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LEAD INDUSTRIES ASSOCIATION

420 LEXINGTON AVENUE
NEW YORK 17, N. Y.

January 26, 1955

SUBJECT: MATERIALS THE RAILROADS BUY - THE STORY OF LEAD

To Members of the Lead Industries Association:

Attached please find a copy of an article entitled "Materials the Railroads Buy - The Story of Lead," reprinted from "Railway Purchases and Stores," December, 1954, issue.

The second article in this series which will deal with the railroads use of lead particularly in bearings, batteries and paints will appear in their February issue, and reprints will be sent you when available.

We hope you will find this reprint of interest. If you would like additional copies, we shall be glad to supply them upon request.

Sincerely yours,

Robert L. Ziegfeld

Secretary

Materials the Railroads Buy

The Story of Lead

Reprinted from

RAILWAY PURCHASES AND STORES

December, 1954

Distributed by

LEAD INDUSTRIES ASSOCIATION

420 Lexington Avenue

New York 17, N. Y.

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A lead mine and concentrating mill in Idaho

Materials the Railroads Buy

No. 17 of a Series

The Story of Lead

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, the principal lead producing country of the world, currently accounting for about 20 per cent of the world's output of approximately 1,900,000 tons. Commercial quantities of lead are mined in 20 of the 48 states with the western states predominant. However, Missouri is the largest producing state with Idaho, Utah, Colorado, Montana, 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

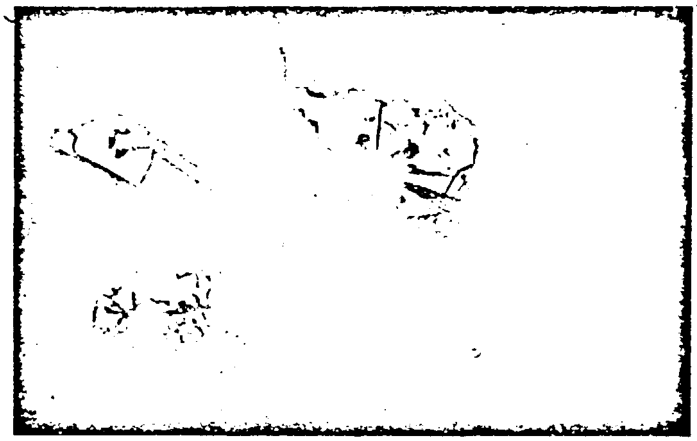
Few mines produce ores rich enough or pure enough to be shipped directly to a smelter without intermediate processing. More often the miner will struggle with a comparatively low grade of lead ore. On the other hand, an ore can be phenomenally rich in lead but contain so much zinc and copper that special 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 per cent, 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 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



Loading ore in a Missouri lead mine

water, and agitating the mass violently with air in a tank to which a fraction of one per cent 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 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.

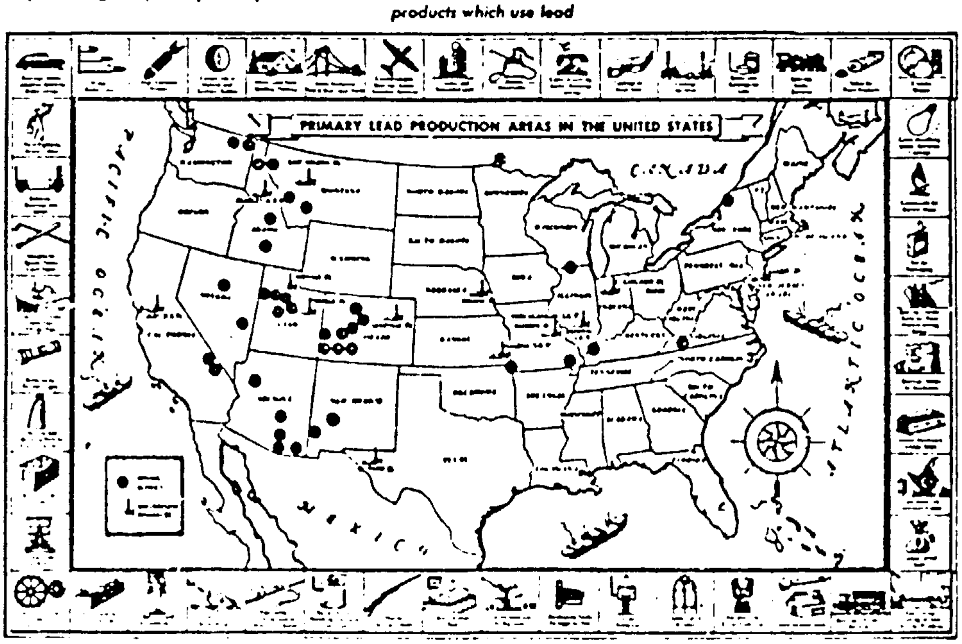
Flotation practice has reached such a stage of perfection that extraordinarily efficient work is being done, not only in extracting a single mineral from an ore, but also in separating the several minerals in so-called complex ores, for example, an ore consisting of an intimate mixture of lead, copper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

Map showing the primary lead production areas in the United States. The sketches around the border show some of the products which use lead



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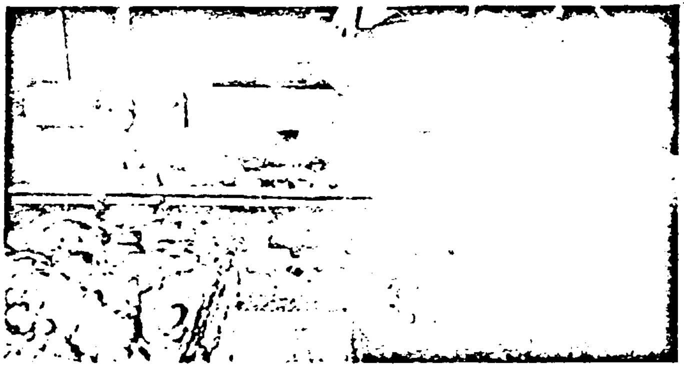

One of a bank of flotation cells in a concentration mill. The froth which overflows the cell contains the leadrich component of the ore

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 per cent 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 equip-

STANDARD SPECIFICATION FOR PIG LEAD

A.S.T.M. Designation: B29-49

Chemical Requirements

	*Corroding Lead**	*Chemical Lead**	*Acid Lead**	*Copper Lead**	*Common Desilverized Lead A**	*Common Desilverized Lead B**	*Soft Undesilverized Lead**
Silver, max., per cent	0.0015	0.020	0.002	0.020	0.002	0.002	0.002
Silver, min., per cent	.....	0.012	....	....	....	....	....
Copper, max., per cent	0.0015	0.060	0.080	0.080	0.0025	0.0025	0.04
Copper, min., per cent	.....	0.040	0.040	0.040	....	....	....
Silver and copper together, max., per cent	0.0025	....	....	....	....	....	....
Arsenic, max., per cent	0.0015	....	...	....	....	....	....
Antimony and tin together, max., per cent	0.0095	....	....	....	....	....	....
Arsenic, antimony, and tin together, max., per cent	.....	0.002	0.002	0.015	0.015	0.015	0.015
Zinc, max., per cent	0.0015	0.001	0.001	0.002	0.002	0.002	0.002
Iron, max., per cent	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bismuth, max., per cent	0.05	0.005	0.025	0.10	0.15	0.25	0.005
Lead (by difference), min., per cent	99.94	99.90	99.90	99.85	99.85	99.73	99.93

*Explanatory Note:

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

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

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

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

Soft undesilverized lead is used in the trade to describe the type of lead produced from ores of the Joplin, Mo., district.

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ment requirements.

After softening, the lead goes to the desilverizing kettles where small 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

Pouring lead bullion into a kettle for fire refining

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.

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 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.

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 1953, in the United States, approximately 435,000 tons of lead were produced from secondary sources accounting for more than a third of all the lead consumed by American industry in that year.

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 28 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.

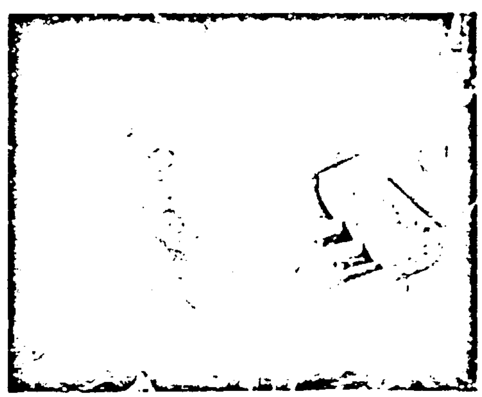
Much of the secondary lead produced is sold as lead alloy, particularly lead from reclaimed batteries and cable sheathing which contain small percentages of antimony and other metals. The bulk of the secondary lead recovered containing antimony is re-sold to battery manufacturers. Secondary lead containing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

Lead and Lead Alloy Products

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



Casting fully refined lead into pigs

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.

Because of its low melting point, lead is readily cast into practically any shape

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 hardened and strengthened with small amounts of tin, antimony and arsenic, or even smaller percentages of the alkaline earth metals is a standard anti-friction material for many types of bearings, and the largest consumer of lead for this purpose is the railroads. The standard A A R solid bearing assembly contains about 8 lb. of lead.

Incidentally, speaking about railroads, the lead industry is a pretty important customer. In a recent year about 1,124,000 net tons of lead ore and concentrates were shipped in a total of 20,000 railroad cars within the borders of this country. More than 8,000 cars shipped over 447,000 tons of lead-containing residues and scrap. About 757,000 tons of lead bullion and pig lead were shipped in 14,500 cars. Thus American railroads in one year used about 42,500 railroad cars to transport more than 2,325,000 tons of lead and lead-containing materials to and from lead smelters and refineries.

These large tonnages are still only a part of the total lead shipped by rail each year. A major source of domestic supply of lead comes from foreign sources and the bulk of this tonnage, 555,000 tons in 1953, upon arrival at American ports is shipped by rail. Secondary lead, the third source of supply amounting to 435,000 tons in 1953, is also shipped by rail, though to a lesser extent than the primary sources.

The use of the railroads by the lead industry does not stop with the raw material. Pig lead, and the hundreds of products made from lead, such as the storage battery which contains approximately 20 lb. of lead, are also major users of rail freight.

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 by 1959 there would be no more lead left in the U. S. to be mined. However, in the report of the President's Materials Policy Commission, published in June, 1952, reserves are estimated 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 reports admit 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.