PRACTICAL ELECTRONICS

Solder, fluxes, irons — and how to use them

The art of soldering has been part of what we now call electronics since the early days and looks like being around for a long time yet. It presents a minor hurdle for the beginner, but one which must be tackled. This article points out the major pitfalls and discusses the practical requirements for good soldered joints.

by PHILIP WATSON

Nobody gets very far in practical electronics before encountering the need to make soldered joints. While it is possible to get by with screw terminals, clips, twisted wires, etc for elementary — or temporary — projects, anything which is intended to be at all permanent really calls for soldered joints.

The reason is not difficult to understand. A properly made soldered joint comes about as close to a perfect electrical connection as we can get. It provides a low resistance connection between the two conductors, and one which should not deteriorate due to oxidation, as can happen with mechanical joints.

Soldering also offers good mechanical strength, often comparable with that of the conductors themselves, and at least adequate for most ordinary situations.

But note that we referred to a "properly made" soldered joint. Good joints don't just happen; they call for a certain amount of skill. Not a lot, and nothing to get hung up about, but it does involve some effort on the part of the student, and guidance from someone with more experience.

Which leads us to another important point: even though it may appear, superficially, to be normal, a poorly executed solder joint can cause a lot of trouble in service. (Ask anyone who has ever had to track down a "dry" joint in a piece of electronic equipment!)

While we would be the first to admit that the practical skill required cannot be learnt from a book, we can at least put the beginner on the right track. After that he — or you — will have to learn by doing.

A formal definition of soldering might read thus: "The use of a low temperature molten alloy, flowing over the surfaces to be joined, and adhering to them, a flux being used to assist the adhesion." That is accurate enough as far as it goes.

It is not our intention to delve deeply into the "chemistry" of soldering. This has been done in many other articles, including those in this magazine in November 1962 and January 1963. Our aim here is put the reader on the right track regarding essentially practical requirements.

In a properly made soldered joint the solder will adhere to the metal with exceptional tenacity. It cannot be prised loose, nor can it be drained off by heating. The structure of the bond is quite complex but it is important to know what constitutes a good joint.

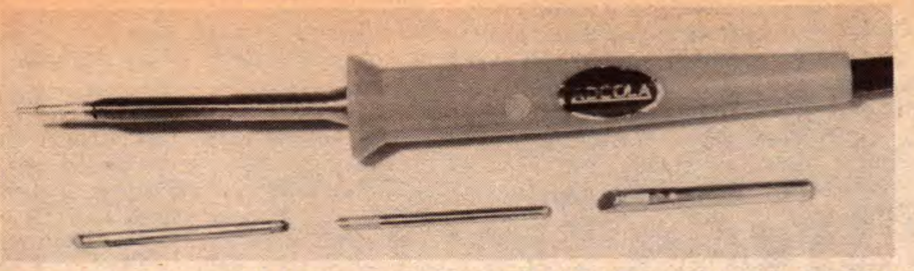
There are two basic requirements:

(1) The metal surfaces must be clean and free from oxides.

(2) The temperature of the metal surfaces must be raised to that of the molten solder.

When these requirements are satisfied the molten solder will "wet" the metal surfaces and flow freely over them. The ability to recognise the "wetting" action is part of the skill to be learned. Also, from the "wetting" concept comes an opposite term: a "dry" joint. It implies that the solder has failed

Solder comes in many forms and grades but, for electronics work, the wire form, with mutiple flux cores, is virtually standard. At left is a fine gauge, 0.71mm, and at right the more common 1.6mm gauge. Both are 250g reels.



Typical of modern soldering irons suitable for the beginner is this "Adcola" 240V, 12W unit. As well as the fine tip shown fitted to the iron there are three more tips displayed, intended for heavier jobs.

to wet the metal and therefore has not adhered to it.

Consider first the cleaning: in heavier applications, such as plumbing, it is customary to use files, wire brushes, glass paper, emery paper etc. In electronics, we can usually regard the surfaces as being basically clean as we receive them, since most terminals and wires are tin plated. However, bare copper wire may need to be scraped with a sharp edge or rubbed with glass paper to remove surface oxide.

Unfortunately, no matter how clean the surfaces are initially, they will not stay that way for very long when we start soldering. The act of raising their temperature to that of molten solder tends immediately to create an oxide coating, thus inhibiting the solder bond.

This brings us to the subject of fluxes. What might be termed the primary function of a flux is to provide a protective coating over the surfaces while they are being heated, to exclude the air and prevent the formation of oxides.

Petroleum oils, jellies, or waxes will perform this function and can serve as fluxes in ideal circumstances; they are seledom used in practice, however. The truth is that most surfaces, no matter how bright they might appear, are oxidised to some extent, so that practical fluxes need to provide a secondary function, that of dissolving residual oxides.

Acids as fluxes

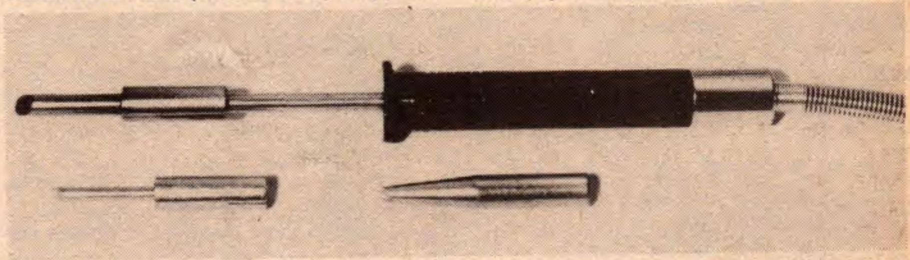
Many acids will perform this function very well at, or below, typical soldering temperatures and so we find that most fluxes consist of or contain acid to a greater or lesser extent. These may range all the way from hydrochloric acid (spirits of salts) used by plumbers on galvanised iron to pure rosin for electronic work.

The problem with acid fluxes is that most acids are corrosive and any flux residue left after soldering can continue to attack the surrounding metal, particularly under conditions of high temperature and high humidity. This is not much of problem for the plumber, who can slosh a bucket of water over the job and wash away the residue, but it can be a serious problem in electronics.

Corrosion in electronic equipment simply cannot be tolerated, particularly where fine wires are concerned, as in coils. It can eat away such wires, rendering the equipment useless.

It is for this reason that a lot of care has gone into the development of "non-corrosive" fluxes for the electronics industry, and also why the range of suitable fluxes is rather restricted.

For many years rosin was the standard and almost exclusive flux used in electronic equipment, usually in the form of a core in thin wire solder. Rosin releases an acid (abietic acid) at typical soldering temperatures, but becomes inert again when it cools.



Typical of low voltage irons is this "Mico" 12V, 10W unit, together with three of the most commonly used tips. Although requiring a transformer, many people prefer the smaller, lighter irons available in the lower voltage types.

But pure rosin is still not the ideal flux. Where individual components have more than a certain amount of oxide coating and/or are contaminated with other foreign matter, rosin is not equal to the task. The result is a dry joint and, in mass production, it is inevitable that a percentage of these will not be recognised by the operators, or during subsequent inspection, and will go into the field. Sometime later they appear as intermittent faults.

This led to the development of activated fluxes; rosin fluxes to which are added small quantities of chemicals which release an acid vapour when heated and which makes for a much more effective flux. They are still regarded as "non-corrosive" because most of the chemical acid is vapourised and any that remains is rendered inert by the solidified rosin. This forms a hard glossy surface over the metal and protects it from any atmospheric moisture which might activate residual chemicals. In practice, they work extremely well.

This brings us to basic requirement (2) which we listed earlier: that the temperature of the metal surfaces must be raised to that of the molten solder.

We normally melt the solder onto a joint by means of a hot copper bit, "tinned" with a coating of solder, and which is the business end of a complete implement commonly called a soldering iron.

The need to raise the temperature of the metal surfaces to that of molten solder should be obvious. The solder cannot remain molten while it is in contact with a metal surface at a lower temperature. Even if the main body of solder remains molten because it is in contact with the bit, there will be a thin layer against the cooler metal which will become solid.

"some authorities advocate . . ."

So important is this requirement, that some authorities advocate that the solder should never be applied to the bit, the bit being used only to heat the metal to the point where it (the metal) will melt the solder when it is applied. In this way the operator can be sure that the metal is hot enough, since it will not melt the solder otherwise.

The theory behind this is sound enough, and it is often applied in practice, particularly in heavier duty applications, such as plumbing. "Yorkshire" fittings are a typical example, where a flame is used to heat the metal pieces until they melt the built-in solder ring, which then flows and completes the joint.

Conflicting requirements

Unfortunately, it is not quite that simple in the electronics field. A conflicting requirement here is to protect adjacent components and materials from excessive heat, while still ensuring that adequate heat is applied to the actual joint. To apply the aforementioned technique is to risk taking so long to complete the job that other components may be damaged.

One reason is the difficulty of making good thermal contact between the bit and the work, particularly as the latter may be irregular in shape. By flowing a little solder between the bit and the work, we use the solder to conduct the heat to a much larger area than can be reached by the surface of the bit alone.

This heats the metal quickly and, when it is hot enough, the solder will wet it and flow freely over the surface. Recognising this condition is part of the skill of soldering. A classic mistake is to observe that the solder flows freely over, say, a solder lug, but to neglect to check that it also flows correctly over the wire passing through the lug. The result is a wire passing through a hole in the solder, but completely "dry".

A bad habit, when using cored solder, is to carry molten solder to the job on the tip of the bit. This is a carry-over from situations where the flux is applied separately, before the solder. When using cored solder most, or all, of the flux can be vaporised in the time needed to convey the solder to the job. This applies particularly to the more volatile chemicals used in activated fluxes.

The practical approach

As a result of all the factors we have discussed, most workers follow a fairly standard procedure when making a joint. When using new components, already tinned, it is reasonable to a assume a basic cleanliness; at least to the point where the flux will take care of slight contamination or oxides.

Normally, the bit and the solder is applied to the job at the same time and a little solder melted onto the tip of the bit to aid thermal conductivity between the bit and the job. When the solder flows, more can be applied if the size of the job demands it, preferably to the job rather that the bit.

Although the solder is designed to set quickly, it is important that no movement of the parts should occur during the setting period. If it does, it can produce a faulty joint, similar to a dry joint, at least as far as the end result is concerned.

Where one or more of the parts to be joined are other than bright and shiny, extra care is necessary. The usual procedure is to treat such components separately, before attempting to make a joint. Excessive dirt or oxide is best removed by scraping with either the blade of a knife or fine glass paper, until bright metal is revealed. The surface is then "tinned" with a coating of solder, particular attention being given to the manner is which the solder flows. If any doubt exists the process should be repeated.

The need to make joints quickly is most evident when working on printed boards. Prolonged heating can destroy the bond between the copper and the base material, allowing the copper to lift. On the other hand, the copper pattern normally accepts solder very readily, the boards being sprayed with a protective coating, which is also a flux, while the copper is still bright. As a result, the solder should flow over the copper almost immediately it is applied.

Another factor which helps is that the mass of copper involved in any part of a printed board is very small, therefore reaching the required temperature very quickly. Be aware, however, that this may not apply to the wire being soldered to the pattern; it may form part of a substantial component and so take somewhat longer to heat.

In the event that a printed board joint does not "take" immediately, do not continue to apply heat and try to force the situation. The result will almost certainly be a damaged board. Back off and determine what has gone wrong. If it is a dirty pigtail, for example, clean it and tin it away from the board, before trying again.

So far we have made only passing mention of solder, flux, and the soldering iron, without delving too deeply into the practical form in which these are found. For the beginner, some elaboration is justified.

Electonics grade solder is normally supplied in wire form, with a core, or cores, of activated rosin flux. It is normally a 60/40 tin/lead alloy, the proportion being chosen deliberately because it combines a low melting pont with rapid setting.

"Wire" solder is available in a variety of wire gauges, the most popular in the past being 16SWG or 1.6mm, and 18SWG or 1.25mm. More recently, thinner gauges, such as 22SWG or 0.71mm, have become popular for use with miniature components and, particularly, complex printed board patterns. Such boards often have terminating pads very close together and it is all too easy to apply excessive solder and thus bridge adjacent points. Thinner solder makes the amount applied easier to control.

The 250g reel is a popular size and, although it may look expensive, one reel will last the average hobbyist a long time.

Multiple flux cores

The use of more than one core of flux — five is a popular number — is intended to reduce the risk of no flux being available at a particular point, due to minor breaks in the flux continuity. The reasoning is that it is unlikely that several cores will all suffer a break at the same point.

There is a large variety of soldering irons available; so large that it is beyond the scope of this article to deal with them all in detail. We may do that in a separate article. However, we will give a brief summary of the more usual types.

All are heated electrically and include 240V types for direct connection to the mains, and low voltage types operated from a transformer. Typical power ratings are from 10W to 25W. There are quick-heat types, which are turned on only when a joint is to be made, variable wattage types with manual adjustment, and automatic constant temperature types.

The more elaborate types may be hard to justify at hobby level, and a simple type, of about 15W rating, either 240V or 12V will suit most beginners. The quick heat type is handy in situations where there may be long breaks between joints, as when developing a circuit, but they are rather more expensive, and call for some additional skill in their use.

Care of the bit.

All irons are fitted with a removeable bit, since this will need to be replaced eventually. This also allows a variety of bit shapes and sizes to be used, according to the job requirements. In any case, the bit should be removed at regular intervals and both it and the barrel cleaned of scale. Failure to do so can result in the two becoming "frozen" together, with the chance of the iron being damaged in trying to free them.

The first thing to be done with a new bit is to tin it, by giving it a coat of solder over the working faces. Shape the bit, if necessary, with a file, then allow it to reach working temperature. This will normally cause the formerly bright copper surface to darken with the formation of oxides and may prevent the solder from wetting it, flux notwithstanding. A good idea is to give each face a quick rub with the file, while hot, then apply solder immediately.

In use it is desirable to clean these tinned surfaces if they become oxidised, usually by rubbing with a scrap of cloth. When the tinning shows signs of pitting or breaking up, the faces should be filed down to copper and retinned.

And that about sums up the soldering scene as it is applies to the electronics hobbyist. Having digested all that we have said, it remains to put it into practice. Try making up some simple dummy circuits, but preferably using previously unsoldered pigtails, terminal lugs, etc. A little practice should enable the reader to appreciate the various points we have made throughout this article, and set him on the road to becoming a skilled worker.

But never take this skill for granted. Even the most experienced worker can make a dry joint if he becomes careless — every joint needs to be made with care.