

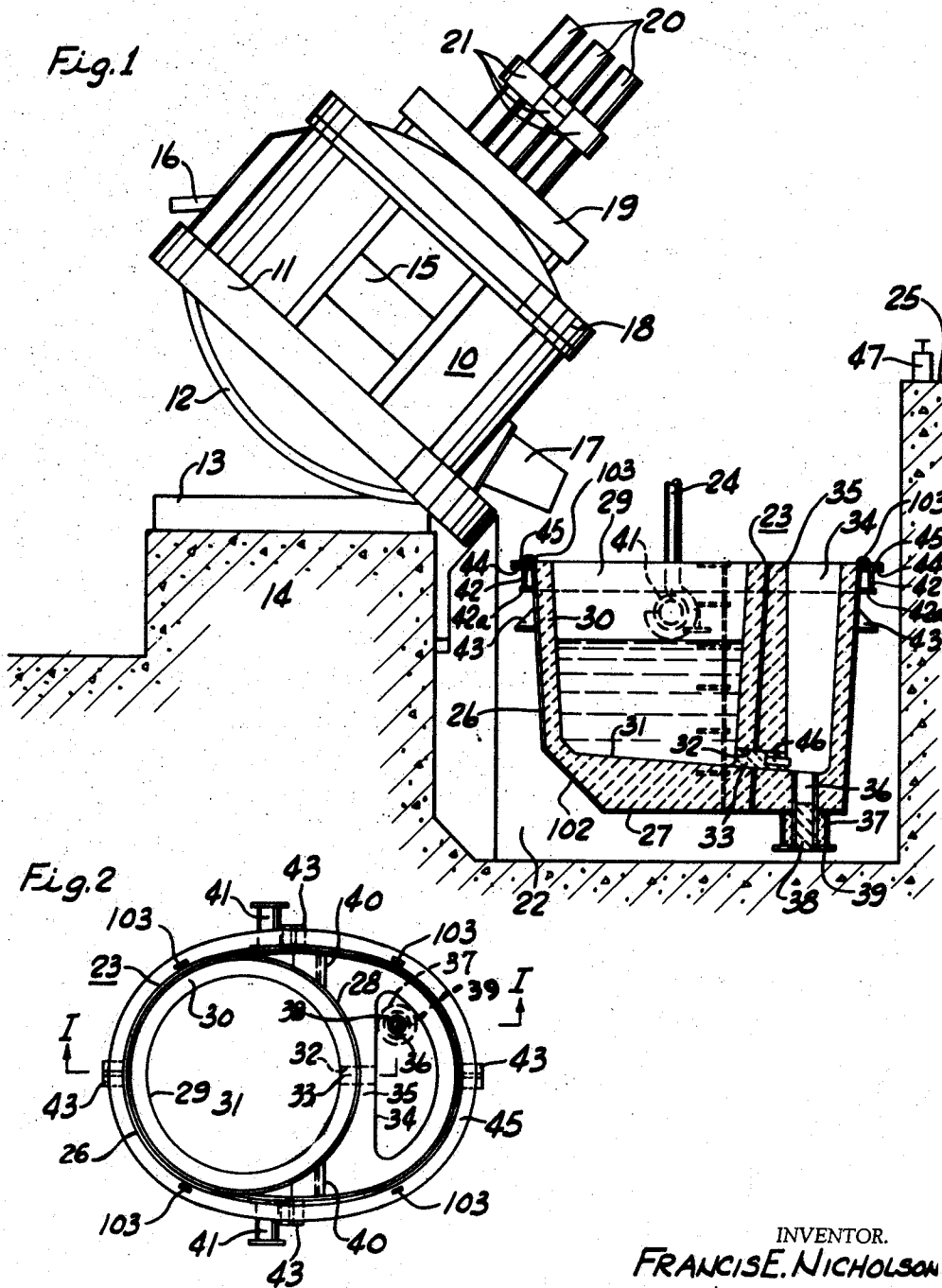
Sept. 22, 1964

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DOUBLE CHAMBER VACUUM DEGASSING
METHOD, APPARATUS, AND LADLE

3,149,959

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4 Sheets-Sheet 1



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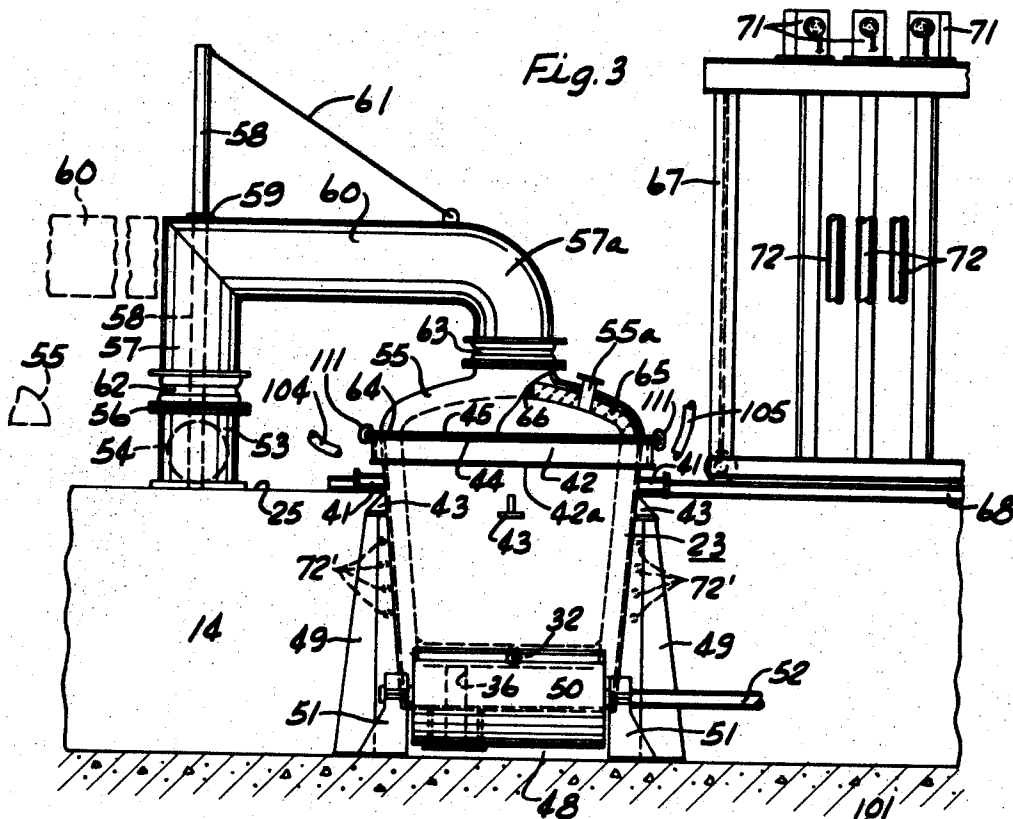


Fig. 6

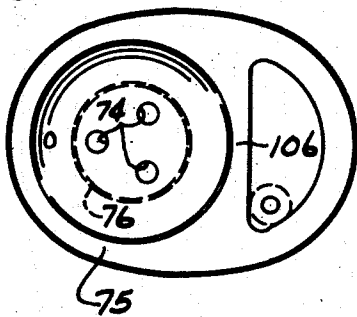
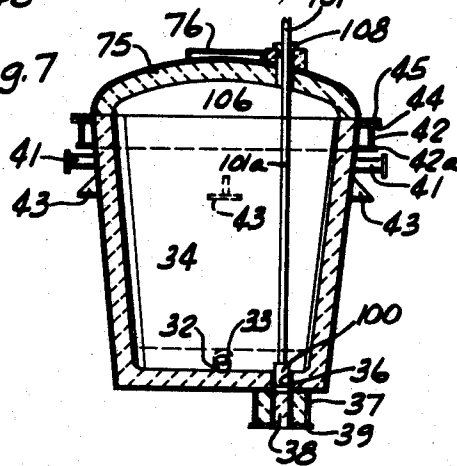


Fig. 7



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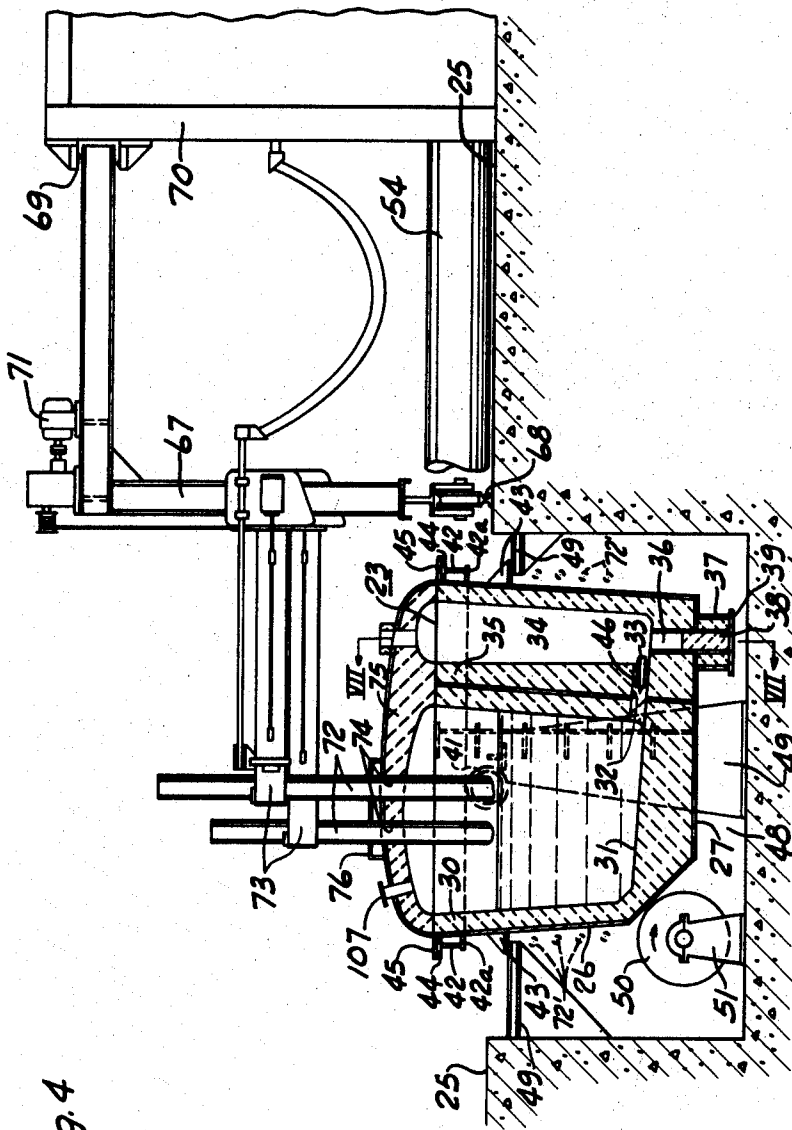


Fig. 4

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1

3,149,959

DOUBLE CHAMBER VACUUM DEGASSING METHOD, APPARATUS, AND LADLE

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13 Claims. (Cl. 75-49)

This invention relates to a vacuum degassing ladle operation for teeming and casting of ferrous and alloy metals and the like. More particularly, this invention relates to a vacuum degassing operation with a double-chamber tap ladle for relatively high production of relatively high strength alloys.

Many efforts have been made, particularly in recent years, for the production of castings including ingots relatively free from foreign inclusions and from porosity, blowholes and dissolved or other gases by vacuum degassing of the metal while molten. A number of such efforts have endeavored to provide such degassing while the molten metal was being poured in a stream into a mold or flask, or to draw out such gases under vacuum from relatively small pools of the metal following tapping of the metal furnace in which it was produced. In addition, efforts have been made to wholly enclose and seal the melting furnace itself for the removal of such gases therein by the application of a vacuum to its interior. Consequences have been either the handling of relatively small amounts of degassed metal at one particular time, or costly expense as in the case of attempting to seal an entire furnace, with results often unsatisfactory in terms of handling steps, or attainable production, or expense of degassing, or a combination of such difficulties.

The foregoing deficiencies will be overcome in a practice of this invention. Under this invention, relatively sizeable quantities of metal may be relatively rapidly handled between melting furnace and pouring location with efficient vacuum degassing and production of degassed molten metal at relatively lower cost. Such benefits, moreover, are attainable hereunder without requiring sealing of any melting furnace, or special handling of smaller lots, and preferably employ a double-chamber ladle particularly suitable for a practice of this invention.

Other objects, features and advantages of this invention will be apparent from the following description and the accompanying drawings, which are illustrative only, in which:

FIGURE 1 is a view in side elevation and section of a tapping step in one illustrative practice of this invention utilizing my double-chamber ladle;

FIGURE 2 is a plan view of the double-chamber ladle shown in FIGURE 1, the section in FIGURE 1 being taken along line I—I of FIGURE 2;

FIGURE 3 is a view in elevation of apparatus and stations for performing vacuum degassing and any desired reheating in a practice of this invention;

FIGURE 4 is a view in end elevation of the apparatus shown in FIGURE 3 with a reheating step being performed in an operation thereof;

FIGURE 5 is a view of the degassed molten metal being poured in the illustrated practice of this invention;

FIGURE 6 is a bottom view of the cover utilized in the reheating and teeming steps of FIGURES 4 and 5, respectively; and

FIGURE 7 is a view in section taken generally along line VII—VII of FIGURE 4 and indicating utilization of a stopper where, for example, more than one container is to be filled from the ladle in one operation.

Referring to the drawings, a melting furnace 10 is shown therein utilizing the electrical arc principle for the production of ferrous or other metals, or their alloys, of

2

desired composition, respectively. The melting furnace schematically shown has a base 11 on a rocker 12 which rocks on a support means 13 secured to a foundation 14. The body of furnace 10 is provided with a charging door 15, a slag tap 16 and a metal tapping spout 17. A top 18 of the furnace is secured to a frame 19 to enable the top to be removed at desired times. Electrodes 20 extend through openings in roof 18 and are connected to holders 21 which, by means not shown, automatically or manually regulate the axial movement of the electrodes in an operation of furnace 10. Foundation 14 is provided with a tapping pit 22 for a tapping ladle 23 supported in pit 22 by a ladle bail 24 normally suspended from a crane hook above it. The other side of foundation 14 rises to a height 25 which represents the level of the plant floor in the illustration. In the tilted position shown, furnace 10 is on the point of completing the pouring of molten metal into a relatively large capacity tapping ladle 23 before the furnace is rocked back to a vertical position whereupon ladle 23 can be lifted out of pit 22 for furtherance of an operation in accordance with this invention.

Ladle 23 is a double-chamber ladle having an outer shell 26 which is oval in plan and includes a bottom 27. The shell 26 is made of steel or other suitable metal. The lower part preferably is made of relatively non-magnetic metal such as stainless steel. The lower front edge of ladle 23 is beveled at 102 to enable an induction stirrer to be positioned in juxtaposition thereto as illustrated in FIGURE 4. An inner shell 28 of steel defines a receiving chamber 29 which is lined with refractory 30 around the walls and across its bottom. A refractory floor 31 in chamber 29 slopes toward a bughole 32 which is normally closed by a plastic or clay plug 33. The bughole is a passage which passes through shell 28 into a smaller discharge chamber 34 which also is lined with refractory 35. Chamber 34 has an outlet passage 36 in the bottom thereof, which may be lined with carbon blocks, extending through a bottom pouring spout 37 which may normally be closed by a clay or plastic plug 38 and/or by a stopper 100 of a conventional type having an operating rod 101 with insulation 101a thereon. Rod 101 would be operated by linkage (not shown) adjacent the top of ladle 23 outside of any cover that may be used. The lower end of spout 37 is provided with an annular flange 39 for a sealing connection.

Steel bulkheads 40 are provided, imbedded in refractory, to be secured to and extend between inner shell 28 and outer shell 26. Trunnions 41 are provided in transverse alignment and extend outwardly from shell 26 to enable ladle 23 to be lifted and set down by bail 24. Brackets 43 are provided at the ends of the major and minor horizontal axes of ladle 23 to serve to support the ladle when the brackets are engaged by posts, or a stand, or the sides of a ladle opening in a ladle car, or other ladle support. A hollow metal brim 42 is secured to shell 26 and extends around the periphery of ladle 23, the annular lower plate 42a of which may also serve as a support when ladle 23 is to be held up by posts or a stand. An upper annular plate 44 comprises a sealing surface. A ring bib 45 is placed on plate 44, preferably, during a tapping operation in pit 22, to keep molten metal splashes from adhering to plate 44, the bib being capable of being removed and replaced by eyebolts 103 secured thereto. The hollow interior of member 42 is preferably filled with water during at least part of an operation to act as a coolant when ladle 23 is held by a stand such as stand 49, during which time coolant may be circulated through the interior of brim 42 by flexible inlet and outlet hoses 104 and 105 connected to suitable inlet and outlet fittings on brim 42 communicating with the interior thereof. Normally, there is no water in the interior of member 42 during the tapping

operation shown in FIGURE 1. Plug 33 at the desired time for casting or pouring from ladle 23 may be removed, e.g., by exploding a cartridge 46 imbedded therein at the time that passage 32 is plugged. A remote operation, or a wire-connected, detonator 47 may be used for such purpose; or plug 33 and plug 38 at the time of pouring from ladle 23 may be burned out with an oxygen jet lance. Plug 38 would not, of course, be required in the event that a conventional bottom pouring stopper is utilized in passage 36 of sufficient tightness to enable the ladle to be evacuated by the use of a vacuum hood.

The molten metal from furnace 10 is tapped only into receiving chamber 29 and desired ladle additions may be provided at that time. No metal enters discharge chamber 34 by reason of plug 33 and after spout 17 returns to its level position, the bail 24 may be raised to lift the ladle 23, which may be filled either wholly or partially, out of pit 22 and deposit it in a nearby pit 48 so that it rests on the appropriate parts of stand 49 which engage support brackets 43 and allow the bail 24 to be disengaged and taken away. Pit 48 preferably also contains an electric induction stirrer 50 which, as shown, has trunnions which are journaled in bearing supports 51, the stirrer being turned by a shaft 52 connected to a nearby motor (not shown); or the molten metal contents of chamber 29 in ladle 23 may be stirred by a bed-type of induction stirrer positioned in pit 48 beneath the underside of the ladle, as desired.

The plant floor 25 in the vicinity of pit 48 is provided with a fixed hollow base column 53 connected to a vacuum pipe 54 through which gases in ladle 23 are evacuated after a vacuum degassing hood 55 is attached to the ladle in a sealed connection. Base column 53 is connected by a swivel joint 56 to a swing pipe column 57, the vertical reach of which is rotatable about a water-cooled post 58 which extends above column 57 and has a bushing seal 59 provided where post 58 passes out therethrough. Hood 55 is connected by an elbow 57a in pipe 57 to the horizontal reach 60 thereof, a horizontally rotatable guide 61 being employed to support pipe 60 and hood 55 in the course of operation and swinging about the axis of post 58 between its operative position shown in full line in FIGURE 3 and its inoperative (vacuum shut-off) position shown in dotted outline. Axially extensible sections 62 and 63 are provided in pipe 57 respectively just above the swivel joint and between hood 55 and its elbow 57a. As shown in FIGURE 3, hood 55 is provided with a horizontal flange 64 which seats on plate 44, after bib 45 has been removed, so that the two may clamp together, as by C-clamps 111 after the parts 64 and 44 have been brought together, sealing the interior of ladle 23 inasmuch as passage 36 is also plugged. If a conventional single chamber top pouring ladle should be used it would also be necessary to seal the spout before evacuating the interior of that ladle. All seal connections are provided with suitable gaskets that may be required. Hood 55 comprises an inner refractory roof 65 having a central opening 66 through which fumes and gases drawn off and out of the molten metal in chamber 29 and the ladle may pass through the vacuum apparatus and out through pipe 54 in the course of an evacuation operation. During such evacuation, induction stirrer 50 preferably is rotated to agitate the molten metal to promote the evacuation of gases therefrom. Hood 55 is provided with a fitting 55a communicating with the interior thereof and having a plate closure, the fitting serving as and when desired for use as an observation port when a suitable window is provided in the closure plate, or for any ladle addition which may be desired during the evacuation step when the plate is opened or removed.

Upon completion of the vacuum degassing operation upon the ladle 23, the ladle may be left in place in pit 48 should it be desired to restore the temperature of the metal to offset heat loss or even to raise the tem-

perature of the molten metal in chamber 29. In that event, a swingable gantry frame 67 rolls on an arcuate track 68 about a pivot 69 on a post 70 to enable it to be moved from the line position shown in FIGURE 3 to an operative position above ladle 23 as shown in FIGURE 4, after hood 55 has been raised and swung to the dotted line position shown in FIGURE 3. The top of frame 67 is provided with motor-operator sets 71 for each of the three electric heating arc electrodes 72 in holders 73, which holders regulate the movement of the electrodes in a conventional way.

Again, if desired, stirrer 50 may be operated to stir the metal contents of chamber 29 during the heating thereof by electrodes 72, the electrodes being raised and removed when the desired temperature in the molten metal is achieved as indicated by thermocouples or other temperature indicating means. In lieu of, or in supplementation to, the electrode heating means shown, an induction heating coil 72' may be provided in pit 48 for heating of the contents of ladle 23.

Such electrodes, as shown, pass through openings 74 provided therefor in a refractory cover 75 which is placed on ladle 23 by the crane between the time the removable hood 55 is swung away and the gantry frame 67 is moved into the position shown in FIGURE 4. Cover 75, as shown in FIGURES 4 to 6, inclusive, has a metal shell and is lined with refractory. It is provided with a refractory partition 106 and, as shown, rests on the edge of the ladle proper rather than on the annular plate 44 of brim 42, the partition 106 providing an individual cover for chamber 29 and a further individual cover for chamber 34. Cover 75 also is provided with an openable fitting 107 which may be used for observation, for supplying inert gas to the space in chamber 29 above the molten metal surface, for depositing a floating protective cover material to such surface, or for any other purposes, as desired. A bushing seal 108 is also provided in cover 75 for rod 101, in alignment with passage 36 so that the rod may pass through the cover and be raised or lowered as the case may be by outside linkage. The stopper 100 and its rod 101 may be put in position, if to be used, between the time of removal of hood 55 and the placement of cover 75 on ladle 23. When no stopper is to be used, the cover may be made without any bushing seal 108.

Preferably cover 75 remains on ladle 23 and the openings 74 therein are covered with a lid 76 which is not airtight inasmuch as it is not desired to maintain a vacuum inside ladle 23 during casting or pouring therefrom. After reheating and the return of gantry 67 to the chain line position shown in FIGURE 3, the bail 24 may be reattached to the ladle 23 and the ladle carried to a pouring station 77 preferably nearby. At station 77, the ladle 23 preferably is set down upon a stand 109 and the bail removed from gudgeons 41, freeing the crane and bail for service elsewhere in the plant.

Preferably, casting or pouring station 77 is an airtight tunnel-like enclosure 78 along the bed of which tracks 79 are provided for cars 80 on which, as shown, big-end-up ingot molds 81 with suitable casting stools (or casting flasks, not shown) are supported. Tunnel 78 may be suitably lagged and provided with a fitting 110 which may be used either to connect the interior of the tunnel to a vacuum exhaust pump; or to supply inert gas to the tunnel, such as argon, at a desired pressure, such an inert gas accommodating teeming into the containers 81 without contaminating the metal being poured or cast through passage 36 from discharge chamber 34. The ends of tunnel 78 are closed by doors which when closed seal the interior so that it may be evacuated through fitting 110 or an outlet (not shown) connected to vacuum pipe 54 or other vacuum-producing apparatus. Further, the cars 80 may carry other containers than ingot molds 81, such as foundry flasks, for direct casting therein, or other molten metal containers to receive molten metal

5

teemed from ladle 23 when plugs 33 and 38 are removed and any stopper is raised. Tunnel 78 preferably is made of metal and is provided with an inlet 82 for pouring or casting, such inlet preferably being refractory-lined and having an annular flange 83 to engage in sealing connection with flange 39 when the two are brought together and clamped by C-clamps or otherwise. Inlet 82 preferably is provided with a conventional aluminum sealing diaphragm to preserve the evacuated status of the tunnel 78 and thereby of the containers 81 until ladle 23 is seal connected thereto. Either at station 77, or before ladle 23 is brought thereto, preferably as and when stopper 100 is inserted in chamber 34 and connected, plug 38 may be removed as by an oxygen jet lance; further any wire connection needed for cartridge 46, if it is not a remotely firing cartridge, may be made. Vacuum degassed molten metal in chamber 29 will upon removal of plug 33 run into relatively small discharge chamber 34 where it is not greatly exposed and preferably is but a brief time before exiting (plug 38 being removed and any stopper up) through passage 36 and entering inlet 82 and the container 81 immediately below inlet 82.

No sealing diaphragm or other tunnel inlet sealing provision would be required in the event that interior space 84 of tunnel 78 is evacuated after flanges 39 and 83 are seal connected. Tunnel 78 may be long as practicable and may be straight, or arcuate, or circular. Many suitable means may be used to move the cars 80, to remove a car as it successively reaches the front of the line and to add new cars at the back of the line, or the tunnel 78 may be filled with cars having empty containers thereon at one time and an inlet 82 provided above each container, if desired. Moreover, where there is a plurality of containers in an evacuated enclosure, a plurality of ladles with vacuum degassed molten metal therein may be used to fill the respective containers through a like number of tunnel inlets. And, of course, inlet 82 may itself be the mouth of an individual container capable of taking all or a portion of the contents of ladle 23, a stopper being used in the ladle if such container is to receive but such a portion.

A modification of the illustrated practice hereinabove described may be performed by having ladle 23 after tapping placed upon a ladle car and moved from station-to-station as desired until pouring or casting is to take place. If desired also, a bed-type induction stirrer may be provided on such car beneath the ladle and energized by flexible electric cables during the movement of the car to the vacuum degassing station or to both such a vacuum degassing station and a reheating station. In a number of cases, the tapped molten metal will be vacuum degassed only and will not be reheated prior to casting or pouring; and in some practices of this invention, the stirring of the molten liquid in the ladle may be omitted. Still further, while the invention is preferably practiced in the double-chamber ladle disclosed herein, a conventional tapping ladle may also be employed.

Various modifications may be made in details of the apparatus and steps of operation disclosed herein and other embodiments provided which are within the spirit of this invention and the scope of the appended claims.

I claim:

1. In a double chamber ladle vacuum degassing method, steps comprising, in combination, pouring molten metal into a receiving zone in a double upright zone ladle, covering at least said receiving zone, vacuum degassing said molten metal in said receiving zone, transferring said ladle to a pouring station, opening said receiving zone near the bottom thereof into a discharge zone in said ladle, and discharging said degassed molten metal from said discharge zone and ladle promptly upon said opening.

2. Method as set forth in claim 1 comprising a plurality of containers in said pouring zone, moving said containers successively beneath said discharge zone and bot-

6

tom pouring from said discharge zone into the container therebeneath at the time being.

3. Method as set forth in claim 1 comprising regulating the temperature of said molten metal in said ladle by electrical energy means and stirring said molten metal by electric induction energy during said vacuum degassing.

4. Vacuum degassing ladle apparatus comprising an open top double chamber ladle having a molten metal receiving chamber and a discharge chamber separated therefrom, said chambers being generally upright, a normally closed passage connecting said chambers adjacent the respective bottoms thereof adapted to be opened for admission of degassed molten metal into said discharge chamber from said receiving chamber, said ladle further having a normally closed bottom spout in said discharge chamber with a flange for sealing connection to evacuated container apparatus, means for supporting said ladle with molten metal in said receiving chamber, hood means for covering said open top of said ladle and subjecting it to a vacuum to remove gases from said molten metal in said receiving chamber, means for reheating said degassed molten metal, evacuated container means, means for seal connecting said spout flange to said last-named means for pouring or casting of said degassed molten metal when said normally closed passage and spout are opened.

5. Apparatus as set forth in claim 4 comprising a gantry frame in said means for reheating, a plurality of reheating electrodes movably mounted on said gantry frame, means for effecting relative movement between said gantry frame and said ladle to position said electrodes above said ladle for reheating and to remove them therefrom upon the conclusion thereof.

6. Apparatus as set forth in claim 5 comprising a cover for the receiving and discharge chambers of said ladle, said cover having openings therethrough above said receiving chamber for said electrodes and a removable lid for said openings.

7. Apparatus as set forth in claim 4 comprising a beveled lower edge in said ladle, external electro-magnetomotive energy means stirring means positioned in nested arrangement to said lower edge, said ladle having generally non-magnetic material between said energy means and molten metal in said receiving chamber for stirring of molten metal in said ladle when it is subjected to said vacuum.

8. Vacuum degassing ladle apparatus comprising an open top double chamber ladle having a molten metal receiving chamber and a discharge chamber separated therefrom, said chambers being generally upright, a normally closed passage connecting said chambers adjacent the respective bottoms thereof adapted to be opened for admission of degassed molten metal into said discharge chamber from said receiving chamber, said ladle further having a normally closed bottom spout for said discharge chamber, means for covering said open top of said ladle and subjecting it to a vacuum to remove gases from said molten metal, container means, means for connecting said last-named means to said spout for pouring or casting of said degassed molten metal when said normally closed passage and spout are opened, and means for opening said normally closed passage immediately prior to said pouring or casting.

9. An apparatus as set forth in claim 8 comprising a plug for said normally closed passage, means for removing said plug immediately prior to pouring or casting, seal connection support means affixed to said ladle around the periphery thereof and adapted to operatively engage said means for covering said open top of said ladle, said means for covering said open top and said means for reheating being operative relative to said ladle in a single position of said ladle.

10. Apparatus as set forth in claim 8, comprising an evacuated enclosure for said evacuated container means, a plurality of degassed molten metal containers in said

7

enclosure and means for providing and maintaining a vacuum in said enclosure.

11. Vacuum degassing ladle apparatus as set forth in claim 8 in which said last-mentioned means may be remotely actuated.

12. A double chamber ladle, comprising, in combination, a metal shell, a relatively larger open top refractory-lined receiving chamber in said shell, a relatively smaller open top refractory-lined discharge chamber in said shell, means for covering at least said receiving chamber around the top thereof to provide a vacuum therein, a normally closed bunghole connecting said chambers adjacent the respective floors thereof and a normally closed spout connected to said discharge chamber, whereby molten metal poured into said receiving chamber may be vacuum degassed before the opening of said bunghole and spout to discharge degassed molten metal into said discharge chamber and from said ladle.

13. A double chamber ladle, comprising, a metal shell, a relatively larger open top refractory lined receiving chamber in said shell, a relatively smaller open top refractory lined discharge chamber in said shell, metal strength members containing said respective chambers, a normally plugged bunghole connecting said chambers adjacent the respective floors thereof, the floor of said receiving chamber sloping toward its end of said bunghole, a normally closed bottom spout in said discharge chamber, the floor of said discharge chamber sloping to-

8

ward said spout, lifting gudgeons extending transversely from said shell in general alignment with the center of gravity of said ladle when containing molten metal and a support sealing ring surrounding said shell having an upper sealing surface.

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