"BACK TO TAWS"

This article was prompted by the sight of an elderly craftsman sitting on the side of the road wiping a lead sheath. He had nothing to aid him but a small metal tube, a stick of solder and a lighted candle. By blowing through the tube into the candle flame, the solder was melted; and using the molten wax as a flux, the job was quick and the finish perfect.

SOLDER

It is not often we have the opportunity in this machine-age of watching a craftsman from the old school at work and it prompted us to dust down our school books for a refresher course on the subject of solder.

Soldering, one of the oldest methods of joining, is an exacting and often time consuming operation. Like a boy scout and his knife, the technician and his iron seem to belong together, yet we rarely give the subject much thought.

Figure 4 illustrates the range of soldering alloys available today in order of temperature with the temperature of the base metals also given to show the marked change in melting point after alloying. The range is by no means complete as each solder manufacturer can offer a wide range of alloys for special applications. The alloys illustrated in Figure 4 are the better known types which may be used for electrical purposes and solder readily with non-active fluxes. For example, high temperature silver solder has not been included as the soldering technique is different and the melting point of 650°C makes electrical jointing difficult.

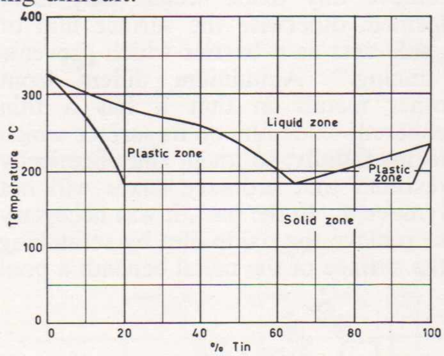

Fig. 1

TIN/LEAD ALLOYS

Alloying or "wetting" of the joint.

The most common type of solder used in electrical equipment is tin/lead alloy. Tin "wets" copper very well because of their mutual solubility thus forming an alloy layer with the copper. The alloy layer varies from the solder composition through all phases of tin/copper alloys to pure copper. The thickness of the layer is proportional to soldering temperature, time at that temperature, and ageing time at elevated temperature in service. The "wettability" of a solder increases with an increase in tin up to 50% after which "wetting" becomes constant.

Strength of soldered joints.

In choosing a solder it should be remembered that the joint strength decreases rapidly with increase of temperature and consideration should be given to joint stress in service. If the operating temperature exceeds 120°C in assemblies subjected to pressure or vibration, tin/lead alloys

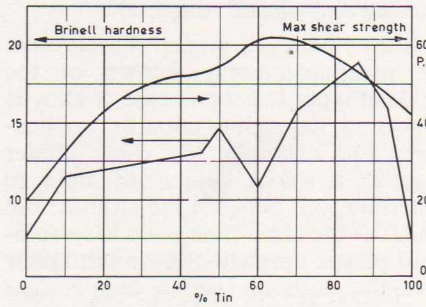

Fig. 2

are likely to be unreliable and a special high temperature alloy such as No. 3 should be used. Figure 3 illustrates the decrease in strength at high temperatures. The shear strength figures are obtained from rapid tests at .060″/min. but over long periods soldered joints will creep and as a general rule the maximum load applied should not exceed 5% of the shear strength.

Eutectic point.

The eutectic state is the point of alloying at which the mixture becomes completely homogeneous. The melting point is below that of each of the constituents and is well defined. Below this temperature it is solid; above it, the alloy is molten, with a complete absence of a plastic state.

In the case of tin/lead alloys the eutectic state occurs with a 63/37 alloy but if the lead content is increased excess particles of lead are formed surrounded by the eutectic mixture. On raising an alloy of this form to the melt-point the eutectic mixture melts at 185°C; the lead particles then float forming a pasty or plastic state until eventually a temperature is reached (depending upon the lead content) at which the lead melts and the liquidus state is reached.

Figure 1 shows both the liquidus and solidus lines plotted against tin content. Note the temperature of solid alloy is the same for compositions from about 20% to 97% tin. The plastic state is the region between the liquidus and solidus boundaries and is an important characteristic to consider when selecting a composition to suit a specific application.

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is 8.9W. With this maximum power dissipation the BYZ13 data sheet also states that the mounting base temperature (T_{amb}) must not exceed 97°C.

Tests have shown that a blackened vertical aluminium heat sink, measuring 6in x 6in and made from 16 s.w.g. sheet, with both rectifiers mounted on the centre line and 3in apart, is quite satisfactory.

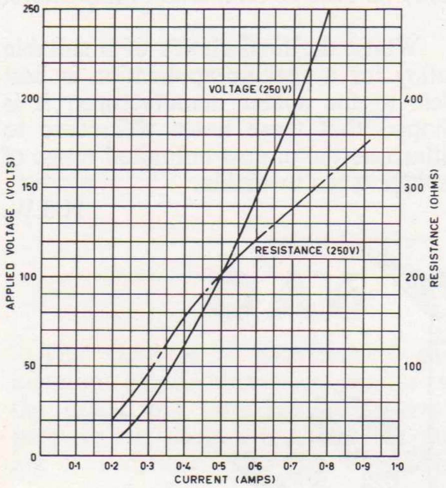

Fig. 2

COMPONENT PARTS LIST

Semiconductors:	Two Mullard BYZ13's
Incandescent lamps:	Two 250V 100W
Transformers:	Ferguson PF1788 National D8395 A & R PT2215 (or equivalent types)
Fuse:	English Electric Type Z590112 rated at 5A (or equivalent type)
Meter:	Paton Type RN216 (or equivalent type)
Heat Sink:	As described
Chassis, hardware, etc., as required.	

Figure 2 shows the effect of tin content on the Brinell hardness and shear strength. The maximum shear strength occurs at the eutectic point, but the maximum hardness occurs at 83% tin. Note the sharp difference in hardness between 50% tin and 60% tin compositions.

Fluidity and plastic range.

Alloys Nos. 4, 6, and 7 represent the most commonly known of the tin/lead types but the choice of alloy is important, depending upon the application. For example, the cable jointer requires a solder sufficiently fluid to penetrate well between the strands, but which at the same time must have sufficient plastic range to allow him to pour over the core at such a temperature that it will start to set between the cable and the ferrule before running out. For this purpose the jointer would probably choose an alloy between 50/50 and 40/60.

Solders for wiping need to have a very long plastic range in order that the jointer has sufficient time to complete the wipe, but at the same time the molten solder must adhere well to the sheath. The jointer would probably choose an alloy between 40/60 and 30/70 for this work.

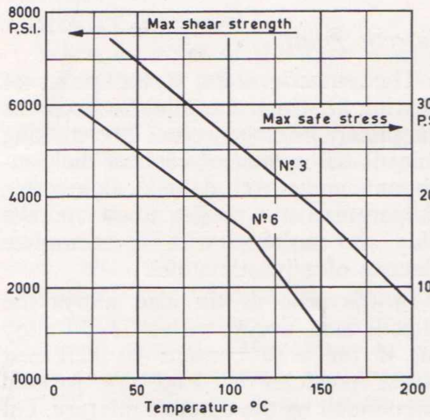

Fig. 3

For hand soldering of electronic equipment a lower melting point together with good fluidity is desirable in order that the solder will penetrate the joint in the shortest possible time and for this reason a 60/40 alloy is usually chosen. On the other hand, a solder with a larger plastic range is desirable for printed circuit boards due to the nature of the joint and to allow time to shake off the excess, and so an alloy between 60/40 and 50/50 would be chosen.

SOFT SOLDERS FOR ELEVATED TEMPERATURES

Alloys Nos. 1, 2 and 3 are representative of the high temperature soft solders suitable for electrical equipment operating at temperatures of 120°C to 150°C. No. 1 is simply the lead/silver eutectic state (304°C) and consequently has no plastic range. This is a rather difficult solder to use and is usually restricted to the hot dipping process. Alloy No. 2 contains 5% tin and "tins" more readily than No. 1. It can be used with a non-corrosive flux and finds use in hot dipping of commutators and other electrical equipment. Perhaps the most interesting of the high temperature solders is the tin/antimony alloy (No. 3), which can be used in place of tin/lead solder and is easily applied with a conventional hand iron. This type of solder is useful for all electrical equipment designed for 120°C operation.

SOLDERS FOR ALUMINIUM

When metals such as copper or brass are soldered, a flux is used to provide protection against oxidation and to remove any oxide which may have formed, otherwise the surface film of oxide acts as a barrier which prevents "tinning." Aluminium differs from other metals in that it has a thin coherent oxide film on its surface which forms rapidly; so tough and chemically resistant that ordinary fluxes will not remove it. In the past, it was necessary to remove the oxide film by scratching the surface of the metal beneath a pool of solder in order that the surface would tin before reoxidation could take place, however, fluxes and solders are now available which make aluminium soldering almost as easy as tin/lead soldering of copper. Solder suitable for aluminium is usually a tin/lead/zinc alloy represented by No. 5. The alloy indicated in the diagram has a high liquidus temperature but would have good capillary flow characteristics due to the large plastic range and would be an excellent choice for aluminium cable jointing. Alloys are available with a shorter plastic range (170°C-176°C) with which hand iron soldering is possible.

LOW TEMPERATURE AND FUSIBLE ALLOYS

The fusible alloys shown in Figure 4 (Nos. 8, 9, 10 and 11) make excellent soft solders and can be applied in the same way as tin/lead alloys. Low temperature alloys are often required where materials such as plastics, fabrics, lacquer or glass are easily damaged by heat. They are often used for glass to metal seals and are also used extensively for casting and pattern making. Eutectic alloys in this range exhibit a sharply defined melting point and for this reason are often used as safety plugs or fuses and also may be used as temperature indicators.

Whilst the final choice of a suitable alloy for a specific application is best left to the solder manufacturer, it is hoped that these notes will serve to illustrate the almost unlimited range of solder types available.

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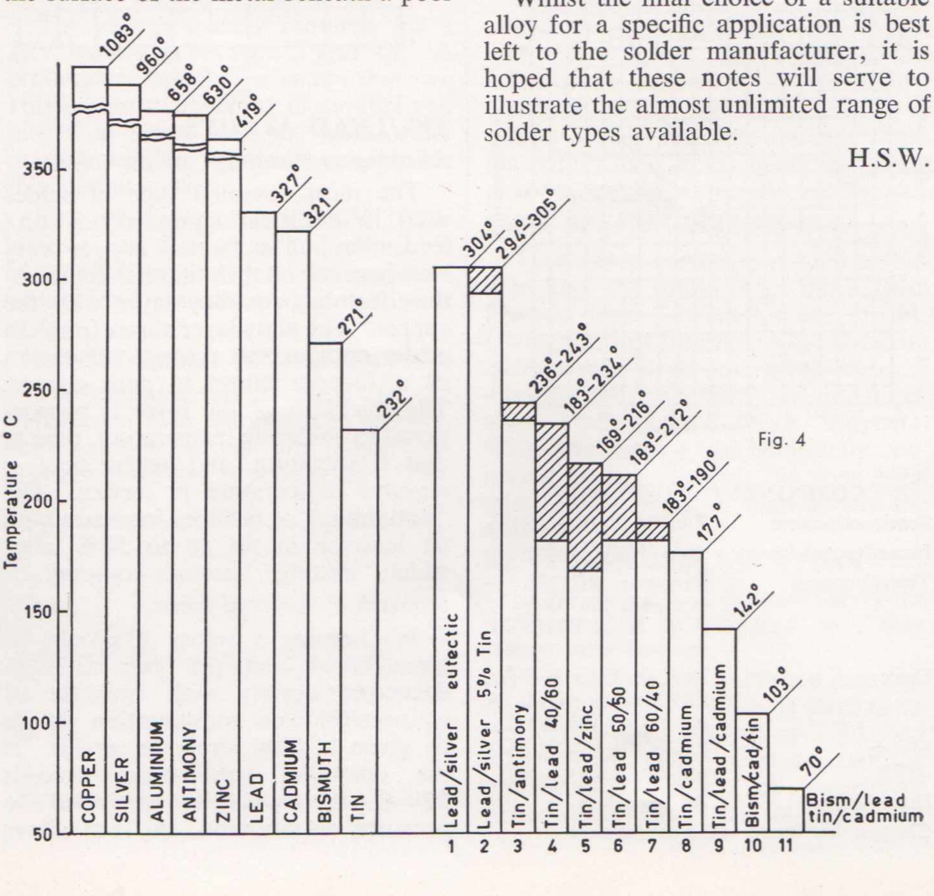

Fig. 4