

USEFUL INFORMATION
ABOUT

LEAD

5



A lead mine in the Cerro d'Aline district of Idaho.
Courtesy Engineering & Mining Journal

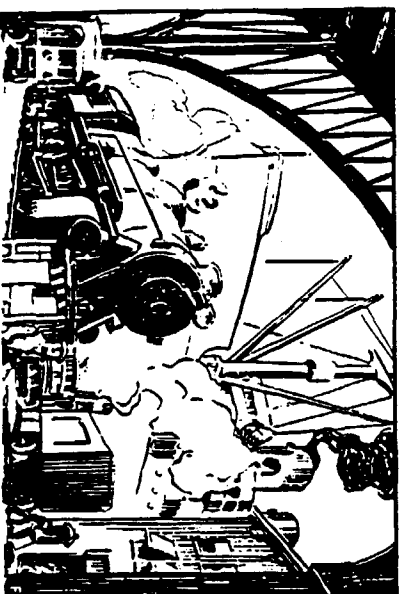
USEFUL INFO ABOUT

First Edit

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*" . . . ; but thou, thou meagre lead,
Which rather threat'nest than dost promise aught,
Thy plainness moves me more than eloquence. . . . "*
— MARSHALL OF ANNEUR.

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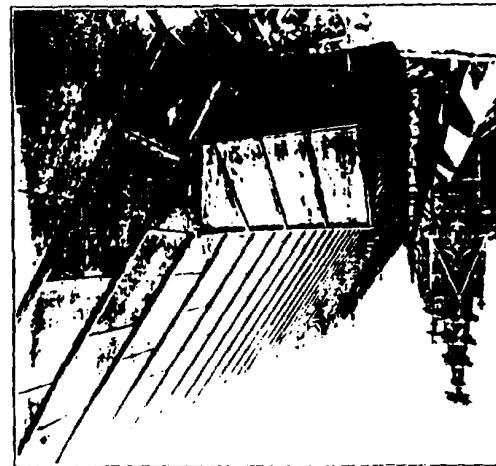


INTRODUCTION

EVERYONE knows something about lead, but detailed information regarding its physical or chemical properties and application to industry is scattered throughout technical literature. The purpose of this book is to supply those who use, or contemplate using lead, a comprehensive account of its characteristics and, at the same time, to indicate how and why lead has always been an exceedingly important material of commerce. Lead is noted for a great variety of uses; dozens of industries find the metal indispensable. To mention only a few examples of lead's diversified usefulness: it helps to operate our automobiles, not only as the principal element of storage batteries, but also — and this is a comparatively new development — as an anti-knock ingredient of modern gasoline. Then again, lead protects telephone cables from deterioration. In the form of paint it preserves our homes from decay and unsightliness; steel work from rusting. It may be found in the ammunition of the sportsman, the type of the printer, the foil of the tobacconist, the solder of the tinsmith, and has hundreds of other common adaptations, many of them described in the text.

Back of many applications is, primarily, lead's remarkably high durability — greater than that of any other common

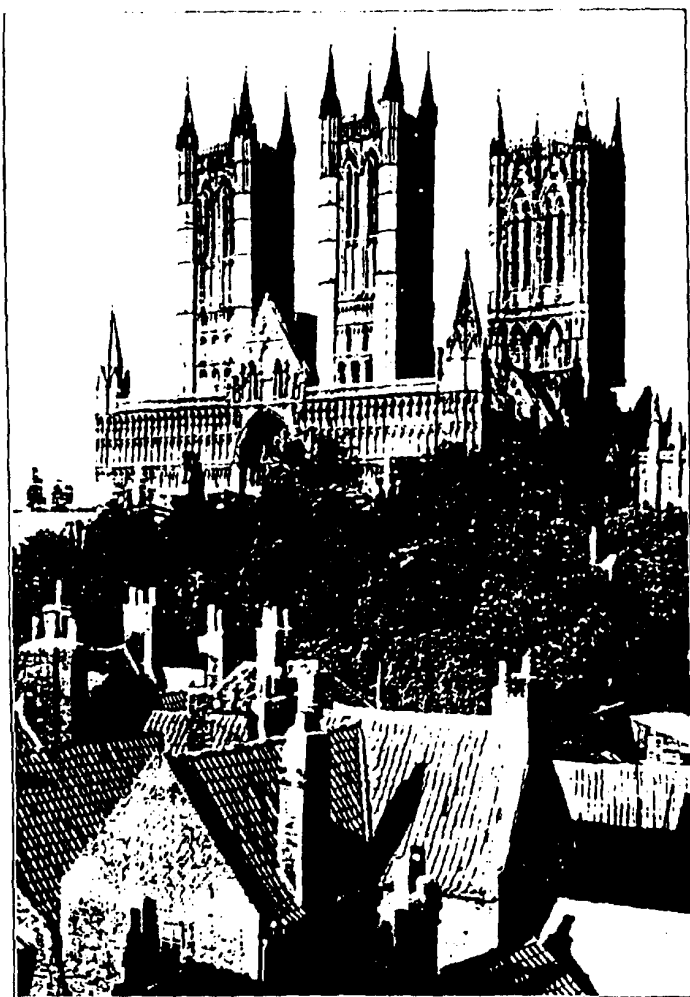
its dependability, qualities which have been long experience of users over many centuries ago, discovered and utilized. But other industrial products also give lead widespread industrial use, for example, its weight, malleability, comparative strength, excellent corrosion resistance to many acids, electrical properties, and the long life of products and paints made from lead pigments. It will be discussed in the following pages.



National Cathedral at Mt. St. Albans, Washington, as a hard lead roof, flashing, rain-water pipe heads, bands and pipe.

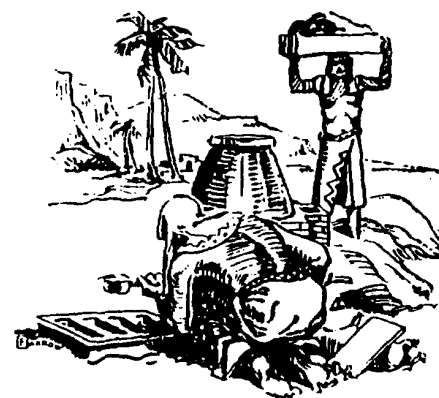
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Ewing Galloway

Lincoln Cathedral in England, with its leaded pinnacles, gutters, parapets and roof, dates from medieval times.



MAINLY HISTO

LEAD is one of the oldest metals known, and its modern uses have persisted through the centuries. Lead gray metal was evidently well known in ancient times, mentioned in Exodus and several other books of the Bible. In the days of the Pharaohs, lead was used in pottery, to make solder and ornaments. Lead pipes have also been found in Egypt. In ancient times, lead was used as a cosmetic by women, and was employed for weights of various kinds. Lead was also used as a charm, and as an early monetary metal. The ancients had many uses for lead, and the hangings of the pyramids were floored with sheets of lead soldered together to keep moisture necessary to the vegetation. The Romans also used lead for caulking purloins, and bolts in the masonry of bridges, dams, and fortifications, much as it is used to-day.

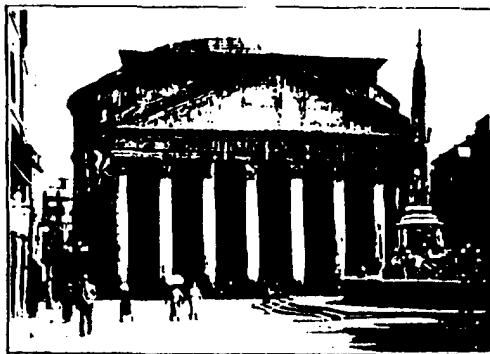
The ancient Chaldeans of Persia were the first to use lead; in fact, they were the first to associate the sun, moon and planets. This custom was followed by the alchemists, predecessors of modern chemists, who used planetary signs in their work with metals. Thus their sign for Saturn, which was lead, was ♄. Authorities differ as to the real



Lead leader-heads on historic Haddon Hall, England, are more than three centuries old.



The leaded dome of old St. Paul's dominates London.



The lead-roofed Pantheon was built nearly 2000 years ago.

Photos by Ewing Galloway

Two

with Saturn, some saying because lead to be the oldest of the metals and gods; others that the dull, heavy metal, the most distant and slowest moving.

In 2000 B.C. the Chinese made their first coins, later, when silver coins came into use, working the lead mines to stop coinage. A number of industries that would be taken in modern times. In ancient times, coinage contained from 3 to 30 per cent lead, and impoverished governments have coated with the precious metals.

One of the most important historical uses of lead was its general use for water pipes. The pipe was made in fifteen standard foot lengths. Many of these pipes, in preservation, have been dug up in Rome, Pompeii and London, and in England, during the invasion. Roman pipes were completely lined with sheets of lead. A Roman pipe has been uncovered in which the walls were proofed with lead. The Romans used lead, to denote spouts, or water conduits. Its modern counterpart in our time also understood the art of lead burning.

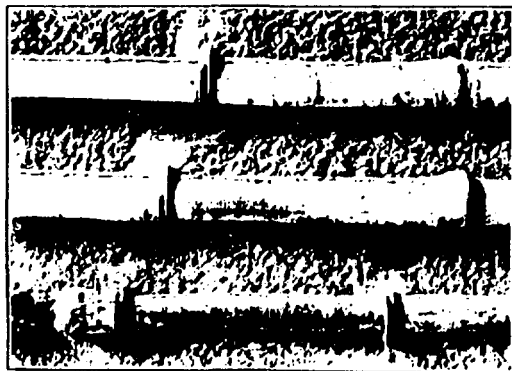
Lead has always had an important part in warfare. Our modern bullets and shells, and projectiles hurled from slings, and modern weapons, the solid metal were often thrown down upon a besieged town upon its invaders. They wore leaden knuckles to give their hands more power.

Many famous warriors, among them Richard II, as well as men prominent in the life, lie buried in leaden caskets, inscribed. Richard Coeur de Lion's body was kept in a lead casket at Rouen. A lead casket at Santo Domingo Cathedral is said to contain the body of Columbus. Still another, recently discovered, is believed to be that of Edward the Martyr, long been lost.

It is said that Nero wore a plate of lead.

singing, to preserve his voice. There is a story that Philetas, a teacher of Ptolemy Philadelphus, was so thin that he wore lead-soled shoes to keep from being blown over. Greek gamblers used lead-loaded dice.

In medieval times lead was widely used as a material of construction. Many magnificent buildings built in the 15th and 16th centuries still stand under their original lead roofs. Leaden ornaments, statues, leader-heads and cisterns were widely used and lent distinction to the arts of the period. Although many of these old uses were based on some supposed property of lead that did not exist, by far the majority depended on the easy working qualities, the permanence and beauty of lead.



Ewing Galloway

Lead pipe found under the floor of the ancient Roman house of Liria.



A dull, colored pig of lead gives story connected with its production. The risk someone must have ore from which the metal was made, the skill necessary to control the technique involved in subsequent smelting, and the need for some appreciation of these items are apt to make one think that lead mining, like other metal mining, is a simple and unexciting business with few of the worries plaguing the following paragraphs are intended, for those who are interested where lead is a raw material of commerce.

The world produces and uses close to a million tons of lead each year. This huge amount is sufficient to train a train extending solidly from New York to Los Angeles. The quantity of lead and its uses throughout the world is roughly equal to the quantity of iron, having slightly the better of it over iron. Where does all this heavy metal come from?

Although the principal lead producer in the United States mines only about 35 per cent

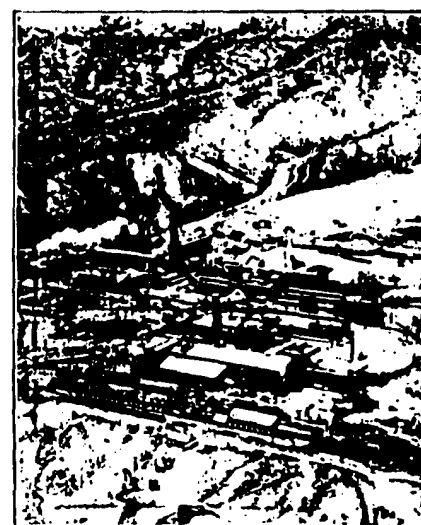
practically all this lead is used within its borders. In addition, enough lead is generally imported from Mexico, mainly in ore and concentrate, to bring consumption of lead up to about 40 per cent of the world total. Mexico ranks second, followed by Australia, Canada, Germany and Silesia, Spain, Burma and many other countries. Lead production is scattered under many flags.

In the United States, Missouri mines the most lead, with Idaho, Utah, Oklahoma, Kansas, Colorado and Montana adding to the supply in the order named. The lead mining districts of the Union have contributed immeasurably to the welfare and prosperity of their respective States.

Lead occurs in nature usually associated with other metals, notably silver and zinc. Its association with silver is especially noteworthy, and there was a time, not so many years ago, when lead was considered mainly a by-product of silver mining to be sold for extremely low prices. Although many minerals containing lead are known, the most important by far is galena, lead sulphide, an easily recognized brightly metallic mineral. Of the other lead minerals the carbonate, cerussite, and the sulphate, anglesite, are of commercial importance, but are not so frequently found as galena.

It is very pleasing to the miner to find and mine ore rich enough in lead to be shipped directly to a smelter without intermediate processing; but he is ordinarily not so lucky. He is indeed fortunate to find any ore as a result of extensive and costly prospecting with churn drill, diamond drill, shafts, drifts, crosscuts and other development work. Sometimes an ore is phenomenally rich in lead but contains so much zinc and copper that special treatment is required. More often the miner will struggle with a low grade of lead ore, perhaps as low as 3 per cent lead, and attempt to mine it at a profit. One large mining company has to mine about 3,000,000 tons of ore to recover 100,000 tons of lead. Obviously, with low grade ore, large amounts of waste rock, or gangue, must be removed before shipment to a smelter in order to reduce transportation and smelting charges. Moreover, it is necessary to remove nearly all zinc-bearing minerals in the ore so that the miner will not be penalized by the lead smelter for the zinc content, which is classed as an "impurity," because it interferes with the lead smelting operation.

Six



A lead smelter in

To concentrate the lead ore it is crushed to particles less than 1 mm. in size. One of the modern processes of mineral concentration is the remarkable flotation process, may I say, which is enough to describe but complicated. It is a very important and marvelous metallurgical process of the twentieth century that it has left a deep mark on the lead and other metal mining industry. It is principally to the sulphide type of ore that it is most monest variety, or to an oxide ore that it is most liminary sulphiding. Briefly, the process consists of taking finely crushed ore and adding to it times as much water, and agitating the mixture in a tank to which a fraction of one per cent of oil is added without small amounts of other substances. As a result of the agitation the metallic constituents of the ore rise to the surface while the valueless gangue matter remains at the bottom of the tank. The froth floating on the surface 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 considered practically worthless a few years ago have developed into important lead mines. Furthermore, many straight lead ores formerly believed too low grade for economical treatment have suddenly become 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. We shall not discuss these mechanical methods here as they are described in any standard work on ore dressing.

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 but, 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 suitable fluxes and coke. 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. Incidentally, this is the form in which most of the lead imported for treatment arrives into the United States. Specifically, base bullion contains small amounts of gold, silver, copper, zinc, anti-

mony, arsenic, bismuth and other elements which may be removed in whole or in part by refining.

The most widely used refining process is the Pattinson process. By this treatment the lead is first melted in a furnace below the freezing point of copper and other impurities are removed by skimming. It then goes to a softening furnace where the temperature is raised and the molten lead stirred. A blast of air is then added to remove arsenic present, both of which impurities are removed in the term "softening" furnace), and the lead is then cast into pigs.



Large open slope in a

The lead then goes to the desilverizing furnace where quantities of zinc are added. Gold and silver are more soluble in zinc than in lead, and, consequently, they are removed from the lead immediately. As zinc is lighter than lead, the impurities float to the top when the temperature is lowered. This leaves only a little zinc remaining in the lead, which is then oxidized and skimmed in a refining furnace. The refined lead becomes one of the purest of metals.

The Pattinson process, now rare, is the most widely used.

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 two North American plants, is an electrolytic method advantageously used with bullion high in bismuth, which is removed and recovered, as is not the case with the Parkes 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, which comprise corroding lead, common lead (desilverized or soft Missouri), chemical, and antimonial lead, described in detail in the next chapter.

In order of importance, the largest amount of lead used in the United States goes into the manufacture of storage batteries, followed closely by the lead consumed in covering electrical cables. As recently as 1922 the white lead industry was the principal outlet for lead, but the rapid growth in the demand for lead in electrical applications has relegated the consumption of lead in the pigment industries to third place.

The following table based upon statistics of the American Bureau of Metal Statistics is an estimate of the amount of lead, including some scrap lead, consumed in the United States annually by the industries shown:

	<i>Tons</i>
Storage batteries	220,000
Cable covering	210,000
White lead	125,000
Building	95,000
Ammunition	40,000
Solder	35,000
Foil	35,000
Bearing metal	32,000
Caulking	32,000
Red lead	31,000
Type metal	18,000
Castings	18,000
Miscellaneous uses	59,000
	950,000

Ten

GRADES OF VIRGIN LEAD



The American Society for Testing and Materials gives specifications for the following grades of lead:

STANDARD SPECIFICATIONS

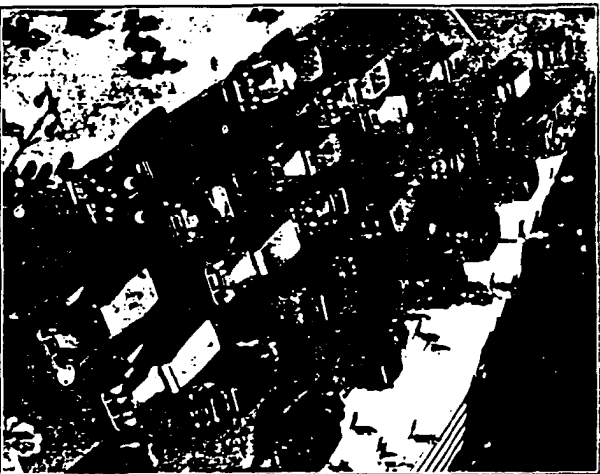
The impurities given below shall not exceed the following percentages indicated:

	<i>Corroding Lead</i>
Silver	0.0015
Copper	0.0015
Copper and Silver together	0.0025
Arsenic	0.0015
Arsenic, Antimony and Tin together	0.0015
Antimony and Tin together	0.0095
Zinc	0.0015
Iron	0.002
Bismuth	0.05
Lead (by difference)	99.9330 ±

Chemical Lead is a designation used for desilverized lead produced from South American ores containing from 0.01 to 0.08 per cent of (1½ to 4½ oz. per ton) of silver and copper.

Pigs of lead generally weigh from 80 to 100 pounds each.
 For information regarding standard methods for analyzing pig lead the reader is referred to the following publications of the American Society for Testing Materials, 1415 Spruce Street, Philadelphia, Pennsylvania:

- Standard Methods of Chemical Analysis of Pig Lead.*
 Serial Designation B 35-24.
- Standard Methods of Chemical Analysis of Spelter* (it contains instruction for zinc analysis referred to in B 35-24).
- Serial Designation B 36-21.



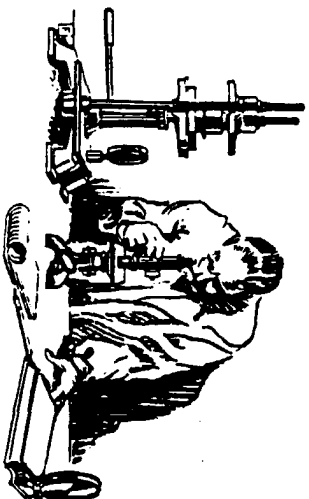
Lead, Cast

Storage batteries, solder, bearings, rubber, anti-knock gasoline and other automotive requirements consume vast tonnages of lead.

Twelve

PHYSICAL PROPERTIES

OF LEAD



LEAD possesses certain physical and chemical characteristics which distinguish it from all other elements. The following exceptionally comprehensive tabulation gives the general, mechanical, optical and other properties of lead and includes nearly every constant which those who use lead may require. These data have been selected from the sources we believe to be the most reliable, but it is always possible that future work may necessitate slight corrections.

GENERAL PROPERTIES

Color	Bluish gray
Atomic number	82
Atomic arrangement (Monatomic)	Cubic Face-centered
Atomic weight	207.22

Lead is the final element in several series of radioactive disintegration. Some leads from undecayed radioactive sources have atomic weights differing from the commonly accepted value. Isotopes of 203, 204, 205, 206, 207, 208, 209, 210 atomic weights have been claimed by various authorities, but common lead is considered to be a more constant mixture of isotopes, of atomic weight 207.22.

Atomic volume, 20 ° C., cubic	18.27
Density:	
Pure cast lead, 20 ° C.	11.34 gm. per cu. cm.
Rollad Sheet, 20 ° C.	11.35 to 11.37 gm. per cu. cm.
Ordinary, 32.7 ° C., just solid	11.005 gm. per cu. cm.
32.7 ° C., just liquid	10.686 gm. per cu. cm.
550 ° C.	10.118 gm. per cu. cm.
800 ° C.	10.132 gm. per cu. cm.

Thirteen

Lead vapor is monatomic.
 Hardness, Moh's scale 1.5
 Density, vapor, (Hydrogen 1) calculated 103.6
 Vapor, calc., 1525° C. 1.67 mg. per cu. cm.

Weight:

Pure cast lead, 20° C., calculated 0.1092 lb. per cu. in.
 equivalent to 707. lb. per cu. ft.
 Rolled, (density, 11.35) calc. 709. lb. per cu. ft.
 Liquid, 327.4° C., calc. 666. lb. per cu. ft.
 Sheet Lead, 1 ft. sq. by $\frac{1}{16}$ in. thick weighs approx. 1 lb.
 Volume of 1 pound of cast lead,
 20° C., calc. 2.11 cu. in.

THERMAL PROPERTIES

Melting point 327.4° C. (621° F.)
 Increase in, for each increase of 150 atm. pressure 1.2° C.
 Boiling point (temp. of visible ebullition). 1525° C.
 equivalent to 2777° F.

Vapor Pressure

Temp. ° C.	Pressure, mm. Mercury
808	0.08
1000	1.77
1200	23.29
1365	166.
1525	760.
1870	6.3 atm.
2100	11.7 atm.

Specific Heat

Temp. ° C.	Specific Heat
-150	.02805
-100	.02880
-50	.02949
0	.0302
50	.03051
100	.03155
300	.0338
(solid) 327.4	.0358
(liquid) 327.4	.0335
378	.0338
418	.0335
459	.0335

Atomic heat, per degree C., calc. 6.26
 Latent heat of fusion, per gram 5.17 gm. cal.

Fourteen

Latent heat of fusion, per mole
 To melt 1 lb. of lead, heating from 20° C.

Latent heat of vaporization, per gram
 Thermal conductivity (silver = 100) .

Thermal conductivity, per degree C., per

Temp. ° C.

-217.1

-160

0

100

200

300

400

500

600

Coefficient of linear expansion (-190 to
 Coefficient of linear expansion (17 to 100)
 equivalent to

Coefficient of cubical expansion (liquid
 point to 357° C.)

Coefficient of cubical expansion calc. (17

Increase in volume from 20° C. to liqui
 point

Decrease in volume on solidifying

Increase in volume on melting.

Shrinkage on casting taken in practice as

Shrinkage in volume calculated from liqu
 ing point to 20° C.

Recrystallization, minimum possible tem

ELECTRICAL CHARACT.

Specific electrical resistance:

Temp. ° C.

-183

-78

0

90.1

196.1

318

600

Temperature coefficient of electrical resis

Specific electrical conductance:

at 0° C. 5.05×10^4 cm.⁻¹ o

18° C. 4.83

melting point 1.06

Atomic electrical conductance, calc. 1.139×10^6
 Relative electrical conductance, (copper = 100) 7.82
 Relative electrical resistance, (copper = 100) 1280
 Electrolytic solution pressure, ions of Pb^{++} 6.3×10^{-3} atm.
 ions of Pb^{+} 3.0×10^{-3} atm.

Electrochemical equivalence:

Valence	Mg. per coulomb	Coulomb per mg.	Gm. per amp. hr.
1	2.1173	0.4657	7.7302
2	1.0736	.9314	3.8651
4	.5368	1.8628	1.9326

Electrodeposition of lead: to deposit one pound requires 117 amp. hr.
 Potential of lead electrode, with normal calomel electrolyte 0.115 volts
 with normal hydrogen electrolyte 0.132 volts
 on absolute scale 0.115 volts
 Thermoelectric strength against platinum 10.44 millivolt per ° C.
 Lead is diamagnetic.
 Magnetic Susceptibility, per gram, 18 to 330° C. -0.12×10^{-6}
 300 to 600° C. -0.08×10^{-6}

ELECTROCHEMICAL OR ACTIVITY SERIES OF THE METALS

In this list each metal is electropositive to all that precede it, i.e., two metals in contact in the presence of an electrolyte form a galvanic couple which tends to cause the more electropositive to be dissolved by electrolysis:

Column headed Thallium follows column ending Cobalt.

Gold	Thallium
Platinum	Cadmium
Palladium	Iron
Silver	Chromium
Mercury	Zinc
Copper	Manganese
Arsenic	Aluminum
Bismuth	Magnesium
Antimony	Calcium
Hydrogen	Strontium
Lead	Sodium
Tin	Barium
Nickel	Potassium
Cobalt	Lithium

OPTICAL CHARACTERISTICS

Optical constants, solid lead, for λ of 0.589 μ (blue):

Refractive index	2.01
Absorption	3.18
Reflection	62 per cent

Sixteen

Stopping power, s, for alpha rays is approx.
 square root of atomic weight, w.
 s (air 1) 4.27
 $\sqrt{w}$ (air 1) 3.78

Coefficient of absorption of beta or gamma rays is proportional to the density.

MECHANICAL PROPERTIES

Brinell number, 1 cm. ball, 30 sec., 100 kg.

Ordinary soft lead	3.2 to 4.5
Chemical lead	4.5 to 6

Influence of temp. on Brinell hardness:

	25° C.	100° C.
Chemical lead	5.3	3.6

Elastic limit (permanent elongation of 0.2%)

Annealed	284 lb. per sq. in.
Wire, hard "drawn"	355 lb. per sq. in.

Maximum load in tension that lead will support for an indefinite time

Fatigue Limits of Lead

(In lb. per sq. in.)

(Townsend and
At 50,000,000

Composition
Per Cent

Lead
Lead + 1 Antimony
Lead + .038 to .039 Calcium

(Beckinsale and W

Composition
Per Cent

99.99 Lead

Lead +	3.0 Tin		
	1.0 Antimony		
	.3 Cadmium		
	.5 "		
	.25 "	1.5 Tin	1.0
	.25 "	.5 Antimony	1.0

Values in the two tables shown above are for standard conditions of experimentation.

Bulk Modulus 0.44×10^{12} dynes per sq. cm.
 Young's Modulus of Elasticity 2,560,000 lb. per sq. in.
 Poisson's ratio of transverse contraction to longitudinal
 extension under tensile stress 0.4 to 0.45
 Compressibility, 20° C., per unit volume, per megabar 2.2 to 2.5×10^{-6}

Ultimate tensile strength:

Soft lead 1100 to 1500 lb. per sq. in.
 Chemical lead 2300 to 2600 lb. per sq. in.
 Wire, hard "drawn" 3130 lb. per sq. in.

Effect of temperature on tensile properties:
 (Lead, annealed at 100° C.)

Temperature		Tensile Strength		Elongation	Reduction
° C.	° F.	kg./mm. ²	lb./in. ²	per cent	per cent of area
20	68	1.35	1920	31	100
82	180	.8	1110	21	100
150	302	.5	710	34	100
195	383	.4	570	20	100
265	509	.2	280	20	100

Velocity of sound in lead 122,500 cm. per sec.
 equivalent to 4,026 ft. per sec.

Surface Tension

at M. P. 44 dynes per cm.
 350° C. 112 dynes per cm.
 100° C. 138 dynes per cm.
 500° C. 131 dynes per cm.

EUTECTICS OF LEAD

Melting point of eutectics of lead with other metals:

Other Metal		Per cent by Weight	Temp. ° C.
Silver	Ag	2.5	304
Arsenic	As	2.5	292
Gold	Au	15	215
Barium	Ba	1.5	290
Bismuth	Bi	58	125
Cadmium	Cd	17.1	219
Magnesium	Mg	3	250
Palladium	Pd	5	265
Platinum	Pt	5	290
Antimony	Sb	12.5	247
Tin	Sn	63	181
Zinc	Zn	2.3	318

Eighteen

COMPARATIVE

	Atomic Weight	Specific Gravity
Aluminum	26.97	2.70
Antimony	120.2	6.76
Arsenic	74.96	5.73
Bismuth	209.0	9.85
Cadmium	112.10	8.65
Calcium	40.07	1.54
Copper	63.57	8.90
Iron	55.84	7.70
Lead	207.20	11.38
Nickel	58.69	8.90
Tin	118.70	7.35
Silver	107.88	10.5
Zinc	65.38	7.14

* Moh's Scale

The table on the following page, prepared by the Institute of Metals, London, and the Department of Chemistry, The University of Birmingham, England, entitled, "The Reactions of Lead with Ferrous and Non-Ferrous Metals and Alloys," contains the results of his study. The specimen of lead was 2 ft. long and 1 1/8 in. in diameter. It was prepared at the air of Birmingham, an industrial city, and was also carried on at Weston-super-Mare, where it was exposed to sea water. The relative corrosion tests and fourth and fifth columns of figures only exceeded by tin and nickel,

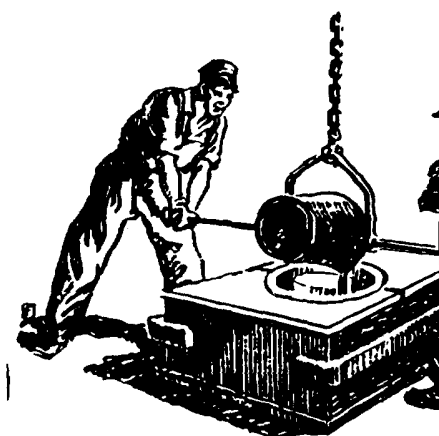
SUMMARY OF RESULTS OF EXAMINATION OF THE BARS EXPOSED TO CITY
AIR AT BIRMINGHAM FOR SEVEN YEARS, 1922-1929

No.	Material	Composition, Per cent	Surface Condition Prior to Exposure	Original Weight, Grams	Loss in Weight, Grams	Loss as percentage of original Weight	Relative Loss as percentage of loss in weight	Relative Loss as percentage of loss in weight	Remarks
40	Copper, "arsenic free"		Polished	3536.4	8.1	0.230	58	73	Green stain under black coat; tena- ciously adherent.
41	"ordinary arsenical"	As 0.01	"	3536.9	9.3	0.263	47		"
42	"	As 0.10	"	3533.6	5.9	0.167	42		"
43	"	As 0.45	"	3481.2	7.7	0.221	56		"
44	"	As 0.43	"	3504.9	6.3	0.180	46		"
45	Nickel-copper	As 0.45	"	3508.9	6.6	0.188	48		"
46	"	Ni 1.75	"	3573.5	13.3	0.369	100		"
47	Nickel-iron brass		"	3503.5	11.4	0.325	88		Closely adherent red stain underneath black layer. Metal surface in excellent condition.
48	Aluminum		"	3514.1	11.7	0.333	90		White deposit under black coating; tena- ciously adherent.
49	"	Fe 0.83	"	1037.7	1.3	0.113	29		"
50	Lead, soft		"	4384.5	3.8	0.086	42		Perfect
51	"	Ph 0.09, 96	"	4372.7	0.3	0.011	3		"
52	Nickel	Sn 1.6	"	3552.5	16.8	0.473	120		Greenish underneath black layer; incipient rusting; closely adherent; white deposit under black coating.
53	Tin, English common ingot	Sn 99.2	As cast	3793.3	2.8	0.100	35		"
54	"	Sn 99.75	"	3833.5	2.0	0.070	18		"
55	Zinc	Zn 98.82	Polished	3819.4	13.7	0.359	93		Small pinhole pitting surfaces roughened and slightly pitted.
56	Wrought iron, mean of 11-12 bars		As rolled, with scale	c. 5000	201.2	6.71	170		"
57	Mild steel, mean of 7 bars		As rolled, with scale	c. 5000	308.1	10.48	300		Surfaces roughened and slightly pitted.
58	Stainless steel, mean of 3 bars	Cr 12-13	Polished	c. 5000	3.0	0.10	35		Excellent condition

* For full analyses, see *J. Ind. Metals*, 1928, 39, 115, Table I.

† Taking iron-iron brass as standard since it had the same percentage amount in weight as the wrought iron taken as standard in the separation tests at Weston.

‡ Calculated from data in Table III, *J. Ind. Metals*, 1928, 39, 122.



LEAD is frequently alloyed with other metals to give it properties which none of the metals in its commercial forms of pig lead, that is, commercial grades of lead are often too soft for plumbing, casting, chemical equipment. In fact, they are ordinarily termed "soft" alloys readily with many metals in a metal may be hardened by the addition of small amounts of antimony, tin, copper, and arsenic. These hardening elements may combine with lead to form either solid solutions, intermetallic compounds, or mixtures.

Hard Lead. In the process of refining certain ores, a by-product alloy containing antimony is produced, commonly called "regulus metal." There is also a lead that it is also produced by alloying lead. As mentioned elsewhere, large quantities of monmetal lead are consumed in cable sheathing. Manufacturers use great quantities of lead containing approximately 7 per cent

strength to the grids of storage batteries and to improve the casting quality of the metal; $\frac{1}{4}$ of 1 per cent tin is frequently added to this alloy to further improve casting quality.

Hard lead sheet and pipe are also used in the chemical industries when chemical lead requires additional strength. Such hard lead most often contains about 6 per cent antimony. For chemical purposes hard lead is frequently cast in the forms of pumps and valves and may contain up to 12 per cent antimony. Hard lead containing about 6 per cent antimony is also used in large quantities as sheets for roofing, and in rain water leaders, leader heads and ornamental objects of all sorts made from rolled, extruded, stamped and cast forms. Shrapnel contains about 12 per cent of antimony. Collapsible tubes for paint, colors, grease, glue, shoe polish and other plastic substances are usually drawn from lead containing up to 4 per cent of antimony, but 2 per cent is the antimony content generally preferred. In rare cases pure lead without antimony may be used, giving a much softer, but weaker, product.

Hard Lead Alloy Compositions (in Per Cent)

	Lead	Antimony	Other Metals
Antimonial lead (hard lead)	100.75	0.25	
Battery plates	93	7	$\frac{1}{4}$ Tin
Bullets, shrapnel	88	12	
Cable sheath alloy	99	1	
Collapsible tubes	100.96	0.4	
Pattern alloy	87	13	

White Metal Bearing Alloys (Known commercially as "Babbitt Metal"). Some of the first pieces of machinery with rotating parts were so constructed that wood functioned both for shafts and bearings. Later, metal replaced wood for these purposes. In 1839, Isaac Babbitt invented an alloy containing 88.9 per cent tin, 7.1 per cent antimony and 3.7 per cent copper, which was used for bearings. Similar alloys are in economical use even today. Where stronger metal is required, the copper content is frequently increased. In many instances lead-rich metals are replacing the original Babbitt metals because they are less expensive and, for some purposes, superior. Common usage has now applied the term "Babbitt metal" to a wide variety of white metal bearing alloys differing from Babbitt's original formula. In modern small machinery there is a ten-

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dency to use replaceable bearings. In shaft bearings are now often brass or Babbitt metal.

Ball and roller bearings used in starting friction than bearings made from the running friction is approximately high internal friction of ball and roller. In considering the use of roller bearings, many people overlook the fact entirely due to bearing resistance but flange resistance, oscillation and cone and grade resistance enter into the total tangent track the roller bearing will s-



A battery of presses extruding copper

creasing starting resistance, but at no advantage is only slightly over 10% advantage is reduced to about 5% advantage is less than $2\frac{1}{2}\%$. Therefore of roller bearings is made careful consideration to all the factors entering into the proper and lubrication Babbitt and bronze bearings the same or possibly even better service and that with very much reduced cost.

Large tonnages of Babbitt metal, per cent lead, 4 per cent tin and 9 per for the bearings in a great majority United States. Large machines use

good service, low cost of installation and ease of replacement. In addition to these factors, Babbitt metals adjust themselves to the alignment of the rotating shafts in machinery and, when trouble occurs, for example, due to lack of lubrication, the Babbitt metal may yield or melt without injuring the shaft with which it is used.

Following are a few formulae typical of lead base bearing metals. There is, of course, a much wider variety of these alloys than indicated here. Compositions depend upon the service to which the metal is to be put as well as upon the ideas and experiences of the manufacturer and consumer. The best guide in selecting a bearing metal for a particular purpose is the reputation of the manufacturer of the product.

LEAD BASE WHITE METAL BEARING ALLOYS (IN PER CENT)

	Lead	Tin	Antimony	Copper	Others
Journal bearing linings	85-88	3-5	8-10		Tin and Antimony 12-14
Piston packing (P. R. R.)	70.5-75.5			18.5-21.5	Nickel 5-7
Piston packing B. & O. thin linings	73-76	12-14	10-15		
B. & O. thick linings	96-94	0.5-1.5	3-5		
Chesapeake & Ohio	86	3-5	10-12		
Dandelion metal (lining cross-heads)	91.5	1.5	7		
Light duty bearings	72	10	18		
Frury metal	90-80	0-10	10-17	0-1	Barium & Calcium 2
French auto bearings	98				
Metallic packing Atlantic Coast Line	75	10	15		
Pennsylvania U. S.	100-70	0-17	0-13		
	85		15		
	87		13		

Bearing Bronzes. Bearing bronzes are in wide use for a multitude of purposes, such as the backing of Babbitt-lined bearings and for uniform unlined bearings. These bronzes generally consist of copper alloyed with smaller amounts of tin

and lead. The formula which best typified lined railroad journal bearings in this country is 73 per cent copper, 20 per cent lead and a maximum of 3 or 4 per cent allowable phosphor bronzes as used for unlined bearings is represented by the formula 80 per cent copper, 10 per cent tin, with up to 1 per cent phosphorus. The Pennsylvania Railroad uses an alloy of copper, 25 per cent lead and 5 per cent phosphorus for bearings. In general industrial use this is probably the most representative.

Similarly, in the case of bearing bronzes, there are many alloys which vary more or less from the above. A list of a few practical bearing

BEARING BRONZES (IN PER CENT)

	Lead	Copper
Journal Bearing Backs:		
Baldwin	15-22	68-77
American Locomotive	18	75
N. Y., N. H. & H. C., B. & O.	16-24	67-77
Norfolk & Western	15-20	70-75
Illinois Central	15-22	72.5 min.
Pennsylvania		
Phosphor Bronze:		
Unlined bearings	10	80
Pennsylvania	8-11	77-82
Baldwin	10-15	77½-82½
American Locomotive	15 max.	78
N. Y., N. H. & H. C., B. & O.	9-11	79-81
Illinois Central	9-11	77-81
Norfolk & Western	10-15	75-80
Driving Journal Bearings:		
P. R. R.	23½-26½	63½-71½
Others (nominal)	10	80
Ordinary Machinery Bearings	10	80
Hall-Scott Motor Bearings	25	75

Type Metal. A large part of the advancement in the art of printing may be attributed to the use of lead alloys as type metal, for lead or lead alloys have been relied upon for this purpose ever since the invention of movable type in the fifteenth century. Linotype or monotype machines, marvels of ingenuity, with keyboards similar to those of typewriters, cast type metal kept molten in small pots, into the shape of the type desired. An alloy must be used that can be depended upon not to clog the expensive typesetting machines.

Type may be used directly or stereotype plates may be made



Linotype machines eat up large quantities of type metal, and in modern plants rest on sheet lead to reduce vibration.



*The News Studio
A newspaper composing room reveals the importance of type metal, a lead alloy, in every day life.*

from it. Stereotypes are usually preferred for long runs, such as newspaper printing. A modern newspaper plant may use 100 tons of stereotype metal cast several times over within twenty-four hours. Stereotype plates are made by impressing the form of type in wet papier-maché and, after this has been baked dry, casting stereotype metal, a lead alloy, in the mold. Electrotypes are formed by making impressions in wax or in sheet lead, called impression lead, instead of papier maché and depositing electrolytically copper, or nickel followed by copper upon the impressed material so that a thin sheet copper replica is pro-

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duced. This copper shell is removed, the surface is then coated with a sheet of solder foil to cause the metal to adhere when it is cast. The backing metal is then removed.

Lead base type metals or electrotype metal is plated on the printing face so as to give a surface that will give twice as much printing can be done before the metal is worn.

Type metal varies in composition with the type of work to be put. Typical formulae follow:

Type Metals (in Percent)

	Lead	Tin
Electrotype metal	93	7
Electrotype metal	96	4
Linotype metal	85	15
Linotype metal (English)	83	17
Monotype metal	87 81	13 19
Stereotype metal	82 67	18 33
Type metal (small type)	70	30

Solders. Lead containing tin has been used for many hundreds of years. Lead-tin solders are soft solders in contradistinction to the hard solders which melt at approximately 200° F. Hard solders contain little or no lead or tin. Hard solders are used for brazing.

An alloy containing 37 per cent lead and 63 per cent tin, a eutectic, melting at 358° F. (181° C.) is the position is the one which, of all possible alloys, has the lowest melting point.) This alloy is used for soldering lithographic plates and is used for soldering lithographic plates. The addition of lead to the eutectic alloy lowers the melting point and, on account of special economic reasons, is usually preferred for work with solder containing 40-50 per cent lead. Such metal is also used by electricians in the production of automobile radiators. Extra hard wiping solders should contain from 3 to 5 per cent tin, the balance lead although some use 61 per cent tin, 1½ per cent antimony and 61 per cent lead. There is need of a higher melting point alloy for applications such as 95 per cent lead and 5 per cent tin.

Soldering is quite an art and various ways of applying solder follow:

1. Application with soldering iron or torches.
2. "Wiping" joints.
3. Soldering by dipping in molten solder.
4. Soldering by "sweating" or heating of parts to be joined with solder previously placed in position.

To facilitate soldering, fluxes are used and some of the varieties are rosin, tallow, zinc chloride, tin chloride, and ammonium chloride (sal ammoniac). The function of the fluxes is to aid the alloying of the solder with the metals joined by removing dirt, reducing, or otherwise altering the metal surfaces so as to furnish intimate contact between the metals involved.

In addition to the application of solder by hand, various



Ewing Galloway

Joining a hook to lead-covered cable by means of wiping solder.

machines have been devised for mechanical or automatic soldering. Machines have also been perfected for sealing the seams in tin cans, joining metals in electric appliances and in a multitude of other ways.

SOLDERS (IN PER CENT)

	Lead	Tin	Antimony
Common	60	40	0-1½
Eutectic	37	63	
Half and half	50	50	
Plumber's (wiping solder)	62 58	38 42	0 2

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Fusible Alloys. By using combinations of the metals, lead, tin, cadmium and bismuth, alloys that melt at low temperatures may be made for considerable use for such purposes as sprinkler systems, and boiler plugs.

FUSIBLE METALS (IN PER CENT)

	Melts About Deg. C.	Lead	Bismuth
Anatomical alloy	60	17	53.5
Bismuth solder		25 40	40 25
D'Arceet		25	50
Eutectic	91	32	52.5
Eutectic	91.5	40.2	51.6
Eutectic	115	32	
Eutectic	181	37	
Eutectic	125	42	58
Guthrie's		19.36	47.38
Lichtenberg's	91.5	30	50
Lipowitz's	70	26.7	50
Newton's		31.25	50
Onion's (see Lichtenberg's)			
Rose's		28	50
Rose's		35	35
Wood's	71	25	50

Terne Plate. Terne plate, or roofing, is made with an alloy of lead and tin. Uncoated, it is called "black sheet," and it is first cleaned with phosphoric acid. The plate is then passed through a bath of lead and tin in which rolls are immersed, distributing the coating on the surface. The rolls which are required to carry extra heavy coating — are redipped by hand. The lead content is 10 to 25 per cent of tin with the balance being iron. The manufacture of terne plate is a large industry and many thousands of tons are now being produced in the United States.

Terne plate is produced in two grades, long terne. Short terne, used largely for roofing, has a coating of 8 to 40 lb. per package of 11 lb. They are comparatively light in weight and are painted at intervals of four or five years. Sheet mill product produced in large

up to 18 x 120 in. Long terne is utilized in the manufacture of gasoline tanks and automobile body parts, in buildings for frames and doors and other fireproof construction, and in caskets. A common weight of coating on long terne plate for the



Ewing Galloway

The can industry is one of the largest consumers of solder.

manufacture of these articles is about 8 lb.; for roofing, valleys, cave troughs and conductor pipe, coatings up to 10 lb. are used.

Reasons for the popularity of terne plate in certain manufacturing processes are the protection it gives against rust, the lubricating effect of the coating on the dies used in fabrication, and the ease with which the terne can be painted or enameled.

Foil. Lead foil may be classified into two distinct kinds: (1) a foil consisting of an alloy of lead rolled generally to a thickness of .001 to .0005 inch, or (2) a lead foil backed with tin which is made by rolling under great pressure a sheet of lead and a sheet of tin placed together, the result being to produce a tight union.

Lead foil has the merit of not permitting destructive light rays to pass through it as well as being a protection against moisture. It is used principally in the wrapping of cigars, cigarettes, chewing gum, tea, rubber insulating tape, flowers, stencils, and in the manufacture of electrical condensers, insulating X-ray machines and other uses. The foil used for wrapping cigarettes is generally .0005 in. thick. Besides being inexpensive, soft lead foil can withstand much bending and abuse without cracking.

Miscellaneous. There are many other alloys of commercial importance that contain lead. In the section on ammunition, is an alloy containing more than 1 per cent of arsenic. Tea casks to protect the tea from the degrading effects of light rays and moisture, is 98 per cent lead and 2 per cent tin, which is to be machined generally to improve its machining qualities. This represents a few of the many miscellaneous alloys, an indication of the possibilities of the

cial importance that contain lead. In the section on ammunition, is an alloy containing more than 1 per cent of arsenic. Tea casks to protect the tea from the degrading effects of light rays and moisture, is 98 per cent lead and 2 per cent tin, which is to be machined generally to improve its machining qualities. This represents a few of the many miscellaneous alloys, an indication of the possibilities of the

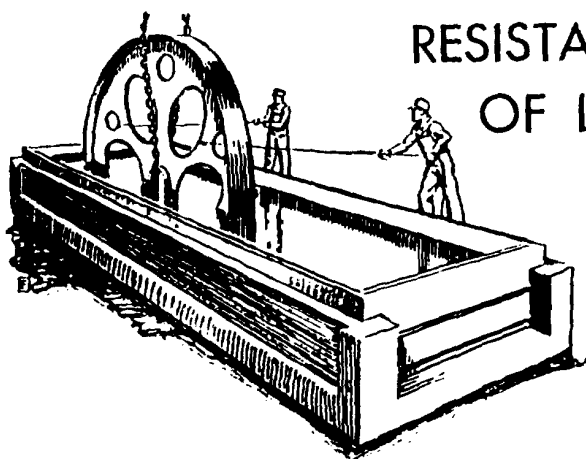
MISCELLANEOUS ALLOYS (per cent)

	Lead	Tin
Condenser foil	90	9.25
Lead tape	95	0.5
Shot lead	99	100
Ten lead	98	2
Brittania metal	0.9	91.70
Pewter	2.20	90.73
Tinsel	40	60
Ounce metal ("85 and three 5's")	5	5
Machine brass	1.7	2.6



Lead-covered pot spinning machine in a factory for pipes and valves in this picture.

CHEMICAL CORROSION RESISTANCE OF LEAD



The remarkably high corrosion resistance of lead is a great advantage when lead is used as a material of construction in those industries producing or consuming corrosive chemicals. For direct contact with common corrosive chemicals lead is an old favorite of the chemist and engineer. As early as 1746 it was utilized in building commercial sulphuric acid equipment and today manufacturers and consumers of sulphuric acid are the principal purchasers of lead for use with chemicals but numerous other corrosive chemicals are also manufactured and handled in lead equipment.

In addition to high corrosion resistance lead possesses other properties valuable in chemical engineering practice. It may be readily rolled into sheets, extruded into pipe or fabricated into the manifold forms of valves, evaporators, cooling coils, digesters and other ordinary and special chemical equipment. It may be used directly as commercial chemical lead, or as hard lead, where strength is paramount, or as crawlproof lead (chemical lead reinforced with hard lead) if a satisfactory corrosion resistance and a higher physical strength are both required. In a few uses, for example with hydrochloric acid, hard lead is more resistant to chemical destruction than pure lead.

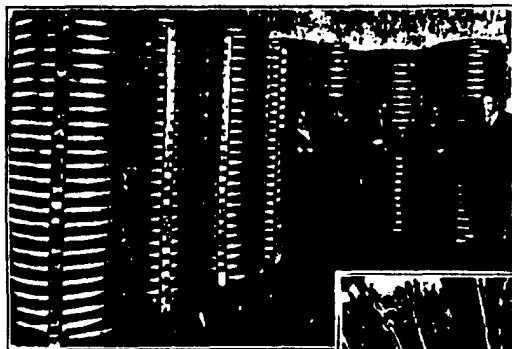
Thirty-two

Developments in the coating and lining of steel and copper with thin or heavy coatings of lead equipment available furnishing great capability to withstand corrosion. Lead pipe fittings are common throughout the industry. Lead steel pipe is being used in paper mill sulphite solutions. Another interesting development is the use of lead-coated steel pipe in the construction of fifty locomotives belonging to a large railway system. These locomotive boilers contain lead-lined boiler tubes with lime and other deposits which have been found to reduce corrosion. The water supply of the country traversed by these locomotives.

Resistance to destruction is not the only factor considered in selecting plant materials for use with corrosive chemicals. Many alloys of lead, which are highly resistant to corrosion, may be used. These alloys are comparatively expensive but are available in all forms. Likewise, the length of life of a material is considered in connection with the initial cost, charges for repair and replacement, and scrap when the material is finally discarded. Lead is eminently suited to fill all these requirements. It is less expensive metals, and is obtainable in all shapes. Moreover, it is easily repaired and replaced. A burner who can also quickly fabricate and repair apparatus right on the job. Because lead is worked and recovered its scrap value is a percentage of the first cost.

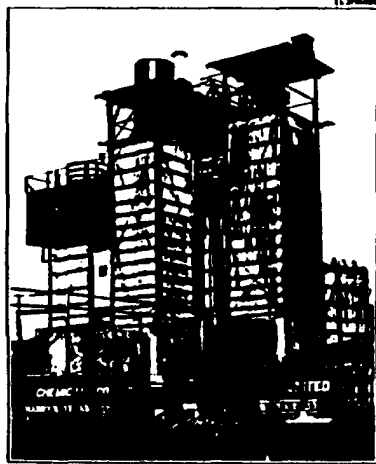
A simple precaution is recommended in the conjunction with cement, concrete or masonry. A considerable amount of free lime, because it seeps through these materials may be detrimental to lead. Therefore it is usually advisable to use means of tar paper or asphaltum.

Listed below are some common corrosive chemicals for which lead, or lead-lined equipment, is used. The selection is complete and it is only intended to be a guide to the conditions surrounding the utilization of lead. The conditions often govern the possibility of employing



Large lead coils for an oil refinery.

(below) Lead towers in a sulphuric acid plant.

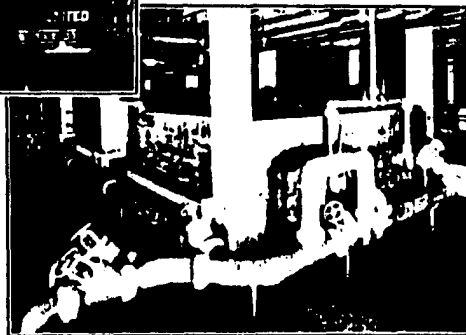


Courtesy Chemical & Metallurgical Engineering

Lead pipe and valves are used exclusively to handle salt water in the great Shedd Aquarium, Chicago.



Burning seams in the lead lining of a Foamite tank.



Courtesy O. G. Kelley & Co.

template working with lead will find it advantageous to consult the manufacturers for technical advice and service which they

SOME COMMON CHEMICALS WITH WHICH LEAD

Acetic Acid, glacial	Phosphoric Acid
Acetic Anhydride	Phosphorus
Aluminum Sulphate	Red Lead
Ammonia Vapor	Sodium
Ammonium Sulphate	Sodium Chloride
Antimony Tri-Chloride	Sodium Hydroxide
Bleach Liquors	Sodium Nitrate
Brown Acid Mother Liquor	Sodium Sulphate
Carbonates, soluble	Sodium Tartrate
Chlorine Gas	Sulphur
Hydrofluoric Acid	Sulphuric Acid
Koch's Acid	Sulphur Trioxide
Melchite Green Mother Liquor	Sulphuric Anhydride
Mixed Acids	Sulphuric Chloride
Nitration Mixture of H ₂ SO ₄ -Acid	Sulphuric Oxide
Para-nitrophenol	Zinc

Lead is also widely used for containing nickel and zinc electrolytes or electrolytic solutions. Lead plating is becoming of ever-increasing importance in a variety of industries. Antimonial lead, containing a small amount of antimony content is in use as lining for tanks and giving satisfactory service. When the tanks are put into use immediately after they have been placed in them, or, if they are given a preliminary treatment, the life of the lead can be extended. Lead is also used in heating coils and anodes in chrome plating.

Lead is used extensively as a lining for tanks containing steel and other metal articles. The presence of sulphuric acid.

Lead table tops, sink linings and other articles are extensively used in chemical laboratories because of their corrosion resistance, easy repairing and low cost. It makes serviceable equipment.



LEAD COMPOUNDS

CERTAIN lead compounds known as basic carbonate white lead, red lead, litharge, basic sulphate white lead, lead chromates, lead acetate and a number of others are produced on a large scale in the United States; the manufacture of white lead alone requires a supply of over 250,000,000 lb. of metallic lead each year. Lead compounds furnish the raw material for such highly diversified industries as paint, storage battery, pottery, glass, rubber and insecticide manufacture, oil refining and other industries. A common designation is the term lead pigments. No reference to the indispensable rôle which lead plays in every day life would be complete without some consideration of the lead compounds, how they are made and used.

Hydrated Basic Lead Carbonate — $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ — more commonly known as basic carbonate white lead or simply white lead, is the most widely used of the lead pigments, and forms the basis of the highest grade paint.

Alone or in combination with other pigments, the use of white lead in paint is so widespread that this subject is discussed

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in greater detail in another section. It is also used in glazing pottery and in the manufacture of orange mineral antiseptics.

Hydrated basic lead carbonate is a fine powder with excellent hiding power. It is produced in this country from highly refined pig lead by the old Dutch, Carter and precipitation processes.

In the old Dutch process, thin pieces of metallic lead about six inches in diameter are placed in earthenware pots with a small amount of water. The pots are covered with moist spent tan bark. The bark produces heat (up to 200° F.) and carbon dioxide. Evaporation of water produces water vapor. Meanwhile, the lead, oxygen, carbon dioxide and moisture combine to form lead carbonate, or white lead.

In the Carter process, metallic lead is melted in steam to a fine powder and placed in a cylinder. The lead charge in the cylinder is treated with dilute acetic acid and water. Carbon dioxide is continuously passed over the lead. The conversion of the lead is brought about by the reaction which takes place in the old Dutch process, and the lead is changed to white lead.

It will be seen that the old Dutch and Carter processes are quite alike in action, but the latter are required to convert lead by the use of a large amount of the thickness of the buckles, which are needed in the Carter process. The particles of blown Carter-process lead are much finer than those of the old Dutch process.

In the precipitation process, as in the Dutch process, litharge is dissolved in acetic acid solution. The solution is brought by bringing the lead acetate solution in contact with carbon dioxide gas. Best known in the United States are the Sperry processes. In the Sperry process, the lead acetate solution is obtained by dissolving lead acetate in water, which pure white lead is precipitated by contact with carbon dioxide gas. The lead acetate solution is obtained by the oxidation of a metallic lead anode in

being precipitated almost instantaneously from the lead acetate by sodium carbonate present in the solution.

Basic Lead Sulphate. This pigment, also known under a trade mark, "Sublimed White Lead," is a fine opaque, amorphous white powder. It is essentially a combination of lead sulphate and lead oxide and contains a small amount of zinc oxide, not exceeding 9%, which is incidental to the ore from which it is manufactured. Unlike basic carbonate of lead, this material is made directly from lead ore by a fire process rather than by the use of chemicals.

Basic lead sulphate is manufactured in a slageye furnace by feeding galena concentrates with the proper fluxes directly into the furnace. The lead and sulphur are sublimed and, in the gaseous state oxidized to form basic lead sulphate. The gases and fume are cooled, precipitating the basic lead sulphate as a fine powder which is collected in a cloth filter bagroom.

Pure basic lead sulphate (a proprietary name for which is "Super Sublimed White Lead") is made by atomization of molten lead in the presence of an excess amount of air and sulphur dioxide. The resultant product is pure basic lead sulphate containing no zinc.

These two white pigments are extremely fine, amorphous and opaque. It is because of these characteristics, that they are used extensively in the mixed paint industry, and also as accelerators of vulcanization in the manufacture of rubber.

Basic Lead Sulphate -- Blue. This pigment, also known by a proprietary designation, "Sublimed Blue Lead," is slate gray in color and consists of basic lead sulphate, lead sulphite, lead sulphide, zinc oxide and a very small amount of carbon.

It owes its color to the small amount of lead sulphide and carbon present. It is manufactured simultaneously with the production of pig lead from galena on a Scotch open hearth furnace. It rises from the furnace as a fume, which is condensed and collected in bags, permitting the gases and air to pass through, and retaining a blue fume which drops down as an extremely fine pigment. The principal use of blue basic lead sulphate is in the manufacture of paint for steel.

It has established a firm position in the painting of steel as it possesses remarkable rust inhibiting qualities. Its pleasing blue-gray color, extreme fineness and unusual hiding power

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make it an excellent pigment for use in prevention.

Litharge. Litharge, a monoxide of lead, and is produced in both a powdered and by heating pig lead in specially designed laboratory or cupel types, in the presence of lead. The product of the treatment in



Courtesy of
Extruding lead or electrical glass
a continuous melting process

is usually powdered litharge; in a cupel litharge. The process generally requires litharge is also made by burning lead in the presence of oxygen.

Litharge contains roughly 93 per cent oxygen, and the numerous grades are listed in the use to which the litharge is to be applied.

Glassmakers' litharge is used in powder

melted with other materials such as silica and potash to make an exceptionally clear, tough and brilliant glass.

Colormakers' litharge is sold in powdered form, dissolved in acetic acid or nitric acid and used to produce chrome yellow and chrome green colors.

Rubbersmakers' litharge is finely powdered and is used as an accelerator, toughener and controlling ingredient in the manufacture of rubber.

Varnishmakers' litharge, usually in powdered form, is used in manufacturing varnish to give proper drying qualities.

Pottersmakers' and enamelers' litharge must be exceedingly pure and is used as one of the pottery or enamel glaze constituents.

Battery litharge is very pure and is used with red lead in making the active plates.

Oil refiners' litharge is used in finely powdered form in the refining of gasoline, kerosene and similar petroleum products. Caustic soda in which litharge has been dissolved is used in the refining operation to break up some of the complex organic sulphur compounds. After this treatment lead sulphide is formed which settles to the bottom of the tank.

Red Lead. This is a bright orange red oxide of lead having the formula Pb_3O_4 , a slightly greater oxygen content than litharge. It is manufactured by heating powdered litharge under carefully controlled temperature, lower than for the manufacture of litharge. The litharge takes up more oxygen and forms an entirely different compound, red lead. A small part of the litharge usually remains unconverted in the form of minute cores in the red lead. "True red lead" is the actual Pb_3O_4 in the commercial pigment. "Pure red lead" may contain some unchanged litharge but is free from other impurities.

Next to white lead the most widely used lead paint pigment is red lead. The outcome of many competitive tests and years of experience by users has made red lead the standard pigment for the protection of metal surfaces, a situation given recognition in another section of this book. (See Page 55.) Red lead is also used in several industries consuming litharge, notably in the manufacture of storage battery plates, high grade glassware, pottery, enamels and varnish.

Orange Mineral. This compound has the same chemical composition as red lead, and is manufactured from basic car-

bonate white lead, or from litharge, that used for red lead. It differs from red lead in color and tone. It has a brilliant vermilion color largely by color makers and manufacturers.

The Lead Chromates -- yellow, orange and red, are used for their color and protective properties. $PbCrO_4$ is made by precipitation from a solution of lead nitrate to which potassium or sodium chromate has been added. The resulting precipitate is a bright yellow color and is known as medium chrome yellow. A paler yellow known as lemon chrome yellow is obtained if acid or sodium sulphate is added to the solution. Some white lead sulphate is added to precipitate the chromate.

Orange chrome yellow is the partly basic form obtained by dissolving an alkali, such as sodium hydroxide, in the bichromate solution before adding to the lead solution.

American Vermilion, also known as chrome red, is basic lead chromate usually obtained instead of from a lead acetate solution.

Between chrome red, which is a deep red, and lemon chrome yellow lie many other shades of yellow which are really mixtures of the different lead chromates obtained by varying the conditions of precipitation described under the different lead chromates.

Chrome Green, the most important green pigment, is made of yellow lead chromate and Prussian blue, made by precipitating the chromate from a solution of divided Prussian blue (ferric-ferrocyanide).

There are, of course, hundreds of other lead compounds. A list of some of them with a few of their properties. It can be seen from this list that lead is a divalent metal, forming both plumbous and plumbic compounds. In rare cases is monovalent. Extremely rare compounds are rarely made or used. The compounds are, i.e., they have the characteristic of acids or bases to form salts. With alkalis and plumbates. In this case the basic character of the oxide are more marked, so that the plumbic compounds developed than the plumbite.

SUPPLEMENTARY LIST OF LEAD COMPOUNDS

Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead acetate (plumbous; sugar of lead)	$Pb(C_2H_3O_2)_2 \cdot 3H_2O$	White or brownish white crystals. Efflorescent.	Soluble in water.	Dissolve litharge in dilute acetic acid heated by steam coils. Crystallizes out when cooled. Lead carbonate may be used in place of litharge.	Used in manufacture of other lead salts, mordant in dyes, drier in paints, lead coating steel.
Lead acetate (plumbic)	$Pb(C_2H_3O_2)_4$	Colorless crystals.	Decomposed by water into PbO_2 and acetic acid.	Add warm glacial acetic acid to red lead and cool.	
Lead acetate, basic	$3Pb(C_2H_3O_2)_2 \cdot PbO \cdot 5H_2O$	Needles.	Soluble in water.	Made from PbO and normal acetate.	
Lead acetate, basic	$Pb(C_2H_3O_2)_2 \cdot 2PbO \cdot 4H_2O$	Amorphous.	Soluble in water.	Made from PbO and normal acetate.	
Lead antimonate	$Pb_4(SbO_4)_3$	Orange-yellow powder.	Insoluble in water.	Interaction of lead nitrate and potassium antimonate solutions, concentration and crystallization.	Used as pigment in paint, ceramics, crockery and glass industries.
Lead arsenate	$Pb_3(AsO_4)_2$	White powder.	Insoluble in water. Soluble in HNO_3 .	Action of arsenic acid on litharge in presence of acetic or nitric acid as catalyst, or add solution of lead acetate or nitrate to sodium arsenate. Latter method gives mixture of basic and dibasic lead arsenate and should not be used if it is to be mixed with lime-sulphur solution.	Insecticide.
Lead azide	PbN_6	Crystalline substance.		Add lead acetate or nitrate to solution of sodium azide.	Used as primer in explosives with nitroglycerine.
Lead benzoate	$Pb(C_6H_5O_2)_2$	White crystalline powder.	Slightly soluble in water.		
Lead borate	$Pb(BO_2)_2 \cdot H_2O$ $PbO \cdot 3B_2O_3$	White powder.	Insoluble in water. Soluble in dilute HNO_3 .	Add an excess of borax solution to a solution of lead salt. Fusion of boric acid with lead carbonate or oxide.	Used as drier in paints. Used in glazes and enamels.

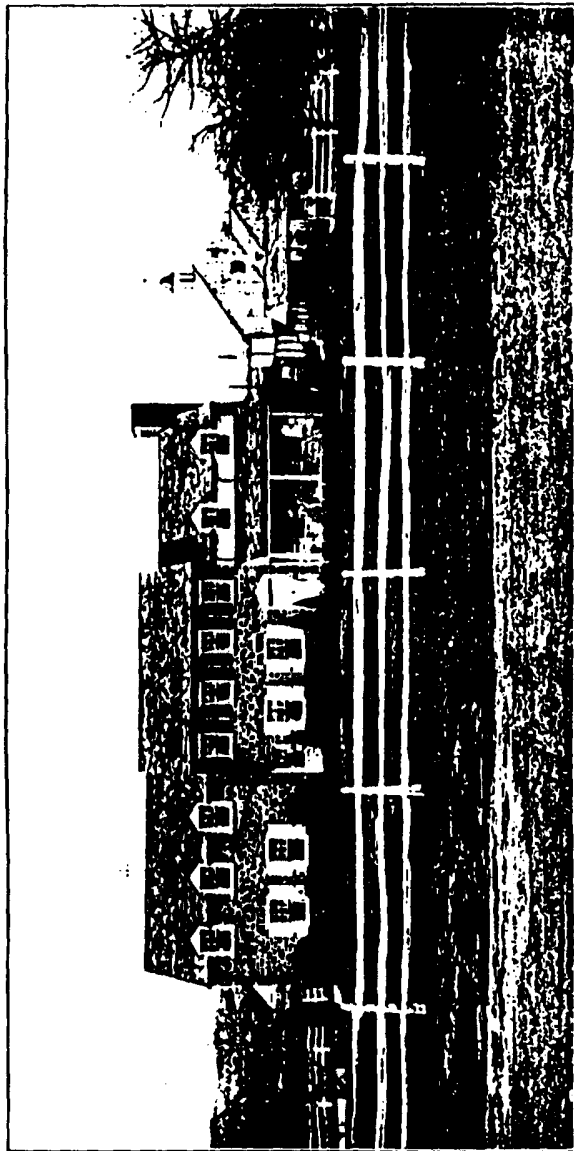
Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead bromide	$PbBr_2$	White powder.	Comparatively insoluble in water.	Same as lead chloride using bromine compounds instead of chlorine compounds.	
Lead butyrate	$Pb(C_4H_7O_2)_2$	Colorless flakes.	Insoluble in water.		
Lead carbonate	$PbCO_3$	Heavy white mass.	Insoluble in water.	Add lead nitrate to ammonium carbonate.	Occurs in nature as cerussite, see page 6.
Lead chloride (plumbous)	$PbCl_2$	White crystals or silky needles.	Slightly soluble in water.	Treat lead oxide or carbonate with HCl or add concentrated solution of soluble lead salt to soluble chloride. On large scale made by heating litharge with excess of HCl at $200^\circ C$ and 25 atmospheres in acid-resisting autoclave.	
Lead chloride (plumbic)	$PbCl_4$	Heavy yellow oily liquid, or with small quantity of water forms crystalline hydrate.		Dissolve $PbCl_2$ in concentrated HCl in presence of excess chlorine. Excess of water decomposes it to PbO_2 and HCl .	
Lead oxychlorides	Numerous. An important one is $PbCl_2 \cdot 7PbO$ (Cassel yellow).	Yellow powder.	Insoluble in water.	Fuse one part ammonium chloride with ten parts massicot, white or red lead.	Most occur in nature. Pigment.
Lead citrate	$Pb_3(C_6H_5O_7)_2$	White crystalline powder.	Insoluble in water.		
Lead cyanate	$Pb(CNO)_2$	White crystalline powder.	Soluble in water.		
Lead cyanide	$Pb(CN)_2$	White powder.	Insoluble in water.	Action of solution of potassium cyanide on lead acetate.	
Lead dichromate	$PbCr_2O_7$	Brick red powder.	Insoluble in water.		
Lead dithiodurate	$(C_2H_5OCSS)_2Pb$				Accelerator in manufacture of rubber.

Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead ethoxide	$Pb(OC_2H_5)_2$	Light yellow friable powder	Soluble in and hydrolyzed by water	Suspend thin sheets of lead over absolute alcohol through which a stream of ozone is passed, then wash with alcohol and dry in vacuo over sulphuric acid	
Lead ferrocyanide	$Pb_2Fe(CN)_6 \cdot 3H_2O$	Yellowish white powder	Insoluble in water		
Lead fluoroborate	$Pb(BF_4)_2$			Made by the action of hydrofluoric and boric acids on white lead	Used in electroplating with lead
Lead fluorish	PbF_2	White powder	Insoluble in water	Made as are other halogen compounds of lead using proper fluorine compounds	
Lead fluosilicate	$PbSiF_6$			Action of H_2SiF_6 on litharge	Solution of about 8% $PbSiF_6$ and 11% H_2SiF_6 used as electrolyte in electrolytic refining of lead
Lead formate	$Pb(CHO_2)_2$	Lustrous white rhombic prisms or needles	Soluble in water		
Lead hydroxide	$Pb(OH)_2$	White amorphous powder	Very slightly soluble in water. Soluble in excess NaOH	Has never been prepared in pure condition	Absorbs CO_2 from the air forming white lead. At $1300^\circ C$ decomposes into H_2O and PbO
Lead "hyposulphite" (thiosulphate)	PbS_2O_3	White crystalline powder	Insoluble in water	Precipitated from lead acetate and sodium hyposulphite (thiosulphate)	Decomposes with age. Sometimes used as accelerator in vulcanizing rubber, and to deposit lead mirrors
Lead "hyposulphate" (dithionate)	$PbS_2O_8 \cdot 4H_2O$	White crystals	Very soluble in water		
Lead iodide	PbI_2	Golden crystals or powder	Insoluble in water	Made as are other halogen compounds of lead using proper iodine compounds	

Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead lactate	$Pb(C_3H_5O_3)_2$	Heavy, white, crystalline powder	Soluble in water		
Lead linoleate	$Pb(C_{18}H_{33}O_2)_2$	Yellowish brown plaster-like mass	Soluble in acids	Add litharge to raw linseed oil and raise temperature to between 300° and $600^\circ F$.	Principal use as dryer in paint and varnish. For this purpose it is dissolved in turpentine while warm
Lead malate	$Pb(C_4H_5O_5) \cdot 3H_2O$	White powder	Slightly soluble in water		
Lead molybdate	$PbMoO_4$	Yellow powder	Insoluble in water, soluble in hot picric acid	Add lead nitrate solution to solution of ammonium molybdate and concentrate	
Lead nitrate	$Pb(NO_3)_2$	White crystalline salt	Soluble in water	Dissolve lead or litharge in nitric acid	Used in manufacture of other lead salts, matches, fireworks, insecticides
Lead nitrite	$Pb(NO_2)_2$	Yellow crystals	Very soluble in water	Decompose silver nitrite with lead chloride and concentrate the solution in a vacuum	
Lead oleate	$Pb(C_{18}H_{33}O_2)_2$	White ointment-like granules or mass	Insoluble in water, Soluble in alcohol or ether	Action of oleic acid on a lead salt	Used as dryer in varnish, used in rubber and lubricants
Lead oxalate	PbC_2O_4	Heavy, white powder	Insoluble in water		
Lead peroxide	PbO_2	Brown powder	Insoluble in water	Action of strong oxidizing agent, as H_2O_2 , on solution of lead acetate or nitrate in presence of alkali. Also by making lead the anode in dilute sulphuric acid solution, and scraping the peroxide off the lead as it is formed	Strong oxidizing agent
Lead phenolate (phenate)	$Pb(OH)OC_6H_5$	Yellowish to grayish white powder	Insoluble in water	Boil phenol with litharge	
Lead phenol-sulphonate	$Pb(C_6H_4(OH)SO_3H) \cdot 5H_2O$	White, lustrous needles	Soluble in water or alcohol		

Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead phosphate	$Pb_3(PO_4)_2$	White powder	Insoluble in water	Precipitate excess of lead acetate with small quantity of sodium phosphate at 100° C.	
Lead propionate	$Pb_2(C_2H_3O_2)_3$	Colorless crystalline powder	Insoluble in water		
Lead resinate	$Pb(C_2OH_3O_2)_2$	Yellowish white plastic compound	Insoluble in water or most solvents	Heat litharge with resin	Principal use as dryer in paints. For this use dissolve in petroleum solvent or mixture of turpentine and petroleum thinner
Lead salicylate	$Pb(C_7H_5O_2)_2 \cdot H_2O$	White crystals	Soluble in water and alcohol		
Lead selenate	$PbSeO_4$	White powder	Insoluble in water		
Lead silicate	$PbSiO_3$	White crystalline powder	Insoluble in water or alcohol	Made by fusion of litharge and silica or action of lead acetate and sodium silicate solutions	Used in glazing, enameling and fire-proofing fabrics
Lead silico-fluoride	$PbSiF_6 \cdot H_2O$	White crystalline powder	Soluble in water	Heat galena or other lead compounds with hydronitrosilic acid, air being blown through mixture and water added	
Lead stearate	$Pb(C_{17}H_{35}O_2)_2$	Yellowish crumbly powder	Insoluble in water; Soluble in alcohol	Heat solutions of lead acetate and sodium stearate	Used as a dryer in varnish and lacquer
Lead suboxide	Pb_2O	Gray powder		Action of water gas on litharge or by heating lead oxalate at about 475° C. with pressure below 5 cm. of mercury. Towards end of process, when pressure is down almost to zero, temperature can be raised to 535° C. or higher	
Lead sulphate (plumbous)	$PbSO_4$	Heavy, white precipitate	Insoluble in water; Soluble in ammonium acetate	Action of soluble sulphate or sulphuric acid on lead acetate or nitrate	
Lead sulphate (plumbic)	$Pb_2(SO_4)_3$	White crystalline substance		Electrolysis of concentrated H_2SO_4 in a divided cell with lead anode. Temperature must be kept below 30° C. If dilute acid or higher temperature is used, PbO_2 will be formed	

Name	Formula	Appearance	Solubility	Manufacture	Remarks
Lead sulphide (galena)	PbS	Lead-gray crystalline solid with metallic lustre	Insoluble in water	Bubble hydrogen sulphide through lead salt solution. This is delicate test for presence of lead, as a small amount will color solution gray or black	Most common lead mineral. See page 6
Lead sulphite	$PbSO_3$	Crumbly white powder	Insoluble in water		
Lead sulphocyanate	$Pb(CNS)_2$	Yellowish micro-crystalline powder		Precipitated from solutions of lead nitrate and sodium sulphocyanate	Used as primer in explosives
Lead tannate		Brownish yellow, odorless, tasteless, amorphous powder	Slightly soluble in water or alcohol		
Lead tartrate	$PbC_4H_4O_6$	White powder	Insoluble in water		
Lead tetraethyl	$Pb(C_2H_5)_4$	Liquid		Produced by action of ethyl iodide on lead-sodium alloy, or by action of lead chloride on zinc alkyls	Used as anti-knock ingredient in motor fuels
Lead tetramethyl	$Pb(CH_3)_4$	Volatile liquid		Produced in same manner as $Pb(C_2H_5)_4$	
Lead thiosulphate	PbS_2O_3	See lead hypsulphite			
Lead tungstate	$PbWO_4$	Yellowish powder	Insoluble in water	Interaction of solutions of lead nitrate and sodium tungstate	
Lead vanadate	$Pb(VO_3)_2$	Yellow powder	Insoluble in water		
Potassium plumbate	$K_2Pb(OH)_6$	White crystals		Dissolve lead peroxide in boiling concentrated potassium hydroxide and allow to stand over strong sulphuric acid	
Sodium plumbate	$Na_2Pb(OH)_6$			Anodic oxidation of solution of lead hydroxide in sodium hydroxide, using platinum anode. Crystallizes out without evaporation	
Sodium plumbite	$NaPb(OH)_3$		Soluble in water	Add litharge to solution of caustic soda, antise by blowing in compressed air and raise temperature to 100° F. Sodium plumbite solution results	Widely used in oil refining, referred to as "doctor solution"



This handsome miniature farm in the suburbs of Philadelphia is painted with pure white lead and oil.

Forty-eight



THE manufacture of paint is an industry and consumes such a great variety of compounds that the uninformed buyer is likely to be trying to ascertain just what constitutes a good paint. He cannot enter here into a technical discussion of the various paint pigments or their properties from lead. Suffice it to say that the painter should do well to consult his painter when in doubt as to what paint to use. Better yet he will make his purchases and uses contains a high quality of paint the higher the better. This is especially true in a field in which unfortunately, innumerable cheap paints to be found, some of merit and others of no merit. Therefore, unless the buyer exercises care to acquire a paint containing paint adulterated with cheap pigments give satisfaction. In this connection it is noted that United States Government Master Painters have painted and tinted paints on a white base.

mixed call for a minimum white lead content of not less than 60 per cent.

WHITE LEAD IN PAINT

White Lead, the oldest white paint pigment known to man, was first employed by the Egyptians, Greeks and Romans. Several descriptions exist, dating from before the Christian era, of the method of making it from metallic lead with vinegar, or wine. The old Dutch Process, by which the pigment is most often made today, is essentially the same in principle as the method used by the ancients. White lead continues to make the best and simplest white paint.

The early history of paint itself antedates any reliable written records. It is known to have been used by the Egyptians as far back as 2500 B.C.; the ancient Hindus and the Hebrews before the time of Moses also were well acquainted with the art of painting for decorative purposes. The Greeks were probably the first to recognize the importance of protecting their structures with paint. Remains of their edifices are often found showing evidence of its use.



Thrifty farmers have made white lead paint a favorite in painting their homes and farm buildings.

Fifty

Paint is now called upon to serve many purposes. Of course, it is to protect and to beautify. With increasing responsibilities and greatly increasing serviceability. Well painted buildings go hand in hand with improved sanitation. Colored paints are important aids in decoration and reducing the costs of lighting. Paints used to make houses or rooms look larger, brighter, cheery, sedate, or what you will. Hospitals the proper use of color now is a science and the effects of differently colored walls have been found to be often quite marked. Paint is a protector against weathering and saves millions of dollars annually, but the value of its functions is not so easily measured.

It is profitable, then, to keep buildings painted. Paint should be selected to do the job economically. It is safe to say that paint is used regardless of cost, for the labor of repainting about 75 per cent of nearly every painted surface. Paint is a secondary item.

What is the best paint? It should be selected which it is applied and remain attractive for a long period. No paint will last forever. All paint must be repainted no matter what paint is used. The paint will last the less will be the cost. White lead paint, that is white lead and linseed oil, paints containing a high percentage of white lead have repeatedly demonstrated their ability. Paints made from other white pigments are not so durable. Like many meritorious articles, they are imitated and adulterated with other materials. Although advantages are sometimes claimed for these adulterants, they would not stand up to low cost compared with white lead.

There is another important side to the question. When it is time to repaint in what color should you be to receive the new coat? White is the best, away, leaving an even, slightly chalky surface for repainting. It does not crack or peel, and, if it does, must be entirely scraped or burned off.

This adds another expensive labor item to the repainting bill. Moreover, paints made with inferior pigments often deteriorate rapidly.

The hiding power of white lead paint is extremely high. The same amount of it will therefore adequately cover a larger area than paints of lesser hiding quality and naturally lower the cost of the paint per unit of area covered.

In house paints, the liquid, or vehicle part of the paint is principally linseed oil. White lead has a natural affinity for this oil possessed by no other white pigment.

A film of white lead paint is extremely tough and elastic. As surfaces to be painted will expand or contract as they absorb or give off moisture and as the temperature changes, hard, brittle paint films will crack and fail. Tough elastic white lead paint will stretch and contract as the surface under it changes.

White lead paint also possesses a property which is too often appreciated by painters only. It works very easily under the brush, i.e., spreads readily, while application is not a difficult and tiring operation. Of course, this is desirable for the painter but benefits the owner too, for the painter can apply more paint in a day and the cost of labor is thus reduced on a given job. Moreover, the paint is more likely to be brushed out properly, thus giving a better job and covering more area than paints of poorer working qualities.

All these factors, and not merely the first cost per gallon, determine the true cost of paint.

No elaborate theories are necessary to justify the use of white lead paint. Performance alone dictates its choice. Almost any paint will look well a year after application — or even two years. The real test of a paint only begins then. White lead paint, or paints containing high percentages of white lead, properly applied, will usually remain in excellent condition at least four or five years. Basic carbonate white lead has preserved many colonial landmarks through the rigorous climate of the Atlantic seaboard for many generations. In colonial days it was the only white pigment generally used. Practically all good painters use white lead because their reputations and livelihood depend upon doing satisfactory jobs for their customers. But, aside from technical reasons, the great preponderance of evidence in its favor has been gained from actual experience and is being increased daily.

Fifty-two



White lead paint is widely used for



Public buildings, such as this, use white lead paint as an actual

Its field of usefulness does not stop with outside paint. For interior decoration white lead is again called upon for the best results. The advantages already mentioned for outside work also apply to interior work. In addition the paint can be washed many times. White lead plastic paint can be used to obtain interesting low-relief wall textures, blended, mottled and figured effects. Objection to white lead is sometimes raised that it is more expensive than necessary for interior work where exposure conditions are not as severe as outside and where re-decoration is constantly desired. The slightly higher cost is largely equalized by the greater ease in application and increased spread, which often makes it possible to have a white lead job done for practically the same price as with cheaper material. Where white lead paint is used the painted surface will retain a solid unbroken paint film.

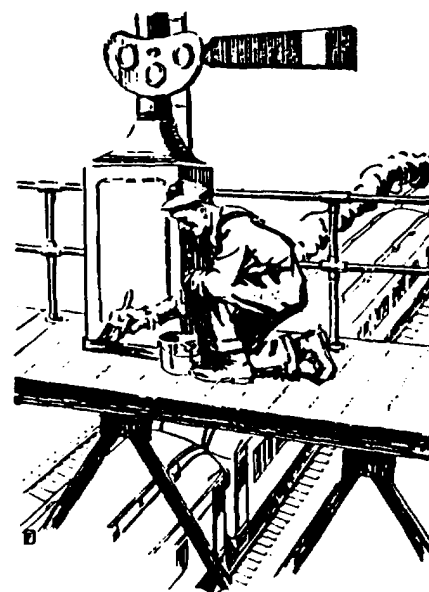
In conclusion, it is of great importance to the home owner, as a protection for his pocket-book, to see that either pure white lead paint, or the best grade ready-mixed paints containing high percentages of white lead are used on his home. It is also important that the painter only use a paint which will insure having a satisfied customer. And, finally, it is important that the manufacturer make only such a paint that his product will earn him goodwill and satisfaction.



Ewing Galloway

Great bridges the world over are protected from rust and destruction by lead paints. This is the Brooklyn Bridge being refurbished.

Fifty-four



For more than a century pure red lead has been considered the standard protective paint against corrosion or rusting. It is a mixture of red lead and oil which, when applied to the surface, forms an adhering, unbroken, impervious film that resists corrosive gases, and air.

The red lead pigment content is generally 25% of the weight of the paint. The best red lead paint contains 26 to 28 lb. per gallon but even heavier grades are used.

Red lead paint resembles white lead paint in its characteristics. For one thing it adheres more tenaciously than any other paint. When applied to a clean metal surface, for a long time, rust or scale may come off through no fault of the paint or scale loosens. Moreover, red lead paint has a strong natural affinity for oil.

Red lead makes a very tough, elastic film that expands and contracts as the metal under it expands and contracts with changes of temperature. This eliminates

occurring in the paint film which would allow water and air to reach the metal and to begin rusting. Rust, even though it starts in one small spot may continue to spread underneath the paint. A great advantage of red lead paint is that it greatly retards the spread of rust even when the paint film is broken. For paint jobs which must be continually under water, such as ship bottoms and other surfaces in contact with water, it has been found advisable to add a little litharge to the red lead paint to give a harder surface, as continual soaking by water tends to soften even the most durable paint.

Competitive tests conducted by the American Society for Testing Materials on the railroad bridge at Havre de Grace, Maryland, as well as other tests made by companies and individuals, have demonstrated the superiority of red lead paint for the protection of iron and steel. After seven years exposure in the Havre de Grace test, the paint made with the most highly oxidized and purest red lead stood at the head, in a class by itself, and the next best paints were those which contained high percentages of red lead.

Railroads are large consumers of red lead for the painting of bridges, cars, signal towers and multitudinous other steel railway structures. In painting railway cars and other equipment, red lead is an excellent paint for a priming coat and as a base for finishing coats of other colors when desired. Highway bridges such as the huge Philadelphia-Camden bridge, Brooklyn Bridge, the new Hudson River bridge and hundreds of others depend upon red lead paint as a protection against rust. It is also favored in building and maintaining ships. Steel work for skyscrapers and other buildings receives a shop coat of red lead shortly after being fabricated. Upon erection the steel is given additional coats of red lead paint. Steel gas tanks, penstocks and other steel structures are also commonly painted with red lead paint.

A comparatively recent development is the use of red lead paint as a baked priming coat on underground oil and gas pipe lines. After application to the pipe the red lead paint is baked at a temperature of about 300° F., and the secondary coat of an asphalt or bituminous base then applied.

For decorative purposes the finishing coat of red lead paint may be tinted to various pleasing dark colors, such as brown, or black. If a light colored finish is desired the top coat may be

Fifty-six

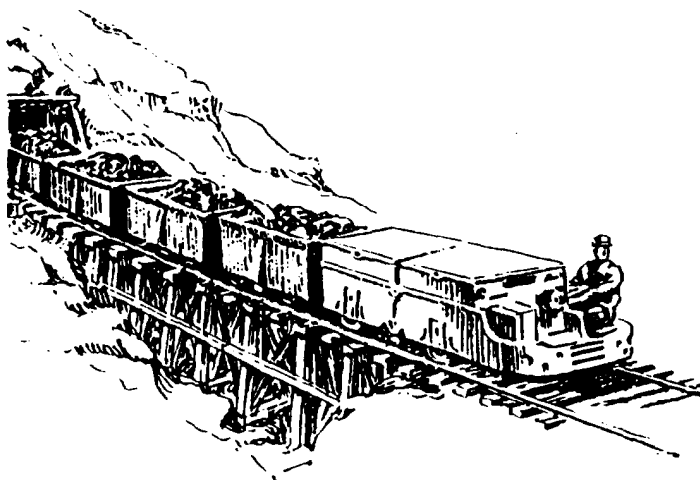
white lead paint tinted to suit. A great deal of whiteness is obtained with a very small amount of white lead. The great opacity of white lead paint, completely hides the brilliant red color underneath.

Blue Lead Paint — In more recent years blue lead paint — blue basic lead sulphate or carbonate — has earned for itself a place in the market.



Metal protective lead paints cover the steel framework of modern skyscrapers.

paints. Competitive tests by impact and performance in actual use, have established its superiority for its purpose. Its blue gray color is very durable. It is manufactured from lead particles which are extremely fine, giving a smooth finish of uniform thickness without brushmarks. It is as hard as red lead paint and exhibits the same affinity for iron and steel as other lead pigments.



LEAD STORAGE BATTERIES

The lead storage battery is so much a part of our every-day lives that we are scarcely aware of our dependence upon it. Yet in almost every industry and home the inconspicuous functioning of storage batteries is felt. Perfected in the short period of seventy years to a high degree of dependability, service and economy, there is practically no substitute for the storage battery in its hundreds of applications.

More than 25,000,000 automobiles in this country are equipped with storage batteries for starting and lighting, a phenomenally rapid growth when we consider that it was only a few years ago, in 1911, that storage batteries were first used in automobiles. Automobile manufacture now consumes about seventy-five per cent of the total weight of storage batteries made in the country. Hundreds of other uses, most of them older than the employment of batteries in automobiles, consume the remainder. Lead storage batteries, of whose total weight lead comprises about 60-65 per cent, consume about 220,000 tons of lead annually — ordinarily the largest single use of lead.

Fifty-eight

Planté, credited with the invention of the lead storage battery, made his first successful experiments with metallic lead plates which gave him the idea of "forming" these plates to give them the desired usefulness took many months. The first practical method of pasting perforated plates was invented. The result was to raise the "forming" time to a few days. This then occurred. Immediately following in 1882, the Pennsylvania Railroad used storage batteries for passenger car lighting; a central power station for standby and peak loads in 1885; a power station in Chicago in 1889; and the first successful application of storage batteries appeared.

A lead battery consists of a number of cells put together, each cell producing approximately 2.1 volts. Each cell contains a number of positive and negative plates immersed in a solution of dilute sulphuric acid. The positives all connected together form the positive terminal of the cell; the negatives similarly connected form the negative terminal. The plates are perforated grids cast in lead-antimony alloy, containing about 7 to 12 per cent antimony. Antimony and tin give additional strength and better casting qualities. The plates are pasted with litharge, or a mixture of lead and antimony, up to 25 per cent, made into a paste with dilute sulphuric acid. The positive plates are made of a higher percentage of red lead. Contained in a hard rubber, composition of large stationary batteries, where the plates are in lead-lined wooden tanks, separated by partitions or a combination of both. The plates are kept closer together without danger of short-circuiting, the plate coming in contact with that containing dilute sulphuric acid.

After the plates have been pasted and assembled, the plates must be "formed" to store electrical energy. This is done by connecting the positive plates to the anode, and the negative plates to the cathode terminal of the electrical circuit containing sulphuric acid. Forming

24 to 48 hours. What takes place is shown by an examination of representative compositions of the active material on the plates before and after formation as in the table below. In the positive plate the red lead, Pb_3O_4 , is taken as two parts PbO and one part PbO_2 . The lead formed on the negative plate is sponge lead.

NEGATIVE PLATE			POSITIVE PLATE		
	Initial Composition	Final Formed Composition		Initial Composition	Final Formed Composition
PbO	90%	3%	PbO	20%	86-70%
$PbSO_4$	10	2-5	PbO	55	7
Pb		95-92	$PbSO_4$	25	7-15

As the compounds making up the final composition are of higher specific gravity than the original compounds, the material tends to shrink on forming, making a porous and less dense plate, which allows the electrolyte to penetrate to the material beneath the surface. Porosity is an important essential of plate capacity.

When a storage battery is fully charged the active material on the positive plate is largely lead peroxide, PbO_2 , and that on the negative plate sponge lead. These substances, when placed in closed electrical circuit, are unstable in sulphuric acid and are converted to lead sulphate. As every chemical change manifests itself in some display of energy, this particular change produces an electrical current. Charging the battery is just the reverse, the lead sulphate being reconverted to lead peroxide and sponge lead. Of course the design of batteries varies rather widely among manufacturers and with the services to which the battery is to be put.

Battery capacity is either rated according to the length of time of discharge or at a definite current rate of discharge, and is stated either in ampere-hours or watt-hours, the former being more usual. Battery outputs per unit of weight and volume vary so widely that it is impossible to generalize.

Everyone is familiar with starting and lighting batteries for automobiles. In this country they are usually the 3 cell, 6 volt type, although 6 cell, 12 volt batteries are also used. The jars are made of a composition material and wood separators are customarily used, although rubber is often substituted alone or in conjunction with the wood. Forty standard sizes are used

Sixty



Three-power locomotives are among the large battery's field of use.

compared with 620 sizes before 1910. The first electric industrial truck was accomplished. Automobile batteries are used at both 5 ampere and 20 minute rate. They must perform of providing large currents for starting and smaller currents for lighting. Capacities commonly used in passenger cars are 117 ampere-hours at the 5 ampere rate. In expensive classes of cars they run at 100 ampere-hours. Total weight varies between 40 and 100 pounds.

The first electric industrial truck was



Fleets of electric trucks are common for delivery work.

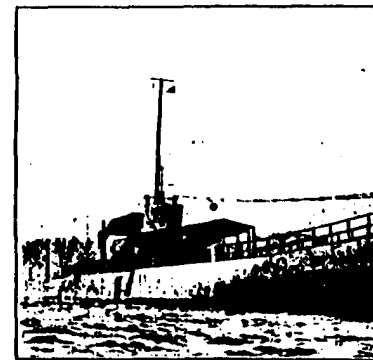
vania Railroad in 1901 and now some 17,000 are in operation in this country. Almost every industry now finds a place for them. The advantages of storage battery trucks are that they increase the capacity of men engaged in materials handling and release laborers for more productive work. They speed up manufacturing by cutting down the idle time of machines; they increase available storage and manufacturing space; they cut inventories, and are also responsible for savings in overhead. Theoretically, the ratio of handling costs of electric truck and manual labor is 1 to 24 as the electric truck moves about eight times the load at three times the speed. The theoretical saving is nearly reached in practice. The equipment, therefore, pays for itself in very short order, usually in four months to a year, often less, and it has a long life. It is estimated that 90 per cent of the industrial truck equipment installed in the past twenty years is still operating, whereas the batteries themselves have a life of about 3 to 5 years. With two sets of batteries, one charging while the other is in use, the truck can operate 24 hours a day.

There are endless variations in the design of industrial trucks, depending on the service for which they are intended. They may be constructed to handle almost every conceivable commodity from pig lead to paper and from molten glass to meat. They range in weight from 1,500 to 12,000 pounds and have a load capacity of 1 to 17½ tons. The first cost varies from \$1,500 to over \$7,000, and operating costs, including all fixed charges such as depreciation and interest on investment, based on figures from nearly 100 plants, vary from \$.35 to \$.50 an hour based on 300 eight-hour days a year.

It has been stated by one of the leading authorities on industrial trucking that "80 per cent of trucking on city routes is electric truck work." Wherever traffic is congested and frequent stops for delivery are necessary, trucking routes total usually less than 45 or 50 miles per day and the electric truck is an excellent mode of transportation. Although the first cost is higher compared with "gas" trucks, the differential decreases as the size of the truck increases. Electric trucks, however, have a life of 20 years or more and lead-acid batteries are usually guaranteed for 40 months and last longer. Depreciation, then, is exceedingly small. Moving parts are few and when the electric truck is not actually in motion no fuel

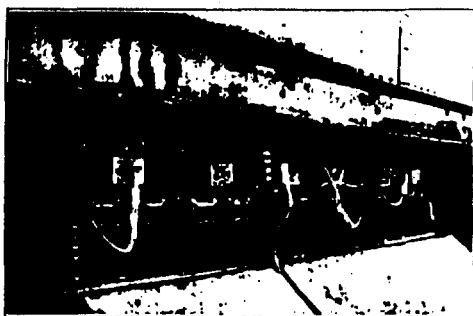
is consumed. Operating costs and are exceedingly low, one mechanic being as many electrics as gas trucks. Electric trucks require less space than either gas or horse-drawn trucks. Operating rates are considerably lower than on horse-drawn trucks. They are faster and more flexible than horse-drawn trucks and require less parking space. In addition they are quiet in operation. The silent operation of electric trucks is a great consideration where early morning delivery is required.

Storage batteries for the operation of industrial trucks and street trucks vary widely in size and type. Generally 42 or 44 cell batteries are used.



Submarines rely on dependable lead-acid batteries as their sole source of power under water.

cause they can be charged from the shore power circuit. On industrial trucks 12 or 14 cell batteries are common. The same type of battery is used on switching locomotives. A recent development is the battery oil-electric locomotive which is being used on railroads for switching service. These locomotives can run several hours on batteries alone, and when the oil engine and oil engine can exert greater power than any other kind of locomotive has.



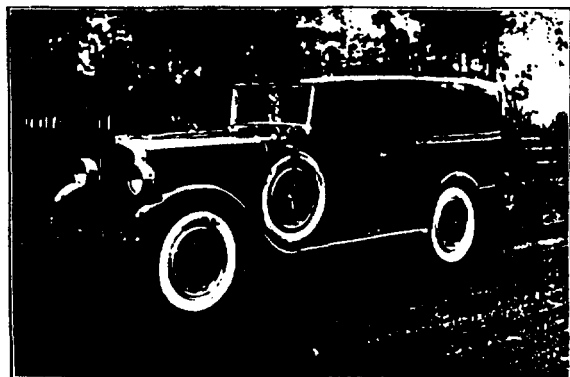
Courtesy Am. Soc. of Heating & Ventilating Eng.

Storage battery compartment on an air-conditioned railway car.

Lead moves lead when this storage battery truck easily lifts and moves 5000 pounds of the metal.



Courtesy Industrial Truck Assn.



Courtesy Walker Vehicle Co.

The modern electric delivery truck may be as attractive as its owner desires.

Farmers and others not contiguous to central power stations have greatly benefited by the use of isolated electric current. These systems consist primarily of a small gasoline generator, and storage batteries. The generator is operated intermittently by engine, and supplies current on the farm, when needed. As these batteries are usually discharged, they are given a 72 hour intermittent capacity, as against the customary 8 hour continuous rating. The average is about 70 per cent of the 72 hour rating.

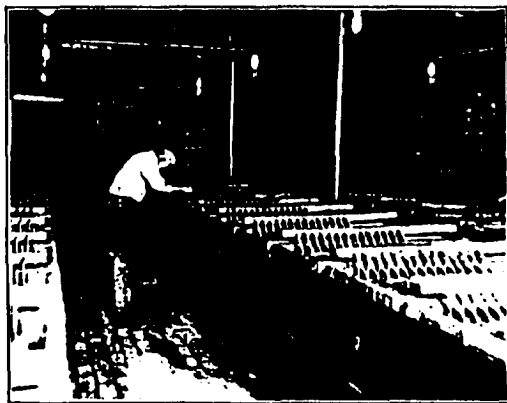
Central power stations are also equipped with lead storage batteries. Formerly the generators take peak loads and are used only in cases of emergencies. Now they are principally used for standby power. When the power fails, the dependable lead batteries carry the entire load of the power station, including elevators and electric trains running on the system. Stand-by batteries must be able to carry the load for a short time. A few years ago the emergency discharge rate, for a station stand-by batteries in New York City, was 100 amperes at 125 volts. These huge batteries are contained in lead-lined enclosures. Lead storage batteries are used in many other places of public assembly. Lead storage batteries are also used for the reliable operation of lift trucks and railway signals.

In central telephone stations storage batteries are used for the operation of the transmitting circuits. In an emergency they carry the load of the system. Generally 11 cell batteries with a storage capacity of 13,000 ampere-hours with the first for toll or long-distance calls and the two are used in parallel. Similar systems are used for telegraph operation.

Scores of other uses for lead storage batteries are appended. The use of them is economical, and the number of uses

disastrous speaks emphatically for the dependability and ruggedness of the lead storage battery.

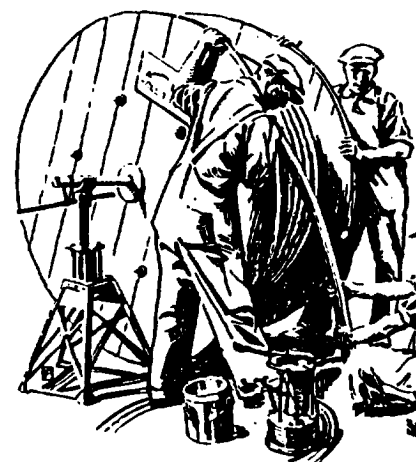
Aiming and firing large guns	Industrial trucks and tractors
Airplanes	Laboratories
(starting, lighting, ignition)	Lightships
Airplane beacons	Mine locomotives
Alarm and call systems	Mine ventilation
Automobiles, gasoline	Motorbus lighting
(starting, lighting, ignition)	Radio
Aviation field lights	Railroad car lighting
Blasting	Railroad signals
Boats (all kinds)	Range finding
Bridge lifts	Stock tickers
Central power,	Street trucks (electric)
light and telephone stations	Submarines
Coal cutting	Switching locomotives
Emergency lighting, etc.	"Talkies"
Farm lighting	Telegraph
Gas detection in mines	Time Clocks



Ewing Galloway

These large batteries supply light and power on a rural estate.

LEAD C

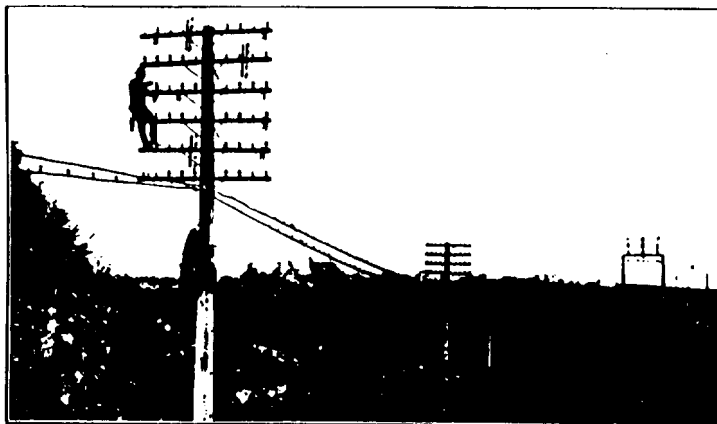


The growth in the application of electrical cable has been little short of phenomenal. Years ago consumption of lead in covered cable was negligible, whereas now lead are used annually for the purpose of covering 10 per cent of the domestic mine production. The use of lead is still growing by leaps and bounds. In 1925 lead used in cable construction was 70,000 tons. It is estimated that more than 100,000 tons of covered cable are now made yearly. This is enough to wrap more than once around the globe, forming a salient role in the distribution of power.

Lead is used in the construction of electrical cables, i.e., cable for voice lines (low voltages), and cable for power delivered by public utility companies (high voltages). A peculiar feature of business and industries selling electric power is that they may, and do, predict accurately the future demand for their services. Telephone companies plan for telephone demand as much as 15 to 20 years in advance, planning of future equipment lead

Public utility companies likewise must anticipate population growth and its prospective effect upon electrical output and distribution.

Lead-covered cables are used both in overhead and underground line construction but the modern trend in the practice of telephone and public utility companies is, in spite of higher first cost, to bury current carrying wires in the ground where they will be undisturbed and out of the way. Overhead wire systems are expensive to maintain because they are at the mercy of the elements — wind, snow, rain and ice — and are subject to mechanical injury. Exposed high tension cables are



Ewing Galloway

Lead-covered telephone cables carry many more talking circuits than open wires in much less space.

also dangerous, and in congested cities overhead wire systems are unsightly.

Underground cable must be protected from moisture of the soil or its insulation quickly deteriorates, with consequent short circuiting and interruption to service. Even overhead telephone cable, with myriad small wires insulated from each other, must be similarly protected. Therefore, underground and exposed overhead cables are commonly lead sheathed.

Cable sheath metal must be pliable so it will not interfere with the easy unreeeling of the cable. Moreover, it must have a melting point low enough not to damage the insulating material

Sixty-eight

of the cable — in telephone lines, is being formed. When in use the resion and failure from fatigue and certain of its alloys, meet the A tensile strength of about 1000 lb cable sheath lead.

Ideas which seem grotesque to us of the first lead-covered cable made was constructed of 20 bare wires tubes and then pulled through a lead and rosin added under pressure. When the glass broke but the wires were saved by the resulting glass compound.

Pure lead was used to make the still principally employed for power contained about 3 per cent of tin. In 1907 experimental research was under which would satisfactorily replace experimentation with lead alloys copper, nickel, and bismuth, and five years later containing 1 per cent been used extensively ever since. Still core, does not need the addition of antimony so that antimonial lead is but is generally preferred for telephone

A recently developed lead-calcium 0.01 per cent of calcium, cooled from of 225–250° C, is reported to make (See page 17.) In England alloys of 10 per cent tin and 0.25 per cent cadmium and 0.25 cadmium have been developed. For submarine cable and cable that the ground, instead of conduits, the tar-impregnated jute roving. In wrapped with galvanized steel wire ground is wrapped with steel tape. always, finished off with another layer with an asphalt compound.

Present telephone cable consists of 26 A. W. gauge wire enclosed in outside diameter sheath. This is

been found desirable in duct work, and the problem has been to increase the number of wires that the sheath may hold. The progress that has been made is shown by the fact that the number of pairs of wires has increased from 50 in 1888 to 1818 in 1930, with the possibility of 2400 in the future. As these wires are first wrapped with paper insulation, improvement in both paper and insulating machines has made it possible to use thinner paper, thus economizing on space. The insulated wires are twisted into pairs which are stranded into groups of 101 pairs and these strands into a compact core.

In the early days the core of wires was pulled into a lead sheath which had already been made, but it was soon found possible to extrude the sheath directly around the core. The principle is the same as that used in the manufacture of lead pipe, except that the fixed mandrel or core which makes the hole in the pipe is replaced by a hollow mandrel through which the cable core passes moving with the lead. Molten lead is placed in a chamber of a hydraulic press and cooled under pressure to the proper temperature for extrusion. When power is applied the lead is extruded through the die and carries the cable along with it. As the filling of the lead chamber and cooling requires more than half the time of operation, the tendency has been toward presses with larger lead containers, which has materially increased the speed of the operation. The pressure on the lead is about 51,000 pounds per square inch. Constant study of temperatures, speed of extrusion and contour of the extrusion chamber have led to marked refinements in the quality of the product.

The completed cable wound on reels, a familiar sight to everyone, is flexible enough to be conveniently handled when it goes into place. Splicing together of lengths is accomplished by the use of two other lead products, a lead sleeve and solder. The joints are wiped with solder forming the well-known strong and durable plumber's joint.

The first long distance lead-sheathed toll cables in the United States were placed in service in 1906 between New York and Philadelphia and between Chicago and Milwaukee. Each was about 93 miles long. In 1914 an underground toll cable was completed between Boston, New York, Philadelphia and Washington, a distance of 453 miles. In 1925 the New York-Chicago line was completed and a year later extended to St. Louis.

Seventy

It is expected that during the next few years the cable will span the continent and extend to the Atlantic and Pacific Coasts. Conversations will be carried from San Francisco via Salt Lake City; San Diego via Chicago to Galveston via Joplin and Miami, Fla., completely over toll cable lines. Even though the development of toll cables is the most intensive in the more thickly populated parts of the United States, on some of the established lines telephone traffic is rapid enough to require intervals of one or two years.

In the late summer of 1930, a 400-mile cable between Los Angeles and San Francisco was completed. One of the features of this line is that 43 miles of it are under pressure and the cable is drawn through steel proof dams. Should the cable sheath



Three types of lead-covered cable. They are standard lead-covered cable, armored single conductor power cable, and ductor power cable.

sure drops in that particular section, sounding an alarm which locates the trouble approximately and allows "trouble shooters" to make repairs before any serious damage occurs.

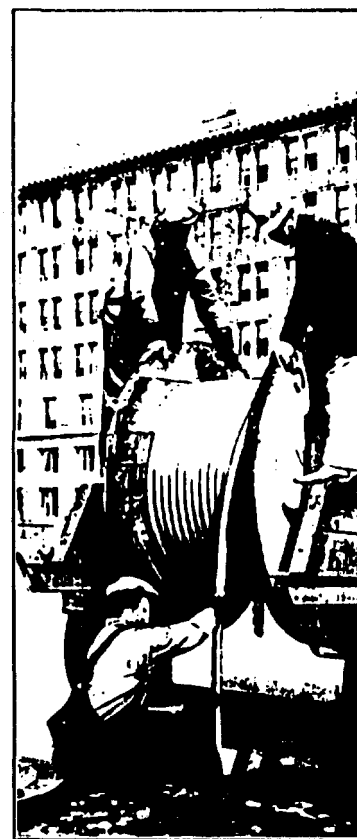
The contrast between the capacity of the familiar telephone pole containing several cross arms and the modern toll cable line is particularly striking. A typical open wire line carrying four fully equipped ten pin cross arms, or 40 pins, provides what is known as 20 physical telephone circuits and ten phantom circuits, a total of 30 voice frequency talking circuits. Toll cable construction furnishes at one time a number of circuits equivalent to 7 or 8 open wire lines. A cross sectional area of less than 6 sq. in. can carry 100 to 300 voice frequency currents.

Power cable does not contain so many wires as telephone cable. For transmitting alternating current at moderately high voltages up to, say, 33,000 v. lead-sheathed cable containing three stranded copper conductors is frequently used. For higher voltages it is customary to employ several lead covered cables each containing a single stranded copper conductor. When only one stranded conductor is used in a cable the finished core is heavily insulated from the surrounding sheath. If more than one conductor is used in a single sheath as in the common 3 core cable, the conductors must be insulated from each other. Each conductor is frequently of an elliptical or segmental shape to fit better inside the lead sheath. Where high voltages are used the insulation must be wrapped with copper or aluminum tape to eliminate a corona effect. Although a patented process, all manufacturers of paper insulated cable are licensed to use it. This tape is, in turn, surrounded by a lead sheath.

Power cables are of many sizes and kinds. They vary from small lead-sheathed wires for the operation of signals or for use on ships, to 3- or 4-in. diameter cables containing a single conductor for high tension transmission. Recently insulated cables using aluminum instead of copper conductors have been developed.

The highest commercial voltage transmitted today through underground power lines is 132,000 v. over a 12 mi. line in New York City from Hell Gate to Dunwoodie, which is now being duplicated, and a six mile and two one-mile lines in Chicago. The cable contains a hollow conductor filled with oil and connected at intervals to oil reservoirs. The oil eliminates voids or air spaces in the cable which decrease its efficiency at high

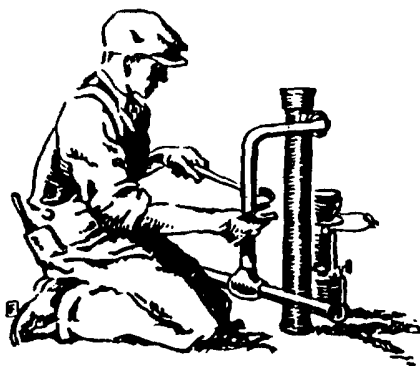
Seventy-two



Installing power cable under

voltages. Other cities contain underground cables that operate at high voltages. Cleveland has a system six years old. Underground cables vary in size from anything that bare overhead wires can carry. The insulation on these cables is usually oil-impregnated paper.

Cable is made in varying lengths, usually from one factory for the utility companies into sections from one manhole to the next. However, the method in which lead sheath is extruded it can be made in sections of great length if desired.



LEAD IN PLUMBING

PERHAPS the least noticeable part of a building, except when it is out of order, and yet the most important to the health and comfort of the occupant, is the plumbing system. From the time of the ancient Egyptians, who were the first to find lead essential to good, trouble-free plumbing, to the present, lead has been an important plumbing material.

At the very beginning of the water supply for a building, that is, in the service pipe which must convey water from street main to house, lead plays a most important rôle. This pipe must often pass beneath lawns and pavements where repairs are expensive, and deliver a clear and undiminished supply of water at all times. The residential plumbing loses its effectiveness if a poor service pipe is selected. Of what use are beautiful chrome-plated brass faucets if they can only discharge a thin trickle of rust-discolored water which may stain the porcelain bowl into which it runs? The best material in a water service, though it may be slightly more expensive at first, is really an economy, and the best material is usually lead. It is only when the water is very soft, or of swampy or peaty origin, that lead should not be used, but under those conditions other metals are also soluble, so lead may be used by adding a little sodium silicate solution to the water, as is done occasionally — or using tin-lined lead pipe.

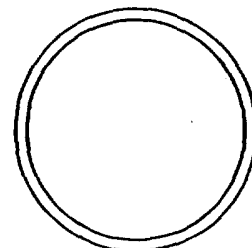
Lead service pipe, with its thick walls and remarkable resistance to soil corrosion, will almost invariably outlast the

building it is called upon to serve. Lead pipe is not subject to clog. Therefore, a smaller pipe may be used in a building constructed of other materials, as in

IN COLD WATER LEAD

- $\frac{1}{2}$ in. lead pipe may be used instead of $\frac{3}{4}$ in. iron pipe
- $\frac{3}{4}$ in. lead pipe may be used instead of 1 in. iron pipe
- 1 in. lead pipe may be used instead of $1\frac{1}{2}$ in. iron pipe
- $1\frac{1}{2}$ in. lead pipe may be used instead of 2 in. iron pipe

Highly resistant to soil corrosion, lead is stronger than other metals whose walls must be made thicker to give a prohibitive expense and to give a flexible joint. Its pliancy allows lead pipe to be bent around obstacles, thus avoiding the great source of weakness in most pipe joints.



Iron Pipe

Comparative sizes of lead and iron service pipes of actual size.

pipe must be made, they are "wiped" joints. The durable and trouble-free type of joint, similar to those used today have been known for centuries. Connections in lead pipe may also be made by slip fittings, which are slipped over the end of the pipe, flanged, and the fittings screwed together. This connection has been widely used by water works for many years with the utmost satisfaction, and by unskilled laborers. Another advantage of lead pipe is that it can adjust itself to ground setting up any internal stresses in the pipe. Pipes of other metals are a source of trouble.

pipes are subjected to any vibration, as from passing traffic. Lead pipe is particularly advantageous where exposure to freezing temperatures must be met, for the pipe can expand when the water freezes. Lead pipe, with an exceedingly smooth bore, offers less resistance to the flow of water than do other materials, a particularly important item when city water pressures are low.

The rate of corrosion of lead buried in the ground will vary in different localities and under different soil conditions. A study of this subject has been made and the following general conclusions may be of assistance in getting maximum service from buried lead pipe.

1. The rate of corrosion of lead in soils decreases in the following order: (a) muck, (b) cinders, (c) sand, (d) clay.
2. In general, the rate of corrosion increases with the amount of organic matter in the soil.
3. Corrosion is more rapid in poorly drained areas than in places where the drainage is good.
4. Lead tends to form a protective coating and in most soils its rate of corrosion decreases greatly with time.

Inside the house, for pipe, bends and traps in water supply, waste and soil systems, the great durability and ease of installing make lead highly desirable. It may be strung like wire, and



Lead service pipe being uncoiled in a trench excavation.



Soldering sidewalk stops and corporation cock couplings to lead pipe.

Seventy-six

joints are few. This is particularly and home modernizing, for the pipe stacks, such as beams, easily and thus saving time and expense. Or cut in floors and walls to allow long l

It is especially important, as a sa and waste systems use only the be allow the entrance of noxious gase



Installing plumbing in a modern building. Lead pipe and wiped joints, and caulking.

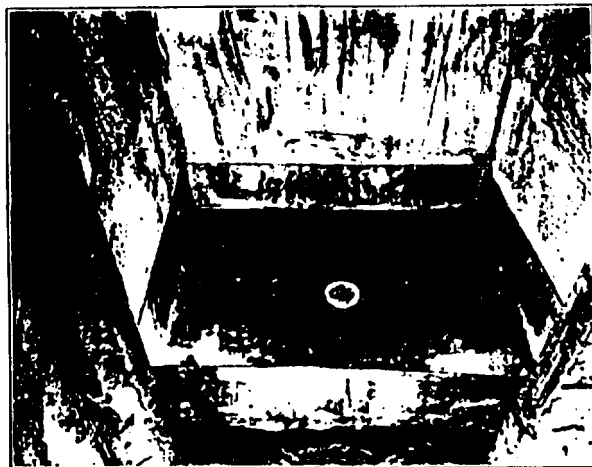
lead finds wide use in pipe and trap in making joints where cast iron pi hub and spigot joints should be join lead or lead wool. This is also true mains, because lead is soft and plia expansion and contraction of the p changes, as well as any distortion t uneven settling or other cause, an enough to make a good joint. Furt roded away. Where iron pipe mu lead wool makes this difficult feat e

Substitutes for pure caulking lea purchasers misled into believing th substitutes, while they may be as st are generally hard and brittle and, adjustments of alignment. Therefo

pipe must give way. Fortunately most up-to-date plumbing codes require the use of pure lead.

The application of lead in plumbing goes far beyond its use in pipe and joints. Where pipes pass through floors and roofs and the joints must be made water-proof, lead flanges and flashings are used. Bathroom floors under tubs and showers, as well as kitchen and laundry floors, are usually lined with sheet lead to prevent water seeping through and ruining the ceiling below or causing beams to rot away. In fact, in the best installations entire bathroom floors and walls are lined with lead, furnishing an invisible protection against the damaging effect of moisture that would otherwise work through the walls. Often an entire ceiling or a wall has to be done over, because false economy was practiced in omitting the protection of sheet lead in the bathroom above.

As pointed out in the section on "Chemical Corrosion Resistance of Lead," seepage water coming in contact with



A lead shower pan installed, underside asphalt coated and top ready to receive a similar coating.

cement, concrete or mortar may be corrosive to lead, making it advisable to use tar paper or asphaltum paint to shield the lead from this possible source of attack. This precaution is often required by building code specifications.

Seventy-eight

AMMUNITION



If you have ever gone home with your marksmanship on clay pigeons, sport of skeet, or brought a buck, you understand why Americans use 40,000 tons of ammunition in a peace-time year. In the early days of the American Revolution, every section had its shot tower and shot was made everywhere in grocery, hardware and other stores. With the advent of the breech-loading shot-gun, the use of shot in shells, and ammunition were quick to realize their opportunity. The country gradually disappeared, and historical reasons, such as one in Philadelphia, and probably the first built in this country, passed to ammunition manufacturers. Now the only active ones remain.

The method of manufacturing shot was invented in 1782 by a plumber, John Watts, who one night dreamt he was

that it was raining lead instead of water and the drops of lead were perfectly spherical like rain-drops. The next morning he decided to try the experiment, and poured molten lead from the tower of St. Mary Redcliffe Church into some water below. The trial was successful, and he is said to have sold the invention for a considerable sum of money.

Lead's great density has always made it the ideal metal for bullets and shot. It permits the attainment of the high momentum necessary to maximum striking power and accuracy, and decreases the surface against which the air resistance can act. Shot up to 0.23 inch in diameter, nearly $\frac{1}{4}$ of an inch, is made in shot towers. Molten lead is poured from the top of the tower through a pan perforated with holes slightly smaller than the shot desired. The necessary height of the pouring floor in the tower depends on the maximum size of the shot to be poured, the larger the shot to be made the higher must be the pouring floor. The bottom of the pan is covered with a sludge of oxidized lead, so that the molten metal will ooze slowly through and form round drops. Small amounts of arsenic, up to one per cent, are added to the lead to increase fluidity and allow it more easily to assume the perfect spherical shape desired. As the drops rain down the tower they solidify and are caught in a tank of water at the bottom so that the spheres will not be flattened on landing. In order to decrease the height of shot towers, an upward blast of air sometimes blows against the falling lead, which has the same effect as a longer fall. The maximum height used in modern shot towers is about 125 feet.

After the shot is collected in the water, it is dried and mixed with graphite to polish it. It is then screened to eliminate odd sizes. It is next rolled down sloping glass tables which have a narrow trough running along the bottom. The perfectly round shot gather enough momentum to leap this trough, but those slightly flattened are slowed in their descent so as to fall into the trough and subsequently are remelted. The grading operation is repeated four times. The shot is then loaded into shells and becomes ready for use.

Shot greater than 0.23 inch in diameter is too large to manufacture by this method, and is cast in revolving split-ring molds. The molds are placed around the circumference of a vertical ring several feet in diameter. The lead is poured in at the top, and solidifies as it passes down one side, until the split-ring

Eighty

opens and drops it out at the bottom. The finished is 0.04 inch in diameter, also pin-hole, and 4565 weigh an ounce. 0.11 inch in diameter and three weigh

Bullets, as usually made, are first and tumbled about in a barrel to smooth then pressed into the finished form. with cupro-nickel or other hard metal from punched discs, the lead inner crimped snugly together. Soft nose



The mass of emptied shells on the ground of the sport of trap-s

stop before they reach the nose of the lead nose flattens out on striking the for these strong jackets, lead bullets the rifling in modern rifle-barrels at the travel.

The modern pointed bullet has Originally, round balls were fired from but the pointed bullet offers much less consequently more desirable. However from a smooth bore would simply would not stay on its course. There

part spin to the bullet, so rifling was tried but was not really successful for many years, as bullets capable of gripping the rifling when fired could not be easily loaded down the muzzles. Various types of expanding bullets and bullets with rings around them to fit the rifling were tried unsuccessfully. It was not until the early part of the eighteenth century, at which time the invention of the patch in America made possible the remarkable shooting of such men as Daniel Boone and Davy Crocket, that rifles attained any real measure of success. The invention of the patch brought forth the famous Kentucky Rifle made in Pennsylvania, and called "Kentucky" because of the great demand for it by settlers of the then newly opened territory of Kentucky. The deadly accuracy of the American marksmen with the long Kentucky Rifles played a very decisive part in ruining the morale of British troops, as the accuracy attained by these backwoodsmen was far ahead of that attainable by the use of any other available weapons of the time. The patch, a greased piece of cloth or buckskin, was inserted ahead of the bullet and cleaned the powder fouling from the previous shot, lubricating the bore sufficiently to allow the bullet to be seated home. Breech-loading arms, also invented about this time, are responsible for the great modern development of rifles, but it was several years before accuracy comparable with the best of the muzzle-loading arms was obtained with breech-loading rifles.

After the shot or bullets have been manufactured they need to be inserted in shells or cartridges before use. Shot gun shells consist of weatherproof paper tubes, capped at the breech end with a brass cap into which the primer is placed. Powder, wads and shot are loaded into the open end which is then closed by turning the paper over onto a "top wad." Rifle bullets are inserted in brass cartridges containing powder and primer, and the cartridge firmly crimped to the base of the bullet. This is, of course, all done automatically by machine.

Today there are scores of types and sizes of bullets and shot manufactured for cartridges for the many kinds of guns, rifles and pistols that exist. About five tons of shot are made in the United States for every ton of bullets.

Most people are probably not aware that guns and lead bullets are used industrially also, for this is a development of only the last few years. In the manufacture of cement, huge rotating kilns, often 150 feet long and 6 to 10 feet in diameter, are used.

Eighty-two

Clinker rings often form around the in old way of removing them was to bar cooled rod wielded by five to seven men much labor and a great loss of time, as to cool somewhat before the barring

Recently a cement kiln gun and developed and proven highly successful man and a few minutes to remove The gun is mounted at the end of the clinker ring. A shell, loaded with a used. It delivers an extremely powerful tons, when it hits the clinker, and only necessary to cut a keyway through the dropped. There is no danger to the shots are fired at such a flat angle as are made of pure, soft lead.

Lead compounds are now quite well for cartridges and other explosives. Lead azide are such materials. Lead are also used in the manufacture of



Firing a cement kiln cli

ARCHITECTURAL AND ORNAMENTAL QUALITIES



DURABLE beauty and permanence have, for centuries, made lead a desirable working material of the architect and builder. For one thing, lead's unsurpassed casting qualities make it possible to execute in lead the finest decorative effects, and with no other metal can equal softness of design be attained. Furthermore, the gray color of the heavy metal is quiet and distinctive. Lead does not stain masonry or paint-work adjacent to it. In addition, as mentioned elsewhere, the extremely high corrosion resistance of lead gives the metal unexcelled durability. Recent independent tests made in England * on the resistance of the various common metals to atmospheric and sea-water corrosion give lead a high ranking. In tests of atmospheric corrosion, hard lead was at the head of the list, the purest tin was second, and soft lead third after seven years' exposure. Other metals such as common tin, copper, aluminum and zinc were farther down the list. In sea-water corrosion tests, lead's resistance to corrosion was only surpassed by that of the expensive metals, tin and nickel, over a period of four years. Other independent tests have verified these results.

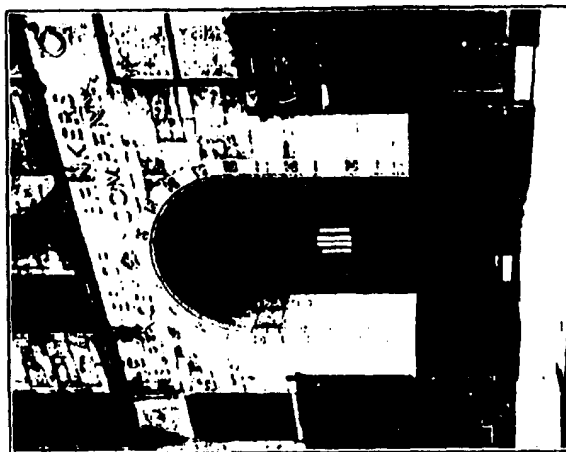
* J. Newton Friend - Relative Corrodibilities of Ferrous and Non-Ferrous Metals and Alloys. 1929. Institute of Metals. London. See page 20.

Classic architecture has many examples of buildings roofed with lead. The Pantheon in Rome has its venerable gray head after weathering for over eighteen centuries largely because of its lasting lead. The leaded roofs of St. Mark's in Venice, St. Peter's in Rome, the Kremlin in Moscow and scores of other buildings have stood for years of service. The unquestioned fact that lead is the only factor in the choice of lead for monumental buildings, for the charm of the patina of the lead, unalterable through the ages, so smoothly with the magnificent architecture gives the architects an added incentive in the use of lead. The low heat conductivity of lead is also a factor in lead roofing. And so today, where a building will not leak and need constant repairs, the durability will be the aim of every builder, and where a building is also a factor, hard lead is a desirable material.

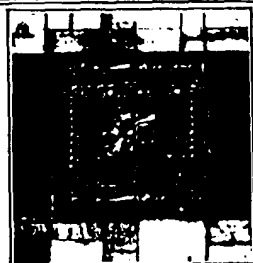
Leaden gutters and leaders have been used for centuries. Many famous buildings, such as Westminster Abbey, with leaden leader-heads dating back to the thirteenth century, are still serviceable. An almost endless list of buildings might be cited. The best modern buildings use lead. Aside from its remarkable durability, lead is a wise unattractive appurtenances on a building, made to add distinctly to the beauty of the building and lead's decorative possibilities.

Until the introduction of hard lead, lead was soft lead. While possessing many advantages, soft lead has the disadvantage of low physical strength. Its use for general roofing purposes lessens its use for a much greater tensile strength than soft lead. Atmospheric corrosion resistance, which permits the use of relatively thin sheets making it thoroughly adapted to modern building construction. It can be rolled or cast in any shape desired.

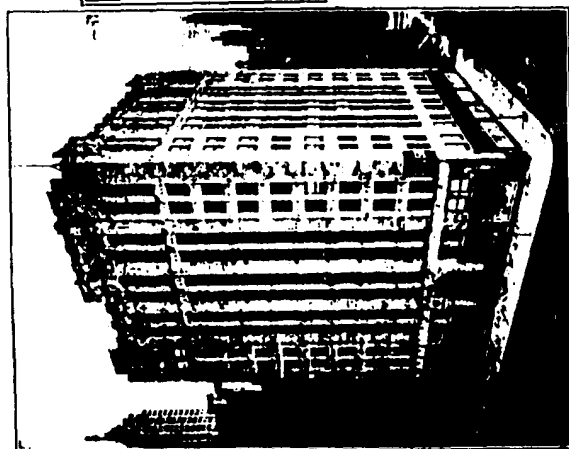
When exposed to the atmosphere hard lead develops a non-staining patina that brings out the natural beauty of the materials and gives a balance to the appearance obtained with other metals. It will last for years to any structure where permanence is required.



The main entrance is surmounted by an exquisite lead grille-work.



One of the beautiful and well-defined hard lead spandrels on this building.



A modern office building on which lead has been freely used.

Eighty-six

Hard lead can be used for all building purposes, and it has a definite and important place in architecture, especially where utility and inviting appearance are required, as in roofs, leader-heads, downspouts, window sills, cornices and flashings. Lead flashings are especially popular in this country. The soft character, combined with the softness of lead, make it easy to install and take up, and its covered, desirable features of a satisfactory material.

When rain-water gutters and downspouts are made of a malleable material they require frequent repainting. Moreover, they often leave stains on the walls of the building. Hard lead gutters and downspouts and flashing eliminate these difficulties. If more expensive, it is true, but once installed, require no attention or additional expense.

Often hard lead is used for purely decorative purposes. Roof crestings, finials, spandrels, and other details can be made of hard lead to advantage. Lead has been used in their origin many years ago, and each year its use is more widespread. Many of our finest buildings are noteworthy contributions to architecture, and lead is used in the numerous forms mentioned.

Hard lead for roofing is generally made in three weights: 2½, 3 and 4 lb. to the square foot. Flashings is usually slightly heavier. Lead commonly weighs 4 lb. to the square foot.

Lead also plays a distinctive but important part in the foundations of large buildings susceptible to vibration from passing trains or surface cars. Advantages of lead, unusual to a common metal, are its property of dampening vibration, by using it in the form of mattresses interposed between the columns and the building foundations. A typical construction of two sheets of 8 lb. lead on top and 1 lb. ¾ in. asbestos board in between and a steel plate or iron in the center. The edges of the lead are turned over the sides to make a tight seal. Hundreds of tons of lead are contained in the foundations beneath many of the huge business buildings in New York City.

in the Grand Central Terminal Zone in New York City, such as the Roosevelt Hotel, Postum Building, New York Central Building and others. The Craylar Building, in which the office of the Lead Industries Association is located, rests on 55 tons of lead. More than 80 tons of lead have gone into the lead mattresses of the new Waldorf Astoria Hotel on Park Avenue. The Pennsylvania Railroad also used lead mattresses for its Philadelphia terminal improvements.

Application of lead-asbestos anti-vibration mattresses is spreading to moving machinery. For example, they are being used beneath the column supports of the printing presses in the huge newspaper plant of the New York Daily News to prevent



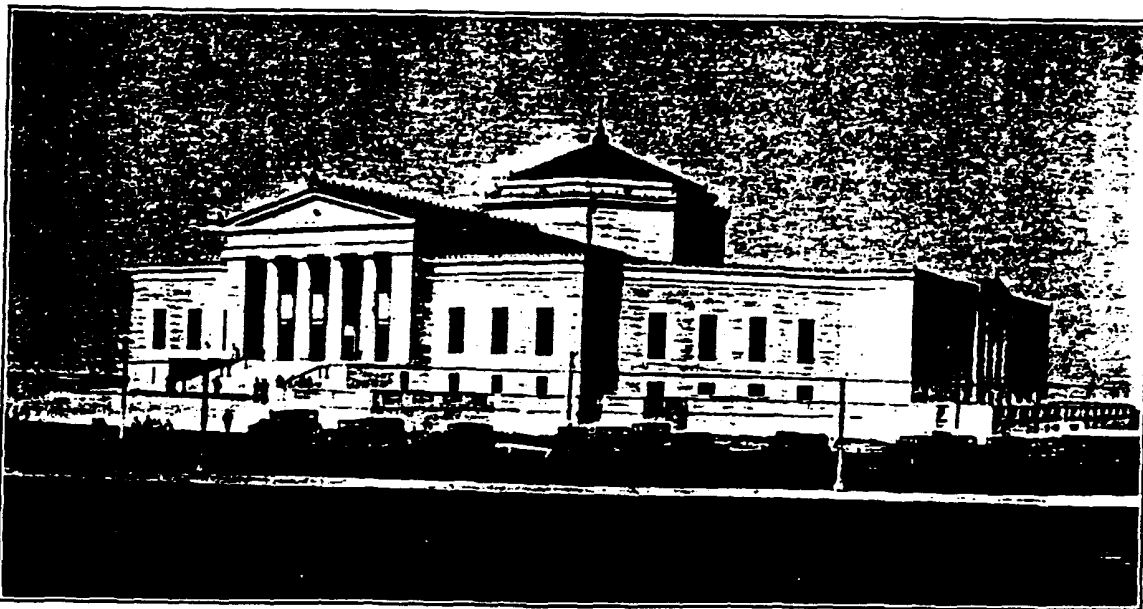
Lead anti-vibration mat in place under a grille in the new Waldorf Astoria Hotel, New York.

vibration being transmitted to the building housing the presses and offices. The New York Herald Tribune has used lead-asbestos mattresses for a similar purpose. Rubber manufacturers are finding lead-asbestos pads useful underneath machinery employed in rubber manufacture.

Generally the mats used with machinery are smaller in size than those applied to the base of skyscrapers. Furthermore, they are subjected to preliminary compression in a hydraulic press at 100 lb. per square inch so as to remove any play.

Although many organic materials, such as rubber and cork, have a greater vibration dampening quality than lead they

Eighty-eight



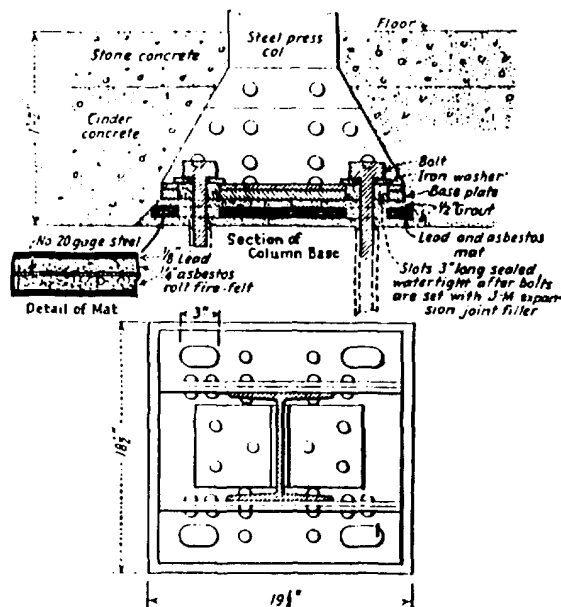
The Shedd Aquarium, Chicago, with hard lead finial, cresting and flashing, lead-covered glazing bars in its skylight and miles of lead pipe within.

Ewing Galloway

Eighty-nine

possess the disadvantage of being susceptible to deterioration with age or from contact with oils and greases, always found near moving machinery. Moreover, they cannot stand the relatively high unit load which lead is capable of carrying. Hence a more elaborate and costly foundation is required when weaker materials are used so that the load will be distributed to within the capacity of the material comprising the mat.

Lead comes, which are extruded bars of lead having an H-



Detail of lead-asbestos pads under newspaper press columns.

shaped cross section, are widely used in artistic glazing of windows, doors, book-cases, china-closets, etc. These flexible strips of lead hold the sections of glass together and they are often made with steel cores so that no other support is necessary to mar the beauty of the leaded window. Modern lead comes reproduce mechanically many hand wrought effects, such as rustic, antique and other finishes. Sheets of lead are frequently cut out in artistic designs and soldered to the comes over the

Ninety



A half dozen uses for lead on this house—gutters, leader-heads, downspouts, flashing, bay window roof, sun-dial, and leaded windows.

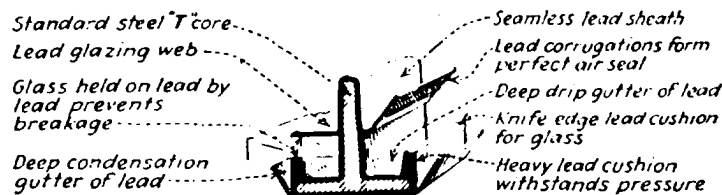
A lead-roofed bay window and leaded windows blend pleasingly with the architecture of this modest home.



W

glass. The finest examples of the art of glazing have been accomplished through the medium of lead and glass. Lighting fixtures are also sometimes wrought of lead, to beautiful effect.

Glazing bars made of steel are naturally subject to the ravages of rust and must ordinarily be kept painted as a protection. In order that no trouble need be experienced with them and to eliminate painting, lead-covered bars have been developed and have found ready acceptance and application on many fine buildings. Steel "T" bars, cut to proper lengths, are completely encased in seamless extruded sheaths of pure lead, the ends of which are afterward hermetically sealed, thereby providing airtight protection for the steel which is at no point exposed to the destructive action of the elements. A lead web,



Detail of lead-covered steel glazing bar.

an integral part of the sheathing, provides a cushioned support for the skylight glass and another flexible web above it furnishes a convenient means for sealing the glass against the entrance of air and moisture. (See diagram.) Thus, skylights and windows may be constructed with the utmost durability requiring no upkeep attention or replacements. These lead-covered steel glazing bars have been used extensively in railroad terminals, schools, auditoriums, industrial and public buildings of all sorts.

Another interesting application of lead along similar lines is the insertion of a double strip of lead in window frames. One side of the pliable strip is bent down, the glass inserted in place, and the strip bent back firmly against the glass to hold it. This is a quick and neat method of glazing which eliminates the necessity of painting right up to the edge of the glass and therefore the necessity of scraping paint off the glass later. It is also much simpler to replace the window panes, when necessary, than is ordinarily the case.

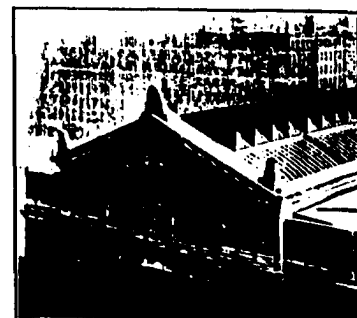
Ninety-two



Installing lead flashing on the ridge constructed of lead-covered



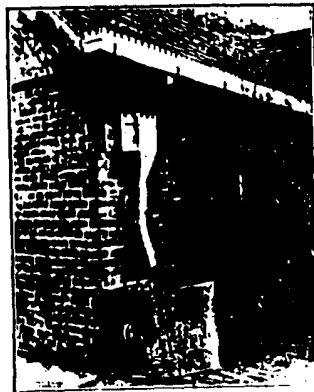
*Frank Ehrenford
Leaded window, Riverside Church, New York.*



*Chicago's Union Station has a large ex-
covered glazing b*



George H. Van Ande



Wurts Bros.

Lead is ideally suited to ornamentation both on buildings and in gardens for its soft gray patina forms a



George H. Van Ande

restful contrast to brilliant flowers and harmonizes with other building materials.



Ninety-four

Wurts Bros.

Lead wedges and lead wool are widely used to adjust and align the stone. This is true of columns, monuments and tombstones. To compensate for the irregularities of stone, courses of corrugated sheet lead are often used on large brick or stone buildings, replacing the stone to allow for uneven settling or movement without injury to the masonry, as the movement is absorbed by the flexible lead. Lead is particularly suited for this purpose because its color is approximately the same as that of the stone.

In the garden is another place where lead can be used to beautify and decorate. Statues, fountains, bird-baths made of lead add to the beauty of a garden without being obtrusive. Lead is itself, and yet retain decorative features.

In short, wherever architectural beauty is desired, lead should receive careful consideration. Especially England, which has long realized the ornamental quality of lead, and American experience.

Where a first cost more moderate than that of lead-coated copper or steel is available, lead is extensively used for roofs, leaders, gutters and downspouts. Lead-coated steel is in demand from industrial building construction to residential structures. It is particularly suited for culverts and other purposes where high strength is required where corrosion is a factor. These advantages of exposing a coating of lead on low-priced metals, giving steel or copper the appearance of lead, are well known.





SOME MISCELLANEOUS USES



Far from being a new use for lead, the recent development of an all hard lead casket in this country is merely a resumption of an application that prevailed for centuries. As pointed out in the historical section of this book, lead was one of the foremost materials of the casket maker in the middle ages. It is so widely considered as the standard metal for casket trim that hard lead for this purpose is simply designated as c. t. (casket trimming) metal. Modern lead caskets are cast in only two pieces, one casting being the entire body of the casket, the other the top. There are no soldered or burned joints or bracing, and they are built of nothing save the most durable of the common metals.

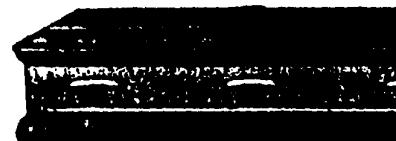
Representative of lead's great versatility is its use in the manufacture of molded rubber hose, such as ordinary garden hose. The method followed by one large company is typical of this process. A rubber tube is first extruded, around which is braided one or more plies of strong cord, and a rubber cover applied. The lead is then placed in a huge press which exerts a pressure of 6,000 lb. per sq. in. and the metal extruded around the hose through a fluted die, forming the mold. The process is similar to that of manufacturing lead sheathed cable. From 12,000 to 18,000 ft. of lead-covered unvulcanized hose, depending on size, are wound on huge reels and vulcanized at a time. This is accomplished by the application of high pressure steam

Ninety-six

on the outside and water under high tension through the inside of the hose pressing it against the lead. Air under pressure is sometimes used instead. After the hose takes a permanent form corresponding to the inside of the mold, which is either corrugated or smooth, after vulcanization the lead is stripped off, and the hose is ready for use again.

Lead is often used in an unrecognizable gasoline. In this case tetraethyl lead, $Pb(C_2H_5)_4$, a pound of the metal, removes the knock from a gallon of gasoline. When combined with small amounts of ethyl alcohol, it prevents the formation of lead oxide, halowal valve lubricant, and a red aniline dye, mercerized cotton, from other gasolines, ethyl fluid is formed. These are added to various commercial gasolines under different brands of ethyl gasoline. Only about 2 grains of lead are used in a gallon of gasoline, but several millions of gallons are used annually for this purpose, so great is the demand for this anti-knock motor fuel.

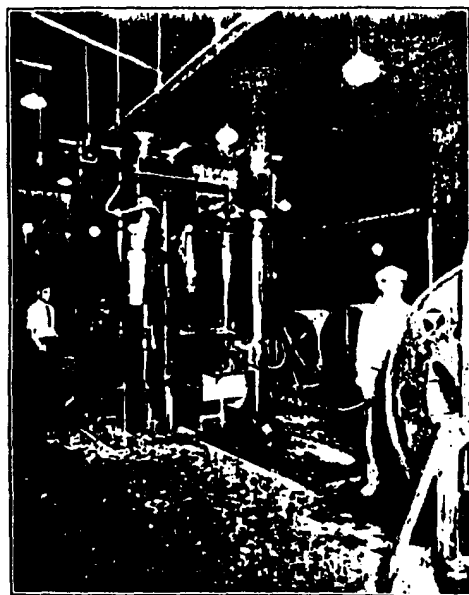
In the field of sport there are also many uses for lead because of its great weight. Lead tape, painted with white paint, is used for markers on the best tennis courts as it does not wear off constantly renewing lines marked with lime. Lead is used for tripping over canvas tapes. Lead is used



Courtesy Sterling Casket Co.
A modern hard lead casket.

balance to golf clubs, baseball bats, decoys and sporting accoutrements. Its use for ammunition is well known elsewhere. In fishing, be it for sport or industry, lead sinkers hold lines and nets down. Sounding lead is an all-important piece of equipment for boats of many kinds and sizes carry tons of lead. It is also used for clock weights, dress weights, and in short, wherever great weight and compactness are required.

Lead washers are widely used where it is important to prevent the seepage of moisture and where the wear is too rough for non-metallic washers. They have been widely used in the construction of freight cars. Along similar lines are the lead-headed nails for use in sheet metal work or with slate roofing. The nail head is completely covered with lead so that when the nail is driven home the hole is completely filled and is water-tight.



Courtesy B. F. Goodrich Rubber Co.
Extruding rubber hose in its mold of lead.

Thin sheets of lead are frequently used as gaskets in machine construction. The lead lends itself easily to stamping and by virtue of its softness and corrosion resistance, makes an excellent gasket material.

For many years one of the country's largest transportation companies has used ribbed strips of lead along the edges of street-car steps. These strips, about 2 in. wide, 18 in. long and $\frac{3}{8}$ in. thick, are used for the dual purpose of presenting a slip-proof tread in all kinds of weather and protecting the edge of the

Ninety-eight

step from wear. When the lead has worn out, it is removed, remelted, recast. Lead is also employed as a backing for slip stair treads as it gives a slightly yielding surface, easier to walk on than perfectly rigid.

Lead is also sometimes applied as floor covering. In one manufacturing establishment the floor was dragged about continually on the concrete floor the hose no longer wore out.



Many tons of lead are used for

in addition a slipless and practically no noise is obtained.

Lead finds a large use in explosive operations, particularly for its use in pipes and fittings, primarily for its ability to be easily fabricated into shapes. An ability to be easily fabricated into shapes adds to its value in such operations where a strike a spark is required. Where floors are exposed to corrosive liquors that are readily absorbed, causing deterioration or the creation of unhealthy conditions, the use of lead assists in the general cleanliness of operations.

Lead is used in making many kinds of products, particularly interesting at this time is its use in consumption. It is known as lead,

is used for Neon signs, and in radio tubes and lamp bulb stems. This special glass contains about 22 per cent of lead introduced in the form of litharge and is extruded from a continuous melting tank in lengths up to 200 ft. It is drawn from the mandrel on rollers and automatically cut into short lengths. Lead glass is generally extremely tough and capable of standing wide temperature ranges without injury.

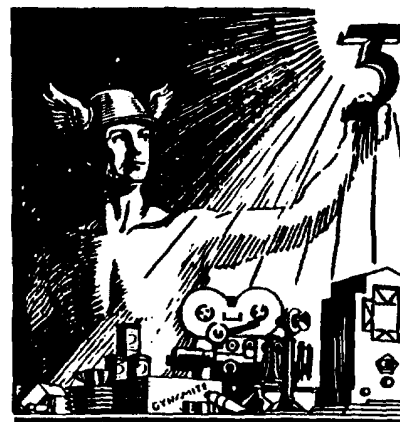
It is impossible in a short space to review all the many uses of lead, but the foregoing paragraphs give an idea of the great variety of these applications and the widely different reasons for using this versatile metal.



Courtesy Public Service Coordinated Transport

A street car equipped with lead safety treads.

One hundred



INDUSTRIES USING LEAD

AN idea of the wide diversity of industries in which lead can be gained from the following list. It is not possible to list for scarcely an industry of any importance that does not use one form or another. Perhaps the reader will find other purposes for which the use of lead is suited in his own industry.

- Air conditioning equipment — Lead coated fan blades
- Aircraft — Storage batteries, bearings, solder, lubricant
- Ammunition — Bullets and shot
- Anodes — Plating, electrolytic production of chemicals
- Artificial leather — In rubber, oil cloth, enamels
- Artists materials — Collapsible paint tubes, easels
- Assaying — Litharge and test lead
- Automatic signals, railway — Storage batteries
- Automobiles — Storage batteries, solder, bearings
- Babbitt metal — Bearings
- Bearing bronzes
- Boiler tubes — Coatings
- Bolts and washers — Expansion bolts and nuts
- Boots and shoes — Blocks on which leather is tanned
- Bronze and soft metal castings — Alloys
- Building — Paint, plumbing, roofing, ornamental castings, joints, anti-vibration mats, stair treads

room tiling, leaders, gutters, sash weights, flashings, caulking, spandrels

Cable — Sheathing

Canning — Solder

Cars, railroad and street — Bearings, batteries, paint, solder, noise reducers, safety trends

Caskets — Lead and lead lined, trim

Cast iron pipe — Coating or lining

Caulking — Molten lead or lead wool

Cement — Litharge with glycerine, etc.

Chemicals — Equipment, pipes, pumps, valves, tanks, drums, etc., all lead or lead-lined

Chemical laboratories — Equipment, table-tops

Chewing gum — Foil

Chimney — Glaze

Clocks — Clock weights

Clothing — Dress weights

Coatings, metallized — Corrosion resistance

Copper and iron sheets — Lead coatings

Doors, skylights and windows — Cases, puttyless frames, sash weights, putty, lead covered glazing bars, expansion joints.

Die castings

Divers — Lead shoes and belts

Dyeing — Dye fixer

Electrical — Storage batteries, cable sheaths, fuses, bearings, light bulbs and insulator glaze, solder

Enameling

Enameled iron wear

Explosives — Lead sulphocyanate, lead azide, lead nitrate, lead peroxide

Fire sprinklers, automatic — Low melting alloys to keep valves closed

Fishing — Sinkers, net weights

Flooring — Explosive plants, chemical plants, etc.

Foil — Tea, tobacco, etc.

Gaskets — Machinery

Gasoline — Tetra-ethyl lead (anti-knock compound)

Glass — Litharge and red lead in high grade glass

Glue — Collapsible tubes

Hammers — For removing dents in sheet metal

Industrial trucks — Storage batteries, bearings

Ink, printing — Pigments

Insecticides — Lead arsenate

Jewelry — Lead glass for imitation gems

Lead acetate

Lead Chromate

Lighting fixtures, ornamental

Linoleum — Dryer and pigment

Litharge

Locomotives — Bearings, coating for boiler tubes, paint

Lubricating grease — Collapsible tubes

Marble and stone work — Lead wedges

One hundred two

Machinery — Bearings, noise reducers, gr
metallic packing, anti-vibration m

Matches — Red lead and lead thiosulphate

Motion pictures — Lead glass lenses

Motor-bouts — Solder, paint, bearings

Mucilage, paste, etc. — Collapsible tubes

Musical instruments — Organ pipes, player
weights

Navigation — Sounding lead

Oilcloth — Dryer and pigment

Optical goods — Lead glass

Orange Mineral

Packing — Metallic

Paints and Varnishes — Pigment and dryer

Paper — Litharge cement, lead-lined equip

Petroleum refining — Lead and lead-lined e

Photographic apparatus — Lead glass lense

Pickling — Lead and lead-lined equipment

Plumbing — Pipe, solder, bends, traps, ferr
lead wool

Pottery — Glaze

Printing — Type metal, printing inks

Pumps — Lead and lead-lined for handling

Radio — Tube caps, solder

Radium — Lead-lined cases and rooms

Red Lead

Regalia, badges, emblems — Die cast lead m

Roofing — Sheet lead roofing, lead-coated m

Rubber — Litharge, lead thiosulphate, white

Rubber Hose, molded

Scales and balances — Lead weights

Seals — Freight cars, etc.

Shipbuilding — Paint, bearings, shaft sleeve
keel weights, solder

Solder

Sporting and athletic goods — Weights in d
etc., ammunition, tennis court ma

Statuary and art goods — Statues, garden fig
tablets, etc.

Steel treating — Hardening and tempering

Steel barrels, kegs and drums — Lead lining

Storage batteries

Structural and ornamental iron work — Pai

Submarines — Storage batteries, paint

Sulphuric and mixed acids — Lead or lead-l

Telephone — Storage batteries, lead covered

Tin foil — Lead coated

Tin cans — Solder

Terneplate — Lead and tin coating on steel

Tobacco — Foil wrapping on cigars, cigarette

One of the purposes of the Lead Industries Association, an organization of lead mining, smelting, refining and manufacturing companies, is to disseminate accurate information regarding lead products and how they best may be used. In furtherance of this object, the information contained here-in is published. The Lead Industries Association will be pleased to cooperate with readers on any questions relating to the use of lead or lead products, without obligation.



Lead as protection against and deterrent for any
Lead
Lead
Lead