

March 11, 1958

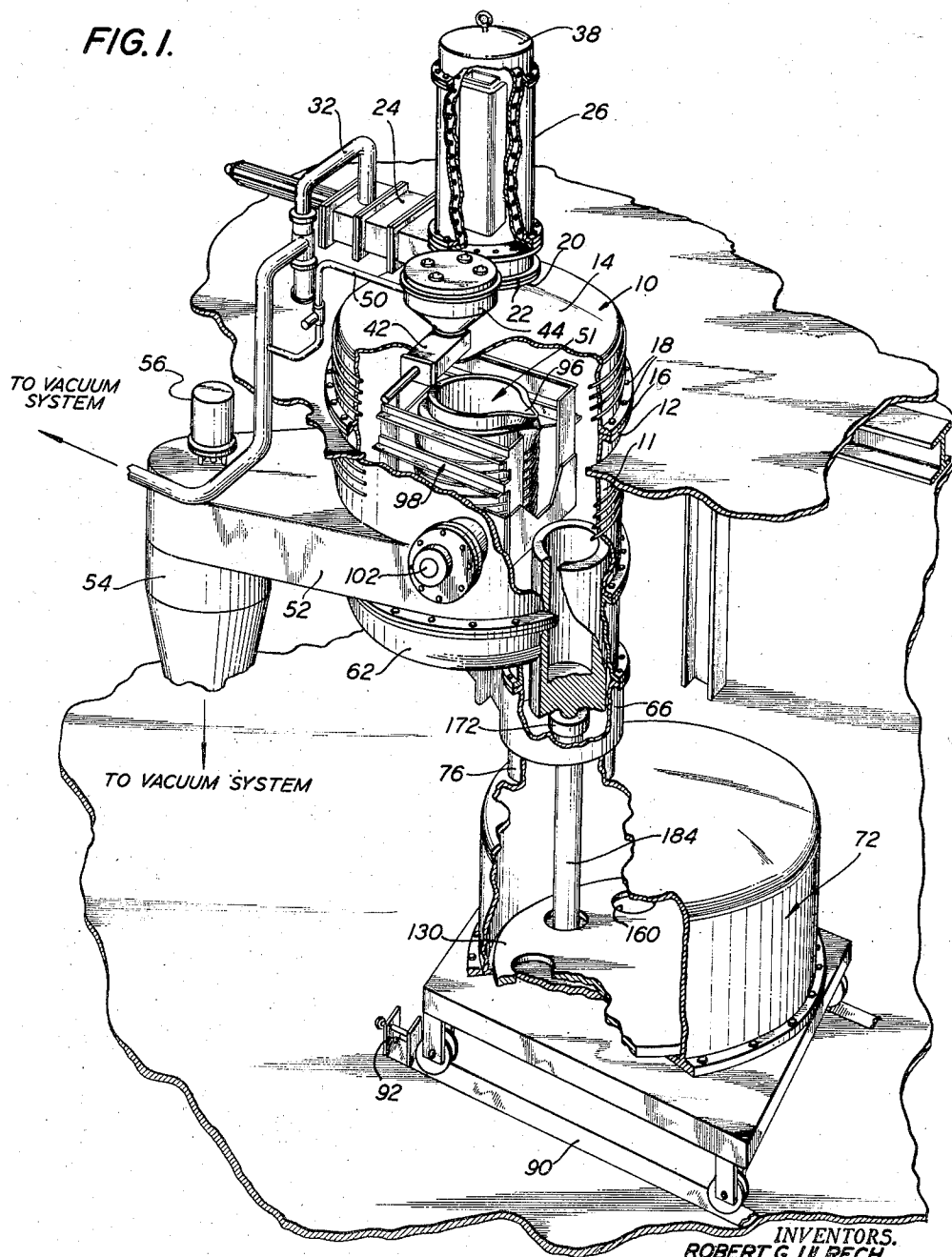
Filed May 3, 1955

R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

6 Sheets-Sheet 1

FIG. 1.



INVENTORS.
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

Christie, Parker & Hale
ATTORNEYS

March 11, 1958

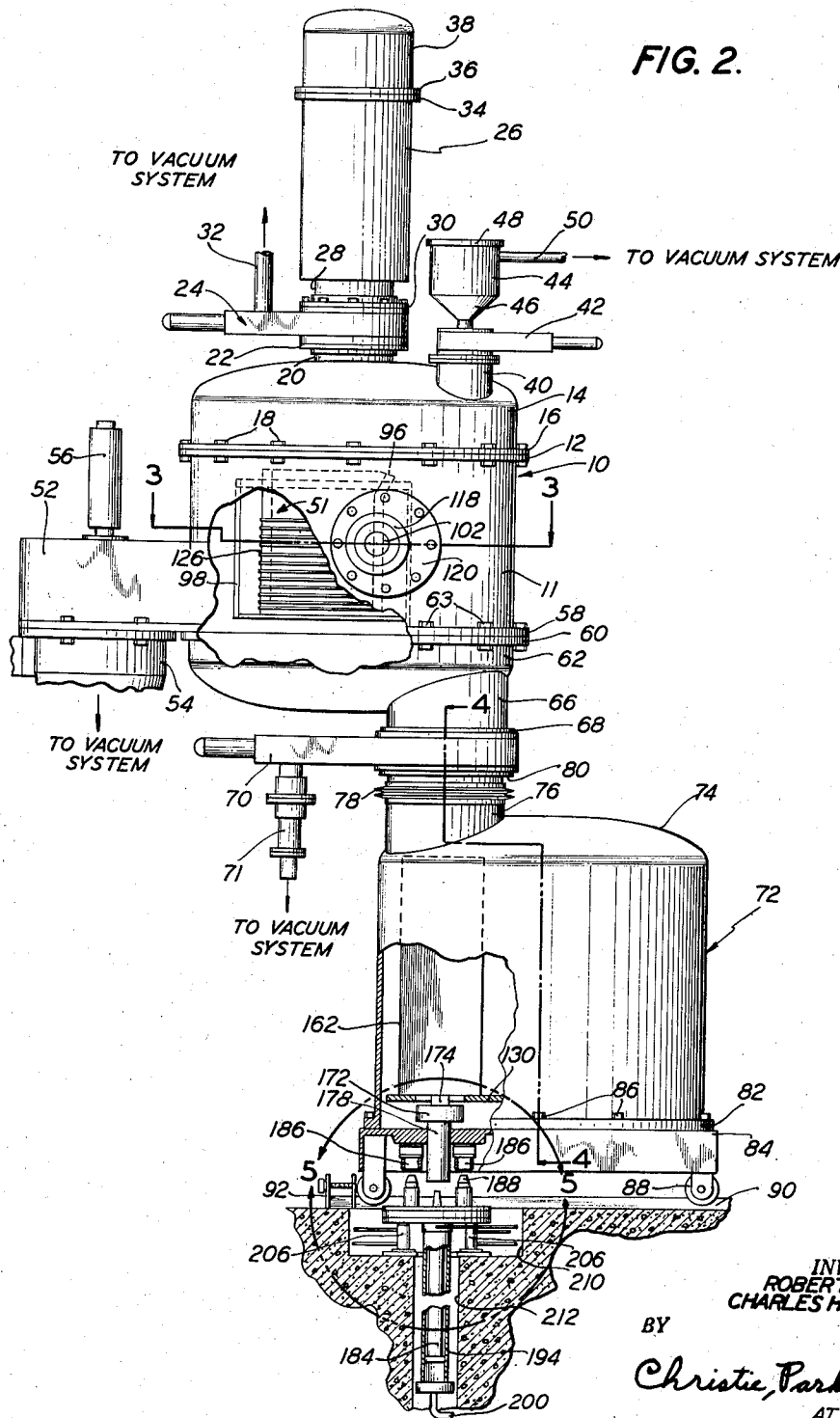
R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

Filed May 3, 1955

6 Sheets-Sheet 2

FIG. 2.



INVENTORS
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

Christie, Parker & Hale
ATTORNEYS

March 11, 1958

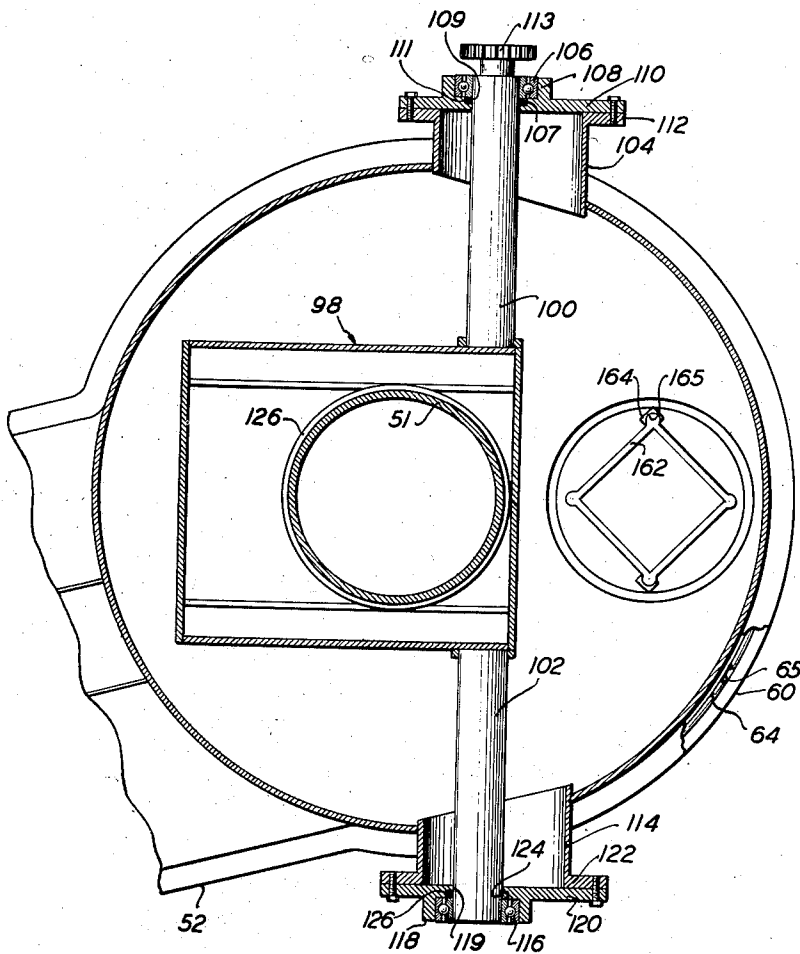
Filed May 3, 1955

R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

6 Sheets-Sheet 3

FIG. 3.



INVENTORS.
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

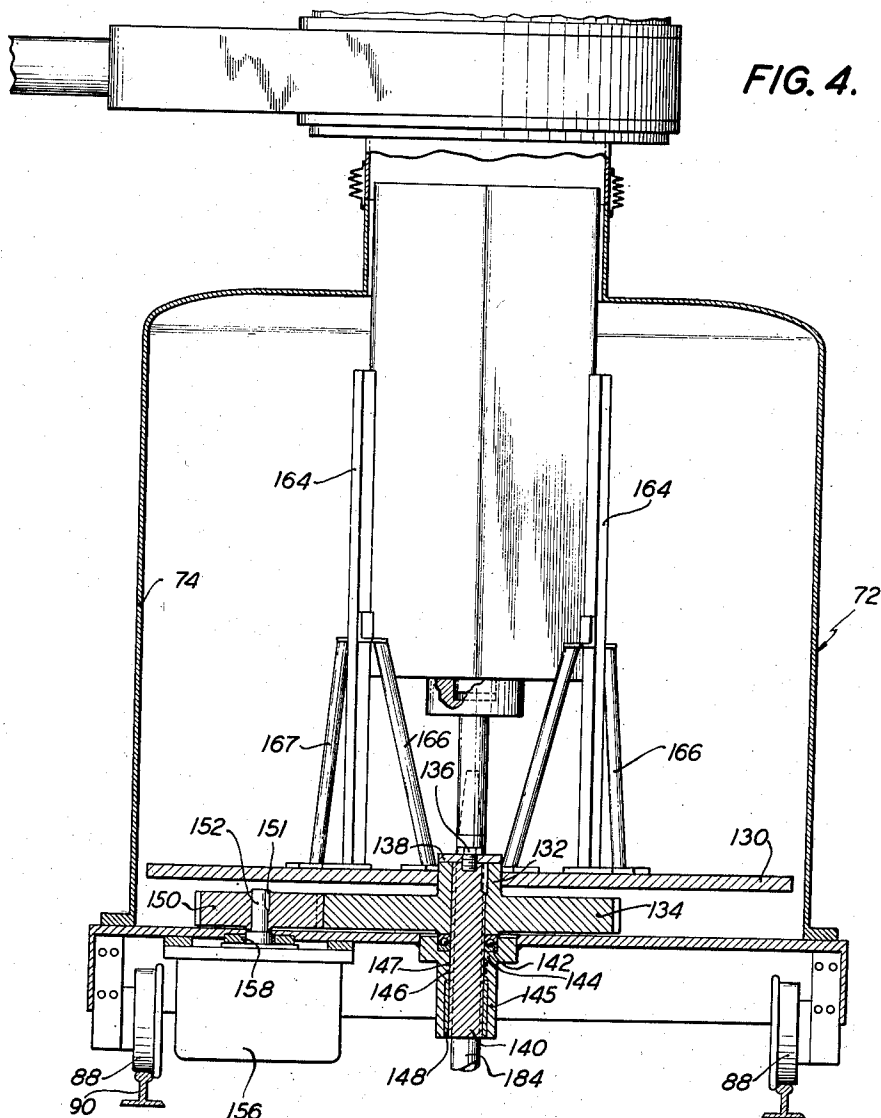
Christie, Parker & Hale
ATTORNEYS

Filed May 3, 1955

R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

6 Sheets-Sheet 4



INVENTORS.
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

Christie, Parker & Hale
ATTORNEYS

March 11, 1958

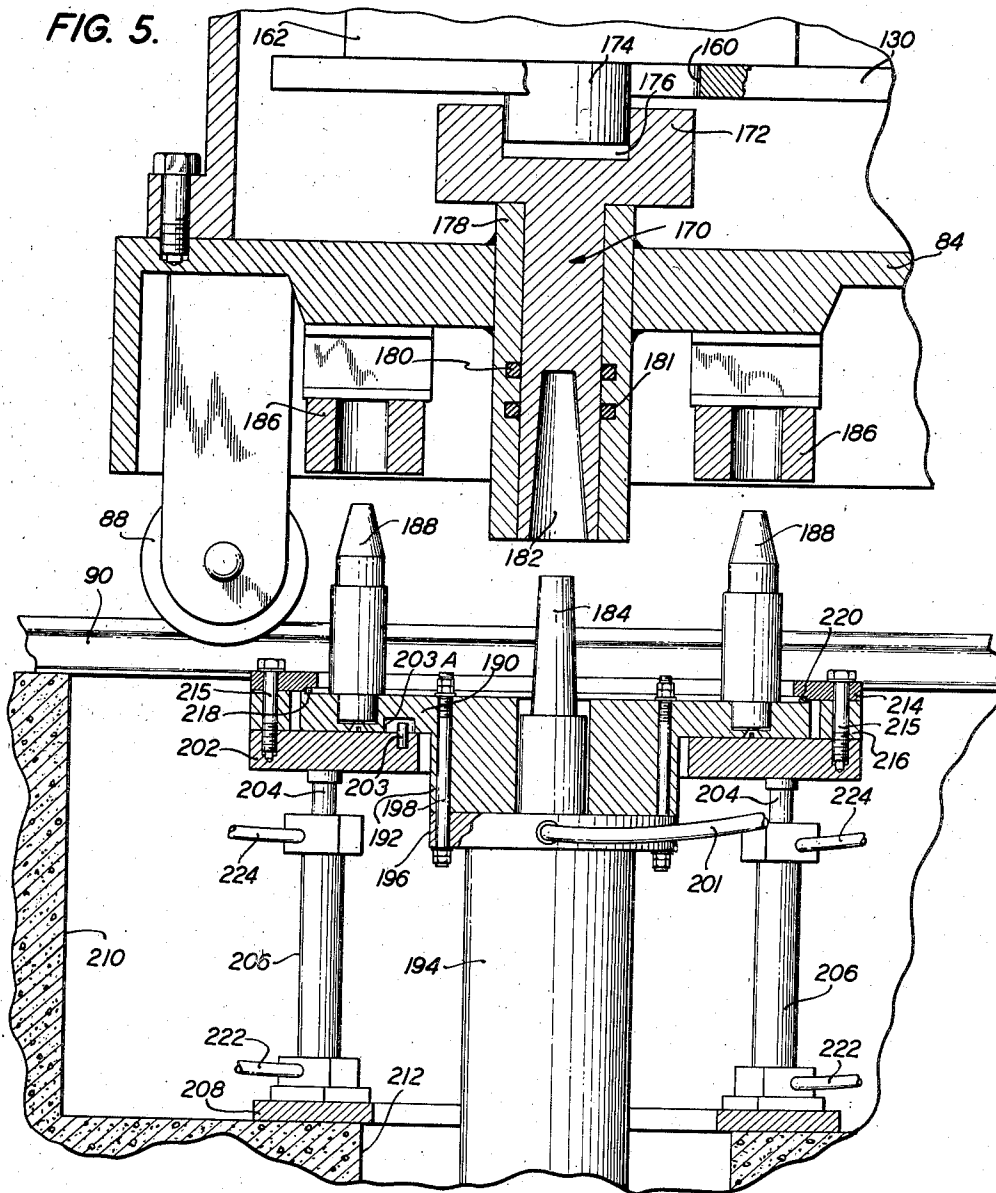
R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

Filed May 3, 1955

6 Sheets-Sheet 5

FIG. 5.



INVENTORS.
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

Christie, Parker & Hale
ATTORNEYS

March 11, 1958

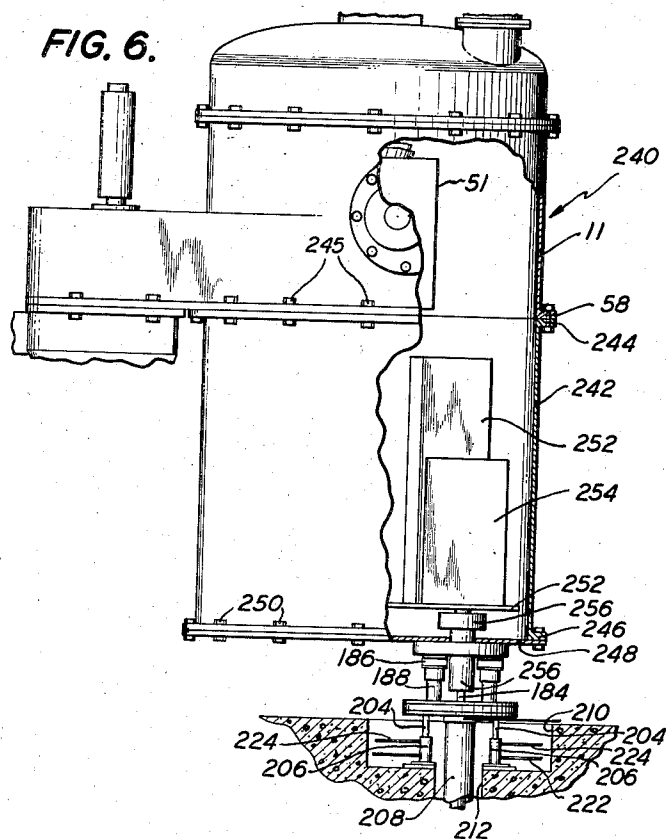
R. G. ULRECH ET AL
APPARATUS FOR MELTING METAL AND
SUCCESSIVELY CASTING INTO MOLDS

2,825,945

Filed May 3, 1955

6 Sheets-Sheet 6

FIG. 6.



INVENTORS.
ROBERT G. ULRECH
CHARLES H. NAUNDORF

BY

Christie, Parker & Hale
ATTORNEYS

1

2,825,945

APPARATUS FOR MELTING METAL AND SUCCESSIVELY CASTING INTO MOLDS

Robert G. Ulrech and Charles H. Naundorf, Rochester, N. Y., assignors, by mesne assignments, to Consolidated Electrodynamics Corporation, Pasadena, Calif., a corporation of California

Application May 3, 1955, Serial No. 505,632

7 Claims. (Cl. 22—73)

This invention relates to furnaces for melting and casting metal under vacuum.

In recent years increasing attention has been given to the casting of metals and conducting metallurgical reactions and processes under vacuum. It has been found that the physical and electrical properties of metals and alloys can be vastly improved, if the metals are cast or processed under vacuum. For this reason, vacuum metallurgy is receiving considerable attention in the metal industries, however, its growth is retarded because many potential users of vacuum furnaces are not able to predict their future requirements and are therefore reluctant to make an investment in equipment which might become obsolete or fail to meet their future needs. This problem results from the fact that furnaces in use prior to this invention usually consist of a large integral furnace chamber open at the top and provided with a removable cover. A crucible for holding the metal is disposed within the furnace chamber and means are provided for heating the metal above its melting point. Means are also provided for discharging the molten metal from the crucible into molds disposed within the vacuum chamber. This type of vacuum furnace suffers from the disadvantage that the furnace is opened to the atmosphere after each casting of the molten metal into a mold or else a separate mold chamber is provided which requires evacuation and exposure to the atmosphere for each mold which is filled with molten metal. The prior furnaces also have the disadvantage that if the crucible should break or fail and spill molten metal onto the furnace bottom, the entire furnace chamber is either ruined due to the metal burning through the bottom or operations must be suspended while the interior of the furnace chamber is cleaned.

This invention overcomes these disadvantages by providing a vacuum furnace which has a removable bottom. This not only permits the furnace bottom to be cleaned rapidly and easily or replaced quickly in the event of molten metal spilling in the furnace but also gives a high degree of flexibility to the furnace, since the bottom of the furnace can readily be changed to accommodate a plurality of molds of any size or shape. In addition, the removable bottom may be adapted to be connected through a relatively large conduit to a mold chamber which may be of any required size to accommodate various types and numbers of molds. A rotatable table is disposed in the bottom of the furnace or mold chamber, if a mold chamber is used, to rotate about a substantially vertical axis and carry a plurality of molds successively under the discharge of the crucible so that once the furnace chamber or mold chamber is evacuated, a plurality of castings can be made rapidly. This reduces the time that molten metal is in contact with the crucible and provides the advantage of increasing crucible life and reducing contamination of molten metal with impurities from the crucible.

In a preferred form of the invention, means are provided within the furnace bottom or mold chamber to raise each mold from a lower position to an upper position

2

just prior to the discharge of molten metal from the crucible into the mold. This reduces the length of drop of molten metal from the crucible to the mold and virtually eliminates splattering of molten metal outside of the crucible and mold. Furthermore, by reducing the distance between the crucible discharge and the mold into which molten metal is poured, a larger variety of metals can be handled without changing the position of the crucible as is sometimes required with other types of furnaces since different metals pour in different manners.

The preferred form of the invention also includes trunnions for supporting a crucible frame in which the crucible rests and trunnion supports or bearing surfaces which may be readily shifted to change the position of the crucible with the furnace without requiring any structural changes in the furnace.

These and other aspects of the invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is an overall perspective view, partially broken away, of one embodiment of the invention in which a furnace is provided with a removable bottom having a large downwardly extending conduit to which a mold chamber is attached;

Fig. 2 is an elevation, partially broken away, of the furnace and mold chamber shown in Fig. 1;

Fig. 3 is a horizontal section taken on line 3—3 of Fig. 2 showing the mounting of the crucible frame and trunnions in the furnace;

Fig. 4 is a vertical section taken on line 4—4 of the mold chamber showing the details of the rotatable table mounted therein;

Fig. 5 is an enlarged view taken on line 5—5 of Fig. 2 showing the details of the means for lifting a mold up toward the crucible; and

Fig. 6 is a schematic fragmentary elevation, partly broken away, of a furnace of the type shown in Figs. 1 and 2 except that the relatively shallow bottom of Figs. 1 and 2 has been replaced by a deep bottom and the mold chamber is omitted, the molds being carried on a rotatable table disposed within the deep bottom.

Referring to Figs. 1 and 2, a vacuum furnace 10 comprises an upright cylindrical shell or furnace chamber 11 provided with an outwardly turned flange 12 around its upper end. A dome shaped top closure 14 is provided with a flange 16 which matches that of the furnace chamber and seats thereon to effect a vacuum-tight seal. The top closure is secured to the furnace chamber by means of bolts 18, and may be provided with a bridge-breaker mechanism, removable sight glass assemblies, a sampling device and other accessories which are not shown, since they are not a part of this invention.

A relatively large diameter conduit 20 is provided in the center of the top closure and has an outwardly turned flange 22 at its upper end. A large vacuum gate valve 24 is bolted to the flange 22 and a main charging chamber 26 having a conduit 28 at its lower end with an outwardly turned flange 30 is bolted by means of flange 30 to the top of the valve 24. The gate valve 24 is provided with a conduit 32 which extends to a vacuum system (not shown) so that the charging chamber can be evacuated through the vacuum valve even though the valve is closed to isolate the charging chamber from the furnace. The vacuum valve 24 may be of any suitable type, but preferably it is of the type disclosed and claimed in co-pending application Serial No. 504,563 filed April 28, 1955. The upper end of the charging chamber is provided with an outwardly turned flange 34 on which there is seated a matching outwardly turned flange 36 formed integrally with the lower end of a dome shaped cover 38 for the charging chamber. The charging cham-

ber is provided with a conventional sealed hoisting mechanism (not shown) for lowering a fresh charge of metal into the furnace.

A smaller second upwardly extending conduit 40 is attached to the edge of the furnace cover and a vacuum gate valve 42 is attached to the upper end of conduit 40. An alloy addition chamber 44 having an inverted frusto-conical bottom 46 is flanged to the upper side of the valve 42 and is provided with a removable cover 48 for the addition of alloy or other chemicals as required. A conduit 50 leads from the alloy addition chamber to the vacuum system so that the alloy addition chamber can be evacuated even though the vacuum valve 42 is closed to isolate the alloy addition chamber from the vacuum furnace. A movable chute (not shown) is provided in the furnace chamber for directing alloy addition material into a crucible 51 disposed within the furnace chamber 11.

A large horizontal and flat conduit 52 is attached to the side of the furnace chamber and at the lower end thereof. A large vertical conduit 54 extends downwardly from conduit 52 to lead to the vacuum system, and the upper end of conduit 54 is adapted to be closed by a vacuum valve 56.

The lower end of the furnace chamber is provided with an outwardly turned flange 58 to receive a matching outwardly turned flange 60 formed integrally on the upper end of a dome shaped bottom closure 62. The two flanges are releasably held together to form a vacuum-tight seal by any suitable means, for example, by bolts 63. An O-ring 64 in an annular groove 65 formed in the upper surface of the flange 60 insures a seal between the two flanges (see Fig. 3).

A relatively large conduit 66 extends downwardly from the edge of the bottom closure and is provided with an outwardly turned flange 68 at its lower end to which is secured a vacuum gate valve 70 having a conduit 71 leading to the side of the valve away from the furnace chamber. A mold chamber 72 having a dome shaped top 74 is connected to the bottom of the vacuum valve 70 by means of a conduit 76 attached to the edge of the mold chamber top and provided with a bellows 78 at its upper end which in turn is sealed to a flange 80 bolted to the valve 70. An outwardly turned flange 82 formed on the bottom of the mold chamber top is secured to a bottom plate 84 by means of bolts 86. Railway-type wheels 88 support the mold chamber and ride on a track 90 which extends under the furnace and is provided with an adjustable stop 92 for positioning the mold chamber directly under the conduit 66.

Referring to Figs. 2 and 3, the crucible 51 which is open at its top and provided with a pouring lip 96 sits in a crucible frame 98 provided with a horizontal outwardly extending drive trunnion 100 on one side and at its forward portion and with a support trunnion 102 extending co-linearly with the drive trunnion on the other side of the frame. The outer end of the drive trunnion extends through a conduit 104 in the side of the furnace chamber and is journaled in a bearing 106 carried within an outwardly extending annular boss 108 formed around an opening 109 located eccentrically in a plate 110 bolted to an outwardly turned support member which may be a circular flange 112 formed integrally on the outer end of conduit 104. An annular groove 107 in the outer surface of plate 110 around opening 109 supports an O-ring 111 which forms a vacuum-tight seal between the drive trunnion and circular plate 110. The outer end of the drive trunnion is provided with a spur gear 113 for receiving power from a suitable source (not shown) to tilt the crucible as required.

The outer end of the support trunnion extends through a conduit 114 in the side of the furnace chamber and is journaled in a bearing 116 carried within an outwardly extending annular boss 118 formed around an opening 119 located eccentrically in a support member which may

be a circular plate 120 bolted to an outwardly turned flange 122 formed integrally on the outer end of conduit 114. An annular groove 124 in the outer surface of plate 120 around opening 119 carries an O-ring 126 which forms a vacuum-tight seal between the rotatable support trunnion and the circular plate 120.

An induction heating coil 126 is disposed around the crucible and adapted to be connected to a suitable source of electric power, not shown.

Referring to Figs. 2 and 4, a rotatable horizontal table 130 having an outside diameter slightly less than the inside diameter of the mold chamber is secured at its center to an upwardly extending hub 132 (Fig. 4) on a horizontal spur gear 134 by means of a bolt 136 and retaining washer 138 at the upper end of a shaft 140 keyed to the spur gear 134 which rests on an annular thrust ball bearing 142 housed in a bearing housing 144 formed in the center of the mold chamber bottom. The shaft 140 extends down into a hub 145 on the lower side of the bearing housing and is rotatably sealed to the hub by means of a pair of O-rings 146 and 147 disposed in annular grooves in the interior of the upper portion of the hub. The lower portion of the hub is provided with an inner bearing sleeve 148 to give stability to the shaft which terminates flush with the lower end of the hub.

The gear 134 is supplied power from a driving gear 150 which is secured by a key 151 to a vertical drive shaft 152 journaled in the mold chamber bottom. The drive shaft extends downwardly through the mold chamber bottom and into an electric motor 156 which is supplied power by any suitable means (not shown). The drive shaft is rotatably sealed to the mold chamber bottom by means of an O-ring 158.

The table 130 is provided with a plurality of holes 160 around its periphery over each of which a separate mold 162 of square cross-section is adapted to sit. A pair of upwardly extending guide bars 164 are disposed in diametrically opposed positions around each hole for guiding the respective molds as they are raised and lowered in a manner described below. Each guide bar is rigidly attached at its lower end to the table and has a vertical channel 165 opening toward its respective hole to fit around the nearest corner of the associated mold. An upwardly and outwardly extending brace 166 and an upwardly and inwardly extending brace 167 are attached to each guide from the table for increased stability.

Referring to Figs. 2 and 5, the molds are raised from their respective positions on the table up into pouring position by means of a vertical ram 170 and provided with an enlarged portion 172 at its upper end to support the mold. Ordinarily each mold is provided with a downwardly extending projection 174 on its bottom and the enlarged section of the ram is provided with an upwardly opening recess 176 to receive the mold projection. The lower portion of the ram extends through a support sleeve 178 rigidly sealed through the mold bottom, for example, by welding. A pair of O-rings 180, 181 in the sleeve maintain a vacuum-tight sliding seal between the sleeve and the ram. The lower end of the ram is provided with an inwardly tapering bore 182 which receives a main piston 184 shaped at its upper end to match the bore, the outside diameter of the remainder of the piston being equal to the outside diameter of the ram so the piston can mate with the ram, lift the ram up through the sleeve 178, and maintain a vacuum-tight seal while sliding in the sleeve.

A pair of downwardly extending guide sleeves 186 are rigidly attached to the bottom side of the mold chamber on each side of the support sleeve 178. The guide sleeves are adapted to receive a matching pair of upwardly extending guide posts 188 tapered at their upper ends and having their lower ends attached to the upper surface of a horizontal aligning ring 190 having a downwardly extending boss 192 co-axially disposed about the upper portion of the main piston 184. A main cylinder 194 is dis-

5

posed around the lower portion of the main piston and is provided with an outwardly turned flange 196 at its upper end which is rigidly secured to the underside of the boss 192 by means of bolts 198. The main piston is raised and lowered within the main cylinder by hydraulic pressure supplied through lines 200 (Fig. 2) and 201 located at the lower and upper ends of the cylinder respectively. The aligning ring is slidably supported on the upper surface of a thrust ring 202 having an outside diameter greater than that of the aligning ring and an inside diameter greater than the outside diameter of the boss on the aligning ring. A vertical stop pin 203 fixed in the thrust ring protrudes from the upper surface of the thrust ring into a radial slot 203A in the bottom of the aligning ring. The radial dimension of the slot is equal to the diameter of the stop pin plus the possible displacement of the aligning ring, that is, approximately one-half the difference between the inside diameter of the thrust ring and the outside diameter of the boss 192 and makes sliding contact with the sides of the pin so that the pin acts as a bar to rotation of the aligning ring. The thrust ring is supported by a plurality of pistons 204 (preferably at least 3 pistons equally spaced around the main cylinder) which slide in their respective aligning cylinders 206, each aligning cylinder being rigidly attached at its base to a support ring 208 disposed in the bottom of a cellar 210 provided with a cylindrical sump 212 to accommodate the lower portion of the main cylinder 194.

A retaining ring 214 of the same outside diameter as the thrust ring and having an inside diameter slightly less than the outside diameter of the aligning ring is secured to the thrust ring 202 by means of bolts 215 and spaced from the thrust ring by an annular spacing ring 216 having an outside diameter equal to that of the thrust ring and an inside diameter slightly greater than the outside diameter of the aligning ring. An annular groove 218 in the lower face of the retaining ring and at its inner periphery holds an O-ring 220 which effects a sliding seal between the aligning ring and the retaining ring.

Fluid is supplied to the aligning cylinders to raise and lower the aligning pistons by means of fluid lines 222 and 224 disposed at the bottom and top respectively of the aligning cylinders. Thus, the main cylinder and main piston can be raised and held in an elevated position by the aligning cylinders, the guide posts fitted into their respective sleeves to slide the aligning ring laterally as required to bring the upper end of the main piston into alignment with the bore in the bottom of the ram. This insures perfect alignment of the main piston with the ram and avoids the possibility of the ram being lifted before the main piston is properly seated in the bore, thus permitting some latitude in the positioning of the mold chamber over the main piston.

The operation of the apparatus of Figs. 1 through 5 is as follows: The crucible is filled with metal prior to evacuating of the furnace and vacuum valves 24, 42 and 70 are closed and vacuum valve 56 leading to the vacuum system is opened so that the vacuum furnace may be evacuated. After proper vacuum is produced in the furnace, power is applied to the induction coils around the crucible to melt the metal and achieve additional outgassing. The mold chamber is rolled into position under the conduit 66 and attached to the bottom side of the valve 70 while degassing of the furnace continues. The mold chamber is then evacuated through valve 70 by means of conduit 71 attached to the valve and leading to the vacuum system. After the mold chamber is evacuated to the required pressure, the valve 70 is opened and the mold 162 positioned directly under the conduit 76 and is raised by means of the main piston and the ram after the aligning pistons are actuated to slide the guide posts up into their respective guide sleeves. The crucible is tilted by means of power applied to the drive trunnion so that molten metal is poured into the raised mold. After the required amount of metal is poured into the mold, the

6

main piston is actuated to lower the ram and mold to their original positions as shown in Figs. 2 and 5. The guides 164 serve to steady each mold as it is raised and lowered. The electric motor 156 is then actuated to rotate the table 130 until another empty mold is positioned under the conduit 76. The above cycle is then repeated until all of the molds in the mold chamber are filled. Thus, a plurality of castings are made rapidly without having to make and break vacuum for each casting. This not only speeds up the casting process, but also increases crucible life due to the reduced time that the crucible must be in contact with molten metal for a given number of castings and also reduces contamination of the molten metal from impurities in the crucible due to reduced contact time.

Although not shown, appropriate interlock circuits are incorporated with the furnace to insure, among other things, that, (1) the ram is not raised until the table is properly indexed with a hole directly over the ram, (2) the crucible is not tilted until a mold is raised to the proper position, and (3) the table is not rotated until the ram is returned to its lower position.

After all of the molds are filled in the mold chamber, vacuum valve 70 is then closed and the mold chamber is disconnected therefrom and removed so that the filled molds can be removed and replaced, or so that a second mold chamber may be rolled into position to replace the first and permit additional ingots to be cast as described above.

New charges of metal may be introduced as required into the crucible during the casting operation through the charging chamber 26. With the valve 24 closed, the cover of the charging chamber is removed and a new charge of metal is placed in the chamber. The charging chamber cover is then replaced and sealed. The charging chamber is evacuated through conduit 32. After the required pressure in the charging chamber is attained, valve 24 is opened and the new charge of metal is lowered into the crucible by the charging chamber hoisting mechanism (not shown). The new charge of metal is released and the hoisting mechanism withdrawn back up into the charging chamber. The valve 24 is then closed so that another charge of metal may be introduced into the charging chamber.

Special alloy material or chemicals can be introduced into the crucible independently of the main charge of metal by means of the alloy addition chamber. For example, with the valve 42 closed, alloy addition material or chemicals are placed in the alloy addition chamber and the cover of the chamber is then sealed in place. The alloy addition chamber is evacuated by means of conduit 50 and when the required pressure is achieved in the alloy addition chamber, the valve 42 is open and the alloy addition material is discharged into the crucible by means of the chute (not shown) which is moved to extend from below the alloy addition chamber downwardly to end over the crucible. After the addition is completed, the chute is moved, for example by conventional winch means (not shown), clear of the crucible to permit pouring.

An alternate embodiment of the invention is shown schematically in Fig. 6 in which a furnace 240 is shown similar to the furnace described above except that the relatively shallow bottom of the previously described furnace is replaced by a relatively deep cylindrical bottom 242 having an outwardly turned flange 244 at its upper end which is secured to the flange 58 of the furnace chamber by means of bolts 245. An outwardly turned flange 246 is formed on the lower edge of the furnace bottom and a plate 248 is secured to the flange 246 by means of bolts 250. A horizontal table 252 is rotatably supported just above the plate 248 in a manner described for the rotary table of Figs. 2 and 4, the driving means and support means for the table not being shown for simplicity. The table is provided with holes around its periphery to support a plurality of molds 252 and 254 which may be of

7

various shapes. A ram 256 is slidably sealed in the bottom of the furnace and the main piston 184 is adapted to fit into the lower end of the ram and raise the ram and mold above the ram in the same manner as described above. Associated with piston 184 are the guide posts, aligning ring, thrust ring, aligning piston, aligning cylinder, main cylinder, cellar, sump and guide sleeves as described for the apparatus of Figs. 2 and 5 so that the molds in the furnace bottom can be raised to a point just under the lip of the crucible when the crucible is tilted into pouring position.

The operation of the furnace of Fig. 6 is similar to that of the furnace of Figs. 1 through 5 except that after the casting operation into the molds is completed, the furnace must be opened to atmospheric pressure and the furnace bottom removed so that the molds can be withdrawn. Thus, this furnace does not have quite the same degree of flexibility as the furnace shown in Figs. 1 through 5, but it does permit the rapid pouring of a plurality of ingots without having to make and break vacuum connections. For many types of batch operations this is entirely satisfactory and it greatly increases the speed of casting with the resultant increase in crucible life and decrease in metal contamination.

We claim:

1. In apparatus for melting metal and successively casting the metal into a plurality of molds under vacuum, the combination which comprises a vacuum-tight furnace chamber, a crucible disposed within the furnace chamber for holding the metal, means for melting the metal in the crucible, means for discharging the molten metal from the crucible, a conduit leading downwardly from the bottom closure and located directly below the crucible discharge, a mold chamber disposed below and sealed to the conduit, a ram slidably disposed in and sealing a bore in the mold chamber bottom in a first position directly under the crucible discharge, a plurality of molds positioned within the mold chamber, means for successively moving the molds in the chamber into position over the ram, a piston disposed below the mold chamber in alignment with the ram, means for moving the piston up to engage and lift the ram and a mold overlying it to a second position closer to the crucible discharge, the piston having a cross-section substantially the same as that of the ram so that the piston forms a sliding seal in the bore in the mold chamber bottom as the ram moves up to the second position, and means for lowering the piston to return the ram to its first position to receive the next mold so that a vacuum is maintained during the filling of all the molds.

2. In a system for melting material in a crucible contained in a furnace chamber and for pouring the melted material into a plurality of molds without permitting pressure change within the system, the combination comprising a movable mold chamber having an opening therein releasably connected to an opening in the furnace located below the crucible discharge, a ram slidably disposed in a bore in the mold chamber bottom in a first position directly under the crucible discharge, a piston disposed below the mold chamber in alignment with the ram, a plurality of molds in the mold chamber, means for successively moving onto the ram each of the molds contained in the mold chamber, means for moving the piston up to engage and lift the ram to a second mold-filling posi-

8

tion, the piston having a cross-section substantially the same as that of the ram so that a seal is maintained in the bore as the ram moves the mold toward the second position, and means for lowering the piston to return the ram from its second to its first position so that a filled mold can be moved off the ram and the next mold moved onto the ram.

3. A system in accordance with claim 2 wherein the means for successively moving the molds over the ram comprises a rotatable table provided with a plurality of holes around its periphery over each of which a separate mold is adapted to sit.

4. Apparatus according to claim 2 provided with indexing means for aligning the movable mold chamber in fixed position with respect to the piston and the furnace chamber.

5. Apparatus according to claim 2 provided with mating means for urging the piston into alignment with the ram as the piston is moved upward.

6. In apparatus for melting and casting material, the combination which comprises a furnace chamber having apertures on opposite sides, a crucible disposed within the chamber between the apertures, a trunnion connected to and holding the crucible and provided with coaxial shaft portions extending into the apertures and of smaller cross-section than the apertures, bearings on the respective shaft portions, support members holding the respective bearings and extending across the apertures in the furnace chamber, and means for holding the members to the furnace chamber in a plurality of positions with the members sealing the apertures in each position but with the shaft portions differently located with respect to the aperture in each position.

7. Apparatus according to claim 6 provided with flanged conduits projecting from the apertures and sealed to the chamber, the support members holding the bearings being fastened to the conduits and adjustable with respect to them so that the position of the shaft portions within the apertures can be changed in a direction transverse to the shaft axes.

References Cited in the file of this patent

UNITED STATES PATENTS

735,795	Morse	Aug. 11, 1903
1,056,101	Howard	Mar. 18, 1913
1,062,289	Maxwell	May 20, 1913
1,354,286	De Bats	Sept. 28, 1920
2,060,134	Summey	Nov. 10, 1936
2,060,137	Bahney	Nov. 10, 1936
2,085,450	Rohn	June 29, 1937
2,133,634	Rohn	Oct. 18, 1938
2,379,401	Poulter	June 26, 1945
2,625,719	Moore	Jan. 20, 1953
2,635,310	Morgan	Apr. 21, 1953
2,713,183	Winkler	July 19, 1955

FOREIGN PATENTS

723,699	Great Britain	Feb. 9, 1955
1,076,658	France	Apr. 21, 1954
305,560	Germany	Aug. 28, 1919

OTHER REFERENCES

The Iron Age, June 19, 1947, pp. 55-59.