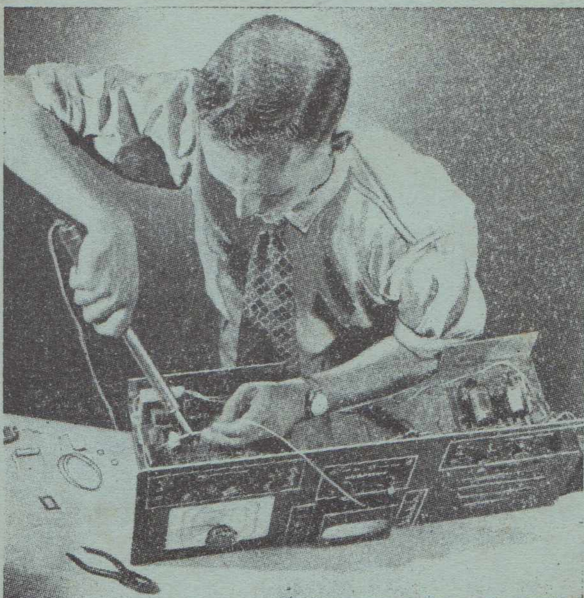
AUSTRALIAN RADIO & TELEVISION COLLEGE PTY. LTD.

PRACTICAL RADIO COURSE



of

HOME PRACTICAL INSTRUCTION

Lesson No. 1

THIS Radio Course of practical home instruction is the result of many years' experience, and months of final experimental work by some of Australia's most competent Radio engineers. It is designed so that you acquire a thorough and most comprehensive practical Radio training by building up the kits which are supplied with these lessons. When the course is finished, and all the kits have been built up into the final unit, you will possess a complete professional outfit of Radio testing apparatus, which in itself is not only worth far more than the money you pay for it, but which will also enable you to earn many times its actual value from the Radio work you can perform with it.

This lesson will show you how to:–

HOME PRACTICAL INSTRUCTION

LESSON No. 1.

Radio is indeed a most fascinating and interesting subject to study. Whether it be studied with the object of obtaining a lucrative career in the radio industry, for the betterment of one's position, or merely to provide an entertaining hobby, it has an appeal to thousands. Perhaps this is due to the glamour associated with any thriving, young industry, developing at a rate faster than any other industry. Perhaps it is due to some of the achievements of radio in the past or the unlimited potentialities of radio in the future, but whatever the cause, it is hard to conceive any more fascinating or interesting subject to study.

Some students have the ability of absorbing knowledge readily from textbooks or printed lesson papers. Their minds are able to clearly grasp the subject they are studying from the printed text and illustrations, and many become just as proficient ultimately as others who are more favourably placed in obtaining extensive practical experience. There are some, however, who find it much easier to visualise the intricate actions which occur in radio apparatus and are able to more readily understand a written description of a particular radio component or circuit if they are able to handle actual radio parts, assemble them into practical working circuits and make the necessary tests and experiments to bear out in practice what is set down in a text.

Many people, especially those in remote locations, are handicapped in not having ready access to radio parts and test instruments with which to experiment. It is with the needs of these enthusiasts in mind that a practical instruction kit has been evolved especially to cater for them, to provide a means for carrying out hundreds of interesting experiments and which will ultimately make possible the construction of an extremely efficient and useful set of radio servicing apparatus.

The kit of equipment described is fundamentally intended to be used in conjunction with the Australian Radio College course of Radio Service Engineering. This course deals thoroughly with the principles of radio and electricity, performance of the various stages in radio receivers and efficient systematic service technique. For this reason, some reference is contained in these practical instruction papers, which accompany the kits of parts, to the lesson papers contained in the Radio Service Engineering Course. These references are intended only to amplify the descriptions contained in the practical instruction papers accompanying the practical material kit. These instruction booklets are clearly set out, explained in simple language and profusely illustrated to enable the student to carry out a large number of experiments with every kit he receives. This course may therefore be considered to be complete in itself, the cross-references to the lessons of the A.R.C. course merely serving to provide additional and amplified descriptions of the actions being explained.

As a particular instruction kit will be of particular interest to those in outlying areas where electric power supplies are rarely available, it has been decided to base it principally upon battery operated equipment; and the necessary batteries for operating amplifiers, receivers, test instruments and so on, constructed throughout the course of training are included with the kit. This makes the course completely universal so that it can be used with equal efficiency in any area regardless of whether or not electric power is available.

Every student taking up a course of radio training desires ultimately to become proficient in adjusting new receivers and locating faults in defective receivers and for this class of work needs some testing instruments. The most essential testing instruments are a multimeter for checking voltages, currects and resistances in radio apparatus: a test oscillator for providing radio frequency signals for testing receivers and a signal tracer for rapidly and efficiently locating defects in faulty receivers. This practical course of training has been very carefully planned to provide a variety of radio parts which may be assembled in many combinations to provide instructive practical training throughout the course and yet, towards the completion of the course of training, the parts can be grouped in such a fashion that they form an efficient multimeter, a modulated radio frequency test oscillator and a 3-valve signal tracer. Thus, the student on the completion of his course becomes the proud possessor of one of the most modern test outfits possible; which will enable him to make practical use of the knowledge he has gained throughout his training period.

You will receive nine big parcels of radio parts at regular intervals throughout the course of training. Each of these parcels enables a large number of individual experiments to be carried out. Each parcel is accompanied by a carefully prepared instruction booklet which explains in full detail the experiments to be conducted with the kit supplied, tests to be made and examples of the principles examined in actual radio apparatus. Each component part supplied in the parcel is clearly labelled so that no difficulty will be experienced in recognising it or applying it in the correct manner.

Parcels themselves do not all contain goods of equal monetary value. This is necessary because some of the parcels, to make them complete and versatile, contain quite a lot of expensive components. To enable the student to build up credit for these expensive parcels the preceding one may not contain goods of quite as much value. For example, the first parcel contains a soldering outfit, a quantity of wire, solder, resistance panel, insulation tape, and a soldering iron to enable the student to become proficient at soldering. The monetary value of this first parcel is somewhat below the average value and this enables the second parcel to contain some more costly items such as a high quality permanent magnet moving coil meter, fitted in an attractive plastic case and provided with a universal scale. This will eventually become a complete multimeter.

As most people have a few simple tools available no tools have been included in the kits with the exception of a small soldering iron which can be heated over a fire or stove of any kind. The other necessary tools are something with which to cut wire, e.g., an old pair of scissors or a knife, a pair of pliers, a file or sheet of emery cloth for keeping the soldering iron clean and a small and large screwdriver. The metal chasis frames provided for the assembly of experimental units are furnished complete with all necessary mounting holes already cut in so that other tools are not essential although they may prove handy if available.

LISTS OF KITS CONSTRUCTED.

To give some indication of the flexibility and wide variety of experiments which may be carried out the following list, of units constructed during the course of training, is provided. This list merely indicates some of the work and a few of the units which are constructed and it should be borne in mind that on each of these units there are many experiments which may be conducted so that the extent of practical training is very great.

Soldering instruction.
Wire splices and joining.
Insulation.
Aerial construction.
Fault location with voltmeter.
Continuity tester, - for testing radio and electrical parts and circuits.
Coil winding.
Ohmmeter.
Multimeter.
Output meter.
Valve testing.
Valve Curves.
Valve amplifiers.
1 valve receiver.
2 valve receiver.
Radio frequency oscillator.
Audio frequency oscillator.
Morse code practice oscillator.
Modulated radio frequency oscillator.

3 Valve T.R.F. receiver.
Vacuum tube voltmeters, for D.C.
Vacuum tube voltmeters, for A.C.
Class A,B and C amplifiers.
Inverse feedback.
Push-pull amplifier.
Condenser tester.
Superheterodyne receiver.
Signal tracer.

The experience gained from the construction of units such as those listed above will not only promote a clearer understanding in the student's mind of the basic principles and theory of operation of the equipment but it will also breed a feeling of confidence so that on completing the course the student will not only be the possessor of a sound technical training, but will also be thoroughly equipped and confident to carry out radio receiver construction or repairing work.

KIT 1. SOLDERING OUTFIT.

A radio receiver constructed without the use of soldered connections would be entirely impracticable. Even though it may perhaps be coaxed into working at first, before very long crackles and noises would interfere with reception and the receiver would soon become inoperative. It is essential for all the connections in a radio receiver to be soldered and consequently one of the first essentials is for you to learn the art of soldering efficiently and quickly.

The reason for the widespread use of solder in radio receiver construction is the fact that the amount of electricity which will flow in any circuit is dependent upon the resistance of the paths through which it has to flow. Most metals have a fairly low resistance and if their surfaces are perfectly clean merely clamping them together will initially cause a low resistance path so that normal values of current can pass through the connection. However, all metals in contact with the air, will eventually have a film of oxide formed on their surface. This oxide, in the case of iron, is called rust. Other metals also have a film which is not always as apparent as in the case of rust, on iron, but nevertheless exists to some degree. The oxide films on metals are normally fairly good insulators of electricity and consequently would increase considerably the resistance to the path of electricity and reduce the current to a lower than the correct value. Eventually, the thickness of the oxide film may become so great, as the result of moisture in the atmosphere that in a radio circuit it may completely prevent current from flowing. This may happen even though the oxide film may only be a fraction of a thousandth of an inch in thickness and hardly noticeable to the eye.

The use of soldered connections is not so important in high voltage circuits such as those used used for electric power and lighting because the high voltages used are strong enough to cause any oxide film to break through and for the current then to be able to flow directly from one metal surface to the other. With receivers, however, some of the signal voltages are only a few thoudandths or even millionths of a volt in strength and these low voltages are not enough to drive electric current through an oxide film of any appreciable thickness. The film will form even on pieces of metal which are fairly tightly clamped together due to air getting in between the surfaces and corroding them. One certain way of assuring a permanent connection of low resistance between two pieces of metal is to exclude any possibility of air reaching the surfaces across which the current has to flow and at the same time bridging the gap between the two pieces of metal, with a third metal, solder, which is itself a good electrical conductor.

Solder is not a very strong metal and consequently should not be relied upon where a great deal of mechanical strength is required. It is always preferable to make a strong mechanical joint before the solder is applied. This can often be achieved by carefully twisting together two wires to be joined or, where a wire is to be connected to a solder lug the wire can sometimes be passed through a hole in the solder lug as shown in Figure 2.

If no hole is prvoided in the solder lug, it may be possible to wind the wire once or twice around the solder lug before

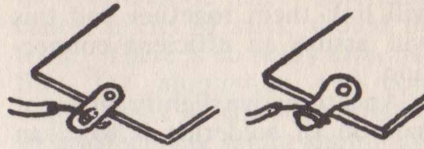


Fig. 2.

solder is applied. After this has been carried out, the application of solder will fill any spaces between the two wires or the wire and lug and will assure a permanent and lasting connection of low resistance between them.

Solder will only "wet" a surface of metal which is perfectly clean and free from any oxide coating. Therefore, the first principle of soldering is that both surfaces to be joined must be thoroughly clean, any oxide film being removed from them.

It is not sufficient only to remove any oxide coating from metal surfaces to be soldered together. It is essential that a substance called "flux" should be applied to the metal surfaces to that when heat is applied the flux will melt and flow over the hot surfaces to prevent air from coming in contact with them and forming a new oxide film. Preferably the flux is applied simultaneously with the solder. The particular type of solder supplied with this kit enables this to be done quite easily because the flux is actually contained within the solder as a central core. When the two surfaces to be joined have reached a temperature higher that the melting temperature of solder, the solder will flow onto them and coat them both. A film of solder will link them together and this will assure an efficient connection.

An alternative slightly different method of soldering is to clean the surface of each piece of metal separately and then apply solder, flux and heat to each. As each heats solder will eventually flow over them and form a coating of solder. This is known as "tinning" a surface. The two pieces to be joined are then brought together and heat again applied until the two lots of solder melt and merge into one. On removal of the heat the solder will solidify and hold the two surfaces together.

SOLDER

Solder is a metal consisting of a mixture of tin and lead. The most suitable type of solder for radio work is composed of 50% tin and 50% lead. This solder, when heated, starts to become soft at a temperature of 358 degrees F. and becomes really fluid at 415 degrees F. At any temperatures higher than this, it flows quite readily. Due to the high cost and shortage of tin there is a tendency nowadays to use solder composed of 40% tin and 60% lead. This solder also becomes soft at a temperature of 358 degrees F. but does not really melt and become fluid until it is heated to 460 degrees. On cooling, it remains quite liquid until its temperature drops to 460 degrees and it then becomes plastic or soft until it cools to 358 degrees and then it finally sets hard at temperatures below this. Although not quite as good as 50–50 solder it is nevertheless quite satisfactory for radio work.

FLUX

Previously it was mentioned that it is essential for both materials to be joined to be thoroughly cleaned before any attempt is made to solder them. This is necessary to remove any oxide film. After the surfaces have been cleaned, the application of heat from a soldering iron would immediately tend to form a new oxide film before the surfaces became hot enough for solder to flow on them. To prevent this new oxide film from forming, a flux is employed. There are a number of different fluxes which may be used in soldering although for radio purposes resin is desirable. The purpose of a flux is to melt as soon as heat is applied, and form a film over the surface of the metal. Thus air is excluded and an oxide film cannot reform. As the temperature of the surfaces increases, the flux boils and commences to evaporate. When solder is applied it penetrates through the film of flux and flows over the surface of the metal. Meanwhile the continued application of heat evaporates most of the flux so that by the time the process of soldering is complete there should be little, if any, flux remaining.

Resin, while being fairly effective in preventing the formation of an oxide film during the soldering process, is not very active in removing any corrosion or film which has not been thoroughly removed by prior scraping, filing or cleaning of the metal. For this reason, resin is only suitable as a flux on work that has been previously cleaned efficiently. Some of the soldering pastes available are more effective in their cleaning action than resin and have the property of removing to some degree small amounts of corrosion or film on surfaces so that is many instances, especially in the case of tinned copper wire, no previous scraping or cleaning is necessary unless the wire is badly corroded. However, most of these patent fluxes are slightly corrosive and therefore should not be used in radio or electronic equipment of any kind. Although these patent soldering fluxes when used very carefully by thoroughly experienced technicians are reasonably safe, the risk of using too great a quantity is very real so far as the beginner is concerned and so he should avoid them completely.

For soldering large sheets of metal it is sometimes preferable to use a liquid known as "zinc chloride". This is manufactured by dissolving the metal zinc in hydrochloric acid until no more zinc will dissolve. The remaining fluid is then suitable as a soldering flux for use on most metals with the exception of aluminium, zinc and galvanised iron. For galvanised iron or zinc a dilute solution of hydrochloric acid, sometimes called spirits of salts, should be used. There is no really effective flux for aluminium and consequently it is almost impossible to satisfactorily solder aluminium. Zinc chloride and hydrochloric acid are of course corrosive, and should never be used in the wiring of a radio receiver. They are only suitable for joining together large sheets of material. If they are used in the construction of a radio set, after a period of time the thin wires will be corroded completely through.

Because of the suitability of resin as a flux for radio work, most solder used for radio is supplied in the form of a thick wire or rather, a tube with a centre core of resin. Where two clean bright surfaces are to be joined, some of this solder can be applied either by transferring a drop with the iron to the surfaces to be soldered or by applying the end of the wire solder to the joint and melting some of the solder and resin contained in it onto the material with the hot iron. In this case, the resin and solder will flow together over the surface of the metal.

SOLDERING IRON

The name soldering iron is not really a correct one for in practice the end of the soldering tool is always made of copper. For this reason a more correct name is "soldering bit". However, most people refer to the tool as a soldering iron.

A simple soldering iron, such as the one supplied with the kit of parts, may be heated by placing the copper portion over any flame. It is preferable to use a blue coloured flame such as that from a gas stove, blow lamp, or correctly adjusted kerosine burner rather than the yellow flame similar to that produced by an ordinary fire. A yellow flame will deposit a film of soot on the iron and this makes soldering difficult. Where electric power mains are available a far more convenient form of soldering iron is an electric one which will operate from the power. These are extremely handy and remain hot while ever the power is switched on.

In the case of an ordinary soldering iron, care should be exercised not to heat it excessively. If it is made red hot the surface will become badly oxidised and it will be difficult to solder with. Before any soldering iron is used it must first be "tinned". This consists of heating the iron to a fairly high temperature, filing the pointed surface of it until it is thoroughly clean and then applying solder so that the solder spreads readily over the end of the iron leaving a silvery coating.

INSTRUCTIONS FOR SOLDERING PRACTICE.

Having read the foregoing basic principles of soldering you are now in a position to carry out some experiments yourself by soldering various forms of wires together and onto solder lugs.

Supplied in the first kit of equipment you should find the following goods:

1 Soldering iron.
1 Coil of resin cored solder.
1 Coil of aerial wire.
1 Coil of insulated hook-up wire.
1 Coil of bare tinned copper wire.
1 Coil of heavily insulated lead-in wire.
1 Piece of sandpaper.
1 Length of resistor panel.
1 Reel of insulation tape.
2 Plastic insulators.

As mentioned previously, the first step is to heat the soldering iron. This is done by heating it in a flame until it is hot enough for solder to run freely when applied to it. You will notice, however, that the solder instead of spreading smoothly over its surface merely drips off. This is because of the oxide film which is present. You then quickly take a file, and file the pointed surface of the copper until it is quite shiny and then, before it has cooled, immediately apply some resin cored solder to the pointed end. Instead of the solder dripping off it will now spread in a film over the surface you have cleaned.

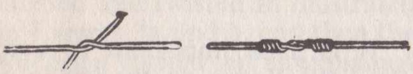
If you experience difficulty in getting a smooth film or surface on the pointed end of the copper the first time you try, then repeat the process again.

If you do not possess a file you will be able to clean the end of the iron by polishing it thoroughly first with sandpaper, before it is heated. You should then heat it in a flame and quickly polish it again with sandpaper before applying the flux and solder.

If you should ever overheat the iron, by making it red hot, you will burn off the film of solder and it will be necessary to repeat this process of tinning.

EXERCISE 1
BARE TINNED COPPER WIRE

Take two short pieces of the bare tinned copper wire and join them together mechanically by forming a splice as illustrated in Figures 3a and b. The splice is made by crossing the ends of the wires so that about an inch of each is protruding as shown in Figure 3a. The end of one is then twisted several times around the



a. b.

Fig. 3.

second and then the end of the second is twisted several times around the first as illustrated in Figure 3b. Pulling the two wires will simply lock the joint tightly and it will be found quite strong mechanically. Before crossing and twisting the wires, the ends of each should be cleaned with the sandpaper for about two inches so that the wires are perfectly clean and shining.

The best method of applying heat to a joint of this nature is to hold the hot soldering iron underneath the twisted portion of the wires and at the same time hold a length of resin core solder in contact with the joint until the solder and flux melts and flows freely down through the wire. The flux will sizzle and smoke and, after a few moments, the wires will become so hot that the solder resting on them will become molten and run down through all the crevices of the twisted wires, filling them with solder.

After the solder has flowed down through the wire the soldering iron may be removed. It is not necessary to continue pasting a lot of solder on top of the wire so that all of the turns are completely hidden under a thick pasting of solder. The joint will be quite secure so long as the crevices are each filled with solder.

It will probably be necessary to start at one end of the twisted section of the wire and then, after the solder has run through this portion, to move the iron along a little further towards the other end, at the same time moving the solder along so that it spreads and eventually covers the whole length of the joint.

Repeat this exercise over several times until you feel quite confident that you can make a successful soldered connection.

EXERCISE 2
JOINING INSULATED STRANDED WIRE

Cut two short lengths of the insulated hook-up wire supplied. Before soldering, it is of course necessary to remove the insulation from the portions of the wire to be joined. One method of removing the insulation is to cut lightly around the outside of the wire with a razor blade or knife. Care must be exercised not to press so heavily as to cut the thin strands of wire inside. After making a circular cut right around the insulation the section to be removed may be pulled off with one's fingers. This method is not to be recommended because of the liklihood of cutting through the insulation and cutting off some of the strands of wire inside.

A far more effective method which can be used in the event of a pair of pliers with wire cutting jaws being available, or alternatively in the case of a pair of scissors being used is to grip the scissors, place the wire between the jaws and then squeeze just tightly enough to make an indentation in each side of the insulation with the jaws. Do not squeeze too hard or you will cut the insulation and wire right through. After making the indentation you should pull the scissors along the wire firmly and you will find that they strip off the insulation between the point where they are touching the wire and the end.

In the case of a pair of pliers fitted with wire cutting jaws, they should be held as illustrated in Figure 4.

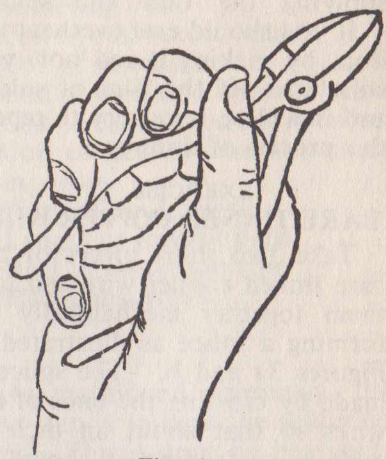


Fig. 4.

It is most important to keep the little finger on the inside of one of the handles and not to place all of the fingers around the handle in the natural manner. By keeping the little finger inside the handle it is possible to hold the jaws slightly apart and prevent them cutting right through the wire when they are squeezed gently onto the insulation. When the pliers have been closed sufficiently for each jaw to bite gently into the insulation the pliers may be pulled firmly along the wire and they will strip off the insulation.

The natural tendency at first, is to close the pliers too firmly so that the jaws bite not only through the insulation but through the wires too and cut several or all of the strands. Several attempts may be necessary before you are successful in stripping off the insulation without damaging the wire but it is most important to practise this art so that you can strip wire cleanly and quickly.

Having bared about two inches of each of the wires to be joined, you will probably find the strands of wire inside are perfectly clean and bright because the surrounding insulation minimised the tendency to oxidise. In this case you can probably twist them without any further cleaning and proceed to carry out the soldering operation. The wire should be crossed and twisted as illustrated in Figures 3a and b. and then the soldering carried out as explained in the foregoing exercise. One point about which we must be particularly careful is not to apply the hot soldering iron for too long a period. The iron must be used cautiously so that it is applied long enough to allow the solder to run down through the wires but yet not long enough to melt off the insulation for a considerable distance back from the joint. The type of insulation used on hook-up wire will generally melt or soften under the influence of the heat of the soldering iron and will tend to peel back from the joint. If you are not fairly quick in carrying out the soldering operation you will find the insulation damaged for an inch or so back from the joint.

If you have used the right amount of soldering flux in the first place, no surplus will remain, but if you have used an excessive amount quite a lot will remain and this will have to be removed by means of a cloth dampened with methylated spirits or alcohol before any insulation is placed over the joint.

After joining insulated wire it is generally necessary to replace some form of insulation to prevent a short circuit where the wire has been bared for purposes of making the joint. Enclosed with your kit you will find a reel of insulation tape which you should use to wind carefully around the joint to restore the insulating quality of the wire.

When using insulation tape it should not be peeled back off the reel until you are ready to use it. You then peel it off the reel and commence winding a length of it around and around the wire starting about half or three-quarters of an inch along the insulated part of the wire and working towards the joint, across the joint and for about another three-quarters of an inch on the other side. Each time you wind the tape around the wire you should move the tape along a distance about equal to half of the width of the tape so that the insulated joint is covered everywhere with at least two thicknesses of insulation tape. The final joint will appear somewhat as illustrated in Figure 5.

Fig. 5.

Practise stripping the insulation off the wire until you can do this without damaging the wire and practise soldering the spliced joint till you can carry out the soldering without damaging the insulation on each side of the joint.

EXERCISE 3
ATTACHING LEAD-IN TO AERIAL WIRE *

The aerial and lead-in wires are provided so that later on you may erect an efficient aerial and earth system for use in conjunction with some of the receivers you will be building. It is not advisable for you to complete the erection of the aerial and earth system in this case unless you have some receiver with which you can use it, but you can practise the correct method of attaching a lead-in wire to an aerial so that you will be proficient when the time comes to erect your aerial and earth system.

The wire normally used for an outdoor aerial consists of three strands of fairly thick gauge copper wire. This wire is normally bare but the lead-in wire has to be insulated. Consequently, because of the necessity for using two different types of wire a soldered connection is necessary where they join.

One method of attaching a lead-in wire to the aerial wire is to carefully scrape the aerial wire so that it is quite clean for a length of about two inches at a point a distance of about 6 inches or so in from one end. You should then remove the outside braiding and rubber insulation from the thick lead-in wire provided. It will be found difficult to remove two or three inches of this insulation in one attempt so it is generally necessary to remove about an inch of insulation at a time and make two or three attempts to bare the necessary length of lead-in wire. Even after this process it will probably be found that particles of the rubber insulation are adhering to wire and these must be very thoroughly removed by scraping the wire with a knife or alternatively, cleaning it properly with the sandpaper provided. When the wire is perfectly clean it may be wrapped around the aerial wire itself as shown in Figure 6a and b. After it has been twisted around the aerial wire five or more times you may apply flux to the joint

* See A.R.C. Service Engineering Course. Lesson 4.

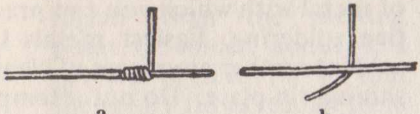


Fig. 6.

and carry out the soldering operation as explained in Exercise 1.

Because of the difficulty of procuring 3/.036 bare copper wire which is the type normally used for outdoor aerials, a special single copper wire covered with special insulation to withstand outdoor climatic conditions has been supplied in the kit. The wire should not be mixed with the ordinary hook-up wire because it is especially suitable for aerial construction, and you will need it for this purpose later on. However, you may practise with a few short lengths cut from one end of it at this stage, to become proficient in making a joint.

Because the thin strand of copper wire used in this form of aerial wire is not very strong it is not advisable to remove the insulation at a point somewhere along the length of the aerial and attach the lead-in. With this type of wire, it is desirable to thread the aerial wire through or around the insulator and then to knot the end of the aerial wire around the aerial itself as shown in Figure 7. The end of the knot may then be bared of insulation, a length of lead-in wire formed into a right angle to lie parallel with the aerial wire and the end. The aerial wire is then wound around the bared end of the lead-in wire and solder applied. After the soldering is completed a heavy binding of insulation tape should be used to bind the lead-in wire, aerial itself and the end of the aerial wire, all into one solid mass. The tape should be extended over the soldered joint so as to minimise corrosion at the point where the insulation is removed from the thin aerial wire. This is illustrated in Figure 7.

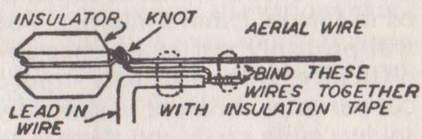


Fig. 7.

EXERCISE 4
RESISTOR PANEL WIRING

Before attempting to solder any wires to solder lugs attached to a length of resistor panel, it is desirable to tin the solder lugs. This is accomplished by applying a very small dab of flux to each lug and then picking up a drop of solder on the end of the soldering iron and carrying it across to deposit it upon the lug. The iron of course should be left in contact with the solder lug long enough for the lug to be heated and for the solder to flow freely from the hot iron and spread over the lug. It any difficulty is experienced in making the solder flow over the lug it will be necessary to sandpaper the surface of the solder lugs until they are perfectly clean and bright. However, in the case of new resistor panels the lugs are usually clean enough to enable the soldering operation to be carried out without any necessity for cleaning the lugs with sandpaper.

After you have tinned the solder lugs, cut several short lengths of bare tinned copper wire and several short lengths of insulated hook-up wire. You can then practise twisting these around the solder lugs as illustrated in Figure 2, and soldering. You will probably not experience any difficulty with the bare tinned copper wire, because it generally solders quite easily and there is no insulation on it to be damaged by leaving the iron in contact with the work for too long a period.

In the case of the insulated hook-up wire, however, after baring the wire and twisting the end around the lug you should carry out the soldering operation fairly quickly so that the heat of the iron does not damage the remaining insulation on the wires. At the same time, the iron must be left in contact with the work long enough to heat both the wire and the solder lug up to such a temperature that the solder will run freely onto both.

After carrying out the exercises described you should be fairly proficient in soldering lengths of wire. It is still desirable, however, for you to obtain additional practice by soldering small pieces of metal to one another. You will doubtless be able to find several small pieces of metal with which you can practice soldering. Easiest metals to solder together are pieces of clean shining tin plate. Do not attempt to solder very large pieces of metal with the small soldering iron supplied with this kit. Cut the pieces of metal up into strips about half an inch wide and practise on these. If you can obtain any brass, copper and other metals, practise with these also because unless you are very thorough in cleaning these metals, you will find them difficult to manage and consequently some practise is desirable. As mentioned earlier, it is not an easy task to solder aluminium and consequently it is unlikely that you will meet with any success should you try.

The resin core solder provided will be sufficiently effective on all metals excepting aluminium so that it will not be necessary for you to worry about trying any other special form of soldering flux.

SOLDERING

In conclusion, I will again list briefly the important points which must be observed before you can solder successfully.

(1) The iron must be clean and well tinned.

(2) The two surfaces to be joined must be thoroughly cleaned of all forms of oxide film so that both surfaces of metal are bright and shining.

(3) The soldering iron must be left in contact with the work long enough to enable both surfaces to be joined, to be

heated to a temperature higher than the melting point of solder, about 450 or 460 degrees F., so that the solder flows readily from the iron and spreads evenly over both surfaces. If the iron is not left in contact with the work long enough to heat each surface sufficiently, the solder may be pasted onto the work but it will be found later that the solder will peel off easily when given a slight pull. This is known as a "dry joint".

(4) When the solder has run freely onto the work and the soldering iron is removed, care should be taken not to shake or disturb the work or the solder until it has had time to cool and solidfy. If the work is shaken when the solder is in the plastic state, before it finally sets hard, a bad connection will often result as the solder will not effectively grip the wire it surrounds.

Good soldering is quite an art and is only learnt through a considerable amount of practice. Therefore, repeat the various exercises outlined over and over again until you feel quite confident and efficient at soldering.

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