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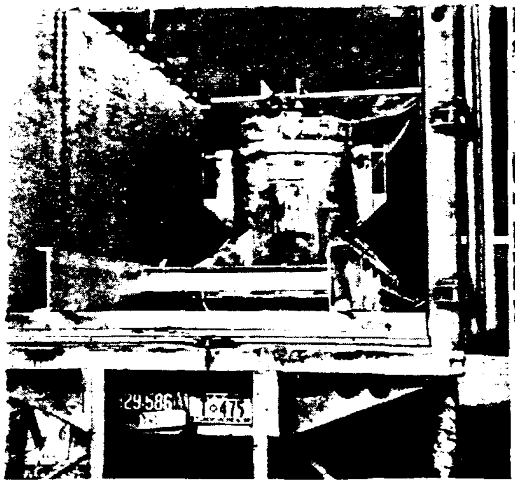
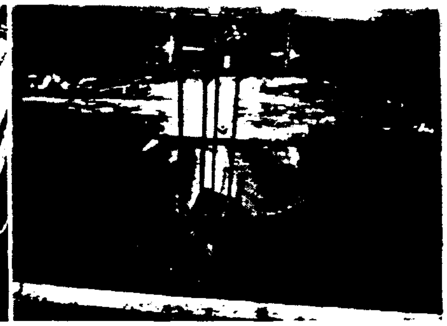
VOLUME TWENTY-TWO 1958 NUMBER FOUR

One of Boston and Maine's 24 lead-acid battery powered baggage tractors heads up a 7 per cent ramp, 117 ft. long. See story page 6.

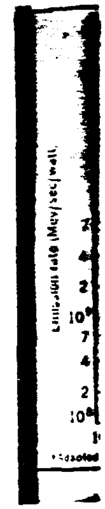
LEAD INDUSTRIES ASSOCIATION
0 EAST 42ND STREET, NEW YORK 17, N. Y.



At left and above. Receiving and unloading the 12-ton lead cask at the laboratory.



Lowering the lead transfer cask into the "hot well" within the radiation cave.



Spent MTR Fuel Elements

Part 1 — Shipment

Use of relatively inexpensive, freely available source of radiation energy is the basis for and part of the impetus behind the construction of the spent fuel element irradiation facility by the Sinclair Oil Co. at their central Research Laboratories, Harvey. Ill. Under the direction of Dr. A. I. Snow. a would-be waste material product of the Materials Testing Reactor. an AEC facility at Idaho Falls, Idaho, containing residual useful radiation energy is put to work ferreting out unknowns of petroleum science. Radiation induced ionization reactions have already made available to industry and the public the advantages of radiation stabilized Polyethylene and radiation vulcanization of rubber, and there are many other rewards both actual and foreseeable.

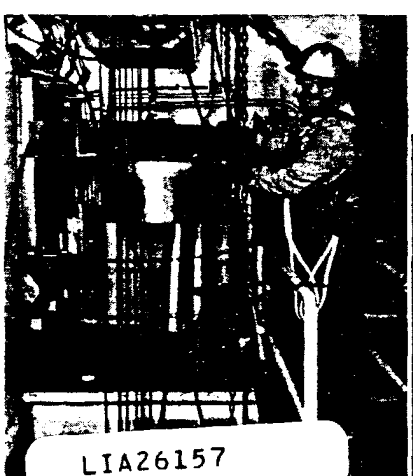
In effect complementing radiation research facilities using energetic isotopes like cobalt-60, spent elements may be looked upon as the logical successors to "cooked" sources years in the making. However, there is one sustaining feature in the make-up of such facilities and perhaps making fuel element or isotope programs commercially possible — the radiation shielding proclivities of lead.

In two parts, the story of Sinclair's entry into utilization of spent fuel element irradiation with receipt of their first shipment will be told, typical of other entries like Continental Oil Co.'s facility at Ponca City, Okla.

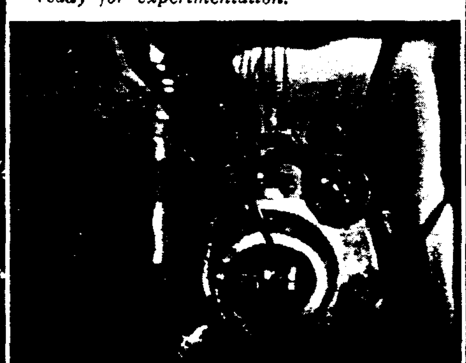
The photographs portray the receipt of the first shipment of four spent fuel elements from MTR. The shipping cast is removed from the approved truck carrier (cask and truck owned and operated by the Tri-State Warehousing and Distributing Co.), drained of its liquid coolant (methyl alcohol solution used in preventing freeze-ups), and lowered into the "hot well" within the radiation cave. The top plug-type cover of the cask is removed under eleven feet of demineralized water which acts to prevent exposure to harmful radiation during withdrawal of the four elements using remotely controlled tongs. The last photograph shows the operating basket in sixteen feet of water ready for experimentation.

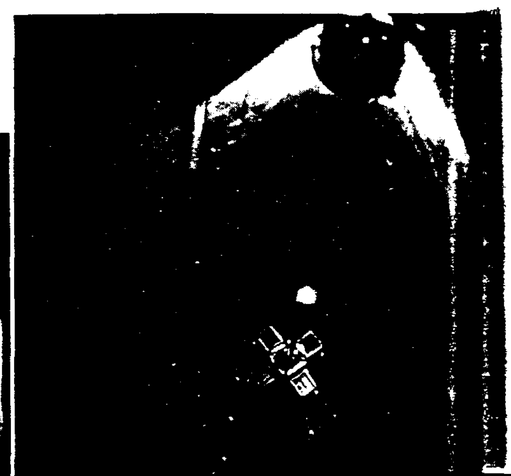
The four fuel elements, aged for about 300 days, were shipped in a lead cask weighing 24,800 lb. affording shielding and handling facilities sufficient for up to eight elements aged for as short a time as twenty days. The transfer cask, designed by the General Electric Co. for AEC is approximately 38 in. in dia. by 64 in. high with an open core 15 in. in dia. by 40 in. high to receive the fuel elements. Inner and outer surfaces are of 304 stainless steel clad low carbon steel plate. Lead is cast between the inner and outer shell giving a minimum of 11 in. of lead shielding between the elements and any point on the outside surface. The plug entry to the top of the cask is approximately 21 in. in dia. by 11⅜ in. thick, shown in photograph.

The dose from the elements received in use was 216,000 roentgens per hour. Each shipment contains about 560 g. of U^{235} with a maximum of 700 g. licensed as contained in four MTR or ETR elements. The planned use of thirty day decay age elements delivering 2.5×10^6 r/h will be approximately equivalent to 46,000 curies of cobalt-60 using the same source geometry. MTR elements are expected to last four to six months, having then lost about three-fourths of their energy. This assures a continued demand for spent fuel elements and conjures the view of suitably implemented trucks crisscrossing



Left. Removing the plug-type cover with cask under water. Below. Removing spent fuel elements from cask under water. Right. Operating basket under 16 ft. of water ready for experimentation.





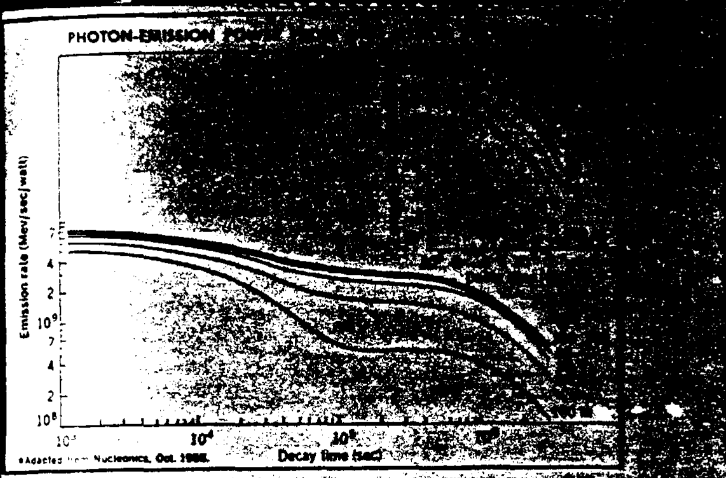


Fig. 1. *Photon-emission power from U^{235} fission products as a function of irradiation time and decay time. The energy and emission rate, important for shielding calculations, is largely the sum of the contributions from isotopes emitting hard gamma photons $\geqq$ 1.60 Mev. Contributions of Zr^{95} and Nb^{95} which become significant at longer delays are included in the curves in the inset and in the inset of Fig. 2.*

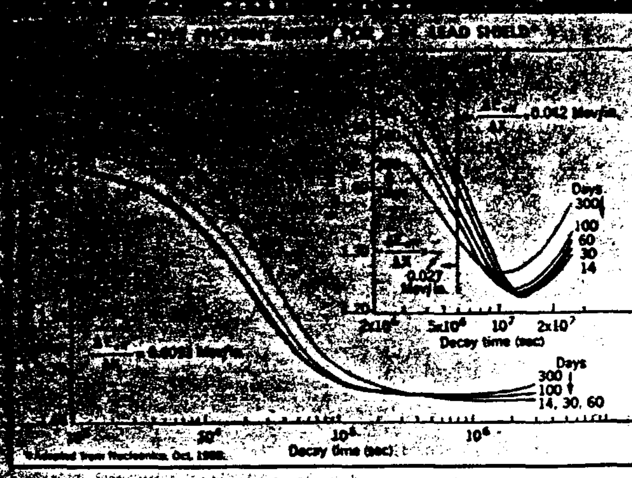


Fig. 2. *The effective energies calculated for 8 in. of lead shielding with separate sets of curves for two intervals of decay time, see Fig. 1. In the region of overlap, the curves that cover the longer decay time are the more accurate. Coefficients are shown which permit use of the graphs for thicker and thinner lead shields.*

the country servicing a multitude of reactors, spent fuel irradiation facilities, and the end-of-line fuel reprocessing centers. (The first large power reactor in the United States will start discharging spent fuel elements in about two years.)

Important to the practicability of such visionary accomplishment would be the development of carriers meeting the factors largely governing economical instate and interstate commerce—weight, volume and safety. The use of lead in MTR cask construction and in other shippable research reactors as primary shielding give lead and mobility synonymity. Seemingly the cost and design factors are resolvable in lead construction.

Going a step further, the recent literature reflects a desire for a more ready and facile design approach to shielding of mobile carriers for spent fuel elements. Ashley of Atomics International in a recent issue of "Nucleonics" puts forth a shield design simplification. The conversion of spectral energy, Figure 1, to an effective photon energy for a fast determination of shield sufficiencies is made possible by suitable graphs, Figure 2. They permit the substitution of a single photon energy for a fission product spectrum. The shield problem, then, is to find the penetration of photons of this energy.

With an effective photon energy figure for different lead thicknesses and corresponding linear absorption coefficients, flux to dose conversion factors, and build-up factors, the effectiveness of lead shields can be computed with fair accuracy. Since lead shields required for spent fuel are thick shields, thin shields are not considered in the analyses. The method should only be applied to thick single region shields of more than six inches.

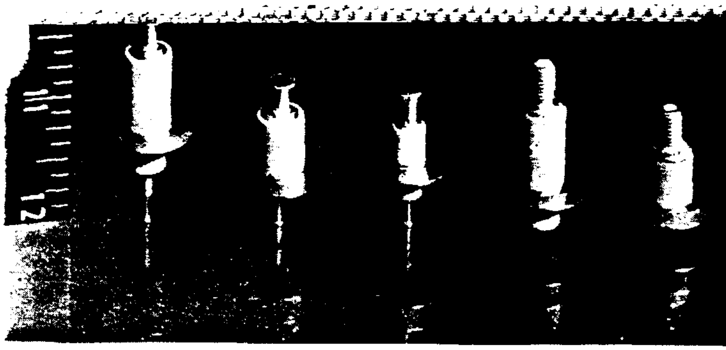
In addition to lead's contribution to effective and economic handling and transport there is also the all-encompassing protection against accidental conditions taking into account flood, fire and wreckage. For example, a bulletin from United Press International, Grand Junction, Colo., dated June 23, 1958 reported that a submerged atomic capsule which threatened to contaminate the Colorado River to the California border had been recovered. An Atomic Energy Commission monitoring team said no radiation had leaked through the capsule's lead shield after the truck on which it was loaded plunged into the river about five miles east of Palisade, Colo.

Reference: R. L. Ashley, "Graphical Aids in the Calculation of the Shielding Requirements for Spent U^{235} Fuel," NAA-SR-1992 (1957), available from the Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. The reference includes sample calculations with explanations suitable for use by engineers not trained in shielding.

Lead Brazed Ceramic To Metal Seals

Lead base solders have been used extensively in electronic and metallurgical applications as an inexpensive and efficient method of joining metal parts. The versatility of lead in jointing applications is demonstrated by a recent development from the Research Laboratories of Sylvania Electric Products, Inc.—a high lead braze for low cost production of high quality ceramic-metal seals, useful up to working temperatures of about 300° C. This high lead braze is essentially a low or medium temperature seal comparative in cost but offering distinct quality advantages over plastic and other low cost sealing methods.

The accompanying photograph shows some representative ceramic-metal seals that have been made with this lead braze. The braze alloy is essentially a lead-copper alloy containing 3 per cent titanium. Copper improves the fluidity and wetting characteristics of the alloy, and in addition, increases the hardness and mechanical strength. A concentration of 7 per cent will sufficiently strengthen the braze alloy for most applications. A range of copper contents up to 70 per cent is possible, however, exhibiting higher melting points and higher



Some sample lead brazed single lead terminals. The braze joins steel to alumina and the terminals are cadmium plated for oxidation protection.

hot strengths. But for most applications, 90Pb-7Cu-3Ti alloy appears to be quite satisfactory.

Three per cent titanium is introduced, due to its ability to reduce other metallic oxides, to promote the wetting of ceramic materials. Without titanium, the lead-copper braze would not be able to wet ceramic materials, but with the titanium addition, a strong chemical bond is formed.

The braze alloy can be used in either a powder, sheet or wire form. The powder can be mixed with a nitrocellulose lacquer to form a paint and then applied with a brush before firing, or, alternatively, sheet material can be cut into brazing washers or inserted as "shims" into the assembly before brazing. If the material is applied as a paint, the titanium is introduced in the form of TiH_2, which breaks down to metallic titanium when heated to the brazing temperature.

No auxiliary flux is required to promote the bond. All that is necessary for good bonding is that the surfaces be clean. The assembly is fired in the furnace at 900°-1,000° C. until bonding occurs. Due to the presence of titanium in the alloy and its known affinity for oxygen and nitrogen, it is necessary to fire in an atmosphere of dry hydrogen or an inert gas—argon. The result is a mechanically strong, completely hermetic seal.

This lead-copper braze method has both a quality as well as a cost advantage over silver paste and other low cost commercial ceramic-metal sealing products because it is nonstrippable and has a higher breakdown strength—300° C., compared to 190° C. This method of sealing is also competitive with plastic compression seals. Although, at present, slightly more expensive in some applications, the breakdown temperature is distinctly superior than the 200° C. obtainable with the best of the silicone seals and unlike plastic seals which contain leaks and will loosen under stress, a vacuum tight seal is obtained.

The lead-brazing technique lends itself to a one step operation in the great majority of cases where other sealing methods frequently involve many steps. The most significant uses that are expected are in the fields of hermetic terminals and electric lead-throughs. Products such as transformer top assemblies lend themselves very well to this process and the hermetic assembling of multi-conductor headers in one operation is an equally plausible use. In this case, the brazed assembly can be hot tin dipped to finish, avoiding multiple handling.

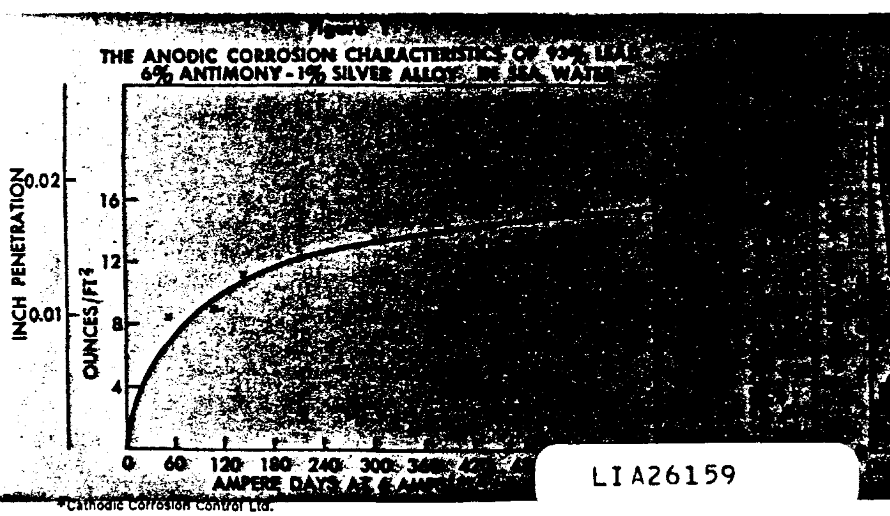
Nonsacrificial Lead Anodes For Corrosion Control In Waters

Lead alloy anodes for impressed current cathodization have been approved by Lloyd's of London for the protection of ship hulls against corrosion. Also the result of actual sea trials on a Royal Canadian Navy destroyer, reported by the Naval Research Establishment, Nova Scotia, for both economic and technological reasons, have shown lead alloy anodes to be superior to either graphite, steel, platinum or magnesium.

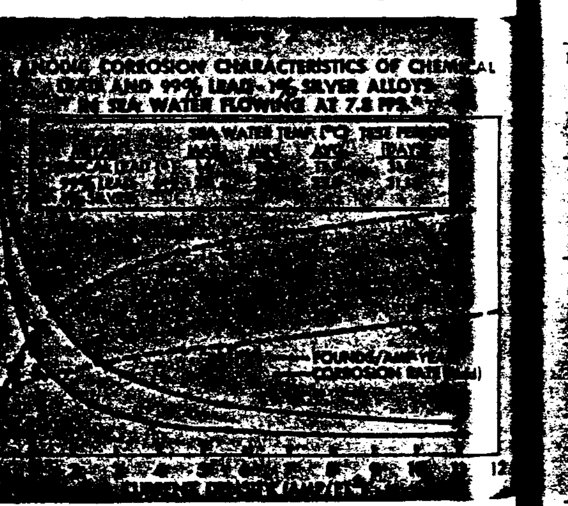
Depending on alloy and water composition, a wide range of current densities is practical, wherein lead develops a hard, conductive, passivating lead peroxide film. Proper alloying contributes greatly to decreased anode corrosion as Figures 1 and 2 demonstrate, the latter comparing rates with and without passivation interfering.

While economics will generally dictate the type of anode system to be used, namely galvanic or impressed current, the latter has particular advantages in extreme conditions of use or where space or other consideration make mounting or replacement difficult. The impressed current system approved by Lloyd's employs extruded lead alloyed with 6 per cent antimony and 1 per cent silver, Figure 1, known as the CX_3 line anode made by Cathodic Corrosion Control, Ltd. Figure 3 shows diagrammatically the system's arrangement which offers the following working advantages:

1. Long thin anodes lose only a small amount of current per ft., producing a small voltage stress in their immediate vicinity and consequently



*Cathodic Corrosion Control Ltd.



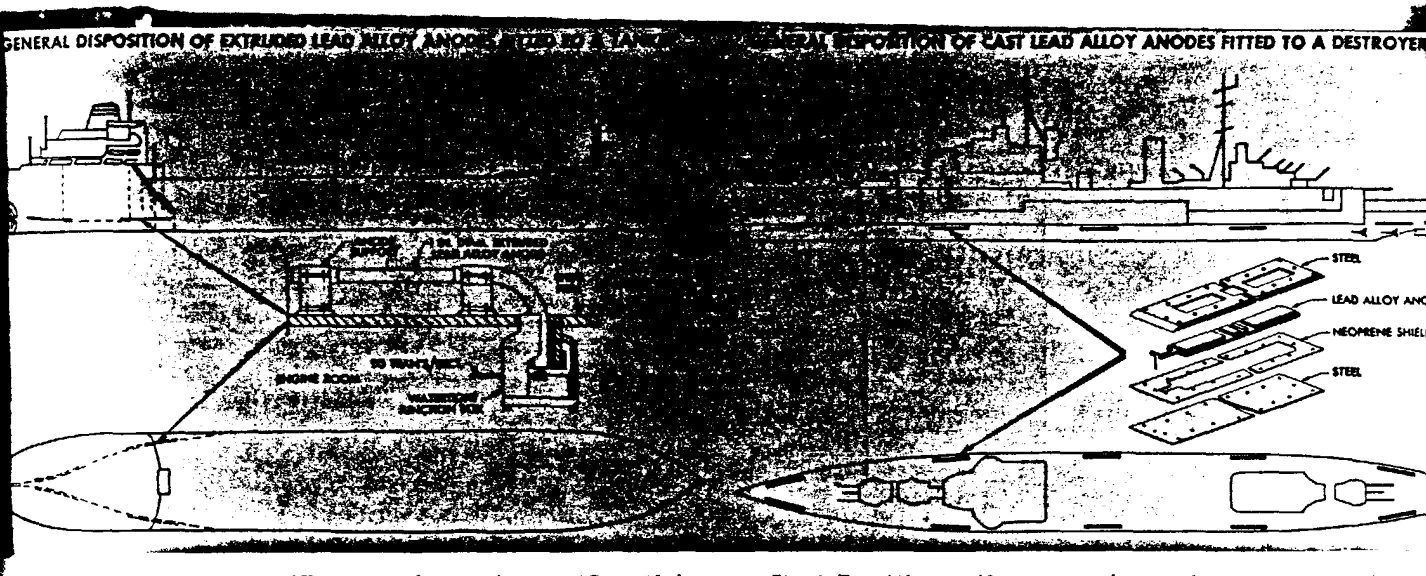


Fig. 3. The system, using CX₃ type anodes, requires an AC rectified source, a unit having a maximum output of 150 amp., and one appropriate single core insulated cable of copper which would be connected to each anode on either side of the ship's hull. The anodes might consist of some 30 ft. of 1-in. diameter installed towards the stern. Owing to the deterioration of paint and to full speed operation in tropical waters, a zinc reference potential plug is welded into the hull near the stern to accommodate appropriate variations in the applied current.

Fig. 4. Two 440 v. rectifiers were used to supply power to the anodes, 5 anodes each, having a D.C. rating of 0-12 v. and 0-100 amp. The anode current-voltage relationship varied for each type of anode, Fig. 5. Each anode had its individual supply cable to the rectifier in order that any anode could be disconnected at any time for scheduling or other purposes. To compensate for variations in potential or applied current made necessary in use, an over-the-side reference potential electrode was used and found to be satisfactory.

if the paint film is suitably reinforced, no other shield is necessary.

2. The anode and mountings can be easily applied to any hull shape.

3. The lead alloy will give an almost indefinite life.

4. Virtually negligible resistance to ship's movements through water.

Lead alloy anodes were shown to be suitable by the Canadian Naval Research Establishment which installed ten anodes, Figure 4, on a high speed R.C.N. destroyer in July, 1956. The alloy composition was 98 per cent lead and 2 per cent silver. Six-foot (Mark II) size anodes were mounted in pairs on the bilge keels and 3-ft. (Mark I) anodes at the stern above the propellers. The ship was docked on two occasions since the installation, and the hull was found to be rust-free and in excellent general condition. After two years of service, the anodes showed very little wastage of active material and an intact peroxide film on all working surfaces.

The film was preserved by operating the anodes at a minimum current density of 3 amp./sq. ft. When current demand was low, some anodes were switched off and the remainder operated at the above current density or higher rather than operating the entire system at less than this value, which would result in stripping or softening of the peroxide film. There was no apparent deterioration of the film on unconnected anodes.

The mechanical properties and expected lifetime of the lead alloy system is compared with those of a galvanic system and other impressed current systems in Table I. An economic comparison of the more common anode systems is given in Table II.

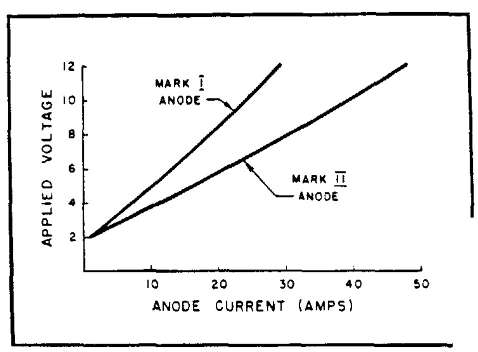


Fig. 5. Anode current-voltage relationship for 3-ft. Mark I and 6-ft. Mark II anodes.

TABLE I—Lead Alloy Anodes vs. Other Anode Systems (a)

Anode System	Expected Life Time Years	Streamlining	Ruggedness	Maximum Current Density	Ease of Fitting
Lead—2% Silver	10+	Good; (bracket 1" thick). Test indicates overall thickness may be halved.	More than graphite or platinum—less than steel and magnesium. Conforms to unevenness on ship. Excellent shock resistance.	Depends on power considerations rather than anode. Better than graphite; slightly less than platinum.	Requires current shield and special bracket as do graphite and platinum. Easier to fit and cheaper than graphite bracket. More expensive than platinum bracket. Labor for fitting less than steel, more than magnesium.
Steel	3 (renewable every three years)	Fair, not as good as lead-silver, thicker bracket.	Anode rugged but wooden bracket susceptible to mechanical damage and subsequent loss of sections.	Depends on power considerations and expected lifetime of anodes.	Does not require current shield. Wooden bracket must be fabricated to conform to contour of bilge keel. Steel anode sections difficult to handle and to adapt to contour of bilge keel.
Platinum 90-10 (Pt-Ir) alloy 10 mils thick	10+ (indefinite if not damaged and remaining intact)	Good, same as present lead-silver. Bracket of inside 1" thick.	Thin foil platinum anode susceptible to tearing. Platinum clad on less noble substrate more rugged but still susceptible to pinholes and corrosion attack on substrate.	Limited only by power considerations.	Requires current shield and special bracket. Bracket less expensive than for other impressed current systems. Fitting labor same as for lead-alloy.
Graphite	10 years	Poor. Requires 3" thick, short versatile bracket.	Poor. Graphite fragile, susceptible to cracking and shocks.	Limited to 10 amps per sq. ft. to maintain 10 yrs. life. Less than lead or platinum.	Requires current shield and costly bracket. Difficult to adapt to hull contours. Must be used in short, thick sections only.
Magnesium	2 years	Poor due to irregular corrosion pattern and discontinuous structure of anode array.	Very good. Poor corrosion pattern resulting in necking at securing straps. May cause sectioning and loss of portions of an anode necessitating earlier replacement.	1 amp/ft² may be limited further by circuit resistance.	Easily fitted, no current shield required. Can be adapted to mild changes in hull contour.

(a) Naval Research Establishment, Nova Scotia

TABLE II

Relative Costs of Anode Installations for Destroyers (e)

Item	Lead Alloy	Magnesium	Steel
Cost of fitting (including overhead)			
LABOR	$2,800	$1,556	$8,248
MATERIAL	1,000	980	3,192 (a)
TOTAL	$3,800	$2,536	$11,440
Capital cost			
Anodes (complete)	$2,443 (b)	$1,500 (c)	Included above
Rectifiers and Cable	1,754	Rectifiers not required	Included above
Neoprene Shield	900	Not required	Not required
GRAND TOTAL	$8,897	$4,036	$11,440
Cost per year (d)	$890	$2,018	$3,813

Notes: (a) Material cost includes anodes and rectifiers
(b) 8 Mark II anodes, 2 Mark I anodes
(c) 30 anodes
(d) Estimated from expected lifetime, Table I
(e) Naval Research Establishment, Nova Scotia—adapted

From both tables, it can be seen that the lead alloy system is in a very favorable competitive position.

Other possible uses are in ship ballast compartments, dockyard structures, sheet steel piling, offshore drilling rigs and radar towers, and associated equipment, internal protection of salt water pipe lines and storage tanks, sea water coolers and heat exchangers, jetties and piers, tidal hydroelectric turbines, and laid-up shipping.

In fresh water industrial applications, the working voltage is high but an almost parallel performance is indicated. Performance of alloy anodes in saline mud and sands is almost the same as that obtained in the saturating electrolyte. Generally, in saline mud and sand and in any water whose resistivity falls below 1,000 ohm cm., the peroxide layer occurring is hard, tough, adherent, and functionally protective.

Editor's note—A more detailed paper "Lead-2% Silver Alloy as an Inert Impressed Current Anode," by K. N. Barnard, D. G. Gage and L. G. Christie, covering the experiences of the Naval Research Establishment herein referred to, was presented at the Northeast Regional Corrosion Conference of NACE at Boston on November 6, 1958, and will soon be published in "Corrosion."

Lead-Acid Battery Powered Industrial Trucks Are Economical

Lead-acid battery powered industrial trucks, carrying loads of 1,000 lb. to over 100,000 lb. and to 30,000 lb. up grades as much as 10 per cent, are transporting all types of industrial products at comparable speeds and doing it more economically than other types of powered trucks.

From handling baggage and mail for a major eastern railroad to the handling of a variety of products at a San Francisco warehouse, lead-acid battery powered industrial trucks are proving their worth in better operating conditions and greater dependability at lower cost.

The experience of the Boston and Maine Railroad is a prime example of how savings can be effected by the use of battery powered tractors. In one year, in the handling of mail and baggage, they saved actual out-of-pocket expenses of over $32,000 by replacing their gas powered tractors with electrics. This saving was being realized while the actual efficiency of their material handling procedures was being increased.

This multi-thousand dollar saving was realized by reductions in fleet operating and maintenance costs to the extent of 50 per cent for fuel, 75 per

The battery powered lift trucks of the San Francisco Warehouse Co. are in constant use with little down-time for repairs.

TABLE I

COMPARISON OF GAS AND BATTERY POWERED TRUCKS
MAINTENANCE AND REPAIR COSTS

Year	Total Trucks: Gas	Total Trucks: Electric	Maintenance and Repair Costs: Total, Gas	Total, Electric	Average, Gas	Average, Electric
1948	6	6 (new)	$1,921.03	$ 21.12	$320.00	——
1949	7	6	1,741.71	337.91	250.00	$56.50
1950	7	8	1,969.10	285.07	282.00	35.75
1951	7	8	3,400.18	744.21	587.50	93.00
1952	8	10	1,371.23	577.53	172.00	57.75
					$1,611.50	$243.00

Average cost per year per truck:
Gas-powered———$322.30 Electric-powered———$60.75

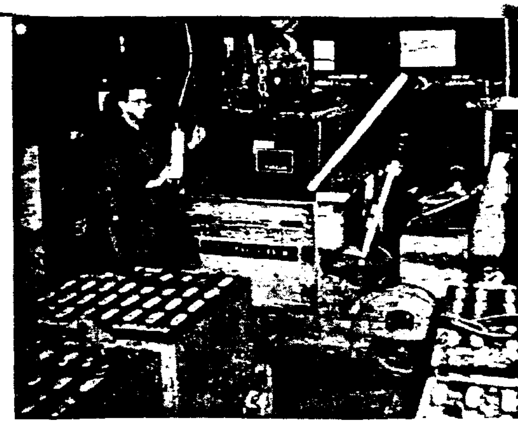
cent for maintenance parts and 60 per cent for maintenance labor. Whereas 6 to 8 men were formerly required for proper servicing and maintenance of the gas fleet, the equivalent of 3 men now handle the battery powered fleet.

The switch-over by the Boston and Main Railroad from gas to electric powered tractors was the result of exhaustive tests which included the pulling of 5 ton loads up and down 7 per cent ramps. That the tests were completely conclusive in favor of the lead-acid battery powered tractors is proved by the fact that the entire fleet of 34 gas tractors was replaced by 24 electrics.

Another example of the lower repair and maintenance costs of lead-acid battery powered trucks is the experience of the San Francisco Warehouse Co. In a careful analysis of cost figures kept over a five-year period at two of its warehouses, the repair and maintenance costs for a lead-acid battery powered lift truck were only one-fifth as much as a comparable gas powered lift truck. The San Francisco Warehouse Co. is using both types of lift trucks and both were included in the cost analysis. A summary of the cost analysis is shown in Table I. Though these cost analysis figures are for the years 1948-52, the company believes that the figures are equally valid today.

Another interesting conclusion reached in this analysis was the fact that depreciation, tire and fuel-power cost are comparable for the two types of trucks. The wide divergence in cost is realized by the economy of repair and maintenance effected by using lead-acid battery powered trucks.

In both instances, the lead-acid battery powered industrial trucks were "Automatics," manufactured by the Automatic Transportation Co., a division of the Yale and Towne Manufacturing Co.



The recharged lead-acid battery is easily lowered into one of the Boston and Maine Railroad's baggage tractors.

The World's Largest Passenger Railway Relies On Red Lead

The World's largest passenger-carrying railway system does not cross any State lines and surprisingly enough does not even go beyond its own city limit. Despite this area limitation, however, it carries more than 1.4 billion passengers each year, three times as many as the combined load of all the rest of the railroads in the United States. The railway is of course the New York City transit system.

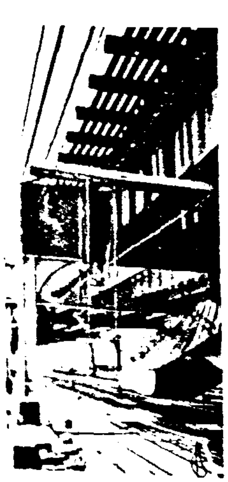
The New York Transit Authority has been responsible since 1953 for the operation and maintenance of the system that includes 725 miles of running track. The major portion of this trackage is underground with approximately 208 miles on overhead structures.

Another staggering statistic is the cost. $2 billion to construct, purchase and equip the entire system. It is conservatively estimated that the replacement value of the entire system at today's prices would be a least twice that much. Maintenance of the existing structure is therefore of prime importance and red lead paints have played a major role in this maintenance program.

The current practice of the New York Transit Authority calls for painting cycles of 6 years for outdoor structures and 12 years for underground structures. In recent years, this maintenance program has required the use of about 14,500 gallons of red lead primer per year. Total surface requiring the primer is about 3,000,000 square feet.

The red lead primer currently being used, Transit Authority Specification Formula M-20, see Table I, provides faster drying characteristics than the previously used Formula M-1, see Table II. The faster drying primer will facilitate the application of the white lead-zinc oxide top coat, see Table III, which should reflect lower application costs.

The IRT Corona line last painted in 1932 with red lead was still in excellent condition for repainting in 1958.



Work goes on while trains meet tight schedules without interruption or delay. To satisfy this requirement, the Transit Authority must use paints that are easy to apply and provide years of protection. Red lead meets these requirements.

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TABLE 1

New York Transit Authority Specification Formula M-20—Red Lead-Red Oxide Primer

Pigment	Percentage Minimum	Maximum
Red Lead (ASTM D83-41, 95% grade)	74.0	
Red Oxide (ASTM D84-51, Class II)	23.0	
Aluminum Stearate ..		1.0
Vehicle		
*Synthetic resin solids	22.0	
Linseed Oil (TT-O-369)	51.0	
Volatile (TT-T-291a, Grade I)		26.7
Driers (TT-D-643b, Types I, II, III) ..		0.3

* Glyceryl phthalate, 41 plus or minus 2 per per cent, linseed type (TT-R-266a, Type III).

Weight per gallon (lb.).. 22
Drying Time (Hour) ... 24

[illegible]

New York Transit Authority [illegible] Formula M-[illegible]

Pigment	Percentage
Dry Red Lead [illegible]	[illegible]
Vehicle	
Raw Linseed Oil	[illegible]
Boiled Linseed Oil	[illegible]
Drier M-2*	[illegible]
Turpentine	[illegible]

Weight per gallon (lb.) 25[illegible]
Drying Time (Hour)... 24

* The drier (Formula M-2) is a mixture in the proportions of 20 pounds of dry red lead, 1[illegible] pounds of 85% grade manganese dioxide, 50 gallons of raw linseed oil, and 50 gallons of turpentine. Red lead and linseed oil must be varnish makers grade. Red lead and manganese dioxide are dissolved in linseed oil by boiling. The mixture is then thinned with turpentine.

The drier must be clear and free of sediment or suspended matter and mix in the-

[illegible] 18 parts of [illegible]

Pigment	Percentage
Carbonate White [illegible]	[illegible]
Barium Sulphate White [illegible]	[illegible]
Zinc Oxide	[illegible]
Tinting Colors	[illegible]
Silica	[illegible]
Magnesium Silicate	[illegible]
Vehicle	
Raw Linseed Oil	[illegible]
Drier M-2	[illegible]

Weight per gallon (lb.) 15[illegible]
Drying Time (Hour)... 18

Tinting pigments (extra light yellow oxide of iron, raw umber, french ochre, and lampblack) must be shaded to standard color with chrome oxide (green) or phthalocyanine green.

The effectiveness of red lead primers on outdoor structures exposed to weather, salt spray, railway and industrial smoke, road dust and dirt, tar, grease and oil, was forcibly brought home to the Transit Authority by two examples revealed during their present maintenance program. The IRT Corona line that runs elevated to the 1940 World's Fair site, was last painted in 1932. At that time it was given a single prime coat of Formula M-1, red lead paint. When it was repainted in 1958, 26 years later, the steel surface was still in excellent condition. For the most part, it was just dirty with only occasional, small patches of rust, with one exception. Where the line passed over the Long Island Railroad tracks, where steam locomotives predominated until a few years ago, corrosion was more severe, though by no means critical. Even under this most adverse condition, the red lead primer continued to provide some protection to the steel. A more horrible example is the old BMT Myrtle Avenue elevated line in Brooklyn. No record is available as to when it was last painted and the Transit Authority engineers believe it must be all of 50 years ago, long enough ago to include years of service with steam locomotives. When it was repainted in 1958, the structure, protected by red lead primer, was still sound. It is of course not recommended that 50 years elapse between painting of steel structures but if such does happen, then it is important that the prime coat be red lead.

THE *Lead* LIBRARY
of Technical Information

The following articles and reprints contain information, drawings and specifications on the use of lead products helpful to architects, engineers and others interested. They are available free of charge except where otherwise indicated, upon request to the LEAD INDUSTRIES ASSOCIATION, 60 East 42nd STREET, NEW YORK 17, N. Y.

MATERIALS OF CONSTRUCTION ANNUAL REVIEWS—LEAD AND LEAD ALLOYS
Lead and lead alloys in design and construction including research progress, engineering applications, and technological advancements. With bibliography, 1958, 1957 and 1956 reviews (editions are not cumulative) are available. Reprinted from "Industrial and Engineering Chemistry," September, 1958, September, 1957 and September, 1956.

BEST DESIGNS FOR LEAD INSTALLATIONS
A special report on the applications of lead and lead alloys in the chemical and metallurgical industries. Recommended practice for joining lead sheets, and the construction of wood stave tanks, launders, towers and flues where lead is involved are included. Reprinted from "Chemical Engineering," March, April and May, 1956.

USE LEAD TO CONTROL REFINERY CORROSION
Latest practices in lead construction for the petroleum refining industry are described. How to avoid the difficulties sometimes experienced with lead-lined equipment is also outlined in detail. Reprinted from "Petroleum Refiner," April, 1958.

RADIATION PROTECTION
The place of lead in shielding against radiation in X-ray and atomic energy applications. Principles of lead shielding construction. Reprinted from "Lead In Modern Industry."

PORTABLE RADIATION-SHIELDING MATERIALS
A special report on commercially available shielding forms that can be used to build readily assembled, hand stacked shielding walls. Prepared by the editors of "Nucleonics," May, 1955.

LEAD WORK FOR MODERN PLUMBING
$1.50 Postpaid, $1.00 per copy in quantities of 10 or more
Profusely illustrated with over 140 photographs and drawings, the textbook presents clearly to the plumbing student the necessary tools, procedures and the methods required for lead work.

LEAD IN MODERN INDUSTRY
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A fully illustrated, 230 page, cloth bound book describing all phases of the production and use of lead, lead alloys and lead compounds.

LEAD BUILDING CONSTRUCTION BULLETINS
A series of specifications for the use of lead in building construction. (Available separately.)
- BULLETIN NO. 1
  Specification for Lead Waste Connections for Plumbing Fixtures with Integral Traps (Water Closets—Pedestal Urinals—Service Sinks).
- BULLETIN NO. 2
  Specification for Lead Shower and Safe Pans
- BULLETIN NO. 3
  Specification for Lead Chemical Laboratory Drainage Systems.

FEDERAL SPECIFICATION WW-P-325
For Pipe, Bends and Traps: Lead
Dimensions and weights of lead products used in the plumbing and water works fields are given. *Published by the Government Printing Office.*

LEAD WELDING
An informative as well as practical guide to lead welding. Reprinted from the "Welding Handbook, Third Edition" published by the American Welding Society.

LEAD FLASHINGS IN MODERN CONSTRUCTION
Lead flashings as used in an ultramodern house in Randolph, Vt. Reprinted from "National Roofer," October, 1954.

SHEET LEAD FOR ROOFING AND FLASHING
Preferred installation methods for the new 2½ and 3-lb. hard lead are given along with detailed drawings. Reprinted from "Sweet's Catalog," 1958.

LEAD FOR MODERN PLUMBING
Preferred installation methods for lead pipe and fittings in the plumbing systems of today's industrial and residential structures. Detailed drawings are included. Reprinted from "Sweet's Catalog," 1958.

THE STORY OF LEAD—MATERIALS THE RAILROADS BUY (Parts 1 and 2)
Lead from mine to finished product with special reference to its uses by the railroads. Reprinted from "Railway Purchases and Stores," December, 1954 and February, 1955.

RED LEAD TECHNICAL LETTERS
A series of technical letters containing red lead paint formulations. (Available separately.)
- **Technical Letter No. 11—Recommended Surface Preparation of Steel for Red Lead Paints.**
- **Technical Letter No. 12—Painting Highway Structural Steel.**
- **Technical Letter No. 13—L.I.A. Formula 9-2. A Single Red Lead Primer for Rusted, Weathered or New Galvanized Steel.**

FEDERAL SPECIFICATION FOR PAINT: RED-LEAD-BASE, READY-MIXED TT-P-86a
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