# IMPORTANCE AND USES OF LEAD*

*Robert L. Ziegfeld*

Lead is ubiquitous in our industrial and every day life. It can be safely said that, even though it is not the largest of the non-ferrous metals in production and usage, it is the broadest in its applications. It starts our cars, keeps the knock out of their engines, and makes the car bodies sleek and smooth. It is in the paint on our houses and bridges, in the glazes on tiles and the porcelain enamels on aluminum; it is in the finest crystal and optical glass. It shields against nuclear radiation. It makes the joints in cast-iron pipe and is in the type metal from which we print. It does a thousand and one things for us every day.

But unfortunately it is not always easy to recognize. About a third of its use is in chemical compounds that bear no resemblance to the metal itself. Often it is in alloys with other metals or is only a hidden component of some device we commonly employ. At the other extreme, lead sometimes plays the part of the little man who wasn't there. The leads of lead pencils, for example, are not lead at all. Many paints contain lead, but many do not.

Thus it is not possible to generalize about lead nor to jump to conclusions about where it is used or where it isn't. To understand lead's usage, its importance in industry and its significance to the average person in or out of the lead industry, some knowledge of lead's background is essential.

## Lead Mining, Smelting and Refining

Before proceeding to a discussion of the industries that use lead, some word about its production is in order. The producing end of the industry is divided into two parts - mining, and smelting and refining. Today Australia has superseded the United States as the free world's largest lead miner, with Canada, Mexico, the United States, Peru, Southwest Africa, and others also as important miners. Russia and Yugoslavia are also important producers. In the U. S. the largest mine production comes from Missouri, with Idaho, Utah and other western states also important factors.

Lead is generally produced from underground mines, galena or lead sulphide being the principal mineral in the ore. The carbonate and sulphate are of much less importance. In the western mines lead minerals are often associated with the minerals of other metals like zinc and silver, which are also recovered.

*Presented at the Lead Symposium, at the Kettering Laboratory, Cincinnati 19, Ohio, by Robert L. Ziegfeld, Executive Vice President, Lead Industries Association, Inc., 292 Madison Avenue, New York 17, N.Y.

In the United States the lead content of ores mined is generally low - from 2 to 7 or 8 percent - but abroad the lead content is frequently much higher. These ores are then concentrated to a lead content of 60 to 80 percent or more before being sent to the smelters. The process of concentration is usually that of flotation, a process in which finely ground ore is mixed with water and special chemicals which cause the heavy lead particles to rise to the surface in a froth and overflow, or by gravity in water where the heavier lead sinks to the bottom.

The lead smelting and refining industry itself is also divided into two parts - primary and secondary smelting and refining. The former produces pig lead essentially from ores and concentrates with a small admixture of scrap; the latter reclaims the lead from scrap, mainly old batteries, cable sheath, solder, babbitt and the like.

The ores and concentrates are produced mainly at mines in this country, but a sizable portion is imported. Last year about 240,000 tons of primary lead was produced from domestic ores and 140,000 tons from imported material.

Secondary smelters are also of great importance and in 1962 produced pig lead, antimonial lead and other lead alloys estimated at about 440,000 tons. The rest of the lead used in the United States is imported as pig lead produced at foreign smelters and refineries.

It is obvious that smelting and refining is a big industry. Primary smelters are relatively few in number and generally large. Secondary smelters are large in number and range in size from very small, producing only a few hundred tons a year, to quite substantial operations.

Smelting generally involves the use of blast or reverberatory furnaces, although some small secondaries merely smelt and remove dross. Refining is accomplished by fire in this country except at one plant which uses the electrolytic process.

## Consumption of Lead

More than 1,075,000 tons of lead were used in the United States in 1962. In fact, the consumption of lead in the United States has averaged little less than 1,100,000 tons per year for the past ten years. Obviously this is a sizeable tonnage of a metal that now sells for $200 a ton and has sold considerably higher most of the time since World War II. It indicates the magnitude of the industrial applications of lead.

The interesting thing however is the variety of industries and variety of products into which this tonnage of lead enters. In the first place over 40 percent of all the lead used last year went into chemical compounds like white lead, red lead, litharge, black oxides, lead silicates, lead chromates, and tetraethyl lead, to name only the more important few

The other 60 per cent of the lead consumed is largely in metallic form either as pure lead or as alloys. Among the more important products in this group are storage battery grids, cable sheathing, ammunition, pipe, sheet, solder, babbitt, type metal, calking lead and many others.

I think here a breakdown of the consumption of lead in 1962, in terms of the resultant products, may be enlightening. This is given in the following table.

Lead Consumption By Products
1962 (Est.)
(In Short Tons)

| | | |
|---|---|---|
| Tetraethyl lead | 172 000 | |
| Litharge | 87 000 | |
| Black Oxide (est.) | 150 000 | |
| Red lead | 23 000 | |
| White lead | 11 000 | |
| Lead chromates | 20 000 | |
| Lead arsenate | 2 500 | |
| Miscellaneous lead compounds | 6 000 | |
| Total lead compounds | | 471,500 |
| Antimonial lead products | 190,000 | |
| Cable sheathing | 56,000 | |
| Solder | 63 000 | |
| Calking lead | 73,000 | |
| Ammunition | 47,000 | |
| Pipe and extruded products | 20,000 | |
| Rolled products | 30,000 | |
| Type metal | 27,000 | |
| Bearing metals | 17,000 | |
| Miscellaneous | 82 500 | |
| Total metallic products | | 605 500 |
| TOTAL | | 1,077,000 |

Another way to break down these consumption figures is by industries rather than by products. While it is difficult to make a clear-cut separation in this respect, it is probably a more interesting and valuable breakdown from many standpoints. Here is such an approximate analysis:

Lead Consumption by Industries
1962
(In Short Tons)

| | |
|---|---|
| Storage batteries | 387,000 |
| Oil Refining and gasoline | 175,000 |
| Cable | 55,500 |
| Construction | 123,000 |
| Paint and varnish | 29,000 |
| Ammunition | 47,000 |
| Brass manufacturing | 21,000 |
| Printing | 27,000 |
| Ceramics | 17,000 |
| Colors | 20,000 |
| Can manufacturing | 7,000 |
| Automobiles (other than batteries) | 12,000 |
| Railroads | 7,000 |
| Insecticides | 2,500 |
| Steel and wire | 4,000 |
| Foil | 4,000 |
| Collapsible tubes | 12,000 |
| Rubber and hose | 3,500 |
| Coatings | 1,500 |
| Unclassified | 122,000 |
| Total | 1,077,000 |

It is clear that the foregoing is not strictly on an industry basis because of the difficulty and even impossibility of tracing the ultimate disposition of a number of lead products. Yet in most cases it indicates clearly the industry in which the lead is fabricated.

It certainly must be clear from this tabulation that there are many industries which, to a greater or lesser degree, depend upon lead or its products. Yet I think that it may be of benefit to go beyond any such general summary as I have presented and to examine exactly in what form and in what manner these industries employ lead.

## Storage Battery Industry

The electric storage battery industry is the largest user of lead in the United States. At the same time, worn-out storage batteries provide the secondary smelting and refining industry with its largest source of raw material. About 80 per cent of the lead that goes into batteries comes back as scrap, after a cycle of 3 or 4 years, which reduces the net consumption of lead by this industry substantially.

There are several types of storage batteries which are of industrial significance. The most important are lead-acid, nickel-iron-alkaline, nickel-cadmium and silver-zinc. The first of these has many times the industrial significance of all the others combined, since it is the lead-acid battery that is used for automobile starting and lighting. It is the only one which will deliver the high current densities, over short periods of time, at low cost, required for automotive engine cranking. The other three types mentioned are far more expensive. Nickel-iron batteries find some use in industrial applications but lead-acid industrial batteries have put themselves in a much better competitive position in recent years through improved design and performance. Nickel-cadmium battery applications are limited by high cost and restricted supplies of cadmium and nickel. Silver-zinc batteries are so expensive as to relegate them to the field of special and exotic applications.

Therefore, by far the bulk of the storage battery business falls to the lead-acid type of battery, since it is used for practically all automotive batteries, thereby accounting for 75 per cent or more of the total battery business, as well as for many other batteries. Batteries for new cars number 6,000,000 or 7,000,000 per year at current rates of production. Even more important is the replacement automotive battery business, because the average life of an automobile battery is about 26 months. Thus, in 1962, more than 28,000,000 replacement batteries were produced.

The balance of lead storage battery production goes into a variety of industries. They are used as stand-by batteries by power companies, and in hospitals and places of public assembly, where power failures might have tragic consequences. They are used in the telephone system, for railway car lighting, for industrial trucks, for railway and aircraft signals, for airplanes, for mine locomotives, and for many other purposes. Growing markets appear assured in golf carts and personnel carriers, in short haul delivery trucks, and power tools.

The lead in storage batteries is in two forms - metallic lead to make up the grids and lugs, and lead oxide, which is the active material pasted on the plates. The grids are made of a lead-antimony alloy containing between 4 and 8 per cent of antimony, depending upon the preference of the individual manufacturer. These are made from metallic ingots of antimonial lead by melting and casting. Latest developments tend to reduce the antimony content and add small amounts of arsenic and silver.

The oxides on the other hand are made from pure metallic lead. The oxides used are litharge (PbO), red lead ($Pb_3O_4$), and black oxide ($Pb_2O$).

Battery manufacturers generally buy the antimonial lead ingots used to make the grids, from either primary or secondary lead refineries. A few battery companies, however, also operate secondary smelters wherein they produce their own antimonial lead from scrap batteries. The melting and casting of the grids is generally done in the battery plant, although a number of very small battery manufacturers buy the grids already cast from larger battery companies.

A few of the large battery makers produce their own oxides, while most battery companies buy their supplies of oxides from lead manufacturers.

In assembling batteries, lead welding is employed in the battery plants to connect the plates and battery connectors. About 60 to 70 per cent of the weight of a battery is lead and this lead is about equally divided between metallic antimonial lead and lead oxide. About 80 per cent of all the lead used in storage batteries is recovered at secondary lead smelters, and this forms the basis of the large secondary lead smelting industry which produced about 450,000 tons of secondary lead and lead alloys in the year 1962.

Thus the storage battery industry is almost entirely dependent upon lead, and there seems little likelihood at this time of any important substitution taking place in that industry. Because of the automotive industry's dependence upon the storage battery industry, it likewise, at least indirectly, is heavily dependent upon lead. In fact there are probably more pounds of lead used per car, if batteries are included, than any other non-ferrous metal or alloy. A car wouldn't be much good to us today without a battery because the number of electrical gadgets in a car is multiplied each year and there is no crank or even a place to insert a crank except behind the steering wheel.

## Petroleum Industry

The next industry we may consider is the petroleum industry, which in recent years has leaped into second place as a consumer of lead. Actually this industry uses much more lead than statistics show, because it employs large quantities of sheet lead and lead pipe in the construction of corrosion-resistant equipment. Since it is impossible to segregate that tonnage from other sheet and pipe used for similar purposes in other industries, the lead used by the petroleum industry for construction purposes is classed in the category of construction discussed later.

Therefore, we are now considering only the chemical compounds of lead which enter into the refining process or become a part of the gasoline itself. These alone totaled over 170,000 tons of lead in 1962.

In oil refining, litharge is used in the so-called "doctor solutions" which contribute to removal of undesirable sulphur compounds from certain products. The litharge is dissolved in caustic soda and, when added to the petroleum products, reacts with the sulphur compounds and is removed as lead sulphide, thus taking the undesired sulphur with it. Less than 5,000 tons of lead as litharge is thus consumed today. Once this use was much larger, but changes in refining methods have reduced the need for litharge.

Most sensational of lead's relatively recent developments has been tetraethyl lead and other lead alkyls used as anti-knock ingredients in motor fuels. Only 40 years ago this use of lead was unknown. Last year it consumed 172,000 tons of lead.

I think this typifies one important thing about lead, namely that its industrial significance is not dependent upon only a few attributes, but rather on a wide variety of both chemical and physical properties. We all know that changes in our industrial economy frequently outmode certain uses of any material. Because lead is so versatile, as old uses become outmoded new ones seem almost inevitably to crop up.

As an example, in a few moments the changing pattern of the use of lead in the paint industry will be discussed, wherein the volume of lead used has declined over the last 40 years. During that same period, however, the use of lead in tetraethyl lead and other lead alkyls has shown a corresponding increase. These two applications are both dependent upon chemical properties of lead, but each upon different chemical properties.

Lead alkyls as a class are among the few liquid compounds of lead of commercial significance. They are colorless liquids, the most important of which, tetraethyl lead has the formula $(Pb(C_2H_5)_4$. Three of four domestic manufacturers treat a lead-sodium alloy with the corresponding organic chloride. After completion of the reaction, the product is distilled with steam to recover the lead alkyls.

The anti-knock fluid is a mixture of lead alkyl with halogenated hydrocarbons, chiefly ethylene dibromide and ethylene dichloride, together with a dye, the latter to distinguish it from non-leaded gasoline. While there are refining methods to increase the anti-knock rating of gasoline, that rating can always be increased by the addition of lead alkyl. Despite the temporary trend to smaller and lower powered cars a year or two ago, this trend has been reversed. This year the average amount of lead alkyls per gallon of gasoline has increased over last year. The permissible limit of tetraethyl or its equivalent in other alkyls per gallon of automobile gasoline has been increased recently from 3 to 4 mil. per gallon.

Another development in the last couple of years has been the growing use of lead alkyls other than tetraethyl lead in gasoline. Lead alkyls are now produced by four companies in the United States, one in Canada, one in the United Kingdom, one in France, and three in Italy; another plant is under construction in Mexico. As the internal combustion engine continues to improve and the thirst for automotive power with economy increases, the continued growth of the use of lead anti-knock compounds appears assured.

## Cable Industry

The power and communications industries are also heavily dependent upon lead. Here it is used to sheathe the transmission cable which transports the energy from the source at which it is generated to the point at which it is consumed. Obviously generators and telephones or telegraphs are useless unless the power or messages can be safely delivered to the proper place.

The purpose of sheathing on cable is to protect the wires and insulation with a covering absolutely impervious to moisture and one which will withstand the corrosive attacks of soil and atmosphere for many years. At the same time this sheath must be sufficiently flexible to permit coiling and uncoiling of the cable and installation through manholes, to provide for ground movement; it must also be capable of economical application to the cable.

Lead answers all of these requirements admirably, and, as the figures shown earlier indicate, it is very extensively used. However, there has been intensive research for substitutes to relieve the cable industry of its entire dependence on lead. In communications cable, combination sheaths of aluminum, terne plate, and polyethylene have been developed and are now probably as widely used as lead, particularly for overhead cables and those not buried directly in the ground. In power cable, lead has been displaced to a large extent in the very low voltage and very high voltage field, but is still used for the big bulk of power cable which is in the 6 to 66 kv. range. Experimental work is being done on aluminum sheaths, but there are still many difficulties in the way of its use, such as joining problems, beading, corrosion, and manufacture itself. Despite these attempts at substitution the use of lead for cable sheath remains large because the industries using it have grown so greatly.

For communications cable, an alloy of lead with 1 per cent antimony is most popular. For power cable, there is preference for an alloy of the nature of 0.15 per cent arsenic, 0.10 tin, 0.10 bismuth, and the balance lead. It is applied to the cable in an extrusion press. The pigs of lead or lead alloy are melted in a kettle adjacent to the press, often in a reducing atmosphere to prevent oxidation, and the molten metal allowed to flow into the cylinder of the press, where it solidifies. The unsheathed cable is fed into the cylinder through an opening at one side near the bottom and passes out through a die in the opposite side. The cable forms the core of the die and the die has a diameter equal to the outside diameter of the cable sheath. As hydraulic pressure is applied to the lead in the cylinder, the cable is fed through the die and lead is squeezed out around it in the space between the cable and the die. Thus, a continuous, seamless sheath of lead is formed around the cable.

Some 55,000 to 60,000 tons of lead were used in this way in 1962. This industry is to a very large extent dependent upon lead for protection of its transmission lines. It appears that the trend toward substitution for lead has about gone its limit in the cable sheathing industry. In Europe much more dependence on lead has been maintained. Even here the leading telephone company appears to be swinging back to greater dependence on lead, while other telephone companies have never swung away from lead to the same extent. Lead remains the material on which power and communications companies depend under the most severe service conditions.

A new method of production which results in more uniform and more economical lead sheathing is also becoming an important factor. In the press, molten lead is fed into one end, solidifies as it passes through a screw feed, and emerges as solid sheath through a die around the cable at the other end. Some of these continuous presses have been perfected to a point where they can handle all common sheathing alloys and many are being installed in cable manufacturing plants.

The power and communications industries, to a much lesser extent, depend upon a lead-tin alloy, solder, to make the joints in their lead-sheathed cable. Yet it is the ease with which such joints can be made and the dependability of those joints that give lead sheathing one of its distinct advantages over other types.

## Construction Industry

The next industry in order of importance as a user of lead is the construction industry. Because of the difficulty of making an accurate separation, the term "construction industry" is here used to include not only ordinary building construction such as homes, apartments, office buildings and the like, but also some of the utilities which serve these buildings, as water distribution systems, and chemical equipment employed in industrial buildings. Lumped together, the construction industries used nearly

125,000 tons of lead in 1962.

Three principal lead products are used in construction. They are pipe, sheet and calking lead. In ordinary construction, pipe is used in the plumbing system to handle plumbing wastes and in the water distribution system to conduct water from the street main into the house. It is rarely used for the distribution of water within the house. In industrial construction, it is also used extensively to conduct corrosive chemicals such as sulphuric acid, and to handle corrosive industrial wastes.

Lead pipe is made in much the same way as cable sheathing. The lead is melted and flowed into the cylinder of an extrusion press, where it solidifies. At the top of the press is a circular die through the center of which extends a core or mandrel which also extends down through the lead and is fixed to the bottom of the cylinder. The core has an outside diameter equal to the inside diameter of the pipe to be made, and the die has an inside diameter equal to the outside diameter of the pipe. When pressure is applied, lead is forced out through the space between core and die as a continuous seamless pipe.

It may be interesting to note here that the manufacture of lead pipe is an extremely old industry dating back more than 2,000 years. As you know, our modern plumber takes his name from the Latin word for lead, "plumbum." In the days of the Roman Empire, lead pipe manufacture was well established, pipe being made in ten-foot lengths and 15 standard sizes. That pipe, however, was much cruder and was not seamless. The lead was first cast in a sheet, then bent up into the shape of a pipe and the longitudinal joint crudely welded. The age of these old pipes, many samples of which still exist, is easily determined because the name of the emperor ruling at the time of manufacture is cast on each length.

Sheet lead is used only to a limited extent in building construction, usually being confined to roofing, flashing, gutters and the like on the more monumental types of buildings or industrial or other buildings where special corrosion problems are involved. This is because of its relatively high cost and great durability. It is also widely used as a waterproofing for shower stalls and for X-ray room shielding. In industrial construction, however, large tonnages of sheet lead are employed to construct storage tanks, reaction vessels and other equipment for the manufacture and storage of corrosive chemicals.

Sheet lead is made by casting large slabs of lead several inches thick and weighing several tons. When solidified, these slabs are placed on the rolling mill and cold rolled to the desired thickness.

In ordinary building construction work, both lead pipe and sheet are usually joined by soldering with conventional lead-tin solder. In chemical construction, however, lead welding (commonly called lead "burning") is employed more frequently because corrosive chemicals generally attack solder. In welded equipment, no metal but lead is exposed to the corrosive chemical. Lead welding is a true homogeneous welding operation, but it is conducted at much lower temperature than welding of most other metals, notably steel. In fact, care must be taken not to overheat the lead and burn a hole through it, since lead melts at only 621°F.

Calking lead, the other important lead product used in construction, is simply soft metallic lead either in large pigs or small ingots or cakes. Its main use is to make joints in cast iron water or soil pipe of the bell and spigot variety. The pigs or ingots of calking lead are simply melted, usually at the site of construction, and are poured by ladle into the pipe joints into which strands of oakum have already been calked to partly fill the joints. After the lead has solidified in the joint, it is calked to make a tight joint and take up contraction of the lead on solidification and cooling.

## Paint Industry

The paint industry, with some 30,000 tons of lead consumption a year, is still an important user of lead products, but is nowhere near the consumer it was 40 years ago. In this industry, it is used in a variety of forms. It is an important pigment in house paints. For that purpose it is employed as basic carbonate (white lead), basic lead sulphate, leaded zinc oxide, and certain lead silicates. Basic carbonate was once the backbone of outside house paints, but over the last 40 years its use has gradually contracted, because it costs the paint manufacturer more to put it into his paint than any other white pigment. In that highly competitive industry, some of the qualities that white lead imparted to paint have been sacrificed. However, most paint manufacturers still agree that a certain amount of lead pigment is needed in outside paints and most of them formulate their paints on that basis.

The basic carbonate was formerly made almost exclusively by the famous "Old Dutch Process" which required three or four months to convert the lead to the basic carbonate in stacks through action of acetic acid, moisture and spent tanbark. In recent years the trend has been toward quicker processes involving electrolysis, chemical precipitation and other methods to reduce cost so that the last "Old Dutch Process" stacks in this country went out of existence in 1949, and that process is no longer used.

There are several quick processes. In one, metallic lead is melted and blown with air or steam to a fine powder. It is placed in large rotating wooden drums, into which acetic acid and water are periodically sprinkled. Heated air and carbon dioxide pass continuously through the drum. The reactions are the same as in the "Old Dutch Process" but, due to the finely divided form of the lead, the conversion requires less than two weeks.

In one of the chemical processes, lead is dissolved in acetic acid to form basic lead acetate, and the basic carbonate is precipitated by passing carbon dioxide through the solution.

White basic lead sulphate, also used extensively in paints, is made either by a fuming or chemical precipitation process. Leaded zinc oxide is generally a product of fuming, while the newer silicates are produced chemically. All enter into the manufacture of outdoor paints. None of the white lead pigments is today employed in the manufacture of indoor paints.

Red lead ($Pb_3O_4$) is still the world's standard pigment for metal protective paints. It is successfully meeting the competition of newer pigments, and is used either by itself with linseed oil or other suitable vehicles, or mixed with other pigments, usually in smaller amounts, in the proper vehicles. Red lead is made by further oxidation of litharge at carefully controlled temperatures.

Another lead pigment, "blue" basic lead sulphate, is also used in metal protective paints. It is made directly from lead concentrates by fuming, and is a mixture of basic lead sulphate, lead sulphite, lead sulphide, zinc oxide and a very small amount of carbon.

Considerable research is currently being conducted on lead pigments to be used with water soluble vehicles both for house paints and for finishes on metal such as automobile bodies. Results to date not only indicate that some of the known lead pigments will do a good job but also that a whole new series of lead pigments may be developed. For several years now a line of pigments having a silica core and active lead pigment, such as chromate, on the surface, have been on the market and finding commercial acceptance. Recent research also indicates that certain organo-lead compounds may find application in anti-fouling paints.

Lead compounds are also used as driers in paints but they are included in exceedingly small quantities per gallon of paint.

## Colors

Closely allied to the use of lead in the paint industry is its employment to make certain colored pigments, notably the lead chromates. This industry consumed about 20,000 tons of lead last year. Most of the yellows, greens and reds are lead chromates, either alone or precipitated with other pigments. These are made by chemical precipitation, starting generally with litharge as the raw material. They are also used as colors in printing inks, and the yellows are rapidly growing as traffic marking paints.

## Ceramic Industry

The use of lead in this industry has increased substantially in the last few years and now consumes some 25,000 to 30,000 tons of lead per year, mostly in the form of oxides and silicates, some of which are imported and do not show in the consumption statistics. The finest glass tableware and optical glass, as well as most glass for electrical purposes, contain large amounts of lead. Glazes for china and many structural clay products also contain lead. Applications of the latter are growing in architecture with glazed brick and light-weight aggregate among the products receiving much acceptance. The use of lead in porcelain enamels for aluminum is growing and the trend to lower firing temperatures for enamelled steel indicates that the use of lead will grow substantially here. Lead's fine fluxing ability and foolproofness run through all these ceramic applications. But the use of lead in electronic applications is also becoming an important factor, such as lead zirconate-titanate as a piezo-electric product in ultra-sonic cleaners and other devices, and lead tellaride in thermo-electric materials.

## Ammunition Industry

The ammunition industry is an old stand-by in the lead picture, using around 47,000 tons in a peacetime year. Bullets for small arms are made of lead alloyed with up to about 2-1/2 per cent of antimony. They are molded from sections cut from extruded rod. Shot for shotgun shells, which is more important than bullets in peacetime, is usually made of lead alloyed with small amounts of antimony and arsenic. It is melted and poured through a sieve at the top of a shot tower. It forms into spheres as it descends and is caught in water at the bottom. Large shot is cast in split ring molds.

## Printing Industry

The printing industry used about 27,000 tons of lead last year in the form of various alloys with antimony, tin and sometimes a little copper. The exact composition depends upon the application, that is, whether it is for linotype, monotype, stereotype or electrotype metal. Melting, casting, and remelting and drossing are the principal operations involved. Type metal is used over and over and also circulates back and forth between the printer and the manufacturer, the latter cleaning it up and adding new metal to bring it back to proper composition after frequent use.

## Railroad Industry

The railroads of the country consumed some 7,000 tons of lead in 1962, main in bearings. In some cases, the railroads make their own bearing metals, but more often they buy them from bearing metal manufacturers. Incidentally, in a great many types of bearings, the lead content is much higher than before the war. This came about from the necessity of substituting lead for scarce tin during the war, with the result that the higher lead content bearings were found to do the job well and at less cost.

## Automobile Industry

The automobile industry employs about 12,000 tons a year in uses other than that of storage batteries. These are mostly as solder and bearing metal. The solder is largely used for the radiator, which is soldered by a dipping operation, and for body solder to smooth out joints and other irregularities in the body surface. It is sometimes called filler metal which aptly describes it. Automobile body repair shops are large users of body solder to help heal the wounds incurred in modern traffic, but in repair work, various plastics rather than solder are often employed today.

## Miscellaneous Uses

The farmer is a user of lead as an insecticide. About 2,500 tons were used last year, and this figure has been much higher. Lead arsenate is the compound employed, made by chemical reaction on litharge.

The tin can industry uses 7,000 tons of lead in a year just for soldering seams and closures. In addition it uses an inseparable amount, classed under coatings, in the form of terne plate to make certain types of cans for non-food items. Terne plate is sheet steel coated with an alloy of lead and tin, the lead content of the coating usually running between 80 and 90 per cent. Terne plate is also used for various fabricated metal products such as automobile gas tanks and radio chassis, and for roofing.

A growing use of lead is as a stabilizer in plastics. For this purpose a variety of lead compounds are employed, some inorganic and some organic. While the lead content is usually small, amounting to only a few per cent, the total use for this purpose amounts to several thousand tons per year. The principal use is in vinyl plastics for electrical cable insulation, but it is also used in this type of plastic for many other purposes, such as floor coverings, hose, pipe and sheet.

Collapsible tubes of lead are manufactured by impact extrusion from discs cut out of sheets of lead alloy. The alloy usually contains around 2 per cent of antimony. When the tubes are to contain a substance that might conceivably be contaminated by contact with lead, the lead sheets from which they are made are rolled with tin on one or both sides. Also wax liners are often used in lead or tin-coated lead tubes.

The iron and steel industry uses lead in several ways. Terne plate coatings have been mentioned, but heat treating baths are often molten lead. Lead in the form of shot is added to molten steel to produce free machining steel and, while small, this use is growing.

Lead is also used in brass and bronze, either for the properties it imparts to bronze for bearings, for example, or for free machinability in brass.

## Radiation Shielding

Lead has long been recognized as a standard shield against X-rays, although no reliable figures are available to measure the extent of this use. It is safe to say, however, that if all X-ray equipment were adequately shielded much more lead would be employed for this purpose.

A whole new shielding field has been opened by the development of the nuclear industry, wherein lead forms a standard shield against gamma radiation. Lead is the most efficient commonly available, low-cost material for the purpose, although other materials like concrete and iron or steel can be employed. Generally speaking, lead is the choice for nuclear shielding where space, weight saving and portability are at a premium. For example, laboratory shielding, shipping containers, ship shielding and the like are usually lead. From 200 to over 1,000 tons of lead shielding may be used on a submarine or larger vessel. Viewing windows are glass of very high lead-content. Doors are usually lead filled. Special lead-containing cements are used. Lead may be used in various forms as sheets, castings, shot, wool, leaded plastics or other products. It is difficult to estimate the tonnage of lead currently involved, but it is probably safe to say that it is at least in five figures per year.

## Noise and Vibration Control

There is nothing essentially new in the use of lead to control noise and vibration. Lead-asbestos pads under building foundations, to prevent transmission of vibration from railroads into buildings, have been employed in a limited way for over forty years. For over thirty years, particularly in Europe, such devices have been used to prevent transmission of vibration from machinery to buildings in which machinery is housed. Over the same period, lead linings have been used to confine objectionable noise in laboratories, music studios and broadcasting facilities.

What is new is the tremendously increased interest in these properties of lead in the last few years, and in some of the new lead products developed in this field. Probably accounting for this is the tremendous interest in noise and vibration control being shown today both in industry and every day living. Much research is being conducted to develop more detailed and accurate engineering information on the ability of lead to reduce transmission of sound and vibration, and to damp them at the source. Also much work is being conducted on the development of products involving lead, for these purposes. Among lead products that are being used are sheet lead and a variety of plastics such as vinyls, epoxies, urethanes and others, which are loaded with lead or galena powder.

## Conclusion

From the foregoing it is obvious that the industrial significance of lead is immense and anything but simple. So likewise is its hygienic significance. Merely to know that a man works in a lead plant or even works with lead is no indication that he has sustained occupational exposure to lead. Because a child has been exposed to paint does not necessarily mean that it has been exposed to lead paint, any more than exposure to a lead pencil means exposure to lead. It seems obvious that many people working with or exposed to lead may have no dangerous exposure, and it seems equally obvious that if the exposure is understood, it can be controlled.

It is not my intention to minimize the importance of effective hygiene in the lead industries. The Lead Industries Association has been fully cognizant of the problem ever since its organization in 1928, has made numerous monetary grants for medical research over the years, and has a health and safety director to cope with these problems. Our plea is for the continuation and extension of thorough investigation of the hygiene problems relative to lead, and the broad dissemination of sound information among all who have reason to be concerned.