SOLDERING:

Hot Tips for the Hot Hobbyist

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THE MOST COMMON method of making connections between electronic components is by soldering. Solder is an alloy of tin and lead that melts at relatively low temperatures. Its function is to make an electromechanical connection between the metal parts to be joined. Solder is fairly ductile, having little mechanical strength, so it is not relied upon to support the components, although one of its functions is to prevent movement of the parts joined. The solder fills the irregular surfaces of a joint, mechanically and electrically bonding them at the same time via an intermetallic bond (see Figure 1).

Seems pretty simple, doesn't it? Well, soldering is half an art and half a science. In manufacturing, people are no longer, in large part, relied on to make individual joints (apart from it being a boring, repetitive task) — special soldering machines do it now. But for prototype construction, for servicing and for hobbyists, knowing how to solder is a necessity.

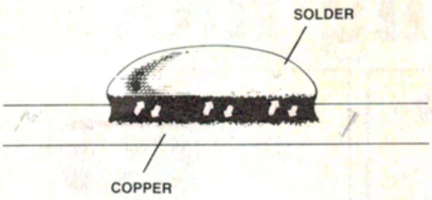


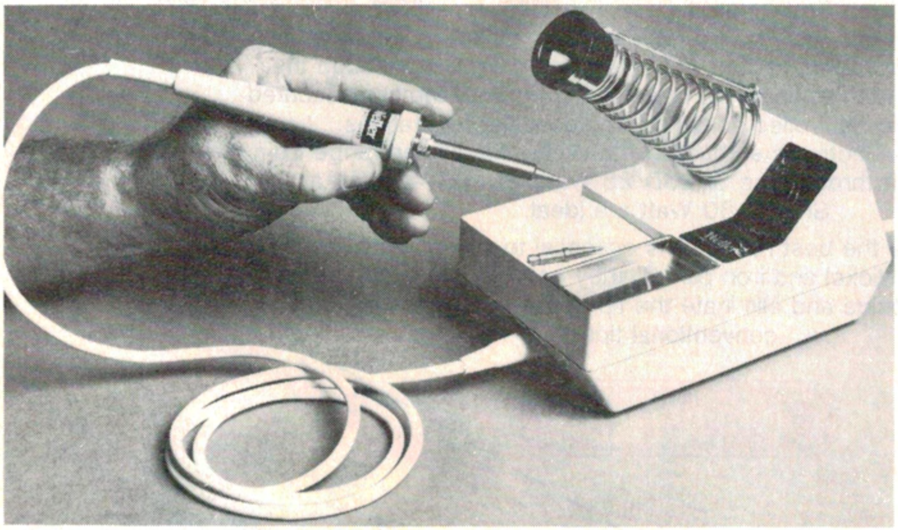
Figure 1. Solder forms an intermetallic bond with the surface of the conductor to which it is applied. (Courtesy Pace training manual, via Coltronics).

There are three elements involved in making a joint: the solder, the soldering iron and the parts to be joined. Let's look at them in turn.

Solder

Solder is a very special alloy composed of tin and lead in certain proportions. Tin melts at 327° C and is 'plastic' down to 283° C. Lead melts are 232° C and plastic is down to 183° C. The plastic state of either metal is fairly brittle, so either alone is unsuitable for making a joint as any movement during cooling (even due to contraction) will result in a faulty joint. If tin and lead are mixed in appropriate proportions, the alloy has a much smaller plastic state temperature range and a lower melting point.

With a composition of 63% tin and 37% lead, the alloy has *no* plastic region. It goes from liquid to solid then at 183° C. This is undesirable as a small region of plasticity reduces brittleness under practical circumstances. The most common composition of solder for electronics work is 60% tin, 40% lead — often just called "60/40" solder. It melts at 188° C and has a plastic temperature range of about 5° C. It combines optimum strength with lowest electrical resistance.



A temperature-controlled iron. This British-made Weller iron, distributed here by the Cooper Tools group, features low-voltage operation and replaceable iron-plated bits that are obtainable for different operating temperatures.

Another type of solder used in electronic work includes about 1.5% copper and is known under the trade name of 'Savbit'. Soldering irons with copper tips corrode rapidly when used with straight 60/40 solder as some of the copper is absorbed into the molten solder. Savbit solder prevents this and can extend the life of copper bit soldering irons by up to 10 times. Some soldering tools have iron-plated tips to reduce this sort of wear and the use of Savbit is not necessary with these irons.

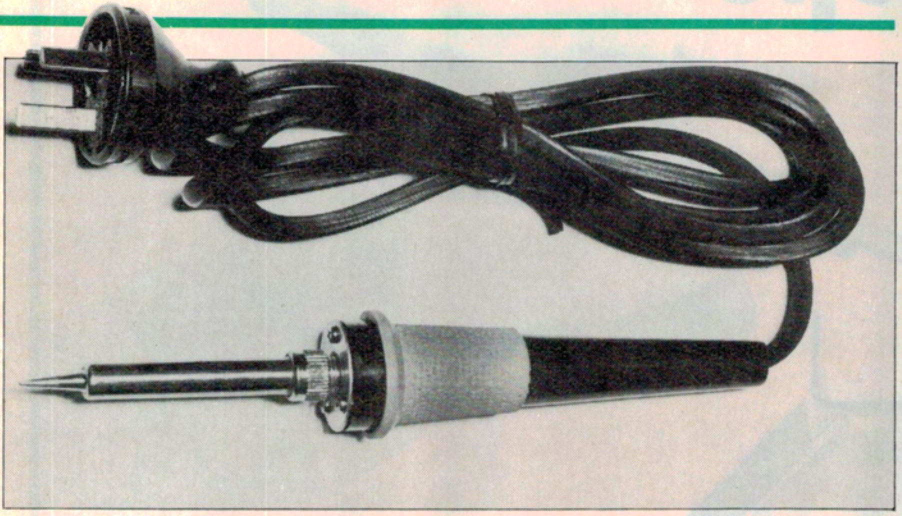
Ordinary solders, such as 60/40 solder, are also referred to as 'soft solder'. Joints that have to withstand high temperatures, or that need greater mechanical strength than obtained with 60/40 solder, are joined with 'hard' solders that melt at higher temperatures. 'Silver' solder, containing 5% tin/93.5% lead/1.5% silver, melts at about 300° C and is mostly used in fabricating brass or copper chassis, etc. Silver solder is usually melted with a gas-burning torch.

Low-temperature solder is also obtainable and is used where components may be damaged or where it is necessary to solder onto a joint that is already soldered without melting the existing joint. This has most applications in special servicing jobs. It consists of 50% tin/33% lead/17% cadmium and melts at 145° C. It requires care in soldering as it tends to fracture the instant it solidifies.

All metals oxidise, or tarnish, on the surface as a result of being exposed to air. This prevents the solder from flowing over the metal surface, resulting in a poor joint; 'flux' is used to remove tarnish. For electronic work this is composed of resin (sometimes spelt rosin), which is obtained from the sap of pine trees plus additives called 'activators'. At soldering temperatures, the activators decompose, liberating an acid that dissolves the tarnish faster than pure resin.

Other fluxes are also made for non-electronic uses, usually sheet-metal work, copper and brassware manufacture. These fluxes are usually highly corrosive (such as

"A good joint is hard to find . . .", someone once said, and we know exactly what they meant. Good soldered joints are of paramount importance in electronics. It's not a matter of 'you make a joint, or you don't'. There are lots of 'not quite' joints — and boy, can they cause trouble! This article's all about the tools and techniques required for making good joints.



Continuous heat iron. This low-cost iron from Altronics, the Micron T2420, features a warm-up time of only a few minutes and fixed temperature operation. The bit is iron-plated and easily replaceable. The ferrule at the end of the handle keeps your fingers cool.

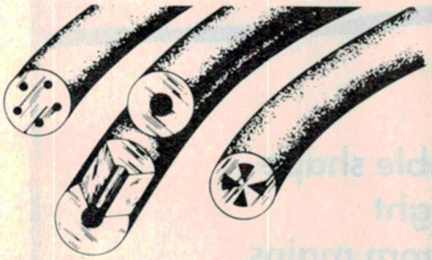


Figure 2. Resin-cored solder comes in a variety of configurations. The solder-resin ratio is varied by varying the configuration of the resin core. (Courtesy Pace training manual, via Coltronics).

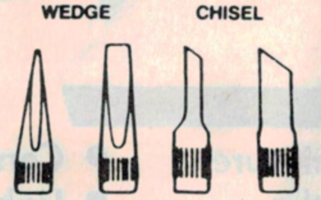


Figure 3. Bits can be obtained in a variety of shapes to suit the job, such as conical, wedge, bevel, chisel, etc. The most common bit shapes are the wedge (or chisel) and the bevel. They can be different diameters and lengths, giving different heat capacities.

hydrochloric acid) and must *never* be used for electronics work as even minute amounts rapidly corrode component leads and printed circuit board tracks.

Solder for electronics work is made as different gauge wires. Most have a resin core along their length, some have up to five separate cores (see Figure 2).

The resin core melts before the solder and flows onto the joint, wetting both the joint and the solder, excluding the air. At the same time the activators dissolve the tarnish on the surface, allowing the solder to flow freely and properly wet the joint. When the solder melts, the increase in temperature deactivates the flux, limiting the possibility of corrosion. It is important to thoroughly heat activated resin during soldering to ensure the complete decomposition of the activators, otherwise they remain corrosive at normal temperatures.

A relatively new flux for flux-cored solders has recently become available, called 'Xersin' (pronounced zersin). This is a chemically compounded flux containing no resin. Developed by Multicore Solders Ltd, it has characteristics very similar to resin at room temperature, melts at 90° C and produces a lot fewer fumes than ordinary resin fluxes when heated to soldering temperatures.

The fumes of resin fluxes can cause bronchial irritation and, occasionally allergic sensitivity in some people, if they work in a situation where the fumes do not readily escape. Xersin is claimed to overcome these problems.

Resin-cored solder is obtainable in a variety of wire gauges. For general and heavy work, such as on sockets, chassis, switch contacts, etc, 16 gauge is suitable. For fine work on printed circuit boards, miniature components, etc, 20 or 22 gauge is best. It pays to have several different gauges handy. Experience will show which is the best under different circumstances.

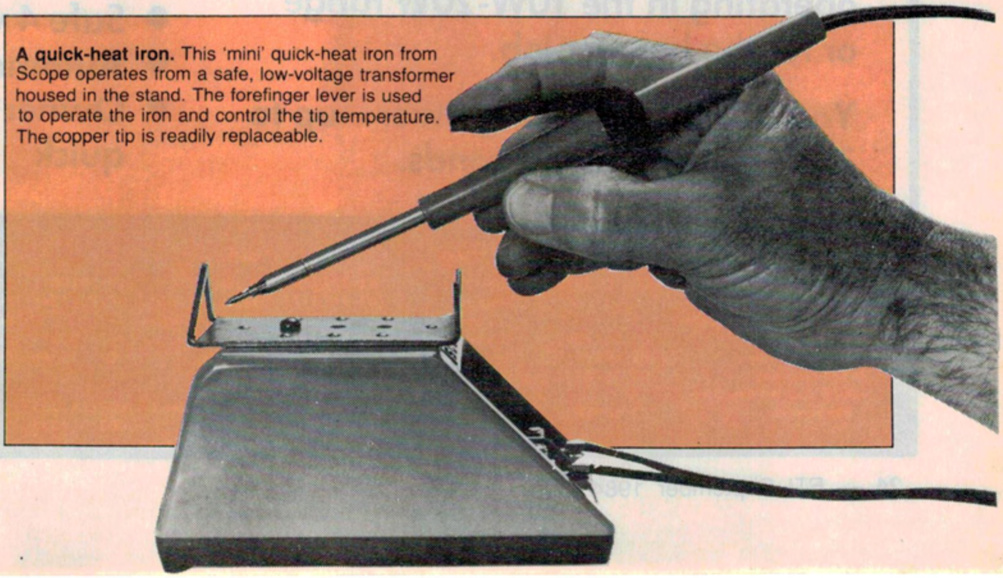
Soldering irons

As I covered soldering irons in Part 1, I won't go over the ground again. However, you will find illustrations of various types through this article. I should emphasise that you should spend as much as you can reasonably afford on a soldiering iron as it will probably be your most-used tool. If you find it hard to make a decision, then start out with a lower priced iron of good quality. You can purchase a more sophisticated iron later when you will know your own needs better.

Soldering bits

The soldering iron bit conducts heat from the iron's element to the joint. Typical bits are shown in Figure 3.

The tip temperature and the amount of heat it stores are important factors in obtaining a good soldered joint. The tip temperature will drop when making a joint due to heat being conducted away by the ▶



A quick-heat iron. This 'mini' quick-heat iron from Scope operates from a safe, low-voltage transformer housed in the stand. The forefinger lever is used to operate the iron and control the tip temperature. The copper tip is readily replaceable.

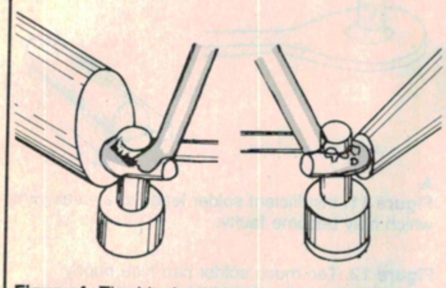


Figure 4. The bit should be large enough for the job, otherwise too much heat is conducted away from it by the joint and the solder will not flow properly. The bit on the left is OK, that on the right is too smali.

Figure 5. Plated bits last longer because they do not oxidise as rapidly as unplated bits. They are usually iron-plated.

parts of the joint. Just how much the temperature drops and how fast depends on the capacity of the bit to store heat and the mass of the parts being joined. The larger the bit, the more heat it will store and transfer to a joint, and the less will be the temperature drop. Temperature-controlled irons minimise these problems to a large extent.

For an adequately rated iron, the correct bit for the job will remain above soldering temperature (without burning the joint) and cause the solder to flow properly. If the tip is too small, too much heat will be conducted away, and the solder, while it may melt a little initially, will not melt and flow properly. This is illustrated in Figure 4.

Bits are usually made of copper, copper alloy or iron-plated copper (Figure 5). Unplated bits transfer heat more effectively but oxidise rapidly, reducing their efficiency. Their life is much shorter than plated bits and they require more frequent maintenance.

The area of the tip face determines the rate of heat transferred to to the joint. A small area will have a higher temperature but less heat reserve (or capacity) than a large tip. Generally, the more heat the work is likely to absorb, the larger the tip area should be. However, the area should not be so large that it obscures the work or damages adjacent parts.

The distance the bit protrudes from the barrel of the iron is also important. The shorter this distance, the higher the tip temperature. usually, it is best to select a bit length as short as practicable to reduce the heat path from the element to the tip, and to minimise wobble and bending of the bit. It should not be so short that the barrel touches or radiates onto nearby components or that the tip temperature becomes too high.

One way of reducing the temperature of a small-diameter bit is to increase the length beyond that used for the larger-sized bit — or vice versa. Bent bits can be used in awkward places where a straight bit cannot reach.

Maintenance

For maximum efficiency and consistently good joints, the soldering iron and bit require frequent but simple maintenance. Heating produces oxidation of the barrel and bit, the oxide forming a scale on the parts. This reduces heat transfer as the scale is an insulator. Continuous heat irons are particularly affected. Excessive scaling is produced by high operating temperatures and by prolonged use without descaling.

To remove scale, remove the bit and tap both the barrel and bit firmly on the bench top. This should be done regularly. Only remove a plated bit from the barrel of an iron when it is quite cold.

For efficient transfer of heat from the bit to the work, the face of the bit should be smooth and coated with a shiny layer of resin-free solder. A bit in this condition is said to be 'tinned'. A clean, new bit is tinned by heating it to soldering temperature (test it by lightly touching solder on the face of the bit) and applying a small amount of solder to the face and letting it flow freely to cover the face. Any excess should be removed by wiping it on a lightly damped sponge or cloth.

With use, the face of the bit becomes pitted and the solder layer takes on a dull grey appearance. During soldering, some of the copper from the face is absorbed into the solder and with repeated use the surface beqomes uneven. There is less absorption with plated tips (See Figure 6).

'Pitting' can be removed by filing. Only file off as much as necessary to produce a smooth face again. Excessive filing reduces the heat capacity and increases the bit temperature. Remove any scaling as well. When a clean tip is obtained, re-tin the face.*Never* file plated tips.

Do not pull the tip further out from the barrel to compensate for reduced length as this overheats that section of the heating element not in contact with the bit, producing excessive scaling and eventually causing the element to fail.

Small surface irregularities on plated tips should be repared with fine emery cloth when the tip is cold. Take care not to remove the plating. After cleaning, heat the bit and re-tin the face. Relatively large pitting on a plated bit means that some plating has come off. Attempts to remedy the situation usually result in more plating being removed. In such cases, replace the bit.

During normal soldering with a plated bit, the molten solder on the face should be replenished regularly while the tip is hot. The face can be cleaned by wiping it on a damp, fine-textured sponge (these are usually supplied with controlled temperature irons). Do not overdo it or you will remove all the molten solder. Wait a few seconds after wiping the bit to allow it to recover heat and then lightly re-tin the face. Plated bits should have a small amount of excess solder on teh face while not being used.

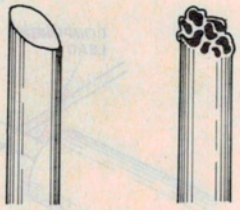


Figure 6. The tip should be in good condition, as at left, for good soldering, not worn, pitted or oxidised, as at right.

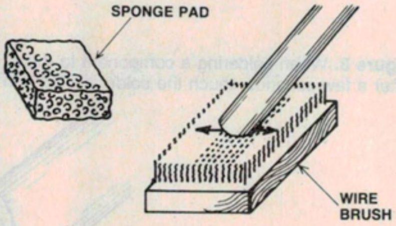


Figure 7. The tip should be cleaned regularly during use. A moist sponge pad (left) is good for frequent wiping, while for unplated tips an occasional scrub on a wire brush keeps the tip in good condition.

With either plated or unplated bits, regular cleaning during the use is a good practice, making soldering easier and ensuring good joints. A damp sponge pad is good for either type of bit. A fine textured wire brush may also be useful with copper bits. (See Figure 7)

Soon after learning soldering, most people will use one of two methods to remove excess solder from the bit: viz: *flicking* or *wiping*. Wiping is the recommended method. Flicking causes blobs of molten solder to splatter on to all sorts of awkward places. If you're a flicker, don't wear shorts!

Apart from ruining the carpet and prompting sudden leaps into the air, molten blobs of solder have a nasty habit of getting into equipment and causing short circuits — which may be disastrous. For habitual flickers, either cure yourself of the habit or screw a low, open-topped container to the bench top and aim in there from close quarters. It is even possible to recycle the solder thus collected — but not in your project.

Basic soldering

Before use, the soldering iron should be turned on for long enough to allow the bit to reach soldering temperature. Irons vary quite a bit in this; some take quite a few minutes to warm up, whereas others are much quicker. The parts to be joined should be bright and clean; if not they ▶

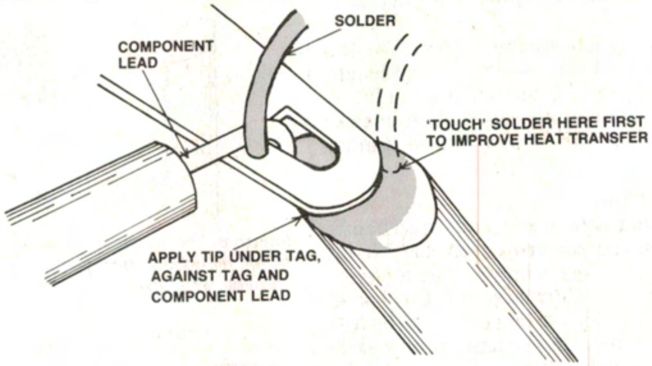


Figure 8. When soldering a component to a tag, apply the iron to the tag and the lead to heat them up. After a few seconds, touch the solder on the iron briefly and then apply the solder to the joint.

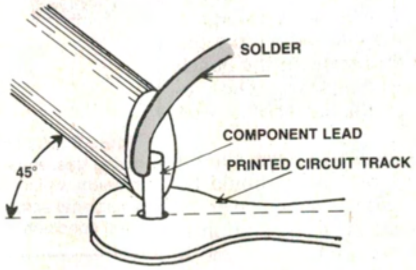


Figure 9. When soldering a component lead to a printed circuit board, apply the iron to the lead with the tip touching the copper track as well.

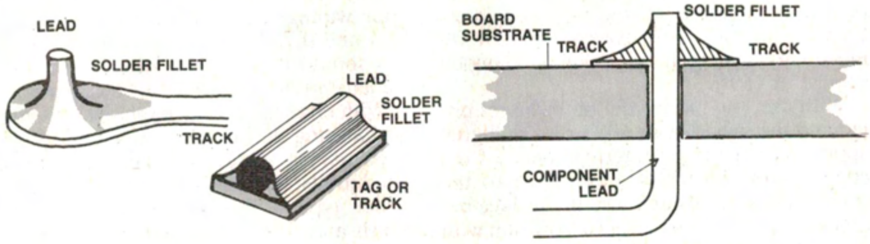


Figure 10. A good joint will be covered by a small fillet of solder which meets the parts of the joint at a tangent. The solder should be smooth and bright.

should first be tinned.

When the parts to be joined are prepared, and with the iron at the correct temperature, apply the face of the bit to that part of the joint having the greatest mass (providing it isn't the most heat sensitive). Allow the joint to heat for a few seconds to raise it to soldering temperature, and then apply a little solder. If the parts are clean, the solder will flow freely as it melts, wetting the joint properly and making a smooth, shiny joint. Remember that the solder must be applied to the joint and *not* to the iron.

Figure 8 shows how to solder a component lead to a tag. Apply the iron to the tag as the tag has the greatest mass. To improve heat transfer and reduce soldering time, first touch the solder to the iron at the junction of the bit and the tag. Just a touch is sufficient. The flux removes any tarnish from the tag and the hot solder tarnish that forms on the face of the bit, allowing rapid heating of a small area. The molten solder improves the thermal contact by wetting both surfaces and filling the minute air spaces between them. Next apply the solder to the tag. The solder will only melt if the tag is at the correct temperature, thus ensuring proper wetting.

Soldering components to a printed circuit board is shown in Figure 9. Always take care not to overheat printed circuit boards as the copper track may lift, damaging the board and making subsequent connections difficult.

Always hold the iron on the joint for a second longer after sufficient solder has been applied. This ensures that all the solder is melted and that the flux has been de-activated. Allow the solder to cool naturally. Don't blow on it to cool it. Don't move the joint while the solder is solidifying — a poor joint may result.

Take care not to apply too much solder as it may conceal a poor joint. On printed circuit boards, too much solder may cause 'solder bridges' to form between tracks.

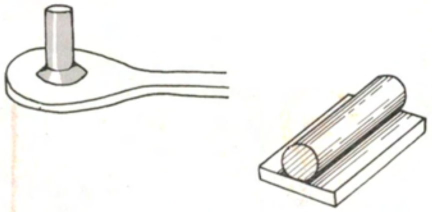


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Figure 11. Insufficient solder leads to a weak joint which may become faulty.

Figure 12. Too much solder can hide poorly wetted surfaces (top left), which results in a poor joint. On pc boards with close conductor spacing too much solder leads to 'bridging' (bottom).
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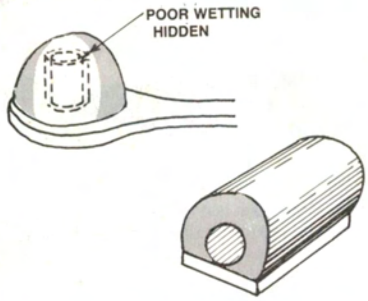

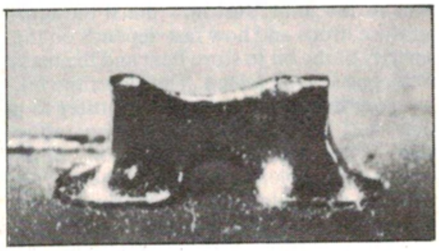

A good joint is . . .

How much is the right amount of solder, and what does a good joint look like?

The size of the solder 'fillet' should be large enough to fill the area of the joint and the contours of the parts should be plainly visible. The surface of the solder should be smooth and bright and meet the parts of the joints at a tangent. This 'feathering' indicates good wetting. The characteristics of a good joint are shown in Figure 10.

There must be sufficient solder filling the spaces of the joint to ensure a good mechanical bond. Insufficient solder results in a mechanically weak joint. The joint is likely to go open circuit or intermittent under slight mechanical stress (such as due to vibration or expenasion and contraction with temperature changes). Joints having insufficient solder are shown in Figure 11.

Too much solder can hide poorly wetted joints. In such cases the solder meets the surfaces abruptly. Too much solder can also 'bridge' adjacent pc board tracks or component leads. (See Figure 12) ●

. . . to be continued.