electric supply authorities adopt, in regard to radio sets, the model regulations formulated and published by the Institution of Electrical Engineers. The little booklet, issued by the Institution, dealing with mains sets, etc., will be found very interesting and full of useful information regarding such matters as suitable test voltages of condensers for use in mains sets and eliminators.

In the present volume, the directions as to building and repairing mains sets are necessarily brief, but they should be read as following in every detail the I.E.E.'s regulations. The importance of conforming to these regulations (which, after all, are drafted for the users' own protection and safety) is exemplified in, say, the seemingly trivial case of a grub-screw on a control-knob, which, unless suitably protected, might be the means of conveying a shock in certain circumstances.

The foregoing remarks, of course, apply equally to repairing mains sets and fitting replacements, as well as to the initial construction; also to external fittings such as flexible wiring, plugs and other accessories, connecting the radio apparatus to the mains.

Finally, the following advice and warning in the I.E.E. booklet regarding mains sets should always be borne in mind :—

> **". . . It is dangerous to open in a manner which will expose live parts, any electrical apparatus connected to the supply mains, or to change valves, etc., without previously disconnecting, from the apparatus, both poles of the supply."**