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SOLDER AND ITS MARKETS*

by

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In 1963, 53,262 tons of lead were used in solder. 12.5% of the lead was used in automobiles, 10% in cans, 2.5% in coatings, and 65% for other purposes.

Before discussing the markets for solder, it might be worthwhile describing briefly what solder is and some of its properties which make it such a versatile material.

Solder is composed primarily of lead and tin. Various other elements such as silver, antimony, cadmium, indium, etc., are added to lead and/or tin to produce solders of different properties. The properties which make it so useful in so many areas are:

1. Its corrosion resistance to atmospheric attack.
2. Its low melting point compared to most metals.
3. Its ability to alloy with or wet a great many metals or alloys.
4. Its ductility and ease of forming and shaping.
5. Its electrical conductivity.

One or more of these properties make it ideally suited to most applications where it is used.

Tin alone, while used as a solder in some cases, is not as suitable for general work as tin-lead alloys. Lead when added to tin reduces the cost, the melting point, and improves the wetting properties. It is for these reasons that lead is such an important ingredient of solder.

To discuss all the markets for solder today is impossible because of the time available and to a greater extent because of my inadequate knowledge of all of the markets. I will mention a few of the more important uses and markets for solders. First, I will indicate the uses of solder in the automotive industries, which accounts for 22.5% of the total lead used in solder.

In the automobile, solder finds many applications. It is used, of course, in the electrical components which operate the electrical system. Every light bulb in the car including the sealed beam headlights contains solder to insure

reliable electrical connections. The vibration and shock automobiles are subjected to, make mechanical connections in electrical systems too undependable and a soldered connection is used. Solder used in the electrical systems contains from 40 to 70% lead. On a weight basis, most of the lead is used in the automobile as a filler metal. In new cars, these alloys called body solders or body leads contain as much as 97% lead, the balance being tin. The solder is supplied in bar form and is used to fill dents and imperfections in the body prior to painting. The body shop also uses body solder, although of a higher tin alloy, for ease of working. The third major category for use of solder in automobiles is in the radiators. A radiator is composed of a series of tubes and fins usually made of copper or brass which are assembled, fluxed and dipped into molten solder to seal the joints. Radiators designed to operate at higher temperatures and pressures have gradually dictated the use of higher lead alloys because of their higher melting points.

In the past fifteen years, solder has been challenged as a material in the automotive industry and has successfully withstood the challenge. Welding and wire wrap techniques have been largely ineffective in replacing solder for electrical connections. Plastics, primarily epoxies containing iron powder, have been attempted as a replacement for body solder for new car manufacture, but higher cost and difficulty in working with this type of material have made them inferior to solder. There has, however, been more general acceptance of the plastic fillers in the automotive repair shops because the price differential is not as great with respect to the higher tin content body solders in use for repair work. The greatest threat to the use of solder in radiators has come from attempts to replace the copper and brass radiators with aluminum. This change, while desirable because of the weight and cost reduction to be gained by the use of aluminum, is more than offset by the problems of joining aluminum.

10% of the lead used in solder goes to the can industry. Solder is used primarily to protect the steel from corrosion and is widely used for cans manufactured to contain materials other than foods, such as gasoline, oil and other non-food products. The lead content of the solder is generally 70 to 80%.

Another important, though relatively small market for solder is the coating field, which consumes 2.5% of the lead used in solder. Here, as in containers, the solder is used for corrosion protection, but is also used to preserve the solderability of surfaces. Millions of resistor, capacitor, diode, transistor, lug and terminal leads are coated with solder and without the protection this coating provides, present automated soldering production techniques would be impossible.

Approximately 65% of lead used in solder is used for unclassified purposes. While no breakdown of this figure is available, it is likely that a large portion of it is used by the electronic industries. This is a vast and rapidly growing industry which should use more solder as time goes on.

The past 20 years have seen tremendous developments in the electronics industry. A number of major developments have been achieved during this period without which our computer industry and space program would not have been possible.

The first development was that of printed circuits. The conventional electronic circuit consisted of a metal chassis on which were mounted, resistors, capacitors, tubes, tuners and other components. These were interconnected with insulated wires soldered by hand with an iron and core solder to terminal posts. The result was a group of wires looking like a bowl of spaghetti. The metal chassis was heavy and the unit was large because space had to be provided to hand solder each connection. A printed circuit consists of a copper circuit pattern on a plastic insulating base. Holes are drilled or punched in the plastic to accommodate leads from components, the components are inserted in the top of the board and the whole assembly is soldered in 8-10 seconds by dipping in a bath of 60/40 or 63/37 solder. The original interest in the printed circuit approach stemmed from the attractive cost reduction possibilities and this has been accomplished. Many girls hand soldering each connection have now been replaced by a soldering machine which solders hundreds of connections simultaneously in a fraction of the time it can be done by hand. This technique has resulted in a major change in the form in which solder is used. Much of the solder supplied as wire containing the flux and heated with a soldering iron is now being supplied in ingot form for use in the dip solder pots. The flux is applied to the board prior to dip soldering. Actually, a printed circuit assembly contains more solder than the same assembly made by conventional hand soldering techniques. The reason for this is that in printed circuits the solder not only makes the connections, but at the same time covers the conductor pattern as well. In hand soldering, the solder is used only at isolated connections. While the usage of solder has gone up in printed circuit soldering, the amount of lead used has remained fairly constant. The reason for this is that in hand soldering, higher lead alloys containing as much as 70% lead can be effectively used; but in printed circuits, 37% lead is the maximum which can be used because of lack of high temperature stability of the printed circuit board material.

In addition to the economic advantage provided by printed circuits, several other outstanding advantages have developed. One of these is that of space saving. The conductor patterns can be placed very close together, making it possible to reduce the space occupied by the assembly to a minimum. The dramatic change can be seen in the size of computers today as compared to those of twenty years ago. Now, one room will hold equipment which used to require a whole building. The weight reduction, accomplished by using printed circuits, has been a real boon to the aviation and space programs where airborne electronic equipment must be as light as possible for obvious reasons.

A second major development which has complemented that of the printed circuit was that of semi-conductors. These are essentially solid materials which perform the functions of amplification and rectification of the well-known vacuum tube. The transistor or diode is many times smaller than a vacuum tube. A hundred transistors can occupy the same space as one vacuum tube. This has been a major contributing factor to the reduction in size of electronic equipment. Semi-conductors use very little energy and throw off very little heat. Twenty years ago, the cooling system, to remove the heat generated by thousands of vacuum tubes, was as large as the computer itself. Now, since transistors produce no heat, the cooling systems are practically eliminated.

Solder plays an important role in the semi-conductor industry. Lead alloys are used as doping alloys in making active germainium and silicon devices. Solder is used to attach the germainium crystal to the base tab. It is also used to hermetically seal the transistor can to the header. It is used to coat the surface of the can and header for corrosion protection, and finally it is used to coat the leads to provide solderability. Thus, it can be seen that solder is vital to the manufacture of semi-conductors.

The computer is the heart of the space program. Without it, the retrieval and rapid analysis of data so necessary to success could not be achieved. It is also the nerve cell of our commercial airline operations and our entire defense and communications system. A major effort is now under way to increase the reliability of these electronic systems. One of the areas under intensive study is the soldered connection. Several missile failures have been traced to faulty soldered connections. There has recently been a concerted effort by the welding industry to replace soldering with welding, but it has yet to be proved that welding as a technique is more reliable than soldering. Generally, a faulty soldered connection is caused by poor workmanship, rather than by the solder. The same can be expected of the welded connection, since so much depends on operation technique. Those of us in the solder industry are proud of the part solder has played in the electronic industry. When it is realized that exotic and complex electronic systems depend on the soldered connection for proper functioning, solder can truly be called "the magnificent trifle."

As I indicated before, no break-down by industries is available on the lead used in solder for the 65% listed as unclassified. In addition to the electronic industry, a large portion of solder is used in plumbing where the 50-lead/50-tin alloy has been the standard for so many years. This market should continue for many years.

The electrical industry which produces relays, generators, transformers, etc., consumes much lead in the form of solder and should continue to do so.

While solder should continue to be used in increasing amounts in all industries, a future threat to solder consumption in the electronic industry lies in the trend to micro-miniaturization and integrated circuits. Whether this will result in materially reducing the amount of solder used is extremely doubtful. Past experience indicates that usually the reverse is true. The industrial revolution, instead of reducing employment, created more jobs. The present trend toward automation will probably do the same. I look to increasing uses for solder in the years ahead.

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