LEAD INDUSTRIES ASSOCIATION, INC.
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SUBJECT: A.I.M.E. PAPER

To Members of the Lead Industries Association, Inc.:

Attached is a copy of a paper prepared by the writer and Mr. David H. Borcina and presented before The Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers at its Annual Meeting on February 20, 1964 in New York.

Extra copies are available as long as our supply lasts. We hope you will find it interesting.

Very truly yours,

Robert L. Ziegfeld

Executive Vice President

RLZ:mk
Enc.

Look Ahead with Lead

LIA24014

THE POSITION OF LEAD IN A CHANGING TECHNOLOGY

By

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And

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To quote one of our fellow members of A I.M.E. who is in large measure responsible for getting us into this mess of trying to explain the position of lead in a changing technology, "The world is in the midst of a technological explosion. New materials and new methods are appearing so rapidly that most of us are hard put even to keep up with developments in our own specific fields."

How true! And yet the basic materials, like lead, with which we work do not change. All that happens is that we learn to make use of the properties they have always had in different ways to meet different conditions, to put them together with other materials to provide other useful properties in new materials. Just for example, lead has always had the ability to stop certain kinds of radiation, but until we put X-rays and radium to work and until nuclear energy became a reality, we either did not know lead had this property or we had no occasion to use it. Thus the technology of radiation created a whole new field of usefulness for lead.

By the same reasoning, but with reverse results, aluminum has always been only about one-fifth as heavy as lead, but until aluminum technology reached the point where it could be produced at reasonable cost and rolled to thin foil, lead enjoyed a big market in foil packaging, as for cigarettes. Since a pound of aluminum will make five times as much foil of the same thickness as will a pound of lead, lead had to move over.

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Just one more example. It has long been known that lead compounds in porcelain enamels provide a flux that results in enamels that can be fired at extremely low temperatures. Because steel has a high melting point and can be fired at high temperatures, the need for such enamels was limited. However, as the use of aluminum expanded and a need for brightly colored enamel finishes on aluminum developed, a need for low firing porcelain enamels for aluminum was created. Thus was also created a new market for the lead oxides and silicates used in porcelain enamels.

We cite these examples simply to prove that, as old as lead is and as long as technologists have put it at the service of mankind, it continues to find its place as technology changes. We merely must learn how to fit its many useful properties into that modern technology.

Before discussing in detail some of lead's modern applications, some review of the overall picture of lead uses will undoubtedly be helpful. The United States consumes over 1,100,000 tons of lead a year today. Of this about 60 per cent is in the form of lead metal or lead alloys, and about 40 per cent in chemical compounds. Table I shows a breakdown by products.

ESTIMATED LEAD CONSUMPTION BY PRODUCTS - 1963
(In Short Tons)

Tetraethyl Lead	190,000	
Litharge	90,000	
Black Oxide	170,000	
Red Lead	25,000	
White Lead	10,500	
Lead Chromates	20,000	
Lead Arsenate	2,500	
Miscellaneous Lead Compounds	8,000	
TOTAL LEAD COMPOUNDS	516,000	
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Antimonial Lead Products	225,000	
Cable Sheathing	58,000	
Solder	73,000	
Calking Lead	80,000	
Ammunition	50,000	
Pipe and Extruded Products	20,000	
Rolled Products	34,000	
Type Metal	26,000	
Bearing Metals	21,500	
Miscellaneous	62,200	
TOTAL METALLIC LEAD PRODUCTS	649,700	
TOTAL		1,165,700

Another way is to break lead's usage down by industries. It is not possible to make this breakdown entirely clear cut because of the difficulty and even impossibility of tracing the ultimate disposition of a number of lead products. Yet in most cases, the industry in which the lead is fabricated is clearly indicated. This is shown in Table II.

ESTIMATED LEAD CONSUMPTION BY INDUSTRIES - 1963
(In Short Tons)

Storage Batteries	430,000
Oil Refining and Gasoline	192,000
Cable	58,000
Construction	130,000
Paint and Varnish	33,000
Ammunition	50,000
Brass Manufacturing	22,000
Printing	26,000
Ceramics	19,000
Colors	18,000
Can Manufacturing	13,000
Automobiles (other than Batteries)	16,000
Railroads	10,000
Insecticides	2,500
Steel and Wire	4,000
Foil	4,000
Collapsible Tubes	14,000
Rubber and Hose	3,500
Coatings	2,000
Unclassified	118,700
	1,165,700

We don't want to belabor the point made earlier of adaptability to changing technology but the table of lead's current usage by industries is extremely illustrative of the point. Considering that lead has been known and used by man for 30 or 40 centuries, when were its important modern uses developed!

The storage battery industry uses more lead than any other industry, over a third of the total. Lead storage batteries were unknown until about a century ago when Planté made the first lead-acid cell. Lead-acid batteries were in commercial use in a small way in the late 1800's, but the automobile brought lead-acid storage batteries into their own. When Kettering developed the self starter for automobiles in 1915 the SLI battery (starting, lighting, ignition) was born and today uses over 80 per cent of all the lead going into batteries. Thus less than 50 years ago, lead's biggest use was born and grew with the horseless carriage. The electrochemical properties which lead always possessed became a great boon to the modern automotive age.

Unlike the storage battery industry in which some 80 per cent of the lead used is recovered from scrap, refined, and reused as secondary lead, the gasoline industry, second largest consumer of lead today, completely dissipates the lead that goes into its products. This industry employs lead in the form of lead alkyls to make antiknock compounds in gasoline. Lead was first used for this purpose about 40 years ago in 1923. Today around 190,000 tons or between 15 and 20 per cent of total lead consumption goes into gasoline antiknock compounds.

About half of all the lead used each year is concentrated in these two applications, neither of which can be termed "old" in relation to the age of lead itself, and both of which relate to the automobile which though mature is still the bellwether of modern industry, modern technology and modern living. It is interesting to note, however, that the amount of lead used each year in these applications is not dependent on the rate of production of automobiles but rather on the number of automobiles in operation and on the distance they are operated. This is because gasoline is used in driving and not in building a car and because about four replacement batteries are needed for every one that goes into new equipment. But we'll hear more about that later!

If any of you feel that these uses developed in the last forty or fifty years are not modern enough to suit you, we have only to turn to the field of nuclear energy or to electronics. There is nothing more modern than our nuclear navy - submarines, cruisers, carriers - or the first nuclear merchantman, THE SAVANNAH. While except for THE SAVANNAH which carries about 530 tons of lead radiation shielding, the amount of lead shielding employed is classified, each of the naval vessels is estimated to have from at least 250 tons to several thousand tons of lead shielding depending on the type and size of ship.

And ships are only one manifestation of nuclear energy applications. There are also huge central power stations, portable power plants for remote locations, isotope shipping containers, irradiation units for treatment of food, industrial and research laboratories. All these and other nuclear applications use lead in various forms and in varying degree. Lead castings, shot, powder, wool, sheet and plate, glass bricks, and extrusions are among the forms of lead employed.

Electronics are giving lead another modern technological boost. An old lead product, solder, is one to benefit most in making permanent, highly conductive joints in the electrical systems. Lead oxide is another old product that goes into the glass of television tubes. But there are some entirely new products involved like lead zirconate-titanate, a piezoelectric material that converts electrical to mechanical energy and vice versa without moving parts and at very high frequencies. For example, this material is the heart of ultrasonic industrial cleaning equipment and sonar, two of its major applications. Some 500 to 1,000 tons of lead a year of this somewhat exotic material are now being used.

Lead telluride is another material that is receiving considerable research and some commercial attention. This is a thermoelectric material that converts heat to electricity and vice versa without moving parts. It has been used in the cathodic protection of pipe lines and in SNAP satellites, and is being experimented with to generate electricity from waste heat in home heating systems. While this is never likely to become a major use of lead, it certainly is a good illustration of lead's place in our modern changing technology.

Now let's turn to two related areas in another field - control of noise and vibration. Here the applicability of lead has been known in a limited way for a long time, 40 or 50 years at least, but only sporadic applications of lead for these purposes have been made. More or less suddenly this picture has changed, largely because people have become strongly conscious of the annoyance, cost and actual damage to health, machines and structures caused by uncontrolled noise and vibration.

Nearly 50 years ago the New York Central Railroad first required the use of lead-asbestos antivibration pads under building columns along its Park Avenue right-of-way leading into Grand Central Terminal in New York. Since then this practice has been consistently followed because of the satisfaction they gave in preventing train vibration from passing up into the buildings. Also the Pennsylvania Railroad used such pads in Philadelphia, the Canadian National in Montreal, and the New York Central in several other locations. However, the growing consciousness of the vibration problem, not just caused by railroads but by subways and street traffic as well and the building boom of recent years have resulted in much wider use of these pads. The use of air rights over railroad rights-of-way have added to the trend so that now it is quite common practice. They have been used under scores of buildings in New York, Montreal, Boston, New Jersey and elsewhere. Their field performance has been scientifically investigated and for the first time, engineering data are available to help in designing for maximum effectiveness.

These pads have also been used occasionally in the past to reduce transmission of machinery vibration. Many newspaper printing presses are installed on such pads and some laundry machinery and rubber mills have been installed in this way. More recently, air conditioning cooling towers on the roofs of a couple of large New York City office buildings have been mounted on these pads. One of the leading manufacturers of electrical transformers is using them under one line of his transformers. It appears that the machinery market has only been scratched and will grow rapidly as more is learned about the nature of the vibration to be controlled in each instance and the areas in which the lead pads are most effective.

Next we have the related field of noise transmission control. Over many years lead has occasionally been used for this purpose, usually in the form of sheet. A laboratory at the Sorbonne in Paris, music studios in London, doors in the N.B.C. studios at Radio City in New York, are examples of sheet lead linings to prevent the transmission of noise. Now three things are spurring wider and more rapid development of lead for such purposes. The public has become noise conscious. It wants quiet. Industry is finding noise costly and damaging to employee health. And lead is finding use not just by itself but in combination with other materials which make it more useful in application.

Considerable research has been done to determine more precisely just what effect lead has in various types of construction. This is giving engineers more data with which to work and design intelligently. A number of experimental installations have been made and tested with encouraging results. It looks like a market for lead will develop in this field, particularly as the economic problems involved are resolved. A Canadian manufacturer is selling movable panels containing lead as room dividers for hotels, motels and schools.

Leaded vinyls in which generally lead powder is incorporated in the plastic binder are finding rather wide use commercially in controlling noise. They are used as cabin liners in most of our newest jet airliners and in helicopters, in typewriters, in removable partitions, or room dividers, and in a number of industrial applications such as for wrapping noisy valves in gas pressure reducing stations. We estimate that some 500 tons of lead are now being used for such purposes.

What about lead chemicals which account for about 40 per cent of current lead consumption? Here technology has really changed the picture. Back in the 1920's white lead as a paint pigment consumed nearly 200,000 tons of lead a year, but newer pigments, particularly titanium dioxide, came along to reduce this market over the last 40 years to only a few thousand tons. However, in 1923, tetraethyl lead as a gasoline antiknock additive was born and in 40 years the use of lead to make this and other lead alkyl additives has grown from nothing to nearly 200,000 tons.

Despite the decline in white lead, other lead pigments new and old are giving a good account of themselves. Red lead remains the standard pigment for metal protective paints. Lead chromate with its brilliant yellow color is growing in use as a traffic marking paint due to its visibility and the respect generally accorded it by motorists. A whole new group of lead pigments in which each particle has an inert core like silica and an active lead pigment on the surface has been developed for both house paints and metal protective paints and are getting wide acceptance. Through research, both old and new lead pigments are finding application in water thinnable baking primers for automobiles and other metal products and in latex house paints.

Extensive research is being conducted on new organo-lead chemicals and several are being tested by industry itself for such possible applications as antifouling biocides for marine paints, pesticides, heat and light stabilizers for polymerized chlorinated hydrocarbons, catalysts for polyurethanes and for esterification generally, and as producers of chemical radicals. They include such compounds as tetraphenyl lead, hexaphenyl dilead, triphenyl lead acetate and diphenyl lead diacetate.

Other lead chemicals are also showing promising possibilities in the treatment of cotton to improve such properties as rot resistance and fire resistance. The ceramic industries are making greater and greater use of lead oxides and silicates because of the fine fluxing characteristics of these compounds. Lower firing temperatures required to enamel aluminum for example, and to reduce the cost of enameling steel have placed more of a load on these lead compounds as has the trend to the use of glazed brick and other clay products which employ lead fluxes.

A moment ago we mentioned the lead alkyls, like tetraethyl and tetramethyl lead, as antiknock additives for gasoline. Their use has grown sensationally both in the United States and throughout the world. The growth in lead consumption for this application was temporarily retarded in the late 1950's by large scale construction by the petroleum industry of cracking facilities capable of producing higher octane gasoline without additives and by compact cars. Construction of plants to produce lead alkyls abroad, such as in Italy, England and Canada, also had a depressing effect on U.S. production which formerly supplied the foreign market. Today most of these deterrents to further growth have been minimized. The new cracking capacity is being used to its fullest and no new such capacity appears to be in the offing. The trend now is to larger and more powerful cars both here and abroad. Only one additional new foreign plant, in Mexico, is under construction. The threat of automobile engines like the gas turbine which do not require high test gasoline appears to be remote. Of course, the change to jet aircraft, the fuel for which does not require lead compounds, is another factor that has had an adverse effect.

Lead sheathing for both power and communications cable has suffered in the last 30 years from intense competition. The tonnage used for this purpose has fallen from a peak of 220,000 tons in 1929 in the United States to around 60,000 tons today. Abroad this substitution trend has been nowhere near so pronounced so far but will probably follow the United States trend in some degree in time. Yet even here the trend seems to have bottomed out, with consumption having reached its low and with the likelihood that the present usage of lead will continue or start to trend slightly upward. In cable today lead continues to be used for the severest conditions where complete impermeability and reliability are essential such as telephone cable buried directly in the ground or power cable such as that which is paper-insulated in which no chance of moisture can be tolerated. Perhaps it is some small compensation to realize from this that even their developers do not consider substitutes as complete equals of lead sheaths but rather as economic compromises.

As previously stated, the lead-acid storage battery is the biggest use of lead and continues to grow, despite the development of nickel-iron, nickel-cadmium, silver-zinc, and other combinations. These newer power storage packages have their special applications, but both, because of economy and reliability seem to be little threat to the lead-acid battery for automobile starting, lighting and ignition, or to lead industrial batteries, the big tonnage markets. In 1963 it appears that shipments of automobile batteries will set a new record for the second successive year.

Industrial batteries which use some 45,000 tons of lead a year of the total of about 425,000 tons in all batteries have also shown substantial increases. In automobiles since the war, improvements have been constantly decreasing the size and increasing the life of batteries, which meant less lead per battery and fewer batteries, affecting somewhat adversely the total consumption of lead. However, this trend has tapered off as apparently it becomes more and more difficult to improve batteries technologically. In motive-power batteries, technology has greatly increased the power output per unit of weight and size, giving these batteries new advantages in competing with other power like gasoline or propane. The trend in all industries to more mechanical materials handling and to the use of powered personnel carriers in large plants is also helping motive power batteries. A new short haul delivery truck is now on the market for milk and bread routes and the like which should in time add substantially to the industrial battery market. An interesting economic development should also help the sale of electric industrial and street trucks which in the past have cost more initially than gasoline trucks. At least one battery manufacturer will now supply the batteries without cost and charge for them based on the power used as shown by a meter, thus reducing the original investment substantially.

The technology of production is contributing to the rejuvenation of an old standby lead product - terne plate. As you know, this is simply sheet steel with a hot dip coating of lead alloyed with up to 20 per cent tin. It is currently used for roofing, automobile and other gasoline tanks, radio and television chassis, non-food cans, and a variety of miscellaneous metal products in which corrosion resistance, deep drawing, solderability, and easy finishing are important. Current lead consumption is only a couple of thousand tons a year in this application but existing productive capacity has been overtaxed to supply the growing demand. As a result, two of the five important United States producers have doubled their productive capacity just recently indicating an industry-wide production increase of about a third, and improvements in production methods indicate a greatly expanded future market.

The old process of hot dipping individual sheets was slow and costly. However, high speed continuous coating liners have been perfected and the product is now available in coils of almost any desired length, produced at high speed, and convenient and economical to use in mass production.

It is obvious that one could go on almost indefinitely discussing the changing pattern of lead's applications due to modern technology. There are many other applications that could be mentioned. We have scarcely touched upon the technology of production and fabrication which would bring us into the realm of high purity metals, smelting and refining developments like the Imperial Smelting process, continuous extrusion of lead cable sheath and continuous casting of thin sheet lead, powder metallurgy techniques for producing wrought and coated products, high speed lead electroplating and more. These could well be the subject of another paper or papers in themselves.

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Our purpose here has been to demonstrate that technology is constantly changing the pattern of use of raw materials, that sometimes these changes constitute threats to long established markets but that constant vigilance and foresightedness can often make wonderful opportunities of these technological developments. In today's technological explosion, it is necessary for any basic industry like ours to make and to recognize these opportunities. They don't just knock at your door.

Research and dissemination of knowledge form a two-pronged approach that can be effective. Research can fill the gaps in our knowledge and apply it to the changing technical needs of the times. And full information about a material and its potentialities must always be kept before the people who can use it in the development of their own products and markets.

This approach we believe is being wisely used by the lead industries. The research need is being filled by the International Lead Zinc Research Organization, supported by lead producers throughout the world, as well as by research of individual members of the industry. Dissemination of information about lead to other industries is being accomplished through the activities of the Lead Industries Association, Inc., and its counterparts in other countries like Great Britain, France, Western Germany, Italy and Australia, and by individual companies. We believe that as a result all industry is taking a new interest in lead and is viewing this old metal with an attitude of "What can we do with lead next?" rather than "Lead did a good job for us in its day, but ...."