Wireless Weekly

RADIO HANDBOOK

FOR SET-BUILDERS, EXPERIMENTERS
BEGINNERS AND ALL INTERESTED
IN THE ART OF SET BUILDING.

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(OF WIRELESS WEEKLY)

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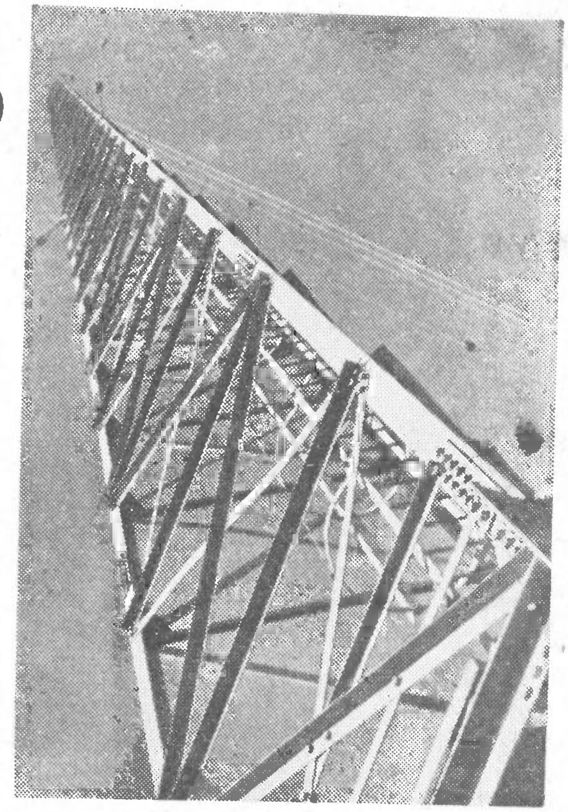
WHAT IS RADIO

How It Is Sent And Received

A discussion of some elements affecting the propagation of radio waves through the ether.



At the foot of an aerial mast of a big broadcast station.

IT is only about 13 years since the first broadcast programmes were put on the air in a big way. In these years something like a revolution has taken place in the entertainment world. Radio has opened up new ideas, given new opportunities and created new technique, which have individually and collectively changed the ideas of half the world's inhabitants. Music, entertainment, sport, politics, and, in fact, almost everything has acknowledged its influence and power.

It has done this because in a fraction of a second it is able to carry its message to anybody and everybody, who has a radio set operating within the radius of a broadcasting station. By linking up many stations, the service area of each is available for this message, whether it be an advertisement for pink pills, or the announcement of a Sovereign's death.

RADIO OUTBACK

One of radio's greatest services to humanity is its ability to link up the isolated sections of a community with civilisation. This is particularly true in Australia, where there are so many living in the outback, miles from anywhere. To these people the radio has brought a new interest. It has been to them a servant of incalculable value, not only in giving them the latest news and information on weather and industry, and in providing entertainment, but it has been the means in many instances of saving lives and protecting property.

With the prospect in the next few years of television services being added to the achievements of radio, we are justified in regarding it as one of our generation's Biggest Things.

The man who starts out in the home-building game should first of all obtain an elementary knowledge of these radio signals, how they are transmitted, how received, and so on. To understand these points means a good deal when one comes to the Great Moment, and the the first home-built set is switched on for the first time.

RADIO SIGNALS

In general, transmission and reception are very simple matters. The transmitter is a large electrical machine composed of valves and tuning circuits. The object of the valves is to generate and amplify to suitable power the necessary high frequency (sometimes called radio-frequency) current, which is to be fed into the aerial at the transmitting station, and from it shot out into ether. The tuning circuits are there to keep these radio-frequency currents operating on a set number of vibrations per second, which we call the station's frequency. Thus a station using 1000 kilocycles (1,000,000 cycles) per second has its circuits tuned so that the high-frequency currents are fed to the aerial vibrating backwards and forwards at the terrific speed of 1,000,000 times per second.

Now radio waves move through the ether at the same speed as light, or approximately 186,000 miles per second. If each second we have 1,000,000 vibrations, we can, by dividing this figure into 186,000, find the distance which would exist between each vibration, if we like to regard them leaving the aerial in a succession of waves, just like the ripples on a pool of water when we drop a stone into the still surface. This distance we generally call "wave-length." For 1000 kc. this wavelength works out at 300 metres, and is generally spoken of that way, in preference to measurements in feet and inches.

WAVELENGTH AND FREQUENCY

A quick way of finding wavelength from a station's frequency is to divide the wavelength in metres into 300 million, which is the number of metres per second at which the waves travel (also equal to 186,000 miles). Conversely, by dividing the wavelength into 300 million we get the number of frequencies per second. It is a long business quoting frequencies to the single unit, and it involves the use of a large number of "noughts" in the numbers. Therefore we generally refer to them in thousands per second (kilocycles), and on the ultra-short waves, or very high frequencies, in millions per second (megacycles).

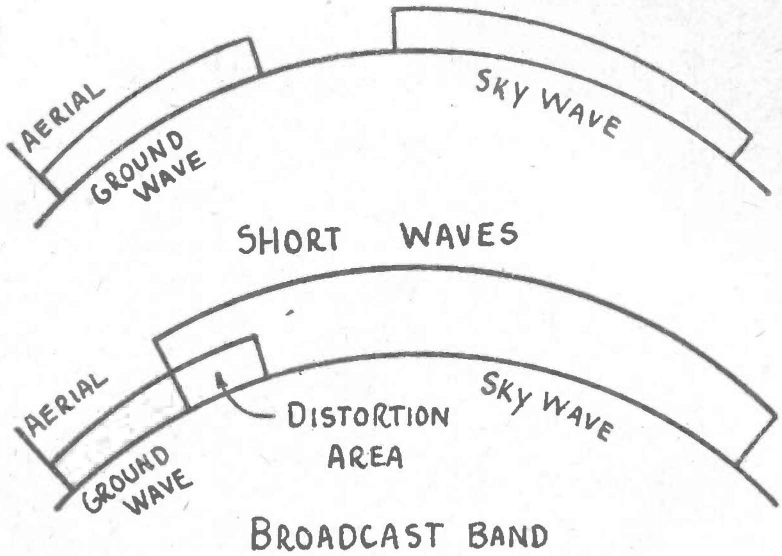
So much for the transmitter. The receiver also has its valves and tuned circuits. The tuned circuits, when adjusted so that they will respond to the wavelength or frequency of the transmitter, pass on the tiny currents they pick up via the aerial, and amplify them until they are strong enough to operate a loud speaker. As the transmitter is only desired to operate on one fixed frequency, its tuned circuits are adjusted, and then left fixed. The receiver, however, must be able to "tune-in" to stations operating on frequencies, all different, which extend in the case of the broadcast band, from 1500 kc. to 550 kc. Therefore we have the tuning control, by which the frequency to which the set will respond is made variable over this "band" in order that we may receive any station which operates within these limits.

THE BANDS

Australian stations, and in fact stations in every part of the world except England and on the Continent, operate on frequencies between 1500 kc. and 550 kc. (200 metres and 545.5 metres). This is known as the broadcast band. The exceptions mentioned above work on frequencies below about 300 kc. or above 1000 metres. These set "bands" are the result of international agreement, and cannot be altered except by subsequent arrangement between the countries concerned.

Between 1500 kc. and 3000 kc. (200 and 100 metres) there is very little activity at all. A good deal of short-wave broadcasting is done between 100 metres and 10 metres, mostly on bands, again recognised internationally, round about 13 metres, 16 metres, 19, 25, 31, and 49 metres (the most often used), with one or two in between and up to 70 metres.

The general behaviour of these wavelengths varies considerably as we go down the scale in wavelength from 1000 metres to 10 metres. So much so that a signal on 1000 metres is quite unsuitable for the work which can be done with a signal on 25 metres, or on 10 metres, or again on 5 metres. The study of the behaviour of transmitters on various wavelengths is a life-study for many men, and there is still plenty of data yet to be gathered, and new facts to be unearthed.



Above.—On short waves, the sky wave and ground wave are generally well apart. No signals are audible between them. Below.—On the broadcast band, the ground and sky waves frequently interact, causing a "distortion area."

★ Fading

THIS rapid review will convey in simple words a good idea of how signals are transmitted and received. Bearing them in mind, we can go on to consider other elements which come into the matter.

Fading is one of these. It is one of the most annoying and puzzling things in radio. It is annoying because it plays havoc with so much long-distance transmission, and puzzling because there is no easy way of overcoming it.

Fading is that phenomena by which the strength of a distant station varies more or less regularly, from full strength often to inaudibility. It will vary with the seasons of the year, and with the individual nights of the week. Some hold that it is largely influenced by the position of the "sun-spots," but, for the moment, we won't worry over such deep considerations. We are concerned here with the question of why signals fade.

GROUND WAVE

To understand the matter, we must realise that each station is regarded as sending out two waves into the ether. One is known as the "ground wave" of the station, and is regarded as travelling parallel with the ground. This wave never extends very far, often less than 100 miles, and peters out gradually until it is quite lost. The things which affect its strength are the power of the station, the wavelength of the station, and the type of country over which the wave travels.

Naturally, the higher power we use on the same wavelength, the stronger our ground wave. The higher the wavelength in metres, also the stronger the ground wave, and the further it will extend. Lastly, a smooth, even countryside will absorb less of the wave than a rough heavily-wooded area.

These are all big questions, and have a tremendous amount of work and calculation behind them. However, it is possible, by mathematics and actual measurement, for engineers to have evolved a set of charts and tables by which they can tell exactly how far the ground wave will be useful, once they know the wavelength of the station, its power, and the class of country over which the waves must travel. Generally speaking, a station working on 1000 metres with high power, and working over good country will have the best ground wave, and a low-powered station working on, say, 200 metres with poor country will have a very unsatisfactory one.

SKY WAVE

The second wave which comes into the question is the sky wave. This is never received directly, but is reflected from a band of ionised air high above the earth named after its discoverer, a man called Heaviside. This reflecting band, unfortunately, is not a constant thing at all, but varies in height and character. Naturally, its reflection characteristics will vary as well, just as in the case of a mirror, for instance, whose surface was subject to many changing waves and ripples.

Whereas the ground wave is not subject to fading, but simply to variation, which takes place due to the night and day, the sky waves depend on this variable reflection for their propogation, and they are the waves which suffer from fading.

Incidentally, most people know that night reception favors distant stations much more than day reception, because the sunlight has a strong "ionising" effect on the air, which means that it imparts to it electrical charges which have a blanketting effect on the signals. Thus it is always harder to get signals through from between points bridged by daylight than it is when these points are bridged by darkness, whether working on the ground wave or the sky wave.

However, to come back to our sky wave. The second area of reception which is important is the area served by the sky wave. The amount of "skip," which is the distance between the transmitter and the nearest points at which the sky wave is received. The area served by the sky wave is a variable factor, and depends to a large extent on prevailing conditions of day and night among other things. We won't get mixed up in such matters at present—the main thing to grasp is that it is received at distances very much greater than the ground wave can ever span.

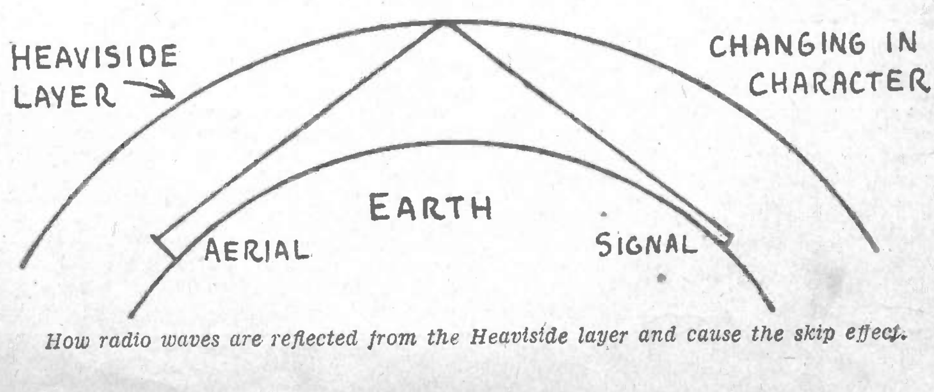
This reflected wave becomes much more critical on the lower wavelengths. It can be said that at 1000 metres there is very little useful reflected wave. By the time we reach, say, 20 metres, the ground wave is quite weak, and often won't efficiently span the suburbs of Sydney.

The reflected wave, however, would be quite strong enough to put a full-strength signal into America, which might not properly be received across the city. It is the reflected wave which we receive from overseas short-wave stations and that is why the signals vary and fade so much.

DISTORTION AREA

There is often an area varying according to wavelength used at which the sky wave returns to earth before the ground wave has petered out. Thus the two signals received by means of each wave are apt to interfere with each other, sometimes reinforcing signal strength, sometimes cancelling it out altogether, and most of the time breaking up reception into the most horrible forms of distortion. These are bad areas for that particular station, and, in many cases, render its programmes useless when these conditions prevail. This is a very common phenomena associated with Australian stations and noticed particularly in country districts more than about 100 miles from a transmitter.

As we have mentioned, the subject is a vast one, and we can do no more than summarise its effects without analysing how it actually causes this distortion. It is safe to make the general



How radio waves are reflected from the Heaviside layer and cause the skip effect.

statement that the two waves simply work one against the other to split up the original carrier in all kinds of weird ways, and completely spoil reception. On rare occasions, conditions will play tricks, and reception might be fine for a little while, but the general tendency is to rule out that station whenever the sky wave and ground wave clash.

A.V.C.

So far, the only thing we have been able to do, in fighting the effects of fading, is the fitting of A.V.C. to the receiver. The effect of A.V.C. or in full, Automatic Volume Control, is to vary the sensitivity of the set automatically, according to the strengh of the signal. More of this scheme will be found elsewhere in this book. However, although it is often effective in holding the signal much steadier than would otherwise be possible, it is not a solution, and cannot do anything at all towards assisting in the matter of distortion, which is a result of fading. Much experiment has been carried out utilising the directional effects of various aerial systems, but the problem in the main still remains unsolved.

★ Aerials and Earths

One of the things which often worry the man who is installing his own radio is this matter of aerials and earths. Naturally, being desirous of obtaining the best possible reception, he regards the matter as being specially important.

It is, of course, quite important. The modern receiver is so good that it is possible to use almost anything for an aerial, and still get good results. This does not mean that we cannot get even better results by using a better aerial.

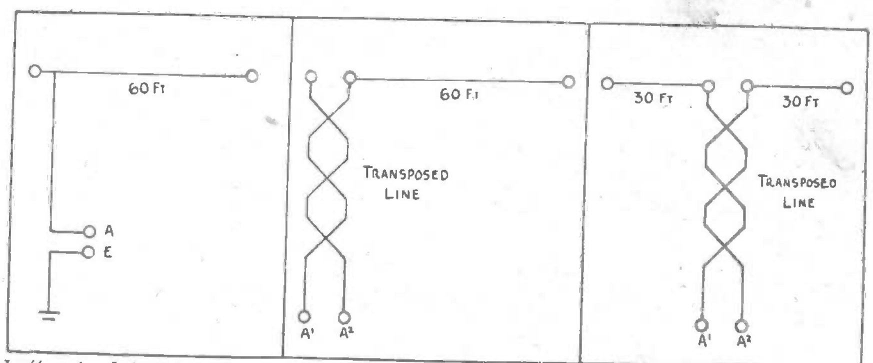
The main purpose of an aerial is to collect electrical energy from the ether, and feed it into the radio set. Therefore, generally speaking, the aerial which is the best collector of energy is the best aerial.

This is why an outside aerial is a more efficient installation than an inside aerial. Most receivers these days will give good local and interstate reception on an aerial round the picture rail, but these stations, particularly the interstate stations, will be received at better strength on an aerial which is outside, and therefore generally higher up, and probably longer as well.

The most desirable feature about a receiving aerial is height. Obviously, a high aerial will have a better chance of picking up signals, than one lower down, and subject to the shielding and damping effects of trees, buildings, power wires, etc. So that the first thing to do is to get the aerial as high as possible.

AERIAL LENGTH

Next comes the matter of length. It is not a good point to have an aerial too long. Remember that it is hitched to the first tuned circuit of the receiver, and the aerial itself has a definite amount of inductance and capacity, which are the important features in a tuning coil. Therefore, it exerts a certain "loading" effect on the first tuned circuit. If the aerial is too long, this effect may be enough to badly throw the set out of line. This will, of course, tend to offset any extra strength of received signal.



Left.—A plain "inverted L" aerial. Centre and at right.—Two forms of doublet receiving aerials.

As a rule, an aerial about 70 feet long and 30 feet high will give good results with almost any set. If any addition to these dimensions can be made, we advise adding height more than anything else. In some cases, it may only be possible to erect a long low aerial, or a short high one. That, of course, is something which cannot be helped, and there is nothing to do but to put up with it.

As a rule, best results are obtained from the inverted "L" aerial, which is simply a single wire with the lead-in coming from one end, and into the set. This type of aerial will do very well in all but special cases, where special aerials will be an advantage.

It does not matter very much whether insulated or bare wire is used for an aerial. Bare wire needs at least one porcelain insulator at each end to prevent it from touching anything, but a good brand of insulated wire may be tied round some support without insulators, and carried down to form the lead-in itself. Of course, the lead-in can be bare wire as long as it comes into the house through an insulated strip, or is insulated itself at that point. It is a good plan to have all leads inside the house made of insulated wire, not only in the aerial system, but the earth system as well. Needless to say, all joints in the aerial and earth wires must be carefully soldered, and, in the case of the aerial and lead-in, kept from touching anything where the wire is bare, and as far from metal objects as possible.

SPECIAL AERIALS

In many cases, a noisy house-power installation, or some other source of electrical interference will cause crackles and other extraneous noises to be fed into the aerial coil of the set along with the signal, and often render reception, particularly short-wave reception, very unpleasant. In many cases, by using aerial systems which render the lead-in wire quite dead as far as picking up signals is concerned, most of this local interference can be avoided. Note that this only applies to such interference as is created locally, and well below the aerial in height. Should the interference come from a block away, it would be fed to the aerial, if strong enough, just as the signal is fed, and the only way to stop it is to suppress it at the source. These special aerials are only useful when the aerial itself can be supported well above the local interference, such as would otherwise be picked up on the lead-in wire.

The most useful form of such an aerial is the doublet aerial, which has the lead-in connected to the centre, and has either twisted double leads for the lead-in, or which has them transposed throughout their full length with special little transposition blocks. Such an aerial is not hard to erect, and is not very critical for reception. A handy length each side of the lead-in would be between 30 and 50 feet. The lead-in may be any length within reason.

The two lead-in wires are connected to the aerial coil of the set. It is necessary to see that one side of the aerial coil is not connected to earth or to the chassis, but is left unconnected to anything but its own feeder, it doesn't matter much which one. Most sets these days have the aerial coil brought out to two insulated terminals, one of which is earthed should the doublet aerial not be required.

There are other forms of shielded lead-ins, which are very effective in bad cases, but these are generally too hard to make, and the enthusiast would do well to buy them complete, and install them as per instructions. Among these is the "double doublet," a noise-reducing aerial which has been designed specially for dual-wave sets.

THE EARTH

Every set should have a good earth connection, not only for best performance, but, in the case of electric sets, in the interests of safety, should the occasion ever arise, which by the way is very remote. Some sets will work quite all right without an earth, but, in any case, it is good practice always to provide it.

A good earth can be made by burying an old kerosene tin in the ground, about six inches below the surface. Punch holes in the bottom, and a few in the sides, first of all, and solder a heavy lead to the tin. Then fill it with ashes or some other material which will hold moisture, and sink it in the garden outside the window, or in some other convenient spot. It is a good idea to keep this area damp, and for that reason, some people have a pipe running down to the centre of the tin, through which the water is poured.

On the other hand, an earthing clip to a convenient water-pipe makes a very good earth, and even a copper rod driven a few feet into the ground, will serve. Have the earth lead as short as possible, insulated, and of heavy gauge wire, stranded or solid. Gauges 16 to 20 should be in order.

RADIO FUNDAMENTALS

Before one can obtain a good perspective of the radio game, it is necessary to have some idea of the laws governing radio in general. In this article, we have attempted to cover in a short space some of the elementary principles which concern electric currents upon which radio as a whole is based.

IT is not necessary for the average home constructor to delve very deeply into the theory of radio, at least, not until he has had some practical experience upon which to base his studies. There are, however, some fundamental points which he should bear in mind, and which he would do well to understand right from the start.

It is true that scientists have never discovered exactly what electricity is. They explain it by regarding an electric current as "electrons in motion." This conception is only to be understood when we know what electrons are, and how they move.

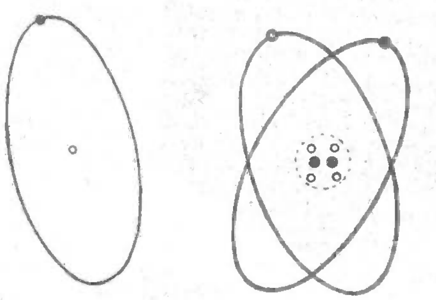
Most people are used to the word "atom" as applied to anything very small. It is regarded as the smallest particle of anything one can have. Groups of atoms make up molecules, and molecules make up the material things we see round us all the time.

THE ATOM

The atom itself, however, is made up of electrons existing in groups. These electrons each have a definite electrical charge or "potential," called negative and positive. These are opposite in character, and one of the fundamental facts about them is that the negative and positive electrons attract each other, while two negative or positive electrons will repel each other.

Thus we find that atoms are made up of a central core of positively charged electrons, with negative electrons grouped round them, according to the structure of those particular atoms.

Round this little group of positive and negative electrons are to be found a number of negative electrons, which under certain circumstances can be induced to leave the group, and attach themselves elsewhere. When this happens, and there is a progression of negative electrons through a body, we get the effect of a current flow, each atom handing on its excess electrons to the next.



Left: The simplest atom—Hydrogen. It has a single proton as nucleus and one electron rotating round it.
Right: An atom of Helium. Here are four protons and two electrons as nucleus, with two rotating electrons.

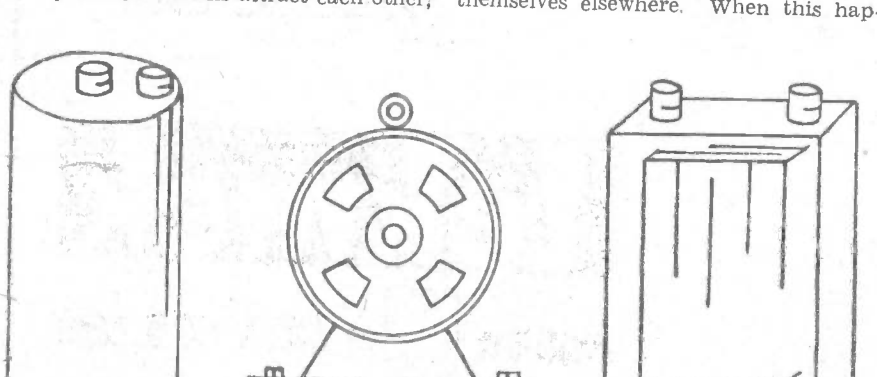
The number of electrons for each atom will vary according to the nature of the atom itself, which in turn is determined by the nature of the element of which the atoms are made. However, the electrons themselves are all alike. Some atoms have more negative electrons to spare than others. Hence a current will flow more easily in a body made up of such atoms, than it would when fewer electrons are available. Thus the first body would be a better conductor of electricity than the second.

GENERATING CURRENT

An electric current may be generated in various ways. The simplest form is by means of a "dry" battery. This is virtually a zinc can containing chemicals, the active compound being generally sal-ammoniac. The zinc forms one electrode and a carbon rod down the centre is the other. The chemical action between the sal-ammoniac and the zinc causes a transference of these negative electrons through the cell, the net result being to provide plenty of them at the zinc, or negative, pole, and a shortage of them at the carbon, which then becomes positive. The battery remains in a state of balance until the two terminals are joined through some load, on which the electrons can move on, the current will flow, and the chemical action keeps up the supply. As soon as the chemicals are exhausted, there is nothing to keep up the flow of electrons and the cell is useless.

Such a cell is a "primary" cell. A number of cells joined together is called a battery.

Electricity is most commonly generated in large quantities by generators which work through electro-magnetic action. They depend on the fact that if we rotate a coil of insulated wire in a strong magnetic field, a current of electricity will flow in the coil. Thus generators are simply large coils wound on iron cores, revolving at high speed inside the full force of a strong magnetic field. The generators may be driven by



Three electric generators. Left to right.—A dry cell, an electric generator, a rechargeable accumulator.

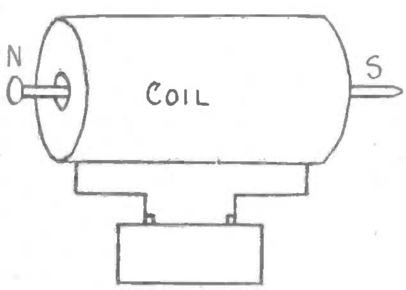
steam, petrol, oil, or other types of motors, powerful enough to keep them revolving. Generally steam turbines are used in the large electricity supplies, such as feed our big cities.

The nature of the electric disturbance causing the flow of electrons is also a very important thing. For instance, a strong electric field will create more electron disturbance than a weak one, and therefore, encourage more current to flow.

Positive electrons are generally termed protons, and negative electrons are called electrons.

ELECTRIC CURRENT FLOW

This little picture of the electric current, as generally understood these days, will help in the study of the three elementary things in electricity, upon which almost every measurement is based. These are voltage, current, and resistance.



Passing current through the coil will magnetise the nail or other iron object.

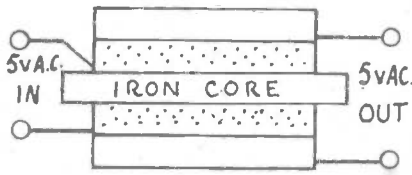
Electric current flow is often likened to the flow of water in a pipe. First consider the force with which the water is propelled. This in electricity is termed the voltage, or the pressure of electric current. A more correct name is "electromotive force," or E.M.F. for short. Note that we can have a high pressure of water whether the actual amount of water flowing is large or small. This brings us to the second point, the amount of water or electricity. The name for this is amperage, taken from the name of the famous scientist, Ampere. (Voltage gets its name from another scientist, Volta.) The third point is possibly the easiest to understand—resistance. Some conductors of electricity will allow it to flow through them much more readily than others—these are said to have a lower resistance. There are plenty of materials which have so high a resistance that they will not allow any current to flow at all. These we call insulators, and we use them to insulate two conductors when we don't want them to come into electrical contact with each other. Most insulators will allow a certain amount of current to flow through them, but it is generally so small that it can be ignored.

Glass, dry wood, and bakelite are all good insulators. Copper, aluminium, and silver are good conductors.

The unit of resistance is called the ohm, after another great scientist, who was responsible for Ohm's Law. Upon this law practically every electrical calculation is in some way based. It deserves a special paragraph all to itself.

✱ Ohm's Law

Ohm's Law states that when an electrical force of one volt is applied to a resistance equal to one ohm, there will be a current flow of one ampere. From this we can obtain our definition. A Volt is the electrical force needed to drive one Ampere of current through



Illustrating the principle of a transformer.

one Ohm of resistance. An Ampere of current is the current which one Volt will drive through one Ohm. And one Ohm is the resistance required for one Volt to produce a current flow of one Ampere.

The full statement of Ohm's Law deals with the calculation of one of these three, when the two others are known. To find the resistance in the circuit, we divide the voltage in volts by the current in amperes. To find the current in amps. we divide the voltage by the resistance in ohms. To find the voltage in volts we multiply the current in amps. by the resistance in ohms. ("Amp." is the usual abbreviation of "ampere.")

For instance, we may have a resistance of 10 ohms, and a voltage applied across it of 50 volts. The current flow will then be the voltage, 50, divided by the resistance, 10. The answer is 5, which represents the number of amps which would flow. From this answer we would know that our source of supply would need to be capable of supplying 5 amps of current, and the resistance would need to be capable of carrying such a current without overheating or burning out.

In this way we can work out all manner of calculations where voltage, current, and resistance are concerned.

POWER

This brings us to another measurement in electricity, that of power. The electrical power in a circuit is the product of the current flow and the voltage. Thus in our previous example, with a voltage of 50, and a current flow of 5 amps. the power would be 250 watts. The unit of power is called a watt.

The voltage (E) in any circuit, from Ohm's Law is equal to resistance (R), multiplied by current (I).

$$P = IR$$

We have said that power equals voltage by current

$$P = EI$$

Therefore by substituting I x R instead of E in our power formula, we find that P equals IR x I, or, in other words,

$$P = I^2R$$

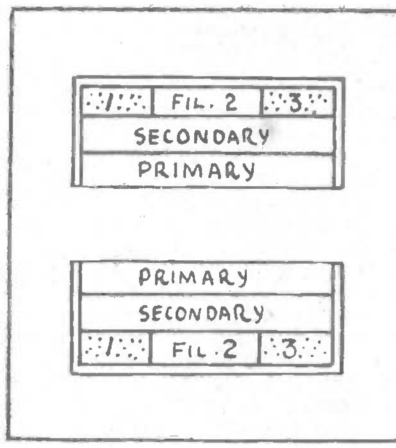
By a similar method of substitution, we can find that P equals E squared divided by R.

$$P = \frac{E^2}{R}$$

All these simple formulae should be studied and remembered, as they will allow all kinds of calculations to be made for any circuit where we are dealing with current, voltage, and resistance.

A.C. AND D.C.

So far we have been dealing with electrical currents which flow in one direction all the time. Such a current is called direct current, or D.C. for short. There is, however, another kind of current which we call alternating current, or A.C. for short. In this case the direction of flow is not in the same direction



A cross-section of a typical power transformer.

all the time. It flows first in one direction and then the other.

This kind of electricity is produced by electric generators. On the other hand such generators can be connected up to give D.C., but as a rule D.C. is either obtained by batteries or from A.C. through rectifying systems. A.C. is easier to handle because it can be stepped up and down in voltage for easy transmission.

MAGNETISM

To understand the value of this A.C. current, we want to say something about magnetism. Everyone knows what a magnet is. It retains its magnetism because the steel is so made that it does not change its internal structure easily. Therefore when we once magnetise it, a process which involves a rearrangement of the molecules in the steel, they will tend to stay that way, unless we deliberately upset them again.

Other metals, such as soft iron, do not hold their magnetism for very long, some types of iron only for a fraction of a second after the magnetising force is removed. Such a metal is said to have a high "permeability." Thus magnet steel has a low permeability.

If we were to wind a coil of insulated wire round a piece of soft iron, and send an electric current through the coil, the iron would become a magnet. This is easily demonstrated with a torch battery, and some insulated wire wound round an iron nail. When the battery is connected, the nail will pick up other iron objects, if they are not too heavy. As soon as the battery is disconnected, the nail will lose nearly all its magnetism.

If we had used steel such as magnets are made of, the steel would retain most of its magnetism, and continue to act as a magnet for a very long time.

If we were to connect the same coil to a source of A.C. current, we would have a different effect. While the current was flowing in one direction the nail would be magnetised with the north pole at one end and the south pole at the other. As soon as the current flow changed its direction, the opposite end of the nail would be the north pole, and the other the south pole. And thus the nail would keep on changing its magnetism in step with the rate of change in the current.

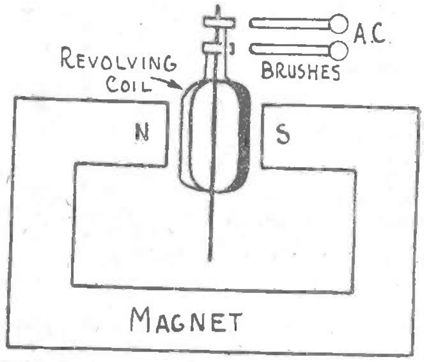
The ordinary house supply is an A.C. supply, and it changes its direction 50 times each second. Therefore we call it 50 cycle current, because each complete change of direction and back again we term a cycle.

The nail is magnetised because of the magnetic field the coil produces. The field would still be there even though the nail was not.

Now imagine that we have an iron rod, or a bundle of iron wires, or the iron laminations such as used in a power transformer, and we wind on them a coil of insulated wire as before. We will now wind a second coil the same size as the first over the top of it, or even alongside it, so that the iron core also runs through the centre of this second coil. If we now apply a voltage of 5 volts A.C. to the first coil we will find a voltage of 5 volts being delivered at the ends of our second coil.

The reason for this is in the magnetic field we have created, which builds up, collapses, builds up again in the opposite direction, and so on (50 times a second in the case of our household supply). Whenever we have such a magnetic field and bring a coil of wire into its influence, a current will be induced into that coil. The more closely it is brought into the field the greater will be the voltage. Maximum "coupling" is obtained when the second coil is wound over the first.

The voltage induced in the second coil depends on the ratio of the turns of wire



How a generator works. Revolving the armature causes the coil to rotate, out across the magnetic field, and deliver current to the brushes, which makes contact with the two metal rings.

compared with the first coil. If our second coil has twice as many turns as the first, we will get double the voltage. If only half as many turns, we will get half the voltage. This is the principle of the power transformers as used in A.C. receivers. The first coil is connected straight to the 240 volt mains. A second coil having a larger number of turns supplies the voltage for the high tension side of the receiver, while other windings, all wound over the first, feed the filaments of the valves.

The size of the core and the gauge of wire in the first or primary coil depend on the total power drawn from the transformer. With slight modifications, the general principle of Ohm's Law still holds good for the A.C. current, and we find the power by measuring or calculating the voltage and current which we will be taking from the various secondary windings. If, for instance, we were drawing 350 volts at 60 milliamps (.06 amps) from the high tension winding, this would represent 21 watts. Then our filament supply might be 6 volts at 1.5 amps, or 9 watts. The rectifying valve might take on the filament 5 volts at 2 amps, or 10 watts. The total would be 40 watts. We would then design a transformer having a core large enough to handle this power. The quality of the iron, mainly its permeability, is, of course, a big factor here.

As the input voltage from the mains is 240 volts, and we are using 40 watts, Ohm's Law tells us that we must allow for a primary current from the mains of about 170 milliamps, or .17 amps. As no device is 100 per cent. efficient, we will have to allow a certain amount of margin according to the efficiency of the transformer.

This ability of A.C. currents to be "stepped up" and "stepped down" at will is a great help in many ways. For instance, long transmission lines from power station to city need to carry quite a high power. If we made all these lines carry 240 votls, the total current would be enormous. Now by stepping the voltage up to 132,000 volts the current is less than one five-hundredth of this amount, and much smaller power lines will be needed. Certainly, great care must be taken to insulate the lines carrying this voltage, but engineers have made a good job of this. When the 132,000 volt lines reach the city they are "stepped down" in a series of substations until the normal 240 volts is obtained.

The high figure of 132,000 volts is not always used, but it can be hand[illegible] if required.

CARING FOR ACCUMULATORS

A 2-VOLT accumulator would be the handiest method of obtaining A battery current for this set. Accumlators will give long and satisfactory service, provided they are properly cared for. Always see that the level of the electrolyte (in this case, acid) is kept above the tops of the plates, and always use distilled water—not tap water, to replenish when needed. The latter has too many impurities. Failure to keep the electrolyte above the plates may lead to "sulphation" of the battery, and its steady deterioration.

It is also bad to leave the accumulator "run down" for any length of time. Always have it recharged before it drops so low that it refuses to function. The amount of charge is best gauged by using a hydrometer to test the specific gravity of the electrolyte. When this drops to about 1170 the battery must be recharged, and when fully charged should be somewhere near 1220. At all times use the figures given by the makers of the battery. This also applies to the charging rate. It is very bad to charge a battery too quickly, as this tends to make the plates come to pieces, and loosens the special paste with which they are prepared. The maximum charging rate is generally marked on the battery; but if not, don't charge more than one-twelfth of the ampère hour capacity. For instance, a 40 a.h. accumulator should not be charged at more than about 3 amps.

DON'T ADD ACID

Under no circumstances add acid to the electrolyte, except in cases where the electrolyte has actually been spilled from the battery, which thus requires more of it to bring the level back to normal. Should water alone be added, naturally the solution will be weakened, and the operation of the battery impaired. We suggest that, in such event, the battery be sent to a battery service station, where the strength of the solution can be adjusted under proper conditions to its original state.

Dead short circuits are very bad for accumulators. Be very careful to see that there is no possibility of metal objects being placed across the terminals to make a circuit. Some people also have a bad habit of deliberately short-circuiting a battery with a piece of wire to see whether it is still charged. This practice is of no value at all, as it gives no indication of the amount of charge, and it is just as easy to connect a lamp across the battery. The hydrometer method is quite the most satisfactory, as no other method really gives the right indication.

Incidentally, acid as used in a battery is a bad corrosive, and will burn holes in carpets, clothing, etc., if not removed immediately it happens to be spilt. Ordinary household ammonia is a good antidote for the acid, and the affected spots should be dabbed immediately with an ammonia solution, and dried. Acid often has a disconcerting effect on colors, and tends to turn them red if it is left long enough. Keep the top of the accumulator clean to avoid corrosion of the terminals. Also, as acid is a conductor, it will provide a leakage path if left lying on the top of the battery, which will slowly but surely help to discharge it. A thin smear of vaseline on the terminals will assist in preventing any corrosion from accidental acid, fumes, etc. Properly cared for an accumulator is a very reliable source of power.

TUNING, AND HOW IT IS DONE

One of the greatest mysteries to the average enthusiast is the matter of how stations are tuned in, and the main factors that govern tuning. This article offers a simple explanation of tuning, and also reviews the purpose and construction of various tuning coils and systems.

THE student of radio does not progress very far before he finds out that one of the most important things in the art is that of tuning. Every radio signal is simply a vibrating wave, and it has a definite rate of vibration at any instant. Every radio station must keep the rate of its vibrations exactly the same, or as nearly the same as possible. And every radio set must have a control by which it can be made to respond to each of these fixed transmitting wave frequencies at will.

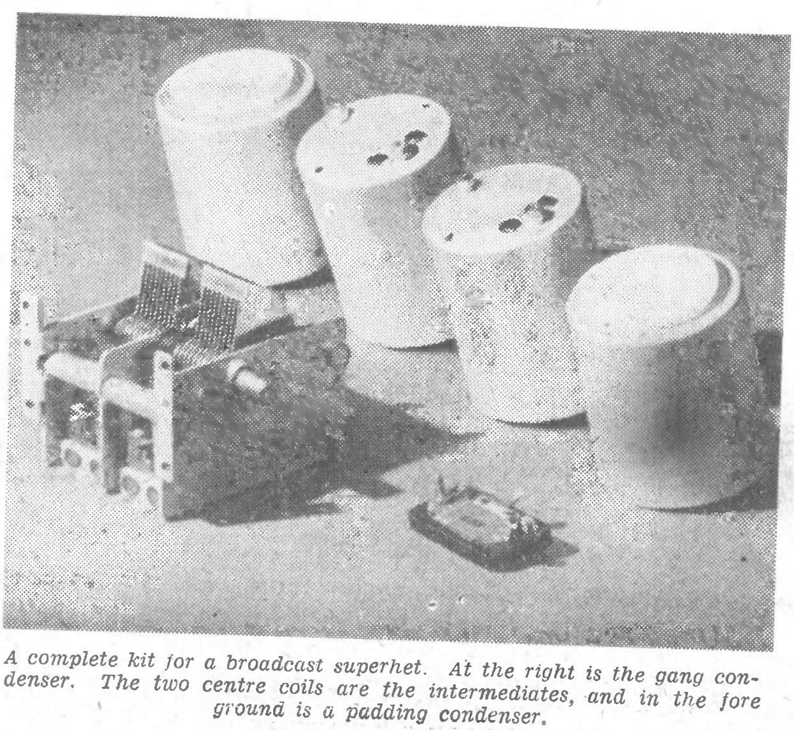
To understand what is meant by tuning, we will reduce the matter to the simplest possible form, a coil of wire wound on a cylindrical former. Such a coil will have one frequency to which it will respond most readily. It will be in tune to that frequency more than any other, and should a number of frequencies be fed into it, its own resonant frequency will be the one which will develop the greatest voltage at the ends of the coil. After all, this is the main function of a coil.

In practice there are two things which make up the "tuning" character of the coil. One is its inductance and the other is its capacity.

If a current is fed into a wire and causes a magnetic field to be set up round that wire, the wire is said to have inductance. Even a straight wire can have inductance, but it is greatly increased by winding the wire into a coil, which concentrates the magnetic field.

CAPACITY

The second thing we have to consider is capacity. Capacity is present when two conductors are brought close to each other. In this state they may be regarded as little storehouses or tanks of electricity. If we make up a large capacity by using two big plates separated by a very small amount of air, and charge one plate negatively, and the other therefore positively, the condenser will absorb power until it can hold no more, and will keep that power for quite a time. If we were to short-circuit the terminals, we would get a spark as the energy stored up was dissipated in heat.



A complete kit for a broadcast superhet. At the right is the gang condenser. The two centre coils are the intermediates, and in the fore ground is a padding condenser.

The adjacent turns of wire in the coil have a capacity between themselves which is important, however small. If we space the turns away from each other the "self-capacity," as it is called, of the coil, will be lower.

Now the frequency to which a coil will resonate, or be most responsive, depends largely on the relation between inductance and capacity. This is generally written as "LC," L being the inductance and C the capacity.

We can most conveniently vary the resonant frequency of the coil by varying either its inductance or its capacity. In practice this is done either by altering the number of turns in the coil, with a slider contacting the turns one after another (as in the old crystal sets) or through introducing extra capacity by connecting a condenser, with a variable area of plate overlap across the coil. Such a condenser is known as a variable condenser.

In practice it is far easier to wind a coil of fixed number of turns and vary the tuning of the coil by varying the capacity of the condenser. If you look at any radio set you will see a number of coils in cans as a rule, and several variable condensers, usually ganged together, by which the tuning is done.

This, in simple language, is how tuning is accomplished in the ordinary radio set.

VALUES

As we have said, the resonant frequency of any coil-condenser combination depends largely on the total inductance and the total capacity in the circuit. For the same size of former and gauge of wire, etc., the larger the coil the higher the wavelength to which it will be resonant. The higher the capacity of the tuning condenser associated with it the higher also the wavelength will be. Average values for coils to cover the broadcast band from 200 to 550 metres would be a coil of 100 turns wound on a 1¼-inch former with 32-gauge enamelled wire and tuned with a condenser having a maximum capacity of .0005 mfds.

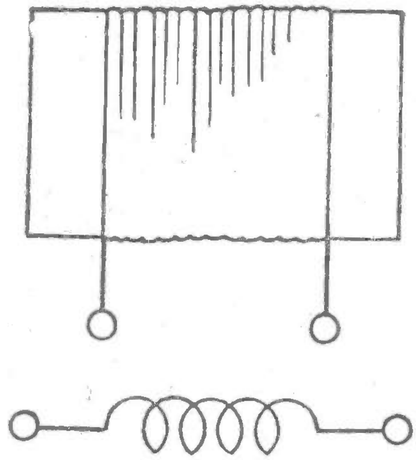
The unit of capacity is the farad, which is so large that we generally speak of micro-farads (millionths). The unit of inductance is the henry. For tuning coils such as this we generally speak of micro-henries, or milli-henries (thousandths).

When winding coils at home the constructor should remember that for the same number of turns the inductance of a coil will increase as the diameter of the coil increases. Thus 50 turns of wire on a 1¼-inch former would have much less inductance than the same number of turns on a 3-inch former.

$$L = n^2d^2x^2lk \times 10^{-3}$$

This is a handy formula for finding the inductance of a coil, and also it illustrates all the factors which affect the inductance. The number of turns is represented by n, and the diameter of the coil in centimetres by d. The letter x represents "Pi" or the familiar 3 1-7th, the ratio of radius to circumference of a circle. l is the length of the coil in centimetres, and k is a figure determined by the ratio of the coil length to the coil diameter. For instance, a coil having the same length as diameter has a k of .688. It is a simple matter to make some interesting calculations with this formula.

To find the wavelength of a coil and condenser combination we use the formula:



An ordinary tuning coil and its schematic symbol.

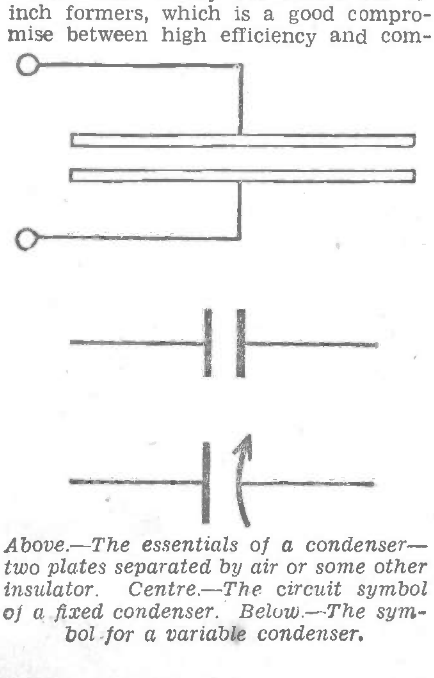
$$W/L = 1885\sqrt{LC}$$

Condensers may be made either variable or fixed. Fixed condensers may be made in many ways. The mica type are usually composed of a number of metal plates insulated from each other with strips of mica. The tubular type are generally made by rolling up two lengths of metal foil with waxed paper as the insulator. The insulator is called the dielectric. Its character is a big factor in the condenser's capacity, which depends first on the area of overlap of the plates, and, secondly, on this dielectric. Different substances have different dielectric constants. Air is generally regarded as having a figure of 1, and no other materials take their rating on this standard. The distance between the plates is also an important factor. The formula for calculating capacity is

$$C = \frac{.885\ A\ E\ (N-1)}{d}$$

Where C is capacity, A is the area of overlap in square centimetres, N is the number of plates (total), K is the dielectric constant, and D is the distance between plates in centimetres. The average dielectric constant for mica is 6.

Most coils to-day are wound on 1¼-inch formers, which is a good compromise between high efficiency and compact size. More efficient coils could be wound having a diameter of 3 inches. Coils having a larger diameter are generally more efficient, and a good size for sets such as single-valvers and crystal sets would be 3 inches. However, when we come to larger sets, where space and shielding come into the question, the smaller diameter is easier to handle.



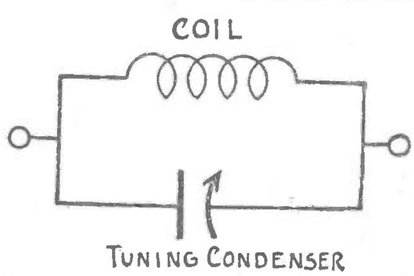
Above.—The essentials of a condenser—two plates separated by air or some other insulator. Centre.—The circuit symbol of a fixed condenser. Below.—The symbol for a variable condenser.

The larger sets have the coils enclosed in metal cans to prevent the magnetic fields round each coil from interacting on each other and causing interlocking and instability between the various stages. Enclosing a coil in a can lowers its inductance by restricting the magnetic field, and as a result a few more turns must be used on coils which are "canned." The distance of the can from the coil also is important, and should never be less than ½-inch. The standard 1¼-inch formers with 2½-inch cans are a good all-round size.

TUNING COILS IN PRACTICE

So much for the coil which does the tuning. But there are other coils in a receiver. For instance, there is the aerial coil, which couples the aerial to the set and the plate coils of the R.F. amplifiers, which couple these valves into the succeeding stage.

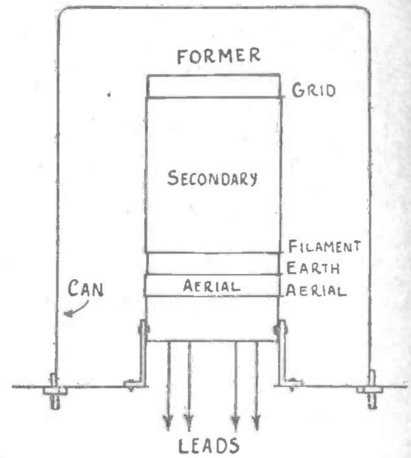
Referring to the diagram, we see a typical aerial coil such as would be found in the average set to-day. The top winding is the secondary tuning coil about which we have already spoken. The smaller coil is the aerial coupling coil. As a rule, one end of this coil is connected to earth, and the other connected to the aerial.



A tuning coil and variable condenser as they appear in a circuit.

In another chapter in this book will be found an explanation of how transformers work. It explains in more detail than we can manage here, just how the energy is transferred from the aerial coil into the secondary coil. Actually, passing the radio signal from the station through the small coil, sets up a magnetic field round it, which is building up and collapsing very rapidly. The received signals are very high-frequency alternating currents. The magnetic field of this aerial coil is closely coupled to the necessary coil, and therefore induces a current to flow in the secondary coil. As with any other transformer, there will be a step up effect in voltage, although the current will be lower, as the total power cannot be greater in the secondary that in the primary. Remember, however, that the valve is a voltage-operated device, so the actual current in the coil doesn't matter very much.

The small coil, although of fewer turns than the secondary, is actually tuned with the secondary because of its close coupling. This type of coil is called aperiodic, and has the handy facility of responding quite well to almost any frequency within the range of the secondary tuning.

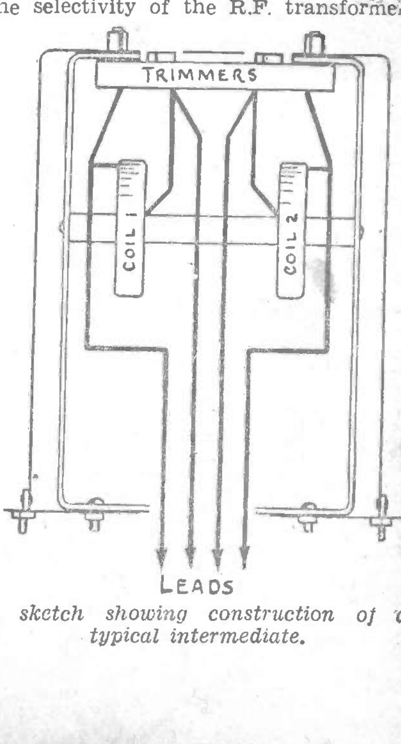


A cross-section view of an ordinary tuning coil.

Such a coil is used for tuning the input to the first valve in a receiver (or to the crystal should it be used). As a rule a similar idea is employed in coupling the output of an R.F. amplifying valve to the following stage. In this case, the smaller coil is fed from the plate of the preceding valve, and the secondary coil is connected to the input of grid circuit of the next valve.

There is a good deal of careful work involved in designing efficient coils. As with most things, there is a big element of compromise to be considered. For the most efficient transfer of energy from a valve, it is necessary to have in its plate or output circuit a load which matches the valve itself. In the case of the R.F. amplifiers used to-day, the load requirements call for a very high impedance load (impedance is the same thing as resistance, except that it is used when speaking of A.C. currents instead of D.C. currents. It is, in effect, A.C. resistance, the resistance which a circuit offers to A.C. currents flowing through it. This does not necessarily mean a high D.C. resistance.)

Unfortunately, to use a primary large enough to match the valve would spoil the selectivity of the R.F. transformer.



A sketch showing construction of a typical intermediate.

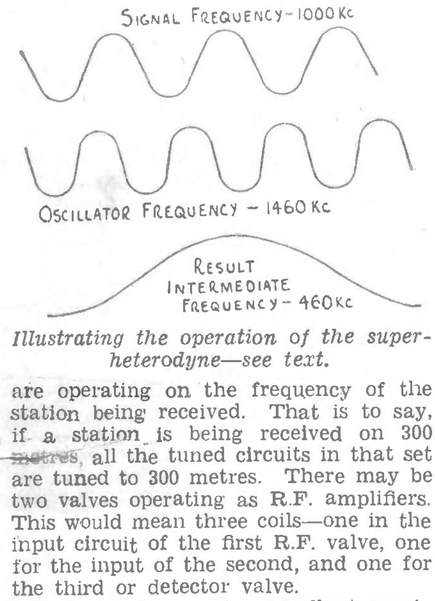
Therefore designers strike a mid course, and use the largest number of turns which will give a high gain for each stage, but at the same time, which will not "flatten" the tuning of the secondary too much.

In order to preserve the aperiodic character of the primary it is coupled very closely to the secondary, generally wound right over it with thin insulation between the windings.

A more efficient transfer of energy is obtained by tuning both the primary and secondary coils to the required frequency, and coupling them inductively or by some other method. This method is used in intermediate frequency transformers in a superheterodyne, where there is no need to vary the tuning. In such I.F. transformers, small mica or air-dielectric condensers are used, which, when once adjusted, need no further attention. In the tuning stages of a receiver it would be a critical and expensive business to tune both primaries and secondaries, as tuning gangs would need from four to six sections each, to say nothing of the extra coil winding involved.

Before leaving this outline of tuners and tuning, it would be a good opportunity to point out the essential differences between a tuned radio frequency receiver and a superheterodyne receiver.

In a T.R.F. set all the tuned circuits



Illustrating the operation of the superheterodyne—see text.

are operating on the frequency of the station being received. That is to say, if a station is being received on 300 metres, all the tuned circuits in that set are tuned to 300 metres. There may be two valves operating as R.F. amplifiers. This would mean three coils—one in the input circuit of the first R.F. valve, one for the input of the second, and one for the third or detector valve.

Such a set can give excellent sensitivity and good all-round performance. However, the superheterodyne receiver will give better amplification and also much better selectivity.

The principle of the superheterodyne is not nearly as complicated as many appear to think. The T.R.F. set is concerned with only one frequency, that of the incoming signal. In the superheterodyne there are two primary frequencies, that of the incoming signal and that of an oscillating valve in the set, which actually produces a second frequency itself. This frequency is adjusted so that it differs from the signal frequency by a definite, fixed amount.

Most people have noticed aeroplanes flying overhead, with two engines in operation. It is possible to pick out the two different engine notes as the 'plane flies by. In many cases the observant will notice a third note, probably very slow, more like a throb than anything else. It is caused by the engines running at different speeds, and its pitch is governed by the difference between the notes of the two engines. When the engines are nearly the same in speed, the throbbing will be very slow. If the pilot slowed down one engine this throb would quicken, as the difference in speeds increased.

A similar thing happens in the superhet. Let us assume that the station being received is operating on 1000 kc. The oscillator valve in the set has its own tuned coil and tuning condenser, and is so adjusted that it will be working on 1465 kc. The difference between these two frequencies is 465 kc., which is called the beat frequency, or intermediate frequency.

In a superhet. the output from the oscillator on 1465 kc. is mixed with that of the incoming signal, and the valve which does the mixing is fed into the intermediate frequency transformers permanently tuned to 465 kc. No matter what station is tuned in, the adjustment of the oscillator valve's circuit is so arranged that it is always 465 kc., higher than the signal frequency. The signals from the broadcasting station are superimposed on this artificially created 465 kc., and can now be amplified by other valves in the usual way, at this intermediate frequency.

The advantages of this scheme are, firstly, that better selectivity is possible because efficient intermediates are easy to design. They need no variable tuning, and also more amplification is obtainable at these lower frequencies without instability, than at the signal frequency. As both primary and secondary coils in the superhet. I.F. transformers are tuned, and at least two of these are used in even the smallest superhet., there are four tuned circuits here, besides the one at the signal frequency. This means very much better selectivity due to the sharpening of the response of the receiver to the various stations, and the better rejection of all frequencies other than those required to receive the desired station and its band of frequencies.

For these reasons the superhet. has been developed until it is almost universally employed in receivers to-day.

INTERMEDIATE FREQUENCY

The selection of the intermediate frequency has a good deal to do with the set's performance. Generally speaking, the lower the frequency of the intermediate stages the more gain and selectivity one can obtain. In practice, various frequencies are used varying from 445 kc. to 175 kc., and even as low as 100 kc. The average 175 kc. receiver is generally more selective and sensitive than a 465 kc., for the same number of intermediate stages. Generally speaking, a single stage of amplification at the 175 kc. I.F. is about equal to two stages at 465 kc.

As a rule, the 465 kc. frequency, or thereabouts, is used for short-wave and dual-wave sets because on the short waves there are more frequencies per metre, and a difference of 175 kc. when we are handling frequencies of, say 15,000 kc. (20 metres) is so little that the two tuned circuits, the first detector and the oscillator, tend to pull each other together, and cause interlocking. A difference of 465 kc. is much easier to handle. It is possible, however, to get good results under certain circumstances with 175 kc. on short waves.

It is desirable to have at least one stage of R.F. amplification before the frequency changing stage of a superhet., particularly if the intermediate frequency is lower than about 465 kc. One reason which applies to all supers. is that a stronger signal is fed to the frequency changer, which also works best without the loading effect of the aerial being coupled directly to its own tuning circuit. The main reason, however, is that otherwise we run the danger of being troubled with second spotting or image interference.

Let us take, for example, a station working on 1000 kc. As the oscillator frequency in the set is spaced in this particular example, 175 kc. higher, it will be tuned to 1175 kc. The signal, which is fed through to the intermediates is, of course, 175 kc.

So far so good. The station we are listening to is on 1000 kc., or 175 kc. below the oscillator frequency at 1175 kc. Let us turn our attention to a station which might be working on 1350 kc. It is also spaced 175 kc. away from the oscillator frequency, but this time above it. The beat note between it and the oscillator will, however, produce 175 kc., which will also go through the I.F. amplifier and badly interfere with the station we want to hear.

DOUBLE SPOTS

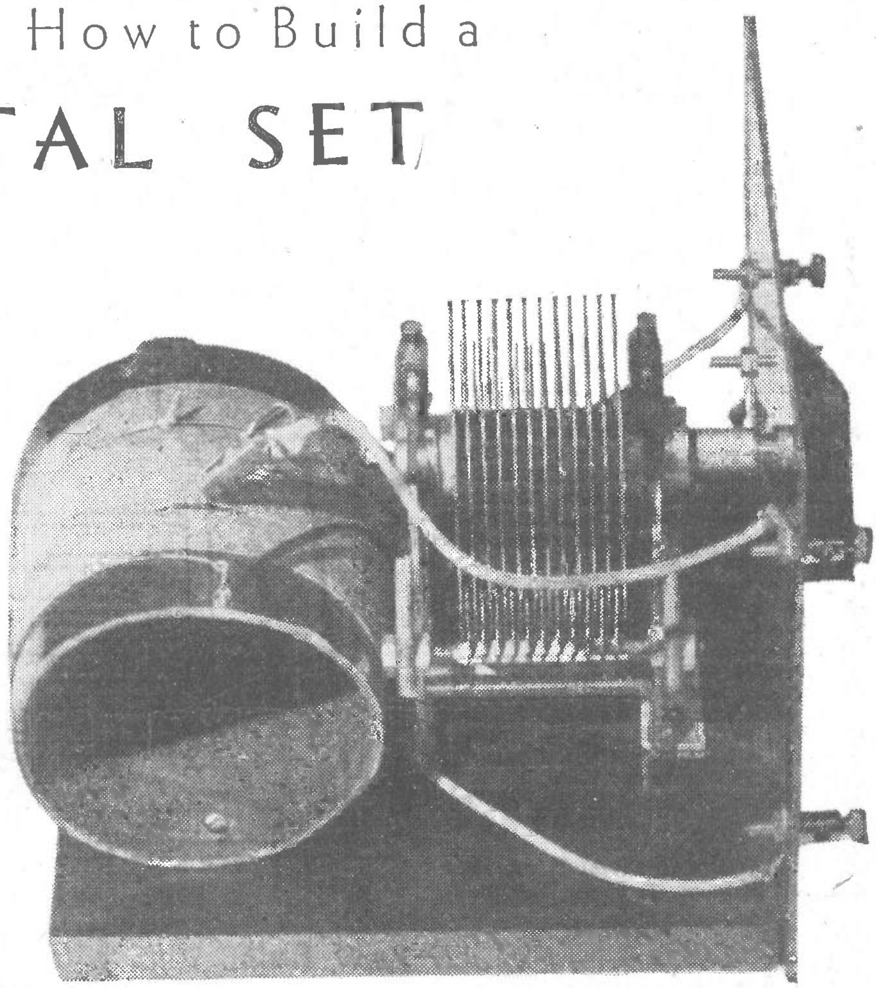
Owing to the fact that the frequency changer valve is preceded by a circuit tuned to our 1000 kc. station, this station should be much stronger, because the tuning circuit, if at all selective, should not be very responsive to the second station, working on 1350 kc. If we use a stage of R.F. and have the advantage of another complete tuned stage to further sharpen selectivity and help reject the 1350 signal it is possible to entirely eliminate the double-spot.

With 465 kc. the double spots all fall outside the broadcast band, which is the main reason we use it. Remember that double spots always occur at twice the I.F. of the set away from the normal dial reading. Thus with 465 kc. this figure would be 930 kc. The broadcast band is only 1000 kc. wide, so that the only chance of double spots would be with a station right down at the bottom of the dial, just fitting in at the top end of the band. And the set would need to be very inselective in its first tuning circuit to bring through much response from a station 930 kc. away from where it was supposed to be tuned. Thus we can dispense with the R.F. stage without suffering from double spots when using 460 kc.

Dual wave receivers using an I.F. of 465 kc. and no R.F. stage will generally double spot on the short wave bands because the tuning range of the short wave band is very much more than 930 kc. Thus each station will be receivable at two places on the dial. It will be strongest, of course, on its right spot, because at this setting the frequency changer circuit will actually be tuned to the station, whereas in the case of the double-spot position the signal makes its way through only because the single tuned circuit is not selective enough to reject it altogether. The two tuning points, as before, will be spaced twice the intermediate frequency apart.

How to Build a CRYSTAL SET

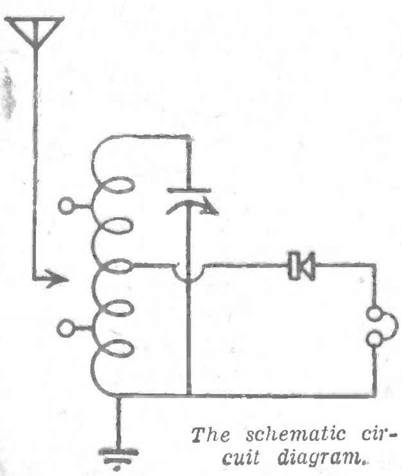
In every home, whether a "real" radio set is installed or not, there is room for a crystal set or two. The boy can listen to a thriller on the crystal set without disturbing the household, his sister can use one under her pillow so that she is crooned to sleep by Bing Crosby. You can easily build such a set for yourself at the cost of only a few shillings. Here are the instructions.



THE simplest of all radio receivers is the crystal set. In the early days of radio crystal sets were particularly popular, mainly because they were so simple, and also because, in the days when radio was so expensive, the crystal set could be built for less money.

The crystal set is quite a good one for the small boy to build as his first radio set. With it he will be able to get a practical demonstration of many fundamental radio principles, and, at the same time, have a good deal of fun. At the same time, it should be realised that modern conditions have rendered the crystal set of doubtful utility, and it should be regarded more or less from an experimental viewpoint.

The main reason for this statement is that at the present time we have a number of more or less high-powered stations operating in the metropolitan area, and the crystal set is not selective enough to separate them all. This lack of selectivity is unavoidable with a crystal set, and is one of its greatest drawbacks. It is due to the very heavy damping which the crystal has on the tuning circuit, and there is no easy way out of it.



The schematic circuit diagram.

Parts List.

1 Baseboard, wooden, about 6in. x 6in. x ½in.
1 Bakelite front panel, 6in. x 6in. x ⅛in.
1 Tuning condenser, 00035 or 0005 mfds.
1 Knob for same.
1 Crystal with holders.
1 Coil former.
50 feet of 24 gauge d.c.c. wire.
10 feet of hook-up wire.
4 Terminals. 1 Crocodile clip.
1 Pair of headphones.

We can improve the selectivity of crystal circuits by various means, but in all cases there is some reduction in volume So we find the best plan is to strike a compromise by having a circuit which is which more or less discounts our results. adjustable for selectivity. Thus we can find a setting which gives us adequate separation of stations with the least possible drop in volume,

Even under these circumstances we don't suggest that a crystal set should be operated close to any strong station, unless reception from that station alone is desired. The chances are that the strong field of the local will bring its signals in over most of the dial range and spoil reception from any other station.

On the other hand, there probably will be some positions in the metropolitan area where several stations may be tuned in and separated from each other.

It is not good policy to use a crystal set farther than about 15 miles from a strong station. There is no amplification in such a set, and the only energy available is that picked up by the aerial itself. At 15 miles the energy as a rule is getting pretty small for the average station, and conditions would therefore tend to become difficult. However, by the use of good high aerials, country people have often achieved some most remarkable reception over long distances with crystal receivers. Such cases are the exception.

AERIAL AND EARTH

As we have suggested, the aerial and earth should be something better than a length of wire round the picture rail. An outside aerial should always be used with a crystal set for best results. Do not make it too long in case interference troubles become too annoying—the longer the aerial the less selective it tends to make the set. We would suggest about 60ft. to 80ft. long and as high as possible.

The earth may be a kerosene tin buried in the ground, as described in an earlier chapter, or one could use a nearby waterpipe and an earthing clip for it. See that the aerial is well insulated to prevent losses in pick-up.

Incidentally we might mention that a licence is needed for a crystal set, notwithstanding its limitations, just as for any other type of set.

CONSTRUCTION

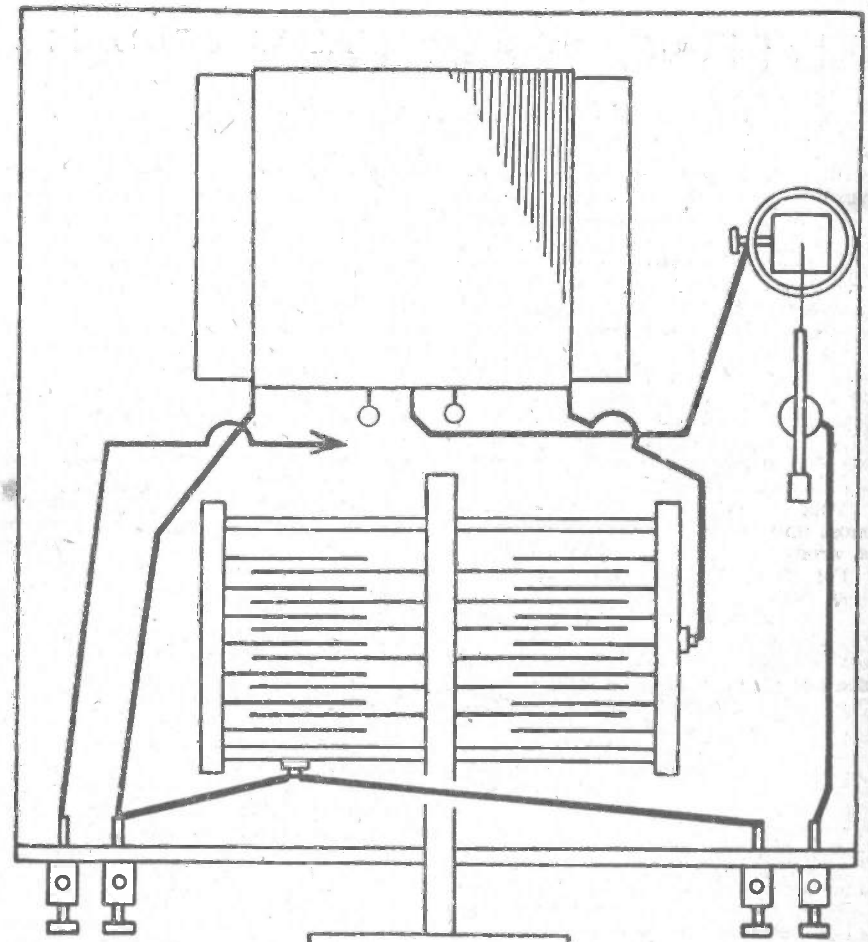
There is very little to the construction of the receiver itself. The main component to worry about is the tuning coil, and there is very little worry to it. A good coil can be made using a piece of cardboard tubing 2½ inches in diameter. Such tubing is obtainable in 6-inch lengths, and the extra length not used can be cut off. The gauge and type of wire we suggest is 24-gauge double-cotton covered. Actually the wire is not a very important factor within limits, and may be anything between gauges 20 and 26, either d.c.c., enamelled, or silk-covered.

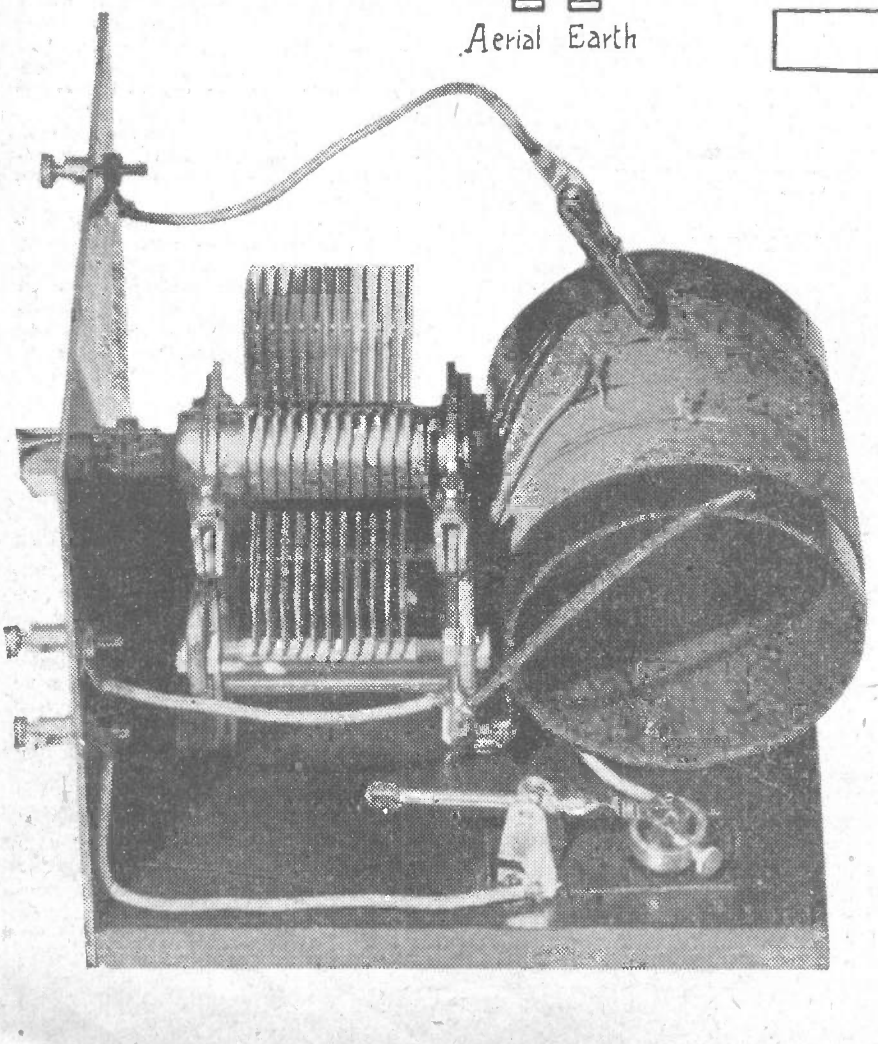
The total number of turns to wind on is 60. If a couple of holes are pierced at the beginning and end of the wiring, and the ends of the wire threaded through them, you will be able to anchor them quite firmly, and thus prevent the coil from unravelling when finished.

When you have wound on 15 of the turns twist the wire into a tight little loop to make a tapping, and continue with the remainder of the turns. Make another such tap after 30 turns have been wound, and a third turn at 45 turns. When the coil is finished the insulation is scraped from these loops so that the aerial clip can make contact with the bare wire underneath.

Leave about 6 inches of wire at the ends of the coil for connecting it into the circuit.

The base-board as shown in our pictures can be made of wood. The front panel may also be of wood or bakelite or other insulating material.





The coil may be mounted to the base-board by lying it on its side and tapping a couple of tacks through the card-board into the wood to keep it in place.

Immediately in front of the coil is the touring condenser. Almost any type will do for our purpose, and the capacity should preferably be .0005 mfds. A condenser of .00035 would probably be suitable, although it would not have such a wide tuning range as the .0005 type.

The crystal detector is shown mounted at the side of the tuning condenser. We prefer the galena type catswhisker crystal in preference to others, although the semi-permanent type will keep their adjustment over longer periods. As a rule, however, the catswhisker type will give better volume, although more likely to have the "spot" altered by jarring the table, etc., and will need re-setting at intervals. It's quite a ritual, this searching for the best spots on the crystal, and it is a good idea to make a thorough exploration of the crystal to find the best spots. A fine catswhisker should be used with a sharp point to it.

WIRING UP

In wiring up the set, the earth terminal of the set is connected to the terminal of the condenser which connects with the moving plates. The nearest end of the tuning coil is also con-

(Continued on Next Page)

CUTTING YOUR OWN CHASSIS

Hints On Working Aluminium

MOST of the popular sets, as described in "Wireless Weekly," can be built on ready-made bases specially stamped out for them. However, many constructors like to cut their own bases, and when a special type set is being made it is necessary to prepare a special base for the task.

Such bases may be laid out first of all on a sheet of brown paper, and the pattern given to a base maker to stamp out in steel. Or an aluminium base of the required size and shape may be obtained, the constructor doing the drilling and cutting himself.

This is not a very hard job, but, like most unusual jobs, there is a right and a wrong way to go about it.

For home making, aluminium is the best metal for chassis. It is easy to work, and quite rigid enough for general requirements. The first step is to get a chassis of the right size and depth, not forgetting to specify a flange along the back to fasten it down when finished, and mark out the positions of the various valve socket holes, transformer bolts, etc., with a pencil.

WOODEN ENDS

As a rule, gauge 18 metal will be heavy enough, particularly if the chassis is not very large, and has no very heavy components to support. Should the chassis be larger than about 14 inches by 10 inches, it is a good plan to use wooden ends instead of metal ends. Just cut out of half-inch butter box, or some other common or garden wood, two ends to fit the chassis, and then screw them firmly to the chassis with round-headed or other wood screws. There is less tendency for the chassis to twist about when so built, particularly as most of the heavy things, such as power transformers, are usually mounted close to the wooden ends.

It is a very easy matter to drill holes in aluminium with an ordinary hand drill. This is one of its main attractions, for it is not so easy to drill holes in a steel chassis. It is rarely possible, when making up a set, to account for every single hole in advance, and there are always a few which must be made as the set is in the process of being built. After the holes have been drilled the burred edges may be removed by using a large bit, and giving it one or two turns with the hand-drill.

So much for plain bolt-holes. More work is entailed in cutting the chassis for the power transformer.

First of all, mark out on the chassis the exact size of the transformer laminations, not forgetting the holes to accommodate the bolts which run through the laminations. There is also a rectangular piece to be cut out so that the terminal board can project through the chassis, in the case of flat mounting transformers, and through which the solder lugs can be reached in the case of vertical mounting types. This hole is, as a rule, a little larger than the actual terminal board, as the solder lugs and the wires which come out of the windings must be able to pass through without damage.

Having decided the size for this rectangular piece, mark it out with a scriber, or some sharp point, and drill a number of holes at each corner to allow a hack-saw blade to commence its cut. By holding the blade in one hand and cutting with a pull it is not hard to cut the rectangle out of the aluminium. A flat file is used to trim up the rough edges, and to enlarge the hole a little if this should be necessary. The holes for the bolts are then drilled out with a drill of suitable size.

It is a good idea to mark the position of each hole to be drilled with a bradawl, in order to give the drill a start, and prevent it wandering from its correct position.

VALVE SOCKETS

Coming now to the valve socket holes, we use a slightly different method. The best cutter for these holes is a 1¼-inch wood bit, with the flange removed, or knocked up out of the way with a hammer. The cutter may also need sharpening with the file, if the bit is a cheap one, to give it a clean cutting edge.

Commence by marking out the position of the mounting holes for the socket on the base, and also a hole in the centre of these two, to act as a guide for the bit. Now drill these holes with a 3-16ths drill before commencing to cut the hole.

The hole is cut by using the bit in a hand-brace just as though you were cutting it in wood. A lubricant is needed to prevent the metal from "tearing," and to allow a clean cut. The best lubricant to use is chemically pure turpentine, which may be bought at the chemist's for 6d a bottle. Ordinary turpentine is not nearly so effective.

Mark out a complete circle in the metal, not deep enough to tear it, but deep enough to hold the turpentine, which is now dropped into it. Using a steady but not too heavy pressure, the bit is revolved, and will cut through the aluminium without any trouble. If the cut runs dry add a little more turps. until it is completed.

The rough edges on the underside of the cut can be cleaned off with a sharp knife. Actually it takes much longer to describe the operation that is needed to make several holes, and it is a very easy and simple matter in practice.

FINISHING

An attractive matt finish can be given to aluminium by swabbing it with a strong solution of caustic soda in water. A pad of cloth tacked to the end of a stick, and used to spread the solution over the aluminium is very handy, and the solution should be kept evenly distributed over the metal in order to ensure an even surface. Take care to keep the caustic soda from coming into contact with clothing, etc., which it can easily corrode, and wash your hands well should you get any of it on them.

About 15 minutes is generally enough to do the job, after which the chassis should be rinsed thoroughly in warm water and dried.

A simpler method of finishing is to rub down the surface with fine emery paper, using water as a lubricant. This does not provide the same finish as the soda method, but it is less apt to mark, and avoids the use of the corrosive solution. Bright aluminium, of course, will show finger marks, etc., very quickly,

HOW TO BUILD A CRYSTAL SET — (From Previous Page)

nected to the earth terminal. The other end of the coil is connected to the fixed plates of the condenser. The 30th turn tapping, which is actually the centre of the coil, is connected to the cup containing the crystal. The other terminal of the crystal detector unit is connected to one of the headphone terminals. The other headphone terminal is connected to the earth terminal of the moving condenser plates (which is really the same thing). A wire connected to the aerial terminal has a clip fastened to its free end, so that it can be connected to either of the two vacant tappings.

This completes the construction of the receiver.

OPERATION

To operate the receiver, the aerial clip is fixed to the tapping furthest from the earthed end of the coil. Set the dial or pointer about the centre of the scale where you are pretty certain to be roughly tuned to a station. Now carefully adjust the catswhisker on the crystal, moving the condenser control to and fro on each adjustment until you can tune in a station. Tune in a good strong signal and adjust the catswhisker until you get the best results.

If you find bad interference, clip the aerial to the other tapping, which will reduce volume all round, but probably improve the selectivity considerably.

HEADPHONES

The limited application and low cost of the crystal set do not encourage one to spend much money on the headphones, and there are quite cheap 'phones available which will do the job very well. However, the better the 'phones, naturally, the better the reception will be in tone and volume. Therefore, if you have the opportunity to get a good pair of 'phones, by all means do so. Either 2000 ohms. or 4000 ohms. 'phones would be suitable, but 2000 ohms. should be regarded as the lowest permissible rating.

Incidentally, some crystal holders are sold in two sections, and others are in one piece, having a glass barrel to keep out the dust. Either type is suitable for this set, and the semi-permanent detectors will also operate quite well.

DO YOU KNOW?

That all matter known to science consists of "elements."

That of the 91 known "elements" 51 are used in the construction of Radiotron Valves.

That Radiotrons are unequalled for sensitivity and length of life.

That more Radiotrons are used annually in the Commonwealth than any other make of valve and a large majority of these Radiotrons are Australian-made.

That the present high efficiency of both Battery operated and "B" Battery-less receivers is due in no small measure to the development of a new Australian series of Radiotron valves.

That Radiotrons are used by leading manufacturers because they have been found, in comparison with all other brands, to give the best service and most satisfaction.

That when buying a radio set you can expect years of trouble-free reception if it is equipped with Radiotrons.

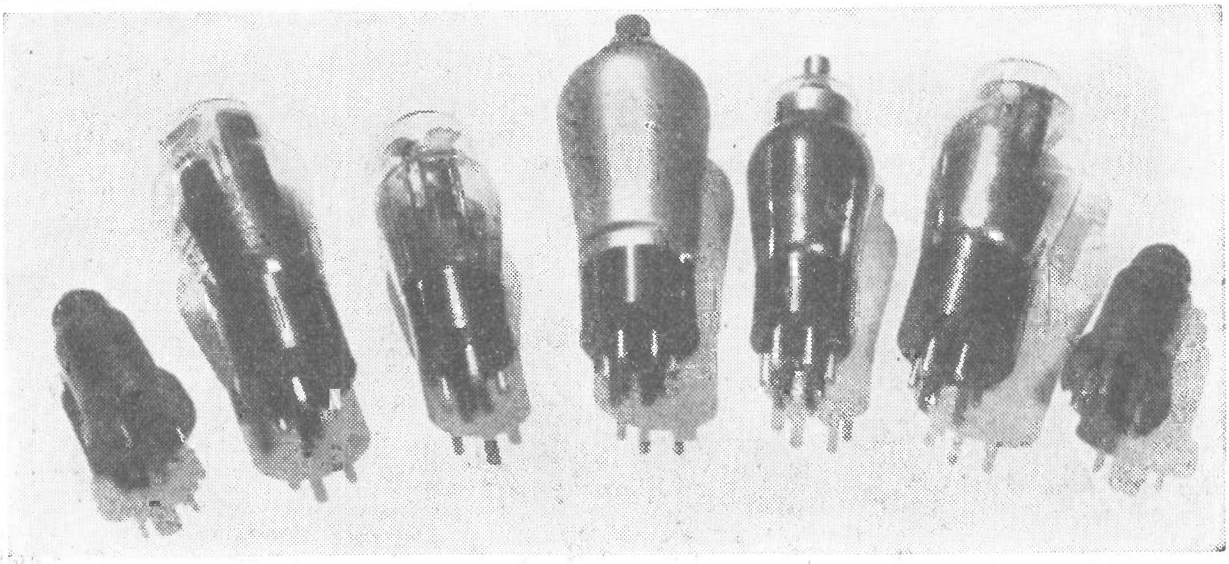
That when valves of similar type are identical in characteristics they are called "uniform."

That this "uniformity" is only obtained by constant and careful supervision with accurate checking and testing at each stage of manufacture.

That the high degree of "uniformity" achieved in the manufacture of Radiotrons accounts for their outstanding performance and longevity.

That Radiotron Valves are tested under actual working conditions before being packed, and are guaranteed to be free from defects in manufacture.

That YOUR Radio needs RADIOTRONS.



THE STORY OF THE RADIO VALVE

The Aladdin's Lamp Of Radio—Valve Rectifiers—The Valve Amplifier—The Action Of The Grid—The Diode—The Screen Grid — The Variable-Mu Valve—Output Pentodes a.c. Valves.

THE radio valve has been described by someone as the "Aladdin's Lamp of Radio." Certainly, its wonders are such that practically every major development these days depends on the valve as an integral part. The reason, of course, is that it is the valve which actually does things to the signals—it amplifies them and rectifies them, and so on. No matter how good tuning circuits, etc., are made, they can only assist the valve to operate more efficiently. Unless there are valves to take advantage of these finer points of design, technicians would be wasting their time and progress would be impossible.

There are some very complicated valves which have been designed by application of the finest examples of radio engineering, but they all arise out of the simple two-element valve designed by Ambrose Fleming early in this century. It was he who discovered that, when a filament is lit inside a vacuum, it emits electrons, or electrified atoms, each having a negative charge of electricity. He found that, if a second element in the form of a metal plate was inserted in the bulb, and a positive voltage applied to this plate, the negative atoms would tend to be collected by the plate. The higher the positive voltage applied, the more this electron flow was accelerated, and the more powerful was the attraction the plate has for the negative atoms. This attraction for negatively charged atoms to a body which is charged positively, and vice versa, is, of course, a fundamental fact in electricity.

The importance of the discovery lies in the fact that, although there is a comparatively low resistance path for these electrons flowing from the filament to the plate, there is a very high resistance in the reverse direction. This means that, if we apply to the valve a signal from a broadcast station, either straight from the aerial tuning circuit or from a radio-frequency amplifier, we can obtain detection, just as in the case of a crystal detector, but much more efficiently. The signal is, of course, an alternating voltage, but the valve will allow current to flow in the valve circuit in one direction only. Such a valve is termed a diode, because of its two elements. Most modern sets use this system of diode detection, either by means of a separate diode valve, or by means of an audio amplifying valve, which has also a diode section contained in the same glass envelope. The signal is detected by the diode section, and then coupled into the amplifying section, which amplifies it as audio frequency.

POWER RECTIFIERS

Power rectifiers such as the 280, 5Z3, etc., are all diode valves, which, instead of rectifying radio signals, rectify A.C. current from the mains transformer. The principle is the same, in that only one-half of the A.C. cycle is passed through the valve, and in one direction only. This is termed "half-wave" rectification. The rectifiers we have mentioned have two plates and one filament, by which we are able to rectify both halves of the A.C. cycle, and thus not waste anything. This is done by applying one end of the energising winding to one of the plates, and the other end to the second. Then each plate delivers its output to the filaments in alternate impulses, as the input voltage changes its frequency. This is called full-wave rectification.

The same principle is sometimes used in detecting radio signals by using a centre-tapped input coil, generally in superhets., working into double-diode rectifiers. However, the half-wave rectifier is most often used, being very simple and effective.

THE VALVE AMPLIFIER

So far, the valve had been useful only as a detector. It remained for someone to conceive the idea of a third electrode placed between the filament and the plate to act as a control over the flow of electrons. So far we have a valve which allows current to flow only in one direction. But the actual audio voltages obtained by rectification in the output "load" circuit cannot be greater than those fed into the valve in the unrectified state. The introduction of the grid, however, changed all this, and allowed the valve to amplify any voltage impressed on the new element, the grid. The grid is generally a coil of wire wound on supports, so that, although of "open" construction, it is nevertheless rigid.

ACTION OF THE GRID

It is not hard to see what will happen if this grid is connected to a source of positive voltage. It will, of course, begin to attract the negative electrons from the filament, just as does the plate. Owing to its mesh-like structure, the electrons do not remain on the grid, but shoot through it to the plate with added force.

If we apply a negative voltage to the grid, it will tend to repel the negative electrons coming from the filament and decrease the electron current flow in the valve. Thus, the grid has a "trigger" action. The input voltages when applied to the grid simply control the amplitude of the signals which will be present in the plate circuit of the valve. In other words, the original signal will be duplicated in the plate circuit exactly as it was impressed on the grid, but


Radio's most
com
THE FINE VALVES OF RADIO
K
KEN-RAD
Piezo Astatic
CRYSTAL PICKUPS
& MICROPHONES
RESISTORS
AB
BRADLEYOMETERS
SOLAR
ELECTROLYTIC CONDENSERS
& "SEALDTITE" PAPER
CONDENSERS

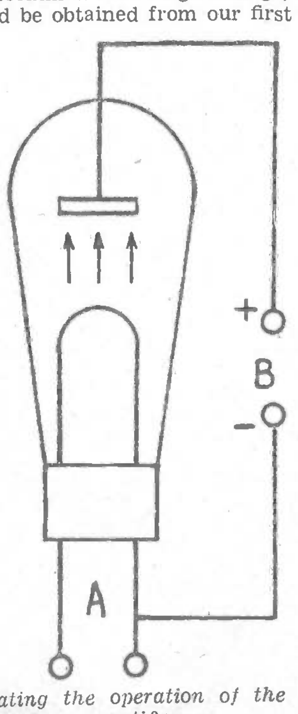
in an amplified form. Generally speaking, the closer the grid is placed to the filament (or cathode, in the case of the indirectly heated valve), the more severe will be its control characteristics, and the higher the amplification of the original signal applied to the grid.

Note that the power for the amplified signal is not obtained directly from the input signal, as in a diode, but comes from the power supply, or high-tension supply for the amplifying valve. The input signal to the grid simply acts as a control voltage, and the amplified version in the plate circuit of the valve can be, in some cases, hundreds of times amplified, according to the design and purpose of the valve itself.

The output circuit of a valve always has some "load" connected to it upon which the amplified signal is impressed. This may be a resistor. The normal plate current which the valve draws will, of course, create a voltage drop across this resistance. The fluctuations of the electron stream in the valve also set up additional fluctuations across this load. These fluctuations represent the signal, and are quite apart from the voltage drop due to plate current.

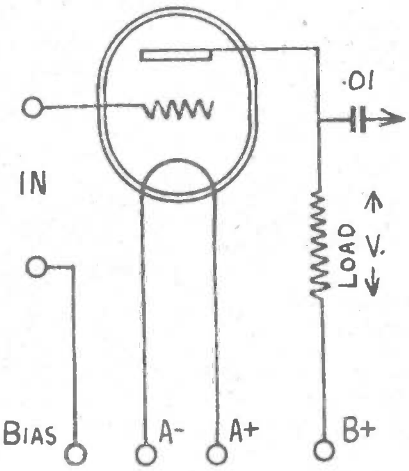
USE OF THE TRIODE

The triode valve for many years was used in all parts of a radio set, with more or less efficiency, according to the circuit. It is mainly useful as an audio amplifier, where it has some valuable advantages not possessed by other more complicated types. It can be made to give very high amplification of small audio voltages, and will amplify faithfully, without much distortion, more than to 100 times. Such an amplified signal would then be suitable to feed into a large triode valve specially made to handle large amounts of power in the plate circuit, such as are required for a loud speaker. This power is supplied from the high tension supply, and controlled as before by applying signal voltage to the grid. Such a valve is designed to accommodate a large voltage, such as would be obtained from our first amplifier, often ranging as high as 84 volts in the case of a large 50 type valve, resulting in 4.5 watts output. If a valve could be designed to give the same output as this valve, but only require an input voltage of 3 volts to obtain it, naturally it would be very much more efficient than the type 50 we have taken as an example. It is not easy, however, to design a triode valve having such a big amplification, which will still give distortionless high powered signals in the plate circuit. A degree of amplification approaching these figures can be obtained from some of the latest pentodes, but these valves have their own problems, and generally do not give the same absence of distortion as do the triodes.



Illustrating the operation of the valve rectifier.

A good triode to-day has an amplification of about 5 times (amplification factor) and output of about 3.5 watts, and needs about 35 volts on the grid to obtain these figures. There are, of course, thousands of different triode valves made, from tiny little special purpose jobs to enormous power handling types for transmitting work.



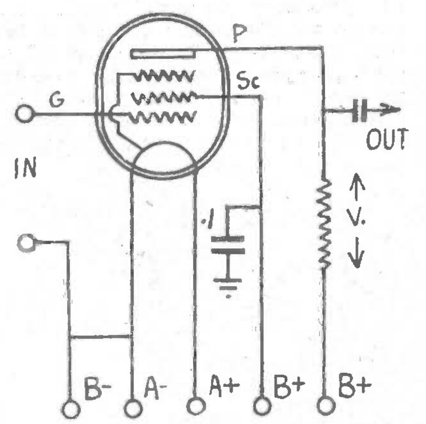
The triode valve shown schematically.

Thus we can make triode valves with very high amplification, handling very small input signals, or we can make big triodes with lower amplification, but which will handle a big signal input and supply big power for loud speakers. Very high amplification is not easy to obtain if the high output and low distortion are to be preserved, and so manufacturers generally make both types. They are called voltage amplifiers, and power amplifiers.

THE SCREEN-GRID VALVE

Triode valves are not generally useful for amplifying R.F. signals. In the early days it was necessary to use them and put up with their troubles. The main difficulty is due to the self-capacity of the valve. When the signal to be amplified is fed into the grid circuit and amplified in the plate circuit, the condenser effect (capacity) between the grid and the plate inside the valve is large enough to feed some of the amplified signal back to the grid, where it is again amplified and again fed back, and so on, finally causing the valve to break into self-oscillation.

This can be overcome by a tricky process of neutralising the self-capacity effect, by deliberately introducing feedback into the grid circuit in the opposite direction to that occurring in the valve itself.



The screen-grid valve. The amplified voltage V appears across the load, which may be a resistance, coil, etc.

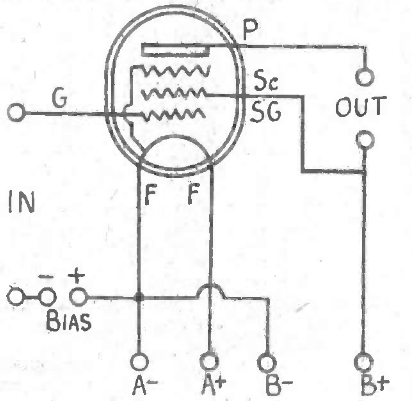
This is a critical operation, and even when completed will not allow a very high gain per stage to be obtained from the valve.

To remove these problems, the screen-grid valve was introduced. Briefly, it is a triode with a fourth element introduced between the plate and the control grid, the main purpose of which is to act as a screen, thus preventing any feedback from occurring. Hence its name, "screen-grid." It is always bypassed to earth through a large fixed condenser, so that from an R.F. point of view it is connected to earth. It also has a positive voltage applied to it, which helps to accelerate the electron flow from the filament, and increase the amplification factor obtainable in the valve. Thus we not only have a valve in which there is no internal feedback, but which can be designed with much higher amplification than the original triode. So much so that a good screen-grid valve will give more amplification than two stages using triodes.

VARIABLE-MU

There has been a good deal of development since the first screen-grid valve was introduced. The next step was to manufacture a valve in which the amplification could be varied by changing the grid bias on the control grid. This valve is known as the variable-mu type, and allows an easy and effective way of controlling volume by varying this bias either with manual control or by automatic volume control. In practice, the grid returns of the circuits to which the control grids are connected may be attached to a potentiometer across a bias voltage supply, or, in the case of indirectly heated valves, the cathodes may be made more or less positive by this method. The result is to control the amplification factor of the valves, and thus the volume of the set.

Higher efficiency still is obtained by using yet another grid called the suppressor grid, mounted between the plate and the screen grid. Because the plate voltage is being swung up and down by the effect of the amplified signal, while the screen (being bypassed to earth) remains constant, there are times when, on a strong signal, the plate, for a split second, may actually be below the screen voltage. At these times, an effect termed "secondary emission" would occur, due to the electrons being pulled back from the plate to the screen, which has the higher attraction for them. We cannot hope to explain such a point fully, as it requires considerable knowledge of valve design to understand it. However,



The circuit diagram of an output pentode valve.

the net result of including the suppressor is to allow better amplification to be obtained from the valve, as we are not limited by the necessity for keeping the plate voltage always above the screen voltage.

It will, of course, be realised that three Handbooks could not hope to cover valve design anything like adequately, and we don't feel like confusing our readers by going more fully into matters which we have covered before, and which are best understood in detail by reference to special books on this highly technical subject.

OUTPUT PENTODES

Most of the remarks just applied to the R.F. pentodes also apply to the power pentodes. These are supplied with filament or cathode, a plate, a control grid, and a screen, the function of which is to accelerate the electron flow with a corresponding increase in amplification and sensitivity. A suppressor grid is also used for the same reason as in the R.F. types, to allow the valve to be run so far that the plate voltage may be swung lower than the screen without losing efficiency. The result is that we can get as much output from a pentode as from a big triode, but with less than half the input voltage. Pentodes are the most efficient of the power amplifying valves for this reason.

Naturally, as with the output triodes, we are dealing with enough power to operate loud-speakers, and, therefore, we must supply plenty of power in the plate circuit for us to work on. Thus for the same output, the pentode valves use and require about the same voltages and currents as the triodes, but their sensitivity is so great that we can get this output without the need for an intermediate valve to amplify the output from the detector.

This pretty well covers the general characteristics of different types of valves. There are special types which the constructor will meet, and others which probably he need not worry about.

THE PENTAGRIDS

One type of valve which deserves special mention is the pentagrid converter. This valve is designed for a mixer valve in superheterodyne sets. A superheterodyne has a valve in the receiver which is oscillating all the time at a fixed distance away from the frequency to which the first detector is tuned. The problem was to make a valve which would give a reliable method of mixing the oscillator frequency into this first detector. Valve engineers evolved the pentagrid converter, which is actually a variable-mu R.F. pentode, with a triode section mounted so that the same electron stream from the filament serves for both valves. The coupling between these two sections is, therefore, "electron coupling," because it is actually the electron stream which does the work. Thus, there is no need to worry about external methods of mixing, and the whole idea has much to recommend it. A more elaborate and very successful modification of the idea is the Octode, a Continental development, which has met with an excellent reception both in battery and A.C. types.

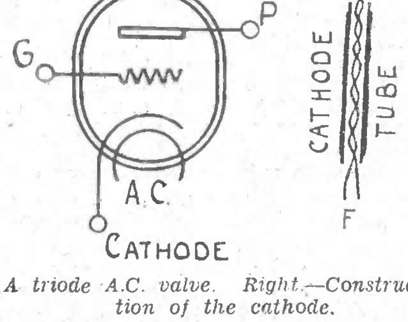
OTHER TYPES

There are other valves which come into the picture. There are the B class amplifiers, actually two triodes specially made for B class work, but mounted in the one envelope. These are almost universally triodes and operate as ordinary amplifiers, subject to one or two conditions which we will cover in another article. Then there are valves such as the 6F7, which has a triode and an R.F. pentode in the same envelope, using the same cathode, but have no internal coupling between these two sections.

Then, of course, there are valves which have a diode section for detection, isolated internally from an amplifier section, which may be a triode or a pentode, according to the circuit. Most sets at the present time, of more than about three valves, use such valves as the second detector, particularly superheterodyne sets.

✶ A.C. Valves

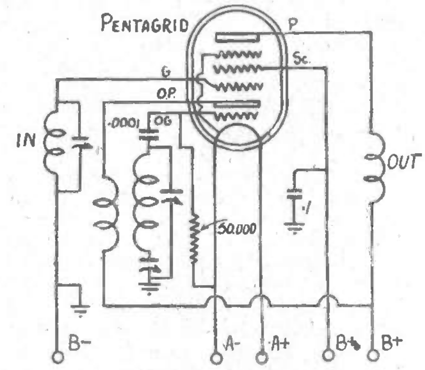
So far most of our references have been made to directly heated valves, which have a filament lit from some external source as an emitter of electrons. The first valves were all of this type, and were called bright emitters, because the valves filaments had to be lit to full brilliance before they would supply enough emission. Later developments showed how, by mixing certain oxides with the filament, it could be made to give the necessary emission with much less heating power. Thorium oxide was mostly used for these early "dull-emitter" valves.



A triode A.C. valve. Right.—Construction of the cathode.

The latest types of valves nearly all use a filament which is coated with a film of oxide, instead of having this oxide actually contained in the filament.

All these valves need some source of current supply to light the filament, and it is the filament which supplies the electrons. With the march of time, technicians got very tired of the messy accumulators which were needed to light



A pentagrid converter valve and its associated circuit connections.

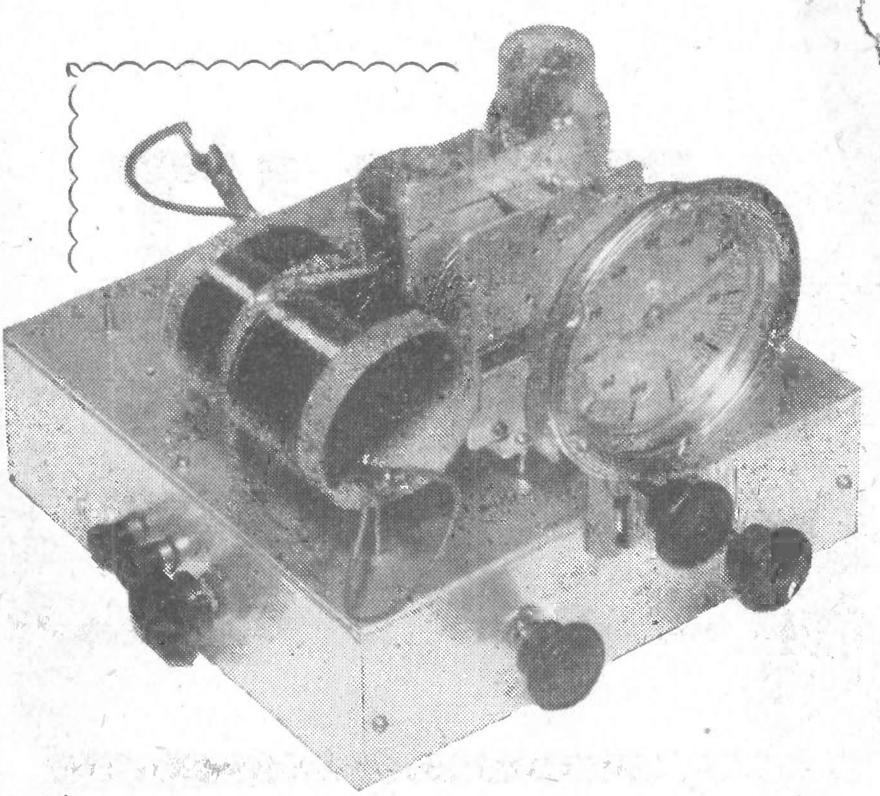
the filaments, and devised the A.C. valve. Because the filament is actually supplying the electrons, unless it is fed with pure D.C. such as is obtained from an accumulator (as against A.C. power obtained from a filament transformer), it is almost impossible to prevent the A.C. hum from appearing in the plate circuit, and spoiling results. Only in the case of output power valves, is this hum so low that we don't need to worry over it. This is, of course, because the amplification in the power valve is so low that the hum never reaches a very high level.

In order to overcome this difficulty, the valve designers adopted a very simple procedure. They made a filament, coated it with insulating material, and placed it inside a small metal tube. This tube was then coated with electron-emitting oxide of the type we have already mentioned as being used for coating filaments. Now, when the filament was lit with A.C., it heated up the tube, or cathode, until it also was hot enough to emit electrons just as the filaments had done.

No hum was introduced into the output, because the filament was not connected in any way with the electron stream, and, in fact, it is generally connected to earth at some point in its circuit.

Before long, valves of this type became very much more efficient than the battery or D.C. types. This was due very largely to the fact that more power could be made available to light the filament, since the A.C. power is so cheap when compared to that obtainable from batteries. There are also many advantages in circuit design, because of the fact that the electron emitting elements in the valves are not connected together, as, of course, they must be when running from a single battery.

Most A.C. valves are made to operate from 2.5, 4, or 6.3 volts A.C. There have been several attempts to make satisfactory valves, which have filaments lit directly from the A.C. mains, but it is difficult to see how their advantages would outweigh possible and demonstrated disadvantages.



When building your first valve set, it is always a good plan to commence with something simple. This receiver will give you plenty of fun on the broadcast band, and also provide an excellent introduction to short waves.

★

A front view of the set. The clips are in the broadcast band position. The condenser is a single gang, of about .0004 mfds.

AN ALL-WAVE TWO-VALVE SET

HERE is a grand little two-valve battery set which will gladden the heart of any boy, or for that matter, any enthusiast who likes to play round with small sets, and see just what they can be made to do.

The two-valve battery set has been one of radio's most popular home-built designs, and is still used by hundreds, particularly in the country districts, where a small portable set is desired.

It is really wonderful what such a set will receive when properly built, and intelligently operated in a good location. It is doubly useful when made so that short-wave stations as well as broadcast stations, can be received on it.

This design is about the simplest that one could imagine to serve this dual purpose. Years ago we described a battery two-valver for broadcast and short waves, and notwithstanding its disadvantages, it is popular even to-day.

This little set is an improvement. For one reason—a big one—there are no plug-in or moveable coils to change, and no switches to confuse and go out of order. Instead, we have used a full-sized coil, and tapped it to take care of the short-wave bands.

EXPERIMENTAL

One of the set's advantages from the experimenter's point of view is that it is itself, an experimenter's receiver. It can be made to operate with components which are approximately equal in value to those given, and provide excellent results. For instance, it is permissible to use a grid condenser of anything from .0001 to .0003 and still get good results. The value of .0001 is our preference if a new condenser is being obtained. Similarly, grid-leaks of anything between 1 and 5 megs. would also be suitable, our preference again being for 2 megs. We found these values to give the best results in our own particular set.

Coming to the tuning coil and condenser, we again have a good deal to come and go on. The tuning coil being tapped, is really a number of coils in one, and we can effectively change its size according to the number of tappings we put on it. The taps may be used for coupling the aerial as well as for altering the effective size, and so we arrive at a very large number of combinations which can be selected to suit almost any size of tuning condenser.

Parts List

1 Base, 8½ x 8½ x 3.
1 Gang condenser. See text.
1 Coil. See text.
1 Audio transformer.
1 5-plate midget condenser.
1 23-plate midget condenser.
1 2 meg. resistor.
1 .25 meg. resistor.
1 250 ohms resistor.
1 .0001 mica condenser.
1 .001 mica condenser.
1 .5 mfds. by-pass condenser.
1 R.F. choke.
1 Filament switch.
3 Crocodile clips.
Sockets—1 4-pin, 1 5-pin.
Valves—See article.
4 Terminals, hook-up wire, nuts, and bolts, etc.
Batteries—2 or 3 45-volt B batteries. See text.
1 2v. 40 to 80 a.h. accumulator.

THE TUNING CONDENSER

Which brings us to one of the main reasons why we find this tapped coil so valuable. The size of tuning condenser best suited for broadcast work, and that best suited for short waves, is not the same. To cover the broadcast band with a single condenser we need one with a maximum capacity of about .0005, or at the smallest .00035. This is rather large for short-wave work, because having such a large variation in capacity per degree of dial tuning, the short-wave stations are very sharp in their tuning. The best all-round value for short waves is about .00015 or thereabouts, much too small to cover the broadcast band without changing coils.

There is another point to be considered—the ratio of tuning capacity to inductance of the coil used. That is to say, best results will be obtained when a small amount of capacity is used with as large a coil as possible. Suppose, for instance, we wish to tune to a station on 31 metres. We would get best results when we used a fairly large number of turns, and only portion of our tuning condenser, than if we used only a few turns and the full capacity of the tuning condenser. This is particularly so should we use a .00035 or larger condenser in order that on the broadcast band, we could cover all the main stations without altering clips on the coil.

By making full use of the taps on the coil, we can tune in almost any short-wave station with the least possible amount of capacity, by using the highest tap we can which will allow us to tune in the station. Apart from the fine tuning which goes with a big condenser, we may use only say one-third of its capacity when tuning short waves, moving the clip further up the coil when we have reached this spot on the dial.

THE COIL

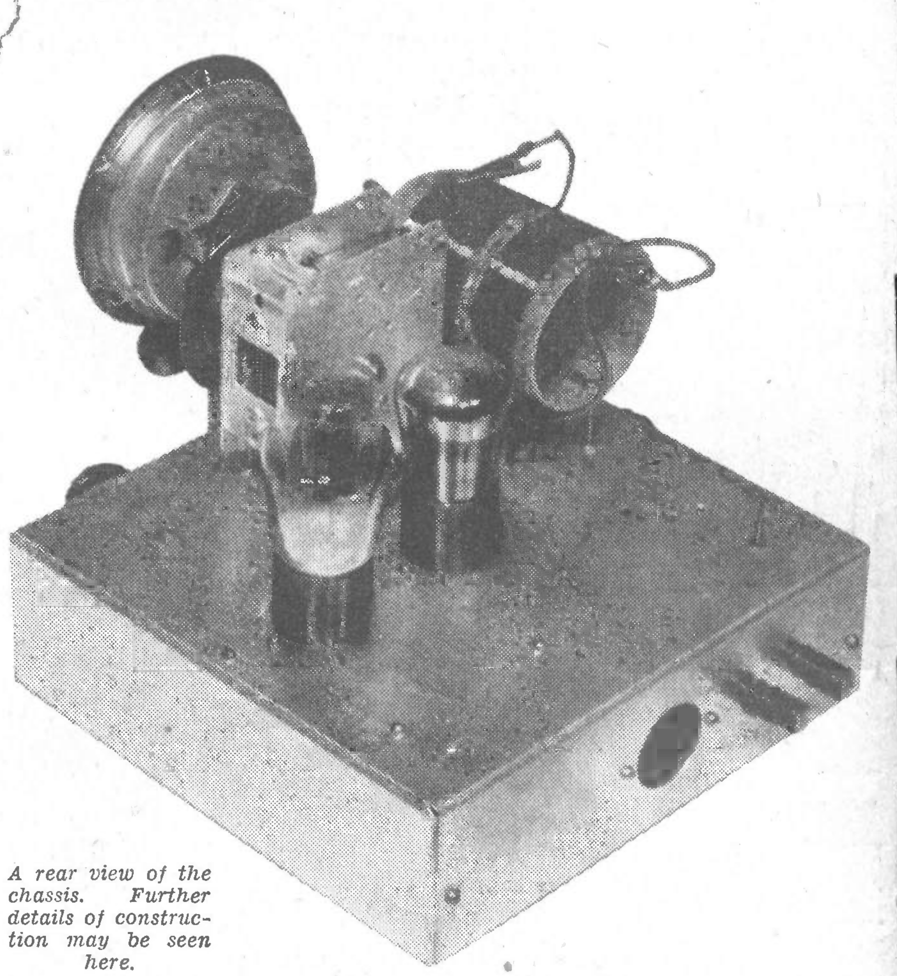
We can best explain by quoting the exact construction of the coil. It has a two-inch former in our own case, with tappings every five turns. The total number of turns is 60, and the gauge of wire 22 enamelled.

At the grid end of the coil our first tapping is not at five turns but at two turns, with the next three turns further on, and five turns from then onwards to the end of the coil.

Now attached to the earthed end of the coil we have a short piece of flexible wire, with a clip attached to its free end. When the clip is not attached to any tapping the full number of turns are in use, and if we use a .0005 condenser we can tune over the broadcast band in the normal way.

Now when we want short waves, beginning with the lowest band, about 19 metres, we attach the clip to the two-turn tapping. This automatically short-circuits the 58 turns preceding it, leaving only two turns in the grid circuit.

With almost any condenser, this two-turn coil will tune down to 19 metres. If we have a large enough condenser, we could tune in 25 and even 31 metre stations without changing the tap, but would probably find results not so good, particularly on the 31 metres. So we move the clip up to the five-turn tapping, which will allow us to tune in these 25 and 31 metre stations with very much less capacity in circuit. Similarly, when we want higher wavelengths, we move the clip still farther down the coil, until we finally arrive at the point where the full number of turns is once again in use, and we are back again on the broadcast band.



A rear view of the chassis. Further details of construction may be seen here.

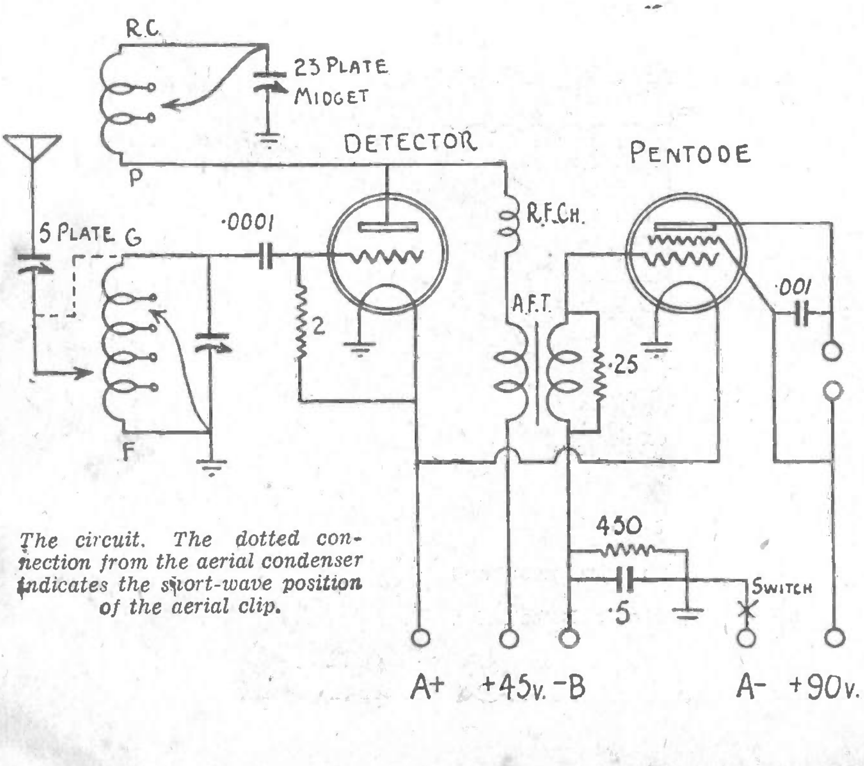
The turns which are short-circuited by the tapping do not affect the operation of the set very much, and any slight loss in efficiency is more than made up for by the convenience of not having to change coils round in the set.

THE REACTION COIL

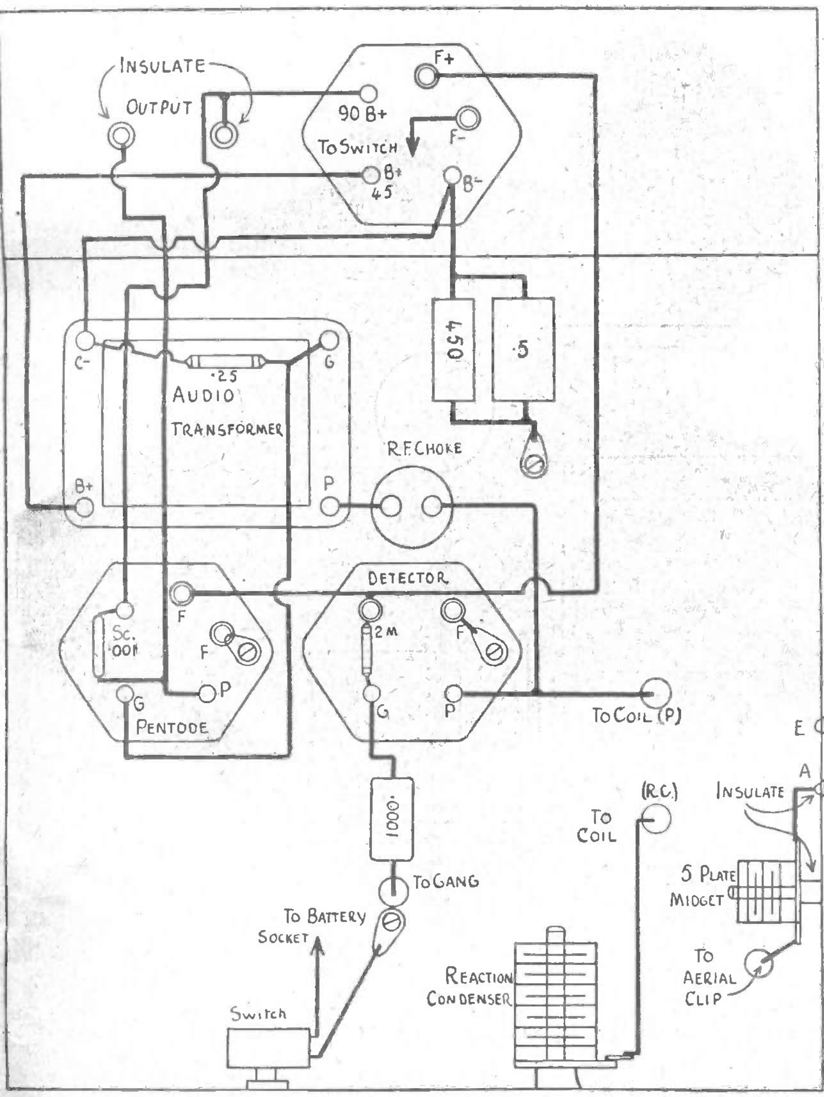
The reaction coil operates on the same principle, except that it uses less turns. We found 30 turns enough for the broadcast band, and by tapping this coil also every five turns, a tap will be found which will allow good reaction to be obtained over the various tuning ranges of the grid coil. In the case of the reaction coil, the clip is attached to the end which is also connected to the reaction condenser (R.C. in the diagrams).

Now it will be seen why almost any tuning condenser can be used with the set. If a small capacity is used, to get the best from short waves, it will be found necessary to move the clip two or even three times to cover the full broadcast band, but this is only a matter of seconds. Once the "feel" of the set is obtained, the operator will learn the right tapping for any range, and be able to make the change to the correct tapping without trouble.

In our set, we used a coil having a diameter of 2½ inches. However, even



The circuit. The dotted connection from the aerial condenser indicates the short-wave position of the aerial clip.



The connections under the chassis may be seen from this wiring diagram.

here, the experimenter can try out other diameters, preferably smaller, down to about 1½ inches. More turns will be needed to cover the broadcast band, and probably a smaller gauge of wire, about 26 enamelled, will be preferable in order to avoid having too long a coil. Plenty of tappings will make sure that every wave-band is covered with the best efficiency.

About 70 turns will be needed on a 1½-inch former to tune over the broadcast band, although the number of reaction turns will probably remain about the same.

VALVES

The builder of this set has also a very wide choice of valves. For the detector valve we suggest one of the following:—30, PM2DX, B217, PM1HL, or B228. The last two valves named will give slightly more gain than the others, but all will work very well. For the output valve, we advise the C243N, PM22a, or 1D4. These valves have practically identical characteristics, and all will work well with the 450-ohm bias resistor shown in the circuit. Other valves will not operate economically with this bias. Should they be used, a separate bias battery would be needed, of a voltage corresponding with the bias specified for each valve.

VOLTAGES

As a rule, 45 volts will suit for the detector valve in all cases. On short waves, smoother reaction with less volume will probably be had with only 22½ volts on the detector—the operator can experiment for the best value. The output valve will operate well with 90 volts, and even with 45, but should the best volume be required 135 volts is best. If a permagnetic speaker is used, the 135 volts is definitely the best. The bias will automatically adjust itself to approximately the right value, as there is less current drain with the lower voltages, at which the bias, according to valve charts, should be reduced.

On the broadcast band, most stations will be received on the loudspeaker, and also the strongest of the short wave stations. Headphones are useful, particularly on short waves, where many interesting stations are to be found which will not be loud enough for a speaker.

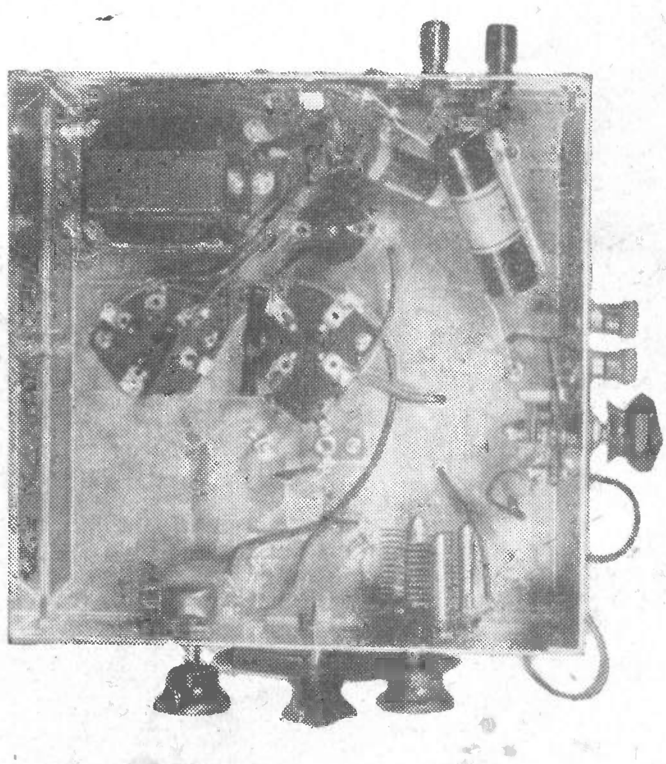
CONSTRUCTION

The set is very easy to build. We have used an aluminium chassis to keep the set in line with modern construction. A wooden baseboard may be used, providing all the earthed leads are connected to the "Earth" terminal with a piece of heavy gauge tinned copper "bus-bar" to provide a good earthing medium. The aluminium chassis itself makes a good earth, and we can save ourselves some wiring by using it.

On top of the chassis are mounted the coil and condenser. The remaining components fit underneath it. Where leads run through the chassis from the bottom to the top, such as the connection to the reaction coil, a hole is drilled, and insulated "hook-up" wire run through them. All the wiring should be done with this same wire, which is obtainable everywhere, and used universally for wiring up sets.

The positions for the various components will be gathered from our

Here is a picture under the chassis of the actual set. We suggest reversing the positions of battery socket and output terminals as shown in our wiring diagram. It may simplify wiring.



wiring diagram, which is drawn to scale. The chassis measures 8½ inches square by 3 inches deep. A smaller chassis could be used, but there is no reason to cramp ourselves for space.

AERIAL CONNECTION

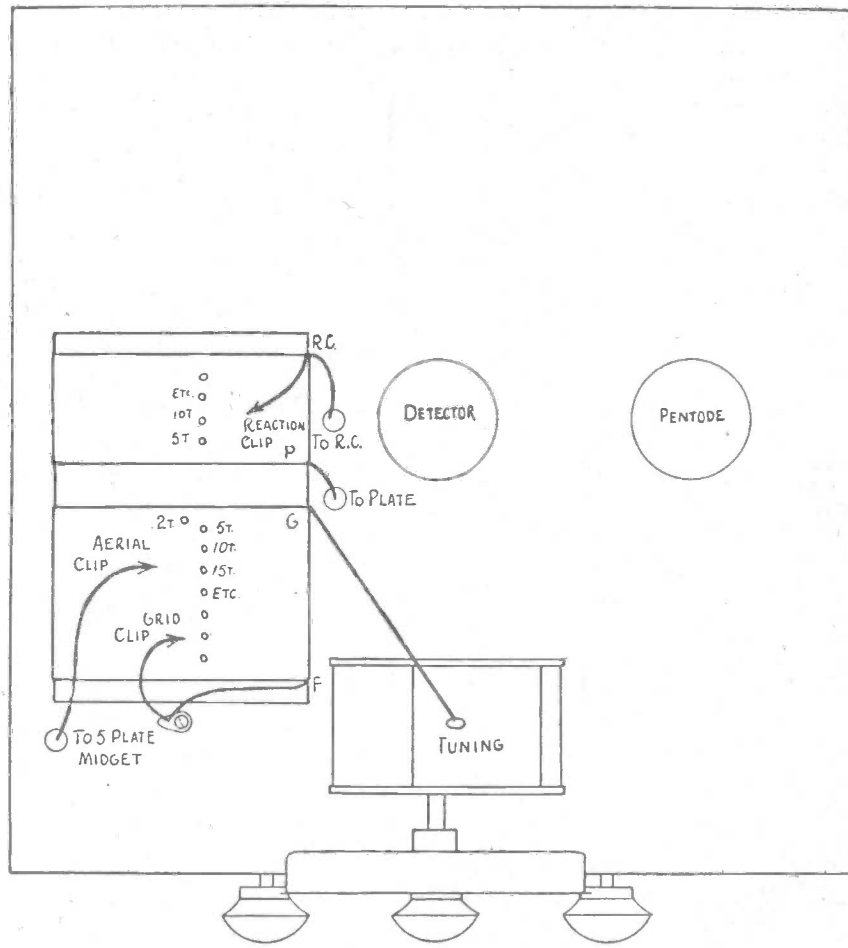
When short waves are being received, the lead from the aerial condenser is connected to the same tapping on the coil as the clip of the grid coil itself. The amount of capacity needed for the aerial condenser will vary with the wave-band used—the lower the wavelength the less the capacity.

The tip of one of the moving plates of the aerial condenser is bent with a pair of pliers, so that when the condenser is turned all in, the tip makes contact with the fixed plates, thus short-circuiting the condenser. The aerial clip is then connected to the tapping on the coil which gives best results from a selectivity and volume point of view. For very selective results, use the first 5-turn tapping; Where more volume and less selectivity is required, use the 10, 15, or even 20-turn tapping for connecting the aerial clip.

When the change to short waves is made, turning the aerial condenser so that the plates no longer short-circuit will bring it back into circuit. The plates must not touch when receiving short waves, otherwise, reaction will not be possible.

WIRING

Having all the components in place, the wiring of the set can be carried out. It should not take very long, and the wiring diagram will show you the correct points to connect together, if you



Here are the connections above the base. The F end of the tuning coil may be connected to a solder lug under the bolt which holds the end of the coil in place.

cannot follow the circuit itself. It is a good plan to follow each wire, both on the circuit and the wiring diagram.

The wiring diagram has been drawn for clarity, and it is therefore quite in order to make the leads more direct than we have shown them. Also it does not matter if the components are not in exactly the same relative positions, as long as their connections are made correctly. No one could follow a wiring diagram, at least not easily, if we drew wires exactly as they appear in the set itself.

It will be noticed that the negative terminal of each valve socket is connected to the chassis through a solder lug screwed under the nut which holds the valve socket in place. This is an easy way, and as the on-off switch is in the negative lead to the battery, one side of the switch is also connected to the chassis via a solder lug under some convenient bolt. One of those holding the gang in place will do. The connection from the grid condenser to the gang is made to the terminal on the gang which is underneath it. The gang itself is raised from the chassis by four long bolts, the height being adjusted to suit the mounting requirements of the tuning dial. The connection to the gang runs through a hole drilled in the chassis, which, of course, we can't show clearly on the above-panel diagram.

The G end of the grid coil is connected to the gang by the terminal at the top. Should you use an old-type condenser, you will probably find a terminal connecting to the fixed plates which will do for both connections.

The earthed end of the grid coil we connected to a solder lug screwed under one of the bolts which hold the coil in place. This is a convenient spot for it. The coil is also held clear of the chassis by two bolts which pass through the ends of the cardboard tube. Keep the coil at least 1 inch from the chassis and in no circumstances allow it to rest on the metal. With a wooden baseboard, it doesn't matter.

Incidentally, almost any good vernier dial will do for the set.

OPERATION

Operating the set is easy. After all the batteries have been connected up, and you are sure everything is in order, tune over the broadcast band (you can double the clips back on themselves and clip them to the points from which they start) and you will hear stations on the broadcast band. To receive short waves, work on the various tappings, and tune more carefully. If reaction is weak, use more reaction turns; if too fierce, use less, or reduce the detector voltage. Very little aerial condenser capacity will be needed on the 19-metre stations, and more may be used as you tune in stations on a higher wavelength.

HOW TO BUILD A WAVE-TRAP

THERE are many instances in which simple sets are being operated near to a strong station, in which case this strong station takes up more than its fair share of the tuning dial. Often the "spread" of the station may be so bad that as much as half the tuning dial is just swamped with the strong signal.

Under such circumstances, it is obvious that reception of stations near this strong local would be unsatisfactory, because they would be accompanied with a strong background from the heavy signal.

Under such circumstances, it is a comparatively easy matter to make up a simple little device which will greatly reduce and generally eliminate this interference. It is called a "wave-trap" because, when installed, it forms a trap-circuit for any signals near the frequency to which it is tuned.

A common fallacy which is often held about a wave-trap is that it makes a receiver more selective. Such is not the case. The selectivity of the set is not affected at all by the wave-trap. What the wave-trap can do is to practically remove a strong station from the dial altogether, so that it will not swamp out other stations near it.

The wave-trap is connected in series with the lead-in wire to the set. In other words, instead of connecting the lead-in to the aerial terminal of the set, it is connected to the tapping we have shown on the wave-trap coil. Then the terminal marked "to set" on the wave-trap is connected to the aerial terminal of the set instead.

The wave-trap can be built in a little box, and left permanently installed. It would be a good idea, if the interfering station is very close, to enclose the trap in a metal box, so as to prevent any direct pick-up by the trap-coil, which would spoil its efficiency.

CONSTRUCTION

It is very easy to make a wave-trap. Almost any tuning condenser will do—an old style .0005 would be excellent.

The coil can be wound in a few minutes. We suggest making it 2½ inches in diameter, and using 55 turns altogether of 22 enamelled wire.

From one end of the coil make about four taps each 5 turns, so that you can use the one which gives most effective results. The connections to be made are only about four in number, and are shown in our diagram.

USING THE TRAP

The method of procedure is as follows:—Connect the trap as directed above, and swing its condenser until the plates are out of mesh. Now tune in to the station which is causing all the bother. Leaving this station tuned in, rotate the wave-trap condenser until you reach a spot where signals will either fade out altogether, or else reach a very low volume. Leave the trap tuned to this spot, and proceed to tune in the stations you desire. You will find that the strong station will no longer interfere with your reception.

Unfortunately, it is not always possible to remove the strong station without also affecting the reception of stations a few degrees on each side of it. This is because the trap is not razor-sharp in tuning, but generally, as in the case of local stations, they are well enough spaced out for the trap not to interfere with reception when tuned to one of them.

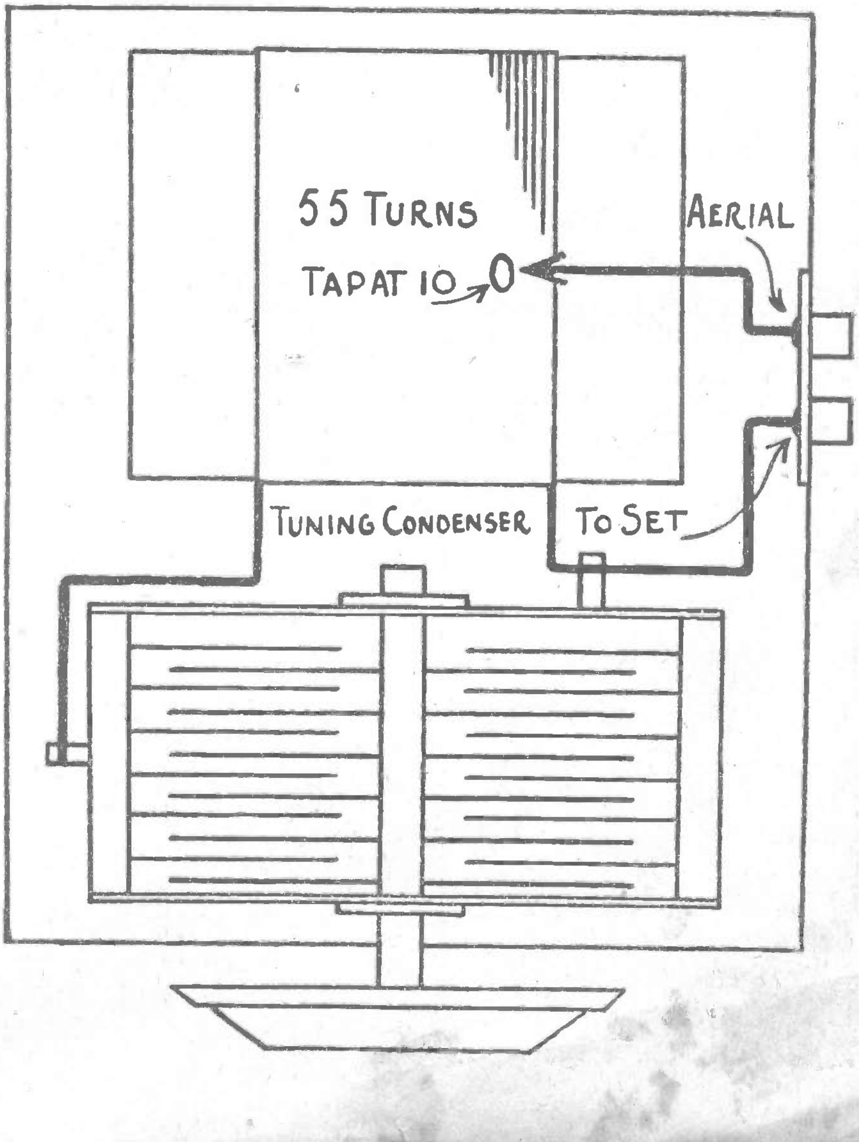
THE TAPPINGS

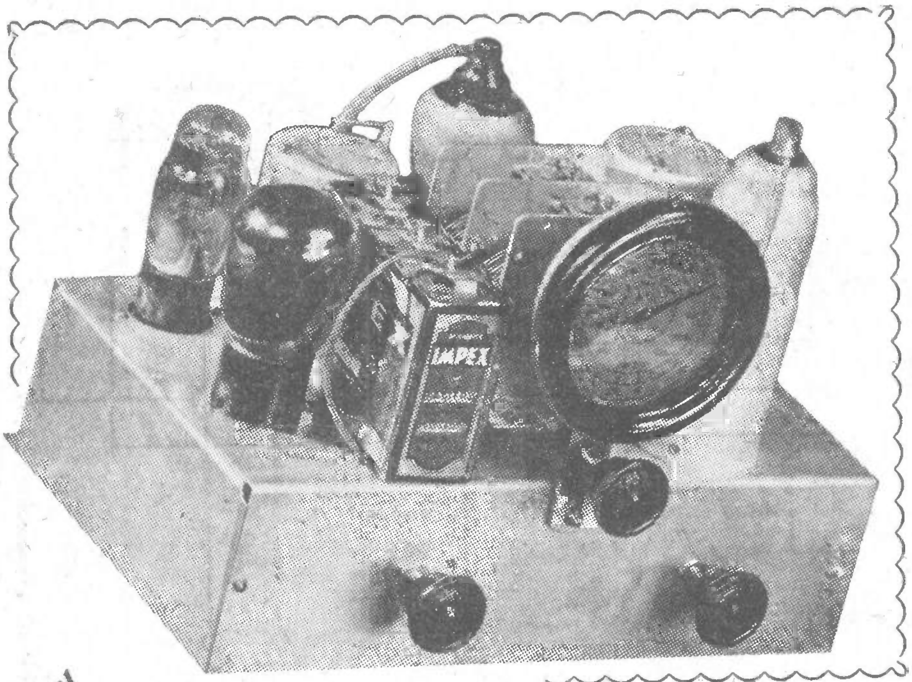
It will be found that the trap is most effective when using the highest or 20-turn tapping, but in this position the trap will affect the largest section of the dial. Moving the aerial connection down to the lower-value tappings will sharpen the trap tuning a good deal, but make it less effective in action. The advantage of the tappings is that you can select the one which gives the best results in any particular case. It is quite a good idea to tap the coil every 5 turns, so that you can have a large number of settings to choose from. If the aerial is clipped to the top end of the coil, so that all the turns are in the circuit, the trap will be very effective in action, but will probably affect reception over a good portion of the dial.

When reception of the strong station is desired, the trap condenser may be swung fully out of mesh, or, alternatively, a switch could be included which short-circuits the coil altogether when the trap is not wanted.

The wave-trap will be found of great value for small one, two, or three valve sets, either A.C. or battery, where the initial selectivity is not very high. In the case of bigger sets, it is also useful if located very near a local station, which sometimes will place an annoying background on the carriers of other stations. Amateur transmitters also find the trap valuable should their transmissions unfortunately cause interference with broadcast sets, as sometimes unavoidably happens.

Only one trap at a time can be used —it is not practicable to connect, for instance, two traps in series to deal with two stations. If the locality is so unfortunate that more than one station has a swamping effect, the only remedy is a better receiver.





When considering the selection of a Four-valve Battery Set for this Handbook, we decided that our best plan was to reprint the complete article describing the A.V.C. Pentagrid Four. Its simplicity and fine performance still make it a hard set to beat.

A FOUR-VALVE BATTERY RECEIVER

THERE has always been a great demand for a good four-valve battery set. In the first place, a four-valve set is quite cheap to build, as there are generally not very many parts. Secondly, a four-valve set is light on B batteries. It represents the bridge between the little sets, with which nothing very much can be achieved in the way of sensational results, and the big ones, in which the designer has a chance to include everything that opens and shuts.

In the past we have proved the popularity of a straight four-valve superhet. The Pentagrid Four has proved the most successful battery set we have ever described. But time goes on, and with it come many opportunities for improvement.

ENTIRELY NEW

Although it is a little while since this receiver was first built, it would be hard to improve upon it very much. Even at this stage we would find it hard to suggest any major improvement in the light of later development. The valves used in this set are still the best all-round types we could recommend.

PERFORMANCE

Let us tick off the various points in performance, which make us so enthusiastic about this receiver. In the first place, it has excellent sensitivity. Its distance-getting abilities are first-rate. We mean by this that in tests it tuned in Melbourne B class stations at audible strength on the speaker with 3 feet of wire hanging from the test-bench. To grasp this wire in the hand was to bring about an increase to good loud-speaker strength. Connection to an outside aerial brought in stations at practically every point of the dial.

On a Sunday evening, when the final tests were run, amateur stations on the broadcast band were tuned in from four States, and at the upper end of the dial three Japanese stations were audible. Not a bad performance for a four-valve set in the suburban area!

SELECTIVITY

The selectivity of the set is quite as good as any other 460 kc. receiver we have handled. Naturally, it has not the ability to separate stations 10 kc. apart, which is only just within the capacity of a six-valve 175 kc. superhet. But it will be found quite adequate for all general purposes, and every programme of importance broadcast from Australian stations should be heard with it.

BATTERY CONSUMPTION

These results were obtained with 135 volts of B battery, and the milliameter in the B minus lead was reading only 10 mills. when receiving local stations! With no signal coming through the current was 13 mills. The valves used in the set were taken at random from available stocks, and were not specially selected in any way. It is quite reasonable to assume that the average receiver as built by the man at home should give just as good economy. Some cases will probably be found where an increase of, say, 2 mills. will be experienced—others may show an even lower consumption. We are simply quoting the accurately measured figures actually obtained by test with the original set. No one will deny that such economy is as good as can possibly be desired.

ON LOW VOLTAGE

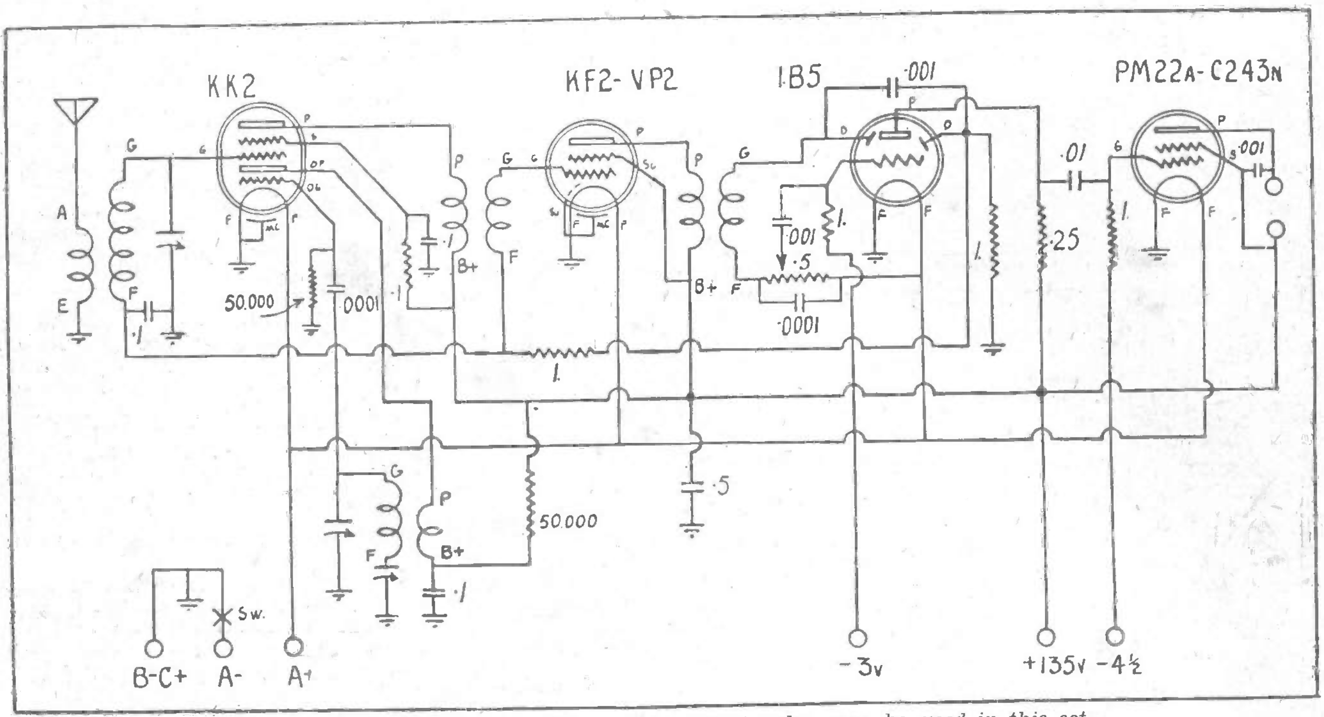
For the interest connected with such measurements we give figures obtained on other voltages. At 120 volts performance was almost as good as with 135 volts, the total consumption dropped to 7½ mills. on local stations. Even with 90 volts high tension inter-State stations were still audible, and the current was some silly figure, such as 3½ mills. or so. Naturally, one would not expect to run the set from such a low supply—owing to the low current drain 135 volts should be ample, and is recommended. At 150 volts results were even better and the consumption up to about 13 mills. on local stations, and 17 with no signal. So that it would still be a practicable proposition at this voltage from an economy point of view.

It will be admitted that such economy is remarkable, particularly when results are considered.

THE CIRCUIT

Coming now to a discussion of the circuit, we find that a 460 kc. type of coil kit is used, with a single intermediate frequency stage.

The first valve is the new battery Octode. This valve is similar in theory to the well-known A.C. Octode, which has been so popular with manufacturers of 4/5 valve A.C. sets, and, of course, with larger sets as well. It has proved to be the best battery pentagrid we have used to date, being economical,



Here is the circuit. The 1D4 pentode output valve may be used in this set.

quiet, and a very certain oscillator. It still perked away merrily with 60 volts total high tension. This means that, no matter how low the batteries drop in service, there is little danger of the valve ceasing to oscillate.

To get the highest possible gain from the I.F. stage we have used the valve with the highest amplification—the KF2-VP2 type. Used with coils designed for it, this valve gives plenty of gain, and is largely responsible for the set's fine range.

The second detector is another new release—this time an American type valve. It is the 1B5, an improved version of the 25S. It is a double-diode-triode valve—quite non-microphonic, and gives diode detection with excellent automatic volume control as well. It is resistance-coupled to the output valve, a PM22a-C243n type.

The A.V.C. operates on the KK2 and the KF2-VP2. It is quite effective in levelling the stations within reason, and has just the right amount of control to combat fading. Checking up with a tuning meter reveals quite a large variation in reading (representing severe fading), with scarcely any noticeable change in signal strength.

BATTERY CONNECTIONS

Another great thing about this set is that there are only four battery leads from the back of the chassis. There are two for the A battery and two for the B battery. Thus we have avoided one of the biggest nuisances and troubles of battery sets—too many battery leads. We could hardly have less than four, and there are no tappings on the batteries to worry about. The batteries will thus run down evenly, with no sections having a greater drain than others.

The C battery has two tappings. It is mounted on the chassis, and beyond replacement on principle, say, once a year, need give no worry. It is not a

Parts List

1 465 kc. superhet. coil kit for KK2.
1 2-gang condenser.
1 Base, 11 x 7 x 3.
1 Vernier dial.
1 .01 mica condenser.
3 .001 mica condensers.
2 .0001 mica condensers.
3 .1 bypass condensers.
1 .5 bypass condenser.
4 1 meg. grid leaks.
1 .25 meg. resistor.
1 .1 meg. resistor.
2 50,000 ohms. resistors.
Sockets—1 7-pin medium, 2 6-pin, 1 5-pin, 2 4-pin.
1 .5 meg. potentiometer.
1 Battery switch.
Valves—KK2, KF2, or VP2, 1B5, PM22a or C243n.
Batteries—3 45-volt heavy duty B batteries.
 1 4.5-volt C battery.
 1 2-volt 40 a.h. (at least) accumulator.
Speaker—Permagnetic, matched for valve.
Battery and speaker plug, nuts, bolts, connecting wire, knobs, etc.

bad idea to test it with a torch globe every few months, and to discard it as soon as it fails to light the bulb to approximately the same brilliance as it did when new. This is a precaution, by the way, which every battery set owner should take, no matter what type of set he uses. So much of the set's performance and economy depends on the bias battery.

THE KK2

A word about the KK2. This valve, when connected as shown with a 135 volt supply, uses about 3 mills. all told. As will be observed, series resistances are used to feed the screen and anode plate, instead of using battery tappings.

There are several reasons for this. One is that we are able to avoid two extra leads to the battery, for the cost of two 1 watt resistors. Secondly, as the battery voltage drops, the current drawn by these sections drops also, and thus the voltages are automatically adjusted in proportion.

The values given here are those advised by the valve makers for the average or standard type of coil. In any case, it will rarely be found advantageous to use any valve but .1 meg. for the screen resistor. In the case of the oscillator plate resistor some variation is permissible, depending on the design of the coil. The coupling between plate and grid coil, etc., determines the degree of oscillation of the valve, and thus the current drawn by the anode. Therefore it is permissible to experiment a little with the value of this resistor within limits—say .1 megs and 25,000 ohms. The main difference will probably be in about 1 mill. of B battery current. Generally speaking, either 50,000 ohms or 25,000 ohms should be used, although we suggest that the set be built with the values shown for a start.

This valve is very quiet in operation, and the noise level of the completed set is almost negligible.

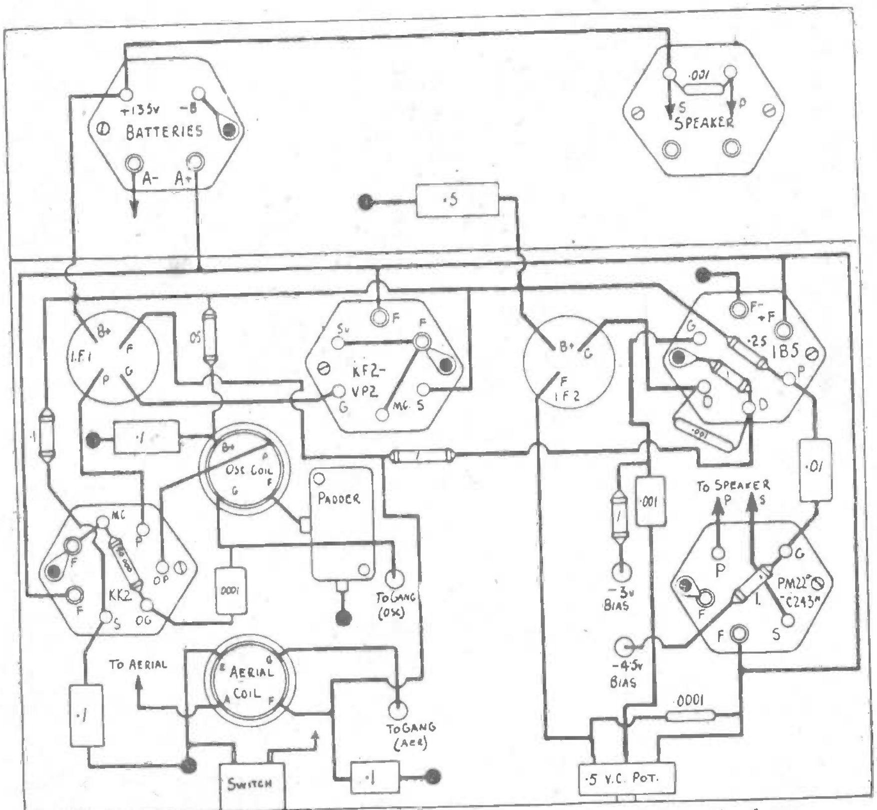
THE I.F. AMPLIFIER

The I.F. amplifier is quite straightforward. An advantage of the type of valve employed is that both plate and screen are run at maximum high tension, which helps to simplify the circuit. Make a point of carefully studying connections to the valve socket, as three terminals are connected to earth. The plate connection to this valve is made above the chassis by the lead coming from the intermediate can. This lead, by the way, is enclosed in a short length of copper braid, which is earthed to a solder lug screwed under one of the mounting screws of the intermediate can itself—see above panel diagram.

SECOND DETECTOR

The second detector is the 1B5, used for diode detection, A.V.C., and first audio amplifier.

The main thing to watch about this valve is the polarity of the filament connections. There is definitely a right and wrong way. We have therefore



Here is the wiring diagram, showing connections below the base.

marked on the wiring diagram which terminal is positive and which negative. It is necessary to get these right, so that the polarity of the diodes will also be right. The set will not work properly if the filament connections are reversed or the wrong diodes are used for detection and A.V.C.

There is no delay voltage on the A.V.C. diode except that brought about by its connection to the negative side of the battery. There is a reason for this—the difference between signal and no-signal drain is only about 3 mills., and as we want all the sensitivity we can get we find results better with the load resistor returned direct to the chassis.

The volume control is in the form of a .5 meg. potentiometer. We shielded the leads to and from this potentiometer with earthed copper braid as a precaution against audio feed-back. It is a good practice, although not always essential, as the set is very stable.

AUDIO CIRCUIT

The audio circuit uses resistance coupling between the 1B5 and the output pentode. We found plenty of gain with this arrangement. The use of an audio transformer would, of course, give still more gain, and would be quite a practicable scheme. However, a good transformer costs about £1, and we did not feel justified, under the circumstances, in standardising on it. We leave this more or less open to the experimenter, but suggest keeping to the original circuit for a start before worrying over such points as this.

SIMPLICITY

One of the most valuable features about this set is its utter simplicity. We have tried to make the wiring diagram as clear as possible, and even the novice should find it well within his powers to follow out the wiring. The diagram shows each component approximately the right size in proportion, although we have taken a few liberties for instance, with the size of resistors to keep it from becoming overloaded. Careful inspection of the photographs will bring out every constructional detail, and comparison with the wiring diagram should make it perfectly clear which component is which.

COMPONENTS

All the components are standard types and are readily available. The coil kit is probably the most important point. It would be well to see that the kit obtained for the set has actually been produced to work in it. The KK2 valve will work with a 1A6 type coil kit, but not as well as with a kit made for it. Similarly, the I.F. valve will work with kits made for 32 or 34 valves, but not as well as with its correct intermediate coils. Therefore again we say, see that the kit is the right one, and also that the gang condenser used is the right one for the coils. Otherwise you may find that the tuning range of the set does not include all the stations on the band.

ABOVE THE BASE

The KK2 has the cap connected to the grid lead, which comes through from the aerial coil. This is soldered to a standard grid clip, and the excess length of the lead cut off.

The I.F. valve has its plate connection at the top, and a wire coming through the can of the second intermediate is connected to this. It is a good idea to enclose this lead in a short length of copper braid, as mentioned previously, earthing the braid to the intermediate mounting screw.

To this screw is connected the C plus lead to the C battery. This battery stands on the chassis beside the gang condenser. Two leads come up from under the base to it, one connecting to the 3-volt tapping and the other to the 4½-volt terminal. These connections are clearly shown on the diagrams. See that the C battery has a 3-volt tapping.

ADJUSTMENT

One of the advantages of the 460 kc. sets is their easy adjustment. Having made sure that all connections are correct and that each wire is in its right place, connect up the A battery of 2 volts. Switch the set on, and see that the filament of the 1B5 lights up. If it does, we can assume that the other filaments are also alight—you will probably be able to see them except the output valve, which usually is silvered right over the bulb.

Now connect up the B batteries and turn on the set once more. The speaker, of course, is plugged-in as well. It is a good idea to include a small torch bulb in the A minus lead in case of accidents. Should there be a short circuit this bulb will immediately blow out and the valves will be safe.

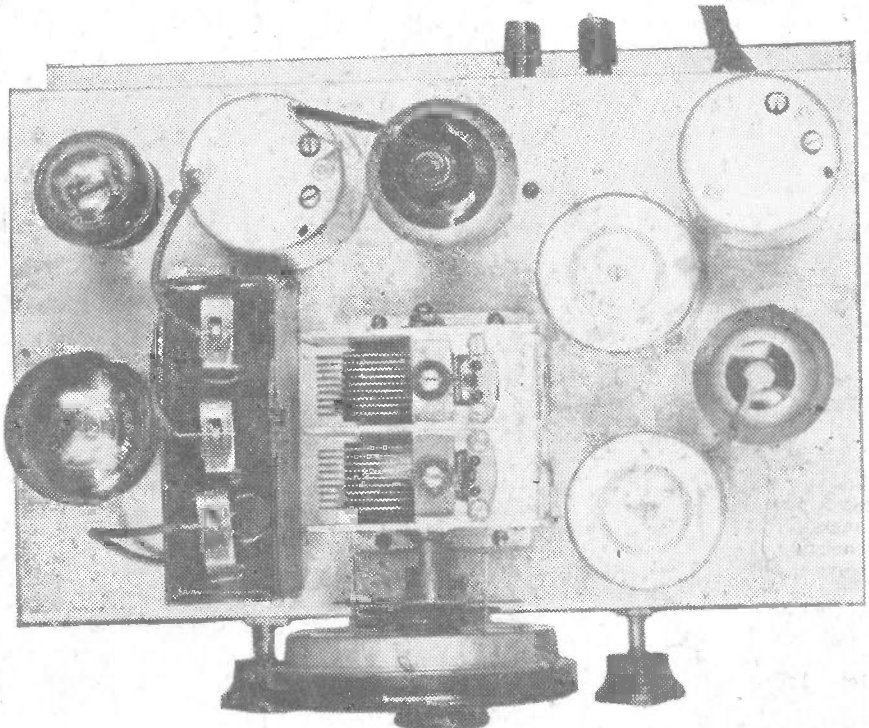
TRIMMING

If all is well, loosen off the trimmers on the gang and tune-in a station at the bottom of the dial. Keep the rear or oscillator trimmer unscrewed as much as possible, and line the aerial trimmer for best volume. Should difficulty be found in lining these trimmers to approximately the same position for each try various setting of the padder beneath the base.

Having got best results on the lower end of the dial, swing to the higher wavelength stations, and, leaving the trimmers as before, adjust the padder for best results on these stations. Keep rocking the dial as the padder is adjusted, so that the station is held in tune. This adjustment completed, return to the bottom end of the dial and finally check up on the aerial trimmer. The set should now be lined up and ready to give its best results.

THE INTERMEDIATES

It is permissible, finally, when all other adjustments are done, to give the intermediate trimmers a touch to see that they are all in line also. Mark carefully the original position before moving any of them, so that you can return to the first setting if desired. Probably not more than about one-half turn will be needed to any of the trimmers. The trimmer across the coil connected to the detector diode will probably need most adjustment—possibly one full turn or even more. Be very careful, however, to see that you make a note of how much the intermediate trimmers are turned, as otherwise you may completely lose the right adjustment, and the coils will then probably need a journey back to the factory for re-alignment on an oscillator. It is quite a simple job if care is taken.



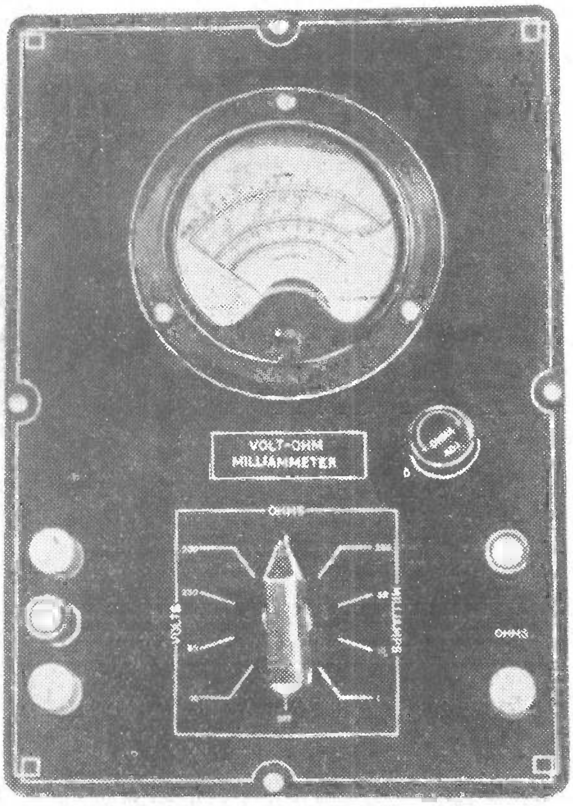
A plan view of the chassis.

AERIAL

A good aerial and earth are the rights of every set. Make your aerial about 75ft., including the lead-in, and as high as possible. In outback areas longer aerials can be used, but they tend to broaden the aerial trimming—permissible, of course, if over-all results are improved, but not desirable otherwise. A kerosene tin filled with ashes, knocked full of holes, and buried a foot underground, makes a good earth. The earth lead is soldered to the tin.

How to Build a MULTI-METER

In this article full instructions are given for building a meter which has a full range of readings, including volts, milliamps and ohms. It will enable the constructor to keep a check on any measurements he is likely to meet in ordinary radio work.



Here is the front view of the multi-meter. The centre terminal of the three is common to volt and milliamp scales.

ONE of the most useful things anyone can have round the radio shack or workshop is a multi-meter, which will read several ranges of both volts and milliamps and also test resistors for value.

In fact, most home-builders are working in the dark unless they have some such meter available. As it is well beyond the purse of the average man to maintain several expensive meters, which, of course, would be very desirable, the next best thing is to have a meter which, complete with a suitable number of shunts and resistors, can be made to do the work of a dozen meters, and, if well built, do the work quite accurately.

In this article will be found all the information needed to construct what we consider to be the easiest and simplest multi-meter suitable for the home-constructor.

HOW IT WORKS

Essentially, all the meters in general use are current-measuring devices. Whether measuring milliamps, volts, or ohms, it is the ability of current flowing in the circuit to operate the meter, which is the basis of all its measurements.

To understand this, it is only necessary for the constructor to do a little calculation in Ohm's Law.

Considering first the milliamp meter, or straight current measurer, we have in the meter a coil of wire mounted on a former, to which is attached an indicator needle, the whole being mounted on swivel points so that the needle can move across the scale. The meter itself has a fixed magnet inside, and when the terminals are placed in series with a lead through which current is flowing the meter will register. This is because the current is made to flow through the coil attached to the meter pointer, and the interaction of the fixed magnet's field we have set up round the little coil by placing current through it is sufficient to rotate the coil. The same principle is used in electric motors, so that the meter is in a sense merely a very sensitive electric motor. The needle is checked by a system of hair springs, something like watch hair springs, which prevent it from shooting over to full scale too easily.

The meter generally used for the multi-meter has a full scale reading of 1 milliamp. More sensitive meters reading only to .5 milliamp could be used, but are expensive and more liable to damage through overload. Similarly, less sensitive meters which need more than 1 mill. for full scale deflection can be used, but this means that no matter what measurement is being made on full scale the meter will draw more than 1 mill., and often this is enough to seriously upset its accuracy.

AS A MILLIAMETER

Having already a 0-1 m.a. scale, we now wish to accommodate larger readings. In the case of 10 mills. scale, we want a state of affairs in which 1 m.a. flows through the meter, and 9 m.a. through a shunt resistor. Assuming the resistance of the meter to be 30 ohms, simple calculation will show that the shunt resistor needed will be 3.33 ohms. With such a resistance, the full scale reading would be 10 mills.

We can go on from this and calculate the value of resistance needed for each desired range of milliamps. However, as meters vary in their characteristics, we suggest that in all cases shunt resistors be purchased from the people who supplied the meter in the first place. This is the best way to obtain accuracy. In our meter, we have fixed on milliamp ranges of 0-1, 10, 50, and 250, as being adequate for all normal uses. Higher ranges can be included by using the right resistances.

AS A VOLTMETER

Considering the meter as a voltmeter we must still remember that the meter is a current measuring device, and that for full scale deflection on each range we want to arrange for 1 mill. to be flowing.

This means the addition of series resistors to limit the current flow through the meter. Assuming we have fitted the correct resistor for a 10 volt scale, the meter will read full scale on exactly 10 volts. If the voltage applied with this resistor is only 5 volts, the meter will pass only .5 mills., and thus register only half scale reading.

With a high-grade meter of 1000 ohms per volt, we will need to use a resistor in series with the meter of 1000 ohms for each additional volt. A general calculation is to divide the voltage scale by .001 (current in milliamps), and we get the total resistance in circuit. Thus for 10 volts we need 10,000 ohms, for 250 volts we need 250,000 ohms, and for 500 volts 500,000 ohms. From these figures we really should subtract 30 ohms, being the meter resistance, but, except perhaps for the 10,000 ohms, this is a very small error. However, we can use 9970 ohms to be on the exact side.

AS AN OHM-METER

To measure ohms, we first of all arrange for a full scale deflection of the meter, by wiring a fixed resistor of 4300 ohms in series with a variable of 400 ohms, and connect a 4.5 volt battery in the circuit. By adjusting the variable resistor, we can at all times send .1 mill. through the meter when the ohms terminals are shorted, as long as the battery does not fall below 4.3 volts.

Now when we connect an unknown resistance in circuit, it will reduce the current flow. The amount of current which it will allow to flow is measured on the meter, and thus a basis for comparison and measurement of unknown resistances is obtained. The sensitivity of this particular meter is useful to about 250,000 ohms. Higher resistors than this do not need to be very accurate, and

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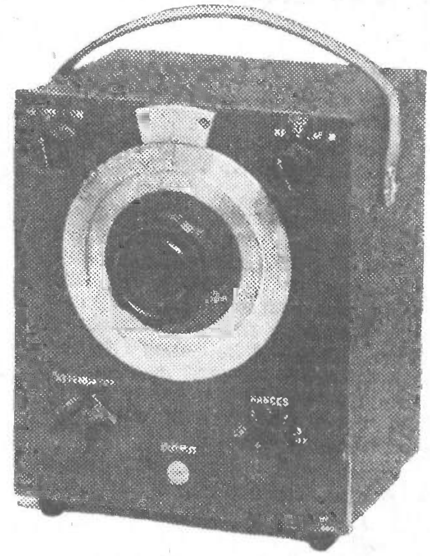

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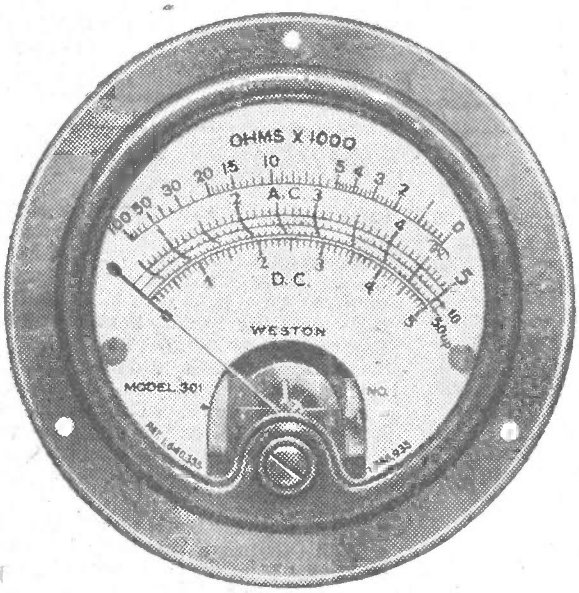

Model 301 Universal Meter 3 1-4in. dia., flush mounting. Wiring diagram, showing how to connect up Universal Meter with shunts and resistors supplied with meter.

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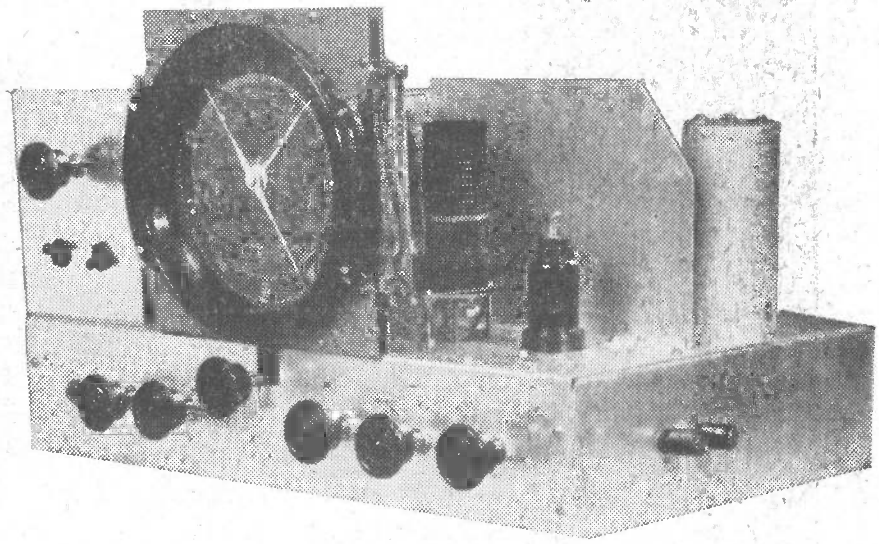


A front view of the 8-valve set.

To cater for the short-wave enthusiast, we give here a number of short-wave circuits we can confidently recommend. Elsewhere will be described a two-valve battery set which can also be used on short-waves.

SHORT WAVE reception has a thrill all its own. More than that, it has a thrill for everybody. Whether one's interest is in hearing and verifying short wave reception from the various countries of the world, or in listening for the sheer fun of hearing foreign broadcasts, or joining in the "amateur" side of radio, the short wave bands are happy hunting grounds.

Most of the general interest material is to be found on the main short wave bands around 19, 25, 31, and 49 metres. Here may be heard regularly stations from Germany, England, France, Russia, Japan, etc., which broadcast from time to time special sessions in English, and many features and items of interest.

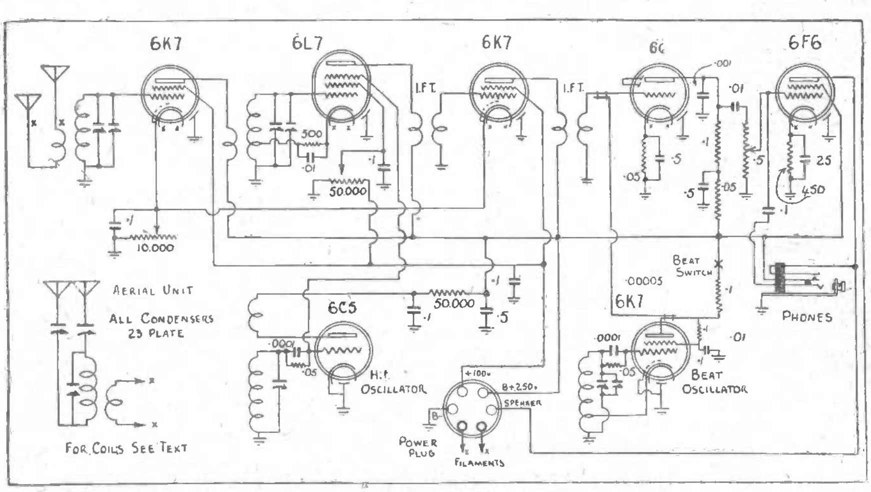
Between these bands, odd stations crop up now and then to give the listener more interest and greater thrills, and even in the regular bands themselves, there are many stations to be heard other than the "regulars."

AMATEURS

The amateur bands, which are located round about 10, 20, 40, and 80 metres, are worth while following, and stations from all over the world are often to be heard on both 'phone and Morse code transmissions. The replies of the Australian or other stations with whom they are communicating are generally audible also, and this makes the whole business very much more interesting.

In this article we want to outline some sets which have proved very popular with our readers in the past, and which can be recommended confidently to the experimenter as being "sure-fire" performers. They are all exceptionally simple to make, and enough data are given here to enable anyone to construct them.

The large set shown here is the 8-valve superhet. with minor modifications, which we have been using now ever since it was originally described in "Wireless Weekly." It has given the greatest satisfaction during that time, and we have not as yet found any way to improve it without adding considerably to complications, and to the number of valves. It is a marvellous performer on short wave broadcasting, and is also admirably suited for amateur communications, for which purpose it has been used continuously.



Here is the circuit. A doublet aerial is advised, but is not essential. Even better results can be obtained by using the aerial tuning unit shown with the circuit. The coupling coil is the same as the aerial coil of the set. The larger coil is tuned and the smaller connected to the receiver with a pair of twisted insulated hook-up wires. Naturally a different coil is used for each band to correspond with the set's tuning coils.

★ An 8 Valve Set

The receiver uses an R.F. stage with a 6K7 transformer coupled to the first detector, a 6L7, which has regeneration to improve its efficiency and gain. It has a separate oscillator, in this case a 6C5 triode, the output of which is mixed into the special injector grid, with which this valve is provided. One stage of I.F. amplification is used, with a 6K7 as the valve amplifier. The second detector is a 6Q7, used as an anode bend detector. The output stage is a 6F6 pentode, working into a dynamic speaker with a jack for headphone work.

A beat oscillator is provided for C.W. reception. It can be switched on and off, and also controlled for pitch, from the front of the set.

This receiver has been designed for use with a separate power supply unit, and the speaker plugs into the unit. It is a good idea to keep the power supply away from the set, although, if desired, the power supply could be mounted on the same chassis as the set itself without necessarily affecting results.

THE VALVES

The valves we have used are metal types, but there is no necessity to regard them as essential to the set's performance. For instance, the same types in the metal-glass series could be used, or plain glass valves would also serve, except in the case of 6L7. Glass counterparts would be for the 6K7-6D6, for 6C5-76, for 6Q7-75, for 6F6-42. These valves will need shielding, excepting the 2A5. If high-gain Continental type valves should be preferred, the EF3 will give excellent results in the R.F. and I.F. stages.

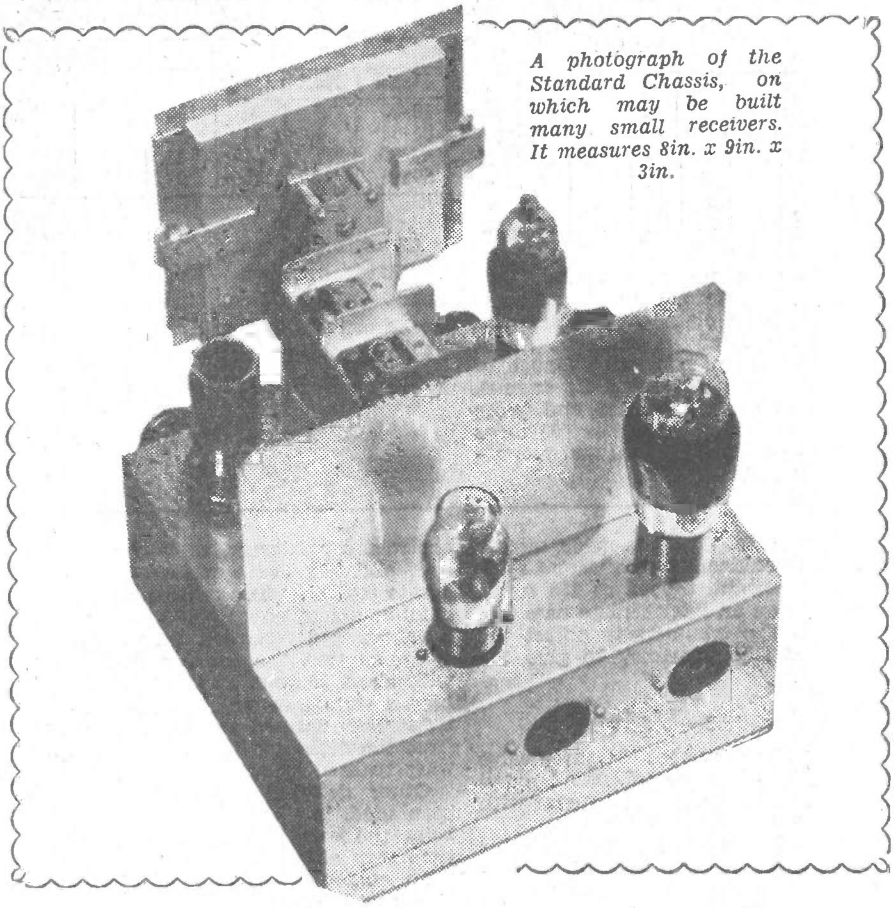
The regeneration on the 6L7 carefully used will give extra gain, but should not be abused on this account. Rather should it be kept as an extra control up one's sleeve when wanted.

The I.F. stage is a straightforward affair, and should be built with the best intermediates possible. Either iron-cored or air-cored types may be used, the former having, as a rule, better gain if well made.

The second detector is an anode bend detector, mainly for simplicity. The diodes may be used, if desired, for detection and also for A.V.C. This set was designed with simplicity in view, and, therefore, we did not use the A.V.C. circuit. It could, however, be used in a perfectly standard manner.

The output pentode drives the speaker, and a phone jack is provided for headphone operation when desired. There is plenty of volume for the phones, and the volume control is effective on both the speaker and the phones.

The beat oscillator is a straightforward electron-coupled affair which is very hard to better. We have used various methods of mixing it into the second detector. The simplest is to hook the end of a piece of hook-up wire round the grid lead of the second detector, and run this down to the plate circuit of the beat oscillator. Here the other end can be bound to the plate lead for about ½ inch to provide very slight capacity coupling. Only a little is needed. The coupling lead may alternately be hooked round the grid lead of the detector at one end and the grid of the beat oscillator valve at the other. In all cases there is no direct coupling to be made—merely the tiny capacitive coupling of the insulated wire. Feeding the beat oscillator into one diode is also a good scheme which we have used with success.



A photograph of the Standard Chassis, on which may be built many small receivers. It measures 8in. x 9in. x 3in.

TUNING CONDENSER

The tuning condenser is a three-gang job of capacity about .00015 per section. Such gangs are procurable, or they may be made by cutting about one-third of the rotor plates from a standard job. Naturally there are no trimmers to be left on the condenser.

TRIMMERS

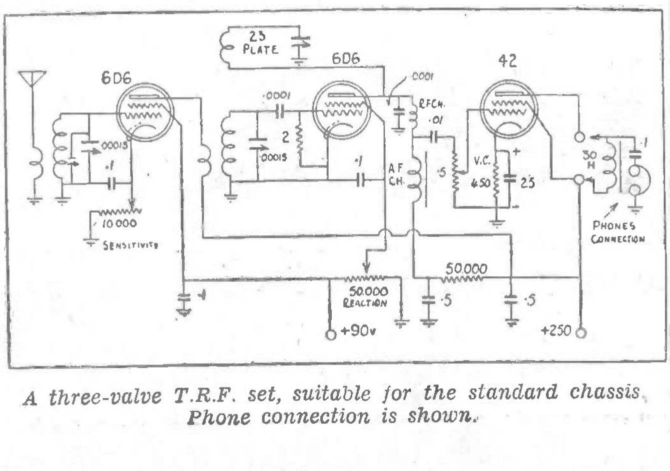
In order to keep the circuits in track, 23-plate midget condensers act as trimmers across the aerial and R.F. secondaries. This idea avoids padding troubles and actually extends the tuning range of each coil.

The aerial and R.F. coils are mounted at one side of the gang, with a plain shielding partition between, and the oscillator coil and valve on the other. Thus coupling is reduced to a minimum, and heavy shielding avoided.

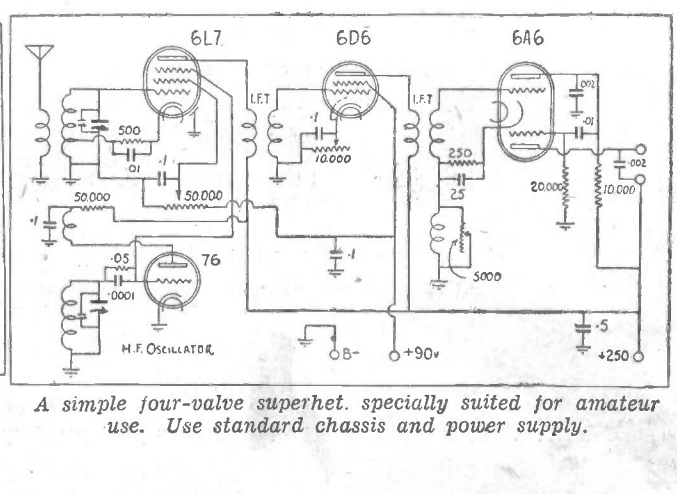
The beat oscillator coil is immediately behind the small panel which carries a three-plate midget wired across the beat coil to give a variable pitch. One of the switches turns the beat on and off—the other is at present not used, but could be employed to switch A.V.C. on and off.

We have used a good band-spread dial, and found it very effective for fine tuning. The dial used should have a positive action with no backlash to spoil accuracy. The coil data given will be found approximately correct, and a little care in winding up each set will allow you to get them all tracking perfectly.

The beat oscillator coil may be pur-



A three-valve T.R.F. set, suitable for the standard chassis. Phone connection is shown.



A simple four-valve superhet. specially suited for amateur use. Use standard chassis and power supply.

COIL DATA FOR 8-VALVE SUPERHET.

Aerial Coil			Detector Coil			Oscillator Coil	
Band	Aer.	Grid	Plate	Grid	Top	Grid	Plate
10-20	2	3½	2	3½	1-3	3½	2
20-40	4	8½	6	8½	½	7	4
40-80	7	20	9	20	1	15	6
80 up	12	35	12	35	2	30	8

All coils are wound on 1¼in. formers. Oscillator coils are close wound, ⅛in. apart. Other grid coils spaced over 1½in. Detector plate coils interwound with the bottom of the grid coil. Aerial coil is ⅛in. from grid coil. Gauge of wire is not critical—about 22 enamel, with 30 enamel for aerial and plate coils. Beat oscillator coil has 400 turns of 32 enamel tapped at 150 and mounted on intermediate base.

COIL DATA FOR 4-VALVE SUPERHET.

	Aerial Coil		Oscillator Coil		
Band	Aer.	Grid	Tap	Grid	Plate
10-20	2	3½	1-3	3½	2
20-40	4	8½	½	7	4
40-80	7	20	1	15	6
80 up	12	35	2	30	8

All coils are wound on 1¼in. formers. Oscillator coils are close wound, ⅛in. apart. Other grid coils spaced over 1½in. Aerial coil is ⅛in. from grid coil. Gauge of wire is not critical—about 22 enamel, with 30 enamel for aerial and plate coils.

COIL DATA FOR T.R.F. SET

	Aerial Coil		Detector Coil		
Band	Aer.	Grid	Plate	Grid	React.
15-35	4	5	4	5	8
35-55	6	10	6	10	12
55-90	10	20	10	20	15

All coils wound on 1¼in. formers. Aerial coil wound about ⅛in. at earth end of grid coil. Plate coils interwoven for half their number of turns with grid coils of detector. Reaction coils wound about ¼in. away from grid coils. Use 22 enamel, with 30 gauge enamel for aerial and plate coils.

Here are coil tables for the sets described in this article.

chased complete. If home-made, use 400 turns of 32 enamelled wire wound on a choke bobbin, and tapped at 150 turns. Mount this on an intermediate base and use one of the trimmers to adjust the coil to the I.F. frequency to give the right beat.

★ A Three-Valver

Next on the list comes the three valve A.C. set. This is an excellent all-round receiver, and has been very popular with amateurs for quite a while.

For its general construction, we refer to the photograph of a standard short-wave chassis shown in this article. As will be seen, there is a two-gang condenser, with the R.F. valve and coil on one side and the detector valve and coil on the other. A shield runs right across the chassis to isolate the tuning from the remainder of the set—not always necessary, but a good thing to have. On this chassis may be built almost any short wave set up to four valves. It is intended to be used with a power supply similar to the one shown with the big set described in this issue. The speaker plugs into the power supply itself, thus keeping the tuner and the power well apart.

The tuning condenser is again about .00015 or thereabouts, and the circuits are kept in line by means of a 5-plate midget connected in parallel with the R.F. section of the gang. It is impossible to wind coils accurately enough to match, particularly as the reaction control alters the detector tuning a trifle. Along the front of our standard chassis are four controls—these will vary according to the set requirements, and sometimes, for instance, only two or three will be needed.

The R.F. valve has a variable resistance in the cathode circuit, which acts as a control for the R.F. sensitivity. It is worth having, although a fixed 350 ohm resistor can be used should a valve not being a variable-mu type be used. Such a valve would be 6C6, 57, etc.

An aerial coupling coil is used in order to keep the two tuned circuits as much in track as possible, and also it gives a more even transfer of energy from the aerial.

REGENERATION

The detector valve has two reaction controls, a condenser, as in the battery sets, and a variable resistance for accurate control. The resistance also has a minimum of effect on tuning as it is advanced and retarded. The condenser is set so that the reaction is obtained with about 50 volts on the screen, or as high a voltage as will give smooth control. This ensures also maximum gain from the detector stage, a point not always realised by constructors.

Other detector circuits might have been used, but we selected this one as being the least critical, and at the same time very efficient.

An audio choke is used in the plate circuit of the detector. Resistance coupling will as a rule make oscillation difficult owing to the drop in voltage—another point which has often troubled constructors. The decoupling resistor and condenser may not be needed, but will prevent any hum which might appear in this portion of the circuit.

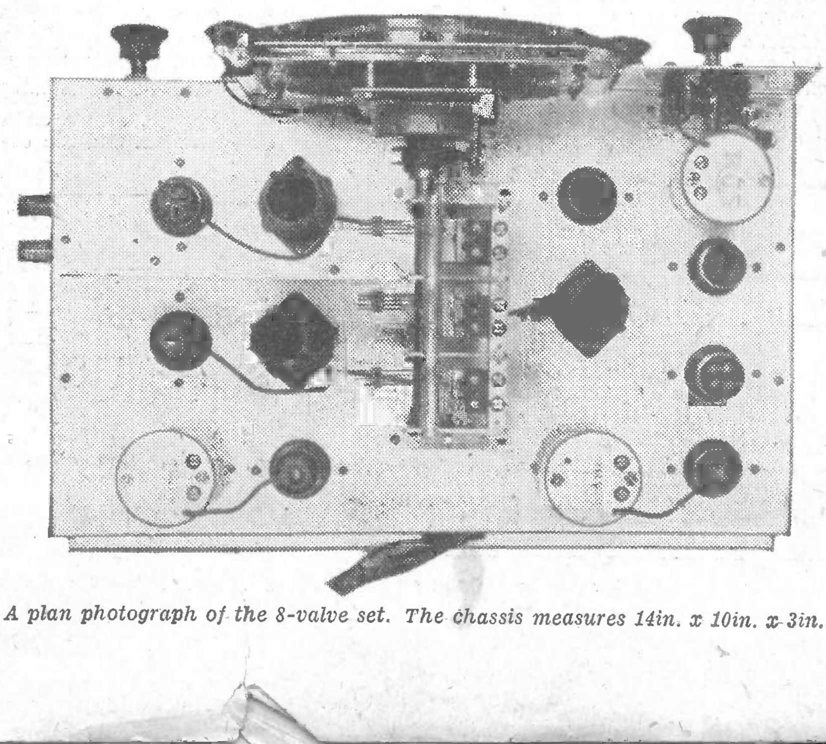
AUDIO VOLUME

An audio volume control is very useful for the output stage, particularly on phone reception, otherwise loud signals may be uncomfortably strong. The output valve is a pentode which feeds a loud-speaker. Should phones be required make up a little coupling unit as indicated on the diagram, to keep the high tension and also the plate current from the phones themselves. A small filter choke of about 30 henries and 40 mills will do, and can, of course, be mounted on the chassis if desired. If the separate pack is used, it will best be mounted on the power chassis, under the base, keeping it well away from the power transformer to avoid hum pick-up.

This is about all we have to say on this set—the rest will explain itself from the circuit. It is a good set, and if built on the standard chassis can be enlarged to a bigger receiver without wasting any parts later on. It would still be a good set if a 6DC is used in place of the 6L7 in the four valve superhet, feeding the oscillator output into the suppressor grid.

★ A 4-Valve Super

A four-valve superhet. which has a performance far better than its size would indicate, the next of our circuits will appeal to many. It has no R.F.

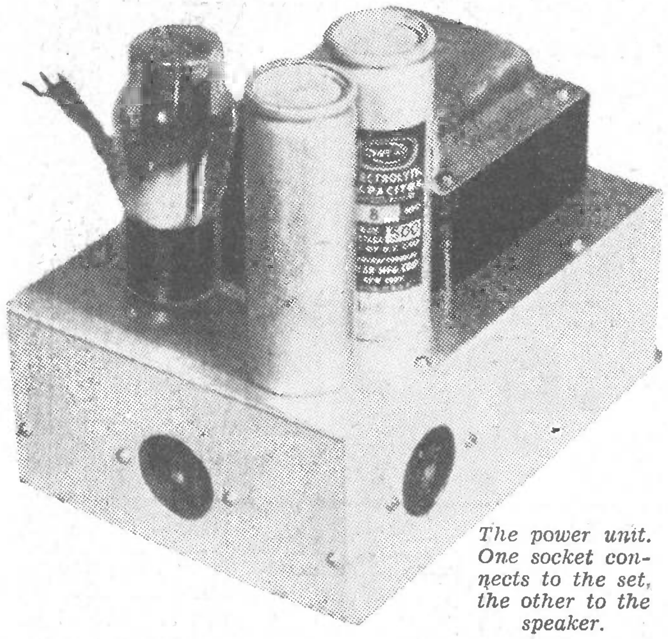


A plan photograph of the 8-valve set. The chassis measures 14in. x 10in. x 3in.

TIME-CHART FOR OVERSEAS STATIONS

Iceland, Maderia.	England, France, Spain, W. Africa.	Germany, Italy, Capetown, Switzerland.	Moscow, Egypt, Durban, Rhodesia.	Aden, Arabia, Kenya, Mesopotamia.	Mauritius.	Bombay, Madras, Ceylon (all add 30 min.)	Calcutta, Burma.	Java, Dutch E. Ind., Siam, China, Saigon.	W. Australia, Manila, Hongkong.	Japan, S. Aust. & Darwin (add 30 min.).	N.S.W., Vic., Q'land., Tas., N. Guinea.	New Zealand (add 30 min.).	Fiji Islands. Samoa (add 30 min.).	Hawaiian Islands (add 30 min.).	Alaska.		U.S.A. Pacific Time, Vancouver, 'Frisco.	U.S.A. Mountain Time, Mexico, Canada.	U.S.A. Central Time, Chicago, Canada.	U.S.A. Eastern Time, N. York, Peru.	Newfoundland, Brazil, Paraguay.	Brazil, Greenland.	Azores, Cape Verde Islands.
P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	Mid-night	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	Noon
1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12
2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1
3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2
4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8
10	11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
11	MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
MN	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN
2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1
3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2
4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3
5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4
6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5
7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6
8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7
9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8
10	11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9
11	12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10
12	1	2	3	4	5	6	7	8	9	10	11	MN	1	2	3	4	5	6	7	8	9	10	11
P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	P.M.	Mid-night	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	A.M.	Noon

Example, on top row of figures:—New York 9 a.m. Monday, England 2 p.m. Monday, India 7 p.m., Sydney Midnight Monday. Look down the column marked New York until you come to MN (midnight) Sunday. In England it is 5 a.m., Sunday, India 10 a.m., W. Australia 1 p.m. Monday, Sydney 3 p.m. Monday.



The power unit. One socket connects to the set, the other to the speaker.

stage, but uses the 6L7 first detector.

The use of the separate oscillator has many advantages over the pentagrid for special short-wave sets, as against dual-wavers, where the saving of the extra valve is important in costs. The actual conversion gain of the 6L7 is very high, and the noise level of the separate oscillator circuit, particularly when hunting weak stations on the 'phones, is very much lower.

As will be seen, there is a reaction control on this first detector, made possible by the use of the separate oscillator, which enormously increases sensitivity when properly used. Improperly used, it will not.

Reaction is obtained by tapping the cathode up a small portion of the tuning coil, in some cases only half a turn. There is a common coupling between the valve circuits through this section which gives the reaction effect. The control is a screen-grid potentiometer. It is essential that the valve will not oscillate until this voltage is at all times about 50 or 60 volts, preferably about 70.

★ The Power Unit

If it is lower than this the gain of the 6L7 will not be anything like its maximum, and the set will be hard to handle, if the valve is to be kept below the oscillating point. As long as the cathode tap is kept well down on the coil, even to a portion of a turn, this should not give trouble. If the valve oscillates with only about 25 volts on the screen the tap must be cut back until it will not oscillate at any time with less than 50 volts. Then you will get not only the maximum gain from the 6L7, but also maximum sensitivity from the reaction.

This reaction, by sharpening the tuning of the first circuit, also reduces the tendency to double-spotting, and will be found a most useful control. It is a scheme almost universal now in sets of this type.

The I.F. amplifier uses a pair of good intermediates. These need not be of the iron-cored type, although efficient iron-cored transformers will naturally give high I.F. efficiency. We have used both, and obtained first-class results from good plain type intermediates. They are, of course, of the 460 kc. type.

The second detector, as will be seen, has one section for the detector and the other for an audio amplifier. The use of low resistance values is necessary to avoid feedback troubles, and the constructor will be wise to keep to those shown.

The reaction control here increases selectivity, and when the valve is made to oscillate provides a beat note for Morse code reception. It can be omitted if such reception is not needed by connecting the lead running to the top of the reaction coil direct to the chassis. The coil itself may be about 70 turns of 32 enamelled wire wound on an R.F. choke bobbin, or about 50 turns wound on an ordinary 1½-inch former. If oscillation is fierce when controlled by the 5000 ohms potentiometer, reduce turns—if no oscillation is present add a few more. Best results are obtained when oscillation is smooth, and even a five turns difference might make a big improvement one way or another.

The 79 valve as second detector is handy for the grid at the top, which is connected straight across to the I.F. transformer lead. The 6A6 will give more output, however, quite enough to operate most of the stronger stations on a magnetic or permagnetic speaker. Its plate current is low, and therefore 'phones can be used. The set will operate from 135 volts of B battery, or from a power supply of 250 volts. If the standard power supply is employed, use a 30 henry filter choke, and a resistance in series to reduce the voltage to 250, as there is not enough current to energise a speaker field adequately.

Using our standard chassis, there is room between the two valve sockets to mount the intermediates, and the whole set will make a very compact little unit.

As there is 250 volts in this section of the circuit, the headphone coupler shown in the last circuit is advised.

The tuning condenser, should the set be used for amateur work, may be a two-gang job reduced to a single rotor plate, or a pair of five-plate midgets ganged together. A pair of 23-plate midgets are mounted under the chassis in parallel with the tuners as "band-setters," with which the required frequency band is located. For general work, a 00015 gang is used, and the 23-plate midget condenser across the detector coil is used as a hand-adjusted padder.

ON WINDING COILS

Although factory-made sets of coils are available for the receivers described in this issue, we have included winding charts as a guide to constructors who would like to try their hand. Note that we used the word Guide, because there are a number of variable factors which will make it impossible for every man to wind up a set of coils and get EXACTLY the same coverages. It is nearly always necessary to make some adjustments over the original coils to get the right coverage for one particular set of conditions.

Of course, it is possible for a factory to work out a set of coils which, used with a specified condenser, will not require adjustment.

However, having wound up the coils from our charts, it may be found necessary to make alterations up to possibly one turn either way, to get the coils starting from scratch with the trimmers all out, and ending up with the circuits still peaking on the highest wavelength end.

A good tip, should a coil prove to have slightly too many turns, is to space out the last few turns at the top of the former, which will generally have the effect of reducing inductance. Similarly, by compressing some turns, more inductance may be gained.

Be respectful in your handling of the oscillator coil turns. It is the oscillator which tunes most sharply, and all the other coils take their position from it. If, for instance, you find that the 20-metre band comes too far from the bottom of its dial position, you will need more turns on the oscillator coil. Don't add or take off more than one turn at a time. Having fixed the position of the dial readings, work on the other coils to bring them into line. If you find that you cannot get the 20-metre band on its right coil, even with the gang all out, you should add turns to the oscillator coil. However, using our chart, we don't think the error would be as bad as this. The necessary modifications probably will be only slight.

When the coils are finished and the spacing is neatly made, put a touch of clear duco where the wire meets the former's ribs, to keep the wire in place.

THE POWER UNIT

We give here the details of a power unit suitable for the operation of A.C. receivers and the 8-valve short-wave set in particular.

This unit can be applied to almost any short-wave set which needs a separate supply, and it could also be used as a separate unit in all cases where such a supply is needed. By using an appropriate power transformer, the unit could be built to give any desired output voltage. It is meant to operate with sets using the field coil for a filter choke. Should no field be available, a 30 henry filter choke would be mounted under or on the base, and wired in place of the field coil connections.

The base size of this particular unit is 6in. x 8in. x 3in., which gives ample room to mount the apparatus.

As will be seen, there are two sockets to the power supply. One of these accommodates the 6-pin plug carrying the power supply leads and the other is the socket for the loud-speaker. The wiring diagram has been worked out to correspond with the wiring of the short-wave set, and should be checked up against the 8-valve circuit.

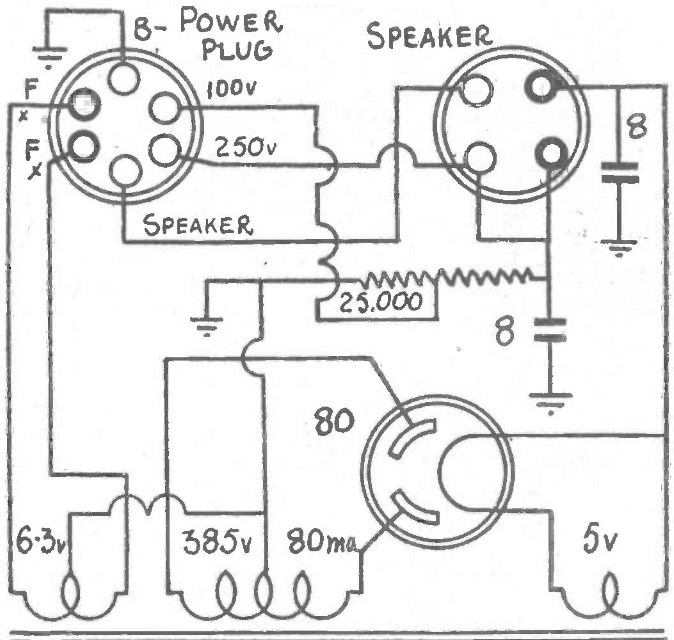
The main components of the supply are the base, the power transformer, the electrolytics, the rectifier, and a voltage divider.

The power transformer will usually need to supply not more than about 70 mills, so that the 80 mill: type would suffice. The electrolytic on the rectifier side of the field could with advantage be a 600-volt type, although the one on the low voltage side of the field may be of the 500-volt type.

The rectifier is a standard 80 valve, and the voltage divider may be anything between 15,000 and 25,000 ohms.

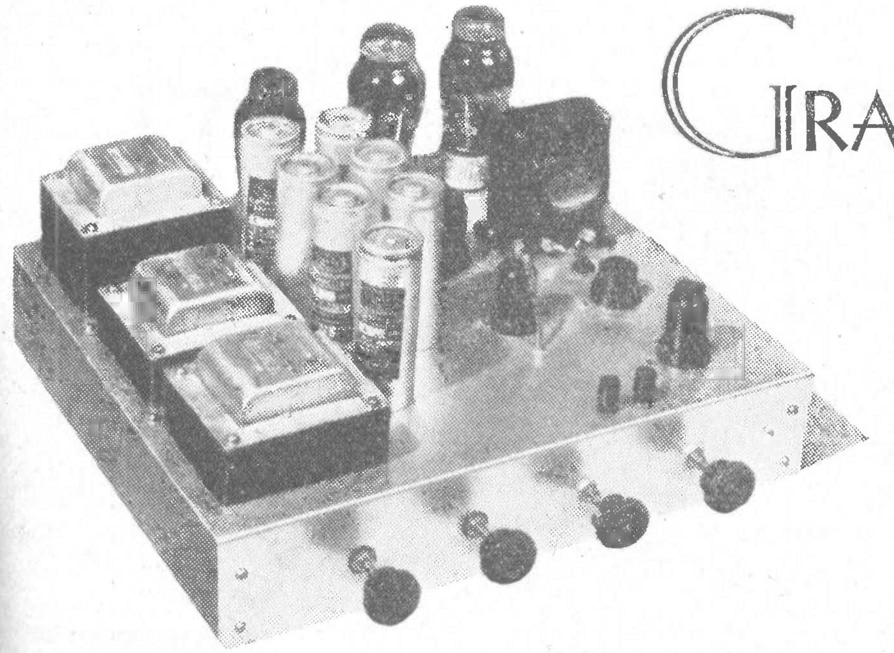
It is quite a good feature to have the speaker plugged into the power supply instead of the set. It means that the receiver can be placed on the operating table, and the power supply and speaker stowed away several feet from the set. Only one power cable is needed. It is a good plan to keep the speaker well away from the receiver to avoid any chance of microphonic feedback, which is always liable to happen when a receiver is in a sensitive condition. The leads to the receiver being quite "dead," it is not very important how long the cable is made.

Strictly speaking, it is always good practise, when connecting a power supply with a plug and socket, to make sure that the socket is in the power supply. It is often more convenient to use a plug and socket at the power supply and again at the receiver. If this is done, it would be possible to turn on the power supply by mistake, while the cable was plugged into the power, but not into the set. The plug for the set would then be alive, and the operator could get a "bump" from it. Therefore, it is not a bad plan to run the cable direct to a terminal strip in the set, making it a permanent connection. Obviously one could not get a shock from a socket alone, and the power cannot be given to the set until the plug is inserted into the power supply. Such "Safety First" devices are simple to use, but are in accordance with good practise and should be used where possible.



The circuit of the power supply. This is particularly designed for the 8-valve set, but the connections may be varied to suit any receiver for which it is desired.

GRAMOPHONE AMPLIFIERS



The Volume Expanding Amplifier. Full details of layout are shown here. One transformer carries the high-tension winding, one the filaments, and the other is a choke. The third component is the filter choke. The filament transformer could also be made to take the high-tension winding for the speaker field.

With the advent of electrical recording and reproduction, a new era was born for the lovers of gramophone music. Since that time things have steadily progressed. A modern gramophone recording when used in conjunction with high quality apparatus, is capable of giving wonderful realism. The amplifiers described here have proved their worth and can be recommended.

BUILDING and operating gramophone amplifiers has always been a great hobby amongst "Wireless Weekly" readers. Every time anything on amplifiers has been published or a new circuit printed, the response from our readers has been immediate.

Consequently, we feel that this chapter dealing with amplifiers will be one of the most popular in this Handbook. Space will not allow us to deal with all the amplifiers we have featured from time to time, but we have selected some of the most popular and most successful.

Let it be explained that although the amplifiers we have described have been used mainly for gramophone reproduction, they will find other uses. For instance, public address work of all kinds, and even small talkie plants, will find possible applications in them. Most of our readers, however, will be using them to play records for their own amusement and entertainment.

Amplifiers are divided into three major sections—the input device, the amplifier proper and power supply, and the loud-speaker. Each of these three must be considered when the amplifier itself is being designed. The relationship which one has to the other is very definite and important.

PICK-UPS

The ordinary home amplifier obtains its input as a rule from some type of gramophone pick-up. A gramophone pick-up is a device for converting the mechanical energy picked up from the record's grooves into electrical energy. The record itself has its grooves cut to a pattern by an electrical cutter operated from an amplifier, before the microphone of which the performer sings his song or plays his instrument. Therefore, when the pick-up travels over the record grooves which are made by a moulding process exactly corresponding with those made in the recording, it delivers electric impulses which correspond with those of the recording microphone.

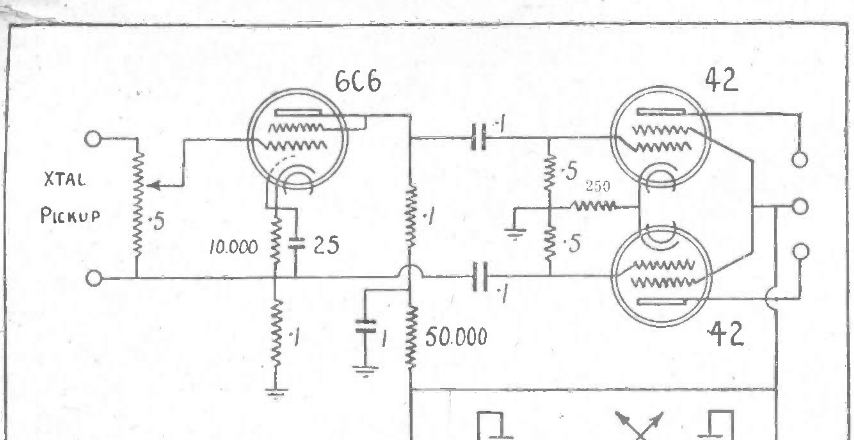
There are many ways of making pick-ups, but the two most favored are the magnetic and the crystal method. The magnetic pick-up operates in a manner very similar to that of a magnetic speaker, except that the movement of the armature sets up an electric current, instead of the electric current causing a movement of the armature.

MAGNETIC PICK-UPS

The essential parts of the magnetic pick-up are the armature itself, which is mechanically coupled to the needle attachment, a strong field magnet, with an air-gap in which the armature vibrates, and a coil of insulated wire, which picks up the generated current, and feeds it into the amplifier.

The frequency response and the output of a pick-up are two very important points which should always be considered when buying. The idea behind selecting any pick-up is generally to obtain from the record equal output of all frequencies which are recorded.

This is one reason why most pick-ups have a rising characteristic in the bass frequencies. This might appear at first sight to be working in the wrong direc-



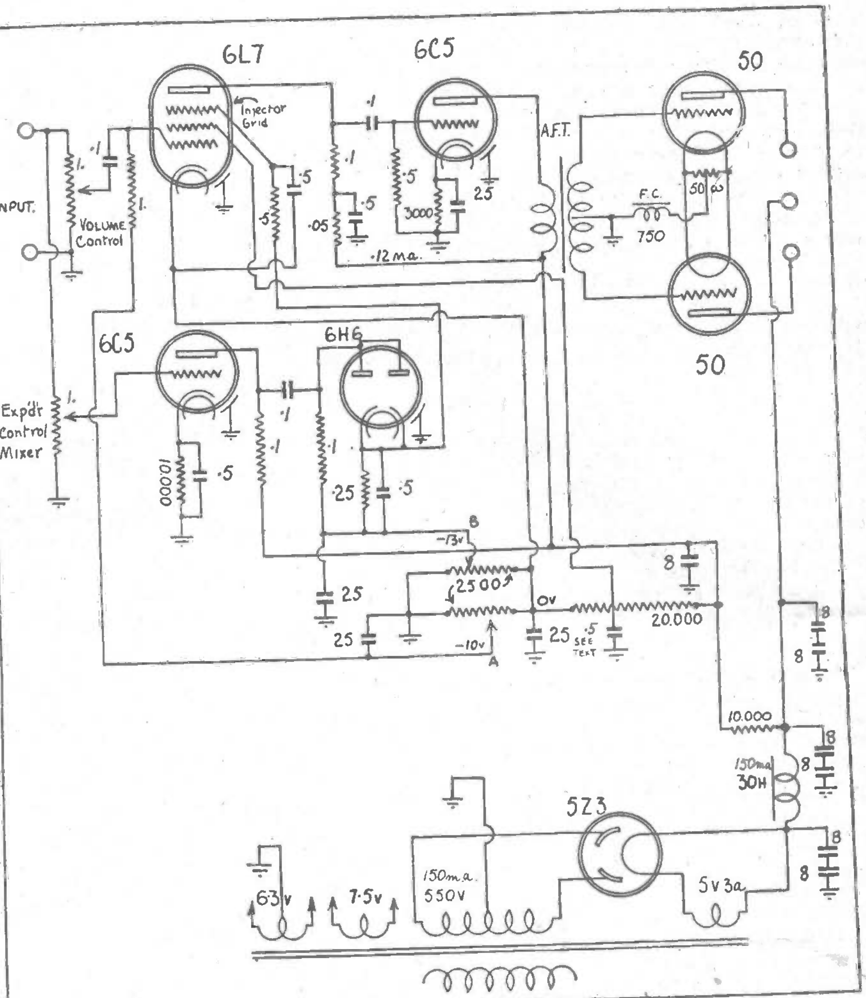
The circuit of the Universal Amplifier. The 8000 ohm field coil is connected across the high tension. Should permagnetics be used with the Genemotor, the pins of the connecting plug leading to this field are left vacant. Other valves could be the 57 and 2 2A5's or 47's. In metal valves, 6J7 and 6F6's.

tion, and actually favoring the bass notes over the remainder of the musical scale. However, gramophone records are not recorded with equal output on all notes. Particularly is this so in the bass register. To prevent one groove in a record from breaking through into the next, it is necessary to limit the amount of recorded bass notes when the record is made. Therefore the bass response of the recorder dies away below about 100 cycles per second, and is down about 15 decibels at about 30 cycles.

By using a pick-up which has a corresponding rise in output equal to the falling off we can to a large extent compensate for this condition, and bring the over-all response nearer to equality over the full range.

The response curve of the average pick-up will no doubt exhibit quite a number of inequalities through its entire range, visible on the curves as peaks and humps. Whenever notes corresponding to these peaks are played, the output will, of course, rise. Unfortunately, the perfect pick-up has yet to be built, and we must just strive to use one which is as free as possible from such peaks. To the average ear, a rising characteristic round the 3000 and 4000 cycle mark may not be unpleasant, giving an impression of brilliance which many like very much. On the very best amplifiers and speakers, however, it is best to avoid these as much as possible, although there are cases where such peaks may even be valuable.

Regarding recordings, these rarely include notes higher than about 6000 cycles, and also most loud speakers begin to fall off very rapidly above this point. Therefore, one can regard for average use a fairly even response to about 6000 cycles as fairly satisfactory, and an amplifier which has a flat response, including the speaker, from about 50 to 6000 cycles, is doing very well indeed.



The Volume Expanding Amplifier. All the circuit details covered in the article are illustrated here. Note the arrangement of the controls, which make the amplifier 100 per cent. adjustable.

THE CRYSTAL PICK-UP

The crystal type of pick-up really deserves special mention because it operates on an entirely different principle from the magnetic. It has a small piece of Rochelle salt crystal attached to the needle. When a section of this crystal is subject to varying physical strain or flexing, as happens when the record is being played, varying voltages appear at each side in proportion to the amount of movement. By coating the sides of the crystal with tinfoil, and connecting to them wires, this voltage may be picked up and fed into an amplifier.

Pick-ups made in this way have a very high output, two or three times as much as some magnetic pick-ups. In addition, they have an excellent frequency response, with just the right amount of rise in the bass to compensate for the drop in the record. They have a very good high-note response, quite adequate for the requirements of a high-class amplifier. The weight on the needle head is also light, as the damping on the needle point is only slight, and, therefore, there is less wear on the record. For these reasons they have proved very popular for many purposes.

As these pick-ups operate as condensers, they need a fixed load across them to develop their output voltage. The average pick-up uses .5 megs., either as a fixed resistor or as a potentiometer volume control, to take care of this. A higher value will give overmuch bass response, and a smaller resistor will give less.

When designing an amplifier, this matter of gain should not be overlooked. Using a low-output magnetic pick-up, which, incidentally, can be obtained with excellent response, one would need more gain in the amplifier than when a crystal pick-up is used. With each of the amplifiers mentioned below the matter of the best pick-up will be mentioned.

With magnetic pick-ups it is generally satisfactory to feed them straight into the grid circuit of the first valve, unless otherwise stated by the manufacturer. Generally as low as 50,000 ohms. may be used for a volume control, as the impedance of the pick-up is quite low. In the case of the crystal, the .5 meg. rule should be observed, and the input also fed between the grid and earth of the first valve. Should there be any prospect of a voltage appearing across the pick-up, it should be fed to the grid through a .5 mfds., condensers, and the volume control of .5 meg. load be used as a grid return for this valve.

Parts List for Universal Amplifier

Base, 12 x 8½ x 3.
1 Power transformer, 385 v. at 150 ma., 6 v. at 3a., 5 v. at 3 amps.
1 30 henry choke, 150 ma.
2 8 mfds. electrolytics.
1 .5 meg. potentiometer.
2 .5 meg. resistors.
2 .1 meg. resistors.
1 50,000 ohms resistor.
1 10,000 ohms resistor.
1 200 ohms bias resistor.
1 25 mfds. bypass condenser.
2 .1 mfds. coupling condensers.
1 1 mfd. 500 v. working condenser.
Valve sockets—3 6-pin, 1 5-pin, 1 4-pin.
Valves—2 42, 1 6C6, 1 5Z3.
Pick-up, Crystal.
Speaker, high-fidelity 8000 ohms field.

★ A Universal Amplifer

The first amplifier to be described features the resistance push-pull circuit which has proved so popular since "Wireless Weekly" introduced it to Australia some years ago. This amplifier, although only three valves are used, will supply about 10 or 20 watts from a crystal pick-up when operated "flat-out." Under the conditions we are using for the output valves, they will not overload when thus operated, and will give enough output for a dance hall, in conjunction with a big speaker.

We designed this amplifier so that it could be used for almost any purpose, either from an A.C. power supply or from a genemotor using a six-volt battery as the only source of power. It was found permissible to run filaments and genemotor from the same six-volt battery without any interference.

The input voltage may be anything between 300 and 350 watts, the higher voltage giving a higher output. Although the maximum authorised rating for the 42 valves is about 315 volts, we have found that with a slightly higher bias, as provided by a 250 ohm resistor, the valves do not appear to be distressed by using something higher, and we have several instances of excellent life and service. These are robust valves, and even if their life were reduced by 20 per cent., we cannot imagine a cheaper or easier way to obtain anything like the same output.

In practice they may be replaced bv the new 6L6 valves, by changing over to Octal sockets, and the results should be practically identical.

The 6C6 is operated as a triode, under which conditions it has high gain. and plenty of output to swing the pentodes. The push-pull effect is obtained by the phase-reversal in this valve, one output being fed from the cathode circuit, and the other from the plate circuit. Decoupling is used to reduce hum to a minimum.

THE PICK-UP

It is essential to use a crystal pick-up with this amplifier, as the gain is not as high as others using more valves. We suggest using a high-quality speaker with good sensitivity, and with an input transformer matched to the pentodes in push-pull. A heavy duty power transformer is used so that the field can be energised from it, through an 8000 ohms field.

Should the amplifier be used with a genemotor for back-country dance-halls, for instance, permagnetic speakers should be used, up to about three in number, with a special input transformer having three secondaries, one for each speaker. Then any speaker can be cut out of the circuit without affecting the others. If the power supply is made on a separate base, the change-over from one to the other need be only a matter of changing a few plugs to the speaker and power sockets.

The frequency response of this amplifier is very fine indeed, and we heartily recommend it for cases where cost and convenience are to be considered.

If a high output carbon-type microphone is available it can be used without any pre-amplification, feeding straight into the amplifier. The use of low output types, such as the crystal microphone, is not advised unless a transformer-coupled pre-amplifier is used to give enough over-all gain. As a rule the single-button carbon microphones have the highest output of the types generally used.

★ The High-Fidelity Amplifer

The high-fidelity amplifier still holds pride of place where the finest possible frequency response is desired. Under tests in two different laboratories it showed less than one half a decibel variation from 10 to 12,000 cycles, these being the limits of the measuring instruments. Fed with a high-output magnetic pick-up, or a crystal pick-up, it will fully load up the output valves, and drive two big speakers if required.

Used with the finest speaker which one can afford, it will give volume, clarity, and realism, very hard to beat.

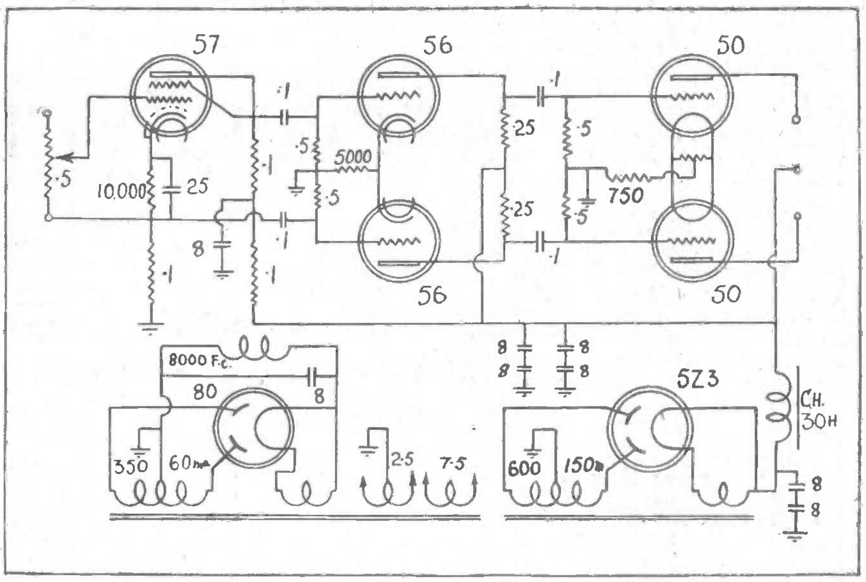
The circuit is the essence of simplicity. The output valves may be a pair of 250's, as in the original, with a 600-volt power supply. We have found these valves exceptionally robust and easy to handle. Some exception may be taken to their use with the grid resistors as high as .5 megs., but provided that a pair of matched valves specially tested for low grid-current are used, no trouble should be experienced with them.

Alternatively, a pair of 2A3 valves with a 300-volt power supply could be used with practically identical results. The use of .5 meg. grid resistors is permissible with 2A3 valves. Theoretically, these valves should give even better results than the 50's, but one must pay particular attention to the matching of the valves to the loud speaker, and also be sure that the output valves themselves are matched to within narrow limits.

The circuit constants may remain unaltered for either valves, with the exception of the power supply voltages.

The power supply may be built on a separate chassis, or the whole amplifier incorporated on a single chassis.

Some of our readers have built this amplifier using 45 type valves in the output stage, with voltages up to 350 on the plates, with an output comparable with that obtained from 250's. The valve makers would probably frown on the use of more than about 315 volts on the plates, but here again it is possible to get away with a little more than we are really entitled to. Using the standard 250-275 volts, the same quality will be realised with the normal output obtained from 45-type valves.



The High-Fidelity Amplifier, showing the circuit for the speaker field power supply. In some cases, it might be found a good idea to use a filter choke in series with the field, together with an extra filter condenser to reduce any hum to a minimum.

Parts List for High-Fidelity Amplifier

1 Power transformer, 600-0-600v., at 150 ma., 7.5v. 4a., 2.5v. 4a., 5v. 3a.
1 Filter choke, 30 henries at 150 ma.
6 8 mfds. 600 v. electrolytics.
1 8 mfds. 500 v. electrolytic.
1 .5 meg. potentiometer.
4 .5 meg. resistors.
3 .1 meg. resistors.
1 10,000 ohm. resistor.
1 5000 ohm bias resistor.
1 750 ohm. bias resistor, 120 ma.
1 50 ohm. C.T. resistor.
4 .1 mfds. condensers, 600 v. working.
1 25 mfds. electrolytic.
Sockets—1 6-pin, 2 5-pin, 3 4-pin.
Valves—1 57, 2 56, 2 50, 1 5Z3.
Speaker, high-fidelity type, field to suit.
Pick-up, any high-grade type of medium or high output.

Extra Parts for Field Supply.

1 Power transformer, 350v. at 80 mills, 5 v. at 2 amps.
1 8 mfds. 500 v. electrolytic.
1 4-pin socket.
1 30 rectifier.

★ The Volume Expander

The volume expanding amplifier is something for the connoisseur in record reproduction, because it is capable of giving a higher degree of realism than any other. This is due to its expansion circuit, except for which it is a normal high-grade push-pull amplifier.

One of the limits in recording is in the matter of volume range. As an example, a symphony orchestra has an actual volume range of about 70 decibels. Owing to the danger of overcutting record grooves, on the one hand, and of allowing the volume to drop below the needle scratch on the other, the very best record does not allow more than

about 45 decibels to be handled, and generally much less than this. There is a very great difference between these limits, and it has long been the dream of music lovers to put back into the reproduction the full range, which has been restricted by the sound engineer, who was forced to turn up his gain control when recording soft passages and turn it down on the loud passages.

The introduction of the 6L7 valve provides us with an easy way of building an amplifier having a variable amplification. Further, this variation is actually controlled by the amplifier itself. We start off from a very quiet level. As the volume of the musical selection mounts up, so does the gain of the amplifier, so that on full volume the output reached is far in excess of that which would be heard if the expanding circuit were not there. As the music becomes quieter again the volume is automatically reduced, and thus we get the extra contrast between loud and soft passages.

The effect is fully controllable. Not only can we control the amount of expansion required, but also the severity with which it is applied. These points will be cleared up on examining the circuit.

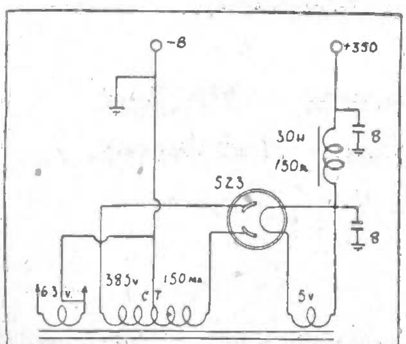
OPERATION

The 6L7 "injector" grid has a very sudden control of the valve's amplification. By varying a negative bias applied to it from 0 to about 16 volts negative we can control the amplification from maximum to nothing at all. The theory therefore, is first to bias this grid negatively until its amplification is low, and then feed into this grid a positive voltage which will be controlled by the output of the pick-up, and will cancel out some or all of the bias as the volume varies, and so allow the valve to amplify more on higher volume.

This is done by splitting the output voltage of the pick-up as shown. Part of it feeds through 6L7 as the first valve in the amplifier, and part of it is fed to a triode amplifier valve in the expander section.

This valve in turn feeds into a rectifier valve (6H6), which rectifies it, so that at the cathode we have a positive D.C. voltage, which will obviously be greater as the output from the pick-up becomes greater. This is the voltage we use to "buck" the standing negative bias on the 6L7 injector grid.

If we apply too much standing bias to the injector we will cut off signals altogether on soft passages. Therefore the



This is the circuit of the power supply for the Universal amplifier. It may be built on the same base, or as a separate unit.

circuit provides a potentiometer by which the bias is set to just sufficient value to allow the soft passages to come down to the limit of the valve's useful control.

A second potentiometer controls the ordinary negative bias of the 6L7 control grid, the valve, of course, being a resistance coupled screen-grid amplifier. Best results are obtained when this valve is biased to draw about 12 mills., and, once it is set, we can forget it.

The amplifier has a volume control and another "mixer" potentiometer to vary

Parts List

Base 16in. x 14in. x 3in.
2 1 meg. potentiometers.
1 1 meg. resistor.
2 .5 meg. resistors.
1 .25 meg. resistor.
3 .1 meg. resistors.
1 50,000 ohms resistor.
1 10,000 ohms resistor.
1 3000 ohms bias resistor.
1 750 ohms 120 m.a. bias resistor (if no field).
2 2500 ohms potentiometers.
1 50 ohms. C.T. resistor.
2 Voltage dividers, 10,000 ohms and 20,000 ohms.
2 25 mfds. electrolytics.
4 .5 mfds. tubulars.
3 .1 mfds. tubulars.
1 Push-pull audio transformer.
7 Valve sockets to suit valves.
7 600v. electrolytics.
1 30 H. 150 m.a. filter choke.
Power Supply—550-0-550 volts at 150 m.a., 6.3v. at 4a., 7.5v. at 4a., 5v. at 3a.
Valves—2 6C5, 1 6L7, 1 6H6, 2 250 1 5Z3, or glass equivalents
Pick-up terminals, hook-up wire, nuts, bolts, solder lugs, power flex, etc.
Speaker—Matched for P.P. 250 valves, 750-ohm. field, if not separately energised.
Pick-up—Any high-grade make.

the voltage fed into the expander system, and therefore to vary the amount of expansion used.

Generally speaking, an optimim setting can be found also for the injector grid bias, leaving only the normal volume control, and the expansion "mixer" control needing any attention in practice.

The resistor and condenser in the injector grid circuit provide a time lag which prevents the expansion from operating too quickly or too slowly. No advantage can be gained by varying the given values of .5 megs. and .5 mfds. for average requirements.

SCRATCH LEVEL

Not the least valuable of the amplifier's features is the effect of reducing scratch level. In order to obtain the wonderful volume level of a full orchestra, it has previously been necessary to run the gain control to such a level that on soft passages the scratch becomes annoyingly apparent. With the expander working, as soon as the soft passages come along and the volume drops down in proportion, the scratch naturally drops with it. On modern recordings it is almost impossible in many cases to detect any scratch at all. For all the world the effect sounds like A.V.C. when applied to an audio circuit, as indeed it is. On scratchy records one can note the effect of the expander by listening to the scratch level rising and falling with the volume of the record.

Very little practice is needed to learn how to use the expander, and few music lovers who are keen on amplifiers would ever be without it, once having heard it in operation. We have demonstrated it to dozens of our readers, and have a wonderful collection of letters giving their impressions of the job in action.

It is essential that the amplifier should have at least 10 wattts maximum output in order to cope with the full volume range available, and, of course, the best speaker is not too good for it. A power handling capacity of 10 watts is also the minimum desirable for the speaker. The fidelity of the amplifier using a high-grade transformer is of the highest quality, and should satisfy any critic. The expansion does not in any way interfere with the fidelity, and the amplifier may be operated without expansion at any time by simply turning off the "mixer" control.

Again 2A3 valves could be used in the amplifier, but these are the lowest-powered valves we suggest. Unless one has the volume available in the amplifier for when it is needed there is little point in using expansion.

OTHER VALVES

It is not essential to use metal valves throughout this amplifier. The 6L7 is, of course, a new type first announced in the metal series, but it is also available in metal-glass types, etc. The other valves may all be replaced with glass types. The 6C5 valves are replaceable with 56 or 76 valves, and even 27's may be pressed into service. The 6H6 has no equivalent in glass types, but as it is merely a rectifier, the diodes of a 55, 85, 2A6, 75, etc., could quite well be used. Even a triode valve with grid and plate tied together and used as a diode, would be permissible. The output valves have already been mentioned in a previous paragraph.

Nor are American types essential, apart from the 6L7. Comparable types in English and Continental triodes and rectifiers would be quite suitable.

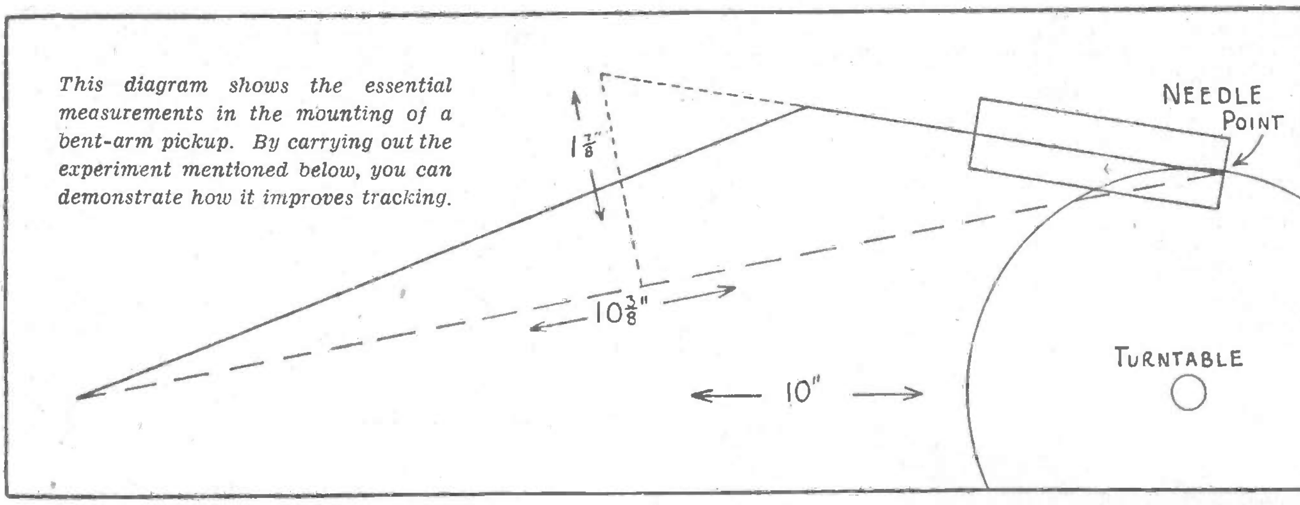
With such a big amplifier, it is worth the trouble to go thoroughly into matters of speakers, baffles, etc., to make sure that reproduction and general results shall be the best. Regarding speakers, one can only say that the best is not too good, and many readers have invested up to £20 in order to get the best possible speaker. Very good speakers are available for about £10 and these usually fulfill the requirements of the average man.

One of our favorite baffles is made from a 6 x 4 feet table top made of 1-inch thick timber. The hole for the speaker is cut about 2ft. 6in. from the floor and the baffle itself closes up the space for double-doors between two rooms, the doors themselves being left open.

The average person will find a Celotex baffle board about 1in. thick and 3ft. square about all he can handle in the ordinary room. One of the most important experiments to make is in the actual placing of the speaker itself. Every room has its own peculiarities of resonance, etc., and there is sure to be one place in which the speaker sounds much better than in any other. As furniture, pictures, carpets, etc., affect the absorption and reflection of the sound, don't forget to move these round a little, to see how reproduction varies.

Also it is not good practice to screw the speaker directly to the baffle, particularly if it is a wooden one. Better provide a separate support for the speaker to stand on, and support the baffle some other way.

CORRECT TRACKING FOR YOUR PICK-UP



This diagram shows the essential measurements in the mounting of a bent-arm pickup. By carrying out the experiment mentioned below, you can demonstrate how it improves tracking.

AMONG the many problems which are to be solved by the man who is keen on the finest record reproduction, there is one very often overlooked. This is the matter of the gramophone pick-up tracking.

In the old days, when amplifiers and speakers were not nearly up to the standard of the present day, many sources of distortion and poor reproduction were often ignored, because the results were not good enough to make them annoying. However, we can command nowadays such a vastly improved frequency range in our amplifiers that every point which can possibly contribute to poor results should be investigated and removed.

RECORD MECHANICS

It should be realised at the outset that the ordinary laterally cut record, by medium of its grooving and the rotation of the record, supplies the power to vibrate the needle point of the pick-up. It will be obvious at the start that, in order to obtain the best results, the needle should lie in such a plane that its axis of movement is at right angles to the record groove. In case we should be taken to task for speaking of a line at right angles to an arc (which is, of course, the record groove), we can also explain it by saying that the movement should be parallel to a line drawn from the needle point to the centre of the record.

If this condition does not occur, then the drive to the needle point will not be efficient. The needle must of necessity be resting sideways in the record groove, and the movement it makes will, instead of being as described above, also be sideways in the groove, according to the amount of error in needle tracking.

The curved tone-arms fitted to so many gramophone pick-ups are not made that way by accident. The idea is to provide needle tracking as nearly perfect as possible. There are still debates being held over the practice. Here we give the case for the bent-arm.

There are other troubles which are set up by this poor tracking. Firstly, there is more surface noise from the record owing to the greater friction set up between the needle and record. There is also greater wear on the record grooves, because the needle, instead of fitting accurately into the path made by the recording cutter, is slipping and sliding in the grooves due to its sideways mounting and movement.

Another very important thing to be remembered, where tracking is poor, is the extra wear on the needle. This is so important that, in our experience, a pick-up using a straight arm, with which perfect tracking is quite impossible, will often be unable to play through a heavily recorded disc without needle failure, whereas with a pick-up having nearly perfect tracking, the needle will be quite equal to the task.

It will be realised also that a needle in a pick-up of the straight-arm type, which may start off with a big error, and finish up with a comparatively small one (the usual thing), the needle has not been worn down evenly. No sooner has the point moulded itself to the record groove than one side is gradually worn down more and more as the arm moves towards the centre of the record. The side thus worn down has generally a pretty sharp edge, which carves into the record material as it wears. All these effects can be observed on examining an old needle through a magnifying-glass.

THE BENT-ARM

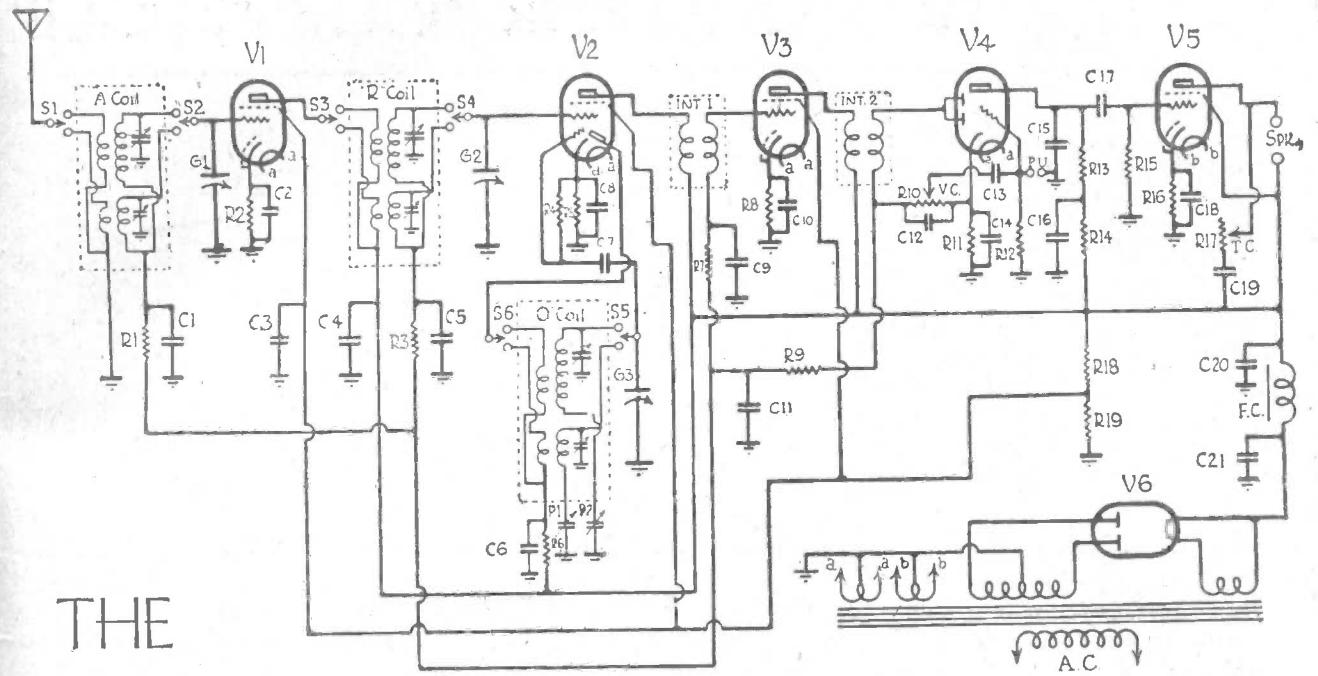
The root of the trouble lies, of course, in the fact that we are trying to make the pick-up head move in a straight line, when it is anchored by the arm, and must therefore move in an arc.

An easy solution is to provide an arm which is not straight, but bent. Without going into geometrical discussion, refer to our diagram, and cut a cardboard "arm" of the dimensions shown. Now draw an imaginary record on a piece of paper, and, with a set square, see how nearly the needle point operates along the radius of the record. Now do the same thing with the straight arm, and see how large the error becomes.

Most of the bent-arm pick-ups on the market can be relied on to give a small error, although perfection is only to be had with an arm moving in a straight line across a record.

In our diagram we have indicated a quick way of obtaining approximately the correct angle for the arm and the distance from the centre of the record at which the arm should be mounted. It does not matter how the arm is shaped, as long as this distance is maintained, and the angle also is maintained.

We have worked out the angle for a 10-inch arm; naturally, the same idea can be applied to larger arms in special cases. However, should the experimenter care to make his own arm, he will, as a rule, find this size the most useful.



The A.C. World Standard circuit. The component values suggested on this page will be suitable for almost any types of valves.

THE WORLD STANDARD RECEIVER

THE World Standard Receivers were designed, and described in "Wireless Weekly," by Mr. A. G. Hull (Technical Editor), after his recent trip round the world.

After observing the various trends of radio design in every country, as well as in Australia, Mr. Hull was of the opinion that at the present time, radio receivers were tending towards the same standard type of circuit, which he outlined in the World Standard sets. Neither the A.C. nor the Battery sets claims to be at all revolutionary, but both can be taken as representing the circuits which the world's industry has taken to be the most satisfactory and serviceable in production. Naturally, the results obtained from both sets are of a very high order, and both are typical in performance of the best commercial sets made at the moment.

THE A.C. RECEIVER

The circuit of the A.C. receiver is given on this page. As will be seen, it has six valves in all. These may be of any type—American, Continental, or English, according to the preference of the builder, or the specifications of the makers of the coil assembly. The circuit has been used by manufacturers using all these types, with equal success in all cases.

It is a good idea when purchasing the coil assembly, to make sure that you are using the valves specified for it. For instance, it would not be a good plan to use the high-gain Continental valves for a kit which was designed to take the American valves. Apart from this rule, any of the well-known valves or coils are perfectly suitable for the set.

In this set, and for the Battery set also, the major coil manufacturers decided to produce special units. Most of them went further and produced complete kits of parts for it. These are known by various names—"Kitsets," "Chassiskits," "Cir-kits," etc. In effect, they are all the same, in that one buys a box containing everything except valves and speaker to make up one of the World Standards. This is a very convenient and helpful method of building a set for the man who either hasn't much time, or enough knowledge, to start in and get together his own particular list of parts. Such kits of parts usually have very complete diagrams and constructions, and even some of the wiring done in advance, which makes them still easier to construct.

We are not considering these people for the moment, however, as most readers of this Handbook will certainly like to build their own receiver right from the ground up. For them, of course, coils are available as separate units.

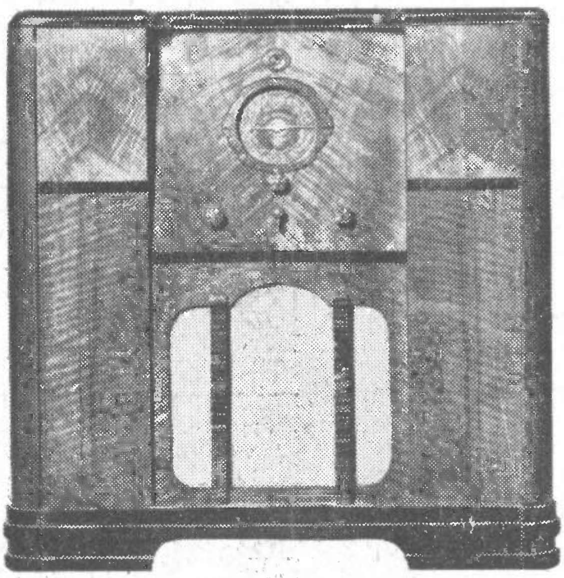
THE CIRCUIT

The circuit, as will be seen, provides for a dual wave tuner using an R.F. stage on both broadcast and short-wave bands. Regarding the coils, it is only necessary to use one of the special units designed for the set, together with the

SUGGESTED COMPONENT VALUES

RESISTORS				CONDENSERS			
R1	100,000 ohms	R10	500,000 ohms	C1	.1 mfds.	C11	.1 mfds.
R2	1,000 ohms	R11	3,000 ohms	C2	.1 mfds.	C12	.0005 mfds.
R3	100,000 ohms	R12	500,000 ohms	C3	.1 mfds.	C13	.01 mfds.
R4	50,000 ohms	R13	250,000 ohms	C4	.5 mfds.	C14	25 mfds.
R5	400 ohms	R14	100,000 ohms	C5	.1 mfds.	C15	.001 mfds.
R6	50,000 ohms	R15	500,000 ohms	C6	.5 mfds.	C16	.5 mfds.
R7	100,000 ohms	R16	400 ohms	C7	.0001 mfds.	C17	.01 mfds.
R8	1,000 ohms	R17	500,000 ohms	C8	.1 mfds.	C18	25 mfds.
R9	1 megohm	R18, R19	V Divider	C9	.1 mfds.	C19	.05 mfds.
				C10	.1 mfds.	C20, 21	8 mfds.

TWO PARAMOUNT WORLD STANDARDS



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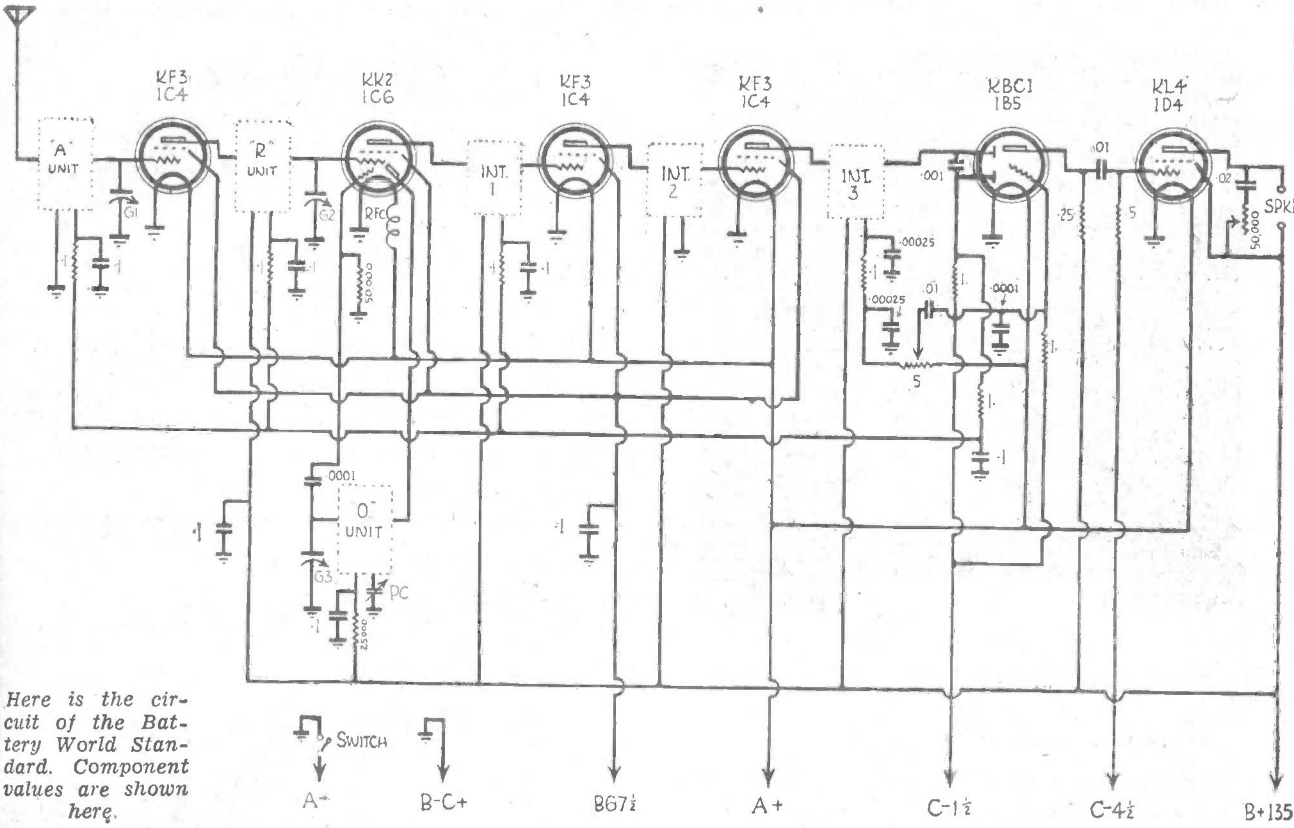


Here is the circuit of the Battery World Standard. Component values are shown here.

exact type of gang condenser specified for those coils. Do not attempt to use any home-made kits of coils, by collecting odd types and hoping to get the same results. The World Standard kit is a compact unit, having the three tuning coils, with the broadcast and short-wave windings on the same piece of former, mounted on a base with the switch directly beneath. Some manufacturers can supply the unit with the coils mounted, wired, and lined up, thus saving the constructor some work in adjusting. It is a wise precaution to buy the intermediates of the same make as the tuning coils, and specified for use with them. By doing this, pitfalls that might occur through using the wrong intermediates can be avoided.

The valve following the R.F. stage is either a pentagrid or an Octode, according to the type of coils used. Either valve will work well. There is one I.F. stage with an intermediate frequency of about 460 kc. This is the standard frequency used for dual-wave sets these days, and modern design and construction allow a very high gain to be obtained from such a tuner.

The second detector is of the duo-diode-triode type, again available in all types. It is used for detection through the diode circuit, which also provides a very effective A.V.C., and the triode section of the valve forms the first audio amplifier. This is resistance coupled to an output pentode, which supplies the energy for the loud speaker.

The rectifier is a standard full-wave type, available in all makes, both directly and indirectly heated.

The speaker field is generally of 2000-2500 ohms, and the input transformer specified for use with a single pentode valve of the type used in the set itself.

The use of resistance coupling in the audio end is almost universal in commercial sets, and is very cheap, effective and gives good tone. The plate circuit of the second detector is decoupled to reduce the danger of hum troubles.

A.V.C. operates on the R.F. amplifier, the mixer valve, and the I.F. amplifier. It is a very simple connection, and works very well in practice. It would be possible to use one diode only for detection and the other for A.V.C., but this calls for a few more components and complications, which we wanted to avoid if possible.

COMPONENTS

We have given here a suggested list of components which would be used in a typical receiver. There should be no variation needed, no matter what valves are used, and the values given may be retained therefore in all cases.

Any good brand of components may be used, as long as the values are the same as those given in our article. None of them are very critical, and we don't think anyone will have any trouble with them.

If using glass types, we suggest for the American series a 6D6, 6A7, 6D6, 75, and 42 output, with an 80 rectifier. Equivalents in the 2.5 volt series would be 58, 2A7, 58, 2A6, and 2A5 output, with the same rectifier. Using Continental valves, the types would be AF3, AK2, AF3, ABC1, and AL2 output, with an AZ2 rectifier. In the 6 volt types, the numbers would read AF3, EK2, EF3, ABCs, and EL2 output valve, with an EL3 rectifier. In the metal or metal-glass valves, use the 6K7, 6A8, 6K7, 6Q7, and 6F6 output valve, with a 5Z4 rectifier.

Again we stress the importance of using the right coils with the valves, as, for instance, satisfactory operation of a kit designed for an octode with a 6A7 will be found almost impossible, particularly on the short waves.

It is a good idea to make the condenser C21 a 600 volt type, in order to protect it against voltage surges when the set is first switched on. The condenser C20 may be of the 500 volt type, since the voltage here is much lower.

CONSTRUCTION

The construction of the set is quite simple, and should not trouble anyone who has previously built a set of any size. The short wave band often worries some people, but there is nothing at all to make you nervous, as it will operate just as does the broadcast band, with possibly a little more care in the adjustment of the coils themselves.

After the parts are all assembled they are laid out on the chassis, the sockets and coils mounted up, and the wiring begun. Use ordinary hook-up wire, and keep all leads as short as possible. Where earthing points are concerned, earth them to the chassis, and then run a piece of heavy gauge tinned copper wire round to them all, making final connection to the earth terminal. This is often very helpful in obtaining a really satisfactory earth connection, particularly with the coils and gang condenser. The idea, of course, is not to rely only on the chassis for an earth. This is particularly important where steel chassis are used which have been sprayed with some paint, etc., to make them rust-proof, and, of course, to improve appearance.

On short waves, the padder is generally a fixed value. Therefore, all one needs to do is to adjust the oscillator trimmer to bring the 25-metre stations, for instance, into the corresponding marking on the dial, and then line up the R.F. and Aerial trimmers for best results. Always make the final Aerial trimmer adjustment on the particular aerial which is to be used. For short-wave results, don't make it more than about 60ft. overall, and as high as possible.

★ Battery Version

The battery version of the World Standard carries out the same principles as the A.C. version—in other words, a standard circuit which will be suitable for any of the standard types and valves, and which will give a performance equal to the best commercial receivers being made all over the world.

It uses the same type of coil assembly as the A.C. receiver, giving it the same comparative simplicity and efficiency.

The circuit is naturally modified to suit the battery valves, but the same general principles are observed throughout.

THE CIRCUIT

There is an R.F. stage in action on both broadcast and short-wave bands, to give best gain, selectivity, and freedom from double-spots. Noise level is, of course, also lower with the R.F. stage.

The converter or mixer valve is again of the pentagrid or octode type, according to the valves used.

Two intermediate stages are used in this set, as against one in the A.C. version. This is because the actual gain of the battery valves in practice is somewhat less, and the two intermediate stages are generally regarded as preferable in order to get the very best of results.

The second detector is a duo-diode-triode, giving A.V.C. detection, and audio amplification. The output valve is a pentode, selected for its economy and high output.

The valves are the 2-volt type, because this type, taking it all round, is the most economical and the most efficient. Two-volt accumulators also do not cost such a great deal, and a large one will last a long time without charging.

Some points about the circuit are worthy of interest. One of the main things to watch is again the matter of the coil kit. Three intermediate transformers are used, and it is very essential that these should be obtained specially made to work together. Three standard high-gain transformers, such as are usually employed with only one I.F. stage, will almost certainly run into oscillation troubles. Secondly, it is still more important because of this, that the intermediates be obtained suitable for the valves themselves. With two stages of I.F. amplification, there is a cumulative effect in the gain which makes this matter still more important than in the case of the A.C. receiver.

A.V.C. in this set is obtained by separating the diodes, using one for detection, and another for A.V.C. Thus we are able to supply a bias of 1½ volts for the controlled valves without upsetting the detector action.

It will be seen that only the first three valves are controlled, leaving the second I.F. amplifier running with zero bias. This is done because, otherwise, the A.V.C. voltage might be great enough to choke back this valve and prevent the strongly amplified signals from being effective.

The output pentode used in this set is of a type which has become universally popular, and is used on almost every battery set, except for the comparative few which have B class amplification. It has not as much output as this latter type, but plenty for the average home. The improvement in loud-speakers for permagnetic use has made it still more useful in the average receiver. Advanced builders could easily use a "B" class output if they wish.

BATTERY DRAIN

The battery drain overall of the set, on a local station, will be about 12 to 15 mills., so that heavy duty batteries can be used. In all cases where a large receiver is operated, it is, however, economy to use the triple duty types, which have a longer and more efficient life.

VIBRATOR UNITS

The latest development to come into the battery set horizon is the vibrator type eliminator. This set is quite suitable for such a supply, provided that a separate 6-volt accumulator is used to operate the eliminator. The difficulty of arranging the valves in series parallel, so that they can be worked from the same battery, particularly when there are several combinations of valves and battery drains which can be used, does not encourage us to confuse our readers with explanations which might be very difficult to carry out. The simplest way to operate one of the units is to buy a 6-volt battery with it, and run the two together. The set can then be regarded as a universal type, suitable for straight battery operation when desired. The constructor can then make up his mind which he prefers to use.

VALVES

Again, either American or Continental-English types can be used on the circuit. American valves would be the 1C4, 1C6, 1C4, 1C4, 1B5, and 1D4. In the Continental types, use KF3, KK2, KF3, KF3, KBC1, and KL4. Again, we remind you to see that the valves used suit the coils. There is not a great deal of difference in performance or battery drain between either set of valves.

CONSTRUCTION

The same instructions for building and lining up the set hold for this battery version, as for the A.C. version. This is, of course, natural, as the coils are of the same type.

In both receivers, it is permissible, once the tuning coils have been lined up, to check over the adjustment of the intermediate trimmers. We would make the point very strongly that the tuning coils must be in perfect line before the intermediates are touched. Otherwise, you will only throw everything out of gear, and probably end up by sending the coils back to the factory to be relined. However, when the tuning coils are O.K., make a little screw-driver out of a piece of hardwood, and, with the set tuned to a station of moderate strength, and steady carrier, carefully move each intermediate trimmer, to see whether you can get better results by so doing.

Always make a pencil mark on the can, so that you can return to the original setting if required, before touching any trimmer. It will probably be only a fraction of a turn in any case, except, possibly, for the secondary coil-trimmer of the last intermediate which tunes the diode detector circuit. This trims rather more broadly, and might need as much as a full turn in some cases. There is no danger in altering the intermediate settings, as long as you make sure that you can come back to the original factory setting should you get lost.

In conclusion, both these sets will be found excellent performers—sensitive, selective, and reliable. They will probably be standard designs for a long time to come.

THINGS TO BE REMEMBERED WHEN BUILDING

IN the course of many years' contact with home construction, we have seen a good many sets built by amateurs, and we have also built many sets ourselves. During those years we have learnt several things about how sets should be built, and the things to be avoided when building them.

In simple receivers, it is usually an easy matter to make wiring a "point to point" business, with all leads very short. Also resistors and fixed condensers can usually be wired direct between the points concerned by their own pigtails, without any other support.

This direct construction is very desirable, and any components which should have short leads attached to them, such as grid leaks, screen and cathode bypass condensers, etc., should be mounted always in this direct method.

In larger sets there are many resistors and condensers which do not have to be mounted right at the valve socket or coil base. In such cases, it is permissible to mount them all on a terminal strip, which is supported by bolts and spacing pieces at the back of the chassis or other convenient spot. Wires from valve sockets, etc., are then run to the strip, and some overcrowding avoided.

Another good method of building up a set is to use long bolts on such things as valve sockets, and support on these bolts, between two nuts, an insulation strip with a solder lug attached. Such strips may be cut from the larger terminal strips. It is often very convenient to make a set this way, as components may be located near their circuit terminations, and at the same time be firmly supported.

The principle of having a firm anchorage for the end of every resistor or condenser is a good one. Nothing is worse than two or three pigtails soldered together in one junction, which is left unsupported, so that the whole network can short circuit or come adrift with the first opportunity. A good builder will have his set so built that one could almost lift the chassis from the table by any one component underneath.

It is generally a good idea to wire filaments first, and keep the wiring right at the edge of the chassis. Screen and cathode wiring would come next, as being close to the chassis. Then the coils would be wired in, and, finally, the wiring to volume controls, etc., which might be regarded as the last layer of wiring.

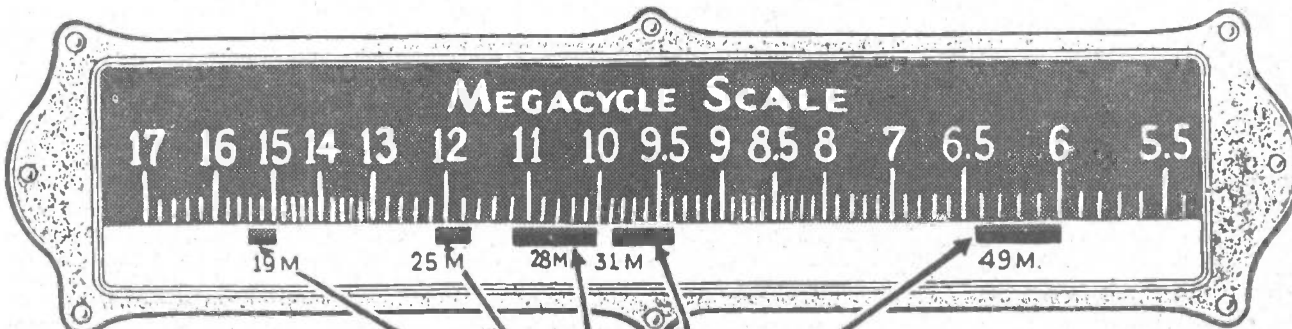
Soldering is, of course, an art which is verv necessary to learn if set building is to be mastered. Cleanliness is the biggest point to watch—it is almost impossible to solder properly two surfaces covered with a layer of dirt or metal oxide. Both surfaces should be cleaned, and then tinned by applying a little solder and flux with a hot iron. The solder will then run over the surfaces. They are next placed in contact, and more solder run over them. Enough should be used to completely enclose the joint—any more than this is not necessary or desirable.

When earthing leads or components, do so by screwing a solder lug underneath a nut on some convenient bolt, and making the connection to this. It is a good idea, particularly if the chassis is steel, or is sprayed, to connect up all these points with a network of heavy bus-bar, or tinned copper wire, which is in turn connected to the earth terminal of the set. This to guard against the possibility of the bolts not making good contact with the chassis, which, in itself, might not be a very effective earth.

Always watch to see that volume controls, etc., are insulated from the chassis, unless otherwise stated. A good way to do this is to mount them through a rubber grommett in the chassis. All power cords, etc., which go through holes in the chassis should be protected by the use of rubber grommetts.

All these points are worth remembering when building a set, and all have their bearing not only on the operation when completed, but in the satisfaction one feels in knowing that a good job has been done.

WHERE THE SHORT-WAVE STATIONS Come in on Your Tuner



GOOD IN MORNING
GSF, Daventry.
GSI, Daventry.
GSP, Daventry.
HVJ, Rome.
2XAD, Schenectady
W8XK, Pittsburgh.

GOOD IN MORNING
RNE, Moscow.
W8XK, Pittsburgh.
W2XE, New Jersey.
DJD, Berlin.
TPA3, Paris.

GOOD IN AFTERNOON
TPA4 Paris.
GSD, Daventry.
TPA3, Paris.

GOOD AT NIGHT
W9XAA, Chicago.
RNE, Moscow.

GOOD IN EVENING
PLP, Bandoeng. (27 - 26)
JVN, Japan. (28 - 14)
PMN, Bandoeng. (29 - 27)

GOOD IN MORNING
W2XAF, Schenectady.
GSC, Daventry.
EAQ, Madrid.
2RO, Rome.
PRF5, Rio de Janeiro.
W3XAU, Philadelphia.
GSB, Daventry.

GOOD IN AFTERNOON
DJN, Berlin.
DJA, Berlin.
GSB, Daventry.
2ME, Sydney.

GOOD AT NIGHT
3ME, Melbourne.
3LR, Melbourne.
YDB, Java.
CQN, Macao.
WIXK, Boston.
XGOX, China.
PLV, Bandoeng.

GOOD IN MORNING
DJC, Berlin.

GOOD IN AFTERNOON
W3XAL, New Jersey.
W8XAL, Cincinnati.
W9XF, Chicago.

GOOD AT NIGHT
9MI, s.s. Kanimbla.
XEXA, Mexico.

RW15, Russia — 70 METRES — GOOD IN EVENING

HOW TO BECOME A RADIO AMATEUR

To the radio experimenter who has run the full gamut of home construction with radio receivers, the field of amateur transmitting offers a new thrill. This article is written to give some idea of what amateur transmitting really means.

SINCE the universal employment of dual-wave receivers by the listening public, the man in the street, when he lights up his pipe in the evenings, has become very much aware of the strange race which inhabits the ether round about 20 and 40 metres on his radio dial. He has heard them swopping yarns, talking technicalities in a strange jargon which somehow they appeared to find intelligible, and making contact with others of their kind in other countries of the world. Many of them carry out their activities in the Morse code, which is heard on the ordinary broadcast set as a succession of thumps and such intermittent noises.

Often he has wondered, this man in the street, just what is going on behind all this mysterious business. Many who are technically inclined of the listening public have wondered how they came to be there, and why they are permitted to occupy this space in the ether, where, apparently, no other radio service is being carried out.

WHY A LICENSE?

There is really no mystery about it. This is the strange and, according to tradition, wild-eyed race of amateur transmitters who are granted licences to transmit signals of an experimental nature on certain wavelengths, which are the same all over the world. This licence is given to them by the Government, after they have passed the necessary examination to prove they know enough about the radio art to maintain and operate an efficient station, and to avoid causing interference with other commercial services. For it is a universal rule that no radio station, whether it be an amateur station or otherwise, shall be permitted to interfere with the legitimate transmissions of any other station. This principle includes the ordinary listener, who, although he does not transmit, has the right, since he pays his licence fees, to enjoy a reception free from interference from other transmitters.

We might mention here that amateur transmitters are very concerned to see that their activities are not causing undue interference with broadcast listeners on the regular broadcasting band. Any listener who is prevented from receiving his ordinary broadcast programmes through interference from an amateur will be showing a great sporting spirit by informing the amateur concerned, who will then take steps to effect a cure. Naturally, the amateur does not always know of the trouble, and will always be found a very decent, approachable fellow. No doubt he will invite you to see his apparatus, and inspect his transmitting "shack," and before long a very interesting and valuable friend might be made.

WHO ARE THE AMATEUR TRANSMITTERS?

No one but an actual amateur knows the joys, the interest and instruction to be obtained from actually operating his own station, and contacting fellow amateurs in all parts of the world. Practically every country in the world has its amateur fraternity, and these, operating on their various allotted wavelengths, talk to each other, either via the microphone or by Morse code, at any hour of the day or night they choose.

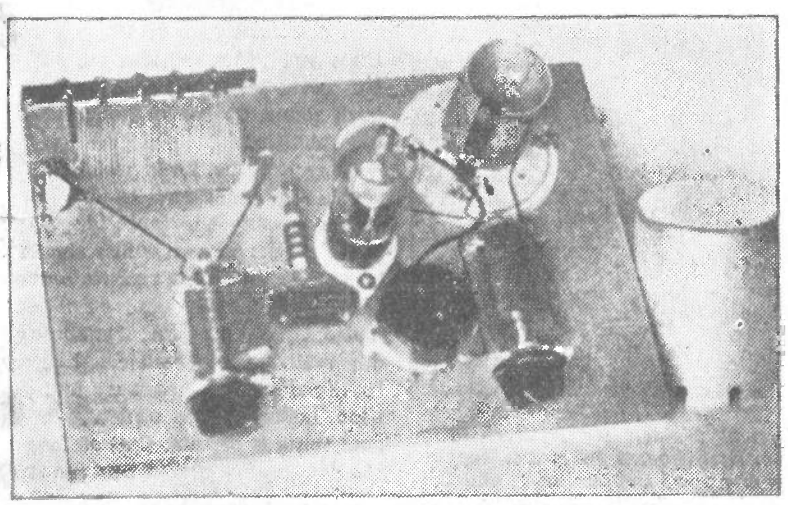
There is no more friendly or sporting band of brothers to be found anywhere than the radio amateurs. Included in their ranks are boys of 16 and men of 80. Some of the greatest scientists, radio engineers and designers, began their activities as amateurs, and still retain their active interest in this greatest of all hobbies. Amateurs number in their ranks men in all professions and walks of life. Whether a university professor, a doctor, or an office boy—they are each "Old Man" to the other, and united in their one interest—the love of the game, and the fellowship it brings. An amateur visiting any part of the world has only to keep his eye open for the transmitting aerial which denotes a "shack" beneath it, walk up to the door, punch the bell, and he is at once among friends. Just listen to two amateurs talking to each other next time you tune in, and draw your own conclusions.

Time after time the value of this amateur network of stations has proved itself, not only to science but to humanity. Recently there were some of the worst floods in America's history, which isolated whole cities from outside communication. Working sometimes for days without a stop, amateur stations formed themselves into an organised chain, and carried on traffic of all kinds with the outside world, bringing relief, and sending news of safety and disaster. This is only one of the services the amateurs can and do render to the community when the occasion arises.

Apart from such things that come so close to this same man in the street, who listens, and wonders, many of the major developments in radio communication have been demonstrated and exploited by amateurs. Their history has always been one of exploration. In the early days, the present broadcasting wavelengths between 200 and 500 metres were considered useless for communication. The amateurs parked themselves there, and proved this to be wrong. This done, they were confined to wavelengths under 100 metres. Before long they demonstrated how the world could be spanned by using these "worthless" wavelengths. It is safe to say that our short-wave broadcasting may never have been on its present basis but for the amateur's exploration and experiment.

Again, he was given bands on the very short, or ultra-short, waves. Again he demonstrated that these had their own invaluable place in communication. Now all our television services are being planned for these wavelengths. And this is still going on.

The powers that rule the radio world know the value of the amateur. That is why he is given definite world-recognised wavelengths on which he alone has the right to operate. You will find him on narrow wave-bands centring about 160, 80, 40, 20, 10, and 5 metres, although the average broadcast, or, rather, dual-wave, set, will only receive two of these bands, the ones at 40 and 20 metres. As it happens, most of the international work between 'phone stations is carried out on 20 metres, and anyone may in the evenings and afternoons hear overseas stations, mainly American, in daily contact with their Australian friends.



A simple low-powered crystal-controlled transmitter.

WOULD you like to join them? This is what you should do. First, you sit down and write a letter to the Radio Inspector in your State, asking him for full information on the necessary examination, which must be passed before a licence is granted. Incidentally, there are heavy penalties, for obvious reasons, for operating any transmitting station without a licence.

You will receive back from the Radio Inspector sheets telling you all about the examination, where and when held, etc., and the subjects on which you will be examined. The examination, you will be told, is held every three months, under the supervision of the P.M.G.'s Department, Wireless Branch. There is a paper in elementary radio theory, with special reference to low-powered transmission, another paper on the various Government regulations which govern the operation of any station, and, lastly, a Morse code test in sending and receiving at a speed of 12 words per minute.

It is this Morse code which so many find difficult. The best plan is to join up with your local radio club, and there you will find plenty of fellows with whom to practice, and among whom you will pick up so many points about the game. You will buy one of the handbooks from which all the necessary technical information can be gleaned. Many clubs have classes in which aspirants for a licence may be assisted. The clubs charge a shilling or two per month for membership, and through them you will be able to contact practically all the amateurs in your district. These will show you their transmitters and demonstrate how they should be operated. Under their watchful eye you might even be permitted to operate, when you have gained the necessary knowledge and skill.

Incidentally, the two main handbooks are the Radio Amateur's Handbook, published by the American Radio Relay League, the national organisation of America, and easily the most active country in amateur affairs, and the Radio Handbook, published by the amateur radio magazine, "Radio." The A.R.R.L. also has a magazine, of many years' standing and authority, called "Q.S.T." "Wireless Weekly" will also keep you informed on amateur activities in Australia. There are fortnightly notes by the Federal President of the Wireless Institute (Mr. W. M. Moore). All the bigger booksellers have these publications on their shelves.

There are also many other publications, mostly American, which will interest the amateur transmitter.

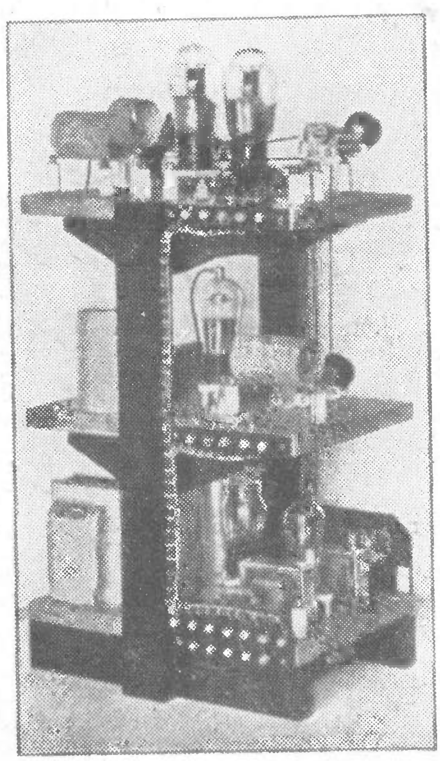
BUILDING A STATION

Assuming that the examination has been passed, the successful candidate will shortly receive a licence on payment of 30/- annually, authorising him to transmit, subject to the regulations, and with a power of not more than 25 watts, on any of the allotted wavelengths. These are: 2000-1715 k.c., 4000-3500 k.c., 7300-7000 k.c., 14,400-14,000 k.c., 30,000-28,000 k.c., 60,000-56,000 k.c., and anything below 110,000 k.c., or below 2.727 metres.

Every radio station must have a call-sign. This is allotted to it by the Radio Inspector when the licence is granted. In general, a call sign has one or two letters denoting the country in which it is located, then a figure denoting generally the State or district decided upon by the authorities for identification purposes, and finally two or three final letters to identify the station itself. Thus VK2JU has first of all VK, which denotes Australian experimental stations, the figure 2, which, as you will recognise, means New South Wales, and finally JU, which identify the writer's station. Should a station be heard signing W6ITH, this would be interpreted as W for American stations, 6 for the sixth district into which America is divided for radio purposes, and finally ITH, which identify the station itself. The number of final letters is generally controlled by the number of stations desiring call-signs, for, obviously, no two stations must have the same sign. New South Wales has just exhausted the 2-letter combinations, and has now 3-letter stations.

The full list of letters and the countries for which they stand is, of course, a large one. Some of them are G for England, VE for Canada, VU for India, ZL for New Zealand, J for Japan, F for France, and D for Germany. In each case these letters are followed by a number and further letters which are allotted by the country in question. The letters denoting the country are set down at World Conventions, which meet regularly to control the allotment of wavelengths for all services, and decide matters which allow the radio stations of the world to work without getting in each other's way.

The first thing to do is to build a receiver for amateur transmissions. This probably will be done while studying for the examination. A simple set will do quite well—a 2-valve battery receiver is still used by many, and costs very little to build. It will probably have coils which are interchangeable for receiving the various bands, and will serve for all but transmissions below 10 metres, where more specialised apparatus is needed. However, the 20, 40, and 80 metre bands are most used by the beginner, and will provide him with plenty to think about for quite a while. We are speaking mainly now of Morse code work. In which the beginner will most probably start out.



A typical 2-stage transmitter. The bottom shelf houses the power supply, the centre shelf the oscillator, and the top shelf the final amplifier, using a push-pull circuit.

Next he will build a small monitor, probably, in which to listen to his own signals, and to check his wavelengths, so that he will not be transmitting outside his official wavebands. Most amateurs these days use crystal controlled transmitters, which have the virtue that they cannot wander off to any other wavelength than that of the crystal itself.

Coming to the transmitter, this need only be a very small and simple affair—one valve only is necessary. Wonderful work has been achieved by some with small one-valve transmitters using battery receiving valves. However, a two-valve transmitter using a pair of 45 type valves, built entirely of parts as used in ordinary receiving sets, and using standard power transformers and rectifiers, will be a very good start.

Transmitting stations, in order to get best results, use aerials slightly different from the ordinary piece of wire used for ordinary receivers, although not much more elaborate. They have to be cut to the right length, and properly connected to the transmitter. As height is important, one can often see these aerials slung between two poles. The commonest type has two wires, spaced with spacers about 3 inches apart, running down from one end. These Zepp. aerials are found in possibly 70 per cent. of amateur stations, because they are easy to make, simple to erect, and very efficient.

Once having become an amateur, you will find much to interest you in your new hobby. There are plenty of radio clubs dotted about Sydney, in addition to the official body, the Wireless Institute of Australia, which holds regular meetings, where you will hear lectures and exchange ideas with others outside your own particular club and circle. Many of these you will have met via the ether, and never contacted in any other w[ay] until found by his call-sign at one [of] these meetings.

Many are the jokes which are m[ade] about the amateur, of his sleep[less] nights chasing the tantalising DX s[ta]tions, of the money which should have bought a new tennis racquet squandered on a new "bottle," and other amusing matters. But the general public is gradually realising under all this banter that the amateur is a necessary and permanent factor of the structure of radio. One thing is certain, that so long as he has his aerial skywards, and the strength to throw over his transmitter switch, he will never lack a friend.

SHORT-WAVE STATIONS OF THE WORLD

ACCURATELY COMPILED BY R. N. SHAW

In view of the fact that some of the most distant and obscure stations are now being heard in Australasia, we have included in this list practically all known stations. All times Sydney time.

Wave Length	Call Sign	Location, Schedule, etc.
13.92	K8XK	Pittsburgh. Midday to 2 p.m.
13.94	W2XE	Wayne, New Jersey. Daily 3-5 a.m.
13.97	GSH	Daventry. Daily 9-11.45 p.m. Empire broadcast.
15.24	GEC	Santiago, Chile. 'Phones.
15.39	LSQ	Buenos Aires. 'Phones.
15.50	PMA	Bandoeng, Java. 'Phones.
15.58	DFA	Nauen, Germany. 'Phones.
15.68	LSM	Buenos Aires. 'Phones.
15.93	PLE	Bandoeng, Java. 'Phones.
16.22	HBH	Geneva. Radio Nations, 'phones and world broadcasts.
16.30	PCK	Kootwijk, Holland. 'Phones.
16.42	ETA	Addis Ababa. Experimental; no definite schedule.
16.44	FTA	St. Assise, Paris. 'Phones.
16.50	CGA	Drummondville, Canada. 'Phones.
16.50	PMC	Bandoeng, Java. 'Phones.
16.55	LSY	Buenos Aires. Experimental, irregular.
16.63	GAA	Rugby, England. 'Phones.
16.82	PCV	Kootwijk, Holland. 'Phones.
16.86	GSG	Daventry. 9-11.45 p.m. daily. Winter only.
16.87	W3XAL	Boundbrook, U.S.A. Daily.
16.88	PHI	Eindhoven, Holland. Sun., Mon., Tues., Thur., Fri., Sat., 11 p.m. to 1 a.m.
16.89	W2XE	Wayne, New Jersey. Relays WABC 4 to 6 p.m.
16.89	IAC	Pisa, Italy. 'Phones ships.
16.89	DJE	Berlin. National broadcasts 8.55 p.m. to 2 a.m.
16.92	HSP	Bangkok, Siam. 'Phones.
17.00	XGN	Shanghai, China. 'Phones.
17.10	VUY	Poona, India. 'Phones.
17.12	DFB	Nauen, Germany. 'Phones.
17.37	DAF	Norden, Germany. 'Phones.
17.52	WOO	Ocean Gate, New Jersey. 'Phones.
18.20	IRY	Rome. 'Phones.
18.44	WLK	Laurenceville, U.S.A. 'Phones.
18.47	KTC	Manila, Philippine Islands. 'Phones.
18.57	FZR	Saigon, Indo-China. 'Phones.
18.71	KKP	Kauhuku, Hawaii. 'Phones.
18.89	FTK	St. Assisi, Paris. 'Phone.
18.91	CEC	Santiago, Chile. 'Phones.
19.02	LSL	Buenos Aires. 'Phones.
19.15	JVE	Nazaki, Japan. 'Phones.
19.20	JVF	Nazaki, Japan. 'Phones.
19.42	IUG	Addis Ababa. Opens midnight.
19.47	KWO	Dixon, California. Irregular broadcasts.
19.50	KKR	Bolinas, California. Experimental irregular.
19.52	HAS3	Budapest. Sunday, midnight to 1 a.m.
19.54	KWU	Dixon, California. 'Phones and occasional broadcast.
19.56	DJR	Zeesen, Germany. Afternoons 4-6 p.m.
19.56	W2XAD	Schenectady, U.S.A. 1.0-6.45 a.m.
19.62	LRU	Buenos Aires. Various hours, 8 a.m. to late afternoon.
19.63	DJQ	Berlin. Experimental; broadcasts programmes at times.
19.64	W2XE	Wayne, U.S.A. Early morning to about 8.30 a.m.
19.66	GSI	Daventry. 3.15 to about 7 a.m. Winter.
19.68	RIM	Tashkent, U.S.S. Russia. 'Phones, occasionally broadcast.
19.68	TPA2	Paris. Usually 9 p.m. to about 1.30.
19.69		Podebrady, Czechoslovakia. 2-4 a.m. and 7-9 p.m.
19.71	PCJ	Eindhoven, Holland. Tues., 6-9 p.m., Wed., 11 p.m. to 2 a.m.
19.71	W8XK	Pittsburgh, U.S.A. 1.30-10 a.m. daily.
19.74	DJB	Berlin. From 3.5 p.m. to 2 a.m. next day.
19.75	ZBW	Hongkong. Heard 7 p.m. to midnight.
19.76	GSO	Daventry. At present 6-8 p.m.
19.80	YDC	Bandoeng, Java. 8.30 p.m. to 1.30 a.m.
19.82	GSF	At present, 9-11.45 p.m.
19.84	HVJ	Vatican City, Rome. 1.30-1.45 a.m.
19.85	DJL	Berlin. Experimental; irregular broadcasts late afternoon and mornings.
19.92	WNC	Hialeiah, Florida, U.S.A. 'Phones.

Wave Length	Call Sign	Location, Schedule, etc.
19.94	RHI	Moscow. 'Phones evenings.
20.03	KAY	Manila, Philippine Islands. 'Phones, afternoon, evening.
20.08	HJB	Bogota, Colombia. 'Phones, morning, evening.
20.08	HII	Trujello, Dominican Republic. 'Phones.
20.08	HJA3	Barranquilla, Colombia. 'Phones.
20.19	OCJ2	Lima, Peru. 'Phones.
20.25	GBL	Rugby. 'Phones.
20.29	ROU	Omsk, U.S.S. Russia. 'Phones.
20.29	RTZ	Irkutsk, U.S.S.R. 'Phones.
20.37	IQA	Rome, 'Phones. Occasionally broadcasts around 10 p.m.
20.42	PSF	Rio de Janeiro. 'Phones.
20.55	JVH	Nazaki, Japan. 'Phones. Occasional evening broadcasts.
20.56	WMN	Lawrence, New Jersey, U.S.A. 'Phones.
20.64	HPJ	Geneva. 'Phones and occasionally for world broadcasts.
20.65	LSN	Buenos Aires. 'Phones.
20.71	HRL5	Nacaome, Honduras. 'Phones.
20.71	TIU	Cartago, Costa Rica. 'Phones.
20.71	YNA	Managua, Nicaragua. 'Phones.
20.71	HPF	Panama. 'Phones.
20.71	HRF	Tegucigalpa, Honduras. 'Phones.
20.71	TGF	Guatemala. 'Phones.
20.73	WMF	Lawrenceville, New Jersey. 'Phones.
20.75	GBW	Rugby. 'Phones.
20.75	DZA	Berlin. Experimental. Occasional broadcasts.
20.97 to 21.26		Amateur Experimental Band.
21.58	WQF	Rocky Point, U.S.A. 'Phones, and experimental.
21.70	SUZ	Cairo, Egypt. 'Phones.
21.91	KKZ	Bolinas, California. Experimental, irregular.
21.98	HJY	Bogota, Colombia. 'Phones.
22.09	GBE	Rugby. 'Phones.
22.35	GCJ	Rugby. 'Phones.
22.40	IDU	Asmara, Eritrea. 'Phones.
22.40	WNA	Lawrenceville, U.S.A. 'Phones.
22.48	XVQ	Maracay, Venezuela. 'Phones.
22.58	CGA3	Drummondville, Canada. 'Phones.
22.70	IRJ	Rome. 'Phones.
22.76	DGG	Nauen, Germany. 'Phones.
22.95	VPD	Suva, Fiji. Experimental, 3.30-4.30 p.m.
23.36	WOO	Ocean Gate, New Jersey. 'Phones.
23.38	CNR	Rabat, Morocco. 'Phones.
23.45	IAC	Pisa, Italy. 'Phones.
23.47	GBC	Rugby. 'Phones.
24.20	DAF	Norden, Germany. 'Phones.
24.40	PLM	Bandoeng, Java. 'Phones and occasional broadcasts.
24.41	GBU	Rugby. 'Phones.
24.56	TXA	Pontoise, Paris. 'Phones and occasional b'casts.
24.69	GBS	Rugby. 'Phones.
24.88	PDY	Kootwijk, Holland. 'Phones.
25.00	RNE	Moscow, 7-9 a.m. Sun, and Wed., 9-10 a.m., Monday 1.30 a.m.
25.02	FZS	Saigon, Indo-China. 'Phones.
25.11	KKQ	Bolinas, California. Experimental. Heard Monday afternoon to 3 p.m.
25.12	FTA	St. Assise, France. 'Phones, late evenings.
25.23	TPA2	Radio Colonial, Paris. 5-8 p.m. and 3-8 a.m.
25.27	W8XK	Pittsburgh, U.S.A. 8 a.m. to noon.
25.28	W9XAA	Chicago. About 9.30 p.m. to midnight.
25.31	DJP	Berlin. Experimental; heard late afternoon occasionally.
25.36	W2XE	Wayne, New Jersey. 7 a.m. to about noon.
25.38	GSN	Daventry. Used at times afternoon in Empire broadcasts.
25.40	2RO	Rome. 11.15 to 11.45 p.m. Midnight to 8.30 a.m.
25.40	HJ4ABA	Medellin, Colombia. Daily 2.4 a.m. and 9.30 a.m. to 1.30 p.m.
25.42	CO9WR	Cuba. 7-8.30 a.m. and noon to 1.30 p.m.
25.42	W1XAL	Boston, U.S.A. Daily from 9 a.m. and Mon., 7-10 a.m.
25.49	DJD	Berlin. Daily 2.35-7.20 a.m. and 7.50 a.m. to 1.40 p.m.

Wave Length	Call Sign	Location, Schedule, etc.
25.52	TJF	Reykjavik, Iceland. Experimental.
25.53	GSD	Daventry. At present 3-3.45 a.m., 9-11 a.m.
25.57	PHI	Huisen, Holland. 10.30 p.m. to 1.30 a.m.
25.60	CJRX	Winnipeg, Canada. 1-3 p.m.
25.63	TPA3	Radio Colonial, Paris. 9 a.m. to 4 p.m.
25.63	KIO	Kauhuku, Hawaii. Experimental.
25.70		Saigon. Late evenings.
25.73	PPQ	Rio de Janeiro. Experimental.
25.93	HH2T	Port au Prince Haiti. Experimental.
26.09	VIZ3	Fiskville, Victoria. Experimental.
26.09	XAH	Merida, Yucatan. Mexico. Experimental.
26.20	COCX	Havana, Cuba. Opens 10.55 p.m.
26.29	CJA4	Drummondville, Canada. 'Phones.
26.35	HBO	Geneva, Radio Nations station.
26.60	HIN	Dominica. Heard around 8 a.m.
27.15	ZLT	Wellington, N.Z. 'Phones with Sydney.
27.26	PLP	Bandoeng. 8.30 p.m. to 1.30 a.m.
27.26	XBJQ	Mexico. 'Phones.
27.35	OCI	Lima, Peru. 'Phones.
27.65	DFL	Nauen, Germany. Experimental; occasionally heard broadcasts.
27.67	KWV	Dixon, California. 'Phones.
27.86	GBF	Rugby, England. 'Phones.
27.93	JVM	Nazaki, Japan. Occasional broadcasts.
28.09	WNE	Lawrenceville, U.S.A. 'Phones.
28.14	JVN	Nazaki, Japan. Daily 6.50-11 p.m.
28.15	CEC	Santiago, Chile, 9-11 a.m.
28.28	WEA	Rocky Point, U.S.A. Experimental.
28.44	WOK	Lawrenceville, U.S.A. 'Phones.
28.49	JIB	Taiwan, Formosa. Experimental.
28.51	2ME	Sydney. 'Phones New Zealand and London, and occasional broadcasts.
28.79	XGW	Shanghai, China. Experimental.
28.80	PDK	Kootwijk. Holland. 'Phones.
28.80	YGB	Medan, Sumatra. 'Phones.
28.82	PDK	Kootwijk, Holland. Opens 6.25 a.m.
28.85	KEZ	Bolinas, California. Experimental. Heard afternoons.
28.91	WCG	Rocky Point, U.S.A. Experimental.
28.98	LSX	Buenos Aires. Experimental. Early mornings to 6 a.m.
29,00	Radio	Teneriffe, Canary Islands. Daily 6-7 a.m.
29.03	ZED	St. George's, Bermuda. 'Phones and experimental.
29.04	ORK	Brussels, Belgium. 5-7 a.m.
29.13	LSQ	Buenos Aires. Experimental.
29.15	DIQ	Nauen, Germany. Irregular. Usually early mornings.
29.25	PMN	Bandoeng, Java. 8.30 p.m. to 1.30 a.m.
29.27	LSL	Buenos Aires. Experimental.
29.45	PSH	Rio de Janeiro. Experimental.
29.50	RIO	Baku, U.S.S.R. 'Phones.
29.58	OPM	Leopoldville. Belgian Congo. 'Phones.
29.76	RIR	Tiflis, Siberia. 'Phones.
29.79	EHY	Madrid. 'Phones.
29.80	JZB	Manchukuo. 'Phones.
29.83	ZEB	Hamilton, Formosa. 'Phones.
29.83	SUV	Cairo, Egypt. 'Phones.
30.07	COCQ	Havana, Cuba. Opens about 10 p.m.
30.09	KAZ	Manila. 'Phones.
30.15	GCU	Rugby. 'Phones.
30.21	HKB	Bogota, Colombia. 'Phones.
30.30	LSN	Buenos Aires. 'Phones.
30.40	WON	Lawrenceville. U.S.A. 'Phones.
30.40	EAQ	Madrid. Daily 8.15 a.m. to 1.30 p.m. Sun., 4-6 a.m.
30.40	JYS	Kemikawa, Japan. Experimental.
30.52	IRM	Rome, Italy. 'Phones.
30.60	GCW	Rugby, England. 'Phones.
30.75	VLK	Sydney. 'Phones.
30.77	WOF	Lawrenceville, U.S.A. 'Phones.
30.90	GCA	Rugby, England. 'Phones.
31.00	CQN	Macao, China. Mon. and Fri., 10-11.30 p.m.
31.08	DGU	Nauen, Germany. 'Phones.
31.09	CT1AA	Lisbon, Portugal. 7-10 a.m., Wed., Fri., and Sun.
31.13	YDB	Sourabaya, Java. 8.30 p.m. to 1 a.m. daily.
31.25	HJ1ABP	Cartagena. Heard around 7 a.m. and 10 p.m.
31.25	Radio	Cartalene, Colombia. Experimental.
31.27	HBL	Geneva. Radio Nations station. 'Phone and broadcasts.
31.28	W3XAU	Philadelphia, U.S.A. 3-9.30 a.m.
31.28	HJ1ABB	Barranquilla. Noon to 3.15 p.m. and 11 p.m.

Wave Length	Call Sign	Location, Schedule, etc.
31.28	2ME	Sydney. Sun., 4-6 p.m., 8-midnight. Also world broadcasts.
31.29	HP5J	Panama City. 2.45-4 a.m. and 10.30-1 p.m.
31.30	GSC	Daventry. Empire station.
31.34	3LR	Lyndhurst. Relays Australian programmes 6.30-11.30 p.m. daily. Sat., 2-5.30 p.m.
31.36	W1XK	Boston, U.S.A. 8.30 p.m. to 3 p.m. next day.
31.36	VUB	Bombay, India. 2-3.30 a.m. daily.
31.37	HH3W	Port au Prince, Haiti. 4-5 a.m.
31.38	DJA	Berlin. National station; heard best 3 p.m. to 5 p.m. and from 11 p.m. also.
31.41	CSW	Lisbon. Opens 7.50 a.m.
31.44	DJN	Berlin. National station. Best from 11 p.m. and in afternoons from 3.30 to about 6 p.m.
31.45	VPD2	Suva, Fiji. Daily 8.30 to 10 p.m.
31.48	LKJ1	Jeloy, Norway. 8-11 p.m. and 2-9 a.m. Best around 7 a.m.
31.48	W2XAF	Schenectady, U.S.A. 7 a.m. to 3 p.m. daily. Occasionally from 6 a.m. with sporting broadcasts.
31.49	ZBW	Hongkong. Daily 7 p.m. to midnight.
31.51	OXY	Shamlebaek. Denmark. Mornings, irregular.
31.55	GSB	Daventry. Empire station. Now 6-8 p.m. and 3-8.45 a.m.
31.55	3ME	Melbourne. Daily, Sunday excepted, 7-10 p.m.
31.56	XGOX	Nanking, China. About 10 to 11.30 p.m. daily.
31.56	PRF5	Rio de Janeiro. Irregular, usually 8 a.m. to about noon.
31.65	EAH	Madrid. Heard about 6.45 to 7.45 a.m.
31.86	PLV	Bandoeng, Java. 'Phones and occasional broadcasts nights.
32.15	CJA4	Drummondville, Canada. 'Phones.
32.33	GCB	Rugby, England. 'Phones.
32.88	HATA	Budapest. Daily 9-10 a.m.
32.97	HJU	Buenos Aires. Experimental.
33.00	ZMBJ	S.S. Awatea. Various hours, morning, afternoon.
33.19	TYA2	Heard daily 5 to 6 p.m.
33.26	GCS	Rugby. 'Phones.
33.29	KEJ	Bolinas. California. Experimental; heard afternoons.
33.52	W2XBY	Rocky Point, U.S.A. Experimental.
34.10	HKV	Bogota, Colombia. 'Phones.
34.21	HOJB	Quito, Ecuador. Monday 10.30 a.m. to 12.30 p.m.
34.29	ZEK/ZBW	Hongkong. 9 p.m. till 1 a.m.
34.56	GEC	Rugby. 'Phones.
34.62	CO9JQ	Cuba. 8.30-9.30 a.m.
34.68	WVD	Washington. Experimental.
34.80	VE9DE	Canada. Experimental.
35.00	IAC	Rome, Italy. 'Phones.
35.02	WOO	Ocean Gate. U.S.A. Experimental.
35.42	DAF	Nordern. Germany. 'Phones.
35.69	HC2CW	Guayaquil. 11 a.m. to 2.30 p.m.
38.06	SUX	Cairo, Egypt. 'Phones.
38.12	HC2JSB	Guayaquil. Midnight to 5 a.m.
38.47	HBP	Geneva. 'Phones.
38.50	PSZ	Rio de Janeiro. Experimental.
38.89	KZE	Bolinas, California. Experimental.
39.34	RIM	Tashkent, U.S.S.R. 'Phones.
39.42	KWX	Dixon, California. 'Phones.
39.47	TI8WS	Costa Rica. 9 a.m. to 1 p.m.
39.95	JVP	Nazaki, Japan. Experimental.
39.97	RKI	Tashkent, U.S.S.R. 'Phones.
40.55	HJ3ABD	Bogota, Colombia. 10.30 a.m. to 11 a.m.
40.65	XECR	Mexico. Monday 9-11 a.m.
41.20	HJ1ARB	Çartagena. 10.30 a.m. to noon.
42.60	EA9AH	Tetuan, Morocco. Daily 7 to 8 a.m.
44.44	JVT	Nazaki, Japan. 9 p.m.
44.60	PMH	Java. Opens daily 8.30 p.m.
44.90	TI2M	San Jose, Costa Rica. Noon to 2 p.m.
45.00	ZPIO	Paraguay. 1 to 3 p.m.
45.00	HO2RL	Ecuador. Mon. 8.45-10 a.m., Wed., 1.45-2.15 p.m.
45.10	IAC	Pisa, Italy. 'Phones.
45.31	PRADO	Rio Tambar, Ecuador. Friday, noon to 2.30 p.m.
45.50	HI4D	Trujillo. 2.40-4.40 p.m.
46.01	YV6RV	Valencia, Venezuela. 3.30-5 a.m. and 9 a.m. to 1 p.m.
46.30	HJ5ABD	Cali. Colombia. 10 a.m. to 1 p.m.
46.44	HJ4ABC	Ibaque, Colombia. 11 a.m. to 1 p.m.
46.50	W3XL	Boundbrook, New Jersey. Experimental; irregular.
46.77	HJA3	Barranquilla, Colombia. Experimental.
46.86	TIPG	San Jose, Costa Rica. 9 a.m. to 2.30 p.m.

Wave Length	Call Sign	Location, Schedule, etc.
47.10	YV4RC	Venezuela. 7.30 a.m. to 1.30 p.m.
47.24	HRY	Honduras. 9.45 a.m. to 12.30 p.m.
47.39	HRP1	Honduras. 9.30 a.m. to 1 p.m.
47.39	JZC	Nazaki, Japan. Experimental. Occasional broadcasts.
47.51	YV12RM	Venezuela. 11 p.m. to 1.30 a.m. and 7.30 a.m. to 2 p.m.
48.00	OAX4G	Lima, Peru. 10 a.m. to 1.30 p.m.
48.50	HI1A	Santiago. 2.40-4.40 a.m.
48.55	XEXA	Mexico City. 11-1.30 p.m. and midnight onward.
48.60	HJ2ABA	Tunja, Colombia. 4-5 a.m. and 9 a.m. to 1 p.m.
48.62	HJ3ABF	Bogota, Colombia. 10 a.m. to 2.15 p.m.
48.78	HJ5ABC	Cali, Colombia. 9 a.m. to 12.30 p.m., except Sun. and Mon.
48.79	CO9GC	Santiago. 6.30-7.30 a.m. and 1-2 p.m., Sun., Mon., 4-5 p.m.
8.85	CJRO,	Winnipeg, Canada. 1.3 p.m.
8.86	W8XK	Pittsburgh, U.S.A. 10 a.m. to 4 p.m. daily.
8.92	ZGE	Kuala Lumpur, Sun., Tues. and Fri. 9.40-11.40 p.m.
48.92	HI5M	Trujillo. 9.40-11.40 p.m.
48.92	COCD	Havana, Cuba. 8 a.m. to 4 p.m.
49.02	W2XE	Wayne, New Jersey. 11 a.m. to 1 p.m.
49.02	XEFT	Vera Cruz, Mexico. 2.30-7 a.m., 10.30 a.m. to 3 p.m.
49.02	HJ1ABE	Cartagena, Colombia. 10.30 a.m. to 12.30 p.m.
49.10	GSL	Daventry. Empire station during summer.
49.10	VE9HX	Halifax, Canada. 11.30 p.m. to 3 a.m. and 8 a.m. to 3 p.m.
49.10	VUC	Calcutta. 12.30-3 a.m. Sun., 3.15-5.30 p.m.
49.15	HJ4ABB	Colombia. 11 a.m. to 2.30 p.m. Occasionally only.
49.18	W3XAL	Cincinnati, U.S.A. Tues., Thur., Sun., 9 a.m. to 3.45 p.m.
49.18	W9XF	Chicago, U.S.A. Mon., Wed., Fri., noon to 5 p.m.
49.20	ZTJ	Johannesburg. 6.30-10 a.m. Probably around midnight also.
49.22	CRCX	Bowmanville, Canada. 8.30 a.m. to 2.30 p.m.
49.30	2RO	Rome. Certain periods year 9 a.m. to about 10.45 a.m.
49.34	HP5F	Colon, Panama. 1.45-3.10 a.m.
49.34	ZHJ	Penang, Sumatra 8.40-11.40 p.m.
49.40	VE9CS	Vancouver. 9-10 a.m. Mon., 4.45 a.m. to 4 p.m.
49.42	OER2	Vienna, Austria. Midnight to 8 a.m., except Sunday.
49.45	HJ4ABL	Manizales, 2-3 a.m. and 8.30-10.30 a.m. Sun. to 1.30 p.m.
49.50	7LO	Nairobi, East Africa. 2-5.30 a.m., occasionally to 6 a.m.
49.50	W8XAL	Cincinnati, Ohio. 9.30-11 p.m. and 2 to 5 p.m.
49.50	W3XAU	Philadelphia, U.S.A. 10 a.m. to 1 p.m.
49.55	HJ4AHD	Medellin. 11 p.m. to 2.30 p.m. next day.
49.59	HI9B	Santiago. 9 a.m. to 1 p.m. and 3.30-4.10 p.m.
49.59	GSA	Daventry. Empire station. Mainly used in summer.
49.60	VPB	Colombo, Mon., Wed., Fri., Sun., 11 p.m. to 1 a.m.
49.65	HJ1ABG	Barranquilla. 9 a.m. to 1 p.m.
49.67	HJ4ABC	Colombia. 1.30-3 a.m.
49.67	W4XB	Florida. 2.30-5 a.m. and 11 a.m. to 4 p.m.
49.67	W1XAL	Boston, U.S.A. 11.15 a.m. to noon on Wed., Fri., and 7 to 10 a.m., Mon.
49.75	VE9CA	Calgary, Canada. Midnight to 1 a.m.
49.75	HP5B	Panama City. 3-4 a.m. and 9 a.m. to 1 p.m.
49.83	XEUW	Vera Cruz. 10.30 a.m. to 3.30 p.m.
49.83	DJC	Berlin. 3 to 7.20 a.m. daily.
49.83	CQN	Macao, China. When not on 49 band see 31 band.
49.90	9MI	S.S. Kanimbla. Heard evenings.
49.90	COCC	Havana, Cuba. 12.30-3.30 a.m., 7.10 a.m., 11 a.m. to 1 p.m. and Sunday to 3 p.m.
49.92	ZKI	Singapore. Mon., Wed., Thur., 8.50-11.50 p.m. Sun., 1.50 to 3.50 p.m.
49.96	VE9DN	Drummondville, Canada. Sunday about 2.30 p.m.
50.00	RNE	Moscow. Mornings to 8 a.m.; summer only.
50.26	HVJ	Vatican City. 5-5.15 a.m. daily. Sun., 8-8.30 p.m.
58.30	PMY	Bandoeng, Java. 9 p.m. to 3 a.m. daily.
59.76	ZFA	Hamilton, Bermudas. 'Phones.
70.00	RW15	Khabarovsk, U.S.S.R. 8 p.m. to midnight.

How To Listen To Short-waves

THERE is no doubt that for the man who has the experimental urge or an interest in radio beyond listening to broadcasting stations (which includes, of course, most readers of this handbook) the short-wave stations have a fascination all their own. One never knows just what is waiting to be heard on the air, according to conditions and the time of the year. These are the two main elements which control the type and number of stations which are to be heard at any given time.

A frequent mistake is to imagine that one has only to tune to the wavelength shown in the above list of stations to tune into the programme. Much disappointment is inevitable until it is realised that all the stations cannot possibly be heard at the one time.

As conditions change, and they do change as the seasons come and go, it will be found that some of the regular short-wave bands are much better than others. It will be found also that night and day have a good deal to do with the bands which are most valuable. For instance, it might be found that the 19-metre stations are very good at night, possible from 9 p.m. until well after midnight, while in the afternoons the 25 and 31 metre bands will give the best reception. A few months later conditions might alter, and the various bands will change about.

This is one reason why "Wireless Weekly" maintains a comprehensive short-wave section, and, in addition, a stop-press panel in which a list of stations, times and wavelengths is given as a guide to the best reception occurring each week. We suggest that the short-wave fan keep in close touch with this section of the paper, and thus save much doubt over when and where to listen.

In addition, it will be found quite often that unexpected transmissions are to be heard which cannot be listed, and conditions will allow odd broadcasts to come through which are all the more interesting and valuable because of this.

When listening, do not neglect the amateur bands, particularly the "20-metre" band, on which, particularly in the afternoons and evenings, can be heard amateurs operating from all parts of the world. These stations have an informality which gives them a character all their own, and most of them welcome reports from listeners on their transmissions. If a card or a reply is to be expected, do not forget to enclose postage, as an amateur's mail during a year is a heavy one and the cost considerable. In your report give time, strength, and readability of signals, a portion of what you heard, weather conditions, type of receiver and aerial, and, if possible, a note on what other stations in that part of the world were also to be heard. Most foreign broadcasters also welcome such reports, and, as a rule, they will be acknowledged.

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Australian and New Zealand Broadcasters

A corrected list of Australian and New Zealand Broadcasting Stations in the order of their frequencies.

Call Sign	Dial No.	Kilo-cycles	Address
2YA		570	National Station, New Zealand Broadcasting Board, Wellington.
3AR		580	National Station, 120A Russell Street, Melbourne.
7ZL		590	National Station, Elizabeth Street, Hobart.
2FC		610	National Station 96-98 Market Street, Sydney.
5CK		640	Regional Station, relaying 5CL, Crystal Brook, S.A.
1YA		650	New Zealand Broadcasting Board, Auckland.
2CO		670	Regional Station, relaying 3LO and 3AR, Corowa, N.S.W.
6WF		690	National Station, Hay Street, Perth.
2NR		700	Regional Station, relaying 2FC, Lawrence, near Grafton, N.S.W.
7NT		710	Regional Station, North Tasmania, Relaying 7ZL and 3LO.
3YA		720	New Zealand Broadcasting Board, Christchurch.
5CL		730	National Station, Hindmarsh Square, Adelaide.
2BL		740	National Station, 96-98 Market Street, Sydney.
3LO		770	National Station, 120A Russell Street, Melbourne.
4YA		790	New Zealand Broadcasting Board, Dunedin.
4QG		800	National Station, State Insurance Bldgs., Brisbane.
2LV		820	Northern Broadcasters Ltd., Inverell, N.S.W.
3GI		830	Regional Station, relaying 3LO and 3AR at Sale.
2YC		840	New Zealand Broadcasting Board, Wellington.
5RM		850	Commercial Station, Renmark, S.A.
7HO		860	Commercial Ltd., 82 Elizabeth Street, Hobart.
2GB		870	Theosophical Station, 29 Bligh Street, Sydney.
6PR		880	Nicholson's, Ltd., Studio, Barrack Street, Perth.
1YX		880	New Zealand Broadcasting Board, Auckland.
3MA		900	Sunraysia Pty., Ltd., 22 Deakin Avenue, Mildura.
4WK		900	Warwick B'casting Co., Pty., cor. King and Albion Sts., Warwick, Q.
4RK		910	Regional Station, relaying 4QG, Rockhampton, Qld.
3UZ		930	Oliver J. Nilsen and Co., 45 Bourke Street, Melbourne.
2UE		950	Radio House, 296 Pitt Street, Sydney.
5DN		960	Hume Broadcasters, Ltd., 29 Rundle Street, Adelaide.
3BO		970	Amalgamated W'less (A'sia), Ltd., Kangaroo Flat, Bendigo, Vic.
4AY		980	Ayr Broadcasting Service, Airdmillan Road, Ayr, Qld.
6AM		980	Northam Broadcasters, Ltd., 23 William St., Perth—at Northam.
2GZ		990	Country B'casting Services, Ltd., Amaroo, Central N.S.W.
4GR		1000	Gold Radio Service, Studio, Ruthven Street, Toowoomba, Q.
3HA		1010	Western Province Radio Co., 37 Gray Street, Hamilton, Vic.
2KY		1020	Trades and Labor Council, The Block, George Street, Sydney.
3DB		1030	3DB B'casting Station Pty., Ltd., 36 Flinders Street, Melbourne.
5PI		1040	Midland B'cast Services Ltd., Relay Unit of 5AD, Crystal Brook, S.A.
2CA		1050	A. J. Ryan, Kingston, Canberra, F.C.T.
4MB		1060	Maryborough Broadcasting Co., Wynne's Stn., Maryborough, Q.
2AD		1080	Northern Broadcasters Ltd., Armidale, N.S.W.
3SH		1080	Swan Hill Broadcasting Co., Swan Hill, Victoria.
7LA		1100	Findlay and Wills, Broadcasters, 67 Brisbane St., Launceston, Tas.
4LG		1100	Central Western Broadcasting Co., Longreach, Qld.
2UW		1110	C'wealth B'casting Corp., Ltd., State Bldg., Market St., Sydney.
4BC		1120	J. B. Chandler and Co., 43 Adelaide Street, Brisbane.
6ML		1130	W.A. Broadcasters, Ltd., Lyric House, Murray Street, Perth.
2HD		1140	Airsales Broadcasting Co., P.O. Box 123, Newcastle, N.S.W.
2WG		1150	Riverina Broadcasting Co., 16 Fitzmaurice St., Wagga, N.S.W.
2KA		1160	Radio Katoomba Ltd., 80 Market Street, Sydney.
4MK		1160	Mackay Broadcasting Service, 64 Nelson Street, Mackay.
6BY		1160	Bunbury Broadcasters Ltd., Bedford Hall, Bunbury, W.A.
4TO		1170	Amalgamated W'less (A'sia), Ltd., Townsville, Qld.
3KZ		1180	Industrial Printing Co., 24 Victoria Street, Carlton, N.3.
2CH		1190	2CH Broadcasting Co., 77 York Street, Sydney.
5KA		1200	Sports Radio B'casting Co., Ltd., Richard Blgs., Currie St., Adelaide.
3YL		1200	New Zealand Broadcasting Board, Christchurch.
2GF		1210	Grafton Broadcasting Co., 47 York St., Sydney. Station at Grafton.
6KG		1210	Goldfields Broadcasters Ltd., 86 Palace Chbrs., Kalgoorlie, W.A.
4AK		1220	Commercial Station, Oakey, Queensland.
2NC		1230	Regional Station, relaying 2FC and 2BL, at Newcastle.
3TR		1240	Gippsland Publicity Pty., Ltd., Raymond Street, Sale, Vic.
6IX		1240	W.A. Broadcasters Ltd., St. George's Terrace, Perth.
3WR		1260	Goulburn Valley and N.E. B'cast. Pty., Ltd., High St., Shepparton, V.
2SM		1270	Catholic Broadcasting Co., Australia House, Carrington St., Sydney.
3AW		1280	Vogue Broadcasting Co., Ltd., 218 Exhibition St., Melbourne.
4BK		1290	Brisbane Broadcasting Co., 47 Charlotte Street, Brisbane.
2TM		1300	Tamworth Radio Dev. Co. Ltd., Peel Street, Tamworth, N.S.W.
5AD		1310	Advertiser Newspapers, Ltd., Weymouth Street, Adelaide.
3BA		1320	Ballarat B'cast. Pty. Ltd., cor. Armstrong and Dana Sts., Ballarat, V.
2BH		1330	Radio Silver City Ltd., 10 O'Connell Street, Sydney; at Broken Hill.
4RO		1330	Rockhampton Broadcasting Co., Studios in Rockhampton, Q.
2XN		1340	G. W. Exton, P.O., Box 138, Lismore, N.S.W.
5MU		1340	Murray Bridge B'cast Co., Regional Unit of 5AD, Murray Bridge, S.A.
3GL		1350	Geelong B'casting Pty., Ltd., National Mutual Blg., Geelong, V.
2MO		1360	M. J. Oliver, P.O., Box 78, Gunnedah, N.S.W.
3HS		1370	Wimmera Broadcasting Co., 84 Wilson Street, Horsham.
4BH		1380	Broadcasters (Aust.), Ltd., Parbury House, Eagle Street, Brisbane.
4CA		1390	Amalgamated Wireless, Cairns, Queensland.
7BU		1390	Finlays Pty., Ltd., Wilson Street, Burnie, Tas.
2GN		1390	Goulburn Broadcasting Co., Auburn Street, Goulburn, N.S.W.
2KO		1410	Newcastle Broadcasting Co., 57 Hunter St., Newcastle, N.S.W.
3XY		1420	Efftee Broadcasters Pty., Ltd., Princess Theatre, Spring St., Melb.
2WL		1430	Wollongong B'cast Co., cor. Edward and Church Sts., W'gong, N.S.W.
4VL		1430	Charleville Broadcasting Service, Burke Street, Charleville.
4IP		1440	Ipswich Broadcasting Service, Brisbane St., Ipswich, Qld.
2QN		1440	Deniliquin Broadcasting Co., Ena Street, Deniliquin.
7UV		1460	Northern Tasmanian Broadcasters Pty., Ltd., Ulverstone, Tas.
3MB		1470	Mallee Broadcasting Pty., Cumming Avenue, Birchip, Vic.
2BE		1470	Bega District News, Box 4, P.O., Bega, N.S.W.
4BU		1480	Bundaberg Broadcasters Ltd., Bourbon Street, Bundaberg.
2AY		1480	Amalgamated W'less (A'sia) Ltd., Pool's Hill, Albury, N.S.W.
3AK		1500	Melbourne B'casting Pty., Ltd., 116 Queen St., Melbourne, C.1.

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