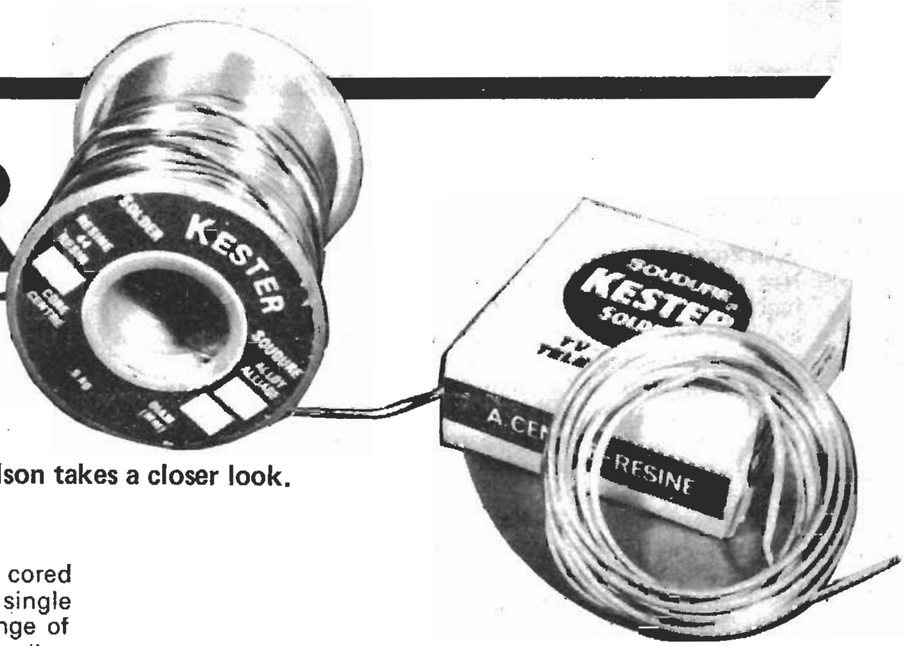
SOLDER



Solder is solder is solder. . . .or is it? K.T. Wilson takes a closer look.

SIMPLE ENOUGH, isn't it? You just buy a reel of cored solder and that's it. Or is it? In fact there is no single material called solder, and there's a very wide range of behaviour that you can expect from solder, depending on their composition. Add to that dozens of materials that can be used for a flux core, and it doesn't look so simple.

Basically, solder is a mixture of lead and tin. Pure lead melts at about 327 C, tin at 232 C, but mixtures of tin and lead melt at temperatures which depend on the composition. Fig. 1 is a diagram which shows the melting points of various alloys — the important solders are the alloys which contain up to 60% tin. This type of diagram shows an important point — that there are mixtures of tin and lead which have melting points lower than either tin or lead. This lowest melting point is for a 63% tin mixture, called the eutectic — a name given to any mixture of materials whose melting point is the minimum.

The graph of Fig. 1 shows only melting points — but there's more to it than that. Pure materials, such as pure tin or lead, have sharp melting points — meaning that they go from liquid to solid for only a tiny fraction of a degree change in temperature. The eutectic mixture (63% tin) does this also, but all other mixtures of tin and lead which contain more than about 15% tin have a 'pasty' stage (Fig. 2), neither liquid nor solid. This pasty stage is important in soldering, because slight vibration during the setting of solder can cause fractures if there is no pasty range of temperatures. Fig. 2 shows the temperature range of the pasty stages for the various mixtures — not that these are always completely solid at 183 C, so that this is the final setting temperature of any tin/lead solder.

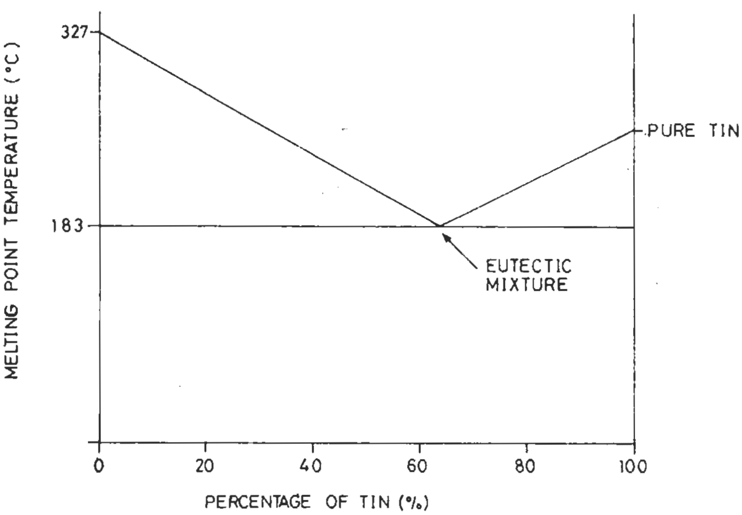


Fig. 1. Graph of melting point plotted against compositon for tin/lead mixtures.

Solder On

The reason for the popularity of the 60/40 alloy (60% tin) is fairly clear. It has a low melting point and a small pasty range; a good combination of qualities for hand-soldering. The low melting point lets us use low-power irons, and also avoids damage caused by the quick burn-off of flux which would occur at higher temperatures. The small pasty range (flux 180 C to 188 C) means that the alloy will set fairly quickly — blow on it once or twice and it's then strong enough to forget about. There are some merits which do not appear in the graph, though. One is that the 60/40 mix is one of the strongest, another is that it is the best electrical conductor of all the tin/lead alloys (about 11.5% of the conductivity of pure copper).

The 60/40 alloy, along with the 50/50, 45/55 and 40/60 alloys are the solders most commonly used for soldering small electrical equipment. Solders with lower tin contents are used for purposes where higher running temperatures are encountered, such as in lamp bases, electric motors, dynamos and fuses.

The lead/tin alloy isn't the only type of solder mixture, though, particularly for the industrial user. A straight lead/tin mixture dissolves copper, and copper is the material that we use for the business end of the soldering iron. The result is that bits of irons wear away very rapidly as the copper of the 'iron' bit dissolves, and the tracks of PCB's can also be dissolved in the same way, causing thinning of the copper layer. This problem is serious for large-scale production soldering work in particular, and can be overcome by making solder which already has a content of about 1.5% of copper. This is about as much copper as a tin-lead solder would normally dissolve, so that the inclusion of copper into the solder virtually puts an end to the dissolving of copper by the alloy from the bit or the PCB. Copper-alloy solder, invented by Multicore (a British firm), and sold under the trade name of SAVBIT is used extensively for large-scale work, and is sufficiently well proven to be approved for soldering work on military equipment.

Gold Solders Never Die

Not all soldering makes use of 60/40 alloys. For high-temperature soldering, alloys with only 5% tin are available (melting at 301 C); at the other end of the composition scale there is non-toxic solder which has 96.3% tin and the remainder silver. Such lead-free solder can be used when soldering has to be in contact with foodstuffs (as in tin-cans for example, or water pipes). Just for a bit of variety, there is also a low melting point solder, melting at 145 C, which contains 50% tin and 18% cadmium. This is of particular use in soldering onto gold, and the very low soldering temperature is an advantage for IC internal soldering. Another low melting point alloy is 62% tin, 2% silver, 36% lead, which solders particularly well to silver-coated sufaces. It finds particular use in soldering ceramics to metals. Table 1 shows some alloy compositions.

The metal, of course, is only half of the solder process. When we solder metals together, the temperature that has to be used is high enough to enable the oxygen in the air to attack the metals and the solder as well. In addition, we want the solder to spread over the surface of the metals. Now the spreading of a liquid over a solid is greatly affected by the presence of other materials — for example, water will not spread on glass if there is a trace of silicone grease on the glass. Liquid solder is equally fussy, and traces of dirt on metal surfaces will simply prevent solder from spreading.

A flux is a material which is used to avoid both of these problems. A good flux should help to clean up the metal surfaces (though it can't be expected to perform miracles) and should form a protective coating around the solder and the metals being joined so as to avoid oxidation.

For non-electrical soldering, acid fluxes can be used. These materials are acid enough to dissolve away impurities; the sort of work that is soldered in this way is usually 'pickled' in acid anyway, so that the acidity of the flux is unimportant. For electrical work, however, strongly acid flux of this type has to be avoided like the plague. It's not very often that we can boil our printed circuit boards in water for several hours to get rid of acid, and if we don't remove it then the life of the conductors will be pretty short.

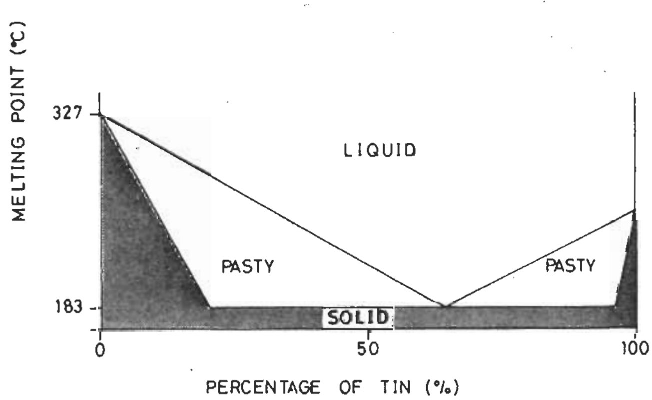


Fig. 2. The pasty part of the temperature/composition graph.

Solder Glue

Electrical fluxes are therefore based on resin, the gummy material which is extracted from wood. Molten resin flows evenly over metals, giving protection for the joint for some time. Any resin which remains on a joint is hard and non-corrosive; a useful protective coating in fact.

Unfortunately, resin by itself does not dissolve a film of oxide from a metal surface, so that it doesn't have the cleaning effect of an acid flux. Fortunately, we can make use here of the fact that soldering is a high temperature operation. Some chemicals, such as the range of salts called halides, will dissociate when heated, meaning that they will release acid vapours which will be neutralised again when the material cools. Chemicals such as tin or lead chlorides can be used for the purpose. The addition of such materials, called activators, to a resin has a very noticeable effect on the fluxing ability of the resin. The release of chlorine from a chloride, for example, cleans metal oxides very effectively, but has less adverse effects than acid on the life of the joint because the chlorine is reabsorbed wherever the material cools. Less strongly active materials can be used when there is any risk of contaminating the area around the joint. In general, fluxes for electronics use have a fairly low halide content. A few types of halid-free fluxes have also been developed, and are used for such applications as circuits which are to be encapsulated. For circuits which must have very long corrosion-free life in hot climates, pure resin-flux is available.

In the early days of soldering, the flux was always applied separately from the solder. Since Multicore pioneered the idea of flux-cored solders, the separate-flux system has died out almost completely. Though several manufacturers now make flux-cored solders, Multicore are still unique in offering five cores (Fig. 3), ensuring quick and even dispersion of the flux. In case you were in any doubt, by the way, resin cored solder is made from a thick rod of solder cast with five holes running through it. These holes are filled with flux, and the whole thing is drawn out into the fine solder which we use.

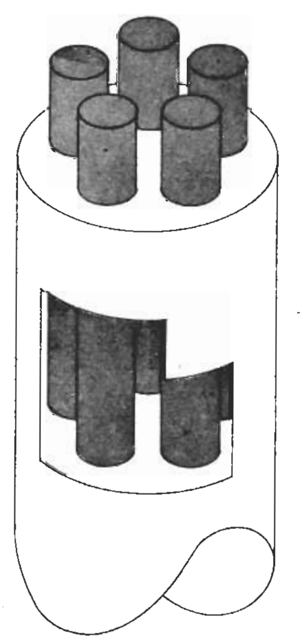


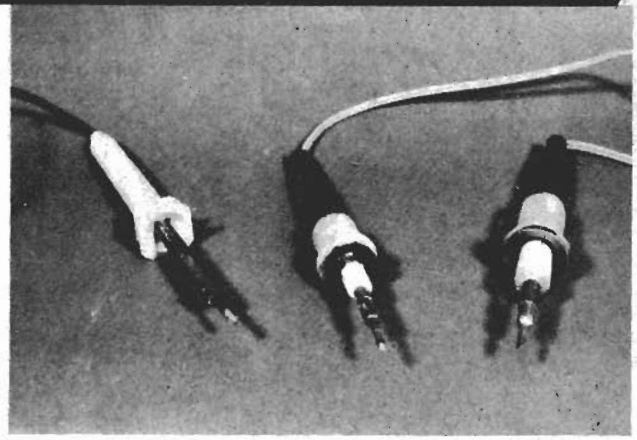
Fig. 3. Cross-section of 5-core solder.

Keep It Clean

And after all that, let's hope we are soldering correctly. Boards such as Veroboard which have copper tracks should be scrubbed clean — don't let the flux have to do all the job of cleaning the board. Similarly, tarnished leadout wires of components should be cleaned by pulling them through loops of emery-paper. For really good joints, it pays to use leads and tracks that are tinned in advance.

Make sure the iron is hot enough. Some irons always seem to run a bit cool and if a very small bit is used, the heat sinking action of a circuit board can be enough to keep the bit too cool to melt the solder properly. A very hot iron, on the other hand, will cause oxidation and burning if it's left on too long. The power output of soldering irons for electronics use is so low that a simple thyristor controller can cope, and excellent heat regulation can be obtained if an auto-transformer is also used (Fig. 4). Incidentally, a lot of awkward problems can be overcome by using ready-formed solder shapes, such as rings and spheres, or by the use of solder and flux mixed in the form of a cream or paint. ●

May the flux be with you!



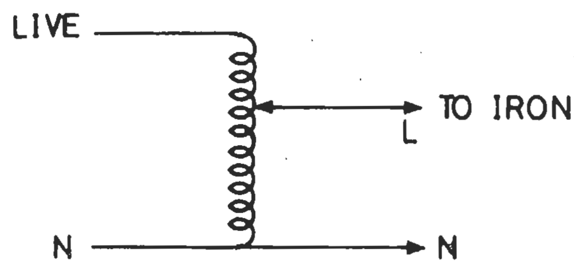


Fig. 4 Using an autotransformer, such as a variac, to control iron temperature.

ALLOY	GRADE	Melting Temp. Solidus °C	Melting Temp. Liquidus °C	USES
2/2/96 Sn/Sb/Pb	DOUBLE TWO	305	315	High temperature High creep strength
5/93.5/1.5 Sn/Pb/Ag	HMP	296	301	High melting point
95/5 Sn/Sb	95A	236	243	High melting point Lead free
Pure Tin Sn	PT	232	232	Lead free
15/85 Sn/Pb	W	225	290	Lamps
96/4 Sn/Ag	96S	221	221	Stainless steel Bright, strong, non-toxic
20/80 Sn/Pb	V	183	275	Lamps
30/70 Sn/Pb	J	183	255	Lamps, motors
31.2/67/1.8 Sn/Pb/Sb	L	185	243	Radiators, general purpose Non-electrical
40/60 Sn/Pb	G	183	234	General purpose
45/55 Sn/Pb	R	183	224	General purpose
50/48.5/1.5 Sn/Pb/Cu	SAVBIT 1	183	215	Saves copper erosion
50/49.7/0.3 Sn/Pb/Sb	Sn 50	183	212	General purpose
50/50 Sn/Pb	F	183	212	General purpose
60/39.7/0.3 Sn/Pb/Sb	Sn 60	183	188	Electrical
60/40 Sn/Pb	KP	183	188	Electrical
63/36.7/0.3 Sn/Pb/Sb	Sn 63	183	183	Electrical
62/35.7/2/0.3 Sn/Pb/Sb/Ag	Sn 62	179	179	Silver-plated surfaces
62/36/2 Sn/Pb/Ag	LMP	179	179	Silver-plated surfaces
18/180.1/1.9 Sn/Pb/Ag	ALU-SOL 45	178	270	Aluminium
50/32/18 Sn/Pb/Cd	TLC	145	145	Low melting point, soldering on gold
70/30 Sn/Zn*	—	196	307	Spray wire for metal
80/20 Sn/Zn*	—	196	268	film capacitors
30/70 Sn/Cd*	TC 30	176	240	Low thermal EMF solder

* These alloys are only available as solid wire. For those purposes where solid wire is still used on automatic appliances precision made solid wire can be made in any alloy to special order.


ETI's HELPFUL HINTS PRESENTS...
THE PROF IN HOW NOT TO SOLDER OR THE RETURN OF THE BLOB!
SIZZLE
FIRST OF ALL WE'LL DEAL WITH 'TINNING THE BIT', THIS IS OBVIOUSLY A COMPLICATED JOB BUT...
SOOP
...IT WARMS UP YOUR SOUP WONDERFULLY!
OBVIOUSLY YOU'LL BE WORKING WITH A LOT OF P.C.B.s...
P
C
B
ALWAYS LEAVE THE COMPONENTS STICKING UP AT ODD ANGLES...
...SO THEY CAN ACCIDENTALLY FLOP TOGETHER...
...WITH THE MOST INTERESTING RESULTS!!
GETTING A STRONG JOINT IS EASY~
A NICE BIG BLOB OF SOLDER WILL JOIN EVERYTHING!
ALWAYS FLICK THE SOLDER OFF THE BIT...
DANGER HIGH VOLTAGE
IT GIVES YOU THAT RAKISH DEVIL~MAY~CARE LOOK!
BUT AS A LAST RESORT~ READ THE ARTICLE ON SOLDERING IN THE NEXT ISSUE...
HARP LESSONS
IT COULD SAVE YOU A LOT OF AGGRAVATION!
FLETCH

SUCCESSFUL SOLDERING

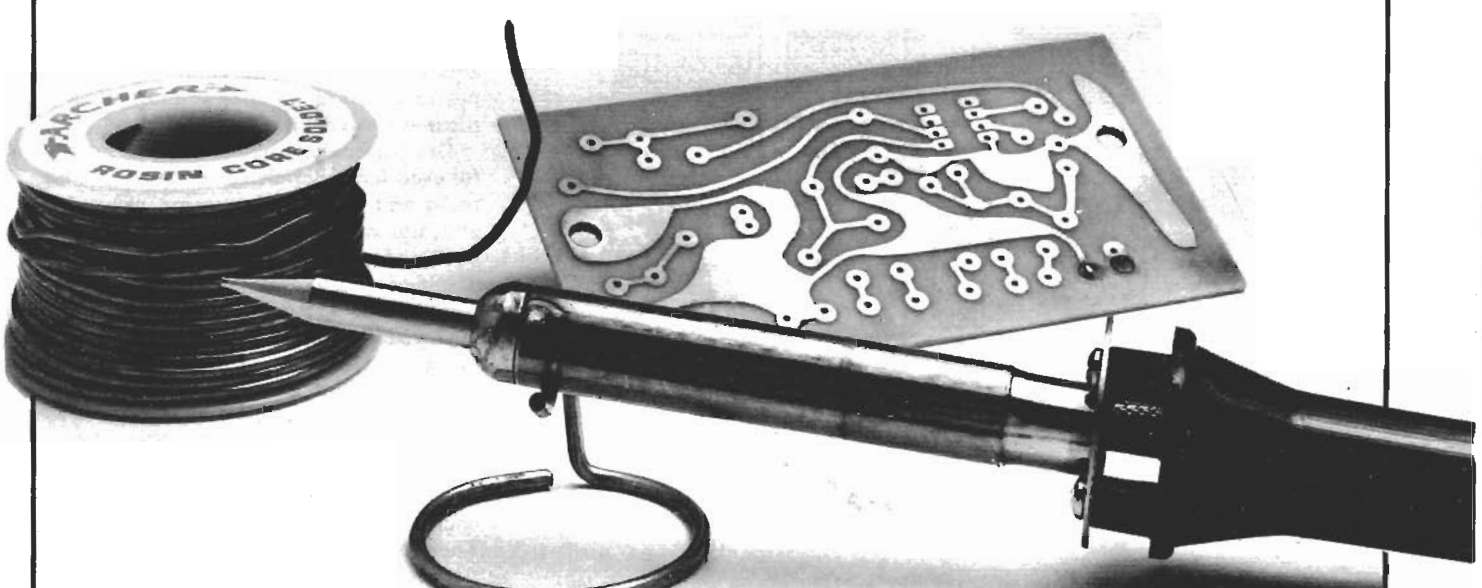
Helpful tips on materials, tools, and techniques

BY JOHN D. BORNEMAN

IN ELECTRONICS, the basic goal of soldering is to electrically and mechanically join two circuit components. For this connection to be reliable, the solder must adhere to or "wet" the mating surfaces of the components being joined. The wetting of solder to a base metal is similar to the action of water spilled on a smooth surface: if the surface is clean and free of dirt, wax and oils, the water will wet and spread evenly over it; if the surface is waxed, the water balls up.

Most manufacturers of electronic components do a good job of making their products of easily solderable material or providing a clean solderable coating. Copper, copper-clad steel, or nickel-steel are some of the common base metals used in the leads of resistors, capacitors, integrated circuits, etc., and they may be coated with silver, tin, tin-lead, or gold to improve solderability. Greases, oils, dirt, and oxides are the principal sources of contamination that prevent good solder wetting despite the original surface. Also, aging deteriorates the surface and inhibits solder wetting by the formation of oxide films.

Solder Alloys and Fluxes. Technically, soldering is the joining of two parts with a metal alloy having a melting point below 800°F. Various solder alloys include combinations of tin, lead, antimony, silver, indium, and bismuth; however, the most common combination is tin and lead. Tin-lead solders range from pure tin to pure lead and include all proportions in between. For plumbing, alloys of 10% tin and 90% lead (10/



90 solder) are commonly used. In electrical soldering, the alloy mix is usually 60% tin and 40% lead (60/40).

Characteristics of alloys of tin and lead are plotted against temperature in Fig. 1. This graph, referred to as a phase diagram, allows one to see that only a 63/37 alloy has a eutectic point--that is, a single melting point. All other alloys start melting at one temperature, move through a "pasty" or semisolid stage, and then become liquid at a higher temperature. Any physical movement of the components being soldered while the solder is in the "pasty" range will result in a "cold" joint. Such a joint appears grainy and dull, and is mechanically weaker, thus less reliable. Therefore, 63/37 or 60/40 solder is commonly used in electronics since they do not remain long in a "pasty" phase. However, a 50/50 alloy can be used if proper care is taken.

An often-ignored aspect of soldering is the *flux*. The word flux comes from the Latin root "fluere" meaning "to flow." Soldering flux, which is usually included in the solder as a central core, or separately in liquid or paste form, helps the solder alloy flow around the connection. Flux also cleans the component leads of oxides and films, and allows the solder to wet their surfaces.

Chemically, flux is either acid or rosin based. Always use rosin flux in electronic soldering since the acid may cause corrosion. "Activated" rosin or "RA" flux produces better cleaning and flowing properties than the popular mildly activated fluxes (RMA), and they are noncorrosive.

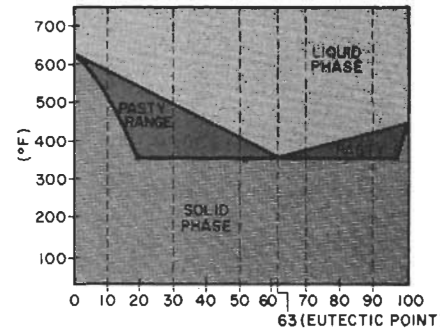


Fig. 1. Melting point, including pasty phase, of alloys of tin and copper.

Equipment. The tools required to solder electrical connections are: a good soldering iron and a supply of replaceable tips, long-nose pliers for holding parts or bending leads (or as a heat sink for temperature-sensitive components), and desoldering braid (or a suction desoldering tool).

There are basically two types of soldering instruments—the "gun" and the "iron," although most people use these descriptions interchangeably. In essence, a soldering "gun" is a pistol-shaped device consisting of a transformer forming the bulk of the "gun," with the secondary winding extending out to form the replaceable tip. Usually, soldering guns come with high wattages, in most cases too high for use with pc foil patterns. Such guns also generate a high magnetic field around the tip that can de-gauss any magnetically sensitive devices close to it. Using a gun may produce too high a heat on the foil pattern so that the cement that secures the copper foil pattern to the substrate is weakened and the foil separates from the printed circuit board.

The "iron" is often called a "pencil iron" because it resembles a thick pencil that is held in the fingers. These tools feature interchangeable (usually screw-on) tips having various shapes—each for its own purpose. Their wattages are usually low enough to be safely used on pc boards. The latest version of the pencil iron is the low-wattage self-contained rechargeable type that can be used remote from the ac line.

Soldering irons are specified primarily by wattage as shown in the table. Wattage represents the amount of heat capacity available at the iron tip. Irons of all wattages usually run at about the same tip temperature, but a lower-wattage iron will cool faster during soldering. The recommended wattages given in the table are to be used as general guidelines only. Slight variations may give perfectly good performance, depending on the particular soldering situation. A higher-wattage iron is more likely to damage heat-sensitive components. If static-sensitive components are to be soldered, i.e. many MOS devices, be sure the iron has a grounded plug. Soldering irons can produce static voltage spikes that will destroy many integrated circuit components, so a grounded tip is a wise safety measure.

Tips are usually selected by preference. Each type and shape has its place and purpose, but the commonly used pointed, conical type is the most versatile and convenient.

Desoldering equipment is always useful even for experienced solderers. Both braid and suction devices are effective and, again, operator preference is the best guide. If you elect to use a suction desoldering tool, pay close attention to the distance and velocity that the "piston" requires. It is very easy to get a black eye, or have glasses damaged, when using those devices.

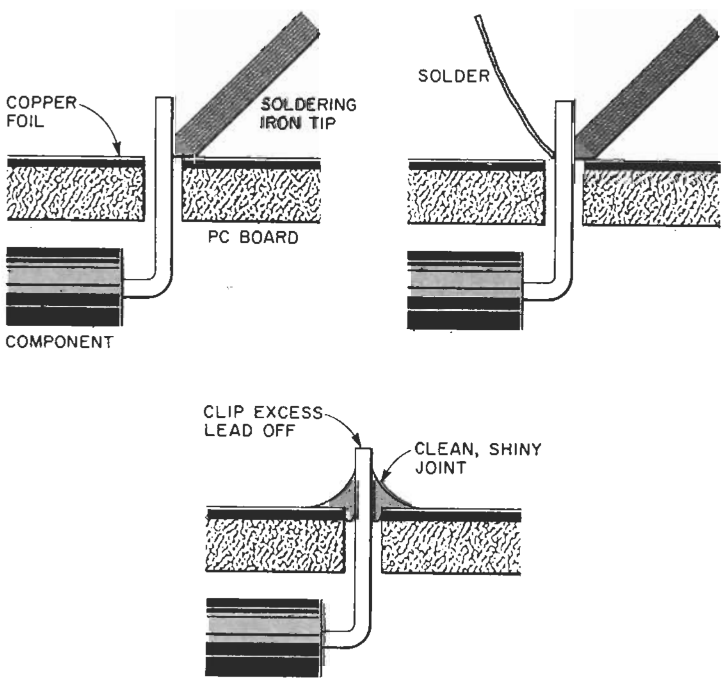


Fig. 2. Steps in soldering. Place heated iron to junction of parts to be soldered (top left). Bring flux-cored solder to the joint after it is hot enough to melt solder (top right). When a smooth-contoured fillet has formed, remove the solder and allow to cool without moving.

Soldering Techniques. The best technique can be outlined simply. First, make sure that the tip of the iron is at operating temperature, and is clean. Then touch the heated tip to the connection, preferrably on the part having the larger mass (Fig. 2). The solder should not be brought to the joint until the

IRON WATTAGES FOR DIFFERENT SOLDERING TASKS

Type of Soldering	Recommended Iron Wattage
Light duty: single joints, repair, touch-up, delicate parts such as ICs or fine wires. Mass of parts in connection is small.	25 to 30
Medium duty: multiple joints; many in succession. Mass of parts is intermediate (for example, 1/4-watt resistors or conventional disc capacitors).	60 to 100
Heavy duty: Mass is large, as in wires soldered to steel case or wires to screw heads for ground points.	over 100

metals being joined have become hot enough to melt it. How long this takes is quickly learned after a few trials. The flux-cored solder is then brought to the joint and placed at the junction of the two parts. When the solder has melted and flowed into a smooth-contoured fillet, remove the solder. Keep the tip on the joint for a few seconds, then remove it. Do not disturb the newly made connection until it has had time to solidify. A good solder joint will be shiny (Fig. 3). Disturbing the joint before it has solidified may produce a "cold" joint.

Problem Solving.

To Avoid Cold Joints. Even when you know that the parts should not be moved while the solder joint is cooling, it is sometimes difficult to find enough hands to hold a soldering iron, solder, circuit board, and the part being attached. In this case, a small vise or a surgeon's hemostat may be used to hold the board and parts. If you are using rosin flux in liquid or paste form, another method is possible. Using long-nose pliers, hold the part to the circuit board. Apply flux to the pieces being soldered and take up the soldering iron. Touch the iron to a length of solder, creating a ball on the tip. Touch the tip to the connection and hold it there until the fillet is formed. This will create a good joint and free your hands to hold the parts.

To Get Good Solder Wetting. Clean the parts well with isopropyl alcohol to remove greases and oils, and use a 10% solution of hydrochloric acid (HCl) to remove the oxides. Fine steel wool may be used on foil patterns to remove oxide films. These chemicals should be available from any drugstore, but remember to ask about any handling precautions before using them. Note that extra liquid flux can also help in soldering contaminated parts.

To Make Solder Flow. Be sure the soldering iron is providing enough heat, with the iron tip on tight and the proper wattage being used. Also be sure enough flux has reached the component leads and that it is not necessary to add extra liquid or past flux. Do not keep the iron on the joint or continue adding solder if a connection is not made after two trials. This will only damage the components or the circuit board.

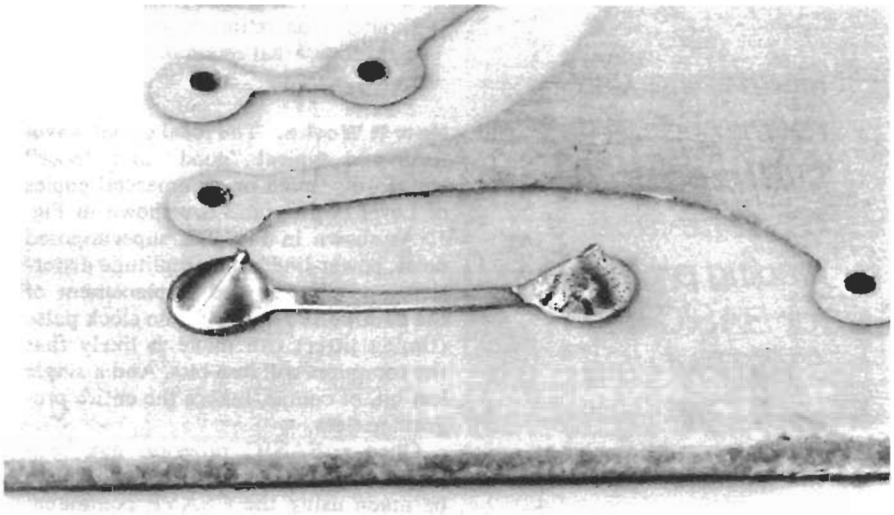


Fig. 3. Photo of two soldered joints. The one at left is shiny indicating a good joint. At right, is a "cold" solder joint.

To Solder ICs and Other Small Components. Use only a low-wattage iron and sharp tip to avoid excess heat. Also, use 0.031-inch diameter solder to help control the amount of solder deposited. Provide a heat sink by using long-nose pliers to grasp the lead between the component package and the portion to be soldered.

After completely soldering a pc board, an inspection of the soldered joints is suggested. A toenail clipper can be used to trim any lead ends so they don't protrude too far from the solder. To help in the inspection, a bright spotlight and low-power lens can be used to examine each joint. A sharp tool can clear away dross, solder bridges, or anything that looks suspicious between solder pads, and a toothbrush can be used to clean the solder joint. To make sure that all joints are checked, a drop of red nail polish can be placed on each after inspection. A minute spent checking a board can save an hour of troubleshooting later on.

Another problem can arise when a plastic capacitor appears to be "soldered" in place, but is not making an electrical connection. This often happens when a small "sleeve" of nonconducting plastic extends from the capacitor body slightly down each lead. The solder will hold the plastic to the pad, but an electrical connection may not result. Use long-nose pliers to break away the unwanted plastic.

Since your fingers may be dirty or oily, handle parts and circuit boards as little as possible. If there is any question of oily spots on a part, clean it using isopropyl alcohol or fine steel wool. If you use steel wool, use lint-free cloth to remove all vestiges of the wool from the parts or board.

To Summarize:

(1) Use clean new parts and circuit boards.

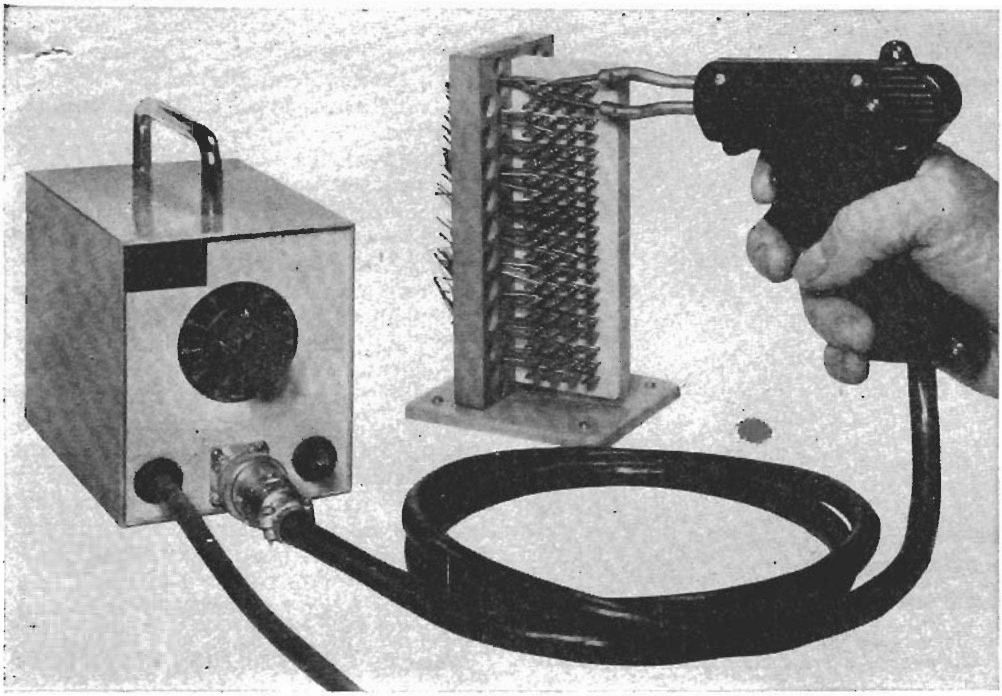
(2) Use 60/40 or 50/50 tin-lead alloy solder with an activated rosin core. Liquid or paste rosin flux may be used to improve wetting when necessary.

(3) Use the proper wattage soldering iron based on the amount of soldering to be done and the type of components being soldered.

(4) Use the proper soldering sequence—tip to parts, solder to parts—solder away from parts—tip away from parts.

(5) Use patience.

(6) Practice. ◇



RESISTANCE SOLDERING

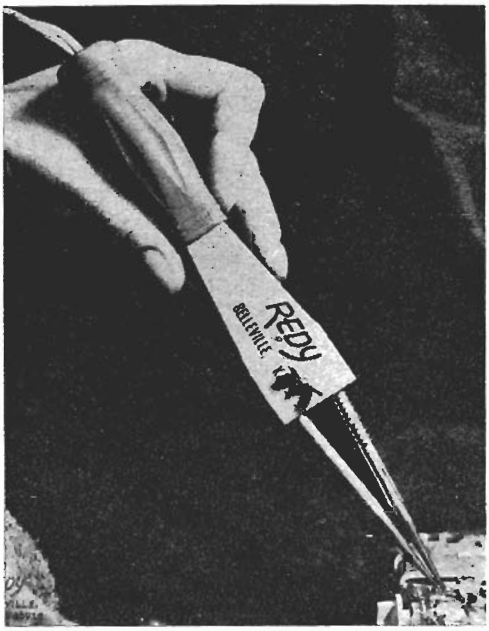
A safe, economical, and reliable technique for soldering modern electronic equipment

BY MELVIN WHITMER

MOST HOBBY ELECTRONICS enthusiasts struggle along with soldering irons and transformer-type soldering guns, little aware that a much safer and more reliable soldering tool is in the offing. This superior tool employs a resistance soldering technique that can eliminate or vastly reduce heat damage, cold-solder connections, and the hazard of burns to the operator.

Resistance soldering—relatively new in hobbyist and experimenter circles—is used in many industrial applications where it is considered to be superior to soldering irons and guns. Advantages include considerable savings in time and cost, better quality in soldered connections, and long-term soldering-equipment reliability. In some instances, particularly the space program, the U. S. Government specifies only the resistance soldering technique.

The purpose of this article is to introduce you to the advantages of resistance soldering and point out that most of the problems that can arise in soldering are due to the use of "conventional" soldering tools.



This is a tweezer-type electrode assembly that is commonly used with resistance soldering equipment.

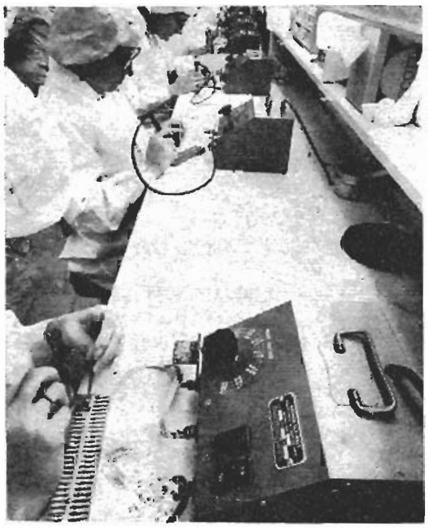
Resistance Soldering Technique. In a conventional soldering iron, heat is produced within the tool by a heating element or cartridge. The heat is then stored in a metal soldering tip. The size of the tip determines the soldering iron's ability to store heat; a small tip stores less heat than a larger tip, thus restricting the application of a small iron to relatively few soldering applications.

Transformer-type soldering guns fare slightly better than the conventional iron. Since the heat is developed directly in the low-mass tip of the soldering gun, no heating element is required. However, any heat produced by soldering irons and guns must be transferred from the soldering tip to the connection being soldered. It is inevitable, since the thermal activity takes place within the tool itself, that some of the heat will be transferred to the connection and some to the air surrounding the soldering tip. And, there is the ever-present possibility of damaging nearby components and wiring while soldering.

A more direct approach to developing heat is employed in the resistance soldering technique. Heat is not developed *in* the resistance soldering tool. Rather, it is generated and confined within the connection being soldered. To accomplish this, a technique similar to that used in the transformer-type soldering gun is employed.

In practice, the 117-volt line is stepped down to a low voltage (25 volts or less) by transformer action, just as for the gun. However, no tip is used in resistance soldering. Instead, two electrodes are applied to opposite sides of the connection to be soldered. Power is applied and alternating current circulates between the two electrodes and the connection. The high current flowing through the connection causes the connection itself to heat up almost instantly to the melting temperature of solder. (The connection generally has much higher resistance than the electrodes, which accounts for the generation of heat.) As a result, individual connections can be soldered in less time than with conventional soldering tools.

Because the connection itself must attain the melting temperature of solder, "wetting" of the joint, necessary to a well-soldered connection, is complete and cold-soldered connections are eliminated. Stating this in more meaningful terms, resistance soldering creates the optimum soldering conditions without passing through a middleground. You can't apply solder to a "cold" connection.



Selectable power ranges and timed-on cycles are features in most industrial equipment.

Advantages Of Resistance Soldering. Once the basic principle of resistance soldering is understood, the advantages of this tool become more obvious. In the first place, generation of instantaneous, yet confined, heat does away with idling time, wasted power, and the potential source of dangerous operator burns. Because the heat is confined to a very small area, heat damage to delicate components and wiring is minimized. (This applies only if the tool is used according to the recommended procedure. Heat damage can still occur if power is applied for too long a time.)

There are also some less obvious advantages to resistance soldering. Most of these are of the long-term type, such as extended equipment reliability. The soldering electrodes, made of carbon, graphite, or an alloy metal, do not become heated while soldering, nor do they corrode—so replacement is an infrequent problem. Finally, efficient generation of heat also means lower electrical power consumption and a saving in the amount of solder used.

The only disadvantage of resistance soldering is the possibility of causing high-voltage damage to some types of delicate transistors and integrated circuits. Bear in mind that a high-current voltage produces the heat. If this applied voltage is allowed to bridge the terminals of some solid-state devices, permanent damage can result. However, a properly designed tool will eliminate this problem.

Some people may feel that the relatively high cost of resistance soldering tools is a disadvantage. But when weighed against the many advantages of resistance soldering equipment, the difference in cost is negligible. And if you construct your own equipment, it is likely you will pay less for parts than you would expect to pay for a top-quality soldering gun.

Now that you're aware of the advantages of resistance soldering, perhaps you'll want to build your own equipment. The instructions follow. —30—

BUILD A RESISTANCE SOLDERING TOOL

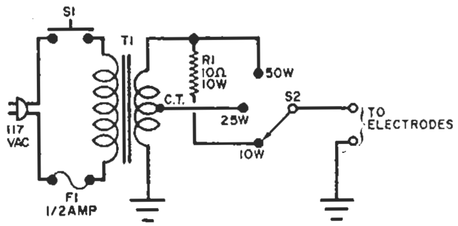


Fig. 1. Center tap and current-limiting resistor provide selection of three power ranges.

THE FACT THAT MOST KITS returned to the manufacturer or supplier suffer from little more than bad soldering is argument enough for the hobbyist to become acquainted with resistance soldering. If you feel that you must exercise undue caution when soldering, then you owe it to yourself to investigate resistance soldering at first hand.

The Power Supply. The schematic diagram of an inexpensive resistance soldering setup is shown in Fig. 1. It consists of a simple low-voltage a.c. source for supplying the high current needed for resistance soldering. Transformer *T1* is a 10-volt center-tapped, 5-ampere filament transformer (Allied Radio number 54B3720, or similar). It is capable of delivering the power ranges indicated at the contacts of *S2*. The 50- and 25-watt ranges are tapped directly from the "hot" and center-tap leads, while the 10-watt range is derived by installing a current-limiter resistor (*R1*) in the 10-volt line.

A top limit of 50 watts may not appear to be adequate for point-to-point soldering, but the power is converted into heat that is contained only within the connection being soldered. As a result, 50 watts is generally more than adequate for all but the largest connections you are likely to encounter.

Switch *S1* almost of necessity must be a footswitch. When a footswitch is used, one hand is free to use the soldering electrode assembly while the other feeds solder.

Construction. Since potentially hazardous 117 volts a.c. is present in the primary circuit of *T1* it is necessary that the power-supply circuit be housed inside a sturdy container, such as a steel or aluminum utility box. The transformer should be located so that all components associated with the primary circuit are completely isolated from those in the secondary circuit. The location of each component, however, is not critical.

When running the line cord and the footswitch cable into the box, use heavy-duty plastic, line-cord strain reliefs to prevent the cables from chafing or working loose. Also, a pair of five-way insulated binding posts or banana jacks will provide a convenient means of connecting the electrode assembly cable to the power supply.

Wire the components together, using Fig. 1 as a guide. Make absolutely sure that neither of the primary taps of *T1* are grounded or otherwise shorted to ground. The only points that should be grounded are in the secondary, low-voltage circuit.

The body or handles of the electrodes must be relatively heat-resistant and non-conductive. Fiber test probes (H. H. Smith Type 323, or similar), or bakelite or fiberglass tubing, are ideal for the handles. Do not use plastic utility test prods.

Two types of materials are commonly used as electrodes. The most rugged electrodes are made of a metal alloy. For careful constant use, carbon or graphite (pencil lead) is suitable. However, for the relatively low power available from the power supply shown in Fig. 1, the original test probe tips will suffice—as long as the chrome plating remains intact.

When you use commercially available alloy electrodes or graphite, the test probes must be fashioned into pin chucks. The drawing in Fig. 2 demonstrates how this is done. First, you cut

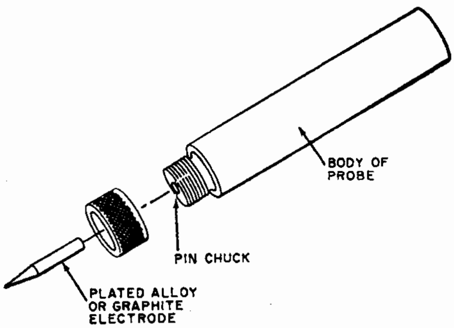


Fig. 2. Fiber test prods, fashioned into pin chucks, serve as holders for the electrodes.

away the pin tip of each probe, remove the knurled retainer cap, and chuck the probe in a vise. Next, drill a hole, slightly smaller than the diameter of the electrode you choose, about 3/8" deep at the tip of the probe. Screw an appropriate brass nut on the threaded end of the probe, and carefully cut a 1/4"-deep notch, as shown, with a fine hacksaw blade. Finally, spread the notch just enough to allow the electrode to drop into the hole.

The drawing in Fig. 3 shows how to make a simple tweezer-type electrode assembly. The spring should be secured to the probe bodies by tightly winding a single layer of #22 bare wire around the probe bodies and spring extensions as shown. Liberally apply epoxy cement over the wire winding, line the probe tips up, and chuck the assembly in a vise until the cement sets.

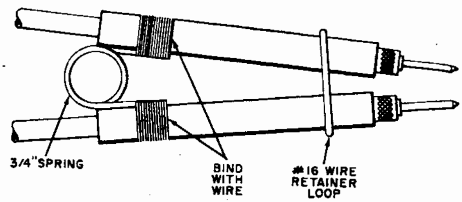


Fig. 3. Tweezer assembly can be fastened by securing electrode holders to torsion spring.

When the epoxy cement sets, form a flat loop of 16- or 14-gauge wire with the inside of the loop measuring slightly larger than the diameter of the probe body. Its length should be calculated to allow a mixirnum *tip* travel of 1" when the loop is fixed in place, again with epoxy cement, to only one probe body as shown.

Slide one end of a 5' length of heavy-duty test lead wire into each probe, securing them in place with the knurled retainer cap removed earlier. Affix suitable connecting plugs to the other ends of the test lead wire.

How To Use. With the electrodes chucked into the probe tips, plug the electrode assembly cable into the power supply and the power-supply line cord into an a.c. receptacle. Connect the leads of an a.c. voltmeter to the probes and momentarily actuate the footswitch. The meter should indicate either 10 or 5 volts, depending on the position of *S2*. Do this for all three settings of *S2*. If you obtain 10 volts in position *1*, 5 volts in position 2, and 10 volts in position *3* (50, 25, and 10 watts, respectively), your wiring is correct.

Use the probes as you would use a pair of tongs, closing them until the tips of the electrodes touch the opposite sides of the connection being soldered. Depress the footswitch, and touch the tip of your solder feed to the connection as close as possible to the electrodes. As soon as the solder begins to flow, release the footswitch and remove the electrodes and solder feed.

To determine which of the three ranges you should use for a given job, start with the lowest range and follow the procedure outlined above. However, if the solder fails to flow after applying power to the electrodes for approximately three seconds, move to the next highest range. The correct range to use is the lowest one that causes the solder to flow within the allotted time.

Two precautionary notes are worth mentioning. First, never apply power to the electrodes before the electrodes are in contact with the connection being soldered—only after. And make sure the electrodes touch only the connection being soldered to prevent a circulating current through nearby components. —30—

SOLDERING TOOL PROBLEMS

I have assembled the soldering equipment as per the instructions provided in the "Resistance Soldering" article (September, 1968). When making the electrode assembly, I took particular care to follow the text of the article and Fig. 3. Then, when the system was completely assembled, I performed the outlined meter check. Since both the primary and secondary circuits checked out good in all three positions of the power range switch, I decided to tackle my first soldering job.

Immediately, I noticed a problem. A few seconds after applying power to the soldering tool, the fuse blew and the solder barely became hot enough to flow. What is my problem?

H. H. LAWLEY, JR.
Box 745
Elizabethton, Tenn.

Several readers have advised us that their Resistance Soldering tools either failed to operate or operated improperly. In most cases, the difficulties outlined were blown fuses and/or test leads that heated up while the electrodes remained cold.

After carefully checking into the problem and rebuilding the prototype exactly according to the instructions provided in the article, your editor finds that the tool should operate as described. However, to clear up the problems, the following advice is given: First, use only extra-heavy-duty test lead cable between the power supply and electrode assembly. Next, make sure your soldering electrodes are sharpened to fine points and that only the points touch the terminal to be soldered. This will assure that the high resistance to the flow of current is at the electrode tips and not inside the power supply or test leads.

MORE ON RESISTANCE SOLDERING

After reading your "Resistance Soldering" article (September, 1968), I wonder whether it would be possible to use two sharpened carbon rods from a dry-cell battery for the electrodes. The rods, at least, won't accumulate solder. Of course, I realize that the rods would have to be insulated.

WILLIAM F. MANGANARO
Portsmouth, N.H.

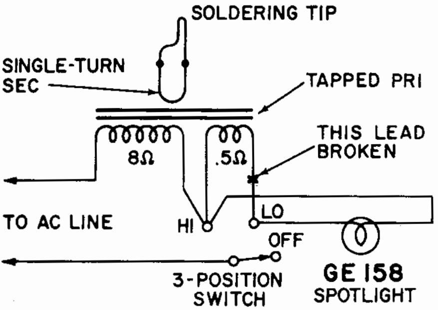
Although we haven't tried using the carbon rods referred to, there should be no reason why you can't try them if you have an old defunct battery handy. It should be pointed out, however, that these rods are soft and very fragile. In use, they tend to crumble, even if only a slight pressure is applied to them.

SERVICE NOTES

GUN TROUBLE

I own a Weller model 8200-N, dual-heat soldering gun. One day, during use, the spotlight burned out. I found that even larger radio supply houses do not stock this item (G-E No. 158), and finally located a pair of them in a large electrical supply house. In the meantime, I had continued to use the gun but found that it was effective only on high-heat. I presumed the switch had broken down. It has 3 positions: OFF, LOW-HEAT and HIGH-HEAT.

I inserted a new lamp, but it burned out instantly when I pressed the switch to the LOW-HEAT position. It appeared that the lamp may have



been defective, so I plugged in my last one. Again, a bright flash! That did it!

I took the gun apart and discovered a broken lead. See diagrams. Note how this break prevented a low-heat connection (without the lamp), and also caused instant burnout of a good lamp. The lead that broke is very short (perhaps accounting for the break) so I extended it about one-half an inch with additional wire before resoldering it to terminal.

If you run into the same problem, investigate before you plug in a new lamp. They are difficult to find, and they cost about 25¢ apiece!—*I. Queen*

Engineer's notebook

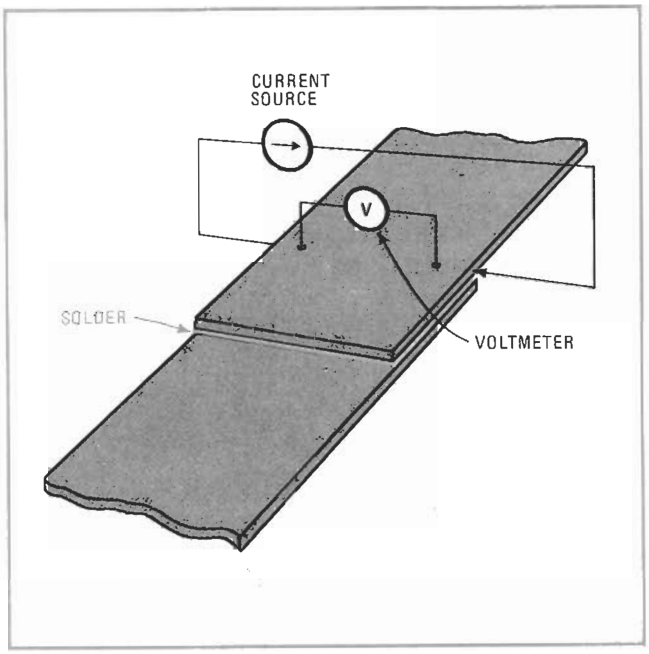
Four-point method tests solder joints

by J. R. Pivnichny and J. R. Skobern
IBM Corp., Endicott, N.Y.

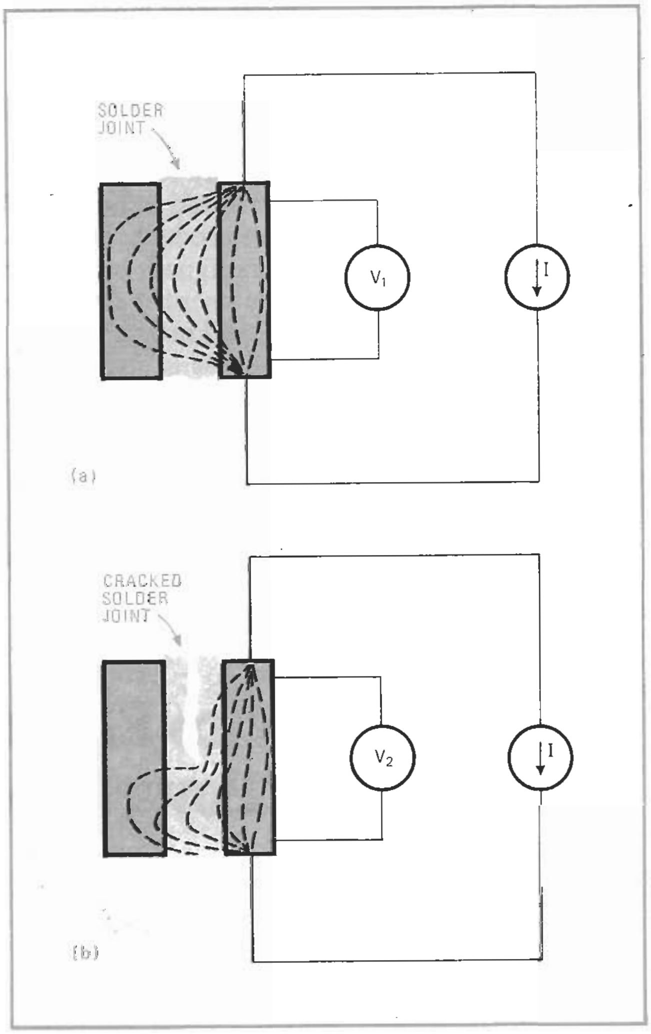
If a solder joint cracks it may cause expensive system failure. And it often will crack when mechanical forces exceed the design limits or when the soldering process is poorly controlled. In either case, electrical testing can detect a defective joint before it reaches the stage of system assembly. Figure 1 illustrates the use of such a test to check the overlap joint between a flat-wire bus and a connector strip.

The quality of the solder joint between overlapping metal strips can be monitored with a four-point (or four-probe) resistance-measurement technique (Fig. 2). The output and return leads of a constant-current

1. Test arrangement. Measurement tests joint between bus and connector. Soldered assembly, in jig, is shown close up in Fig. 4.



2. Solder joint. Four-point measurement monitors quality of connection between overlapped metal strips. Constant-current source drives current into and out of one strip; voltmeter measures drop between two points adjacent to current probes. Voltage indicates resistance to current spreading through solder to second strip.



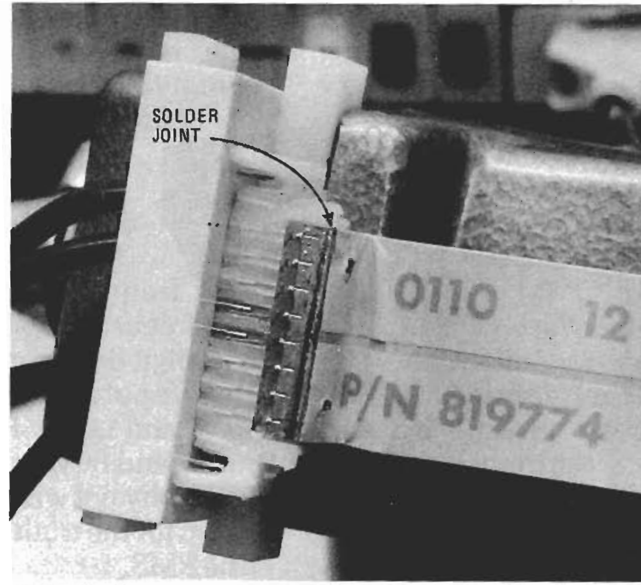
3. Current flow. Section views through metal strips and solder joint show how quality of joint affects current spreading. (Scale of drawings is distorted, magnifying thickness of solder layer for clarity.) Good connection allows conduction through both metal strips, presenting low resistance to current flow and producing low voltage drop. Cracked joint restricts current flow and produces voltage drop that is typically three times as great as for good joint.

source are attached to one strip near the solder joint. The path for current flow includes the conductors on both sides of the joint and the solder interface between them. Voltage drop is measured between two points close to the current probes. This, divided by the known constant current, indicates the resistance between the two points.

A good solder joint allows current to flow through the solder and into the second metal strip (Fig. 3a). This spreading of the current produces a low resistance between the voltage-monitoring points. A cracked joint, however, interrupts the current path to the adjacent conductor (Fig. 3b). The constricted current path increases current density and hence the apparent resistance at the monitoring points.

A typical test arrangement uses a current of 100 milliamperes. The resistance values for good joints lie within 10% or 15% of an experimental average value, but a defective solder joint has a resistance that stands out as a 300% increase over the average level. Therefore, limits for go/no-go testing are readily established. Photographs of a working test arrangement are shown in Figs. 1 and 4. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.



4. Application. This flat-wire bus has been soldered to a beryllium-copper connector strip that has eight terminal points. The connector strip will be used to join the bus to a pc board, but first the quality of the solder joint is checked by using four of the terminal points as measurement probes. Current source is connected to the two outermost points; digital voltmeter is attached to the next two in.

Soldering aluminium alloy

With all due respect, News of the Month (July issue) be blowed!

My grandfather — God rest his soul — showed me how to solder aluminium through mineral oil during World War II. He used to solder ali patches onto frost-bitten alloy engine cylinder heads, instead of welding the heads. This was done because of the shortage of gas and the time taken to pre-heat an alloy casting in a muffle to enable welding to be done without cracking the casting.

I have been using the same method since then to solder ali chassis in the construction of amateur radio equipment without any trouble, and only in June 1971 I demonstrated the very same method in the B.O.A.C. workshops where I am employed. I still have the demonstration piece, if anyone would care to inspect it, which is soldered by its *edge,* not on a flat surface, and is still giving good service in the equipment for which it was made.

Corrosion and electrolytic action have not been found to occur where the oil used was clean and pure mineral, and where the joint was properly washed and protected from the air afterwards, by a light coating of Vaseline or lacquer. Even an untreated joint should not deteriorate for a considerable time, by my experience.

Walter S. Williams,
Ewell, Surrey.

Soldering Iron for PC Work

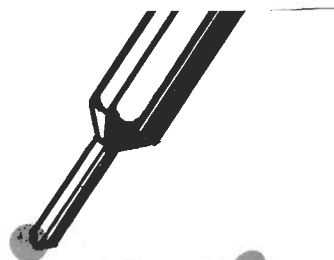
Q. *The only soldering iron I have is rated at 75 watts. I know that this is too much for pc work, so is there any way I can make a new tip, etc., so that I can use the iron that I have?*

A. About the best way to do this is to insert a silicon diode in series with the power line to the iron. Get a diode that has a large enough current rating (in amperes) to take the iron. Then the iron will run at half power and will be "cool" enough for board work. Keep the tip sharp and clean.

Another trick is to wrap some heavy, bare copper wire around the tip, and use the loose end for fine pc soldering.

Have a problem or question on circuitry, components, parts availability, etc.? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

Solder & Soldering



WHAT GOES INTO A GOOD ELECTRICAL CONNECTION

BY CLIFFORD L. BARBER
Research Director, Kester Solder Co., Div. of Litton Industries

SOLDER is one of civilization's oldest and most widely used alloys. Its many uses and applications readily lend themselves to relatively simple techniques and processes. Yet, this alloy is one whose properties are traditionally a subject of wide technical and scientific misunderstanding.

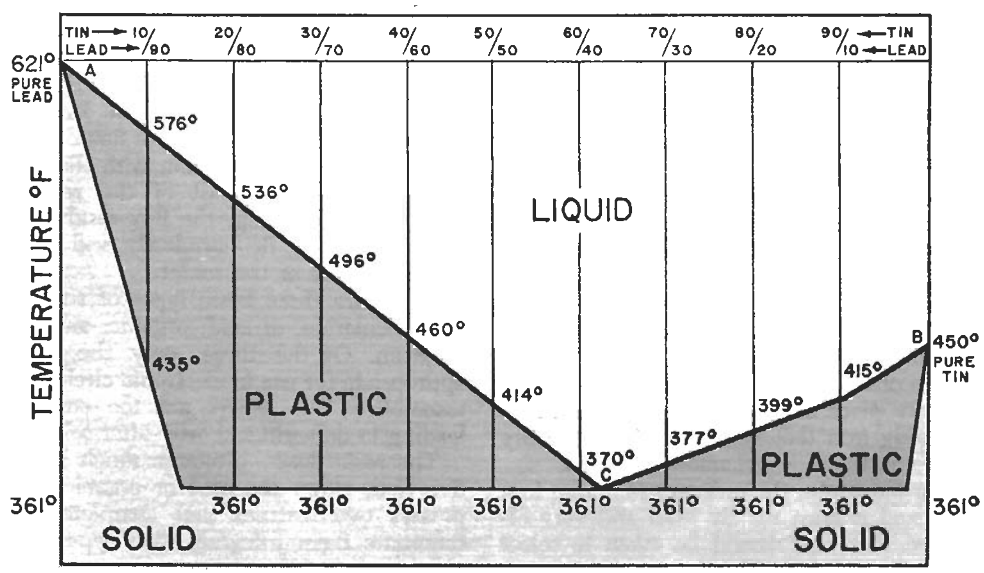
The somewhat limited technical knowledge many people have with reference to solder is even more pronounced in the case of soldering fluxes. In view of the fact that solder and its fluxes are fundamental to electronics, whether in industry or in the pursuit of a home hobby, it is not surprising to learn that a great deal of the difficulties found in electronic equipment can be traced to poor soldering and/or poor solders and fluxes. And that poor soldering can, in turn, be traced back to the operator's lack of knowledge about the principles and practices required for good soldering.

Soft solder is a fusible alloy whose basic components are tin and lead. Occasionally, small amounts of such metals as silver, antimony, or bismuth are added to the tin and lead for one reason or another.

Solder is used to join two metals, in a metallic union, at temperatures well below the melting points of the metals being joined. Since soldering is exclusively an intermetallic proposition that takes place between metals only, it is important that the metals be free from all nonmetallic material. Chief among these materials are oxides which form to a greater or a lesser extent on the surfaces of all ordinary metals.

Oxides form an insulating barrier that prevents metal-to-metal contact. Such ox-

Fig. 1. Tin-lead fusion diagram shows eutectic point with alloy of 63% tin, 37% lead.



ides or any other inert or nonmetallic material on the surface of the metal to be soldered will foil any soldering attempt.

Metal "Solderability." When soldering, the first consideration to take into account is the "solderability" of the metal to be soldered. Solderability is a function of the natural chemical affinity of the metal for solder, the cleanliness of the soldering surface, and any applicable soldering aid, such as hot tinning or electroplating.

It should be understood that some metals are not solderable in their natural states. They simply do not have a metallurgical affinity for solder. Some examples are aluminum, silicon, magnesium, chromium, and tantalum. To solder such metals it is necessary first to plate their surfaces with metals that will readily take to solder. Plating metals to obtain solderability, it is interesting to note, is not confined to the unsolderable or difficult-to-solder metals only. It is also widely used on virtually all easily solderable metals to increase their solderability and prolong their shelf lives.

Nonmetals, too, such as glass or ceramics, can be made solderable by a process known as "firing." Here, powdered silver is mixed with a borate and heated to a point of incipient fusion with the base substance. The result is a physical entrapment of metallic silver on the surface of the nonmetal.

Soldering Problems. One of the most common faults in soldering is the application of insufficient heat. The solution or alloying action in soldering just cannot be achieved without a uniform distribution of heat between the solder and the metal being soldered. If hot solder, for example, is applied to cold metal, or cold solder is applied to a hot metal, there can be no soldering action. Proper soldering can take place only when the metal being soldered is hot enough to maintain the solder in a liquid state. Anything less results in a "cold" soldered joint.

It is important to recognize that soldering depends on the amount of heat absorbed by the metal being soldered. A common source of frustration is the attempt to solder a heavy piece of metal with a low-wattage soldering iron that has insufficient capacity to deliver the required amount of heat.

For most jobs, the ordinary soldering iron or pencil is most widely used and very effective. But care should be taken to select an iron with a wattage capacity that is adequate for the job. The tip, usually a solid bulk of pure copper, should first be cleaned and tinned with solder before any attempt is made to use it in actual soldering. (Wear on soldering tips is not due to erosion or to the soldering flux. It results from the molten solder. Wear is often dealt with by plating the copper tip with iron, but such tips are less effective in transferring heat to the metal to be soldered.) Most important is that the applied heat be adequate to bring the metal being soldered to the alloying temperature.

Flux-core solder combines solder and flux, substances whose properties are physically and chemically very different. Taking into account this dissimilarity, flux-core solder is applied according to a technique that provides for the simultaneous liberation of both substances at a single point where the action of both is required. This application technique can be stated as follows: "Apply the flat surface of the adequately heated soldering iron directly against the assembly and simultaneously apply the cored solder strand at the exact point of iron contact."

Soldering Flux. Soldering is a solvent action that takes place between metals. This action does not take place if the metals are insulated from each other by any type of nonmetallic barrier. It is the function of the soldering flux to remove any such oxide film or barrier and to keep it away during the soldering operation so that the respective metals can make metallic contact and alloy with each other.

A soldering flux, then, is something that causes the liquid solder to make contact with the metal being soldered, or, in technical jargon, to "wet" the metal. Let it be understood, however, that the flux does not enter into chemical reaction with the metal and constitutes no part of the resultant alloy. After soldering, the flux residue and captured oxides, lie harmlessly and inertly on the surface of the solder.

There are three basic types of soldering fluxes: chloride, or acid; organic; and resin or rosin. Of the three, only the last is appropriate for use in electronic circuits and assemblies. The others are too corrosive, leading to difficulties shortly after soldering.

The rosin fluxes, although much less active than either the acid or organic types, possess two features that completely differentiate them from all other types: they

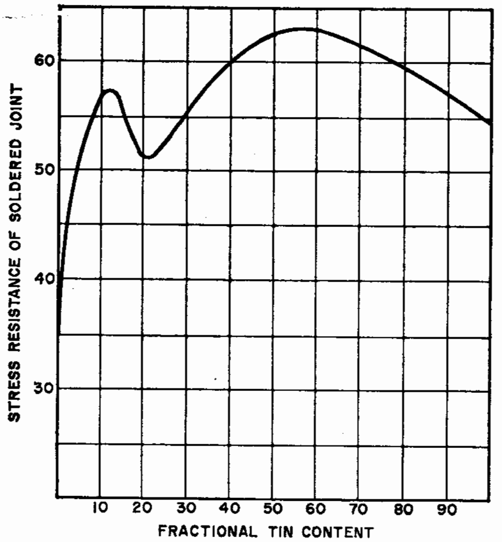


Fig. 2. Graph shows change in joining quality of tin-lead solders with increase in tin content, based on resistance of soldered joint to stress.

are non-corrosive and non-conductive. These two characteristics make the rosin fluxes very adaptable to electrical and electronic assembly.

Most active in the rosin group are the activated rosins, or resins. They are the same as the pure rosins except that they contain small amounts of a dissolved catalyzing substance that causes the rosin to be more active. Although considerably more active than straight rosin, the non-corrosive and non-conductive properties are comparable with those of pure rosin.

In more than 20 years of worldwide use, there has never been an authentic instance of corrosion attributable to the rosin flux residue.

The Solder Alloy. Solder secures attachment by virtue of a solvent or metallurgical action. But this alloy action will not take place unless the solder is of adequate quality with respect to composition and purity.

When tin is added to lead, the melting point of the lead decreases along a composition-temperature line. Similarily, when lead is added to tin, the melting point of tin is lowered along another composition-temperature line. The intersection of these two lines is the eutectic point (see Fig. 1). The composition is the eutectic alloy made up of 63 percent tin to 37 percent lead, and the temperature is the eutectic temperature of 361°F. It will be observed that solder compositions other than the eutectic alloy do not have a sharp "melting point." Rather, they have a plastic range extending from the eutectic temperature of 361°F to the melting point of pure lead or of pure tin (621°F or 450°F, respectively).

The eutectic has a laminated microstructure characteristic of a single constituent. Other solders have a multicomponent microstructure showing high tin or high lead crystals imbedded in the eutectic.

Since tin possesses a higher metal solvent action than does lead, the alloy quality of solder is very closely related to its tin content. As can be seen in Fig. 2, solders containing 30 percent tin are markedly inferior in joining quality. There is an extremely abrupt decrease in alloy quality beginning at about 20 perent tin; solders in this alloy range are sluggish, immobile, and difficult to use.

Complicating the quality of these low-tin solders is a tendency to incorporate soldering fluxes that are inadequate from the standpoints of flux content and flux stability. When attempting to use a low-tin solder, it is particularly important to employ an adequate volume of good flux.

The alloy quality curve reaches its maximum at about 63 percent tin, corresponding to the composition of the eutectic alloy. These eutectic solders are the most mobile and free-flowing of all solder alloys. They are also used almost exclusively for such exacting requirements as printed circuit soldering.

It has been noted that the quality of solder is related to its purity as well as its composition. However, much confusion exists about solder impurities. This is due in part to a lack of definition. For instance, in tin-antimony solder, silver would be an impurity, whereas in tin-silver solder, antimony would be an impurity.

In estimating the quality of solder on the basis of a chemical analysis, it is important to consider not the total amount of the impurity, but the relative significance of each element instead.

Finally, it should be understood that having solder analyzed does not have any effect in solving a solder problem. If solder is causing a difficulty for any reason, the best way to solve the problem is *replace the solder!* ◈

MAC'S SERVICE SHOP

Basic and New Soldering Techniques

BY JOHN T. FRYE

BARNEY was working on a small pc board, his brow wrinkled in concentration. He was vainly trying to unsolder a transistor from the board without burning another component or creating solder bridges.

"Here," Mac said, handing him a slender gray-cased object with a red slide switch on the top and a short metallic rod protruding from the end. "Try this."

"What's this?" Barney asked suspiciously. "It looks like it might suck eggs."

"It's Weller's Model WC100 cordless soldering iron, one of a breed of portable irons introduced by a few manufacturers. It weighs 5¾ ounces and is only 6⅞ in. long without the interchangeable tip. Four tips are available; a regular, a fine point (which is in there now), a long reach, and a miniature which has an extra fine point. The tips, less than 1/5" in diameter, are made of nickel-plated copper. Each is ceramic-cemented to a stainless-steel tube that is Teflon-insulated inside and serves as a concentric path for current to the tip. These sturdy stainless-steel shanks also give the tips a degree of rigidity to inhibit bending during soldering.

"The WC100 comes with a wall-socket charger to keep its NiCd batteries charged. The cord from the charger plugs into a jack on the rear of the iron. Weller says that completely discharged batteries can be recharged in 14 hours, after which 50 to 100 pc board connections can be made before another recharging. For bench work, the charger can be connected continuously without over-charging or shortening battery life."

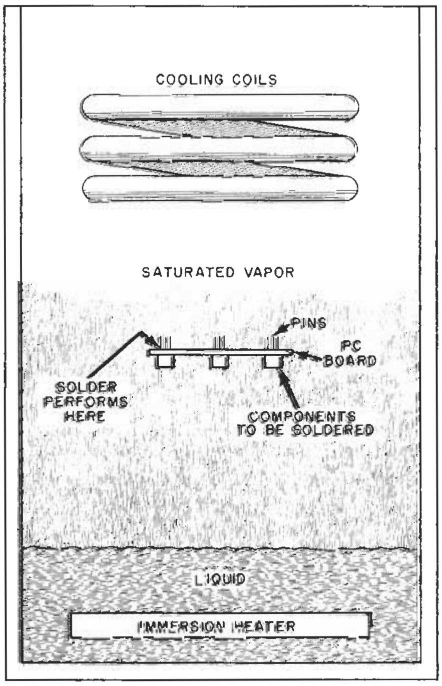
While Mac was talking, Barney had easily unsoldered the transistor. The tiny tip and the built-in worklight just below the tip shank made it easy to put the heat precisely where it was needed.

"Hey, this little rascal has plenty of oomph!" Barney exclaimed.

"That's right. It starts melting solder in six seconds and attains a tip temperature of 700°F (370°C) which is almost twice the temperature needed to melt 60/40 solder."

"Do you think it will replace our conventional irons and solder guns?"

"No, but it will supplement them. Just as we have a wide array of screwdrivers for different jobs, we also need several different soldering tools to work on today's electronic equipment. The important feature of the battery-operated iron



Mac's sketch of condensation soldering system shows how boiling liquid is heated to form saturated vapor. When the vapor condenses above, the latent heat of vaporization melts solder.

is its portability. It's not tied to a wall socket so it can be used in a car, on top of a TV tower, or anywhere that ac line current is not available. Of course, it has limitations. It's specifically designed for pc boards, jewelry, or small-diameter wires. It is not capable of performing heavy-duty continuous soldering. A tip only a little larger than a match head doesn't store up much heat! Getting maximum efficiency out of this little iron calls for a sharpening up of our soldering techniques."

"How's that?"

"When we have a large surplus amount of heat available, as we do with a heavy-duty iron or a gun, we can get by with sloppy soldering procedures—insufficient cleaning of the joint, failure to keep the iron properly tinned, melting the solder on the iron instead of the heated joint, etc. By using far more heat than necessary, we are able to make a fair joint by brute force. This won't happen with the small battery-operated irons. When using them, we must make the most of every watt."

The Right Way to Solder. "For example, with the small irons, we use only high-quality 60/40 solder that has a flow temperature very close to the ideal 361°F (183°C) of the eutectic 63/37 tin-lead alloy. As the alloy moves away from this eutectic point, more and more heat is needed to transform the solid solder into a free-flowing liquid. Also, with small irons, we use 19- or 21-gauge small-diameter solder to insure that most of the heat from the tip goes to the joint instead of being heat-sinked into the roll of solder. Further, we will make sure every joint is really clean before soldering. If at all possible, we'll arrange things so the iron can be applied below the joint. In this way, convection currents will carry the heat up and over the joint. Finally, we'll observe the "Golden Rule" of solder: *Apply the flat face of the adequately heated soldering iron directly against the assembly and simultaneously apply the solder at the exact point of iron contact.*"

"What's wrong with melting the solder on the tip and transferring it to the joint?"

"To appreciate the error in this common procedure, you must understand the functions of the solder flux. The flux—usually an activated rosin—cleans off the solder-repelling oxide that forms on all metal surfaces, but it can only do so in its corrosive hot liquid state. When cool, rosin is chemically inert and has an electrical resistance in excess of 3300 trillion ohms per cubic inch. The flux's other function is to lower the surface tension of the liquid solder and make it flow over and through the joint. Properly fluxed solder will actually flow against gravity to penetrate a small crevice by capillary attraction.

"Keep in mind that making a solder connection is not just a matter of sticking two pieces of metal together with a kind of conducting glue. There is actually a complex chemical action taking place. After the melted flux has cleaned off the corrosion on the metal surfaces, the solder wets and penetrates these clean areas and actually dissolves very thin layers of the juxtaposed metals so that they form an alloy with the solder. They thus unite with each other as an alloy that is partially solder and partially the joined metals. Ideally, this alloyed layer is only 0.004 in. (0.1 mm) thick. Any solder added after this alloy has formed is both superfluous and wasteful.

"Now, let's get back to what's wrong with carrying the molten solder to the joint on the tip of the iron. The rosin core of the solder is very volatile. You can see it evaporating into blue smoke when you touch a hot iron to a piece of solder. When this happens, the flux has dissipated itself on the tip long before you reach the joint, so you have solder with no flux. The solder may surround the oxidized surfaces of the wires, but it cannot wet and penetrate them by itself. The result is a mechanically poor, high-resistance joint."

"OK, I'll follow the Golden Rule no matter what soldering instrument I use," Barney promised. "Manufacturers of electronic equipment must certainly go by the book. Considering how many of their solder joints we look at, it's amazing how few poor connections we find."

Commercial Techniques. "True. They've found that following sound soldering principles pays off. Of course, their mass-soldering methods are much different from those we use, especially with pc boards. We've talked about dip-soldering and wave-soldering before; but recently I read in Western Electric's *The Engineer* about some new and very intriguing methods of mass-soldering.

"One of these is solder fusing with forced convection liquid heating. One problem associated with pc boards is solder slivers. They result from the undercutting of electrode-deposited solder used as an etch resist during copper removal. Unless removed, they can short circuit pad layers in multilayer circuits. The slivers can be eliminated by raising the board temperature to about 410°F (210°C) and holding it there for about 30 seconds. One way to do this is with radiant heat, but heating a multicircuit board uniformly without exposing heat-sensitive components to excessive heat is difficult. Heat shields can be used, but they are expensive. Forced convection heating with hot air is also used, but it requires longer exposure to heat and may also require baffles to protect low-mass areas from excessive temperatures. Immersing the board in a heated fluid, such as glycerol, avoids most problems encountered with the other two methods and provides excellent temperature control, but glycerol requires very careful handling.

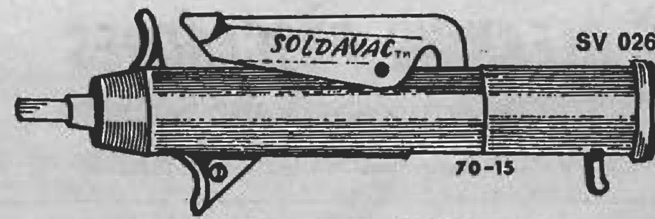
"A new method, called condensation soldering, is now being used not only to eliminate solder slivers but also to perform 'reflow soldering.' In this procedure, rosin-coated solder preforms shaped like little doughnuts are placed over the tops of pins to be soldered to the plated-through holes in the pc board. When the temperature is raised sufficiently, the solder melts and flows along the pin through the plated hole and forms a solder fillet. If the temperature can be precisely controlled, the distance the solder travels along the pin can be easily adjusted—a factor to be considered when the protruding end of the pin will be connected in an automated Wire-Wrapping process. For a good connection of this type, which is common in telephone work, there must be no solder under the wrapped wire—which rules out wave or dip soldering.

"Condensation soldering is accomplished very easily. In simple terms, a tall, open-topped vessel contains a liquid, say fluorinated poloxypropylene, which is brought to its boiling point of 436°F (224°C) with immersion heaters. When a relatively cool object such as a pc board with solder preforms is placed in the saturated vapor, which rises to the top, the vapor condenses uniformly on the object, releasing the latent heat of vaporization. A very high heat transfer rate is associated with this phase change, so the heating process is quite rapid. In fact, 20,000 solder connections have been made simultaneously in 60 seconds with this contamination-free process."

"Wow," Barney said. "All I needed was a little help unsoldering that transistor, and I got an introduction to a new type of soldering iron, a refresher course in good soldering techniques, a lecture on the functions of solder flux and the real nature of a solder joint, and finally a description of some methods of mass soldering. That will do me for today." ◇

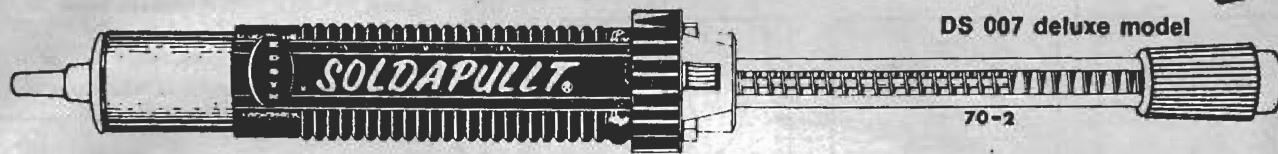
USING YOUR Soldapullt® DESOLDERING TOOLS

SV 026



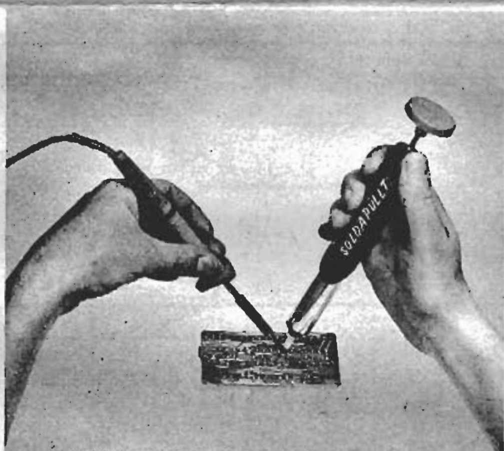
SS 001 standard model

DS 007 deluxe model



NEW

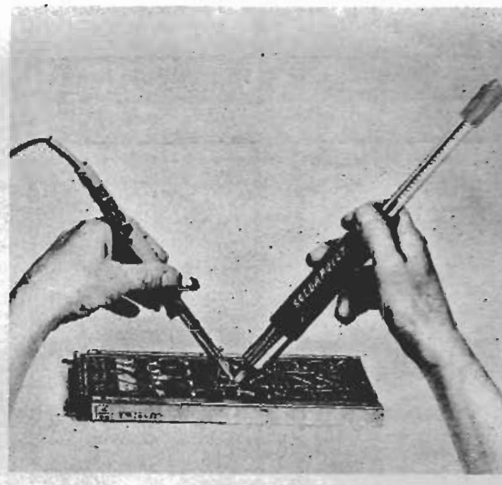
DS 101 deluxe model

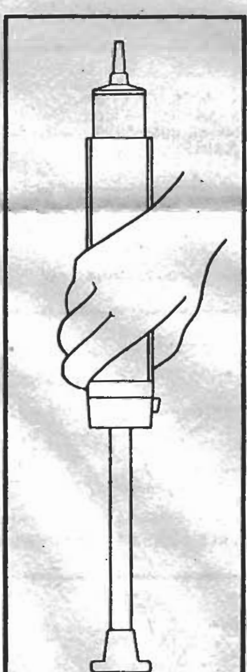


Hold tip gently against joint for long tip life.

HAND POSITION

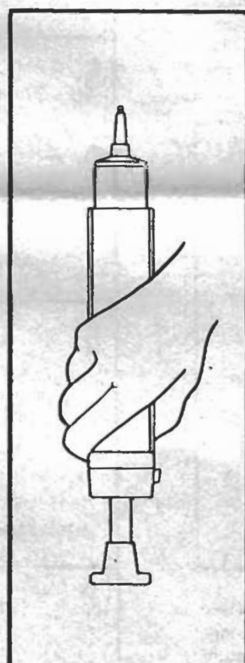
Your SOLDAPULLT is designed for rework or removal of all advanced circuit components. For fast desoldering simply heat the solder joint with your iron and as the solder melts thoroughly, hold the tip of your SOLDAPULLT desoldering tool LIGHTLY against solder joint and press trigger. Keep soldering iron on connection until vacuum stroke has been accomplished. Reloading instructions are shown below.





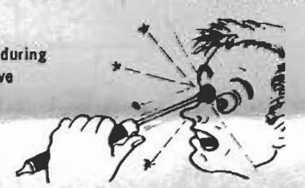
RELOADING

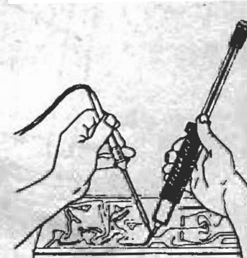
With the SOLDAPULLT DESOLDERING TOOL STILL IN YOUR HAND after the above desoldering operation has been completed, turn hand so SOLDAPULLT knob can be pressed on your bench top. It is not necessary to change hand position. Then with knob on a firm surface and keeping thumb off of trigger, press down until cleaning shaft appears out of tip. Now the SOLDAPULLT desoldering tool is reloaded.



ATTENTION: STANDARD MODEL USERS

WARNING: Keep clear of knob during vacuum stroke, also do not leave SOLDAPULLT loaded when not in use.

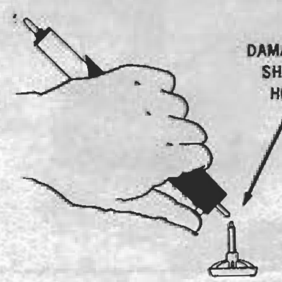




Extend Tip Life

DO NOT PRESS SOLDAPULLT TOOL TIP INTO WORK—HOLD TOOL NEAR THE WORK TO GREATLY EXTEND THE LIFE OF THE TIP.

DAMAGE SHAFT HERE



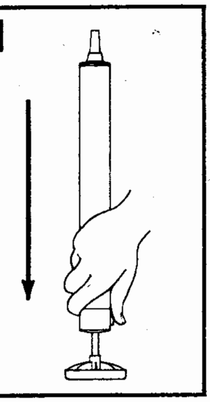
YOUR SOLDAPULLT DESOLDERING TOOL MUST NOT BE HELD AT AN ANGLE WHEN RELOADING AS THIS WILL DAMAGE SHAFT AND KNOB.

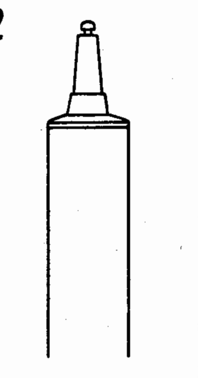
For Best Results & Long Life Read Instructions re Lubrication

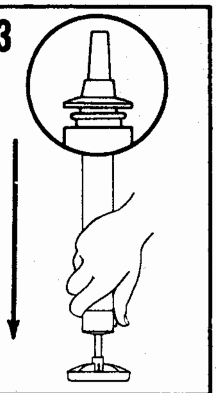
ROUTINE CLEANING PROCEDURES

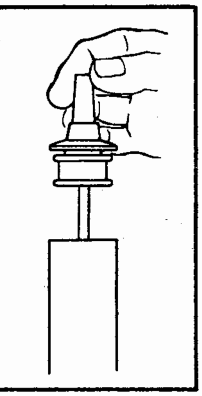
HOW TO CARE FOR YOUR STANDARD AND DELUXE MODEL *SOLDAPULLT®* DESOLDERING TOOLS

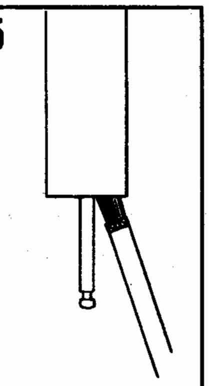
YOUR DESOLDERING TOOL CAN BE CLEANED IN MINUTES BY FOLLOWING THESE SIMPLE STEPS

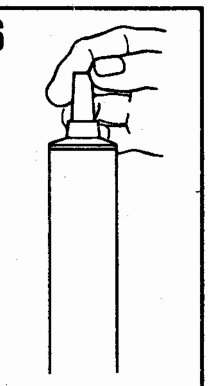
1

START NORMAL PUSH TO LOAD PROCEDURE

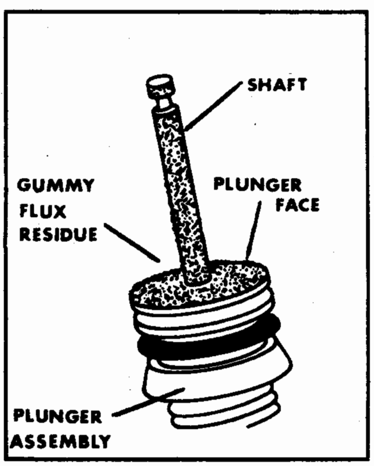
2

PUSHING DOWN HARDER WILL REVEAL CLEANING SHAFT

3

PUSH DOWN MORE FIRMLY TO EJECT TIP

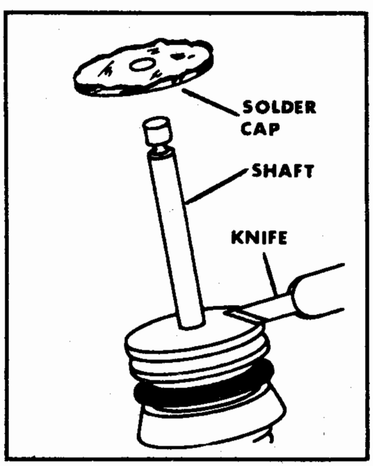
4

REMOVE TIP

5

BRUSH THOROUGHLY

6

REPLACE TIP — PUSHING FIRMLY BACK INTO BARREL



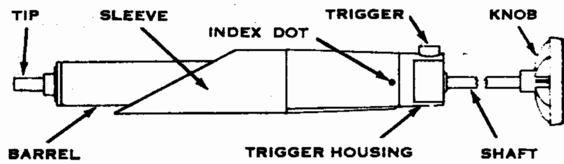
In those instances where liquid flux has been used in the soldering or desoldering process, frequent cleaning of the shaft and plunger face is necessary.



Occasionally a "CAP" of solidified solder and flux will build up on the plunger face. This may be removed by gently prying off with a knife blade. Scraping the sides of the shaft will remove excess flux buildup and eliminate shaft binding in the desoldering tip.

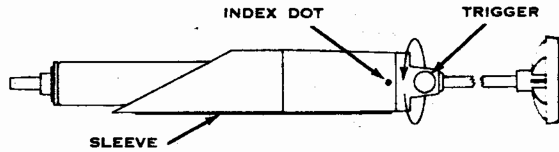
EXTENDED USE CLEANING PROCEDUR

TO REVITALIZE YOUR STANDARD MODEL DESOLDERING TOOL

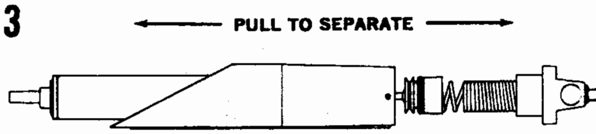
1


TURN YOUR SOLDAPULLT UNTIL RAISED DOT ON SLEEVE FACES YOU.

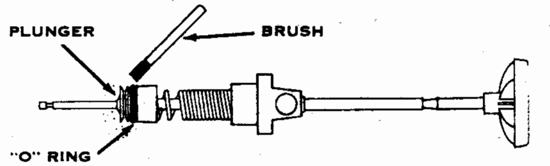
BE SURE TOOL IS NOT LOADED

2


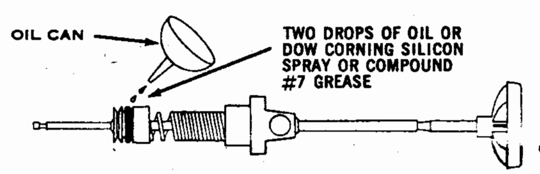
GRASP SLEEVE AND TURN TRIGGER HOUSING COUNTER-CLOCKWISE UNTIL TRIGGER LINES UP WITH RAISED INDEX DOT.

3


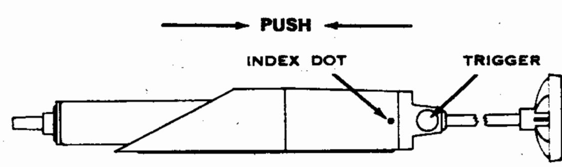
GRASP SLEEVE AND TRIGGER HOUSING AND PULL STRAIGHT APART.

4


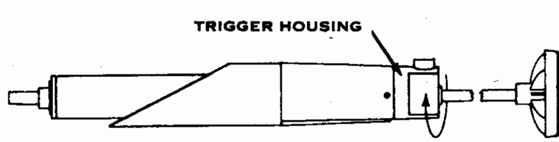
CLEAN PLUNGER AND "O" RING THOROUGHLY.

5


APPLY TWO DROPS OF OIL THOROUGHLY ONTO "O" RING SEAL.

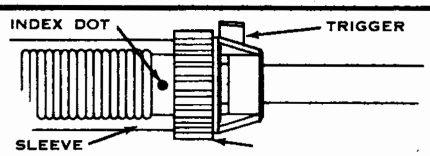
6


ALIGN TRIGGER AND INDEX DOT AS PER FIGURES 2 AND 3, PUSH TOGETH

7


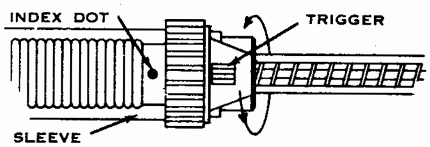
TWIST TRIGGER HOUSING CLOCKWISE ¼ TURN UNTIL IT LOCKS INTO SLE

EXTENDED USE CLEANING PROCEDURES
TO REVITALIZE
YOUR DELUXE MODEL DESOLDERING TOOL



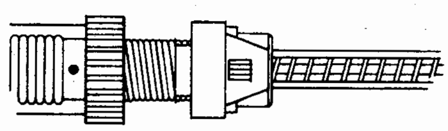
TURN YOUR SOLDAPULLT UNTIL RAISED DOT ON SLEEVE FACES YOU.

BE SURE TOOL IS NOT LOADED
DO NOT LOAD WHILE TOOL IS APART

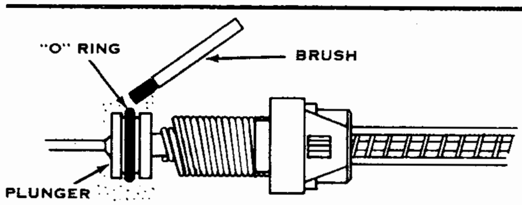


GRASP SLEEVE AND TURN TRIGGER HOUSING COUNTER-CLOCKWISE UNTIL TRIGGER LINES UP WITH RAISED INDEX DOT.

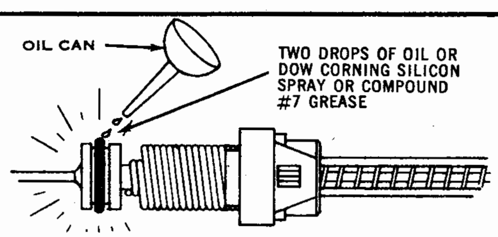
PULL TO SEPARATE



GRASP SLEEVE AND TRIGGER HOUSING AND PULL STRAIGHT APART.

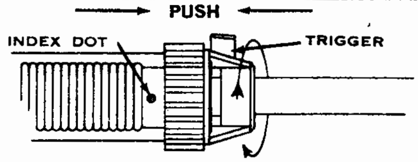


CLEAN PLUNGER AND "O" RING THOROUGHLY.

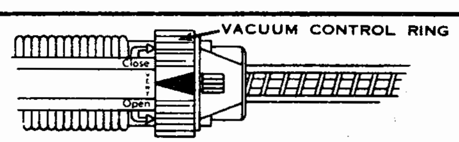


APPLY TWO DROPS OF OIL THOROUGHLY ONTO "O" RING SEAL.

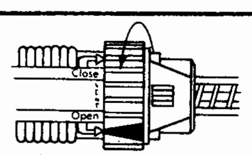
PUSH



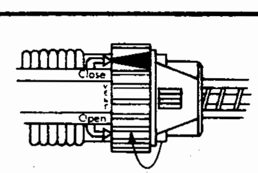
ALIGN TRIGGER AND INDEX DOT AS PER FIGURES 2 AND 3, PUSH TOGETHER AND TWIST TRIGGER HOUSING CLOCKWISE 1/4 TURN UNTIL IT LOCKS INTO SLEEVE.



ADJUSTMENT OF THE VACUUM CONTROL RING WILL PROVIDE AN AMPLE RANGE OF VACUUM SETTINGS FOR YOUR PARTICULAR NEEDS

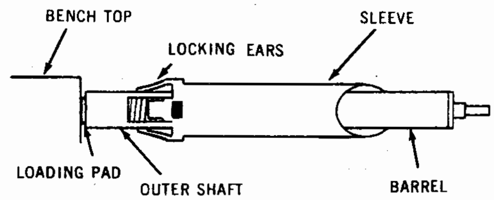


FULL OPEN
HIGH VACUUM

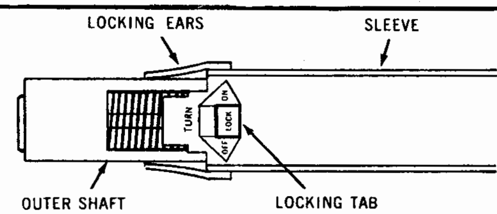


FULL CLOSED — LOW VACUUM
(FOR DELICATE WORK)

EXTENDED USE CLEANING PROCEDURES
TO REVITALIZE
YOUR DELUXE MODEL *SOLDAVAC*™

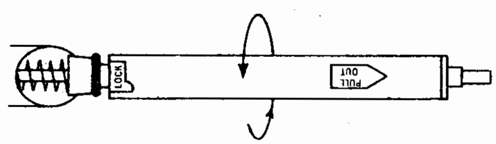


GRASPING LOCKING EARS WITH THUMB AND FOREFINGER, PUSH LOADING PAD AGAINST TOP UNTIL EARS SNAP INTO HOLES LOCATED IN OUTER SHAFT.

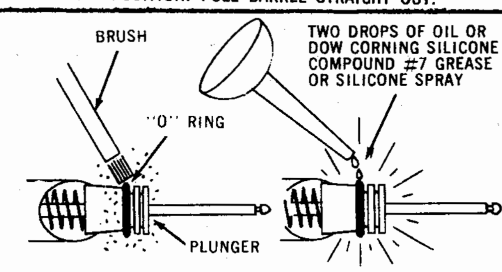


AFTER OUTER SHAFT HAS BEEN SECURED, TURN SOLDAVAC SO THAT TRIGGER FACES AWAY FROM YOU. OBSERVE LOCKING TAB IN WINDOW OF SLEEVE.

TURN BARREL AND PULL TO SEPARATE

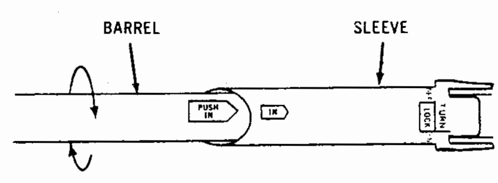


GRASP BARREL AND TURN COUNTERCLOCKWISE UNTIL LOCK IS AT OFF POSITION. PULL BARREL STRAIGHT OUT.

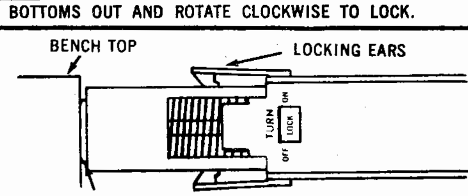


CLEAN PLUNGER AND "O" RING THOROUGHLY. APPLY TWO DROPS OF OIL THOROUGHLY ONTO "O" RING SEAL.

PUSH AND TURN TO LOCK



REPLACE BARREL BY CAREFULLY ALIGNING THE MARKINGS PUSH IN IN AS SHOWN. PUSH BARREL INTO SLEEVE UNTIL IT BOTTOMS OUT AND ROTATE CLOCKWISE TO LOCK.

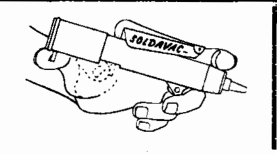


RELEASE LOCKING EARS BY PUSHING OUTER SHAFT LOADING PAD AGAINST BENCH TOP.

DO NOT ATTEMPT TO PRY EARS LOOSE WITH FINGERS OR TOOL AS DAMAGE WILL RESULT.

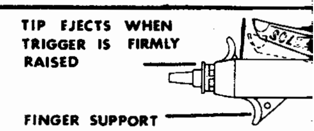
CAUTION: WHEN CLEANING SOLDAVAC DO NOT ACTIVATE PLUNGER WHEN TIP OR BARREL IS REMOVED FROM SLEEVE TO PREVENT DAMAGE.

EXTENDED USE (
TO RE
YOUR STANDARD MOD

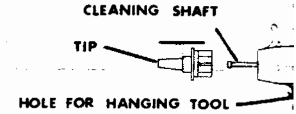


LOADING

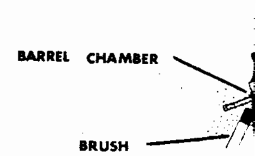
Shown in the illustrations are two simple m



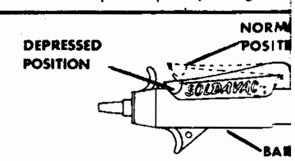
To clean the barrel chambe
the usual way. Then pull u
tip is pushed out of barrel
NOT PULL UP ON TRIGGER



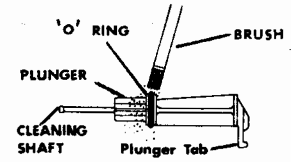
Remove tip with fingers. C
plunger with tip removed.



Brush barrel chamber tho
replace tip — pushing firm



Unload tool, remove retain
lever, and slide plunger as
sary to remove the spring
straight off as shown. Do
cleaning shaft may be be t
when replacing spring on
small end on first. The s
retaining tabs.



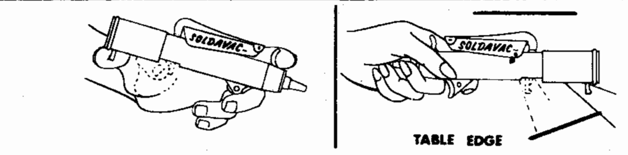
Brush plunger and "O"

Apply two drops of o
seal.

plunger re

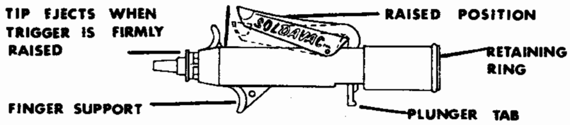
Depressing the trigger l
back into the barrel. Do
barrel to reload. The r
curely on rear of tool
from flying out of rear

ES EXTENDED USE CLEANING PROCEDURES TO REVITALIZE YOUR STANDARD MODEL *SOLDAVAC*™

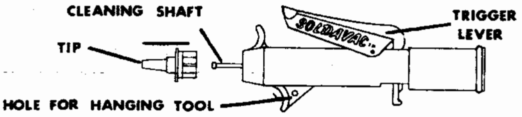


LOADING

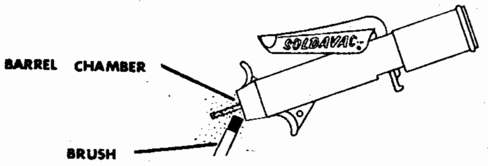
hown in the illustrations are two simple methods to quickly load the Soldavac.



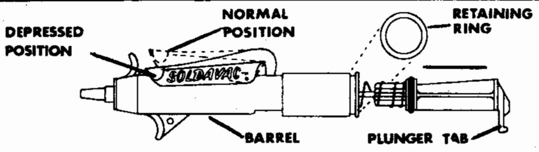
To clean the barrel chamber, load SOLDAVAC in the usual way. Then pull up on lever firmly until tip is pushed out of barrel slightly. CAUTION: DO NOT PULL UP ON TRIGGER LEVER TOO HARSHLY.



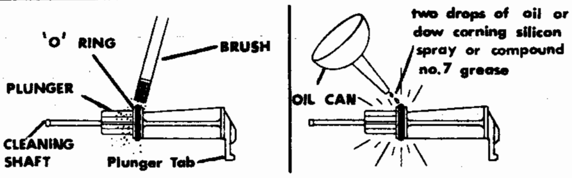
Remove tip with fingers. Caution, do not release plunger with tip removed.



Brush barrel chamber thoroughly as shown and replace tip — pushing firmly back into barrel.



Unload tool, remove retaining ring, depress trigger lever, and slide plunger assembly out. If it is necessary to remove the spring from the plunger, pull straight off as shown. Do not bend spring as the cleaning shaft may be bent and damaged. Be sure when replacing spring onto plunger to push the small end on first. The spring will snap over the retaining tabs.



Brush plunger and "O" ring thoroughly.

Apply two drops of oil thoroughly onto "O" ring seal.

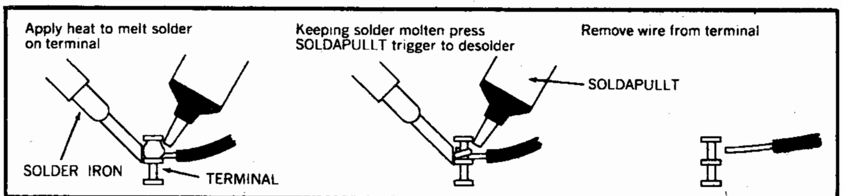
plunger reassembly

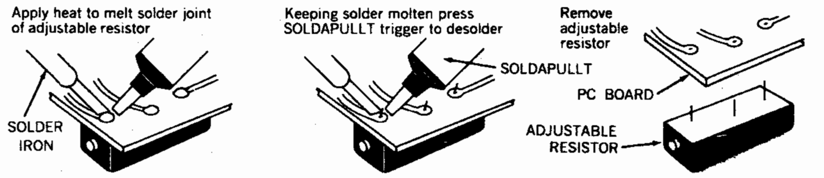
Depressing the trigger lever firmly, push plunger back into the barrel. Do not push far enough into barrel to reload. The retaining ring must be securely on rear of tool to prevent loaded plunger from flying out of rear of tool.

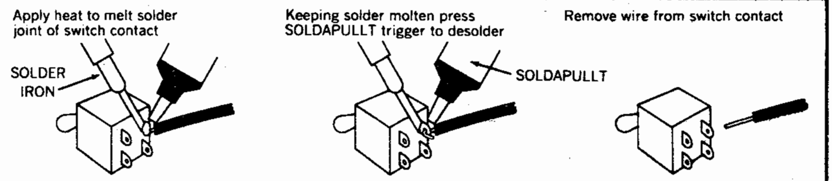
SOLDER ABILITY™

On Off Talk

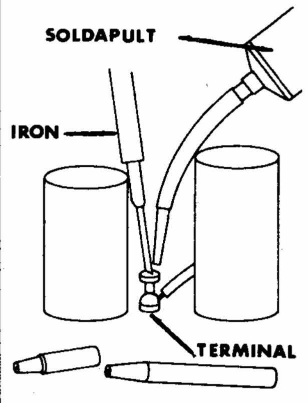
TYPICAL APPLICATIONS



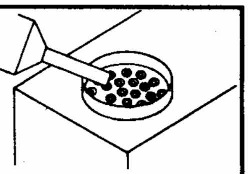




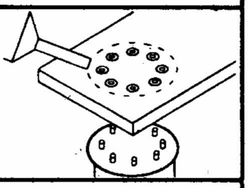
An extension tip or a combination of extension tips may be used effectively in inaccessible or obscurred areas.



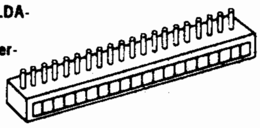
Small foreign particles may be vacuumed up from female connectors with your SOLDAPULLT.

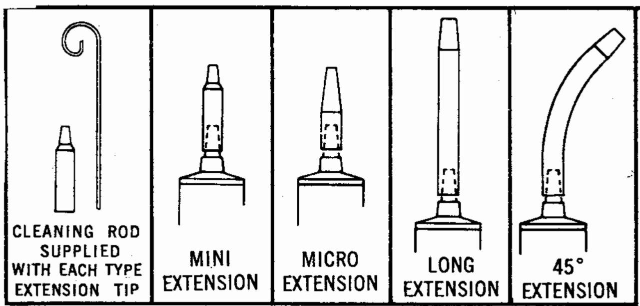


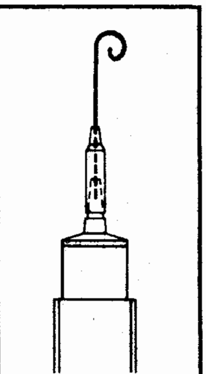
Multiple lead semiconductors may easily be removed using your SOLDAPULLT. The component when usable can be salvaged for another application resulting in substantial savings.



Multiple pin connectors are easily removed with your SOLDAPULLT without damaging PC board or connector by desoldering one connector at a time. PC board will not become overheated.







Extension tips need not be removed when using cleaning rod. Simply be sure tool is not loaded and run cleaning rod thru extension tip as shown

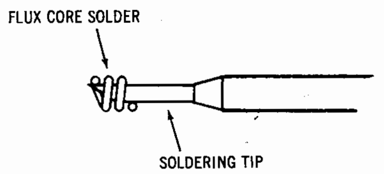
Your standard, long tipped or deluxe model SOLDAPULLT desoldering tool operates most efficiently with the tip supplied; however, the extension tips shown (above) may be used for special applications by slipping them over the existing tip on your SOLDAPULLT. The extension tips may also be used in combination with each other. These tips must be ordered separately and a special cleaning rod is included.

NOTE: When ordering extension tips or replacement tips always refer to price list to determine size, part no. and price.

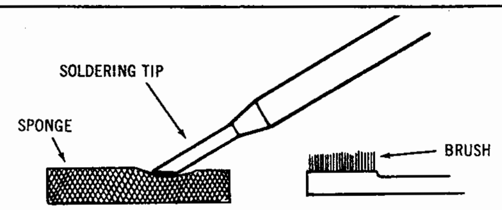
A cleaning shaft is supplied with each extension tip.

SOLDER (EDSYN T.M.) ABILITY -- HINTS

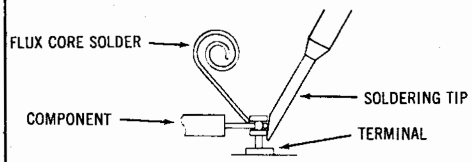
For most efficient solder flow, use iron of sufficient wattage to heat entire connection to solder melting point within approximately 2 to 5 seconds.



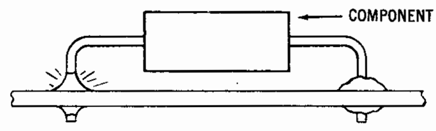
A new tip may be efficiently tinned by wrapping several turns of solder around tip of cold iron and allowing the iron to come up to temperature.



To keep tip in proper condition when soldering, wipe tip clean frequently with dry cloth or damp sponge. A brass wire brush is also commonly used. However, a teflon bristle brush is ideal to prevent tip wear.



For most efficient heat transfer, "wet" tip by melting a small amount of solder on tip before soldering. Place "wetted" tip to terminal and simultaneously apply solder to opposite side. The solder as it melts will flow around the joint towards the hot iron tip. Remove tip from connection as soon as solder reaches it. Do not remove or disturb solder connection until solder has solidified as this will result in a cold or imperfect connection. A cold joint results in an unreliable or intermittent connection.



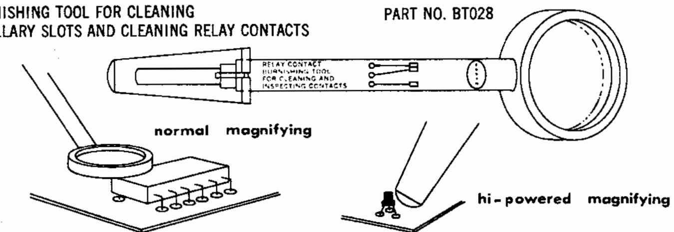
A good solder joint has a bright non crystalline metallic appearance. The solder fillet thins out at the edges and assumes the general contour of the wire or terminal.

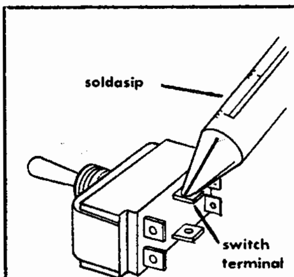
A cold joint may have a shiny appearance but does not flow around the connection to form a fillet.

In the case where the connection has been disturbed before the solder has solidified, the solder joint will be rough or irregular and will appear dull.

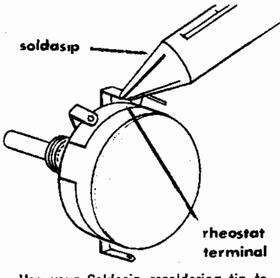
BURNISHING TOOL FOR CLEANING CAPILLARY SLOTS AND CLEANING RELAY CONTACTS

PART NO. BT028





Use your Soldasip resoldering tip to clean out terminals on reusable switches.



Use your Soldasip resoldering tip to clean out terminals on controls and rheostats.

TYPES OF SOLDER AND THEIR USES

In the electronics industry, two types of solder are commonly used, namely SN60 and SN63. SN63 is a 63/37% combination of tin and lead with an inner core of rosin flux. This type has a very short melting range of 364°F completely molten, 362° completely solid. SN63 is used where temperature requirements are very stringent.

SN60 is a 60/40% combination of tin and lead with an inner core of rosin flux. It is very similar to SN63 but having a wider range of 374° completely molten and 362° completely solid.

For the handyman there is SN50 (50/50 tin lead) which is used for bit soldering, sweating joints on plain, tinned or galvanized iron or steel, copper, etc.

Caution must be used regarding flux. Around electronics (PC boards, terminal boards, radio-TV, etc.) NEVER USE AN ACID FLUX as it is corrosive and will damage the components. In addition it leaves a conductive residue. For safety, use a type R or RMA rosin flux. Edsyn's resoldering flux is non-corrosive, non-hygroscopic and non-conductive.

GENERAL CARE OF YOUR SOLDERING IRON

Before inserting a soldering tip on your iron, remove any oxidation scale which may have formed through previous use by tapping tip on the edge of a table. Also use steel wool or brass or wire brush on the element shaft over which tip will be slipped.

ERSADUR permanent plated tips should never be filled. Dress with steel wool or a brass wire brush.

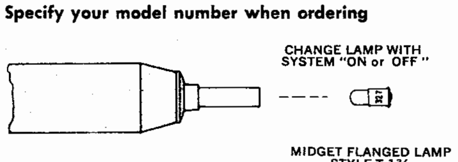
Your iron should be unplugged when not in use. This will lengthen the life of the heating element and tips.

Line cords should be unplugged at the outlet. To prevent internal damage or shorting to the wiring of your iron, do not pull line cord free with your iron.

Lampout™ BULB EXTRACTOR TIP

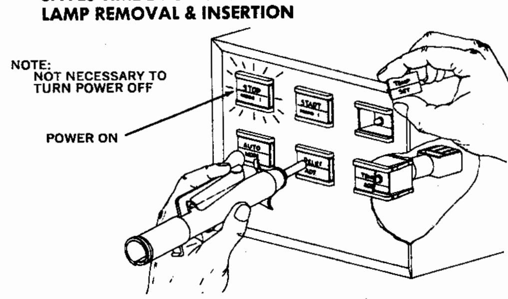
EXPAND THE USEFULNESS OF YOUR EDSYN DESOLDERING TOOL

Specify your model number when ordering



TIP FITS ON YOUR EDSYN DESOLDERING TOOL

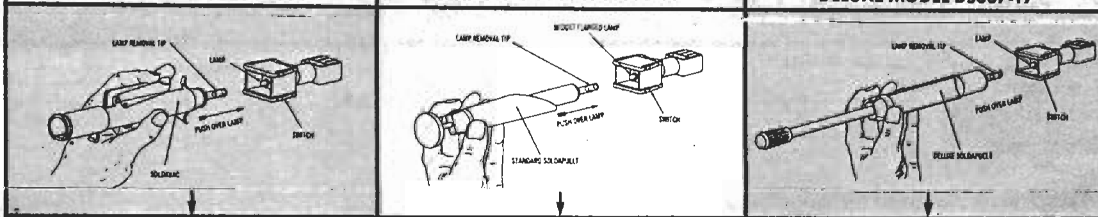
SAVES TIME BY SIMPLIFYING LAMP REMOVAL & INSERTION



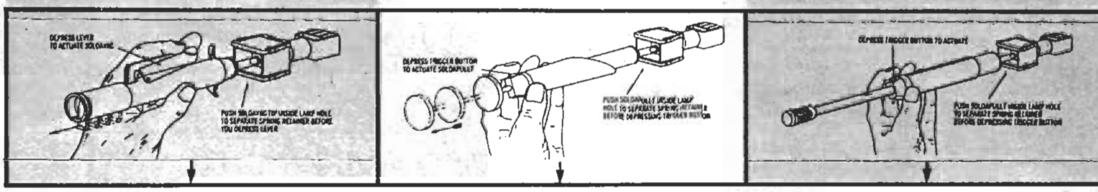
Remove midget flanged lamp. Style T-1-3/4 with vacuum or install with quick insertion action.

TO REMOVE LAMP FOLLOW THESE 4 SIMPLE STEPS ON TYPE 2C & 2F HOUSINGS

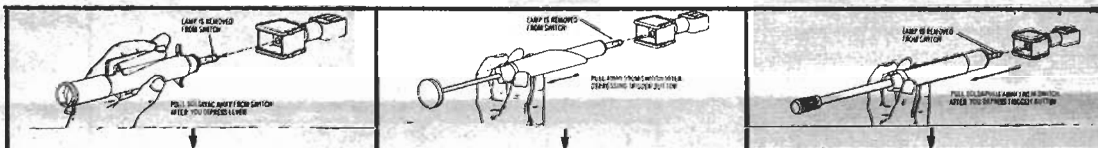
SOLDAVAC.	SOLDAPULLT.	SOLDAPULLT.
STANDARD MODEL SV026	STANDARD MODEL SS001-11	DELUXE MODEL DS007-17



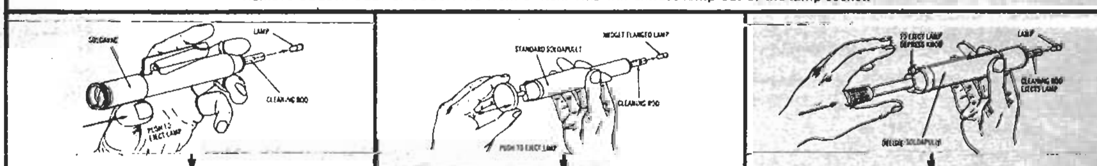
Load your SOLDAPULLT or SOLDAVAC by depressing knob then push into switch so that LAMPOUT™ bulb removal tip slips over lamp to be extracted. Insert all the way into the lamp hole to insure release of lamp by spring retainer.



Depress button on SOLDAPULLT or lever on SOLDAVAC. This will cause a suction at the tip causing lamp to be sucked into the LAMPOUT™ tip.

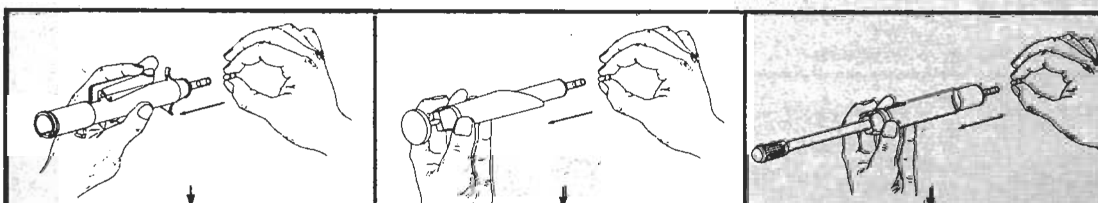


Remove SOLDAPULLT or SOLDAVAC from switch. This will extract lamp out of the lamp socket.

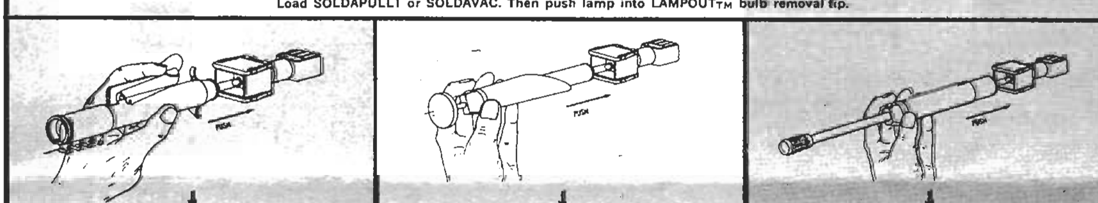


Push loading knob once again to load. This will also eject the lamp from the tip.

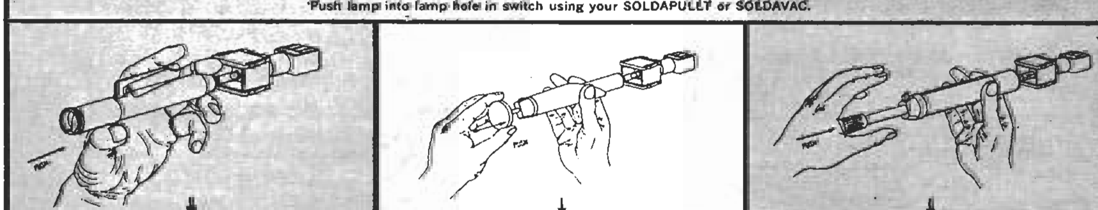
TO INSERT THE LAMP FOLLOW THESE 4 SIMPLE STEPS



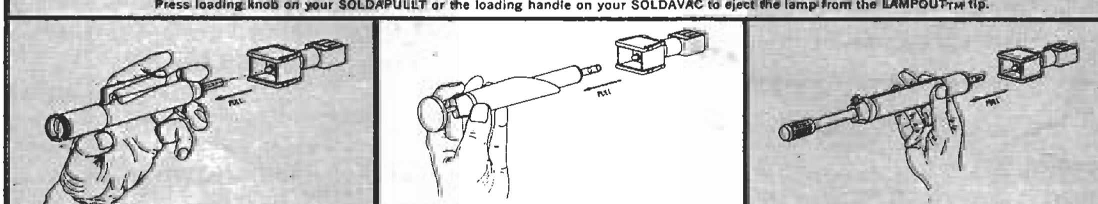
Load SOLDAPULLT or SOLDAVAC. Then push lamp into LAMPOUT™ bulb removal tip.



Push lamp into lamp hole in switch using your SOLDAPULLT or SOLDAVAC.



Press loading knob on your SOLDAPULLT or the loading handle on your SOLDAVAC to eject the lamp from the LAMPOUT™ tip.



As lamp is ejected into switch, withdraw your SOLDAPULLT or SOLDAVAC from the switch leaving lamp inserted.

Solder Al foil to shield your breadboard

The next time you need to determine just what shielding your breadboard requires, try experimenting with ordinary household aluminum foil, using paper-card stock for the necessary structural rigidity, suggests John A. Carroll of Dynamic Measurements Corp., Winchester, Mass. When it's time to connect the pieces or bond a seam so eddy currents can flow, you may not have the aluminum solder on hand to do the job properly. But it's possible to solder the aluminum without using aluminum solder, and yet wind up with a reasonably good connection.

The key to the procedure is to clean the oxide off the aluminum while it is immersed in flux, thus preventing the oxide from re-forming long enough for the joint to be made. Begin by putting a drop of good electronic-type flux, like Kester 1544, on the spot to be soldered. **Next scrape off the oxide coating with a knife or a piece of emery paper. Bring together the parts to be soldered, and clamp them in position.** Clean the tip of the soldering iron, and then melt a drop of solder on it. Bring the iron to the joint and spread the melted solder around, feeding in more solder as needed. Work quickly, for once the joint gets hot even the flux won't delay oxidation for more than a couple of seconds.

DESOLDERING BRAID

An inexpensive source of desoldering "wick" is the outer conductor of RG-58 and RG-59 coaxial cable. Cut your scrap into 8- to 10-inch (20.4- to 25.4-cm) lengths. Hold the braid and inner conductor firmly with pliers, and pull off the outer insulating jacket with your free hand. Then, push the two ends of the braid together to loosen it, and pull out the inner conductor and surrounding insulation.—*Arnold Irvine, Coopersburg, PA.*

IC SOLDERING AID

To prevent heat or static damage to an integrated circuit while soldering, push the pins of the device through a few sheets of aluminum foil measuring 2″ x 2″ (5.1 x 5.1 cm). Then mount the IC on the circuit board. The foil will dissipate heat and electrically tie all the pins together. When the IC is in place, tear away the foil. Check carefully for stray pieces of foil before powering the board. The foil will generally come away in a few pieces without leaving tiny scraps.—*Aart M. Olsen, Newark, DE.*

CONTROLLED TEMPERATURE SOLDERING

What does it have to offer?

CONTROLLED temperature soldering tools have been used for quite a while, though until recently their use was largely confined to critical applications such as life support equipment, communications, weapons, aero-space, etc.

They are more expensive than the conventional 'single-temperature' tool; so what does the man who simply wants to build an amplifier or repair the neighbour's TV get for the extra money?

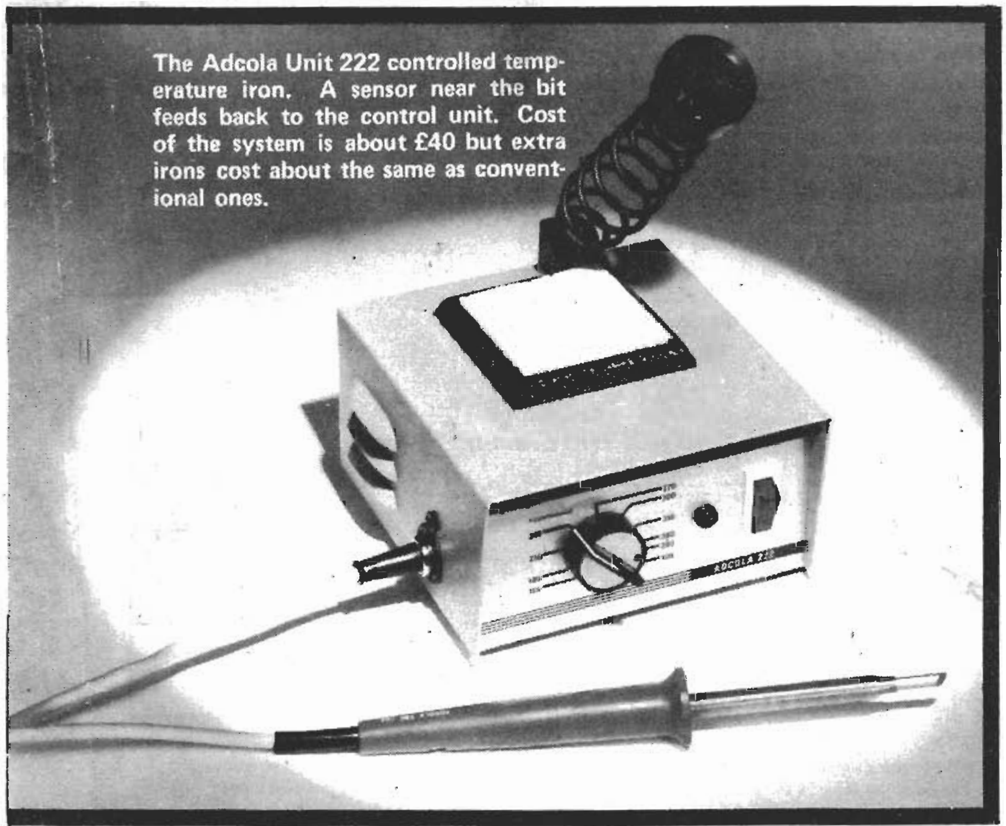
Firstly, let us go back a few years to the pre-printed circuit, pre-integrated circuit era. Then electronic gear was like the motor car of that era — built like a tank. Resistors and capacitors (called condensers then) were soldered, via heavy pigtails, to terminal pins on valve and coil bases large enough to anchor a small boat, other components were mounted on tag strips strong enough to support a house — or that's the way it seems, in retrospect.

In those days the soldering iron bit (why do we persist in calling it a soldering *iron* and a soldering *bit?*) was a great lump of copper rod, little different from that used by a plumber.

With the steady reduction in sizes of components, and the advent of printed wiring and integrated circuits, the heat requirements for soldering have shrunk in proportion. At this point, however, we must define what we mean by 'heat'.

HOW MUCH HEAT?

Just as high electrical power can be obtained from low voltage and high current, so can high thermal power be obtained with low temperature and high thermal capacity. So when we say 'more heat', we don't necessarily mean 'higher temperature'. We may simply mean *more* heat *volume* at a temperature high enough to rapidly melt solder . . . and 60/40 solder at that, since we are talking electronics. As a matter of interest, the optimum working temperature range for 60/40 solder is 245°C to 272°C. (This should not be confused with the melting point, which is 185–188°C).



The Adcola Unit 222 controlled temperature iron. A sensor near the bit feeds back to the control unit. Cost of the system is about £40 but extra irons cost about the same as conventional ones.

HEAT ABSORPTION

Every time a soldering tip is placed on a termination, heat is absorbed by that termination, and the temperature of the tip drops. The ability of the soldering tool element to replace that heat determines its recovery rate. Obviously, a heavy chassis joint or a long sequence of joints will draw a substantial amount of heat from the tip, with the result that the temperature may drop too low for satisfactory soldering — particularly with a small, low mass tip.

Without some form of temperature control, there is inevitably a wide variation in the tip temperature, depending on the mass of the terminations and the frequency of soldering.

This problem was overcome in the blunderbus era by that massive big 'bit' we mentioned, but this is quite impossible with today's high density circuitry and miniature componentry. The only answer, therefore, is some means of rapidly replacing the heat as it is drawn out.

HIGH IDLING TEMPERATURES

In an attempt to compensate for the inevitable temperature reduction, particularly in production soldering, higher initial (idling) temperatures were frequently used, on the principle that the average operating temperature would be more acceptable. So it was — but the first few joints of every soldering sequence were then exposed to an excessively high temperature.

The penalties of elevated temperatures can be quite severe, and they are not all immediately obvious: insidious latent faults in circuits and components frequently result in call-backs.

HIGH TEMPERATURE PENALTIES

Some of the more obvious results of excessive temperatures include:

* Flux preactivation: the flux vaporises and fails to do its job.
* Solder spatter: a short circuit hazard in high density circuitry.
* Printed circuit track and pad delamination: a fault which may not be immediately obvious.
* Excessive oxidation of tip and destruction of tip tinning: makes soldering harder instead of easier.
* Reduced element life: element wire oxides rapidly.
* Damaged insulation: plastic insulation can be damaged, or will 'shrink back', even from the radiated heat.
* Component damage: this is the greatest hazard in today's circuitry, due to the predomination of solid state componentry.

COMPONENT DAMAGE

Both the electrical and mechanical properties of semi-conductor devices are often temperature dependent and excessive heat, even if it does not cause immediate failure, will generally accelerate ultimate failure. It can, for example, cause shear stress along the bonded interface between two dissimilar materials (silicon to ceramic for example) due to their different coefficient of expansions. FETs and integrated circuits based on MOS or CMOS technologies are particularly susceptible to thermal damage during soldering. Excessive soldering temperature, therefore, may well ruin relatively expensive components; or at least reduce component life, undermine reliability, and degrade performance.

Even abnormally low temperatures do not remove this hazard. This simply entails leaving the soldering tip on the termination for an unduly long period, during which the component can soak up more heat than with a hotter tip and a quicker soldering operation.

TOOLS AVAILABLE

Three basic types of controlled-temperature soldering tools are readily available. One of these, the Weller, operates on the Curie principle, whereby a mechanical switch is operated by a magnetic pull. A tip with a specified temperature is first inserted in the tool. Below this specified temperature, the tip attracts the magnetic switch assembly, closing the element circuit. On reaching the elected temperature the magnetic force is reduced and the switch mechanism, via the spring, is released. To change temperature another tip, with the required Curie point, is substituted.

Weller temperature controlled iron. The stand incorporates a transformer in the box. Operating temperature is selected simply by changing the tip.

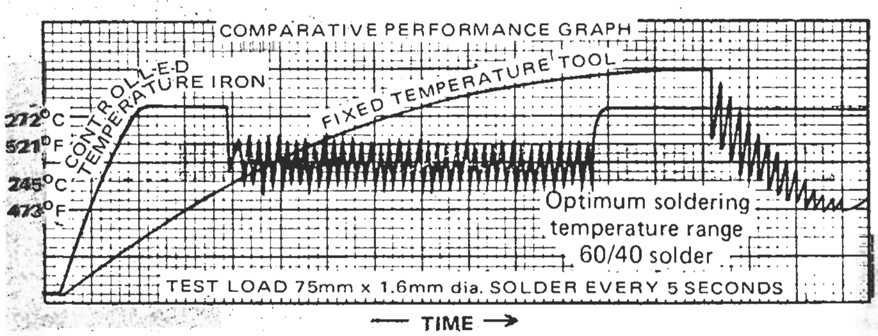
The second type operates on a push-rod system: this is used by Onyx and and Litesold. As the metal expands a bell-crank switches the current on and off.

The third types is the recently developed Unit 222 from Adcola which is entirely electronic. The iron itself contains a wire-wound sensor positioned in front of the heating element. This is fed back to the separate control unit with the electronic switching circuitry.

The temperature can be set between 180 and 420°C and is maintained within 3% of that selected. The 222 is totally earthed from the supply input to the soldering bit to provide maximum safety against leakage currents.

For safety reasons, the iron is operated from 24V and is designed to fail 'cold!

The major benefits of controlled temperature soldering tools will now be evident. In addition to the temperature *control* aspect, there are obvious benefits associated with the temperature *selection* feature. Low temperatures can be selected for specially critical work with low-melting-point solders. Higher temperatures can be selected for soldering self-fluxing wire, where surface oxide retards heat flow at soldering temperatures. For long sequences of heavy chassis joints, higher temperatures may also be permissible. ●



The graph compares a controlled temperature tool with a conventional tool. Note that the heat up time is only a fraction of that required for the fixed temperature tool, which also cools down progressively under identical load conditions.