LEAD INDUSTRIES ASSOCIATION

60 EAST 42ND STREET
NEW YORK 17, N. Y.

March 3, 1959

SUBJECT: THE MATERIALS YOU BUY - LEAD

To Members of the Lead Industries Association:

Please find attached a reprint of an article entitled "The Materials You Buy - Lead" which appeared in the January, 1959, issue of the "New York Purchasing Review."

The reprint will be used primarily for distribution to high school and college students through listings in educational indexes of free literature. It will also be made available to others requesting general information about lead.

Extra copies, up to 25, are available to members free of charge and above this quantity, at our cost of $6.50 per hundred.

The article, including photographs, was supplied to the magazine by L.I.A.

Sincerely yours,

Secretary.

The Materials You Buy—*Lead*

Reprinted from

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New York 17, N.Y.

The Materials You Buy

THIRD OF A SERIES

A lead mine in Idaho.

Lead

By ROBERT L. ZIEGFELD and DAVID M. BORCINA

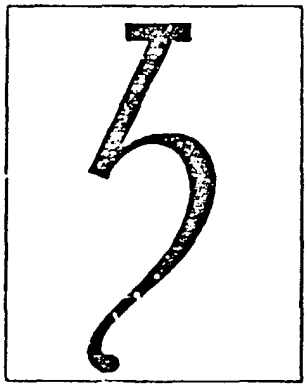
Secretary and Assistant to Secretary, Respectively, Lead Industries Association

The United States is, and has been for a great many years, one of the principal lead producing countries of the world, currently accounting for about 15 per cent of the world's output of approximately 2,360,000 tons. Commercial quantities of lead are mined in 21 of the 49 states with the western states predominant. However, Missouri is the largest producing state with Idaho, Utah, Colorado, Montana, Arizona, Washington, Oklahoma and others adding to the supply each year, approximately in the order named. By far the major portion of the lead mined is by underground methods with the ore generally containing galena, a lead sulphide, and usually associated with other metals, notably zinc and silver. Of considerably less commercial importance are the other lead minerals, cerrusite, a lead carbonate, and anglesite, a lead sulphate.

Lead Ore Concentrated Before Shipment to Mills

Few mines produce ores rich enough or pure enough to be shipped directly to a smelter without intermediate processing. More often the miner will struggle with a comparatively low grade of lead ore. On the other hand, an ore can be phenomenally rich in lead but contain so much zinc and copper that special treatment is required before shipment can be made to a smelter where penalties may be incurred by the presence of such impurities.

Obviously, it is not economically feasible to ship ore containing only 10 percent, let us say, of lead content or ore containing impurities that will penalize the miner, so it becomes necessary to concentrate the ore. Concentrating mills are therefore located in mining areas where one or more mining properties can haul their ore for concentrating and or removal of impurities.

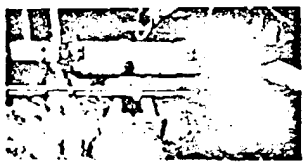


The symbol for lead taken by the ancients from the sign for Saturn.

The Flotation Process

At the mill the lead ore is crushed extremely fine, sometimes to particles less than 1 mm. in diameter, and treated by one of the modern processes of mineral concentration. The remarkable flotation process may be used, a method simple enough to describe but complicated in execution, and such an important and marvelous metallurgical development of the twentieth century that it has left a deep impression upon the lead and practically all other metal mining industries.

Flotation is applicable principally to the sulphide type of ore, fortunately the commonest variety, or to an oxide ore which has received a preliminary sulphiding. Briefly, the flotation process generally constitutes taking finely crushed ore diluted with, say, four times as much water, and agitating the mass violently with air in a tank to which a fraction of one percent of pine oil, with or without small amounts of other suitable chemicals, has been added. As a result of the agitation a froth containing most of the metallic constituents of the ore is formed



A flotation cell showing lead-rich ore frothing.

on top of the tank while the valueless gangue matter remains unaffected at the bottom of the tank. The froth flows from the tank and is easily dried.

Flotation practice has reached such a stage of perfection that extraordinarily efficient work is being done, not only in extracting a single mineral from an ore, but also in separating the several minerals in so-called complex ores, for example, an ore consisting of an intimate mixture of lead, copper and zinc minerals. For years the treatment

of many complex ores baffled metallurgists, but with selective flotation as a tool, many mineral deposits once considered practically worthless have developed into important lead mines. Furthermore, many straight lead ores formerly believed too low grade for economical treatment suddenly became profitable possibilities, adding greatly to the world's available lead reserves.

Flotation has, to a considerable extent, supplanted earlier methods of concentration using gravitational methods of milling, that is, pulsating jigs, vibrating tables, and many other machines, but the older mechanical methods are used alone or with flotation in treating many ores for which they are particularly suited.

Smelting

Lead concentrates when they leave the mill contain 40 percent and upwards of lead. The richer the lead content the better, for it reduces transportation and smelting costs. Smelting is a continuous operation generally conducted in blast furnaces. Before the concentrates can be charged into the furnace, they must be roasted to remove most of the sulphur contained in the concentrates and to agglomerate the very fine flotation product which is not a physically desirable blast furnace material. The roasted concentrate, or sinter, now in the form of lumps, is charged into the top of the heated blast furnace with limestone and other suitable fluxes and coke for fuel. A blast of air is admitted to the lower part of the furnace to aid combustion and to complete the formation of metallic oxides which are reduced to metal by the coke and carbon monoxide present. The non-metallic waste forms a slag with the fluxing materials.

The blast furnace is then tapped so that the lead flows off into kettles or molds. In this form the lead is a semi-finished product known as base bullion, containing silver and impurities. Specifically, base bullion contains small amounts of gold, silver, copper, zinc, antimony, arsenic, bismuth and other impurities which must be removed in whole or in part by refining to produce a commercial lead.

Refining

The most widely used refining process is the Parkes process. By this treatment the lead is first melted and allowed to cool below the freezing point of copper, which crystallizes and is removed by skimming. It then passes to a reverberatory or softening furnace where the temperature is raised and the molten lead stirred. A blast of air oxidizes any antimony or arsenic present, both of which impurities harden lead (hence the term "softening" furnace), and these oxides are skimmed off.

A continuous softening process for the elimination of antimony and arsenic from lead bullion has been perfected which represents more than just a conversion from batch to continuous procedure. In this process, oxidation rates, many times in excess of those obtainable by usual batch softening methods, are realized by the continuous maintenance of the antimony content of the furnace metal within a determined optimum range of 0.01-0.05 percent antimony. The accelerated oxidation rate obtainable in continuous operations permits a marked reduction not only in the operational costs of batch methods, but also in space and equipment requirements.

After softening, the lead goes to the desilverizing kettles where zinc in quantities of zinc are added. Gold and silver are more soluble in zinc than in lead, and, consequently, any of these metals present in the lead immediately leave it in favor of the zinc. As zinc is lighter than lead, the zinc rises to the surface and, when the temperature is lowered, solidifies and is skimmed. This leaves only a little zinc remaining as an impurity which is oxidized and skimmed in a reverberatory furnace. A more recent development removes the zinc as a vapor by creating a vacuum over the surface of the molten lead. The zinc vapor is condensed as metal on the cool dome of the vacuum vessel and re-used. Refined lead becomes one of the purest of the commercial metals through this treatment and is cast into pigs.

Pouring lead bullion into a kettle for fire refining.

The Pattinson process, now rarely used, depends upon the fact that when lead is cooled slowly, part of it will solidify and can be skimmed off while the silver will

STANDARD SPECIFICATION FOR PIG LEAD

A.S.T.M. DESIGNATION B29-35

CHEMICAL REQUIREMENTS

	Corroding Lead*	Chemical Lead*	Acid-Copper Lead*	Common Desilverized Lead*
Bismuth, max., per cent	0.030	0.005	0.025	0.150
Silver, max., per cent	0.0015	0.020	0.002	0.002
Silver, min., per cent	—	0.002	—	—
Copper, max., per cent	0.0015	0.080	0.040	0.0025
Copper, min., per cent	—	0.040	0.040	—
Silver and copper together, max., per cent	0.0025	—	—	—
Arsenic, antimony, and tin together, max., per cent	0.002	0.002	0.002	0.005
Zinc, max., per cent	0.001	0.001	0.001	0.002
Iron, max., per cent	0.002	0.002	0.002	0.002
Lead (by difference), min., per cent	99.94	99.90	99.90	99.85

* EXPLANATORY NOTE:

Corroding lead is a designation that has been used in the trade for many years to describe lead which has been refined to a high degree of purity.

Chemical lead has been used in the trade to describe the undesilverized lead produced from Southeastern Missouri ores.

Acid copper lead is made by adding copper to fully refined lead.

Common desilverized lead is a designation used to describe fully refined desilverized lead

remain in the molten lead left behind. The Betts process, employed in several plants including one in the United States, is an electrolytic method advantageously used with bullion high in bismuth. The bismuth is removed and recovered, which is not the case with the Parkes process.

The Harris process of softening and dezincing by the use of molten caustic salts is used in some plants in England, Europe and Japan. The process is designed to remove impurities from molten desilverized lead by pumping it through a mixture of molten salts contained in a tank above the lead kettle. The metallic impurities react with the chemicals and are collected in the form of their oxides or oxysalts. The Harris process while sound in theory has not been universally adopted since in practice it cannot always compete economically with the Parkes or Betts process.

Some ores, such as those of southeastern Missouri, contain too little silver for profitable desilverizing. Therefore the finished pigs, while free from other impurities, are noted for their comparatively high silver and copper content and are given the designation "Chemical" lead because of wide use in the chemical industries in the form of sheet and pipe. This is but one of the commercial grades of pig lead available to the consumer. These grades are described in the accompanying table of the American Society for Testing Materials specification for the various grades of pig lead.

Casting fully refined lead into pigs.

Scrap an Important Source of Lead

An important source of lead each year is scrap or secondary lead as it is more formally known. In 1957, in the United States, approximately 500,000 tons of lead were produced from secondary sources accounting for more than 40% of all the lead consumed by American industry in that year.

Loading ore in a Missouri lead mine.

The chief source of lead scrap is from automobile storage batteries which contain somewhere between 20 and 25 lb. of lead a piece. The bulk of this lead is recovered after an average service life of about 26 months. Additional sources for lead scrap include such items as lead sheathed cable, pipe and sheet, solder, railroad bearings, type metals and lead drosses.

Secondary lead is reclaimed by fire refining methods in refineries usually devoted exclusively to the handling of secondary lead and lead alloys. A comparatively small percentage is also refined at primary refineries.

Much of the secondary lead produced is sold as lead alloy, particularly lead from reclaimed batteries and cable sheathing which contain small percentages of antimony and other metals. The bulk of the secondary lead recovered containing antimony is re-sold to battery manufacturers. Secondary lead containing tin is most often re-used in the manufacture of solder, bearing metals and other lead-tin alloys.

By applying proper refining techniques, soft lead can be produced from secondary sources to meet primary lead specifications.

Pigs of lead and antimonial lead usually weigh about 100 lb. each, while ingots of lead or its alloys may have almost any desired weight and shape from the small 3- to 5-lb. cakes to be melted in portable gasoline furnaces to 100-lb. cylindrical billets to fit extrusion presses. A recent innovation to facilitate the materials handling problem is the development of shapes weighing approximately 2,000 lb. that have been designed for handling by fork lift truck.

Lead and Lead Alloy Products

In semi-fabricated and fabricated form, a variety of lead and lead alloy products are available. Examples are:

1. Extruded — pipe, rod, wire, ribbon, traps, bends, wedge lead, special shapes
2. Rolled — sheet, foil, strip, blanks for drawing, stamping and spinning, blanks of various shapes
3. Cast — sand or die-cast (gravity or pressure)
4. Chemical Compounds — oxides, carbonates, sulphates, chromates, organic compounds, silicates, acetate, etc.
5. Other — Metallic powder, wool, shot

Lead and its alloys can be fabricated by almost all commercial processes. It can, for instance, be extruded, drawn, rolled, cast, stamped, spun, and can be applied as a coating to other metals either by hot-dipping, electroplating or spraying. Thick layers of lead can be bonded to steel or other metals for greater strength. Joints may be made by soft soldering or welding.

The properties of lead and most of its alloys are quite different from those of other metals, but this very difference makes lead peculiarly suitable for many applications where other metals would not be practical. On the other hand, it is often possible to gain some useful property of lead in cases where lead may not at first seem suitable, if these differences are clearly recognized. For instance, slight design changes or changes in manufacturing technique may make it possible to use lead with greater satisfaction in place of a metal with quite different characteristics.

In general, lead and its alloys have high resistance to corrosion, high specific gravity, are comparatively soft, have a low melting point, are easily fabricated. They have low electrical conductivity and tensile strength and a relatively high coefficient of thermal expansion. However, the properties can be varied within quite a wide range by judicious use of alloying elements. For instance, strength and hardness of ordinary lead can be multiplied many times or melting point greatly reduced by alloying.

Lead Reserves Ample

There has been considerable discussion about U. S. lead reserves in recent years. To the uninitiated figures representing lead reserves can be misinterpreted very easily. For instance, in 1947, hearings before the subcommittee on Investigation of National Resources of the Senate Committee on Public Lands were published. In these hearings, representatives of the U. S. Bureau of Mines and the U. S. Geological Survey estimated recoverable lead contained in reserves in the ground at about 6,500,000 tons in 1944, or about 15 times the average 1935-1944 rate of production.

The layman, given this set of facts, would reach the conclusion that sometime this year there would be no more lead left in the United States to be mined. Fortunately for our economy, the layman can consider these 1944 reserve figures as 100 percent wrong inasmuch as a similar survey today would reveal at least another 12 years supply in reserves and the same situation would prevail year after year. This fact can be substantiated by another Government report made in the intervening years by the President's Materials Policy Commission. This report published in June, 1952, estimated reserves at about 7,000,000 tons in 1950, or about 16 times 1950 production. Thus estimated reserves were somewhat higher in 1950 than in 1944 despite the fact that nearly 2,500,000 tons of lead had been mined from United States mines in the intervening years. Both Government reports admitted that the reserve figures given are minima. This clearly indicates the danger of using reserve figures as of any particular date as a guide to the life of the reserves because they cannot of necessity take into account the new reserves opened up each year.

Also, a mining company will block out its reserves for only a few years ahead of its actual mining operations because of the economic factors involved. The general practice is to find through development work enough reserves each year to replace the amount extracted.

Experience has shown that reserves will be adequate to take care of the World's needs for lead for many years to come and any temporary shortage that has developed has been the result of economic maladjustment and artificial controls. Currently, lead is plentiful and there is nothing to indicate that it will not remain so.

U.S. Largest Consumer

As well as being one of the principal lead producing countries of the world, the United States, as can easily be imagined, is the largest consumer of this most versatile metal.

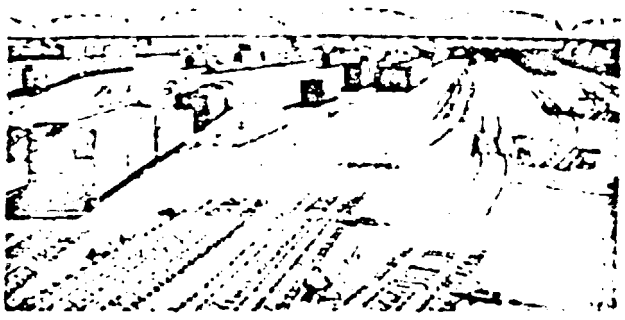
Industrial consumption of lead in the United States has averaged over 1,100,000 tons a year since 1946 with about a third of this consumption attributable to its use in lead-acid storage batteries. The second largest consumer in recent years has been the production of tetraethyl fluid, a use that has grown from nothing in 1925 to more than 175,000 tons in 1957. The cable industry, in third place, easily outdistances the many other uses as indicated in the table of United States consumption.

As old as lead is, the table graphically portrays the fact that the bulk of the lead consumed today is in uses developed in the twentieth century.

Uses of Lead

Some of the important developments and uses of recent years, not indicated in the consumption table, include lead soaps for greases, lead in steel for better machineability, leaded frits for porcelainizing aluminum, lead molds and lead compound stabilizers for plastics and of course its use as a shielding material in atomic energy installations and shipping containers for radioactive material.

Standard A.A.R. axial type lead face bearings make possible the vast interchange of freight cars in classification yards as shown below.



One of the latest and most exciting new uses for lead is in the field of stereophonic sound. Two lead zirconate-titanate elements comprise the heart of a new series of pickup cartridges capable of transforming the vibrations in the groove of a stereophonic record into the wonder of stereophonic sound. Non-sacrificial lead anodes for corrosion control in waters is another new development of scientists and engineers and new and greater developments can be expected from those who "Look Ahead With Lead."

Tetraethyl

Tetraethyl lead, the second largest consumer of lead, is a heavy colorless liquid containing approximately 60 per cent lead. It is the active component in the anti-knock compound and added to gasoline in minute quantities, 0.5 to 4 cc. per gallon, provides a substantial improvement in the anti-knock value or octane rating of the gasoline.

The basic ingredients of tetraethyl lead are pig lead, salt, hydrogen, alcohol and refinery gases. The pig lead is melted and mixed with sodium under a blanket of hydrogen to form a lead-sodium alloy. It is then solidified and ground and reacted with ethyl chloride to form tetraethyl lead. This is steam distilled and otherwise purified and then blended with ethylene dichloride, ethylene dibromide and dyes to form the anti-knock compound.

The Storage Battery

The lead-acid storage battery, a most efficient and economical source of electrical energy, was developed by Gaston Plante in 1859, after a series of experiments that proved battery electrodes or plates made from two different forms of lead were superior to electrodes made with other metals.

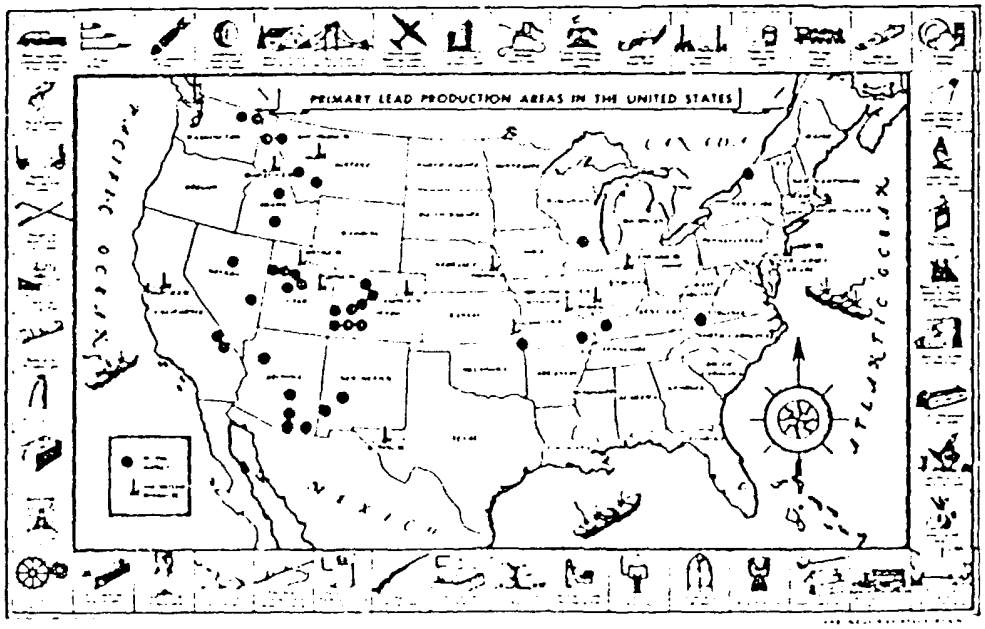
Today's batteries are constructed essentially the same as that developed by Plante and consist of grids cast from a lead alloy containing small amounts of antimony and/or silver or other metallic constituents. A paste made of oxides and finely divided metallic lead is then applied to the interstices of the grid and with different mixtures, the negative and positive plates are formed. The cell is then assembled, using varying numbers of plates, and sulphuric acid added. The plates are then activated by passing an electrical current through them to convert the positive plate into lead peroxide and the negative plate into finely divided sponge lead.

In use, the battery plates on discharge react with the sulphuric acid electrolyte converting them to lead sulphate. Charging the battery is just the reverse. The lead sulphate is converted to lead peroxide and sponge lead and the sulphuric acid is regenerated, increasing the concentration of the electrolyte. This cycle is continuously taking place when the battery is connected to a generator such as is found in every automobile and on railroad cars.

The voltage of each cell remains constant, approximately 2 volts and the addition of plates to a cell only increases its capacity or life expectancy. The ordinary 3 cell-6 volt automobile battery contains roughly 60 to 70 per cent lead or about 20 pounds. The lead contained is split roughly half and half between metallic lead and lead oxide.

Lead covered cable is a product of extrusion. Molten lead is placed in the chamber of a hydraulic press and allowed to solidify under pressure. Within the chamber is a hol-

Map showing primary lead production areas in U. S. Sketches around border show some of the products which use lead.



low mandrel through which the cable core passes. When pressure is applied the lead is extruded through a die controlling the outside circumference carrying the cable core along with it. A pressure of somewhere around 55,000 lb. per sq. in. is required.

Lead As a Compound

Lead is unique among the common metals in that more than a third of the tonnage consumed each year is through the use of its compounds.

Lead as a paint pigment is used to beautify and protect America's homes and industrial structures from the ravages of weather and corrosive media found in the atmosphere.

An oxide of lead, litharge, a major component of storage batteries, also finds widespread use in such diversified industries as the ceramic industry, color making, in rubber, in plastics, and in insecticides.

Dozens of other lead compounds, both organic and inorganic, are used in a variety of industries and hundreds of others with known physical constants are awaiting the development of products to which their unique properties can be used to advantage.

In this latter connection, the lead industry recently embarked on a major research program, both basic and applied research, in an attempt to increase the knowledge of lead and its compounds and to improve their physical characteristics. The research will be conducted by the lead industry working alone or in conjunction with other industries who may have specific problems that can best be answered through research.

Additional information about the properties and uses of lead is available from the Lead Industries Association, 60 East 42nd Street, New York 17, N. Y. The technical staff of the Association will welcome any such requests.

CONSUMPTION OF LEAD IN THE UNITED STATES
(As reported by the U. S. Bureau of Mines
In Short Tons)

	1956	1957	Estimated 1958(a)
Metal Products:			
Ammunition	44,300	42,500	41,000
Bearing metals	28,300	27,000	21,000
Brass and bronze	27,100	24,500	21,000
Cable covering	134,300	108,200	74,000
Calking lead	65,000	63,700	65,000
Casting Metals	12,900	12,700	10,300
Collapsible tubes	11,000	10,300	9,000
Foil	4,600	4,900	5,000
Pipes, traps and bends	28,000	24,700	24,500
Sheet lead	30,300	27,500	24,400
Solder	75,300	70,700	58,000
Storage battery grids, posts, etc.	191,664	183,600	170,000
Storage battery oxides	179,700	173,400	156,700
Terne metal	1,700	1,600	1,800
Type metal	26,700	28,700	26,000
TOTAL	860,400	810,000	707,700
Pigments:			
White lead	17,000	15,700	12,300
Red lead and litharge	79,300	78,300	64,500
Pigment colors	13,900	12,500	12,800
Other (b)	10,300	8,900	7,500
TOTAL	120,450	115,400	96,500
CHEMICALS:			
Tetraethyl lead	192,000	177,000	158,000
Miscellaneous chemicals	3,100	3,600	7,600
TOTAL	195,100	180,600	160,600
Miscellaneous uses	1956	1956	Estimated 1958(a)
Annealing	5,900	5,300	4,500
Galvanizing	1,700	1,400	1,000
Lead plating	900	700	300
Weights and ballast	7,200	7,300	6,500
Total	15,700	14,900	11,900
Other uses unclassified	18,100	17,300	15,300
GRAND TOTAL (c)	1,209,700	1,136,200	992,000

(a) Estimated by Lead Industries Association
(b) Includes lead content of leaded zinc oxide production
(c) Includes lead content of scrap used directly in fabricated products.