April 25, 1961 V. E. KNAPP ET AL 2,980,973

METHOD FOR MAKING LEAD SHIELDS

Filed May 5, 1958 2 Sheets-Sheet 1

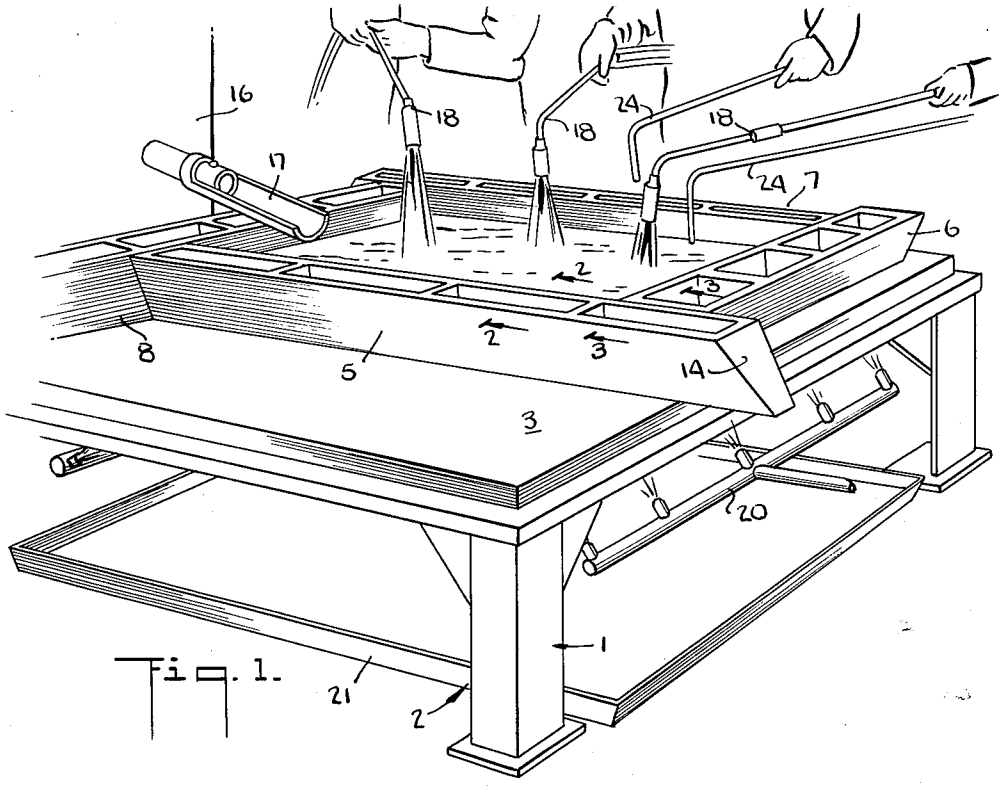


Fig. 1.

Fig. 2.

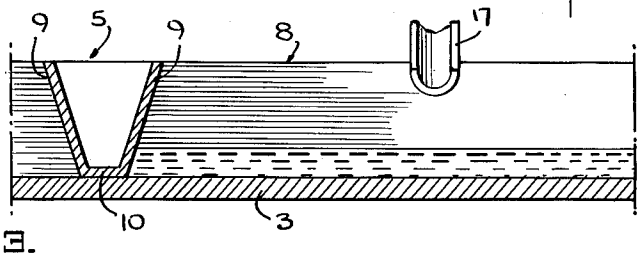
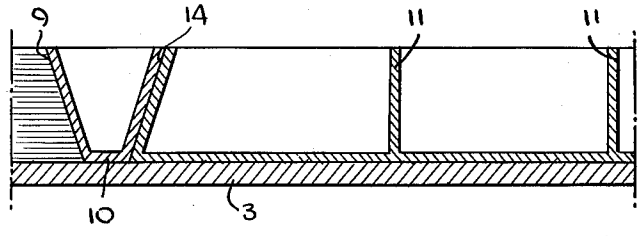


Fig. 3.



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Filed May 5, 1958 2 Sheets-Sheet 2

Fig. 4.

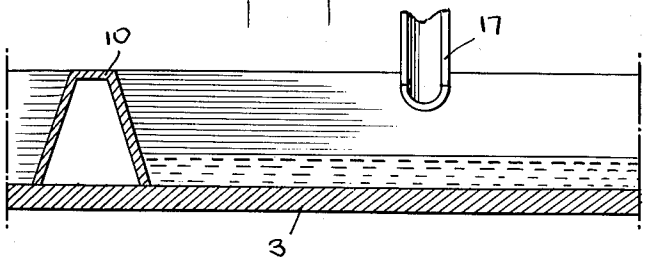


Fig. 5.

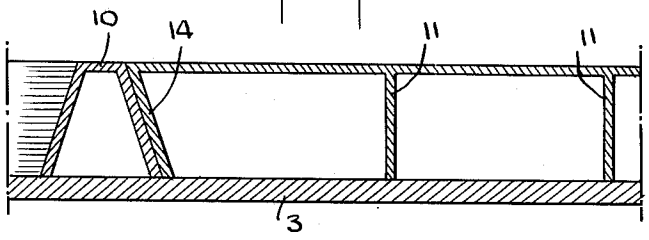
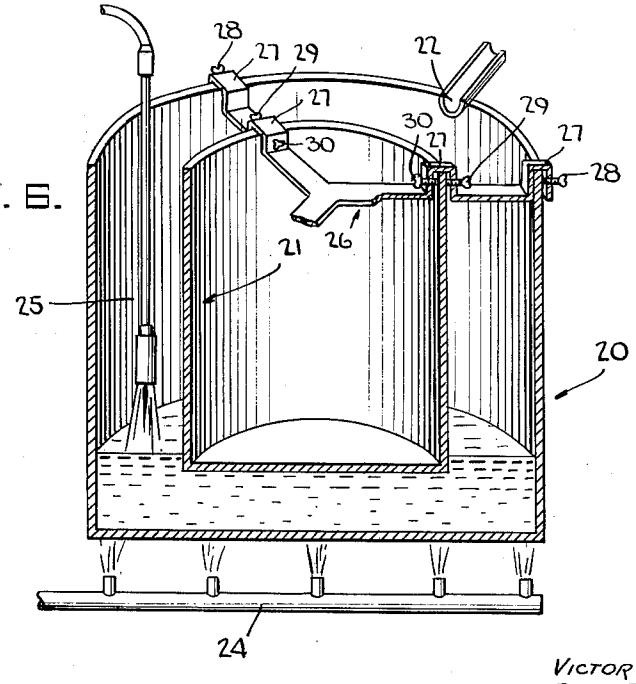


Fig. 6.



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METHOD FOR MAKING LEAD SHIELDS

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4 Claims. (Cl. 22—212)

The present invention relates to a method of making lead shieldings of uniform density and substantially free of cavities and similar defects and to an improved apparatus for use in making slabs with the method.

In previous methods of obtaining the proper thickness of sheets of lead, the practice has been to cast the slabs with a greater thickness than required and to roll the slabs generally maintaining the width constant and increasing the length until the proper thickness was obtained. This rolling reduced the cavities formed in the original casting so that the sheets formed were less objectionable and reasonably thin; for example—a sheet ½" thick could be used for a number of purposes.

In the shielding of gamma rays given off by uranium and other radio-active materials, lead sheets from one to four inches thick and in some cases up to twelve inches thick are required. The amount of rolling, if any, necessary to obtain that thickness, is insufficient to eliminate voids and shrink cavities so that a reliable shielding cannot be obtained.

The present invention aims to provide shieldings of lead or similar metal of any desired thickness and of uniform density free from shrink cavities and voids so that a reduction in thickness is not necessary to reduce the imperfections. Since gamma rays are deadly to humans, adequate and reliable shielding from them is a life and death matter in many installations such as atomic ships, submarines, reactors, etc.

An object of the present invention is to provide an improved method of making such shieldings.

Another object of the invention is to provide an improved method of making lead slabs.

Another object of the invention is to minimize the size and number of cavities or other imperfections in a lead shield so that it may be used for shielding purposes without subsequent treatment.

Another object of the invention is to provide an improved method of making a slab of lead of uniform density free from flaws.

Another object of the invention is to provide an improved apparatus for practicing the method of making slabs.

Another object of the invention is to provide an improved apparatus for utilization in producing different sizes and thicknesses of slabs.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, wherein:

Fig. 1 is a perspective view illustrating a preferred embodiment of the apparatus for practicing the method of making slabs and also illustrating steps of the preferred method;

Fig. 2 is a sectional view along line 2—2 of Fig. 1 showing the relation of a slab of lead and the retaining member used in making it;

Fig. 3 is a sectional view through a corner of the apparatus along line 3—3 of Fig. 1 illustrating the junction of two parts of the apparatus.

Fig. 4 is a section similar to Fig. 2 of a side member inverted to reverse the inclination or bevel at the edge of a lead slab;

Fig. 5 is a section similar to Fig. 3 with the two members inverted to reverse the inclination or bevel at the edge of the slab; and

Fig. 6 illustrates a preferred method of providing a shield for a container.

Referring again to the drawings and more particularly to Figs. 1, 2 and 3 thereof, there is shown a preferred apparatus for making slabs illustrating steps in the application of the method to the making of slabs. There is illustrated in perspective a table or platform **1**, preferably of steel, with suitable legs **2** for supporting it at the proper height. A member **3**, preferably of cast iron, extends over the top of the table to serve as the bottom of the apparatus. Four members **5**, **6**, **7** and **8** are provided for enclosing a space on the table of a suitable size to produce the slab desired. The members may be identical in cross-section, but not necessarily so, and are preferably sufficiently long to produce the largest size of slab desired.

As shown in Fig. 2, the members are preferably channel shaped in the form of a flat bottom V with two flaring sides **9** and a flat bottom **10**. Preferably, suitable webs or cross-members **11** are provided for reinforcement purposes. The ends of the members are inclined to fit against the side of an adjoining member as shown in perspective at **14** and in section at the junction of two members in Fig. 3. By the arrangement of four members as shown, it is possible to make a rectangular enclosure of any desired size. For example, by sliding the member **5** toward the side member **7** and keeping the two parallel, the width of the slab may be reduced as desired. The end member **6** should be moved with the side member **5** while the other two members **7** and **8** remain stationary. The width may be increased by moving the members **5** and **6** in the opposite direction.

The length of the slab may be increased by moving the end member **6** and the side member **7** to the right retaining both in their same right angle relationship. Thus, an enclosure of any desired size may be obtained.

The weight of the side member **5** to **8** is ordinarily adequate to retain them in position on the table. Where the thickness of the slab is such that additional holding means are necessary, suitable slabs of lead or other weights may be buttressed against the member **5** to **8** or any other suitable means may be utilized to secure them in position.

In forming the lead slab in accordance with the preferred method, lead is poured from the heated kettle **16** through a spout **17**. The lead in the kettle has been raised to the proper temperature and is in a molten condition. In the preferred method, the lead flows into the enclosure until a certain depth has been reached and the flow is stopped by turning off a suitable valve. In order to cause the lead to cool and solidify substantially evenly from the bottom upwardly, workmen play flames from burners **18** on the surface of the molten lead to keep the top in a suitable molten condition and to prevent localized portions from hardening to a substantially greater depth than other adjacent portions. Any suitable number of burners **18** may be utilized depending upon the size of the slab. At the same time, in the preferred em-

bodiment, the lower portion or the bottom of the enclosure is cooled by utilizing blasts of air as shown at **20**. Any desired number of blasts may be used to cool the bottom and to attain a substantially even rate of cooling from the bottom to the top which produces uniform cooling over the area without bumps or other irregularities which cause shrink cavities. If desired, water sprays may be utilized instead of air. In that case, a drip pan **21** with a suitable drain may be provided for collecting the used water.

While playing the flames on the surface of the lead, the workmen utilize suitable probes **24** to determine the depth of the molten lead, the condition of the hardened lead below it and the uniformity of its surface. If portions harden too rapidly or create irregularities, the burners may be applied to that portion to decrease the rate of cooling and to obtain a substantially uniform hardening with respect to the depth of the hardened layers. There is a tendency for the side and end portions to freeze more rapidly than the inside. This should be minimized as indicated above. Likewise, the workmen may from time to time remove froth or other impurities from the surface of the molten metal.

Additional molten lead is added to the surface from time to time as the cooling proceeds. Since the lead on the surface is molten, the additional lead mixes with it and uniformity is attained. If localized cooling causes raised portions, the workmen are able to locate them with their probing irons and eliminate them prior to solidification of the surrounding lead and thus avoid cavities. When the proper thickness has ben reached, the upper surface is permitted to cool and the slab is ready for use as a shield or for other purposes.

The beveled edges of the slabs permit them to be joined together with an overlap. The overlap gives a shield to rays substantially perpendicular to the top and bottom surfaces of the slab, which is generally the most important direction. The edges of the slabs may, if desired, be bonded together by heating the surfaces at the time of fitting them or in any other suitable manner.

In the preferred embodiment, the surface of the metal members forming the enclosure is not treated with a solder or flux, which would cause the lead to bond to the metal surface, and hence a bond is not formed between the lead and the contacting surface of the metal members. Thus when the slab is cooled, the members forming the enclosure may be removed and the lead slab transferred for storage or use. When desired, the side members may be inverted as shown in Figs. 4 and 5 and in that case, the flat bottom of the V will be at the top and the open channel of the V will be at the bottom. The end members, by also being inverted, will fit with the side member as shown in Fig. 5. In this way, the beveled or tapered edge is reversed. Hence, the two slabs will fit together when facing the same way. If desired, of course, the slabs may be inverted with respect to each other so that the bevels interfit with each other. The bottom member **3** and the four members forming the enclosure are preferably made of cast iron although steel and other materials may be used.

In the description we have used the term lead but it will be understood that lead alloys may also be used.

In Fig. 6 there is illustrated the application of the method to the shielding of the inside of a container. The container to be shielded is indicated at **20**. Such a container may be utilized for containing a radioactive material during shipment or storage. In forming the shield, a second container **21** is placed within the main container and spaced to give the proper thickness of shield along the sides and bottom of the container **20**. It will be understood that the size of the inner container, particularly its diameter, is such that the desired thickness results.

Layers of lead may be poured from a spout or trough **22** into the space between the two containers. Cooling air or a liquid spray is applied to the bottom of the outer

container **20**, as shown diagrammatically at **24**, and flames are directed against the surface of the molten lead by burners **25**. Probes may be utilized for determining any irregularities in the hardened surface of the lead below the molten surface. Cooling is controlled pursuant to the results of the probing. In this way, any voids due to shrinkage may be avoided and a uniform dense shield may be obtained.

In the embodiment shown in Figure 6, the depth is relatively great as compared with the width between the two containers. Under these circumstances, there is a greater tendency for the edges to freeze first and to create a U-shaped channel of molten metal. This increases substantially the likelihood of cavities as the metal when it freezes shrinks and tends to create voids. Some of them may be several inches in length or thickness thus impairing the shielding properties at that locality. The workmen should maintain the freezing substantially level and apply the flames to retard cooling at the edges and at other localities where there are irregularities. The ideal to be sought is substantially even cooling so that the surface of the hardened lead under the molten layer is substantially level. In this way, cavities do not form but if the hardened surface has cavities filled with molten lead, the freezing of the molten lead in these cavities will cause the metal to draw apart and form voids within the body of the finished shield.

The inner container may be secured in position in any suitable manner—for example, it may be placed in the outer container and permitted to float upwardly on the surface of the lead until the desired bottom thickness is reached. At that time, it is retained in its proper position during the remainder of the shielding operation. The inner container may be secured in position in any desired manner—for example, by means of a bracket **26** having U-shaped portions **27** to fit over the rim of the inner and outer containers and having set screws **28** for holding the bracket **26** on the outer container **20** and set screws **29** and **30** for holding the inner container **21** in place and for centering the inner container **21** with respect to outer container **20**. By uniformly controlling the cooling and the hardening of the lead, cavities and irregularities may be prevented and a solid shield obtained.

If it is desired to bond the shield to the inside of the container, the inside surface of the metal may be suitably treated to facilitate bonding. For example—with a steel container, the surface may be cleaned and a suitable solder or flux applied.

After the shield is completed, the inner container may be removed in any suitable manner or in some cases it may be permitted to remain within the shield. If it is desired to remove the inner container, it may be heated sufficiently to soften the metal at its outer surface and a suitable aperture or apertures may be made to permit air to enter beneath the inner container as it is being removed, thereby to avoid the formation of a vacuum. Preferably, the inner container **21** should have a slight taper extending throughout its length to further facilitate removal.

It will be seen that the present method provides a shield of uniform density substantially free of shrink cavities and other imperfections. As the metal shrinks in hardening, there is a molten metal to fill any cavities formed. Any irregularities in the hardening can be noted by the probing operations and eliminated by the use of the burners or by changing the intensity of the air blasts or by a combination of the two. The resulting slabs or other shielding may be utilized without rolling or further operations for shielding against gamma rays without fear of defects or cavities which would impair their utility.

The preferred apparatus facilitates the manufacture of various sizes of slabs with the same apparatus and facilitates the formation of beveled or inclined edges for interfitting and overlapping when slabs are fitted together in the shielding structure. The method is simple, effec-

tive and both the method and apparatus are inexpensive.

As various changes may be made in the form, construction and arrangement of the parts herein without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.

Having thus described our invention, we claim:

1. The method of forming a lead shield of substantially uniform density comprising flowing molten lead into an enclosure having an open top and closed bottom and side walls to form a layer of molten metal, applying a cooling medium to the under surface of said bottom wall to cause solidification of said molten metal to advance upwardly through said layer, inserting a probing rod into said layer from the upper surface thereof at a plurality of selected points to determine the rate of advancement of the solid-liquid interface upwardly through said layer, and applying a flame to portions of the upper surface of said layer directly over those areas of the interior of the layer in which the solid-liquid interface is advancing more rapidly.

2. The method of forming a lead shield as claimed in claim 1, wherein an additional layer of molten lead is poured into said enclosure while the surface of the previous layer is molten.

3. The method of forming a lead shield of substantially uniform density comprising flowing molten lead into an enclosure having an open top and closed bottom and side walls to form a layer of molten metal whose surface area is much greater than its thickness, applying a cooling medium to the under surface of said bottom wall to cause solidification of said molten metal to advance upwardly through said layer, inserting a probing rod into said layer from the upper surface thereof at a plurality of selected points to determine the rate of advancement of the solid-liquid interface upwardly through said layer, and applying a flame directly to portions of the upper surface of said layer directly over those areas of the interior of the layer in which the solid-liquid interface is advancing more rapidly.

4. The method of forming a lead shield as claimed in claim 3, wherein an additional layer of molten lead is poured into said enclosure while the surface of the previous layer is molten.

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