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.

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 has 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 convey a 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 civilization. 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 become to them a servant of incalculable value, not only in giving them the latest news and information on weather and industry, but in providing entertainment, but it has been the means in many instances of saving lives and protecting property.

With the prospect in the near future 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 trade 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 first home-built set is switched on for the first time.

WIRELESS WEEKLY HANDBOOK

Page Three

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 second has its circuits tuned so that the necessary circuitry is to be used to amplify the high-frequency currents that are faithful 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.

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

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 15 metres, 10 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.
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 to quite weak, and often at considerably greater distances than the ground wave can ever span. Thus it is always harder to get signals from overseas short-wave stations than from those near by. 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 pattered 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
statement that the two waves simply work one against the other to split up the component carriers in all kinds of 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 incoherence of A.V.C. or in full, Automatic Volume Control, is to vary the sensitivity of the set automatically, according to the strength 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 none of them 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 to get 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 not be too particular as to ground and interstake reception on an aerial. The good point is 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 to get it into the radio set. Therefore, generally speaking, the aerial which is the best collector of energy is the best aerial.

AERIAL LENGTH

Next comes the matter of length. It is not a good plan to make it too long. Remember that it is hinged to the first tuned circuit of the receiver, and that an aerial itself has a definite amount of inductance and capacity, which are the important features in a tuning coil. Therefore, it exerts a certain retarding 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.

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 aerial made of insulated wire, not only in the aerial system, but in 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 as metal objects as possible.

SPECIAL AERIALS

In many cases, a noisy house-power installation, or some other source of electrical interference will cause crackling 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 the 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 the aerial is 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 supposed free of 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 not 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 are 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 safety, 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送上 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.
You CAN BUILD IT YOURSELF

WORLD STATIONS IMMEDIATELY YOU
COMPLETE EIGHTEEN SIMPLE CONNECTIONS

IS THE ONLY SURE WAY OF BUILDING YOUR
OWN SET AND GETTING ABSOLUTE LABORATORY RESULTS

Completely Assembled, Fully Aligned and Tested, Partly Wired

The Lekmek ChassiKit-Set provides the only sure way of building a modern dual-wave superheterodyne without risk of wiring and set alignment failures. With only eighteen simple connections to make, the home constructor can provide himself with a receiver equal to any radio on the Australian and New Zealand market. Before leaving the factory the World Standard ChassiKit-Set is completely assembled and aligned, and thoroughly tested both on the air and by signal generator. The fact that only the highest quality components are used throughout its construction assures consistent and dependable performance at all times.

Lekmek World Standard A/C Dual-Wave ChassiKit-Set.
Price ........................................ 16 GNS.
Lekmek World Standard Battery Dual-Wave ChassiKit-Set.
Price ........................................ 16 GNS.

Complete with circuit diagram and all wiring instructions. Only speaker and valves (as well as battery in the battery version) have to be obtained.

AERIAL FILTERS
The Lekmek Aerial Filter prevents all outside interference, such as caused by climatic conditions, from causing static. This means greater clarity in bringing in interstate stations, and much improved reception in local stations. Retail .................. 35/-
Complete with 100ft. cable .......................... 45/-

DOUBLE DOUBLET AERIAL SYSTEM
The Double-Doublet Aerial is specially designed for dual-wave, short-wave, and short-wave converter sets, and gives very satisfactory results in providing noiseless reception.

Besides being a noise and static eliminator, the Double-Doublet is itself a highly efficient Aerial System. All that is required are ropes and supports.

A clear diagram is included for your guidance. Retail .................. 47/-

LINE FILTERS
All interference that enters your radio through the power line; static caused by trams, trains, refrigerators, and other sources, can be eliminated by the Lekmek Line Filter.

Price ........................................ 19/-

LEKMEK RADIO LABORATORIES
(N. S. Gilmour)
75 WILLIAM ST., SYDNEY, AUSTRALIA.
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.

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 center 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
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 very important thing. For instance, a strong electric field will create more electric 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.

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. (Volts are named after 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 metals which have a high 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 electric 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 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 an 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). 

\[ E = IR \]

We have said that power equals voltage by current.

\[ P = EI \]

Therefore by substituting 1 x R instead of E in our power formula, we find that P equals IR x 1. 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 formulæ 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 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 only obtained by batteries or from D.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 must 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." This magnet steel has a low permeability. If we were to wind a coil of insulated wire around 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 bat-
tery, and some insulated wire wound
round an iron nail. When the battery
is connected, the nail will pick up ot-
her iron objects, but it is not too heavy.
As soon as the battery is disconnected,
the nail will lose nearly all its mag-
netism.

If a battery is used for a long time,
the electrolyte above the plates may
become impure. It is therefore best to
always use distilled water—not tap water,
for the tops of the plates, and the
electrolyte (in this case, acid) is
never to be added except in the
amounts indicated. The acid should
be added slowly, and the battery
should be kept under water until
it is completely charged.

It is also good practice to keep
the battery container clean to avoid
corrosion. As acid is used in a
battery, it is a bad corrosive, and
will burn holes in carpets, clothing,
etc. If not removed immediately it
happens to be spilled. Ordinary
household ammonia is a good
antidote for the acid, and the
affected spots should be dabbed
with a piece of cloth moistened
with an ammonia solution, and dried.
As a rule, the ammonia
solution cleans the battery
quickly and effectively.

When the battery is not in use,
the terminals should be disconnected,
and the battery should be kept dry.
When the battery becomes
weak or dead, it should be
recharged. If the battery is
left long enough, the iron plate will
lose its magnetism, and continue
acting as a magnet for a very long time.

The reason for this is in 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 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 and in one direction the top
end of the first coil is north and the
bottom end south, and then wind the
second coil the same way, only in the
opposite direction, and with the iron
coils placed alongside it, so that the iron
core also
will be there even though
the nail was not.

This is the principle of
the transformer. When the 132,000 volt
lines reach the city they are "stepped down"
into 240 volt mains. A second coil
which we will call the primary coil
is connected to each of these 240 volt
mains. A second coil connected to
these mains supplies the voltage for the
transformer, and we wind
the voltage.

A 2-VOLT accumulator would be the
handiest method of obtaining A bat-
tery current for this set. Accumulators will
give long and satisfactory service, pro-
vided they are properly cared for. Al-
ways see that the points of the ele-
ctrolyte (in this case, acid) is kept above
the top of the plates, and always use
distilled water to re-
plenish when needed. The latter has
too many impurities. Failure to keep
the electrolyte above the plates may lead
to "sulphation", or the battery, and its
steady deterioration.

It is also bad to leave the accumu-
lator "run down" for any length of time.
Always try to keep the
battery charged so it drops
slowly that it refuses to function.
The amount of charge is best gauged
by using a galvanometer to test the specific
gravity of the electrolyte. When this
drops to about 1170 the battery must
be recharged, and when fully charged
should stand for a week or two near 1220. At all
times use the fluid when
the makers of the battery. This also ap-
plies to the charging rate. It is very
bad to charge a battery too quickly, as
to make a circuit. Some people also
have a bad habit of deliberately short-
charging a battery with a piece of wire
to see whether it is still charged. This prac-
tice 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 spilled. Or-


under no circumstances add acid to
the electrolyte, except in cases where it
has actually been spilled from the
battery, which thus requires more of it.

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the acid there. If it is left long enough, Keep the
making the
accumulator clean to avoid corrosion of
the plates. Also, as acid is a conduc-
tor, it will provide a leakage path if left
lying on the top of the battery, which will slowly but surely help to discharge
it. An easy means of checking this on the ter-
minals will assist in preventing the
generation of voltage from accidental acid,
fumes, etc. Properly cared for an accumulator is a very
reliable source of power.
Ordinary radio, compared with Kriesler TURRET TOP TONE EXPANSION is like listening to a piano without a soundboard. Musical overtones ordinarily weak or inaudible are enhanced and given a wonderful richness and depth. Entire demodulation of the cabinet is effected and at the same time ALL the sound waves are carried forward to the listener. No other radio accomplishes this to such a marked degree.

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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 nearly so, as the wave from the set. 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 with 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.

A current is fed into a wire and a magnetic field is set up around 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 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.

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 "L/C," 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 former the tuning condenser associated with it will be the higher also the wavelength will be. Average values for home use are broad band from 200 to 550 metres would be a coil of 100 turns wound on a 11-inch former with 22-gauge enamelled wire and tuned with a condenser having a maximum capacity of .005 mfd.

The unit of capacity is the farad, which is so large that we generally speak of micro-farads (millidoros). 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 11-inch former would have much less inductance than the same number of turns on a 3-inch former.

\[ L = \frac{n^2 d^2 \pi^2 1 k \times 10^{-3}} \]

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 the diameter 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:

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

\[ C = \frac{1885 \times A \times E (N-1)}{D} \]

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 11-inch formers with 21-inch cans, which form the comers work. 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

\[ C = \frac{1885 \times A \times E (N-1)}{D} \]

TUNING COILS IN PRACTICE

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

For the average set to-day, the same 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.

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 than 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 few 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 frequeny within the range of the secondary tuning.

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 selection of the R.F. transformers.
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 apochromatic character of the primary it is coupled very closely to the secondary, generally wound right over 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 in the tuning of the intermediate frequency transformers in a superheterodyne there are two tuned coils— one in the receiver and a superheterodyne receiver, the tuning stages of a receiver are tuned to 300 metres.

However, the superheterodyne receiver is more efficient in this respect than the T.R.F. set, and use the largest number of turns in the superhet. I.F. transformers are tuned, and at least two of these are used in even the smallest superhet, and the oscillator circuit. The two tuned circuits are superimposed on this artificially created intermediate frequency.

It is the purpose of 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 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 tuning 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 the oscillator. These two frequencies are arranged so that their difference produces a second frequency which is coupled to the various stages of the receiver.

This frequency is adjustable so that it differs from the signal frequency by a definite amount. Most people have noticed aeroplanes flying overhead, with two engines in operation. If one engine is replaced by another, the speed will be reduced for the same revolutions of the propellers. It will be noticed that the sound of 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 frequencies of the two engines. When the engines are nearly the same in speed, the throb will be very great. If the engines were slowed down so that this throb would quickly, as the difference in speeds increased.

In a superhet, the output from the oscillator is fed into the intermediate frequency transformers, where it is probably even lower than the 1350 kc. station, working on 1000 kc. This station, working on 1350 kc.

Let us assume that the station being tuned is operating on 1000 kc., 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.

The advantages of this scheme are, firstly, that better selectivity is possible because of the fixed intermediate frequency. They need no variable tuning, and also more amplification is obtainable at these lower frequencies with our sensitivity is better. 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, and there are four tuned circuits here, besides the one at the signal frequency. This means very much better selectivity of the sharpening of the response of the receiving circuit.

As a rule, the 465 kc. frequency, or intermediate frequency of the signal, is higher than the intermediate frequency of the signal, which might be working on 1350 kc.

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: 465 kc., 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 reason that we choose a higher intermediate frequency over a lower one.

As the oscillator frequency, but this time above the signal frequency in the set. Because the intermediate frequency is coupled to the intermediate frequency stage of a superhet, it 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.

In order to preserve the aperiodic nature which applies to tuning, it was supposed to be tuned. Thus we listened to the station on 1350 kc., and the oscillator, tend to pull each other together, and cause interlocking.

The two tuning points, as before, will be spaced twice the intermediate frequency apart.

DOUBLE SPOTS

Owing to the fact that the frequency changer valve is preceded by a circuit tuned to our 1000 kc. station, this station will be much easier to tune into a superhet, if all stages of the tuning circuit, if at all, should not be very responsive to the second stage, 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 kc. 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 reason that they are so much more troublesome. With 175 kc. the double spots always occur at twice the I.F. of the set away from the normal dial reading. Thus with 465 kc. this double spot would be 930 kc., whereas 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 insensitive 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 mixing from double spots when using 460 kc.

The selection of the intermediate frequency is almost universal in receivers today. INTERMEDIATE FREQUENCY

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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.

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. 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, not-
withstanding 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 2 3/4 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 tap 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 cardboard into the wood to keep it in place.

Immediately in front of the coil is the tuning condenser. Almost any type will do for our purpose, and the capacity should preferably be .0005 mfd. 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 gaienla type catwhisker crystal in preference to others, although the semi-permanent type will keep their adjustment over longer periods. As a rule, however, the catwhisker 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 catwhisker 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-
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 specifically 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 top plates.

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 aluminum 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, aluminum 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 box wood, 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 aluminum with an ordinary hand-drill if the size of the holes is not too large, but when it is necessary to drill holes of any considerable size, the best plan is to use 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 aluminum. The 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 simple method is to cut with a 1/8-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 cleaner cut. If you find bad interference, clip the bit to spend much money on the headphones, as a rule, 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 contact with clothing, etc., which it can...
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That of the 91 known "elements" 51 are used in the construction of Radiotron Valves.

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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 tubes 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, 523, 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 filament 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
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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 most 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 3.5 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.

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 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 neutralizing the self-capacity effect, by deliberately introducing feed-

![Illustrating the operation of the valve rectifier.](image)

![The triode valve shown schematically.](image)

![The screen-grid valve. The amplified voltage is imprinted across the grid, which may be a resistance, coil, etc. back into the grid circuit in the opposite direction to that occurring in the valve itself. 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 by-passed to earth through a large value condenser, so that 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 the amplification factor 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 control grid. Because the plate voltage is being swung up and down by the effect of the amplified signal, while the screen (being at a large fixed potential) is fixed, there are times when, on a strong signal, the plate, for a split second, may actually be below the screen.
valve. 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 so arranged 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 designed for this work, but mounted in the one envelope. These are almost universally triodes and operate as ordinary amplifiers, subject to one or two conditions which will cover in another article. Then there are valves such as the 6F7, which has a triode and an R.F. pentode section combined so that 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.

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 the filaments, and devised the A.C. valve. Because the filament is actually supplied by the external source as an emitter of 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 filament 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, and, of course, they could not run from a single battery.

Most A.C. valves are made to operate from 25, 4, or 63 volts. 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 the disadvantages.

The Pentagrid Converter Valve and Its Associated Circuit Connections.
DURING the past few years many new ideas have come on the market. Some have been associated with extravagant claims such as the suggestion that they would supplant B Batteries as the source of power for country radio sets.

But where are they today?

Time has seen all of them drop by the wayside, mainly because they lacked the economy and reliability that have always been characteristic of B Batteries and battery operated receivers.

But many unsuspecting people burnt their fingers on these new ideas at the time. Make sure that you don’t follow their example when you buy your new set.

Stick to a radio that has been perfected and proven over the years—in other words a B-Battery set.

An advertisement issued by the Ever-Ready Co. (Aust.) Ltd. in the interests of more economical, more efficient ‘out-back’ radio.
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 mfd.

**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 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-valve 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 3 meg. would also be suitable, our preference again being for 2 meg. 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 tapplings 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.

**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 .00025. 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 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.

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 23 inches. However, even
The connections under the chassis may be seen from this wiring diagram.

**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 permagentic 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. 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...
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The wiring diagram, which is drawn to scale. The chassis measures 8i 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 wave-length 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 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 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 is 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.

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

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 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 21 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 choose from 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 swampying effect, the only remedy is a better receiver.

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.

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The connections to be made are 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
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In the past we have proved the popularity of a straight four-valve superhet. The Pentagrid Four has proved the most popular battery set in the suburban area!

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 milliammeter in the B minus lead was reading only 10 mills, when receiving local stations! With no signal coming through the current was 15 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 71 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 39 mills. Naturally, one would not expect the set to be 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,
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 KP2-VP2 type. Used with coils designed for it, this valve gives plenty of gain, and is largely responsible for the set's fine range.

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 bad idea to test it with a torch globe every few months, and to discard it as a precaution, when connected as shown with a 135 volt supply, uses about 3 mils. 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 adopted 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 bias battery, 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 meg. 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 complete 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...
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 of the battery. We have tried to make the wiring diagram as clear as possible, and even the one 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 part. 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 43-volt terminal. These connections are clearly shown on the diagram. Note 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 IB5 lights up. If it does, we can assume that the other filaments are also alright—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 lamp 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

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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.

**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.

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**PRICE’S RADIO SERVICE**

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ONE of the most useful things any-one 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 be 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 m.a. 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, a 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 m.a.

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 mils., and thus register only half scale reading.

With a high-grade meter of 1600 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 100 (current in milliamps), and use this value as 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 2970 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 connecting 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 resistor 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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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 drop 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 set, 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 marvelous performer on short wave broadcasting, and is also admirably suited for amateur communications, for which purpose it has been used continuously.

★ 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.

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.
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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 6F6-42. These valves will need shielding, excepting the 2AS. 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 1 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 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.

TUNING CONDENSOR

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-
**COIL DATA FOR 8-VALVE SUPERHET.**

<table>
<thead>
<tr>
<th>Band</th>
<th>Aerial</th>
<th>Grid</th>
<th>Plate</th>
<th>Oscillator</th>
<th>Grid</th>
<th>Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>2</td>
<td>31</td>
<td>2</td>
<td>31</td>
<td>1-3</td>
<td>31</td>
</tr>
<tr>
<td>20-40</td>
<td>4</td>
<td>6</td>
<td>83</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>40-80</td>
<td>7</td>
<td>20</td>
<td>20</td>
<td>1</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>80-120</td>
<td>12</td>
<td>35</td>
<td>2</td>
<td>30</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

All coils are wound on 1/16 in. formers. Oscillator coils are close wound, 1/8 in. apart. Other grid coils spaced over 1 in. Detector plate coils interwound with the bottom of the grid coil. Aerial coil is 1/4 in. from grid coil. Gauge of wire is not critical—about 18 enameled, with 20 enameled for aerial and plate coils. Beat oscillator coil has 400 turns of 32 enameled tapped at 150 and mounted on intermediate base.

**COIL DATA FOR 4-VALVE SUPERHET.**

<table>
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<tr>
<th>Band</th>
<th>Aerial</th>
<th>Grid</th>
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<td>10-20</td>
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<td>40-80</td>
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<td>80-120</td>
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All coils are wound on 1/16 in. formers. Oscillator coils are close wound, 1/8 in. apart. Other grid coils spaced over 1 in. Aerial coil is 1 in. from grid coil. Gauge of wire is not critical—about 18 enameled, with 20 enameled for aerial and plate coils. Here are coil tables for the sets described in this article.

**A Three-Valve**

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 tuning and the power well apart. The tuning condenser is again about 0.0005 or 0.0015 microfarad, 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 300 ohm resistor can be used should a valve not being a variable-mu type be used. Such a valve would be 6CG7, 6BQ5, 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—an other 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, a little coupling unit is added, 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 mils 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 Four-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.
TIME-CHART FOR OVERSEAS STATIONS

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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.
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-converters, 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.

Reactions are 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 circuit 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, 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 IF 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 IF 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 these.
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 millis, 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 feed-back, 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 practice, 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 set, 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 practice and should be used where possible.

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B & W WIRELESS WEEKLY HANDBOOK

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GRAMOPHONE AMPLIFIERS

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-
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. Wherever 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 rating characteristic round the 3000 and 6000 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 peaks, 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 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 meg. either as a fixed resistor or as a potentiometer volume control, to take care of this. A higher value will give overmuch bass 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 load to 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 60000 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. There should be any prospect of a voltage appearing across the pick-up, it should be fed to the grid through a 5 meg. condenser, 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 8 x 3.
- Power transformer, 385 v. at 150 ma., 6 v. at 3a., 5 v. at 3 amps.
- 30 henry choke, 150 ma.
- 2 8 mfd. electrolytics.
- 1 5 meg. potentiometer.
- 2 5 meg. resistors.
- 1 1 mfd. 500 v. working condenser.
- 1 10000 ohms resistor.
- 1 200 ohms bias resistor.
- 25 mfd. bypass condensers.
- 2 1 mfd. coupling condensers.
- 1 1 mfd. 500 v. working condenser.
- Valve sockets—3 6-pin, 1 5-pin, 1 4-pin.
- Valves—2 42, 1 606, 1 523.
- Pick-up, Crystal.
- Speaker, high-fidelity 8000 ohms field.

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

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**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.

**A Universal Amplifier**

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 12-volt battery using a six-volt battery as the only source of power. It was found permissible to run filaments and grid-leak from the same six-volt battery without any interference.

The input voltage may be anything between 300 and 350 volts, the higher voltages giving higher outputs. 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 disturbed 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 by 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 pen of 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 800 ohms field.

Should the amplifier be used with a group of Canada or American dance-halls, for instance, *per* magnetic speakers should be used, up to about three in number, with a special input transformer or three secondaries, one for each speaker. Then any speaker can be cut out of the circuit without affecting the others. If the valve 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 general rule, carbon microphones have the highest output of the types generally used.

**The High-Fidelity Amplifier**

The high-fidelity amplifier still holds pride of place where the finest possible speciality is 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 a 5 meg. grid resistor 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 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...
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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 capable of handling without 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 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 that 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 therefore 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 at 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 (6186), which rectifies it, so that we have a single-phase A.C. voltage, which will obviously be greater as the output from the pick-up becomes greater. This is the voltage we use to "build up" 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 circuit provides a potentiometer by which the bias is set. A suitable value to allow the soft passages to come down to the limit of the valve's useful control.

A second potentiometer controls the amount of expansion offered by this 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 mls, and, once it is set, we can forget it.

The amplifier has a volume control and another "mixer" potentiometer to vary the voltage fed into the expander system, and therefore to vary the amount of expansion used.

Generally speaking, an optimum 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 inductor 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 megohms and .5 mfd. 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 many 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 when the bias of the 6L7 is at its lowest and with the volume of the record.

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

It is essential that the amplifier should have at least 5 watts output in order to cope with the full volume range available, and, of course, the best speaker is not too good for it. A amplifier of the highest quality 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 replaced by another 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 type first introduced in the metal series, but it is also available in metal-glass types, etc. The other valves may be replaced by metal-glass types. The 6C5 valves are replaceable with 56 or 76 valves, and even 27"s may be pressed into service. The 6H8 glass equivalents in glass tubes, etc. 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 diodes have already been mentioned in a previous paragraph.

Not are American types, 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 are 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 sheets of glass for about 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, but the doors themselves are 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 suitable baffles 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 about a little, to see how reproduction varies.

It is not good practice to screw the speaker directly to the baffle, particularly if it is a wooden one. Better still is a soft support for the speaker to stand on, and support the baffle in 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.

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 bent-arm mounting arrangement, and the angle also is maintained. It does not matter how the arm is shaped, as long as this distance 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 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—"Kit-sets," "Chassikits," "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

<table>
<thead>
<tr>
<th>SUGGESTED COMPONENT VALUES</th>
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<tr>
<td><strong>RESISTORS</strong></td>
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<tr>
<td>R1 . 100,000 ohms R10 . 500,000 ohms</td>
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<td>R6 . 50,000 ohms R15 . 500,000 ohms</td>
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<td>R7 . 100,000 ohms R16 . 400,000 ohms</td>
</tr>
<tr>
<td>R8 . 1,000 ohms R17 . 500,000 ohms</td>
</tr>
<tr>
<td>R9 . 1 megohm R18, R19 V Divider</td>
</tr>
</tbody>
</table>

| **CONDENSERS**              |
| C1 . 1 mfd. C11 . 1 mfd. 12 |
| C2 . 1 mfd. C12 . 0.0005 mfd. |
| C3 . 1 mfd. C13 . 0.1 mfd.    |
| C4 . 5 mfd. C14 . 25 mfd.     |
| C5 . 1 mfd. C15 . 0.01 mfd.   |
| C6 . 0.5 mfd. C16 . 0.5 mfd.  |
| C7 . 0.001 mfd. C17 . 0.1 mfd.|
| C8 . 1 mfd. C18 . 25 mfd.     |
| C9 . 1 mfd. C19 . 0.05 mfd.   |
| C10 . 1 mfd. C20 . 21 8 mfd.  |
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THE BATTERY WORLD STANDARD

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 valves 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 A22 rectifier. In the 6 volt types, the numbers would read AF3, EL2, 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.

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 painted, etc., to make them rust-proof, and, of course, to improve appearance.

On short waves, the receiver is generally fixed at a 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 60 ft. overall, and as high as possible.

**Battery Version**

The battery version of the World Standard receiver follows 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. To use 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, 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 use of intermediate stages are generally regarded as preferable in order to get the very best of results.

The second detector is a duo-diode type, 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 to keep the battery of the coil kit. Three high 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 difficulties. 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 13 volts for the controlled valves without upsetting the detector action.

It will be well to test 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 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 magnetic 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 milliamps, so that heavy batteries can be supplied with some confidence. It is possible to run the two batteries in series, so that the individual drains which can be supplied is greater than in the case of the A.C. version.

**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 this is very slight, 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 make the point very strongly 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.

**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, KGB1, and KLF4. 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 trimmer 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.

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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接收器 circuit terminations, 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 directly 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 by-pass 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 spaced 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 very 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 grommet in the chassis. All power cords, etc., which go through holes in the chassis should be protected by the use of rubber grommets.

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.

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**Megacycle Scale**

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<tr>
<td>-3</td>
<td>XGOX, China.</td>
</tr>
<tr>
<td>-4</td>
<td>PLV, Bandoeng.</td>
</tr>
<tr>
<td>-5</td>
<td>DJC, Berlin.</td>
</tr>
<tr>
<td>-6</td>
<td>W3XAL, New Jersey.</td>
</tr>
<tr>
<td>-7</td>
<td>W8XAL, Cincinnati.</td>
</tr>
<tr>
<td>-8</td>
<td>W9XF, Chicago.</td>
</tr>
<tr>
<td>-9</td>
<td>9MI, s.s. Kanimbla.</td>
</tr>
<tr>
<td>-10</td>
<td>XEXA, Mexico.</td>
</tr>
</tbody>
</table>

**Cycles**

- 15 M
- 25 M
- 31 M
- 49 M

**Usage**

- GOOD IN MORNING
- GOOD IN AFTERNOON
- GOOD AT NIGHT
- GOOD IN EVENING

**Notes**

- The chart indicates the frequency ranges for various short-wave stations.
- The stations are categorized by their operating times of day.
- The chart serves as a guide for amateur radio operators to tune into the stations effectively.

**Example**

- GOOD IN MORNING: W2XAF, Schenectady.
- GOOD IN AFTERNOON: DJN, Berlin.
- GOOD AT NIGHT: DJC, Berlin.
- GOOD IN EVENING: RW15, Russia — 70 METRES — GOOD IN EVENING.
HOW TO BECOME A RADIO AMATEUR

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 strange 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 as a succession of thumps and such intermittent noises.

Often he has wondered, this man in the street, just what is going on behind the scenes, 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 as a succession of thumps and such intermittent noises.

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.

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.

Any listener who is prevented from receiving his ordinary broadcast programmes through interference from an amateur will be showing a great sport, for being able to harvest a good crop of information 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?

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.

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 many of the professions and walks of life. Whether he is 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," and walk up to the door, punch the bell, and he is at once among friends. Just listen to two amateur 200 ailed 500 metres next time you tune in, and draw your own conclusions.

Time after time the value of this amateur network of stations to 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 organized 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 "worthless" 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 valuable 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 100, 80, 60, 40, 30, 50, and 5 metres, although the average broadcast, or, rather, dual-wave, set, will only receive two of these bands, the ones at 40 and 90 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.
W I R E L E S S  W E E K L Y  H A N D B O O K

BUILDING A STATION

Assuming that the examination has been passed, the successful candidate will shortly receive a licence on payment of a fee, and then is entitled to apply to the Radio Inspector in your State, asking him for full information on the necessary arrangements, 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 you can be assured that you will be given the best assistance in your preparation. The examination, you will be told, is held every three months, under the supervision of the Commonwealth Wireless Inspector. 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. All the 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. The first thing to do is to purchase a 2-letter combination, and have it signed 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 C for England, VE for Canada, VU for India, ZL for New Zealand, J for Japan, P 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 the start of World Conventions, which meet regularly to control the allotment of wavelengths for all services, and decide matters which affect the radio stations of the world at work without getting in each other's way.

The first thing to do is to build a receiver for amateur transmissions. This will probably be done while studying for the licence. 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 not be affected by transmissions below 10 metres, where more specialised apparatus is needed. However, the 20, 40, and 80 metre bands are most used by the beginners, and will provide him with plenty to think about for quite a while. We are speaking mainly of Morse code, of which the beginner will most probably start out.

Next he will build a small monitor, probably, in which to listen to his own signals, and to check his wavelength, 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 some time ago with the single-valve transmitter. Finally, there are the 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, which are 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 rising high into the sky. The commonest type has two wires, spaced with spacers about 3 inches apart, running down from one end. Then, 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, and if you join one, you will find a great deal of pleasure in the friendship of other radio enthusiasts. You can exchange ideas with others outside your own particular club and circle. Many of these will have met via the ether, and never contacted anyone, until found by his call-sign at one of these meetings.

Many are the jokes which are made about the amateur, of his sleepless nights chasing the tantalising DX stations, 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 known stations, all times Sydney time.

<table>
<thead>
<tr>
<th>Wave Length</th>
<th>Call Sign</th>
<th>Location, Schedule, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.94 HRF</td>
<td>Moscow</td>
<td>'Phones evenings</td>
</tr>
<tr>
<td>20.03 KAY</td>
<td>Manila, Philippine Islands</td>
<td>'Phones, afternoon, evening</td>
</tr>
<tr>
<td>20.08 HJB</td>
<td>Bogota, Colombia</td>
<td>'Phones, morning, evenin</td>
</tr>
<tr>
<td>20.08 HI</td>
<td>Trujillo, Dominican Republic</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.08 HJA3</td>
<td>Barranquilla, Colombia</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.19 OCJ2</td>
<td>Lima, Peru</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.25 GBL</td>
<td>Rubio</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.29 ROU</td>
<td>Omars, U.S.S.R</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.37 IQA</td>
<td>Rome</td>
<td>'Phones, Occasionally broadcasts around 10 p.m.</td>
</tr>
<tr>
<td>20.42 PBF</td>
<td>Rio de Janeiro</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.55 JYH</td>
<td>Nazaki, Japan</td>
<td>'Phones, occasional evening broadcasts</td>
</tr>
<tr>
<td>20.56 WMN</td>
<td>Lawrence, New Jersey</td>
<td>U.S.A</td>
</tr>
<tr>
<td>20.64 HFPJ</td>
<td>Geneva</td>
<td>'Phones and occasionally for world broadcasts</td>
</tr>
<tr>
<td>20.85 LSN</td>
<td>Buenos Aires</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 HRL5</td>
<td>Nacome, Honduras</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 TIU</td>
<td>Cartago, Costa Rica</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 YNA</td>
<td>Managua, Nicaragua</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 HFP</td>
<td>Panama</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 HRP</td>
<td>Tegucigalpa, Honduras</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.71 TGF</td>
<td>Guatemala</td>
<td>'Phones</td>
</tr>
<tr>
<td>20.75 WMP</td>
<td>Lawrenceville</td>
<td>New Jersey</td>
</tr>
<tr>
<td>20.76 GWV</td>
<td>'Phones</td>
<td></td>
</tr>
<tr>
<td>20.85 DZA</td>
<td>Berlin, Experimental</td>
<td>'Phones</td>
</tr>
<tr>
<td>21.26 WPQ</td>
<td>Poona, India</td>
<td>'Phones, and experimental</td>
</tr>
<tr>
<td>21.70 SUZ</td>
<td>Cairo, Egypt</td>
<td>'Phones</td>
</tr>
<tr>
<td>21.91 KKZ</td>
<td>Bolinas, California</td>
<td>Experimental, irregular</td>
</tr>
<tr>
<td>21.98 HJY</td>
<td>Bogota, Colombia</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.09 GBE</td>
<td>Rugby</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.35 GCJ</td>
<td>Rugby</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.40 IDU</td>
<td>Asmara, Eritrea</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.40 WNA</td>
<td>Lawrenceville, U.S.A</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.48 XVQ</td>
<td>Maracay, Venezuela</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.58 CGA3</td>
<td>Drummondville, Canada</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.70 IRJ</td>
<td>Rome</td>
<td>'Phones</td>
</tr>
<tr>
<td>22.76 DGO</td>
<td>Buenos Aires</td>
<td>'Phones, Experimental</td>
</tr>
<tr>
<td>22.85 VPD</td>
<td>Suva, Fiji</td>
<td>'Phones, Experimental 3.30-4.30 p.m.</td>
</tr>
<tr>
<td>23.35 WOO</td>
<td>Ocean Gate, New Jersey</td>
<td>'Phones</td>
</tr>
<tr>
<td>21.23 CRN</td>
<td>Addis Ababa</td>
<td>'Phones</td>
</tr>
<tr>
<td>23.45 IAC</td>
<td>Pisa, Italy</td>
<td>'Phones</td>
</tr>
<tr>
<td>23.47 GBC</td>
<td>Rugby</td>
<td>'Phones</td>
</tr>
<tr>
<td>24.20 DAF</td>
<td>Norden, Germany</td>
<td>'Phones</td>
</tr>
<tr>
<td>24.80 ACM</td>
<td>Bandeung, Java</td>
<td>'Phones and occasional broadcasts</td>
</tr>
<tr>
<td>24.81 GBU</td>
<td>Rugby</td>
<td>'Phones</td>
</tr>
<tr>
<td>24.86 TXA</td>
<td>Forteiso, Paris</td>
<td>'Phones and occasional basts</td>
</tr>
<tr>
<td>24.89 OBS</td>
<td>Rugby, 'Phones</td>
<td></td>
</tr>
<tr>
<td>24.89 PDFY</td>
<td>Kootwijk, Holland</td>
<td>'Phones</td>
</tr>
<tr>
<td>25.00 RNE</td>
<td>Moscow</td>
<td>7-9 a.m. Sun, and Wed., 9-10 a.m. Monday 1:30 a.m.</td>
</tr>
<tr>
<td>25.02 PSZ</td>
<td>Saigon, Indo-China</td>
<td>'Phones</td>
</tr>
<tr>
<td>25.11 KKQ</td>
<td>Bolinas, California</td>
<td>'Phones, Experimental, Heard Monday afternoon to 3 p.m.</td>
</tr>
<tr>
<td>25.12 PTA</td>
<td>St. Augustine, France</td>
<td>'Phones, late evenings</td>
</tr>
<tr>
<td>25.23 TPA2</td>
<td>Radio Colonial, Paris</td>
<td>5-8 p.m. and 3-8 a.m.</td>
</tr>
<tr>
<td>25.27 W8XK</td>
<td>Pittsburgh</td>
<td>U.S.A</td>
</tr>
<tr>
<td>25.28 W8XXA</td>
<td>Chicago</td>
<td>9:30 p.m. to midnight</td>
</tr>
<tr>
<td>25.31 DJP</td>
<td>Berlin</td>
<td>Experimental, Heard late afternoon occasionally</td>
</tr>
<tr>
<td>25.38 W2XE</td>
<td>Wayne, New Jersey</td>
<td>7 a.m. to about noon</td>
</tr>
<tr>
<td>25.38 GSN</td>
<td>Daventry</td>
<td>Used at times afternoon in Empire broadcast</td>
</tr>
<tr>
<td>25.40 2RO</td>
<td>Rome</td>
<td>11.15 to 11.45 p.m</td>
</tr>
<tr>
<td>25.49 HJ4ABA</td>
<td>Medellin, Colombia</td>
<td>Daily 2.4 a.m. and 9.30 a.m. to 1:30 p.m.</td>
</tr>
<tr>
<td>25.42 C09WR</td>
<td>Cubs</td>
<td>7-8.30 a.m. and noon to 1:30 p.m.</td>
</tr>
<tr>
<td>25.42 WIXAL</td>
<td>Boston, U.S.A</td>
<td>Daily from 9 a.m. and Mon., 7-10 a.m.</td>
</tr>
<tr>
<td>25.42 DJJ</td>
<td>Berlin</td>
<td>Daily 2.35-7.20 a.m. and 7.50 a.m. to 1:40 p.m.</td>
</tr>
</tbody>
</table>
How To Listen

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 going 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 daytime 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, many interesting and valuable transmissions can be heard. It is often a good idea to make a note of 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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Staiger Gramophone
Pickup
Collaro Gramophone
Motors
Ultimate Sound Systems
Quotes and leaflets sent on request.
## Australian and New Zealand Broadcasters

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

<table>
<thead>
<tr>
<th>Call Sign</th>
<th>Dial No</th>
<th>Kilocycles</th>
<th>Address</th>
<th>Call Sign</th>
<th>Dial No</th>
<th>Kilocycles</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>2VYA</td>
<td>570</td>
<td></td>
<td>National Station, New Zealand Broadcasting Board, Wellington.</td>
<td>6ML</td>
<td>1130</td>
<td></td>
<td>W.A. Broadcasters Ltd., Lot 1, House, Market St., Perth.</td>
</tr>
<tr>
<td>3AR</td>
<td>580</td>
<td></td>
<td>National Station, New Zealand Broadcasting Board, Wellington.</td>
<td>2HD</td>
<td>1140</td>
<td></td>
<td>Airways Broadcasting Co., P.O. Box 123, Newcastle, N.S.W.</td>
</tr>
<tr>
<td>7ZL</td>
<td>590</td>
<td></td>
<td>National Station, Elizabeth Street, Hobart.</td>
<td>2WG</td>
<td>1150</td>
<td></td>
<td>47 Pittamaurie St., Wangan, N.S.W.</td>
</tr>
<tr>
<td>2FC</td>
<td>610</td>
<td></td>
<td>National Station, 29-39 Market Street, Sydney.</td>
<td>2KA</td>
<td>1160</td>
<td></td>
<td>Matie National Station, 80 Market Street, Sydney.</td>
</tr>
<tr>
<td>5CK</td>
<td>640</td>
<td></td>
<td>Regional Station, relaying 3CL, Crystal Brook, S.A.</td>
<td>4MK</td>
<td>1160</td>
<td></td>
<td>Mackay Broadcasting Service, Crystal Brook, S.A.</td>
</tr>
<tr>
<td>1YA</td>
<td>650</td>
<td></td>
<td>Regional Station, relaying 3LO and 5AR, Corowa, N.S.W.</td>
<td>6BY</td>
<td>1160</td>
<td></td>
<td>Bimbury Broadcasters Ltd., Bedford Hall, Bullock, N.S.W.</td>
</tr>
<tr>
<td>2CO</td>
<td>670</td>
<td></td>
<td>National Station.</td>
<td>4TO</td>
<td>1170</td>
<td></td>
<td>Amalgamated Wills (Asia) Ltd., 1925 Bridge St., Sydney.</td>
</tr>
<tr>
<td>6WF</td>
<td>690</td>
<td></td>
<td>Regional Station, relaying 3FC, Lawrence, near Griffith, N.S.W.</td>
<td>3KZ</td>
<td>1180</td>
<td></td>
<td>Industrial Printing and Publishing Co., 23 Victoria Street, Sydney.</td>
</tr>
<tr>
<td>2NR</td>
<td>700</td>
<td></td>
<td>Regional Station, relaying 3AR and 3AF, Arthur, N.S.W.</td>
<td>2CH</td>
<td>1190</td>
<td></td>
<td>A. C. B. Broadcasting Co., Ltd., 77 York Street, Sydney.</td>
</tr>
<tr>
<td>7NT</td>
<td>710</td>
<td></td>
<td>National Station, 120A Russell Street, Melbourne.</td>
<td>5KA</td>
<td>1200</td>
<td></td>
<td>Special Radio Broadcasting Pty., Ltd., Richard Bickers, Currie St, Adelaide.</td>
</tr>
<tr>
<td>3YA</td>
<td>720</td>
<td></td>
<td>National Station, 120A Russell Street, Melbourne.</td>
<td>3YL</td>
<td>1200</td>
<td></td>
<td>New Zealand Broadcasting Board, Circular Quay, Christchurch.</td>
</tr>
<tr>
<td>5CL</td>
<td>730</td>
<td></td>
<td>National Station, Hindley Square, Adelaide.</td>
<td>2GF</td>
<td>1210</td>
<td></td>
<td>Grafion Broadcasting Co., 47 York Street, Sydney.</td>
</tr>
<tr>
<td>2BL</td>
<td>740</td>
<td></td>
<td>National Station, 120A Russell Street, Melbourne.</td>
<td>6KA</td>
<td>1210</td>
<td></td>
<td>Goldfields Broadcasters Ltd., 60 Palmer's, Rainforest, Mt. Ota, Commercial Station, Oaky, Q.</td>
</tr>
<tr>
<td>3LO</td>
<td>770</td>
<td></td>
<td>National Station, Hindley Square, Adelaide.</td>
<td>4AK</td>
<td>1220</td>
<td></td>
<td>National Station, relaying 3LO and 5AR, Corowa, N.S.W.</td>
</tr>
<tr>
<td>4YA</td>
<td>790</td>
<td></td>
<td>National Station, Hindley Square, Adelaide.</td>
<td>2RC</td>
<td>1230</td>
<td></td>
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