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APPARATUS FOR DISPENSING MOLTEN METAL

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3 Sheets-Sheet 1

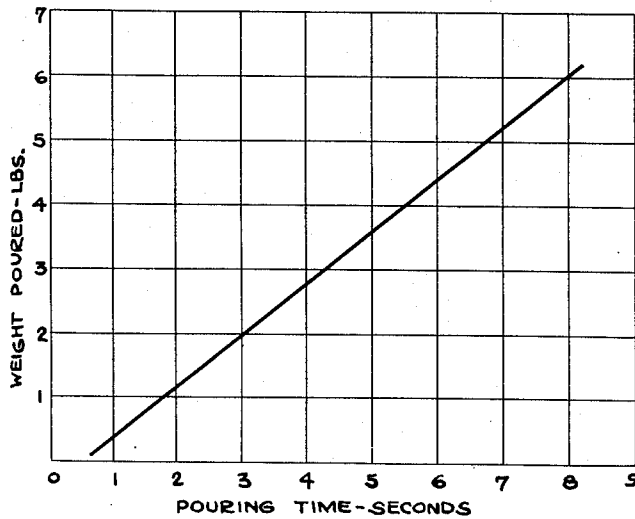
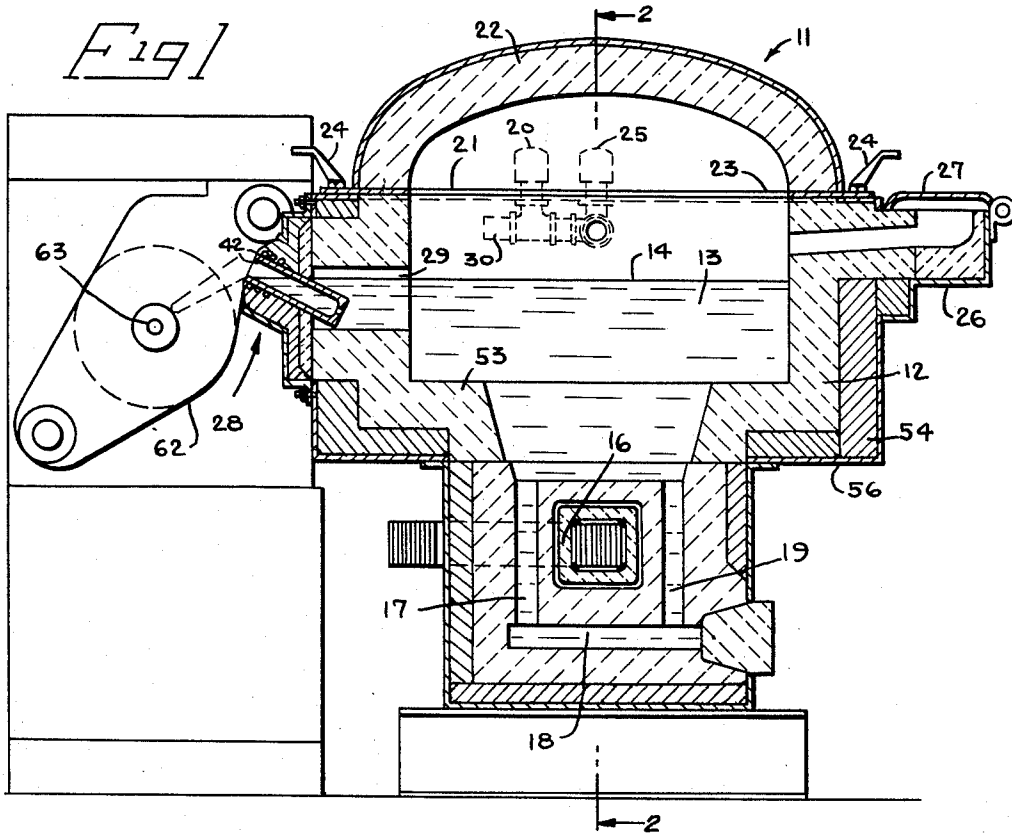


*Fig 6*

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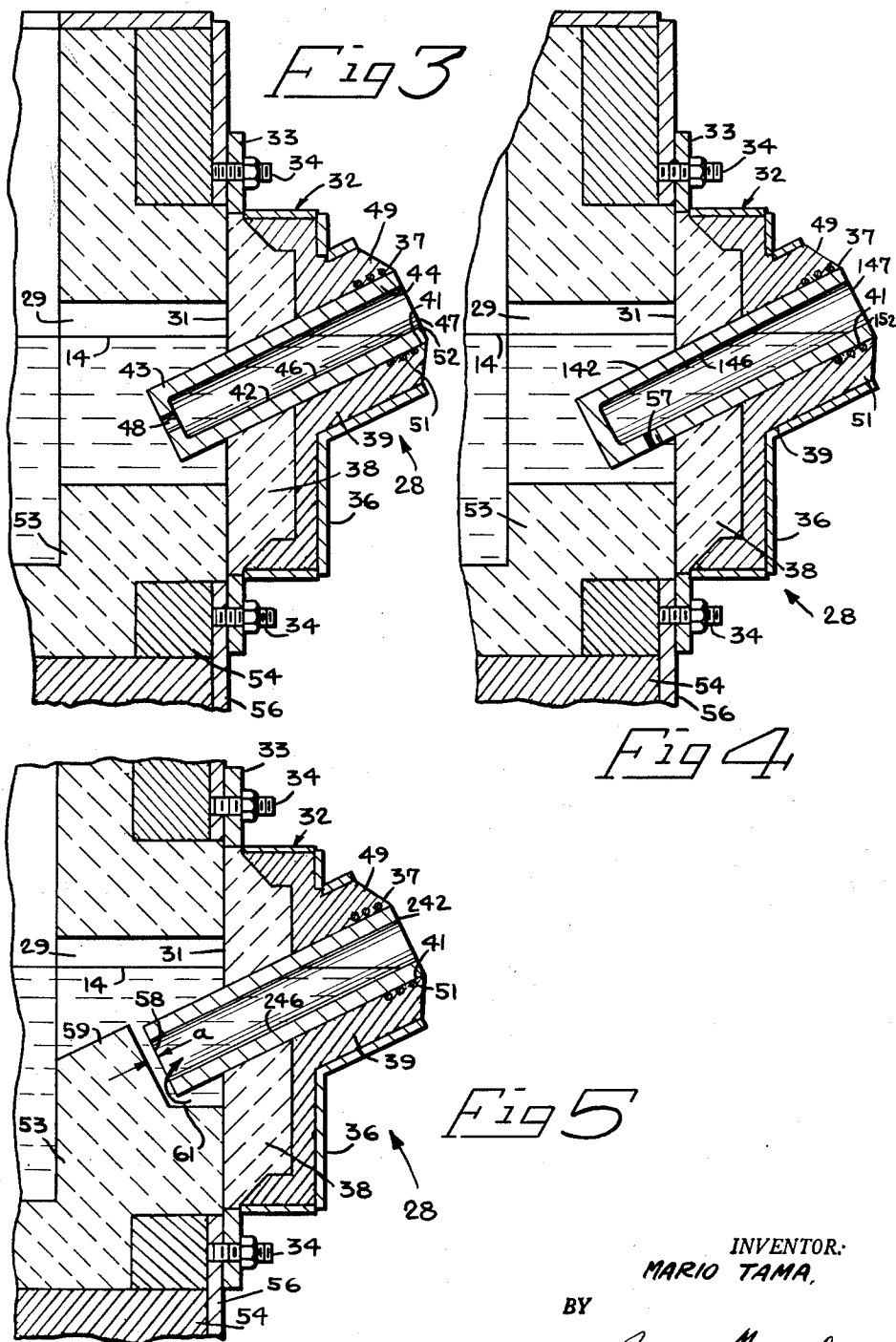
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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

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## APPARATUS FOR DISPENSING MOLTEN METAL

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7 Claims. (Cl. 13—33)

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The invention relates to the art of supplying molten metal from a holding furnace to a mold and relates more particularly to methods and apparatus for intermittently dispensing accurate amounts of molten metal from a container into molds. This is a continuation-in-part of my copending application Ser. No. 29,263 filed May 26, 1948.

In the mass production of castings, it is required to supply repeatedly accurate amounts of metal, free from slag or oxides, delivered to the molds at the proper temperature and in short and uniform periods of time. As all the castings have identical shape and weight, it is important that the amount of metal delivered each time to the mold be uniform.

Heretofore, the conventional and widely used method of supplying molten metal from a holding furnace to the mold has been by manual lading, with numerous attendant disadvantages, among which are predominant variations in metal temperature, inclusion of slag in the discharge for the molds, safety hazards, and the occurrence of fatigue of the operator.

It is accordingly among the objects of the present invention to obviate the disadvantages of the prior art, and to provide for the discharge of accurately uniform amounts of uniform temperature and during uniform discharge time intervals, by semi-skilled or even unskilled personnel.

Generally speaking, I provide a furnace for a molten metal bath which is filled in the space above the metal level with a gas that can be pressurized for the discharge of the molten metal through a discharge device.

With the above and other objects of the invention in view, the invention consists in the novel methods, construction, arrangement and combination of various devices, elements and parts, as set forth in the claims hereof, certain embodiments of the same being illustrated in the accompanying drawings and described in the specification.

In the accompanying drawings,

Fig. 1 is a sectional view of a holding furnace in accordance with the invention;

Fig. 2 is a sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a large scale fragmentary sectional view showing the detail of the discharge nozzle;

Fig. 4 is a sectional view of a modified nozzle detail;

Fig. 5 is a fragmentary sectional view of a further modified nozzle detail;

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Fig. 6 is a graph showing the performance of the apparatus in accordance with the invention in terms of weight of molten metal poured plotted over pouring time; and

Fig. 7 is a graph showing the performance of the apparatus in accordance with the invention in terms of variations in the amount of metal discharged when the metal level is lowered, but the time unit remains the same, as metal level plotted over succession of pourings.

In carrying the invention into effect in the embodiments which have been selected for illustration in the accompanying drawings and for description in this specification, and referring now particularly to Figs 1 and 2 there is provided a casting device generally indicated at 11. It includes a holding furnace 12 that is capable of maintaining a bath of molten metal 13 at the proper temperature. The normal level of the molten metal is indicated at 14.

The furnace is provided with means for heating the molten metal 13, for instance with an induction coil 16, that induces heat in the melting channels 17, 18 and 19 of the furnace 12. The furnace 12 is preferably provided with automatic temperature control equipment (not shown in the drawing).

The induction furnace 12 is of the single-chamber type and is open on top at 21 and has a cover 22 to close the top 21 reasonably airtightly by means of a gasket 23. The cover 22 is removably positioned and may be fastened by rapid fastening means, such as screws 24, or quick-action clamps, along the periphery of the cover. A charging bowl 26 is provided at one side of the furnace 12 and may be closed by a tiltable cover 27 that is sealable by rapid fastening means similar to the cover 22.

The holding furnace 12 should have enough capacity to allow operation for a reasonable time before recharging. The important factor is the surface size. For instance, a furnace with a surface area of 1,000 square inches contains about 100 pounds of aluminum per inch of metal depth. If a level difference of 3 inches is permitted, the furnace does not have to be refilled until 300 lbs. have been processed. Furnaces with a surface area ranging from 500 to 1000 sq. in. are probably best for the instant purpose. In a furnace having a surface of 500 sq in., the metal surface would be lowered by only about  $\frac{1}{60}$  inch for every pound of metal discharged.

As shown in Figs. 1 and 2, a centrifugal air-blower 10 is attached to the furnace and has a conduit 15 connected to the hearth of the fur-

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nace at a point above the level 14 of the molten metal. Two solenoid operated valves 20 and 25, respectively, are used to regulate the pressure of the air delivered by the blower 10. The valves 20 and 25 are switched in such a way that one of them is open when the other is closed. The second valve 25 is connected to the open air by a tube 30. It is operated by a timing device or timer, schematically indicated in Fig. 2.

Although in the foregoing it has been mentioned that air is used, there may instead be used any suitable gas.

The holding furnace 12 is provided with a discharge device, generally indicated at 28, and best shown in Fig. 3. The furnace 12 has a lateral recess or pocket 29 in one of its side walls, and the recess 29 is open towards the exterior at an opening 31. A cover 32 is removably mounted to said side to cover the opening 31 of the pocket 29. Said cover 32 comprises a flange 33 that is fastened to the furnace side walls by means of fastening devices, such as bolts 34. The cover 32 has an outer metallic shell or enclosure 36 of sheet metal or the like and is provided with a projection 37 inclined against the horizontal direction. On the interior the cover has a refractory lining 38 and in the projection 37 a castable insulation 39. The cover 32 is apertured at 41 axially of the projection 37 and has sealed in said aperture a tube or nozzle 42. When mounted, the lower end 43 of the tube 42 is disposed below the metal level 14 and the tube intersects the said metal level and extends with its upper end 44 through the aperture 41 to the exterior of the cover 32.

The tube 42 surrounds a passage 46 for the discharge of molten metal, and the axis  $x-x$  of the tube intersects the horizontal direction at an acute angle for instance at an angle of from  $15^\circ$  to  $60^\circ$ , and the angle shown in the drawing is  $26^\circ$   $33'$ . The passage 46 forms with the terminal of the upper end portion 44 an outlet 47 for the discharge of the molten metal off the furnace, and forms with the terminal of the lower end portion an inlet 48.

There is provided a means for throttling the metal flowing through the passage 46, and that means is disposed below the level of the molten metal. In the embodiment shown in Fig. 3, that throttle means is constituted by the constriction formed by the inlet 48. This constriction 48 is always located below the molten metal level and is disposed near the entrance for the molten metal of the passage 46 of the tube or nozzle 42.

The throttle means serve to regulate the speed of flow in the passage 46 of the molten metal. It maintains the flow constant, regardless of any build-up in the wider upper part of the passage 46 of the tube 42. Such a build-up may form in the parts of the tube which are alternately exposed to molten metal and air. However, in the handling of molten metals, no appreciable amounts of build-up occur below the molten metal level line. Practical experience with the instant throttle means has shown that the lower part of the tube which is submerged in the molten metal stays clean, probably due to the high velocities induced by the throttle means, causing the rapidly impelled molten metal to drive away any impurities that may have been accumulating in the lower part of the passage 46 during idling.

It is important that the throttle means be located near the part of the tube that is immersed in the molten metal. If that means were,

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instead, located above the metal line, its cross-section would undergo constant change, and might finally be practically clogged due to a build-up of solidified "skins" or oxides, as it would be alternatively exposed to air and molten metal.

The throttle means create a pressure drop near the entrance of the passage 46 of the tube 42. Owing to this pressure drop, the pressure created inside the furnace chamber by the blower 10 will have to be sufficiently large to overcome the throttle resistance, so that the metal level can be raised from its normal level position 14 to and above the pouring lip 52. The cross-section of the throttle, for instance of the inlet 43 in Fig. 3, controls the rate of flow through the tube 42, maintaining it constant irrespective of any build-up in the wider part of the passage 46.

The tube 42 is preferably made of good refractory material which is not subject to attack by the molten metal, either below or above the metal level line. I have found silicon carbide to be a suitable material for such a tube, particularly for use in connection with aluminum and its alloys. I have also found that graphite can be used, but preferably only in the section below the metal level.

Returning to the embodiment shown in Fig. 3, the diameter of the inlet is about  $\frac{1}{2}$  inch whereas the diameter of the passage 46 is about  $1\frac{1}{2}$  inches.

The location of the constricted inlet 48 below the metal line which leads into the tube 42 inclined upwardly towards the outside of the furnace, results in a low linear velocity of the molten metal as it is discharged from the outlet 47. Such low linear velocities are important in preventing excessive turbulence as the liquid metal flows from the outlet 47 into the mold or the cold chamber of a die casting machine. Excessive turbulence would cause excessive oxide formation and trapping of air in the castings.

The outer end of that portion of the cover 32 that surrounds the upper terminal of the tube 42 flares backwardly, so that there is provided an annular terminal surface 49, the lower portion of which is substantially vertical when the furnace is in its normal position. As the stream of molten metal leaves the outlet 47 in form of a parabola, the molten metal will not come in contact with the annular surface 49, and thereby there is obtained a free and undisturbed flow of metal to the mold.

The upper end 44 of the tube 42 is heated near the outlet 47, for instance by means of an electric resistor heater coil 51. The coil 51 may be fed from an electric source, which has not been shown in the drawing.

The metal level 14, for all practical purposes should be as near as possible to the pouring lip 52 which is formed by the lower arcuate portion of the outlet 47. The vertical distance of the metal level 14 from the lip 52 should be less than 3 to 4 inches.

When the exchangeable cover 32, including the tube and the coil for the tube, is mounted on the side of the pocket 29, the holding furnace 12 is thereby completed and ready to receive a charge of molten metal. The induction furnace 12 is provided on the interior with a refractory lining 53 and to the exterior of said refractory lining 53 with a castable insulation 54. On the exterior of the furnace there is mounted a metallic shell or enclosure 56 made of sheet metal or the like, which corresponds to the metallic en-

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closure 36 of the cover 32. When the cover 32 is mounted, the metallic enclosures 36 and 56 will surround the furnace 12. This metallic sheet metal shell is arranged to provide for air or gas tightness, as the refractory material 53 and 54 and 38 and 39, respectively, is too porous to be relied upon for air or gas impermeability.

Fig. 4 shows a modified throttle means. An inclined tube 142 similar to the tube 42, is provided that has a passage 146 and an outlet 147 as well as a pouring lip 152. The inlet however is not disposed in alignment with the passage 146 but instead is disposed radially on the underside of the tube 142, and is designated 57. It is located near the lower end of the passage 146, and has a smaller cross-sectional area than the passage 146, and provides thus for the necessary constriction for throttling. Also in this case the constriction provided by the inlet 57 is disposed below the molten metal level 14. It will be understood that instead of a single inlet 57, there may be provided a plurality of radial inlets of this type, all located below the metal level. The radial arrangement of the inlet causes a change of direction of metal flow, and this has the advantage that initial spasms at the beginning of each pouring operation are avoided.

Another modification of the throttle means is shown in Fig. 5. The inclined tube 242 has a passage 246 that extends without change in diameter throughout the length of the tube. The inlet 58 has the same diameter as the remainder of the passage 246, and there is positioned adjacent said inlet 58 a block 59 that is spaced from the inlet 58 for a small distance  $a$ . This distance  $a$  is so dimensioned that the flow of metal along the arrow 61 is restricted as compared to the flow in the passage 246, substantially at the rate as described in connection with the foregoing embodiments. The constriction provided by the space of the distance  $a$  is located below the metal level 14, and the block 59 may be constituted by a refractory brick.

Fig. 6 is a graph showing amounts of metal in pounds poured out from the furnace in different times. These tests were carried out with a furnace containing aluminum at a temperature of 1300° F., with the metal level maintained at the tip of the nozzle. The nozzle had a diameter of 2 inches and the orifice or constriction was  $\frac{3}{8}$  inches in diameter. Under these conditions the time was varied between  $\frac{1}{2}$  and 8 seconds. The amount of the metal poured was between 0 and 6 pounds. In this particular test, the furnace was slightly tilted after each pour, to obtain always the same distance of metal level to the nozzle tip. It will be noticed that no metal is ejected when the time is less than  $\frac{1}{2}$  second. This is the time lag necessary to build up pressure inside the furnace chamber. As soon as this starting time has elapsed, the metal amount is proportional to the time. The time measurements were obtained with an electronic timer. The blower used in these tests was a centrifugal blower with a motor of  $\frac{1}{2}$  horse power, which was capable of building up a static pressure of 27 inches water gauge inside the furnace chamber. In further tests it was found that the volume of air flowing into the furnace was of about 25 cubic feet per minute, which is a small amount, showing that the leakage is almost negligible. One of the important features of my invention is that it does not require hermetic sealing of the furnace, a condition which would be very difficult to achieve in practical operation. It is only necessary to obtain a rea-

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sonable degree of gas tightness. Full tightness would be almost impossible to achieve in a melting furnace which is subject to warping because of the high operating temperatures involved in the practical operation.

Fig. 7 is another graph showing variations of metal poured when the level of the metal is lowered and the time is not changed. The conditions are otherwise the same and described for Fig. 6. The pouring time was held constant at  $2\frac{1}{2}$  seconds. The metal level was gradually reduced from  $11\frac{1}{2}$  to  $10\frac{3}{4}$  inches. The amounts of metal poured decreased gradually from 1.75 to 1.40 pounds, and the decrease was gradual in direct proportion to the metal level, with only small deviations from pour to pour.

While I have shown a single-chamber induction furnace in the embodiment described above, it must be clearly understood that also other furnaces can be used to carry out my invention.

My invention has been described in the performance of repeated shots of uniform weight. However, it can also be used for consecutively producing castings of different weight, since it is a simple matter to change the pouring rate by resetting the timing device.

The timing device can be started either manually, by push button control, or automatically by the casting machine in the case of permanent mold or die casting operation. The timer is started as soon as the die is closed. In this way, not only time is saved, but also a more accurate coordination between furnace and molds is obtained.

In Fig. 1 there is schematically shown a die casting machine 62 having a cold chamber 63 into which the metal is discharged from the pouring lip of the nozzle.

The operation is as follows.

The furnace 12 of Figs. 1 and 2 is filled with molten metal through the charging bowl 26 after opening of the tiltable cover 27. The metal is filled up to the level 14 which is near the pouring lip of the nozzle. The cover 22 as well as the cover 27 is closed by the quick acting fastening means, and thereafter the blower 10 is started.

The air blower 10 is kept running throughout the entire casting period, irrespective of how long a single discharge is made, or how often intermittent discharges are made, through the nozzle 42. A conventional throttle (not shown) may be applied to the intake side of the blower to adjust the air pressure.

The valves 20 and 25 are switched simultaneously in such a way that one is closed while the other is open. When the valve 25 is open, the air flows from the blower 10 to the sealed interior of the furnace 12 into the space above the metal level 14. Experience has shown that it takes only a fraction of one second to build-up pressure and to start the flow of molten metal over the pouring lip 52 of the nozzle 42.

When sufficient air pressure is applied on the interior of the furnace 12, metal will be discharged upwardly, outwardly through the nozzle 42, leaving the pouring lip 52 in a flow towards the mold 62.

When the valve 20 is opened, the valve 25 will be closed and the air contained in the space above the molten metal within the furnace will be ejected into the open air through the tube 30, to release the pressure from the molten metal.

The timer, which is preferably of the electronic type of any well-known suitable construction, and

is shown schematically in Fig. 2, is used to limit the time between valve operations.

As the pattern of flow is closely proportional to the time of pressure application, the time control is a practical way to achieve uniformity of weight in consecutive castings.

As either a single extended pouring continues, or the intermittent short-time-interval pourings continue in succession, the metal level in the holding furnace decreases. This means that the distance of the level from the pouring lip 32 increases and consequently the volume of weight of metal ejected at each successive pouring will be smaller. To counteract this effect, the timer may be gradually re-set for a longer time interval of operation, as the pouring operation proceeds. When the metal level has decreased beyond a predetermined range, the furnace is filled again as described in the foregoing, and the sequence of operations is repeated.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific exemplifications of the invention described herein.

Having thus described the invention, what I claim as new and desire to be secured by Letters Patent, is as follows:

1. An apparatus for intermittently dispensing accurate amounts of molten metals by free flow into molds comprising in combination a refractory-lined container, means to supply heat to the molten metal contained therein, a metallic shell around said container, at least one gas-tight cover above the molten metal surface, means for supplying intermittently gas pressure to the space within the container located above the molten metal surface, a delivery tube having its lower opening below the molten metal surface and having a discharge aperture above said opening and leading with its discharge end into the vicinity of the mold, the axis of said tube being inclined at an acute angle against the horizontal plane, and defining throughout the major portion of its interior an elongated narrow passage extending to and including said discharge aperture, said passage being of substantially uniform cross-section, and said tube having upstream of said passage an orifice of restricted cross-section below the molten metal surface.

2. An apparatus according to claim 1, in which the container is heated by electromagnetic induction.

3. An apparatus, according to claim 1, in which the diameter of the tube is between  $\frac{3}{4}$ " and 2" in diameter.

4. An apparatus, according to claim 1, in which the restricted orifice is between  $\frac{1}{4}$ " and  $\frac{3}{4}$ " in diameter.

5. In an apparatus, for use in dispensing accu-

rate amounts of molten metals by free flow into molds, in combination, a refractory-lined container structure for molten metal open on one side, a metallic shell around said structure, means for supplying heat to the molten metal in said container structure, means for supplying intermittently gas pressure to the space within the container above the molten metal surface, and a discharge unit removably connected to said open side of said structure and including a refractory-lined apertured cover including a metallic outer shell portion, a hollow delivery tube sealed in said aperture and surrounding a passage and including a lower portion having a passage inlet extending in the mounted position below the molten metal surface and including an upper portion having a passage outlet on the exterior of said cover, the axis of said tube being inclined in the mounted position at an acute angle against the metal surface level, said passage having throughout its major portion including said outlet a substantially uniform cross-section, throttle means for said passage located upstream of said major portion and disposed below the molten metal surface, and means for removably fastening said cover to said structure.

6. In an apparatus as claimed in claim 5, further characterized therein, said throttle means including a restriction in said passage near said inlet for controlling near the point of entry the flow of molten metal through said tube.

7. In a discharge apparatus, for use in connection with a pressurizable container for molten metal having a side wall, in combination, a discharge conduit comprising an uprightly inclined tube surrounding a passage and intersecting at an acute angle the level of molten metal in said container and including an upper portion projecting through the side wall to the exterior of said container and including a lower portion below the metal level, throttle means for said passage disposed below the metal level, said passage extending upstream from said throttle means and having throughout its extension therefrom a substantially uniform cross-section, whereby said throttle means is operable to control the flow of molten metal through said passage.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

| Number    | Name        | Date           |
|-----------|-------------|----------------|
| 1,126,079 | Queneau     | June 26, 1915  |
| 1,552,865 | Metzger     | Sept. 3, 1925  |
| 1,601,523 | George      | Sept. 28, 1926 |
| 1,837,031 | Engelhardt  | Dec. 15, 1931  |
| 1,914,354 | Adam        | June 20, 1933  |
| 1,956,171 | Hitner      | Apr. 24, 1934  |
| 2,018,884 | Ferguson    | Oct. 29, 1935  |
| 2,022,112 | Ferguson    | Nov. 26, 1935  |
| 2,224,982 | Morin       | Dec. 17, 1940  |
| 2,597,269 | Tama et al. | May 20, 1952   |