Nov. 19, 1946. C. WESSEL 2,411,176

METHOD OF MAKING METAL CASTINGS

Original Filed Dec. 16, 1940 6 Sheets-Sheet 1

Fig. 1.

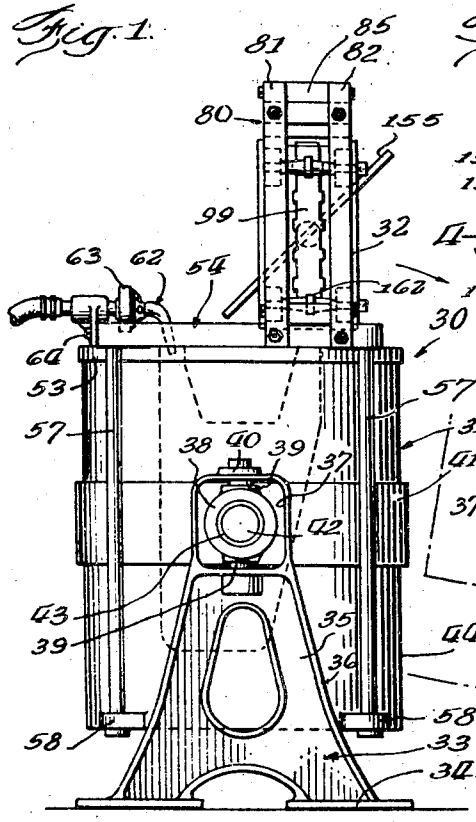


Fig. 2.

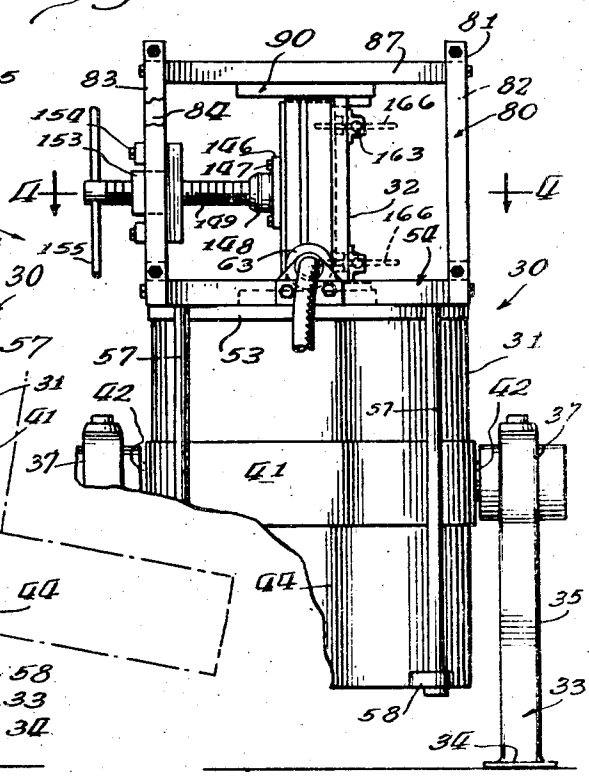
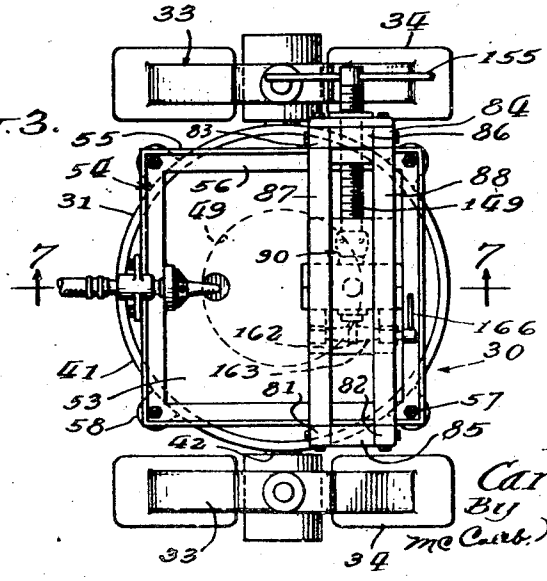


Fig. 3.



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Fig. 4.

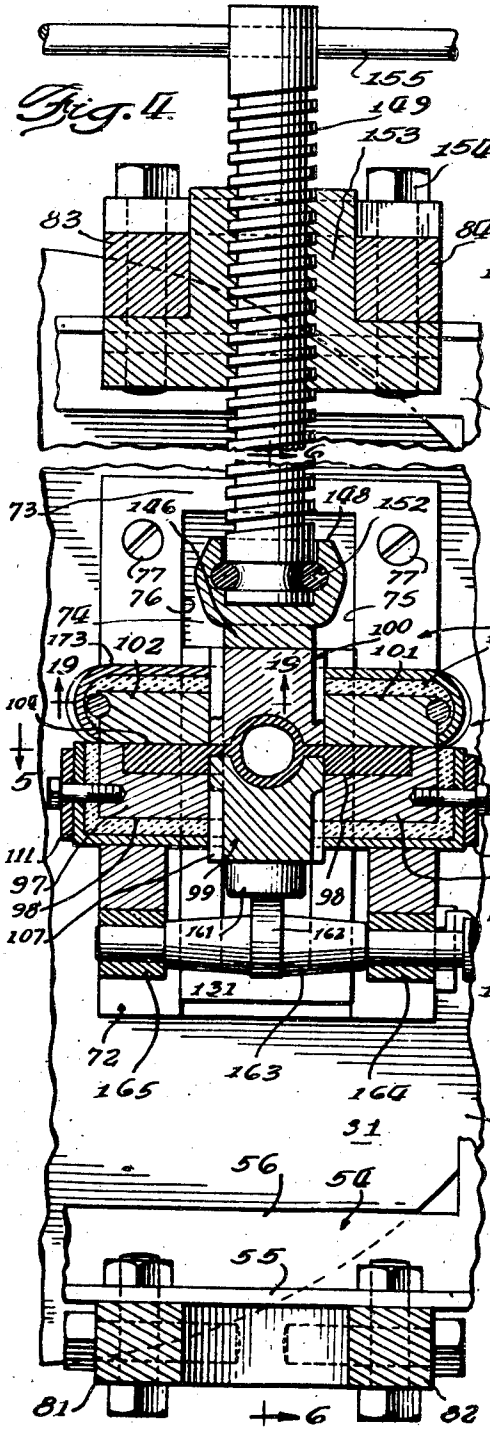
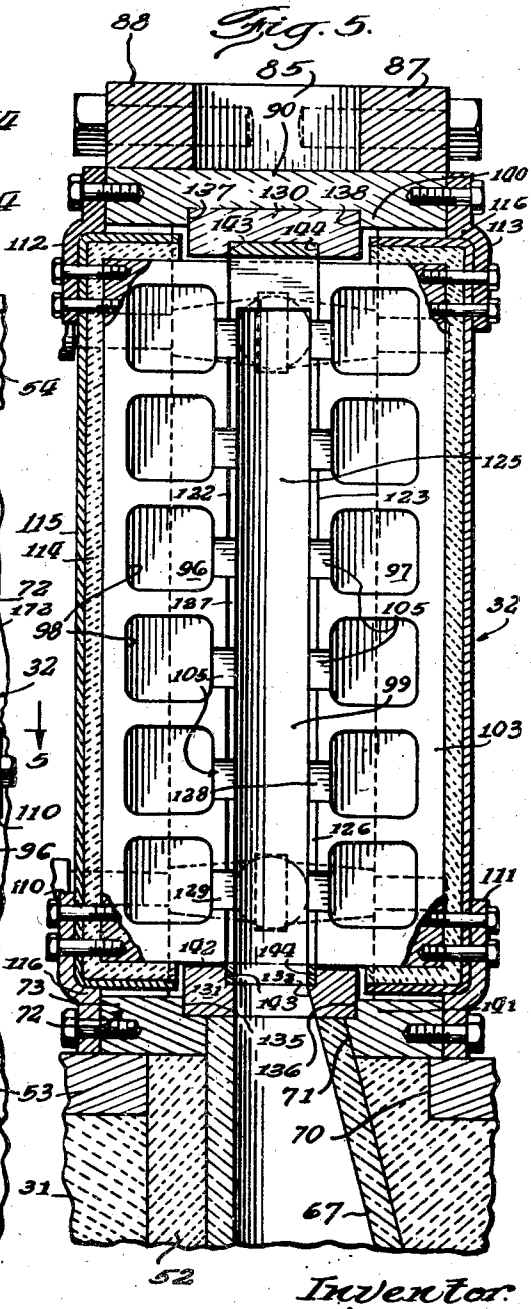


Fig. 5.



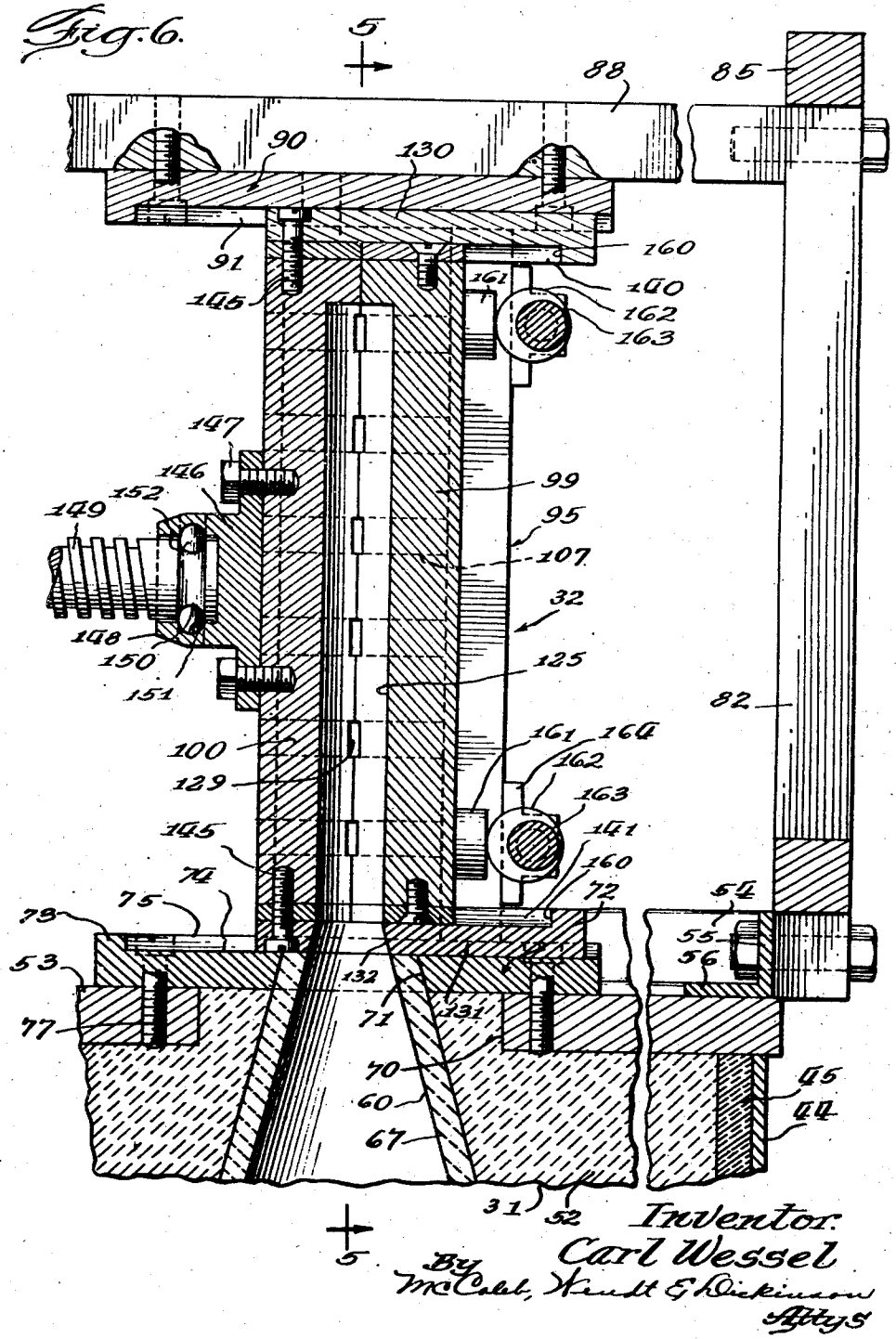
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Fig. 6.



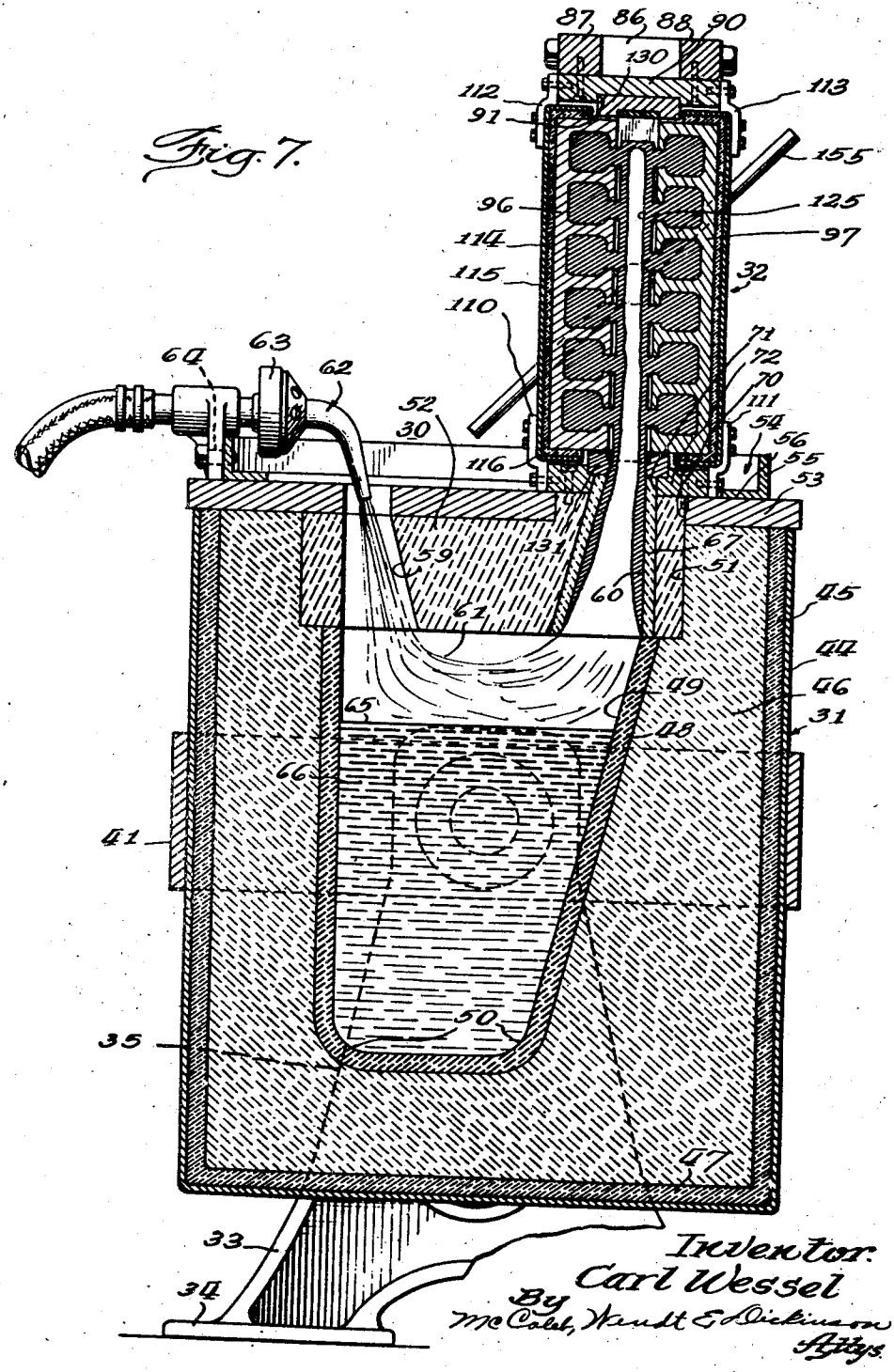
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Fig. 7.



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Fig. 8.

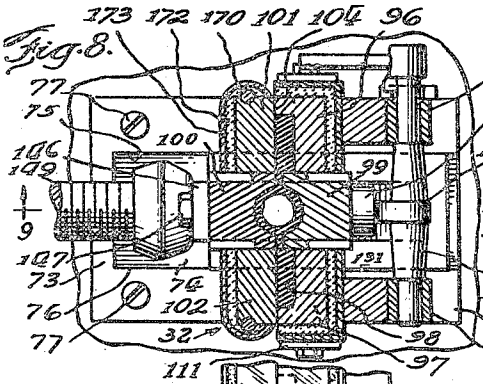


Fig. 12.

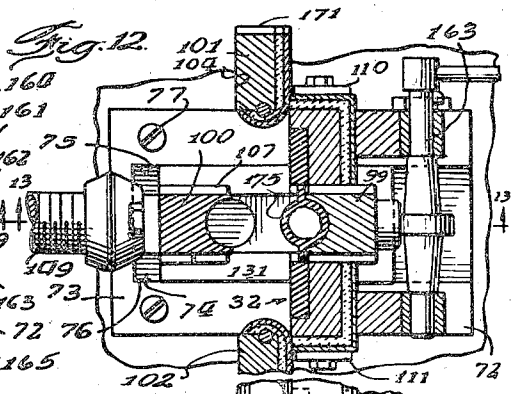


Fig. 9.

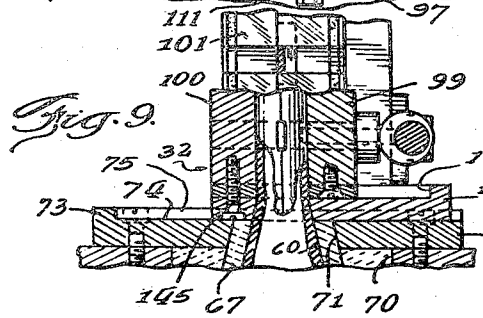


Fig. 13.

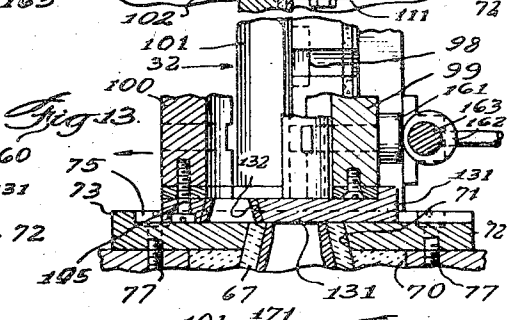


Fig. 10.

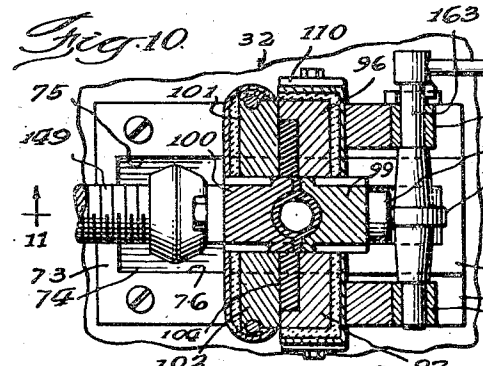


Fig. 14.

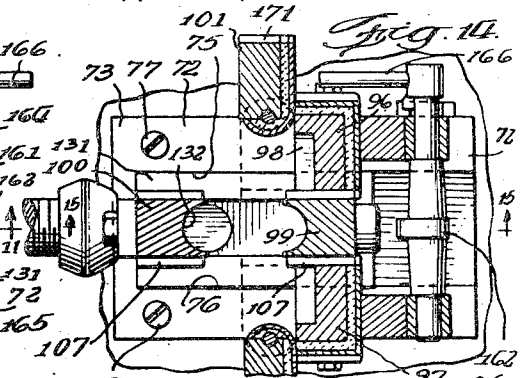


Fig. 11.

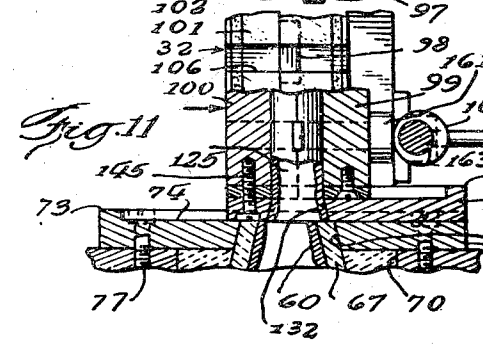
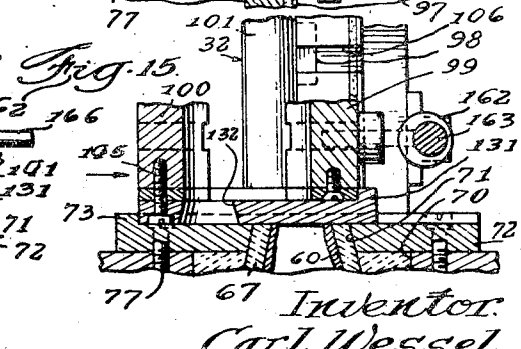


Fig. 15.



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Fig. 16.

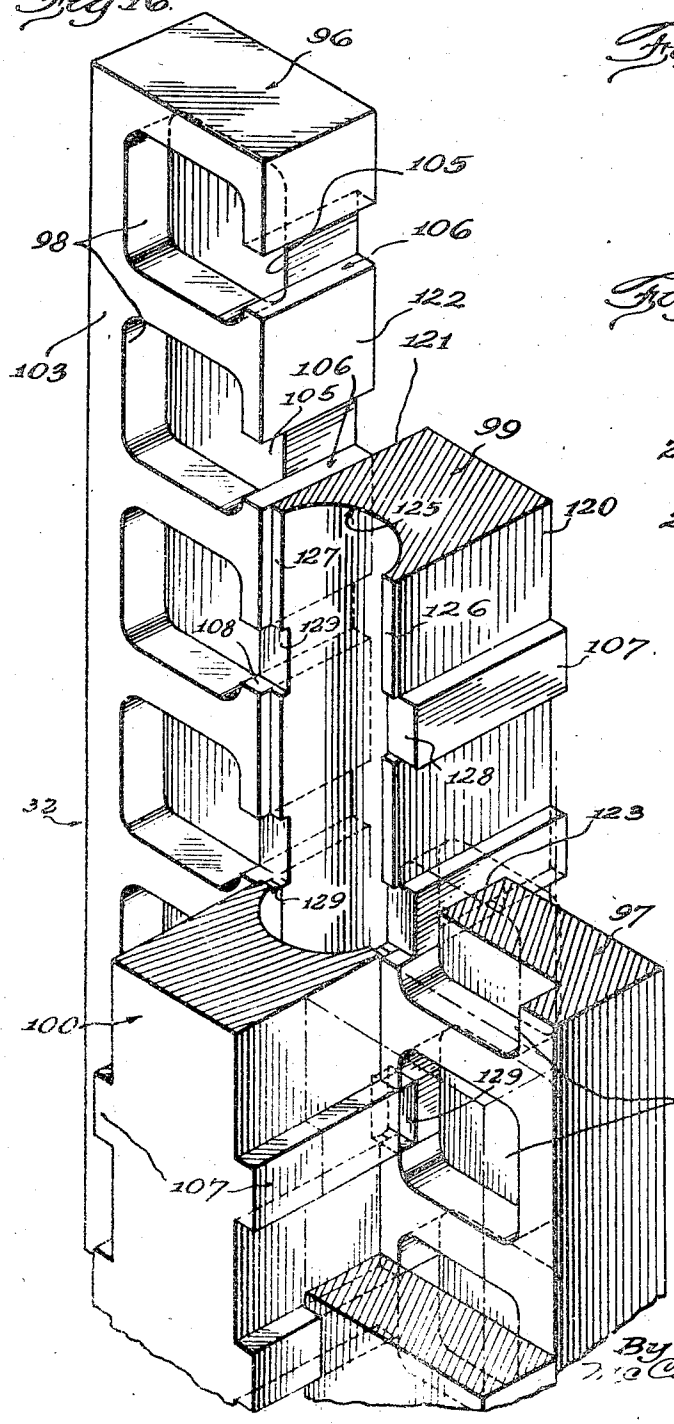


Fig. 17.

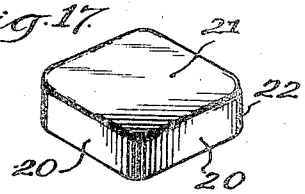


Fig. 18.

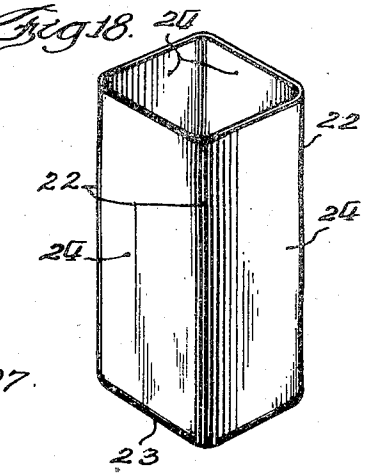
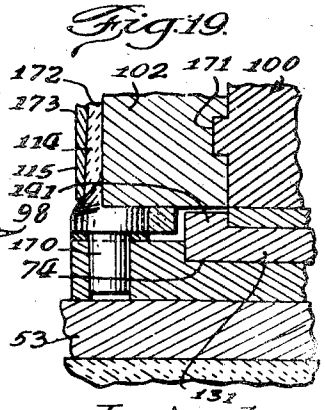


Fig. 19.



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Patented Nov. 19, 1946

2,411,176

UNITED STATES PATENT OFFICE

2,411,176

METHOD OF MAKING METAL CASTINGS

Carl Wessel, Chicago, Ill., assignor to Carl Wessel and Lew W. Cleminson, Chicago, Ill., trustees

Continuation of application Serial No. 370,344, December 16, 1940. This application September 28, 1942, Serial No. 459,893

7 Claims. (Cl. 22—200)

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The present invention relates to methods of making metal castings.

This application is a continuation of my prior application, Serial No. 370,344, filed December 16, 1940, U. S. Patent No. 2,309,608, issued January 26, 1943.

While the present method of making castings may be used for making all kinds of castings it has been illustrated in connection with a mold for making sludge or blanks which are to be drawn into metal containers.

The method according to the present invention may be briefly characterized as follows:

According to my method, any type of clean scrap or any other metal in ingot form that has heretofore been used for drawing may be used as raw material. The raw metal is first melted in a furnace and poured from the furnace in a heavy stream into a tilting ladle so that it will contact a minimum amount of air.

Flame may be applied to the top of the liquid metal in the ladle for the purpose of excluding the oxygen and maintaining the metal and mold at a predetermined temperature. As a general rule, no special fluxes are needed, provided the metal was clean.

The ladle constructed according to the present invention is lined with a suitable refractory and preferably so mounted that it may be tilted, and the mold is preferably secured directly to the ladle at a discharge aperture which is located above the free surface of the molten metal.

The mold may then also be preheated by the application of flame to an opening in the top of the closed ladle, the flame striking the surface of the metal and being deflected upward into the mold through the discharge opening of the ladle. The discharge opening of the ladle into the mold is, of course, open at this time, and the ladle or mold is preferably provided with some means for opening and closing this discharge opening.

The next step is the tilting of the ladle until the free surface of the molten metal passes through the discharge opening into the mold, and the mold is preferably so arranged that the metal wells up into the mold from a filling opening located at the bottom of the mold, driving out the small amount of air which may be in the mold, through the cracks between the mold parts.

The amount of molten metal in the ladle and the amount of tilt of the ladle is such that the mold is not only filled, but there is a head of metal in the ladle at a higher elevation than the metal in the mold, and when the mold is full the metal

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therein is subjected to continuous pressure of the head of metal in the ladle.

As the ladle has a large body of molten metal in it and the mold has a relatively small amount of metal in it and the mold is connected to the ladle at the discharge opening thereof, the outermost part of the mold tends to cool first and this is also true of the casting in the mold. Very soon after the mold is filled, or immediately thereafter, cooling begins and there is a gradient of temperature, the temperature decreasing from the filling opening of the mold to its outermost parts. The casting cools from its outermost parts down toward the filling opening, and as it cools and shrinks additional metal is supplied from the head of metal in the ladle until the shrinkage is all taken up and the metal casting in the mold has congealed.

At this time the supply of metal to the mold is cut off at a relatively large sprue and the ladle may be tilted back, since the discharge opening is now closed, and the metal cannot run back out of the mold. The metal does, however, run back from the closure at the discharge opening of the mold.

The next step comprises the cutting off of the sprue or gate immediately adjacent the surface of the casting, which produces a finished casting without any sprue that must be cut off after the castings are removed from the mold.

The mold may then be opened and the castings removed, and by means of the opening of the closure at the discharge opening of the ladle, any remaining molten metal in the large sprue is permitted to run back into the ladle. The conduits in the mold leading to the actual cavities of the mold are then cleaned of their excess metal or sprue, and the mold may again be closed after removal of the castings for a recasting operation.

Slugs made according to this method are of such uniform homogeneous crystalline structure that they do not need to be preheated before they are drawn into tubes or boxes. Such tubes or boxes may be drawn from slugs made according to this method without preheating and without the difficulties which have been encountered in the drawing of tubes from blank slugs punched out of sheet metal. The boxes made by this method are practically perfect and the amount of rejections reduced to a small fraction of the percentage of rejections according to the methods of the prior art.

The slugs made according to this method have a smooth, bright surface, which may be im-

mediately subjected to polish without any machining or grinding, and as there are practically no imperfections in the slugs, there are none to be drawn out into imperfections in the tubes.

It should also be understood that the present method of casting is not confined to the making of slugs for tubes, but may be used for making castings of all kinds.

Another object of the invention is the provision of an improved method of making blanks for drawing operations, by means of which the blanks may be made of homogeneous crystalline structure without the imperfections that are found in the sheet metal slugs of the prior art, and without the conditions of strain and tension that are produced in the sheet metal slugs by the operations to which they have been subjected.

Another object is the provision of an improved apparatus for casting by means of which castings having larger grain, softer metal, and more homogeneous characteristics may be made.

Another object of the invention is the provision of an improved method of casting by means of which the defects of the prior art methods, such as for example blow holes, inclusions, faults, cracks, and other defects are practically eliminated.

Another object of the invention is the provision of an improved casting apparatus, which is adaptable to use in small plants and which is adapted to produce characteristics of a high degree of uniformity of crystalline structure and uniform smooth outer surface adapted to be polished.

Other objects and advantages of the invention will be apparent from the following description and the accompanying drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the six sheets of drawings which accompany this specification,

Fig. 1 is a side elevational view of a casting apparatus constructed according to the invention;

Fig. 2 is a fragmentary side elevational view of the side which may be seen from the left of Fig. 1;

Fig. 3 is a top plan view of the casting apparatus;

Fig. 4 is a fragmentary sectional view on a larger scale, taken on the plane of the line 4—4 of Fig. 2;

Fig. 5 is a fragmentary vertical sectional view, taken on the plane of the line 5—5 of Fig. 4, looking in the direction of the arrows;

Fig. 6 is a fragmentary vertical sectional view taken on the plane of the line 6—6 of Fig. 4, looking in the direction of the arrows;

Fig. 7 is a diagrammatic vertical sectional view, taken on the plane of the line 7—7 of Fig. 3, showing the complete apparatus as it appears after the castings have just been completed;

Figs. 8 and 9 comprise two fragmentary sectional views showing the condition of the casting in the mold after the mold has been filled by tilting and after the mold and ladle have been held in tilted position long enough for the metal to congeal and shrink in the mold, and to partially congeal in the conduit leading from the ladle.

Fig. 8 is a horizontal section taken on the same plane as Fig. 4;

Fig. 9 is a vertical section taken on the same plane as Fig. 6;

Figs. 10 and 11 are two views taken on the same planes as Figs. 8 and 9, showing the same apparatus, with the parts in the position which they assume in the manipulation of the parts of the mold to cut off the sprue at the side of the casting;

Figs. 12 and 13 are two views similar to Figs. 8 and 9, showing the parts after one side of the mold has been withdrawn and the mold opened for access to the castings;

Figs. 14 and 15 are two views similar to Figs. 8 and 9, showing the parts of the mold after the open mold has been emptied of its castings and of the sprue or excess metal remaining in the conduits leading to the cavities;

Fig. 16 is a diagrammatic view in perspective, with the parts broken away to show the structure of the mold cavities and members which form the conduit leading to the cavities, and which are adapted to cut off the sprue;

Fig. 17 is a view in perspective of one of the cast metal slugs or castings made according to the present method;

Fig. 18 is a view in perspective of a drawn tubular box made from the slug 17 according to the present method;

Fig. 19 is a fragmentary sectional view, taken on the plane of the line 19—19 of Fig. 4, looking in the direction of the arrows.

Referring to Figs. 17 and 18, the slug shown in Fig. 17 is merely exemplary of one of the forms of small castings that may be made according to the present invention.

It comprises a piece of metal, the shape in plan being the same as the plan shape of the box or tubular member of Fig. 18. Thus it has four plane sides 20, and the upper and lower plane sides 21 and the corners are preferably rounded at 22. The opposite sides of the slug are parallel to each other and perfectly smooth and plane.

One of the characteristics of the castings made according to the present method is that the sides of the castings are so smooth that they may be polished without any intervening machining or smoothing operations.

It should be understood, however, that this slug is merely exemplary of the many different forms of castings that may be made, as I have made table knives, spoons, forks, and many other small articles according to the same method.

I desire it to be understood also that aluminum is merely one of the metals which may be utilized according to the present method, and that the invention is not limited in its use to non-ferrous metals, but may be employed for practically all ferrous and non-ferrous alloys and metals.

Referring to Fig. 18, this is the container which is formed from the blank of Fig. 17, and it is provided with a bottom 23, and the four plane sides 24, the opposite sides again being parallel to each other, and the corners being rounded at 22. The box of Fig. 18 is formed according to the usual methods of drawing such members from metal blanks, except that in the present specific instance it is found that by means of my cast metal slugs it is not necessary to anneal the metal or preheat it, as it was in making the tubular containers from the sheet metal blanks of the prior art.

I desire it to be understood also that the tubular container of Fig. 18 is merely exemplary of one form of receptacle or container or drawn metal member that may be made according to the present method. The present methods may be

utilized for making all kinds of containers, such as kitchen utensils or other articles which may be made by drawing processes.

Referring to Figs. 1 to 3 and 7, 30 indicates the casting apparatus in its entirety. This apparatus may have its parts further designated as comprising the ladle 31 and the mold apparatus 32. The ladle 31 is preferably supported for pivotal movement upon a pair of bearing brackets 33, which may be identical in shape.

Each of these bearing brackets has the foot flanges 34 and the upwardly extending columns 35 suitably reinforced by reinforcing flanges 36, and at its upper end the bearing bracket has a horizontally extending socket 37 for receiving the bearing member 38.

The bearing member 38 may be provided with vertically extending trunnions 39 at the top and bottom, and located in bearing apertures 40 so that the bearing 38 is mounted for pivotal movement on a vertical axis, and is self-aligning with respect to the same bearing on the other bracket 33.

The ladle 31 is preferably pivotally supported on the brackets 33 by means of a centrally located metal bearing band 41, which has a laterally projecting trunnion 42 at each end, as shown in Figs. 1 and 2. The trunnions 42 are rotatably mounted in the bearings 38, which are aligned with suitable bearing metal at 43.

The band 41 embraces the sheet metal housing 44 of the ladle, to which it may be secured by rivets, welding, or any convenient method. The trunnions 42 are preferably located substantially midway between the ends of the ladle, or slightly upward of the middle of the container so that when the ladle is empty and the mold apparatus 32 is attached, it is still held in upright position. When it is filled with metal, the ladle tends to maintain its upright position by virtue of its own weight and the weight of the metal in the ladle, but it may be easily tilted because the apparatus is in a condition approximating a balance.

The ladle 31 consists of a member which has an outer sheet metal shell, such as the jacket 44, carried by trunnions 42. Inside the metal jacket 44 there may be a layer of suitable insulation, such as rock wool 45 or other temperature resistant heat insulating material.

The ladle 31 has its next inner layer 46 made of firebrick or other suitable heat retaining and temperature resistant heat insulating material, and the firebrick may be suitably spaced from the metal shell 44 by spacer blocks 47 at the bottom and sides of the shell.

The spacer blocks 47 would also be made of the same material as the firebrick and would transmit a minimum amount of heat through the rock wool 45 to the shell 44.

The ladle has its innermost lining 48 made of suitable refractory material which is adapted to withstand the high temperatures to which this lining is subjected by the molten metal and by the application of heat with flame, as illustrated in Fig. 7.

The shape of the container chamber 49 is preferably round when viewed in plan and tapering from the bottom toward the top, and the lower corners at 50 are preferably rounded so as to facilitate cleaning of the chamber 49.

At its upper end the firebrick lining 46 is provided with a cylindrical recess 51 for receiving a removable cover 52, which may also be made of firebrick material.

The cover 52 fits in the cover aperture 51 and

is of substantial thickness, being substantially equivalent in insulation to the firebrick layer 46. It is carried by an additional metal cover member 53 of substantially disc shape, which in turn is supported by a rectangular metal frame member 54, which may have a vertical flange 55 and horizontal flange 56.

The rectangular frame 54 may project beyond the cylindrical shell 53 at the four corners of the rectangular frame member 54 and may be provided with apertures in the horizontal flange 56 for receiving the elongated bolts 57, which extend to the lower end of the metal shell 44 and there pass through the radially projecting ears 58.

The bolts 57 clamp the upper frame 54 to the shell 44 and secure the cover members 52 and 53 in place. The cover member 52 is preferably provided with a pair of tapered apertures or conduits 59 and 60. The aperture 59 is merely for application of heat by means of the flame 61 from a gas burner 62, having an adjusting member 63 for determining the amount of air which is fed into the nozzle 62 with the gas.

The gas burner 62 may be secured by means of a bolt 64 to one of the vertical flanges 55 of the rectangular frame 54. Conduit 59 tapers upwardly and is arranged at one side of the container 49 so that the flame 61 may be directed inwardly toward the surface 65 of the molten metal 66 and be deflected upwardly into the conduit 60, which is the discharge conduit leading to the mold apparatus 32.

Conduit 60 is preferably also provided with a refractory lining 67, similar to the refractory lining 48 previously described. This conduit also tapers upwardly to the discharge opening leading into the mold apparatus 32.

The cover 52 is secured to the metallic cover plate 53 by means of suitable bolts which are embedded in the firebrick cover 52 at some distance from the lower surface of the cover 52. The firebrick insulation of which cover 52 is made extends upwardly into an aperture 70 in the metal cover plate 53, and the refractory lining 67 extends upward into an aperture 71 in a guide plate 72 so that the conduit 60 is adequately insulated against the transmission of heat.

The metal cover plate 53 preferably supports the metallic guide plate 72, which is provided with the aperture 71, registering with the discharge aperture 60 of the ladle. The guide plate 72 (Fig. 6) comprises a flat metal member, which may be of substantially rectangular shape, as shown in Figs. 8 to 15, and provided with an upwardly projecting border 73 surrounding three sides of the flat surface or bed 74 of this guide plate. The inner walls 75, 76 of this border (Fig. 14) act as guides for certain other parts, further to be described, and the border 72 may be provided with apertures for receiving the screw bolts 77, which pass through this guide plate and are threaded into the metallic cover plate 53.

The mold apparatus 32 preferably includes an upwardly extending frame, indicated in its entirety by the numeral 80. The frame 80 consists of a pair of upwardly extending angles 81, 82 at the side of the machine in Fig. 1, and another pair of similar bars 83, 84 at the opposite side.

These bars are bolted to the rectangular frame 54 at their lower ends, and they are joined together by auxiliary frame members 85, 86 at each side of the machine and by elongated frame members 87, 88 extending across the top of the frame (Fig. 3).

This provides a top frame which comprises the

members 85, 86, 87, 88, supported by the columns 81 to 84. The top frame may support a guide plate 90 (Fig. 2) similar in construction to the guide plate 72 previously described, but oppositely located.

This guide plate also has a depending wall or border 91 which serves to guide the adjacent parts for sliding movement, but is open on one side, that is, the right side (Fig. 6). The mold may be indicated in its entirety by the numeral 95.

Referring to Fig. 16, the main parts of the mold comprise the oppositely disposed mold members 96 and 97, each of which is provided with a plurality of cavities 98 and the two oppositely disposed members 99 and 100, which form the conduit to these cavities, and serve to cut off the sprue.

In addition to this, the mold has a pair of doors, best illustrated at 101, 102 (Fig. 8) and other associated parts for controlling these members.

The mold members 96, 97 may be similar in structure except that they are right hand and left hand members, as disposed in the drawings.

As a matter of fact, if the member 97 is turned end for end, it will be seen to be substantially similar to member 96. Each of these members and all of the main parts of the mold may be constructed of suitable metal of sufficiently high melting point in relation to the metal to be used for the castings, so that it will withstand the heat without damage. For example, the present molds may be made of iron or steel, when used for aluminum slugs, and the interior finish of the mold is, therefore, very smooth, for the purpose of producing a casting of finished characteristics.

Each of the members 96, 97 comprises a bar of metal, having a plane face 103, which is formed with a multiplicity of the cavities 98 complementary in shape to the slug, which is shown in Fig. 17. One of the larger plane faces of this slug is arranged in the plane of the surface 103 of the mold so that it will be formed by means of the plane surface 104 on the door 101 or 102.

The mold member 96 is provided with a filling aperture 105 at one side of the cavity 98, and the filling aperture preferably communicates with a transverse slot 106, which is rectangular in cross section and just as wide as the filling aperture 105 from top to bottom.

The slots or grooves 106 are adapted to receive the regularly spaced transverse ribs 107, which are located on the mold members 99 and 100. These ribs 107 are also rectangular in cross section and have an accurate smooth fit in the grooves 106. They are of such length on the member 99, for example, that they leave a small aperture at 108, which is actually the filling aperture of the mold cavity.

In other words, the ribs 107 partially close the aperture 105, previously mentioned. The molds 96 and 99 are fixedly secured to the framework in vertical position, parallel to each other, and spaced from each other sufficiently so that the members 99, 100 can slide between the molds 96, 97, with the ribs 107 in the grooves 106.

Thus the mold members 96, 97 are secured at the bottom by means of brackets 110, 111 to the guide plate 72. At the top these mold members are similarly secured to the guide plate 90 by means of brackets 112, 113.

These metal mold members are preferably provided with heat insulation, which may take

the form of an insulating covering 114, which is protected by a metal shell 115 extending up the side of these mold members under the top and over the bottom thereof to a predetermined point.

The bolts which secure the brackets 110 to 113 to the mold members pass through the shell and insulation and may be threaded into the mold members. These brackets 110 to 113 are preferably formed with an offset as at 116, for the purpose of the size of the mold apparatus to the size of the guide plates and giving the mold additional support.

The mold members 99, 100 may also be substantially similar in construction, with a few slight differences. Mold member 99 may comprise a bar of iron or steel or other suitable metal, which is provided with the rectangular horizontally extending ribs 107 at regularly spaced points on each of its opposite sides and projecting from the plane parallel surfaces 120, 121.

The sides of the mold members 96, 97 also have plane surfaces at 122 and 123 for engaging the surfaces 120 and 121, respectively. At its inner side the member 99 is provided with a longitudinally extending substantially hemicylindrical groove 125.

This groove has such a diameter that it leaves a plane surface or rib formation 126, 127 at each side of the groove on the inner face. Rib formations 126, 127 are formed with the plane surfaces 128 at their inner ends, registering with what may be called a filling slot 129 leading to the filling aperture 108 of the mold cavities 98.

The mold member 100 is similar in shape to the member 99, previously described, but is oppositely disposed, and it is also adapted to fit against the adjacent sides of the molds, as it has ribs 107 for sliding in the grooves 106. It also has the mold filling grooves 129, a part of which may be seen at Fig. 16. The mold members 99 and 100 may meet at a point between the front and back of the mold cavities.

The guide plates 72 and 90 are adapted to slidably support an additional pair of mold plates 130, 131, one located at the top and one at the bottom of the mold assembly. The mold plates 130, 131 may be substantially similar in structure, except the mold plate 131 has a tapered filling aperture 132, which registers with the refractory lined conduit 60 at the top of the ladle, while the mold plate 130 is imperforate, being located at the top of the mold. Each of these plates is of sufficient width to fit in between the side walls 135, 136, 137, 138 on the upwardly and downwardly projecting borders of the guide plates 72 and 90.

The plates 130, 131 may also be formed with the depending border 140 and the upwardly projecting border 141 for the purpose of providing a guide for other mold parts. These border members 140, 141 also extend around three sides of the plates like those of plates 72 and 90, but the plates are oppositely disposed, having what would be called their open side extending in the opposite direction from the open side of the plates 90 and 72.

The thickness of the plates 130, 131, seen in Fig. 5, is such that there is a clearance between these plates and the mold members 96, 97 at 142 (Fig. 5). The space between the side walls 143 and 144 (Fig. 5) of the plates 130 and 131 is such that the rectangular ends of the members 99, 100 may be fixedly secured or slidably mounted between these side walls 143, 144. Thus the mold member 100 (Fig. 6) may be fixedly secured to

the plate 131 and plate 130 at the bottom and top of the mold assembly by means of the screw bolts 145 which pass through the plate and are threaded into the mold member.

Thus the mold member moves with the plates 130 and 131 at all times, and for the purpose of actuating these members the member 100 is provided with a thrust plate 146, which is secured to it by screw bolts 147, and which has a socket 148. An actuating screw 149 has its end in the socket 148 and is provided with a groove 150 of circular cross section, which registers with a similar groove 151.

A circular wire 152 (Fig. 4) bent to annular shape, and located in the grooves 150, 151, may hold these parts together, but permit rotary motion between the screw 149 and thrust plate 146.

Wire 152 may be forced in through a tangential aperture. Screw 149 (Fig. 4) extends through an internally threaded member 153 constructed like a follower, but fixedly secured to the vertically extending bars 83 and 84 by screw bolts 154. Handle 155 permits the screw shaft to be rotated and causes the mold member 100 to move back and forth as desired, in Fig. 6. In this motion it carries with it the plates 130, 131, which are guided by the plates 90 and 72.

The mold member 99 is slidably mounted between the walls 143, 144 of the plates 130, 131, its movement being limited by the mold member 100 and by the abutment at 160.

This mold member may be provided with a pair of rearwardly projecting lugs 161 for engaging the cams 162 carried by cam shafts 163, which are rotatably mounted in the bearings 164, 165, and adapted to be actuated by lever 166 (Fig. 10). The cams 162 are adapted to provide a variable abutment for limiting the movement of the mold member 99 toward the right in Fig. 6.

The mold doors 101, 102 are best illustrated in Figs. 8 to 15 and Fig. 4. The main bodies of each of these doors comprise a bar of the same metal as the rest of the mold and of substantially rectangular cross section. These bars of metal fit against the plane surfaces 103 of the molds 96, 97 and close the cavities 98 on that side. The doors 101, 102 are provided with upwardly and downwardly extending trunnions 170, the trunnions being rotatably mounted in bearings carried by the guide plates 90 and 72.

The oppositely facing edges of these doors 101, 102 are also provided with the slots 171 (Fig. 12) of rectangular cross section for permitting the sliding of the ribs 107 on the mold members 99, 100 (Fig. 16).

The metal bodies of the doors 100, 101 are preferably provided with a layer of insulation at 172, covered by a metal shell 173 secured to the doors 101, 102 by screw bolts, and the shell 173 is curved around the trunnions 170 so as to permit suitable clearance between the doors and the mold members 96, 97, so the doors may open to the position shown in Fig. 12 from that of Fig. 8 for removal of the castings.

The operation of the mold is illustrated in Figs. 7 to 15. The mold is secured in Fig. 7 in vertical position on the top of the ladle 31. This is satisfactory in the present case because the filling conduits are so large that the metal advances in a solid stream without any splashing.

In other embodiments of the invention, where large castings are made, the mold would be tilted toward the left, for example, in Fig. 7, at an angle to the top of the ladle, such as, for example, thirty or forty-five degrees, so that as the ladle is tilted the free surface 65 of the metal 66 in the ladle would well up into the mold.

When the casting operation is to be begun, the parts are in the position of Figs. 7 and 8. The ladle cavity 49 is filled with a charge of clean metal, which has been kept from exposure to the air as much as possible. The tilting of the ladle 31 caused the metal 66 to well up into the conduit 60 and into the conduit 125 formed by the members 99, 100 between the molds 96 and 97. From the conduit 125, it passes laterally through the apertures 129, 108 into each of the cavities 98, the cavities filling by the gradual rising of the free surface of the metal in these cavities without any splashing or exposure to air other than that which is in the cavities.

The mold cover plates or doors 101, 102 fit quite closely against the molds 96 and 97, but the air may still escape through the cracks, although there is substantially no fin formed on the castings, due to the close fit of the parts of the mold. The ladle is then tilted back to the vertical position shown in Fig. 7, and due to the cooling of the metal the metal in the mold and conduits looks as it is shown in Fig. 7.

The manipulation of the mold is then as follows: Referring to Figs. 8 and 9, it will be observed that the parts are shown here in the position of Fig. 7. The cavities are all filled and partially congealed, and a small amount of metal is congealed in the conduit 125, but the molten metal at the center runs back into the ladle.

The next step is the turning of the stop cam shaft 163 by means of lever 166 from the position of Fig. 8 to that of Fig. 10, establishing a different stop position for the member 99. The screw shaft handle 155 may then be rotated in a clockwise direction to cause the member 100 (Fig. 10) to move toward the right from the position of Fig. 8. Member 100 is secured to the guide plates 130 and 131, which move with it, and the member 99 also moves toward the right by the pressure of the member 100 against it. The turning of the screw is continued until members 99 and 100 are stopped by the engagement of the lugs 161 with the cams 162, as shown in Fig. 10. This motion has caused the member 100 to shear off the sprue at a point immediately adjacent the side of the casting, by means of the cutting edge of the ribs 107 in the grooves 106. In this action the conduit 125 in the mold members 99 and 100 has also been placed slightly off registry with the conduit 60 in the ladle, as seen in Fig. 11.

The next step is the withdrawal of the member 100 by means of the screw shaft 149 and handle 155, bringing the parts in the position of Figs. 10 and 11 to that of Figs. 12 and 13. This movement of the mold member 100 draws with it the lower plate 131 and cuts off the vertically extending sprue at the aperture 132 (Fig. 13).

In addition, the member 100 is wholly withdrawn from between the doors 101, 102, so there will be no longer any binding between the adjacent sides of the doors, and the member 100, and the doors may then be pivotally opened from the position of Fig. 10 to that of Fig. 12.

The castings may then be removed from the cavities, and the hollow sprue 175 (Fig. 12) may be removed from the groove 125 in the member 99, where it stands, and the parts are then in the position as shown in Figs. 14 and 15, when the cam 162 may be turned back to the position of Fig. 8 and the mold closed again to the position of Fig. 8, to be used again.

My method of making castings is as follows:

The ladle 31 and the mold are preheated by means of the gas burner 62 until they have reached approximately the temperature at which the molten metal is to be kept. The ladle is then filled with a charge of metal, which is made by melting down clean scrap or other metal in ingot form. This may be any metal which has so far been used for drawing and extruding, and the melting may be done in a furnace where the metal may be cleaned and skinned off so that it will be clean in the ladle.

It is poured in the ladle in such manner as to reduce the contact between the air and metal to a minimum, such as the pouring in a large stream.

Thereafter, the preheating of the mold may be completed by the application of the gas flame through the aperture 59 into engagement with the metal which deflects it up into the mold.

With the parts of the mold in the positions which they assume in Figs. 7 and 8, the mold is tilted toward the right on its trunnions 42, and the free surface 65 of the metal gradually progresses up the conduit 60 and conduit 125 in a solid stream in such manner that the molds are filled without any splashing or any contact with air other than that which happens to be in the ladle or in the mold cavities.

The amount of oxygen in this air is reduced to a minimum on account of the application of the flame, which carries products of combustion up into the conduit 125 and tends to drive out the air.

When the mold has been filled, the ladle may be immediately tilted back, and it is found, as a matter of practice, that this tilting operation may be accomplished quite quickly with hardly any hesitation, as the mold fills immediately, and the metal begins to congeal in the mold, beginning at a point farthest from the filling openings, and maintaining a gradient of heat, the temperature increasing from the remotest part of the mold to the filling opening.

This is also true down to the metal in the ladle, which has the highest temperature of any metal in the assembly because the metal in the ladle is the source of the heat for the metal in the mold; and the mold, being more remote from the flame, is necessarily cooler than the metal in the ladle, particularly after the mold has been filled.

While the mold is being filled and the metal is congealing, the metal shrinks in the mold cavities, but the shrinkage is taken up by the pressure of metal caused by the head of metal in the ladle, which is above all of the cavities, when the mold is fully tilted.

Thus the free surface 65 of the metal may completely cover the discharge opening 60 inside the ladle chamber 49 when full tilting is reached. When the ladle is tilted back to vertical position, as shown in Fig. 7, congelation has taken place in the mold cavities, shrinkage has been taken up, and congelation has partially taken place in the conduit 125, so that something like a tube is formed, the metal running back out of the hollow tube into the ladle 31.

The next step is the cutting off of the sprue of each slug or casting immediately adjacent the side surfaces of the casting. This is accomplished by means of the mechanism of the molds by moving the parts from the position of Figs. 8 and 9 to that of Figs. 10 and 11.

The next step is the complete cutting off of the larger tubular sprue and the opening of the molds so that the castings and detached sprue may be removed from the mold. This is done while the parts are in the position of Figs. 12 and 13.

Thereafter the castings are taken out immediately, the parts being again placed in the position of Figs. 14 and 15 within a very short time after the ladle and mold have been tilted back to vertical position.

At this time the castings are still very hot, and such shrinkage as takes place during the congelation of any part of the casting is taken up by the supply of additional metal from the head of metal which is impressed upon the mold cavities. By removing the castings from the mold immediately after they have congealed, any additional shrinkage may take place without inducing any undesirable strains because the casting is not held by any mold, nor is there any contraction or strain brought upon the casting by shrinkage of the sprue.

Castings made according to the present invention have a smooth surface, which may be immediately subjected to a polish, and therefore many articles which may be made by casting can be manufactured with a minimum amount of labor. Knives, forks, spoons, and other tableware show a remarkably smooth finish without necessity for any machining or other smoothing operations except polishing.

The slugs which are made according to the present method have smooth surfaces without defects. There are practically no inclusions or faults or cracks, and consequently the slugs are perfectly adapted to the drawing of the tubular boxes which are shown in Fig. 8.

The grain of the metal is large and the metal is easily worked, and it is not necessary to preheat the metal for drawing purposes; but it may be drawn cold into containers or members of all different sizes and shapes.

As distinguished from the tubular members which were made out of blanks that came from sheet metal, the drawing may be accomplished with my blanks without laboring of the machinery, as the metal is much more easily worked. Furthermore, the large percentage of defective boxes, which result from the methods of the prior art, is not present according to my method, as practically all of the tubular members are perfect. There is a large saving in the cost because clean scrap or ingot metal is much cheaper than the sheet metal of which the blanks were made according to the prior art.

In the castings made according to the present invention approximately fifty per cent of the sprue runs back into the ladle so that this effects a large saving in the remelting of metal due to the fact that the sprue is hollow and thin.

One of the most important features of the invention is the location of the mold at a predetermined angle so that the metal wells up in the mold without splashing or spurting. The action is merely a uniform raising of the level from the lower part of the mold.

Another important feature of the invention is the provision of a filling opening for the mold, which is commensurate with the size of the mold cavity.

In some embodiments of the invention, such as the casting of metal plates, the opening of the mold may extend across the full cross-sectional area of one end of the mold. This is to be carefully distinguished from methods in which there is a small opening in which the metal would spurt up into the mold instead of welling up gradually according to the present method.

In other embodiments of the invention the filling opening of the mold does not necessarily cover the whole cross-sectional area, but it is a relatively large opening for filling the mold and always located at the lowermost corner or portion of the mold.

According to my method, no part of the melted metal is separated from the compact stream of melted metal welling up into the mold. Any liquid metal which has separated from this compact stream surrounds itself immediately with oxygen and will not fuse again in the mold to make a homogeneous structure. The arrangement should be such as to provide an uninterrupted stream of metal of large cross-sectional area passing uniformly into the mold.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of casting which comprises maintaining a supply of clean molten metal in a substantially closed container having a mold provided with a filling opening applied directly to a discharge opening of said container, maintaining a neutral atmosphere in said container by projecting a flame in said container in such manner as to heat said filling opening, causing said molten metal to flow upward from the filling opening located at the bottom of the mold in a substantially solid stream into a mold cavity without splashing, maintaining a heat gradient from the extreme portion of said mold cavity to the supply of metal whereby the casting congeals at its remotest part first and at its filling opening last, and supplying additional metal to the mold cavity while shrinkage and congelation takes place by means of a head of metal impressed upon the mold cavity, the mold being made of another metal of higher melting point, whereby the castings may be polished without intermediate smoothing operations, and cutting off the sprue of the casting immediately adjacent the side of the casting promptly after congelation of the metal in the mold cavity.

2. The method of casting which comprises maintaining a supply of clean molten metal in a substantially closed container having a mold provided with a filling opening applied directly to a discharge opening of said container, maintaining a neutral atmosphere in said container by projecting a flame in said container in such manner as to heat said filling opening, causing said molten metal to flow upward from the filling opening located at the bottom of the mold in a substantially solid stream into a mold cavity without splashing, maintaining a heat gradient from the extreme portion of said mold cavity to the supply of metal whereby the casting congeals at its remotest part first and at its filling opening last, and supplying additional metal to the mold cavity while shrinkage and congelation takes place by means of a head of metal impressed upon the mold cavity, the mold being made of another metal of higher melting point, whereby the castings may be polished without intermediate smoothing operations, cutting off the sprue of the casting immediately adjacent the side of the casting promptly after congelation of the metal in the mold cavity, and promptly removing the casting from its mold after congelation to permit further shrinkage of the casting without restraint of the mold or sprue.

3. The method of casting, comprising maintaining a supply of molten metal in a closed ladle having a mold with its filling opening applied directly to said ladle, maintaining a neutral atmosphere in said container by projecting a flame into said container to engage the filling opening of said mold, filling said mold with molten metal from said container by causing the molten metal to flow upward from the filling opening located at the bottom of the mold and maintaining a gradient of heat in said mold and casting diminishing from the filling opening of said mold toward the remote parts of said mold whereby the casting congeals from the remote parts of said mold toward said filling opening while metal is being supplied under pressure to take up the shrinkage of metal in the mold, and separating the mold and the casting promptly after congelation in order to permit the free contraction of the casting in the subsequent cooling thereof.

4. The method of making castings which comprises maintaining a supply of molten metal in a substantially closed and heat-insulated container having a mold attached directly to said container, maintaining a neutral atmosphere in said container by projecting a flame in said container to engage the free surface of the metal and to be deflected backward into the mold, and tilting said container and mold until the metal wells upward into the mold from a filling opening located at the bottom of the mold to form a casting.

5. The method of making castings which comprises maintaining a supply of molten metal at predetermined temperature in a substantially closed and heat insulated container having a mold attached directly to said container and communicating with said container through a filling opening, projecting a flame into said container to engage the free surface of the metal and to be deflected backward into the filling opening of the mold to maintain a neutral atmosphere and effect a heating of the filling opening of the mold, tilting said container and mold until the metal wells upward in a solid stream without splashing or separation from the filling opening located at the bottom of the mold into the mold to fill the mold, and thereafter impressing a gravity head of metal in the ladle on the metal in the mold while the metal in the mold cools and solidifies from all sides inward toward the center of the casting and toward the filling opening to provide additional metal to take up shrinkage during the congelation of the casting.

6. The method of making castings which comprises maintaining a supply of molten metal at predetermined temperature in a substantially closed and heat insulated container having a mold attached directly to said container and communicating with said container through a filling opening, projecting a flame into said container to engage the free surface of the metal and to be deflected backward into the filling opening of the mold to maintain a neutral atmosphere and effect a heating of the filling opening of the mold, tilting said container and mold until the metal wells upward in a solid stream without splashing or separation from the filling opening located at the bottom of the mold into the mold to fill the mold, and thereafter impressing a gravity head of metal in the ladle on the metal in the mold while the metal in the mold cools and solidifies

from all sides inward toward the center of the casting and toward the filling opening to provide additional metal to take up shrinkage during the congelation of the casting, and cutting off the sprue of the casting immediately adjacent the face of the casting while the casting is in the mold, after the casting has congealed to the point of cutting.

7. The method of making castings which comprises maintaining a supply of molten metal at predetermined temperature in a substantially closed and heat insulated container having a mold attached directly to said container and communicating with said container through a filling opening, projecting a flame into said container to engage the free surface of the metal and to be deflected backward into the filling opening of the mold to maintain a neutral atmosphere and effect a heating of the filling opening of the mold,

tilting said container and mold until the metal wells upward in a solid stream without splashing or separation from the filling opening located at the bottom of the mold into the mold to fill the mold, and thereafter impressing a gravity head of metal in the ladle on the metal in the mold while the metal in the mold cools and solidifies from all sides inward toward the center of the casting and toward the filling opening to provide additional metal to take up shrinkage during the congelation of the casting, and cutting off the sprue of the casting immediately adjacent the face of the casting while the casting is in the mold, after the casting has congealed to the point of cutting, and promptly removing the casting from the mold to permit the casting to cool and shrink without constraint of the mold after removal of the sprue.

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