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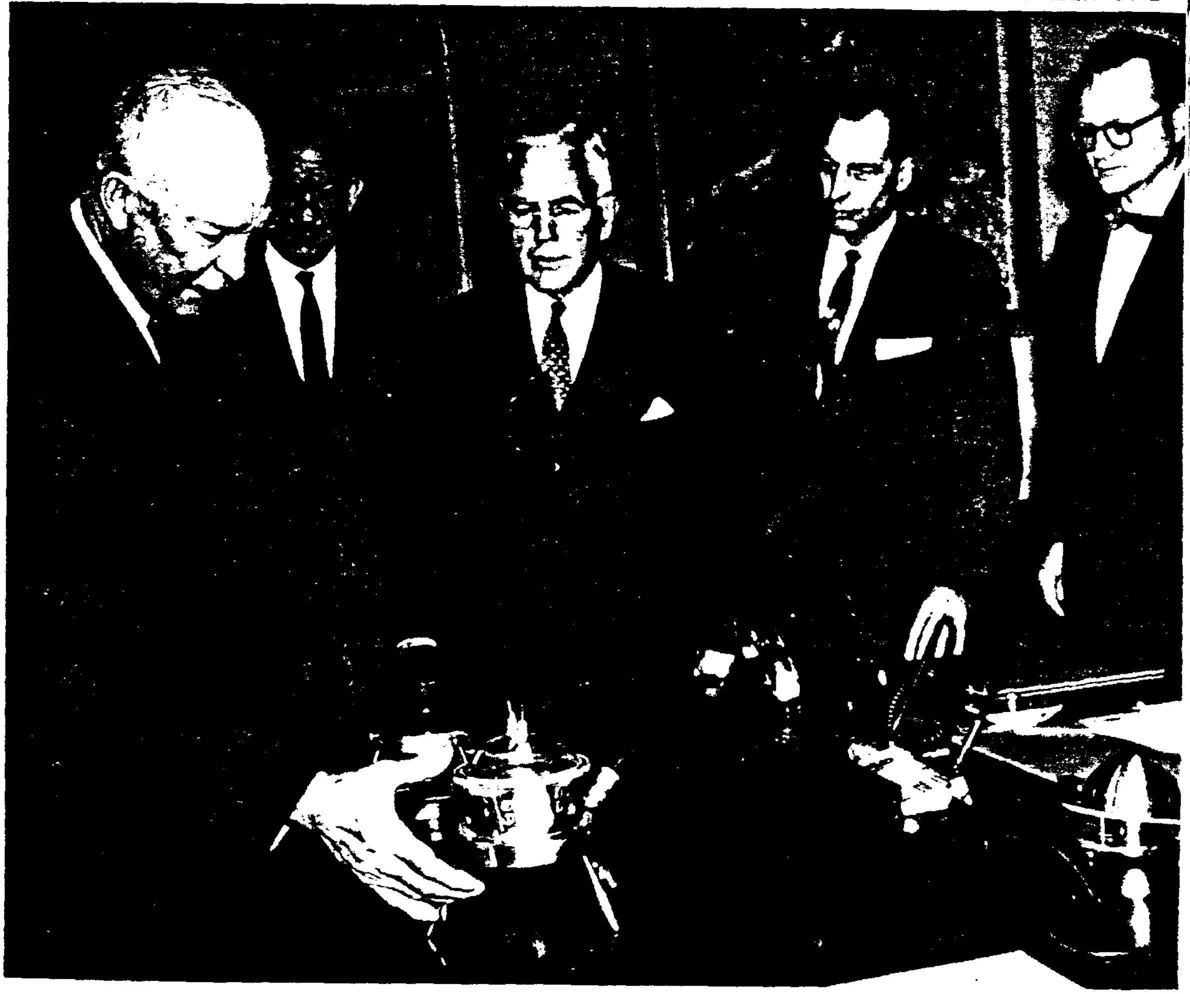
VOLUME TWENTY-THREE 1959 NUMBER ONE



Wide Worl

President Eisenhower (January 16, 1959) inspecting a small atomic device for production of electricity utilizing lead tellurid thermoelectric elements — a development hailed as a major achievement by Atomic Energy Commission officials. With the Presi dent are Major General Donald J. Keirn (mustache, next to President), the AEC's Chief of Aircraft Reactors, and AEC Chairmai John A. McCone (next to Keirn). The 5-lb. device generates 5 watts of electricity. See story Page 2.

INDUSTRIES ASSOCIATION
STREET, NEW YORK 17, N. Y.

Atomic Generator Developed

Classified as a significant breakthrough by the AEC, an atomic generator based on the Seebeck thermoelectric principle has been developed. Combining a heat source and two dissimilar conductors to achieve hot and cold junctions, it incorporates for heat the radioactive isotope, polonium 210, an almost pure alpha emitter with attributes of compactness and safety, and for dissimilar conductors, p and n-type lead telluride as satisfying four material requirements — high thermoelectric power ("Lead," Vol. 22, No. 1), high electrical conductivity, low thermal conductivity, and resistance to deterioration.

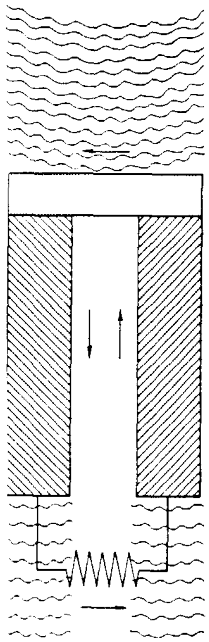
"Snap III" — the code name for the generator derived from "System for Nuclear Auxiliary Power" — was developed as an auxiliary power source for space vehicles. The generator cost the AEC, exclusive of isotope, $15,000 delivered, but quantity production costs are figured at close to $200 per unit. It has a rated capacity of 5 watts for 140 days at 8-10 per cent efficiency and then, 3 watts at 5-6 per cent efficiency.

Two-thirds of a gram of polonium 210, half life 135 days, representing 3,000 curies, generates a 720 deg. F. hot junction at the center of the radiating spoke-like arrangement which involves 20 pairs of double layered (cylindrically concentric) elements. (Use of cerium 144, half life 290 days, is anticipated since its total cost approximates $600 which contrasts with $10,000 per curie or $30,000,000 for the polonium prototype.) The double layers are constructed of p and n-type lead telluride, made so by virtue of bismuth and manganese donor-acceptor doping. This characterizes the elements as either having a surplus or deficit of electrons. As electrons flow from surplus conductors to deficit conductors under the influence of a heat gradient, electric current is generated and tapped at the rim by a central outlet.

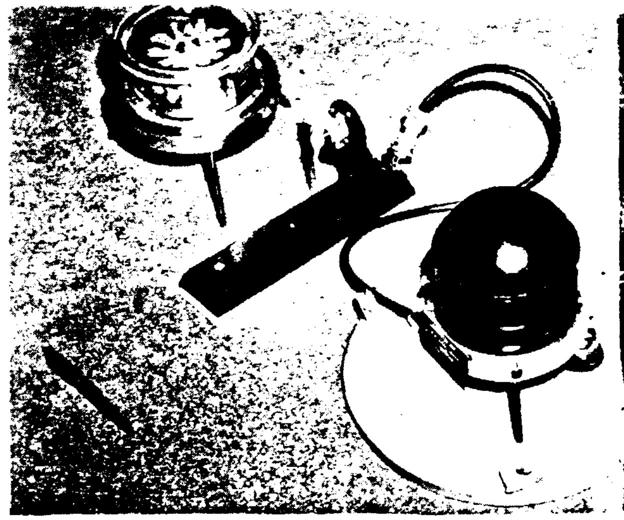
The efficiency of the best thermoelectric elements stands presently at about 10 per cent which compares with the best steam and combustion motor generator efficiencies of 30 and 40 per cent respectively. For small power requirements, i.e., a few electrical kilowatts, thermoelectric generators are competitive with motor generators which for the purpose average 10 per cent efficiency. For very low power requirements encountered in radio, telephone, and telegraph communications, thermoelectricity offers the best engineering solution. However, high power applications might be considered because of the series additive electrical principle and capital cost considerations. One thermoelectrical element is analogous in function to one inductive turn in an electromagnetic generator. It might be attractive from the cost-of-installation and maintenance standpoints, to consider substituting a generator combining a heater and cooler with no moving parts, for a steam generator with furnace (atomic perhaps), condenser, boiler and dynamo.

Development of the atomic generator augurs the revival of thermoelectricity for simplicity and convenience in meeting economical electric power requirements of the future, involving to a great extent use of semiconductors — lead telluride, lead selenide, or their complexes.

SEEBECK THERMOELECTRIC ELEMENT



N-type lead telluride at left, connected by conductor to p-type at right, heat flow from top to bottom, current flow counter-clockwise, plus to minus, yielding tenths of a volt across load at bottom.



Wide World

In a demonstration, the above atomic unit produced enough electricity to turn the propeller and light the bulb on the stand at center. A similar unit, uncovered, is shown at upper left. The device, developed by The Martin Co., in cooperation with Minnesota Mining & Mfg. Co., generates heat, using a radioisotope polonium, has no moving parts and a lifetime power equivalent to a ¾ ton dry cell.

Lead in Plumbing Remodeling Projects

In plumbing remodeling projects, one of the major problems is locating a greater number of fixtures than previously needed or required in space not entirely suitable to such facilities. Occasionally these new toilet facilities must of necessity be placed over areas wherein even the slightest seepage can cause serious maintenance problems as well as create unsanitary conditions. For this reason it is important in such instances to provide for an impervious membrane, such as sheet lead, under bathroom floors.

The sheet lead membrane will contain any seepage, directing it to the waste outlet, and serve to isolate the bathroom from the rest of the structure.

How this type of waterproofing can be accomplished is graphically illustrated in the accompanying photograph of the remodeling of one of the existing bathrooms in a girls' dormitory in the Menaul School in

The sheet lead pan in a shower and lavatory room of a girl's school, and at right, plumbing inspector Hall and plumbing contractors Loy and Campbell inspect the prefabricated lead plumbing connections installed in the same school.

Albuquerque. New Mexico. What had previously been the location of two water closets was changed and extended to two showers and three lavatories. Waterproofing the entire floor was accomplished with 4-lb. sheet lead.

The area. being too large for a single sheet of lead. was lined with several sections joined together with lead burned joints. The shower area is isolated from the rest of the room by a lead covered step. Each of the areas drain to a sump in which weep holes have been provided. Prior to the placing of the tile floor. the sheet lead will be coated with asphaltum to protect the lead until the free lime in the mortar has carbonated.

In addition to the room just described, the remodeling of this building erected in 1903 involved a number of other toilet rooms wherein lead pipe and fittings were used to connect all fixtures to the plumbing system.

Lead because of its flexibility and its minimum space requirements is generally favored for remodeling work by plumbing contractors. As Otis Campbell, of Campbell-Jones Corp.. Albuquerque, New Mexico, plumbing contractor for the remodeling of the girls' dormitory in the Menaul School in Albuquerque. stated "Lead has helped me through the years to make seemingly impossible installations where other materials could not be used for lack of space and adaptability."

MTR Fuel Elements Part II — In The Laboratory

This part concerns itself with the nature of lead's contribution to the effective conduct of radiation experiments within the laboratory. making use of spent elements and radioactive isotopes.

Spent fuel elements were chosen as a radiation source for the following reasons:

1. Their high gamma radiation dose and their availability.
2. The MTR (or ETR) elements have physical dimensions which make them convenient for use with standard laboratory process equipment.
3. Fuel element radiation represents fairly well the spectral energy that will be available from reactors

FLOOR PLAN OF SINCLAIR'S RADIATION LABORATORY

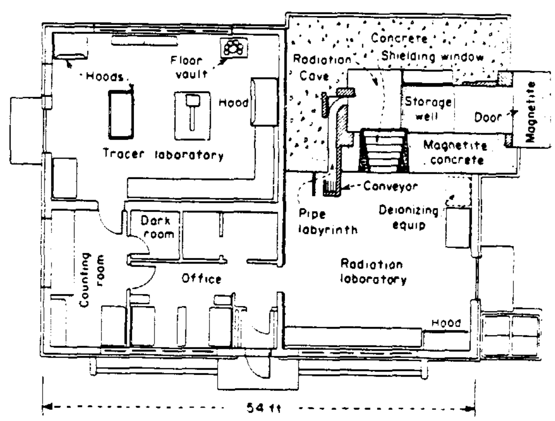


Fig. 1. The floor plan of Sinclair Oil Company's radiation laboratory reveals a compact, workable arrangement.

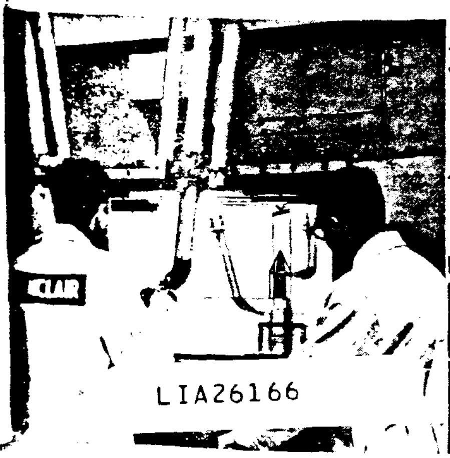


Fig. 2. Sixty-inch leaded glass window for viewing and manipulation of experimental setups.

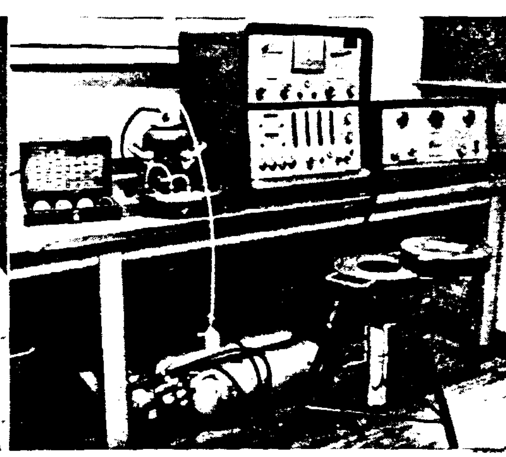


Fig. 3. Absorber discs and lead shielded Geiger counter on table with lead shielded container (on floor) for sodium iodide scintillation counting.

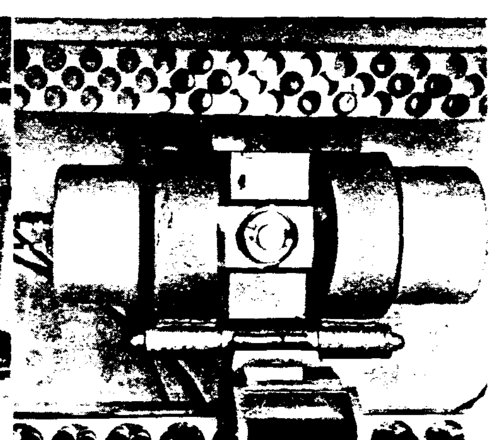


Fig. 4. Lead shielded Tri-Carb liquid scintillation spectrometer with cover open.

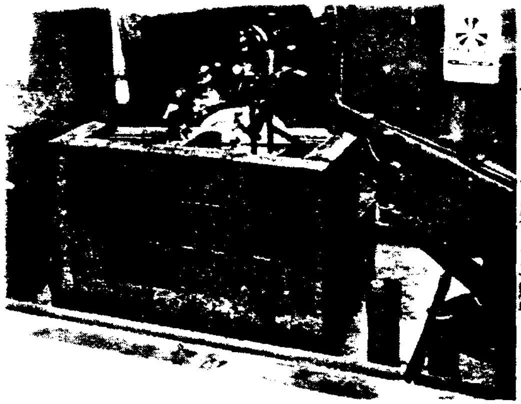


Fig. 5. Lead brick assembly in a special hood for protection in remote handling of radioactive materials.

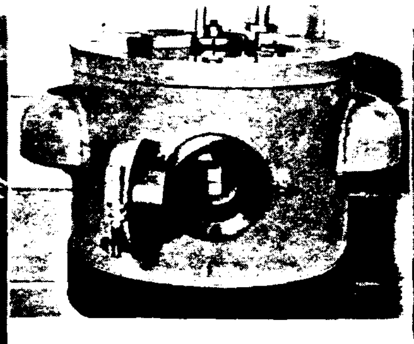


Fig. 6. Lead shielded storage container for radioactive cutting tool tips.

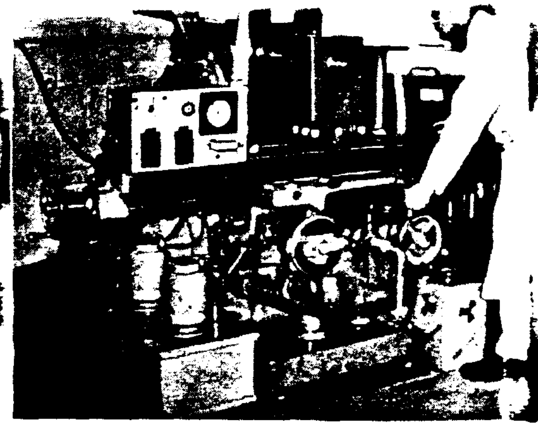


Fig. 7. Milling machine with lead shielded radioactive cutting tool arrangement at top center.

designed specifically for radiation processing — the ultimate outgrowth of research into the commercial aspects of radiation chemistry or chemical processing.

4. The emitted gamma radiation is suitable for use with heavy process vessels that are required for high-pressure experiments.

Inside the cave, the fuel element geometry is such as to allow special purpose process vessels to be surrounded by the four elements. The vessel and source holder are arranged so that the vessel can be connected to experimental apparatus in the laboratory by means of pipes, tubes, and wires passing through the pipe labyrinth. In arranging experiments and for subsequent raising of the element sources from the well for positioning, the optical and shielding qualities of 60 in. of leaded glass permit observation of necessary manipulation. Figure 1 gives the layout of Sinclair's facility — a compact, workable arrangement. The variety of supporting equipment dispersed throughout the laboratory may be gaged from the illustrations. In planning radiation experiments and in determining results of a given run, the ready nature of such equipment constitutes a necessity. In like manner, effective functioning of such equipment is dependent upon the various shapes, sizes and conformities of lead radiation shields.

In the counting room of the tracer laboratory, figure 3, a box shown to the left on the table contains calibrated absorbers used to help identify radiation by measuring their energies or penetrating power through discs of known thicknesses. Several of these absorber discs are made of lead and are used for measurements on the more penetrating radiations. To the right of the absorber discs is a windowless flow counter similar to a windowless Geiger counter in that the sample is located inside. It is used to identify weak beta ray emitters in the solid state and contains a lead shield to lower the cosmic ray background. The tanks on the floor supply special counting gas for use with the counter. The Ultrascaler shown is a device for indicating the number of rays being measured and, to the immediate right is a single channel spectrometer used to identify gamma ray emitting substances by measuring ray energies. In front of the Ultrascaler on the floor is a lead shield container with a large sodium iodide scintillation crystal used to detect gamma ray emitters in very small concentrations. The shield around the counter involves at least 2 in. of lead to cut down cosmic ray background. For work at low concentrations such shielding from cosmic ray interference is essential.

Figure 4 shows the lead shielded Tri-Carb liquid scintillation spectrometer with the lead cover in open position, which is used to detect minute concentrations of materials emitting weak beta rays such as carbon-14, sulphur-35, and tritium. The 2-in. lead shield is again used to reduce the background count due to cosmic rays.

A lead brick assembly, figure 5, acts to protect the tracer chemist performing manipulations in a special hood designed for handling radioactive materials. The hood has been designed to carry 1,300 lb. of lead bricks, each 2 in. thick, of the interlocking type which prevents leakage of radiation at the joints. A remote pipetting device can be seen which enables the chemist to work from behind the lead brick shield with the aid of a mirror.

Figure 7 shows a milling machine equipped with a shielded radioactive cutting tool used in the evaluation of experimental cutting fluids under development to prolong tool life. The shield on the milling machine protects operators from gamma radiation and is a composite of 4 in. of iron and 1 in. of lead at the front with sides of 1 in. each of iron and of lead. Chips collected during cutting operations are subsequently removed via a mesh basket incorporated in the shield box and counted using the sodium iodide scintillation detector as an accurate measure of cutting tool wear. Finally, figure 6, is a view of the storage container used for radioactive cutting tool tips which was designed and built at Sinclair Research Laboratories. The container has a 3-in. lead shield to protect personnel and can hold six radioactive cutting tool tips at one time in a turret-like arrangement permitting the selection of any tool at will. Provision has been made for rotating the tool tips while they are shielded in the container. When an operator inserts a tool tip holder at the end of a 5-ft. handle into the door, the cutting tool tip is automatically and remotely removed from storage — accurately locked in place on the holder. This remote automatic loading feature allows for safe routine operation.

While no attempt has been made in this article to treat the whys and wherefors for the selection of lead over other materials for shielding of such devices, the very presence of lead speaks for itself.

STRUCTURAL IRON AND STEEL PAINT SPECIFICATIONS (EXCERPTS)

Pigment		
Red lead 97% [illegible]	[illegible]	[illegible]
Aluminum [illegible]	[illegible]	[illegible]
Vehicle		
Raw linseed oil	[illegible]	[illegible]
Pale heat bodied linseed oil	15.[illegible]	[illegible]
Volatile mineral spirits and driers	[illegible]	[illegible]
	100.0	
Pigment	[illegible]% min.	
Vehicle	23.0% [illegible]	
Wt./gal.	24.[illegible] lb.	

SANDSTONE PAINT, INTERMEDIATE COAT

	Per Cent by Weight Min.	Max.
Pigment		
[illegible]	41.0	—
[illegible]	25.0	30.0
[illegible]	14.0	—
Magnesium silicate and [illegible] extending pigments	—	15.0
	100.0	
Vehicle		
Raw linseed oil	30.0	—
Alkyd resin solids	31.5	—
Volatile mineral spirits and driers	—	38.5
	100.0	
Pigment	63.0%	min.
Vehicle	37.0%	max.
Wt./gal.	15.4	lb.
PV	36	

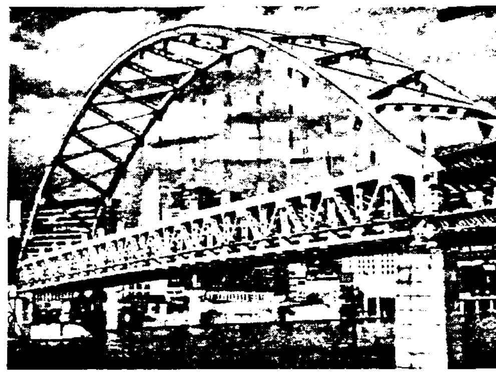
Lead Paints on New Fort Pitt Bridge

The first of its kind, the new Fort Pitt highway bridge across the Monongahela River at Pittsburgh, has through its utilitarian design achieved an aesthetic appeal that fits in well with the master plan to beautify Pittsburgh's famed Golden Triangle. As with all such "firsts," lead pigmented paints have been selected to protect and beautify the structure.

Designed by Richardson, Gordon and Associates, Pittsburgh, for the Pennsylvania Department of Highways, K. H. Jensen, Bridge Engineer, the Fort Pitt Bridge is the world's first double-decked bridge using box sections as arch ribs and with the tied arch using trusses instead of girders as ties. Four lanes of one-way traffic will be carried at each level.

High strength steel was specified for all portal members including end floor beams, all chords, and most diagonals and verticals and wherever the stress ratio of high-strength steels over structural carbon steels was higher than the price ratio. In fabricating and erecting the Fort Pitt Bridge, the American Bridge Company used USS-Man-Ten Steel components in more than two-thirds of the 750 ft. spans. The total weight of fabricated steel is 8,500 tons.

As is general practice on all of the steel highway structures in Pennsylvania, a shop coat of rust-inhibiting red lead paint was applied to all of the steel used on the Fort Pitt Bridge. In addition, a lead pigmented paint that will add further protection for the steel against the ravages of wind and weather was used for the intermediate coat. The lead pigmented paint formulations above, are excerpts from the Pennsylvania Department of Highway Specifications for Paints.

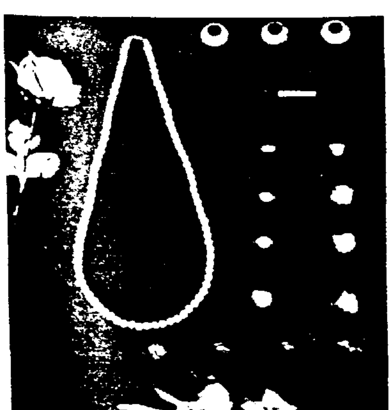


Post-Gazette by Coughanour

The steel work of Pittsburgh's new Fort Pitt Bridge is protected against corrosion by lead pigmented paints.

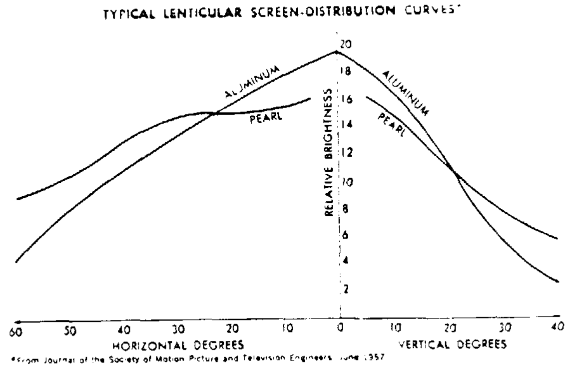
Pearlescent Lead Pigments

The appearance of pearls or mother-of-pearl has been achieved with synthetic nacreous (pearly) pigments, widely used by makers of costume jewelry, motion picture screens, synthetic leather, and other products, as substitutes for more costly guanine (natural pearl essence), an organic product from fish scales. Very thin, parallel, plate-like crystals of high index of refraction of such compounds as basic lead carbonate and lead monohydrogen phosphate impart the lustrous aura due to an optical effect dependent upon multiple reflections. The development of plate-like crystals in both pigments is related to crystal structure: the orientation of the plates is analogous to flaking in aluminum or graphite. Necessary orientation in a vehicle is derived by virtue of mold flow or movement of the platelets during the molding of pearl plastics or in application of pearl lacquers. In nitrocellulose, polystyrene, methyl methacrylate, and casein plastics and lacquers they are strikingly decorative and contribute strong sales appeal. Take the automobile industry, for example. Automotive manufacturers pearlize a number of the custom models and "Cars of the Future" which are included in "Motoramas," "Cavalcades" and



Colorful products enhanced by pearl pigments include buttons, costume jewelry, artificial flowers, fishing lures, packaging, and other items. Courtesy The Mearl Corp., New York, N. Y. and Francis Earle Laboratories, Inc., Peekskill, N. Y.

The pearlized upper portion of this screen surface has the highest overall reflectance and the most uniform degree of reflection over wide viewing angles when compared with its aluminized counterpart below. see plot. Courtesy Hurley Screen Co., Corona, N. Y.



*From Journal of the Society of Motion Picture and Television Engineers, June 1957

Pearl coatings provide the maximum gain to the maximum number of seats in the average theater and in such show places as New York's Radio City Music Hall. The distribution pattern is elliptical and the relative brightness readings are indicated along the major or horizontal axis, and the vertical or minor axis of the ellipse.

other similar occasions. Pearl finishes tend to accentuate sweeping curves. There is also the trend toward pearlizing some of the leather and vinyl fabrics, particularly the pastels.

In addition to decorative virtues, nacreous lead pigments afford outstanding optical qualities in the scientific vein as well. The average theater patron or home projectionist may not be aware that lenticular screens coated with pearl pigments minimize the disadvantages of conventional aluminized screens, which produce fade-away at angles to the normal and variations in brightness, as indicated by the typical lenticular screen distribution curves, and with beaded screens, "peaky" reflectance, i.e., most of the light is reflected back toward the projector. (Lenticular screens have tiny depressions or lenticules embossed into the screen material which enhance the light distribution characteristics of the coating.)

Pearlized screens give the highest integrated reflectance and the most uniform degree of reflection over wide viewing angles. Even plain non-lenticular pearl screens provide greater brilliance than the best diffuse white matte screens to make the picture more vivid and lifelike. Throughout the country pearl lenticular screens are receiving wide acceptance as the very best, by amateur and professional alike.

Editor's Note: Those interested in nacreous lead pigments from the standpoint of optics may obtain more detailed information by referring to the following:

Hurd, Y. G., *Journal of the Society of Motion Picture and Television Engineers*, **66**, 340-346 (June 1957).

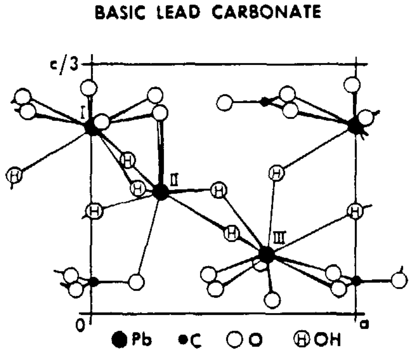
Mitchell, R. A., International Projectionist, **32**, No. 10, 7-10, 26-28 (October 1957).

The pearly effect is due to proper crystallization and therefore responsive to both crystal structure and habit. Some connecting lines are drawn between atoms to show positions with respect to the plane of the paper; the thick part of the connecting line is above, the thin part below. The basic lead carbonate composite is bonded top and bottom by planes of carbonate ions and between them is sandwiched a "puckered" layer of hydroxyl ions. Two layers of lead atoms (I and III) in hexagonal array lie between the carbonate planes and the hydroxyl layer but closer to the carbonate. The other layer of lead atoms (II) lies at the center of the composite and is surrounded by the hydroxyl ions.

The structure of lead monohydrogen phosphate, although not determined, is deduced from that of lead monohydrogen arsenate with which it is isomorphous. As a rule, each pigment is used separately but under some circumstances, mixtures might be employed.

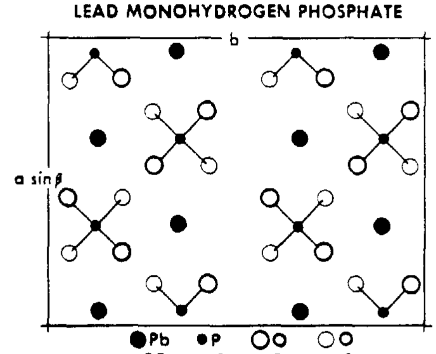
ATOMISTIC VIEWS OF NACREOUS PIGMENTS

BASIC LEAD CARBONATE



Arrangement of atoms in y=0 plane

LEAD MONOHYDROGEN PHOSPHATE



Positions of hydrogens not shown

Arrangement of atoms in z=0 plane

Properties of Nacreous (Pearly) Lead Pigments

Compound	Crystal Structure	Space Group	Lattice Constants	Specific Gravity	Index of Refraction Ord.	Index of Refraction Ext.	Remarks
Basic Lead Carbonate $Pb_3(OH)_2(CO_3)_2$	Rhombohedral / Trigonal*	[illegible]	[illegible]	[illegible]	2.09	1.94	Birefringent, colorless crystals, tabular or lenticular with perfect basal cleavage.
Lead Monohydrogen Phosphate $PbHPO_4$	Monoclinic	[illegible]	[illegible]	[illegible]	[illegible]	1.83	Birefringent, colorless crystals, tabular or lenticular with layering normal to basal, good cleavage on (010).

*Unit cell for layer by itself

**Assuming 2 formula wts. per cell.

References: Bengtsson, E., Arkiv. Kemi, [illegible] Mineralogical Magazine, 29, 287-290 (1950); Cowley, [illegible] Acta Crystallographica, 9, 391 (1956); [illegible] Descriptions of Minerals," Fourth Edition, p. 119, 123, N. Y., John Wiley [illegible] Lead Compounds," The Shell Petroleum Co. Ltd., [illegible]

Electronic Components Made of Leaded Ceramics

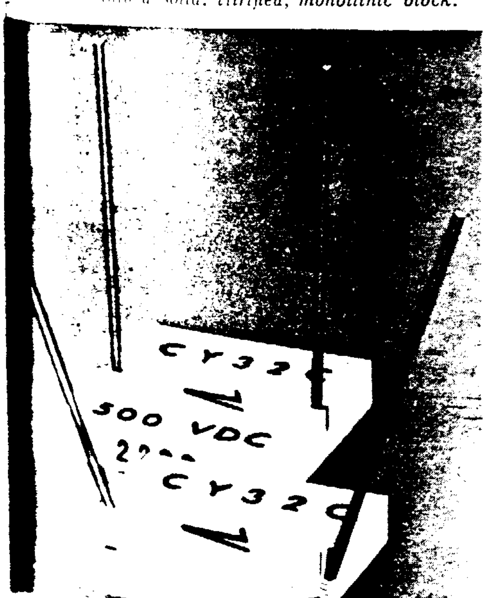
Increasingly, the superior electrical properties of leaded ceramics are finding new and exciting applications in critical areas of our burgeoning electronics industry. Electronic components in this age of missile and electronic brains, are being subjected to operating conditions of great severity, while at the same time, industry is demanding not only high electrical properties, but more reliable and reproducible performance. Vitramon, Inc., is manufacturing a series of high performance porcelain capacitors for the electronics industry to fill this need. These capacitors use lead boro-silicate vitreous enamel as the dielectric material. They are monolithic bodies with the silver electrodes integrally fused within the dense porcelain.

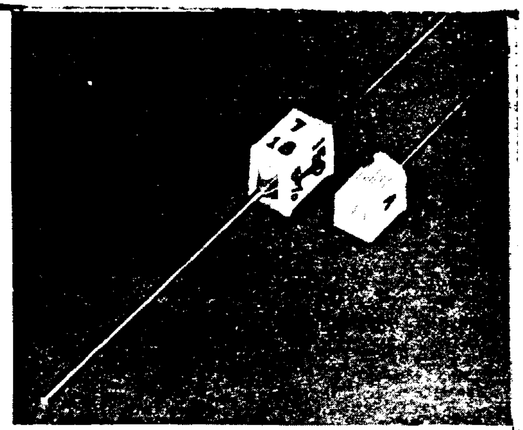
Some of the high performance characteristics of these capacitors are listed in table 1. As these capacitors are made in values below 6.800 micro microfarads, they are used in higher frequency applications such as:

1) Tank, coupling, and by-pass circuits (where low loss is required); 2) tank capacitors in high stability beating oscillators; 3) low-drift R-C oscillators; 4) ultra high frequency circuits requiring minimum inductance; 5) where minimum noise and or 200 deg. C. ambient temperatures are specified.

This product is used to the greatest

A lead bearing porcelain capacitor of recent design. The leads as well as the porcelain and silver electrodes are fused together into a solid, vitrified, monolithic block.



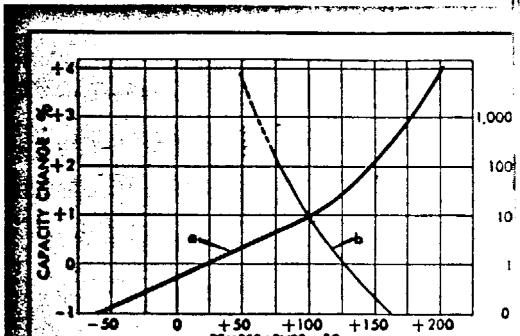


Lead-borosilicate porcelain capacitors and a cutaway, in foreground, showing the silver electrodes. These capacitors are used in guidance systems, fire control systems, all airborne missiles and other applications where reliability is paramount.

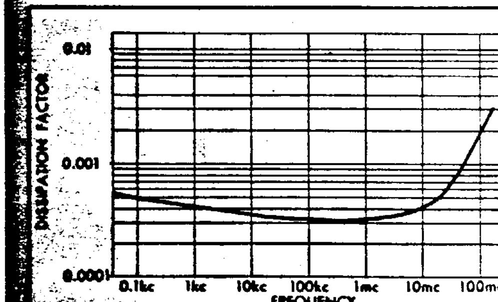
extent in critical circuitry and military applications where reliability is paramount, e.g., guidance systems, fire control systems, high speed computers, communication gear, telemetry components, fuse systems, well logging tools and, in general, all airborne missiles and many conventional aircraft. The temperature coefficient (change of capacity with temperature) and temperature stability (permanent change of capacity after temperature cycling) shown in Curve 1a and Table I demonstrate the high predictability of performance and the great stability of the capacitors.

Of great significance in many applications is the dielectric loss of the component. The loss in capacitors is related to the low loss characteristic of the dielectric material as well as to the design and construction of the component. The very low loss shown in the intermediate frequency range (refer to Curve 2) is principally associated with the dielectric. The presence of lead ions in the porcelain is in great part responsible for the low loss character of this material. At higher frequencies, even though the losses due to the dielectric continue to decrease, other losses become significant. However, the use of lead silicate with its excellent self-glazing properties has allowed a well designed, compact, monolithic construction, which, in conjunction with the use of low resistance silver electrodes, serve to keep losses below 1 per cent even at very high frequencies. Curve 3 compares the loss characteristics of monolithic lead silicate capacitors to mica and glass. In this curve, Q is inversely proportional to the dissipation factor.

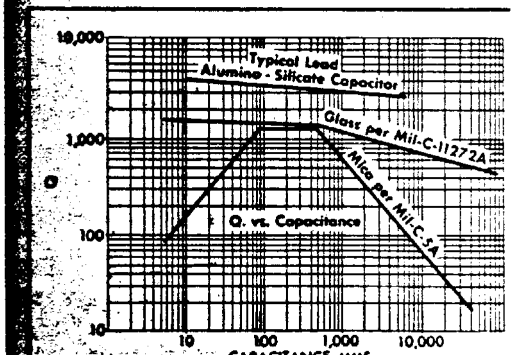
Curve 4 shows the relationship between dielectric loss and temperature taken at 1 kc. The 1 per cent dissipation factor at 200 deg. C. shown is as good as is commercially available today.



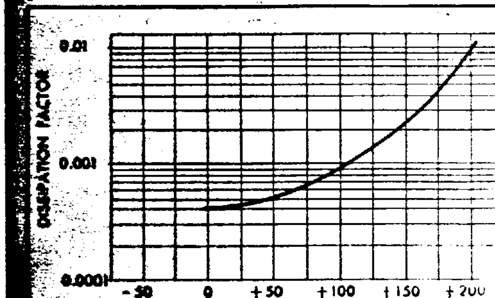
Curve 1 - TEMPERATURE CHARACTERISTIC AND INSULATION RESISTANCE



Curve 2 - LOSS vs. FREQUENCY AT 25°C



Curve 3 - LOSS vs. CAPACITY



Curve 4 - LOSS vs. TEMPERATURE

1. Capacity — between 6,800 [illegible]
2. Temperature coefficient of [illegible] 25ppm/° C. from -55° C. to 125° C [illegible]
3. Temperature stability — 0.05 [illegible]
4. Maintains its insulation resistance after [illegible] sion or operation under 100 [illegible] conditions.
5. Over 10,000 hour life at 85° C [illegible] 125° C; 350vdc, 200vdc.
6. Low internal noise characteristics.
7. Rugged — highly resistant to shock, vibration and high G loading.

[illegible]

The low dielectric loss and high resistivity of this dielectric material is due in great part to the presence of lead ions in the glass network. The high fluxing power of lead — promoting self-glazing — tightly cements the body so that dielectric loss due to elastic factors is kept to a minimum. In addition, the presence of lead ions yields an ultra low dielectric loss in the glass phase. This is related to the greater tendency of lead ions to form covalent bonds in the boro-silica glass than other positive ions (e.g., sodium). Due to the great strength of the covalent bond, the lead ions can be considered to exist in deep potential wells in their lattice positions in the Pb-Si-O network. The dielectric losses in a glass are directly related to the time lag of the positive and negative polarization of the ions. Polarization under an applied field occurs by two processes, ion diffusion, and by shifts of the ions from equilibrium position in the potential wells. The presence of deep potential wells restricts ionic movements and consequently losses are low. Moreover, conduction in a glass is strongly influenced by ionic mobility. Here again, deep potential wells restricting this movement result in glasses of high resistivity.

Some examples of the dielectric losses of various glasses showing the superiority of the lead-bearing glasses and their relation to the low loss of pure silica are given in Table II.

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