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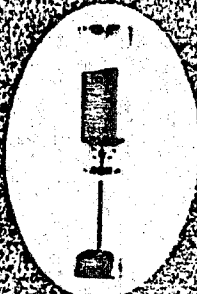
NLI 116275

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Ditch Boy

**"FREE-FLO"
LEAD SHOT**



Flexible Fluid

**GAMMA RAY
SHIELDING**

NATIONAL LEAD COMPANY

77-96-58

LEAD SHOT-SHIELDED

where conventional lead shi

Where it is not possible or feasible to employ the conventional forms of lead—sheet, slab, brick, etc.—for gamma ray shielding, lead in the shape of small shot may well be considered.

The following data were obtained in carefully conducted tests, using a standard cobalt 60 source which emits γ with maximum energy of 1.33 mev:

Counting instrument	0.75" LEAD SHOT	1.00" LEAD SHOT
Survey meter	0.000 Mr/hr	0.001 Mr/hr
Microscope	000	003

A conservative interpretation of the above figures indicates that "Free Flo" Lead Shot has 70% of the shielding efficiency of solid lead. In practice, a 52" shield of shot equals 40" of solid lead.

The shielding test sections, encased in clear "Plexiglas," are shown at far right below.

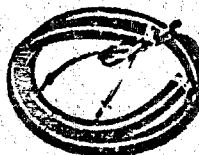
To demonstrate the high density of "Free Flo" lead shot, a quantity was poured into a vessel size 3" x 3" x 12", with "Plexiglas" sides. Holes were drilled through the walls of the case and 1/2" diameter studs inserted. As the lead shot was poured in it was possible to observe (and photograph) how it flowed around the studs. One photo was taken immediately after filling the vessel. This showed small voids directly under the studs. After a slight jarring of the container, these voids promptly filled, as shown in the other view.

This test indicates that, used in a massive spherical shield, formed to enclose the gamma source within a 6" diameter steel sphere, is the inner wall, and with an 8" diameter sphere as the outer "skin"—the two shells being held centered in place with fooling the bolts—the lead shot could be poured in through a hopper, at the apex. The shot would flow around the bolts, perhaps aided by a few blows of a sledge. Insurance against any settling voids would be obtained by a small, gravity fed reserve of

Where it is necessary to conduct moderately "hot" liquids from one location to another in laboratories or other work areas via hard ducts or piping, shielding often is a problem. It is usually necessary to use rigid lead pipe, elbows, tees, laterals and other fittings to bypass obstacles, turn corners and otherwise change direction.

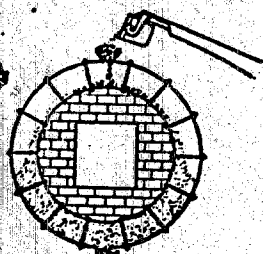
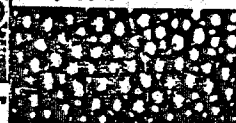
To avoid cumbersome, expensive installations entailing welded or flanged joints and, at the same time, provide adequate gamma ray shielding, a combination of flexible piping and lead shot shielding has been developed.

The illustration below shows a "working model" of this new flexible piping. It consists of a 10' length of 2" ID. polyethylene pipe carrying a centered "hot" liquid conduit of 1/2" ID. (1/2" OD) polyethylene tubing flexible lead shielding separating the inner tube from the outer is provided by a uniform 1/2" thickness of "Free Flo" lead shot. Nine point star lead spacers, placed at 6" to 12" intervals, keep the inner tube centered. The spacers permit easy passage of the shot which is poured from a dipper into a funnel placed in the open end of the large tube, as shown in the other photo.



In the piping illustrated, the open ends of the large tubing were stopped off with lead plugs. Plastic or tin-lined lead tank connections may be used for joining the tubing to storage or processing vessels, and similarly made bibbs and cocks employed for the outlet end of the tubing. Thus a completely lead shielded, highly flexible circuit is possible, the contained "hot" liquid at no point in direct contact with lead.

The appearance and lead distribution of "Free Flo" lead shot is shown in the photograph, right-hand side.



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10" LEAD

where conventional lead shielding is difficult to install

Where it is not possible or feasible to employ the conventional forms of lead—sheet, slab, brick, etc.—for gamma ray shielding, lead in the shape of small shot may well be considered.

The following data were obtained in carefully conducted tests, using a standard cobalt 60 source which emits γ with maximum energy of 1.33 mev.

Penetrating Instrument	0.75" SLAB LEAD	1.00" LEAD SHOT
Gamma Meter	0.000 mR/hr	0.001 mR/hr
Geiger Counter	500	500

A conservative interpretation of the above figures indicates that "Free Flo" lead shot has 70% of the shielding efficiency of solid lead. In practice, a 0.75" shield of shot equals 4.0" of solid lead.

The shielding test sections, encased in clear "Plexiglas," are shown at far right below.

To demonstrate the high fluidity of "Free Flo" lead shot, a quantity was poured into a vessel size 3 1/2" x 3 1/2" x 12", with "Plexiglas" side flues were drilled through the walls of the vessel and 1/2" diameter studs inserted. As the lead shot was poured in it was possible to observe lead photograph how it flowed around the studs. One photo was taken immediately after filling the vessel. This showed small voids directly under the studs. After a slight jarring of the container, these voids promptly filled, as shown in the other view.

This test indicates that, used in a massive spherical shield, formed to enclose the gamma source within a 6" diameter steel sphere as the inner wall and with an 8" diameter sphere as the outer wall, the lead shot being held centered in place with four long tie bolts, the lead shot could be poured in through a hopper at the top. The shot would flow around the bolts, perhaps aided by a few hours of a sledge insurance against any settling voids would be obtained by a small, gravity fed reserve of

shot in the hopper. If desired, a valve could be placed at the bottom of the sphere for shot drainage and use elsewhere.

In installations in which it may be necessary to shield a coil with lead shot (since it would be impractical to apply conventional solid lead shielding and still leave the coil accessible to repair in case of leak), there is little possibility that the weight of the shot shielding would distort the coil.

In a test of this application, a 3" O.D. 4 turn coil of 1/2" soft copper tubing was formed. The height of the coil was measured at three locations and the coil then set into a 6" diameter cylinder into which "Free Flo" lead shot was poured. The coil, entirely unarmored in shot, was located with 11 1/2" of shot at the bottom, 1 1/4" around the perimeter and 1" over the top turn. Varying pressures were applied and any permanent distortion of the coil measured after each lead application. The results of this test, together with calculated equivalent pressures in "feet of lead" of "Free Flo" shot follow.

COMPRESSION TEST ON SOFT COPPER COIL IN "FREE FLO" LEAD SHOT				
Test No.	Applied Pressure in psi	Pressure Exposed to Shot in feet of lead	Distortion of Coil in inches	Relating Data
1	100	100	0.00	none
2	200	200	0.00	none
3	300	300	0.00	none
4	400	400	0.00	none
5	500	500	0.00	none
6	600	600	0.00	none
7	700	700	0.00	none
8	800	800	0.00	none
9	900	900	0.00	none
10	1000	1000	0.00	none
11	1100	1100	0.00	none
12	1200	1200	0.00	none
13	1300	1300	0.00	none
14	1400	1400	0.00	none
15	1500	1500	0.00	none
16	1600	1600	0.00	none
17	1700	1700	0.00	none

It can be seen that one would have to exceed a pressure of 330 psi or 100 feet head of lead before any significant deflection of the coil was observed. It should be mentioned that in this test the projected area of the coil was 1 sq in. With the maximum pressure of 1300 psi, there was no distortion of the tubing.

To test for settling or flow, 3" diameter pipes of 12, 30 and 36 ft. heights were filled with "Free Flo" lead shot. After filling the pipe was left with a horizontal slope 1/8" length to get a complete initial settling. Thereafter, the slope at the top surface of the lead shot was measured periodically at 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36 months, the following amount of settling was observed:

Head of Lead Shot	Settling after 6 Months
12 ft.	1/8"
30 ft.	1/8"
36 ft.	1/8"

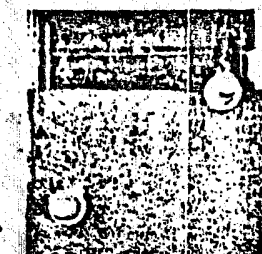
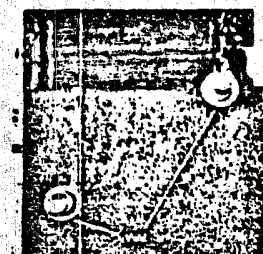
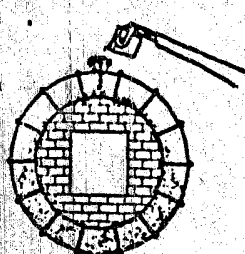
Most of the settling occurred during the first month and in all instances and purposes, the shot in each pipe had reached equilibrium.

Still another test was made to determine if what pressure "Free Flo" lead shot would deform. Various pressures were applied to the shot contained in a steel cylinder 2 1/2" x 2 1/2" high, and the shot examined after each lead application. The results of these tests, along with equivalent calculated "feet of lead" of lead is recorded in the following table:

COMPRESSION TESTS OF "FREE FLO" LEAD SHOT			
Test No.	Pressure Applied in psi	Pressure to which Shot Exposed in feet of lead	Degree of Deformation
1	100	100	none
2	200	200	none
3	300	300	none
4	400	400	none
5	500	500	none
6	600	600	none
7	700	700	none
8	800	800	none
9	900	900	none
10	1000	1000	none
11	1100	1100	none
12	1200	1200	none
13	1300	1300	none
14	1400	1400	none
15	1500	1500	none
16	1600	1600	none
17	1700	1700	none

The deformation of the shot consisted of a slight flattening which was observed only in the bottom 1/2" layer of the column under an applied lead of 90 psi and greater. Shot above this level showed no deformation.

This would indicate that one could safely use a 30 foot head of lead shot with assurance that the shot would retain its spherical shape and could be re-used time and again with no loss of its flow properties.



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