

# How to Solder

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**E**VERY TRADE and profession has some implement which is associated with it. The gardener has his spade and rake, the carpenter his hammer and nails, and the doctor his stethoscope. The basic tool for anyone who works in electronics is the soldering iron and until you can use it reasonably well, you will never get much satisfaction from your work. There is no magic about using a soldering iron. As in any craft there are some tricks and bits of knowledge which come only with practice. However, there are some fundamental requirements which will be discussed in this article.

## *Cleaning Surfaces*

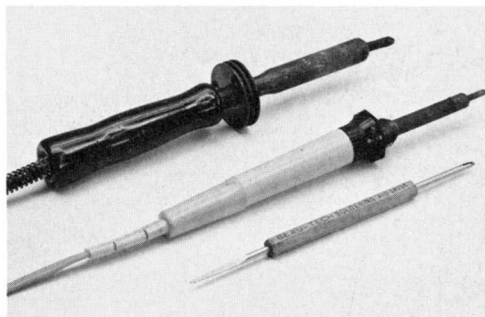
Solder is an alloy, a mixture of tin and lead, sometimes with small amounts of other elements. This alloy melts at a fairly low temperature. On the cleaned surfaces of some metals the molten solder will "wet" the surface and penetrate a tiny amount into the structure making a bond which is as effective as though there were no joint at all, but a continuous piece of metal. To get this result the first essential is that the surfaces should be completely free from contamination. Plumbers and sheet-metal workers achieve this by using acid (this

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is called a "flux") to etch the surface and remove all dirt and corrosion. But in electronics work it is not suitable to use this drastic method because the acid left on the joint eventually corrodes the components. So it is necessary to use a non-corrosive flux such as resin. Resin has the ability to dissolve some of the impurities which are on the surface, although the surface must be fairly clean before this can happen. When the metal to be soldered is tin the resin is very effective, as the tin alloys with the tin in the solder, and a perfect bond is formed. This is why most components and hookup wire are made with a tin coating over the copper conductor wire. An additional advantage of tin is that it does not corrode (that is, tarnish) in the atmosphere as much as other metals. Circuit boards, also, often have their copper foils coated with tin. Occasionally you will find circuit boards, copper braid, and so on, without any protective coating at all. If the copper is clean and bright you will have little difficulty in soldering. However, if the surface is dull and discolored, it may well be impossible to make a good solder joint unless you scrape the surface thoroughly to remove the impurities. Sometimes surplus components which have been stored for a long time have corrosion even on the tin-coated surfaces. Again, the only remedy is to scrape the surface thoroughly until it is bright and shiny.

## *Choosing Suitable Solder*

The solder itself doesn't present many problems. As mentioned above, it must be used with a noncorrosive flux and the best way to get this is to use solder which is in the form of a tube with the resin flux in the center. This is known as resin-core solder and is used almost universally in electronics work. Some manufacturers make solder which has not only one, but five separate cores so that the flux is distributed more evenly. Resin-core solders can be bought in different gauges and the use of the correct gauge for the job not only makes a better soldered joint but makes the work easier. For the wiring of tube-type equipment and general heavy work, No. 16 gauge is quite satisfactory, while for soldering integrated circuits onto circuit boards (and other fine work) a gauge as small as No. 22 can be used to advantage. Experimenting with different gauges will soon show you the best one for a particular job. It will pay in the long run



The iron at the top is the type used for heavy work. The smaller iron is a common kind used for etched circuit-board work and for soldering small devices, such as semiconductors and integrated circuits. The tool shown at the bottom is called a soldering aid and is handy for looping wires around terminals.

to have two or three different sizes of solder handy.

### Choosing the Correct Soldering Iron

Probably the most important thing of all is to use the correct soldering iron. There are many brands and types of soldering irons on the market. They range from those which are excellent to some which are so unsuitable that one wonders if some manufacturers ever used a soldering iron! A fairly common mistake occurs when some manufacturers try to make a general-purpose tool. If you see an advertisement which tells you that a particular soldering iron is a universal tool and is suitable for the entire radio industry, don't buy it. Because it is intended to do everything, you can be certain it will do nothing really well.

There are several reasons why this should be so. The purpose of a soldering iron is to store heat and apply it to the joint. The question is *how much heat* is needed and *how hot* should it be? A little soldering iron is fine for small joints but it can only store a small amount of heat. If this iron is applied to a large joint which contains a large amount of metal, there just isn't the necessary amount of heat available to raise the temperature of the large volume of metal to a level where a satisfactory bond can be made. The manufacturers of these so-called universal soldering irons try to get over the problem by increasing the power which the soldering iron uses. What they seem to overlook is that a small bit (tip) stores only a small amount of heat and has a small surface area also. So when the iron is not in use and is resting on its stand, the air around it has only a slight cooling effect and the bit gets far too hot. This means that the solder on the bit and the bit itself oxidizes (that is, burns or corrodes) at a very rapid rate and the bit has to be constantly scraped and retinned. However, when the iron is used on light work, such as circuit boards, the heat is so great that small components and the adhesive material which bonds the copper foil to the board are burnt and ruined. Even if joints are made, the overheating causes them to be unreliable. On the other hand if the iron is used on heavy work it is still unsatisfactory because, although it may be too hot, it will still not have a sufficient amount of heat stored to heat the large volume of metal. Thus, the spot where the iron touched may be overheated for an instant and then the heat will spread out and the temperature drop so that the rest of the area is still too cold.

Even for a person who is an expert at soldering, the use of the wrong type of iron can make good-quality soldering almost impossible, and for a beginner the results can be disastrous. Quite a lot of people have lost interest in electronics because they can't solder without burning components and spoiling circuit boards. In almost every case the fault is not with the person but because he was using the wrong soldering iron and possibly the wrong solder.

Now that you can see how important it is to choose the most suitable iron, here are some hints which will help you.

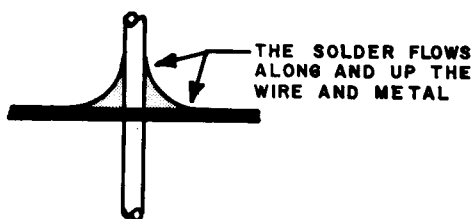


Fig. 1 — In a good solder connection the solder flows along the metal and presents a smooth, shiny appearance.

1) Look for an iron which you find is comfortable to hold. (You will be holding it a lot!) A lightweight cord is an advantage because it doesn't drag when you move the soldering iron around. Also make sure that the cord is not too short.

2) If you expect to do a lot of work with printed boards, transistors, and integrated circuits, then choose a small iron but don't expect to be able to use it on heavier work. The power rating of such an iron would be about 40 watts.

3) If you are building only tube-type equipment, then a bigger soldering iron would be more suitable. It should of course be much larger physically and have a bit at least a quarter of an inch in diameter.

4) Every modern soldering iron has replaceable bits. See that these are available when you buy the iron. With care and an iron which does not overheat the bit should last a long time, but it is a good idea to have a spare on hand for when you need it. There are some fancy-shaped bits available, but unless you are doing very specialized work they are not much use. A simple circular bar with the end filed at an angle of 30 to 45 degrees is all that is needed.

5) Finally there is a special type of soldering iron which should have a mention. This type has a switch on the handle so that the iron can be switched on and off during the actual soldering operation. Such an iron is usually called a soldering "gun." This is very useful if one is not soldering continuously, as the soldering iron heats up quickly and the temperature can be controlled. But a fair amount of experience is necessary because if one does not release the switch soon enough the iron can become too hot and everything burns. These irons are available in different sizes for heavy and light work. When you have selected your iron and brought it home you should make or buy a suitable stand and mount it firmly on the bench so that if the lead is accidentally pulled the iron does not fall and smash on the floor possibly giving you a nasty burn in the process.

There is one final accessory you will need. When you have been soldering for a while you will find you are either a "wiper" or a "flicker." Even though the soldering iron bit does not get too hot, or the solder burn off, it is still necessary when making a joint to have a bright and shiny film of solder on the point of the bit. If the iron has not

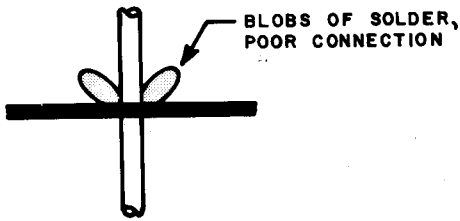


Fig. 2 — A common practice of beginners is to wind up with a ball of solder on the connection. This usually means the material was not hot enough to melt the solder and cause it to flow around the connection.

been used for a couple of minutes the surface of the solder on the bit oxidizes and becomes dull, and this impedes the transfer of the heat to the joint. So to get a bright and shiny film of solder it is necessary to melt a little fresh solder directly onto the bit just before using it. To remove the blob of solder thus formed one either wipes it off or flicks it off. The writer, a confirmed "flicker" from way back, has an open-top container about four inches square screwed to the workbench under the soldering-iron stand. Over a period of months this box gradually fills with solder and saves a mess on the floor. The "wipers" should organize a similar container with a piece of sponge slightly dampened, or a suitable piece of rag.

### Soldering Technique

And so we come to the soldering operation itself. Soldering is something like painting a house. If you have the correct materials and equipment and the surfaces are perfectly prepared, then the job is easy. If not, no amount of skill can make up for poor materials and lack of preparation. Careful preparation of the materials means seeing that they are bright and clean, as mentioned earlier, but contrary to what many people seem to imagine there is not the slightest need to wrap wires around terminals or twist them together before soldering. This idea has come about because some manufacturers assemble a lot of components and then solder the lot at once to save time. If you can't hold the wires and solder them at the same time, there is no reason why you shouldn't hook them together but it won't make the slightest difference

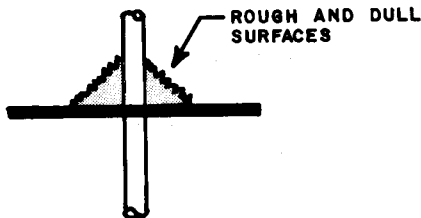


Fig. 3 — A cold solder joint presents a rough and dull appearance, and can be caused by insufficient heat or movement of the connection while it is cooling.

to the strength of the joint. In fact a wrapped wire can sometimes make a badly soldered joint harder to detect. And if you want to dismantle the project later and use the components again, a wrapped joint makes it very difficult to do so. What is a properly soldered joint? The important characteristics are shown in Fig. 1. The sketch represents a wire being joined to a flat surface, end on.

The solder should run or flow over the metal and the wire. The usual description for this is that the surfaces should be "wetted." The opposite situation is where the solder does not wet the surfaces but draws away from them like water on a greasy surface. This kind of poor or dry joint is shown in Fig. 2. If you see this effect anywhere on the joint you can be sure it is a bad one and it should be recleaned and resoldered. By the way, if you want to remove the solder from a joint then a piece of clean copper braid laid on the joint and heated with the soldering iron will soak up the solder as though it were blotting paper.

Finally, if the solder is not heated sufficiently or if the wire is moved before the joint has hardened properly, you can get the kind of result shown in Fig. 3. This is called a "cold" solder joint. A joint which looks like this should be reheated until it looks like the one in the first sketch.

There is one general tip which applies to all soldered joints from the finest wire in a meter movement to the soldering of gutter and down-piper for a house. If you have any trouble making a good soldered joint, take the joint apart and clean and tin each surface separately and try to put them together only after both have been completely wetted with solder. Incidentally, if you use this method it is quite easy to solder a wire to a sheet of aluminum or to solder two pieces of aluminum together, provided of course that the soldering iron has enough heat capacity to bring the aluminum up to the soldering temperature. This is how the joint is made. Clean the surface of the aluminum as thoroughly as you can and put a drop of ordinary engine oil on it. Then, with a sharp knife or scriber, scratch the already cleaned surface of the aluminum underneath the oil film and without wiping the oil away, tin the surface of the aluminum as you would do with any other metal. Once it has been tinned you can solder any other tinned metal onto it. But remember that if the aluminum is even moderately thick you will need a very heavy iron (a very hot small iron is no substitute, as has already been explained) in order to provide the large amount of heat needed to heat the aluminum.

That covers most of the basic information that you will need to make a success of the craft of soldering — essential for everyone who works in electronics. The formula for success can be summed up as: preparation, the right tools and materials, practice and patience.

There are many more practical tips that one picks up through experience, but if you master the basic technique and start in the right way with a suitable iron and the correct solder, you will have won the major battle. Good soldering!

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