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METHOD AND APPARATUS FOR PRODUCING TUBES OF VITREOUS MATERIALS

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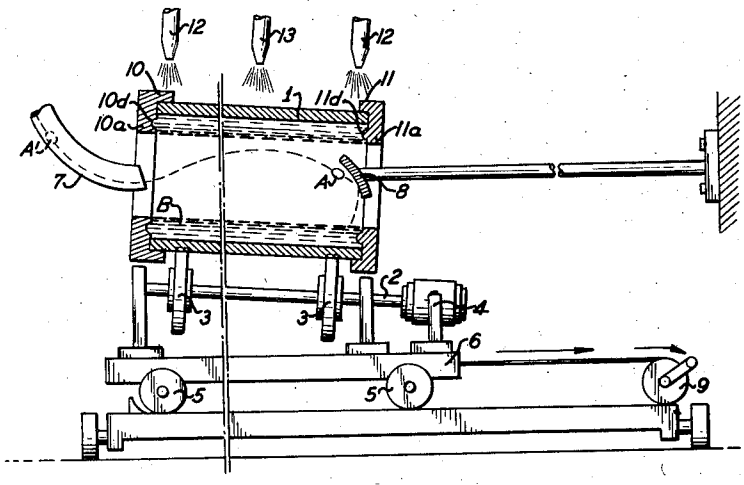


Fig. 1

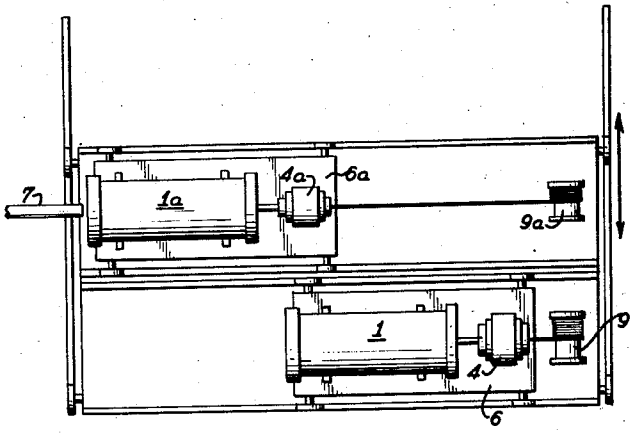


Fig. 2

INVENTOR

WALTER LERCH

BY Burgess & Dinklage

ATTORNEYS

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METHOD AND APPARATUS FOR PRODUCING TUBES OF VITREOUS MATERIALS

Walter Lerch, Gelsenkirchen, Germany, assignor to Glas- und Spiegel-Manufactur Act.-Ges., Gelsenkirchen-Schalke, Germany, a corporation of Germany

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12 Claims. (Cl. 49—29)

The present invention relates to improvements in a centrifugal casting method for producing tubes of fused vitreous masses, such as, for example, glass, ceramics, slag, basalt, or other mineral substances, and to a new apparatus for carrying out such method.

Prior to this invention, several different methods have already been proposed for applying and carrying out the centrifugal casting method for producing tubes of fused vitreous materials. Thus, for example, one of these prior methods consisted in pouring the fused mass continuously into a rotating vertical ingot mold provided with a bottom and in which a molding core is rigidly mounted. The wall strength of the tube to be produced by this method was determined by the width of the gap or clearance formed between the inner wall of the mold and the core thereof.

According to another prior method, the inner shape of the hollow body to be produced, and thus the particular wall strength of such body, was determined by inserting a rigid tool into the mold which was likewise provided with a bottom.

In other prior methods, while subjecting the fused mass to centrifugal force, a plunger was moved upwardly from the bottom of a vertical mold so as to form the inner shape and determine the wall strength of the tube or hollow body.

All of these and similar centrifugal casting methods have inherent disadvantages which render them impractical. It has also been found that it is by no means possible simply to apply the well-known methods of casting metals by centrifugal force to molding fused, vitreous materials. Such a conversion of the known metal casting methods will not be successful because of the difference in the chemical and physical qualities of the two types of materials. While fused metallic masses have within the range of their melting point a viscosity of approximately 2 to 5 centimeter-gram-second units, (C. G. S.-units), vitreous masses, for example silicate glasses, have within their processing range a viscosity of 10^2 to $10^{2.5}$ C. G. S. units. Extensive research and experiments by the present inventor have shown that such low fluidity of vitreous melts requires special operations and treatments for filling the mold and for obtaining tubes of uniform wall strength.

While metallic melts flow easily into the mold and are uniformly distributed when subjected to centrifugal force, vitreous melts act entirely different since they flow very slowly and easily stick to the feed channel. A very great disadvantage of vitreous melts as compared with metallic melts also resides in the fact that the vitreous melt will not flow from the end of the feed channel into the mold but due to its viscosity will form a thread which, when the mold is being rotated, winds into a spiral shape, so that when these spirals then overlap each other, considerable amounts of air will be enclosed between them.

All prior proposals to remedy this disadvantage, such as pouring the melt with a ladle into a vertical mold, or inserting cores and other tools, did not lead to any satisfactory results since the wall strength of the tubular or other hollow bodies thus produced could never be made uniform.

Also, the difficult application of different molding cores, tools, or plungers for determining the wall strength of such tubular bodies renders such methods unduly complicated, especially since it requires separate operations for inserting and removing such tools or cores.

The worst difficulties of these prior methods, in which a mold with a solid bottom was used, however, consisted in the removal of the molded solidified objects from such a mold. This difficulty was aggravated by the absolute requirement that glasslike products, and particularly those made of melts containing silicate, must, after being molded, be very quicky removed from the mod so as to avoid crystallization of these materials which would lead to excessive tensions in the product and breakage thereof.

In order to overcome these disadvantages, it has also been proposed to design the mold so as to be pivotable about a horizontal axis. However, even this proposal did not lead to any satisfactory results since by the centrifugal force of the molding operation, the material is forced tightly against the inner wall of the mold and the solidified product will thus cling to the wall of the mold and will not simply side out of the mold even though the latter is pivoted, or even placed upside down. Also, the machinery required for pivoting the heavy molds rendered the entire mcehanism very expensive.

It is the primary object of the present invention to provide a new method of producing tubes of fused vitreous materials by the application of centrifugal force, a method which is superior to all those known prior to this invention and which by the application of very simple and effective means overcomes all their disadvantages as outlined above.

The principal features of the invention for carrying out this object consist in the use of a rotatable mold which is preferably slightly inclined to the horizontal; in feeding the melt intermittently and drop by drop into the mold; and, while thus feeding the melt, in successively, although preferably intermittently moving the mold away from the inlet point of the melt, or in depositing the melt intermittently side by side within the mold.

The new method of feeding the melt drop by drop into the mold has the considerable advantage over prior methods that the vitreous mass may be fed at a much higher speed than when it is fed in a continuous stream, since the individual drop or slug will hardly cool off while being inserted into the mold.

The first drop or slug will then pass to the end of the mold directly opposite to the place of insertion, and the rotation of the mold will shape this drop into a ring. Shortly, thereafter, the second drop follows and, by the lateral travel of the mold, it will be deposited next to the first ring and form a second ring which through the centrifugal force fuses together with the first ring so as to form a single unit. This continues until the mold will be filled entirely. Although not absolutely necessary, such depositing of the successive slugs of molten material and the fusion of one ring of material to the preceding ring may be facilitated by slightly inclining the entire mold so that the molten material has the natural tendency to slide toward the preceding ring to combine therewith.

Another object of the present invention consists in producing tubes of glass or similar materials which are free of enclosed air.

This object is likewise attained by the new method of feeding the vitreous mass drop by drop which thus avoids the disadvantage of prior methods of forming spiral threads which, when superimposed upon each other enclose considerable amounts of air intermediate the different threadlike layers.

Another important feature of the invention resides in

the use of a rotatable mold which is open at both ends and thus permits the solidified product to be easily and quickly removed therefrom.

Another feature of the invention consists in the use of removable rings which are adapted to be placed upon the two ends of the mold and project radially inwardly of the inner edge of the mold, and determine the wall strength of the tubes to be formed.

Thus, as soon as the molded body has cooled off sufficiently, the two rings are removed from the open ends of the mold, permitting the molded body to be ejected quickly and without difficulty from the mold by means of a suitable ejecting tool placed upon the one free end of the body.

According to another feature of the invention, the end rings of the mold are preferably designed so as to be pivotable relative to the mold. Furthermore, in order to facilitate the ejecting operation, it is another feature of the invention to make the inner wall of the mold slightly conical, but of a degree which does not affect the wall strength of the tubes to any appreciable extent.

The present invention also has the important advantage that all the complicated means for removing the molded article from the mold, required by previous methods, such as, for example, mechanisms for pivoting the entire mold, will be unnecessary.

The experiments and tests carried out by the present inventor have also shown that considerable advantages are obtained if the mold itself, and possibly also the mass to be molded or while being molded, be heated before, during, and after the molding operation or at one or another of these times, and if the central part of the mold also be cooled at such time. Ordinarily, the ends of the mold will, as a matter of course, cool off relatively quickly as compared with the central part of the mold. Such uneven cooling of the molded article may, however, cause excessive tensions therein, in consequence of which the article may break easily. By thus heating the ends or cooling the central part of the mold, the molded article will cool off uniformly and excessive tensions therein will be avoided.

A further object of the present invention resides in providing the front and rear end surfaces of the molded article with suitable profiles.

This object may be accomplished according to the invention by providing those parts of the rings which project radially inward of the open ends of the mold, and which during the rotation thereof form the front and rear end surfaces of the molded article, with profiled portions in accordance with the desired shape or cross section of the end surfaces of the final product. If tubes are, for example, to be cast which are to be used for conduits, one of the rings is preferably given the profile of a groove and the other that of a corresponding tongue. The individual tubes thus cast in the mold will then have the respective opposite profiles and may be easily fitted together with the tongue at the end of one tube fitting into the groove in the end of the adjacent tube.

In order to assure an even and firm placement of the ejecting tool upon the respective end of the molded article when removing the same from the mold, it is also desirable that such tool be given a suitable end profile corresponding to that of the respective end of the article to be ejected.

Further objects, features, and advantages of the present invention will be apparent from the following detailed description of the invention when regarded with reference to the accompanying diagrammatical drawings, in which

Fig. 1 shows a side view, partly in section, of a mold according to the invention which is rotatably supported on a carriage; while

Fig. 2 shows a top view of two molds according to the invention supported on their carriages on a traverser.

Referring particularly to the drawings, the mold **1** is rotated by rollers **3** secured on the shaft **2** of the motor **4**, and mounted together with such driving means on a carriage **6** provided with wheels **5**. For a clearer illustration of the principal features of the invention, those parts of the mold outside of the longitudinal section thereof and required for rotatably mounting the same, such as suitable mounting rollers, have not been shown in the drawings, as they do not form any essential part of the invention and may consist of various different means known for similar purposes.

According to the present invention and as diagrammatically illustrated in Fig. 1, the fused vitreous mass is fed into the mold **1** through the feed channel **7** intermittently and in the form of individual drops or slugs A. For throwing the slug A so as to pass along its trajectory far into the interior of the mold **1**, the lower end of the channel **7** is made horizontal or even slightly upwardly inclined. For limiting the extent of the trajectory, a stationary deflector **8** is inserted into the open outer end of mold **1** by moving the mold relative thereto. As soon as the first slug A has dropped upon the inner wall of mold **1** at the outer end thereof and has by the rotation of the mold **1** been spun into a ring, the mold **1** together with its driving means will be shifted slightly in the direction shown by the arrow by means of a winch **9** which is preferably driven by a suitable motor. Thus, deflector **8** then extending slightly deeper into the mold, the next slug A will be dropped immediately adjacent the first ring of fused material. Since the successive slugs follow each other very quickly, the ring of fused material formed on the inner wall still retains such a high temperature that the newly formed ring fuses together with the first ring into a homogeneous unit. These steps of slightly advancing the mold **1**, throwing a new slug A of molten material into mold **1** against the deflector **8** so as to drop immediately adjacent the ring of molten material previously formed, and forming the next ring and fusing the same to the preceding ring are then continued in quick succession until the entire tube B is formed along the inner wall of mold **1**.

For predetermining the wall strength of the tube B, ring-shaped members **10** and **11** are secured to the two ends of the mold so as to be easily removed therefrom. These ring-shaped end portions **10** and **11** are made of smaller inner diameter than the inner wall of mold **1** so as to form inwardly projecting flangs **10***a* and **11***a*.

The amount of molten material to be fed into the mold **1** in the form of drops or slugs A may be predetermined for each particular tube to be cast by means known as such so that the area bordered by the wall of the mold **1** and the flanges **10***a* and **11***a* will just be filled out. As soon as the molten mass has solidified, rings **10** and **11** will be removed, permitting the completed tube to be easily ejected from one open end of the mold **1** by means of a suitable tool placed upon the opposite end of the tube B.

In order to expedite the ejection of the tube B so that it may be pushed out as soon as the material has solidified, the ring shaped members **10** and **11** are provided with suitable means which permit them to be quickly disconnected and removed from the outer ends of mold **1**. Preferably, the rings **10** and **11** are for this purpose suitably mounted so as to permit them to be pivoted relative to the ends of mold **1**. In connection with such pivoting means, suitable quick-acting locking means may also be provided so as to retain the rings **10** and **11** in firm contact with the ends of the mold.

The ends of the mold may be heated by directing a heating fluid or flame through the nozzles **12** against the ends of the rotating mold and the central portion of the mold may be cooled by directing a cooling fluid through the nozzle **13** against the central portion of the rotating mold.

For neutralizing any tensions remaining in the tubes,

the same are then subjected to a slow cooling process as customary with silicate products.

Further, according to the invention as illustrated in Fig. 1, the flanges **10***a* and **11***a* which are projecting inwardly of the outer wall of the mold **1** may be provided with suitable annular projections or recesses which may be desired for the subsequent use of the tubes produced in the mold. Thus, for example, the flange **10***a* of the ring **10** may be provided with an annular groove **10***d* of any suitable cross-sectional shape, while flange **11***a* on the other ring **11** may be provided with a corresponding annular projection or tongue **11***d*. When centrifugally casting tubes in the mold **1**, the molten mass automatically flows or presses into the annular crevices formed by the groove **10***d* and the projection or tongue **11***d*, leaving an accurate negative imprint thereof on the respective end surface of the tube B, so that each tube when solidified has a corresponding annular tongue and groove at its outer ends, permitting a series of such tubes to be fitted together to form a continuous conduit, the tongue and groove of adjacent tubes then interengaging with each other so as to form a tight seal.

The provision of such tongue or groove on the respective ends of the tube has the further advantage that the ejecting tool may be more accurately applied to the respective end of the tube for ejecting the same after the material has solidified. Such ejecting tool is then preferably provided with an end surface corresponding to the shape of the respective end of the tube, that is, either with a recessed portion to fit over the tongue **10***d* of the finished tube B or a projecting portion to fit into the groove **11***d*, depending upon the direction from which the ejecting tool is applied upon tube B. Thus, a damage of the respective end of the tube B by the application of the ejecting tube may be more safely avoided.

In the practical operation of the new centrifugal casting mold it has been found desirable to provide two such molds in a tandem arrangement, as illustrated, for example, in Fig. 2. Such arrangement permits the casting operation to be carried out continuously and especially the operation of the mechanism which produces the individual drops or slugs of molten vitreous material and feeds the same intermittently, although in quick succession through the channel **7** either to the drum **1** or the drum **1***a*. These two drums are preferably of identical size and shape and are each mounted together with their own driving mechanism **4** or **4***a* on a separate carriage **6** or **6***a*, respectively, in opposite positions to each other. Separate winches **9** and **9***a* draw the carriages **6** and **6***a* along a slightly upwardly inclined track in the direction toward the right as shown by the arrow and in the manner as previously described, so as to advance the respective mold relative to the stationary deflector **8**. A suitable mechanism may also be provided as diagrammatically indicated in Fig. 2, to shift the deflector **8** as well as the feed channel **7** from one mold to the other. The entire operation of the tandem arrangement, including the shifting of the deflector **8** and the feed channel **7** from one mold to the other, may be controlled automatically so that one mold will always be rotated and filled with molten material, while the rings **10** and **11** are removed or pivoted away from the ends of the other mold, the completed tube is ejected therefrom, the rings **10** and **11** are again placed on the ends of the mold, and the latter is returned toward the left to its starting position to be newly filled during the next operating cycle.

Obviously, instead of mounting the entire mold **1** including its driving mechanism **4** on a moveable support or carriage **6** and moving such carriage relative to a stationary deflector **8** so as to deposit the slugs of molten material successively but intermittently adjacent the preceding ring of molten material, the arrangement may also be made to mount the molds including their driving means in a stationary position, and to provide suitable means for shifting the deflector **8** intermittently toward and into the respective open end of the mold.

While I have described my invention with reference to the preferred embodiments thereof I wish to have it understood that it is in no way limited to the details of such embodiments or to the specific examples described, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. Method for the centrifugal casting of tubes from viscous melts, which comprises intermittently progressively depositing individual slugs of a viscous melt on the inner wall of a rotating centrifugal mold at points located within adjacent planes extending at right angles to the mold axis, whereby the individually deposited slugs are formed by the rotation of the mold into rings which are fused together forming a tube in the mold, and recovering the formed tube from the mold after solidification thereof.

2. Method according to claim 1, in which said rotating centrifugal mold is maintained with its axis slightly inclined to the horizontal.

3. Method according to claim 1, in which said depositing is effected by feeding individual slugs of the melt to the mold and throwing the slugs into the mold along a trajectory terminating at said points.

4. Method according to claim 1, which includes heating the mold near its ends.

5. Method according to claim 1, which includes cooling the central portion of the mold after the formation of said tube.

6. Apparatus for centrifugally casting tubes from viscous melts, comprising a rotatable mold, means for depositing individual slugs of a viscous melt upon the inner wall of said mold at points located within adjacent planes extending at right angles to the axis of rotation of said mold and progressively from one end of the inner wall of said mold to the other, and means for rotating said mold.

7. Apparatus according to claim 6, in which said mold has its axis of rotation slightly inclined from the horizontal.

8. Apparatus according to claim 6, in which said mold is an open-ended mold having annular flanges removably secured to its ends.

9. Apparatus according to claim 6, in which said mold has at least one open end, and in which said means for depositing said slugs includes a channel extending into the open end of said mold and curved slightly upwardly.

10. Apparatus according to claim 9, including a deflector extending into said mold and positioned within the trajectory path of slugs passing through said channel to deflect said slugs upon the inner wall of said mold, and including means for producing a relative movement between said deflector and said mold, so as to move said deflector from one end of said mold toward the opposite end thereof for depositing said slugs uniformly along the length of said wall.

11. Apparatus according to claim 10, in which said mold is an open-ended mold having annular flanges removably secured to its ends and mounted with its axis of rotation slightly inclined to the horizontal, said deflector being a fixed deflector extending to the opposite end of said mold, and including means for progressively moving said mold with respect to said deflector.

12. Apparatus according to claim 11, in which said mold is mounted on a carriage and in which said means for moving said mold relative to said deflector are means for moving said carriage.

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