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METHOD AND APPARATUS FOR HANDLING MOLTEN METAL

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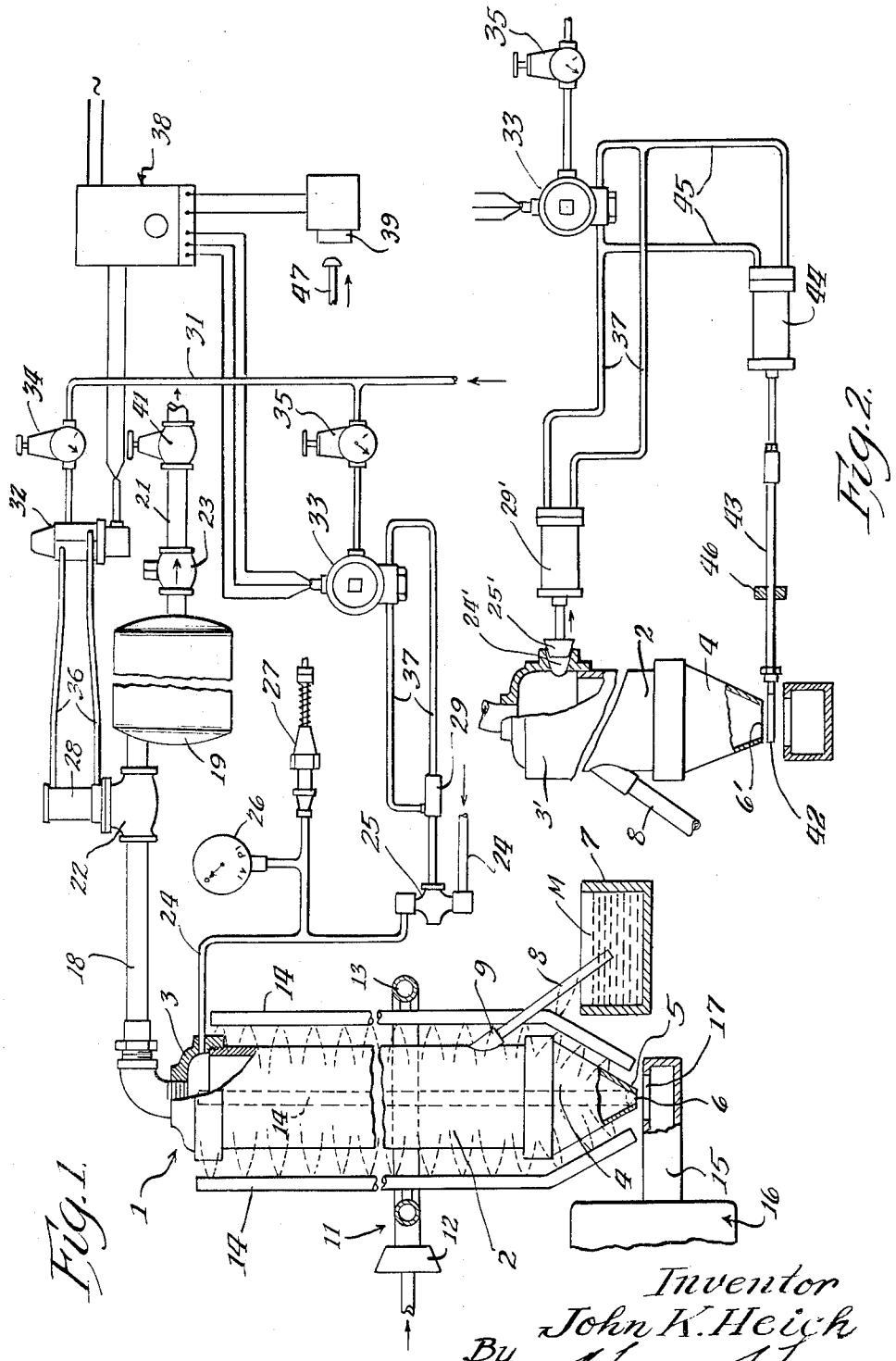

Fig. 1.

Fig. 2.

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METHOD AND APPARATUS FOR HANDLING MOLTEN METAL

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The invention relates generally to the transfer of molten metal and the like, and more particularly to a novel method and apparatus for measuring a desired amount of molten metal and conveying the same from a point of supply to a point of use.

The invention is particularly applicable to casting operations, as for example, supplying metal to die casting machines and the like.

While furnaces and die casting machines employed in connection with the die casting of aluminum and other metals have been improved and operational rates increased, production techniques and, in general, production capacity has not kept pace with the advances made in the equipment. The inability to approach the capacity potential of the die casting equipment has been to a very large measure due to problems attendant to the handling of the molten metal involved in measuring and transporting such metal from the furnace to the die casting machine, such operations originally and in most cases currently accomplished by hand ladling operations. Efforts have been made to automate or mechanize such operations but on the whole these have not proved too satisfactory. Generally either one of two approaches has been employed—the first involving a mechanical device which substitutes power for the manual operation, as for example, mechanical ladles which have a predetermined movement into the supply of molten metal and a quantity of the metal physically carried to a point of discharge, at which point the ladle is mechanically manipulated to discharge its contents into the sleeve of the die casting machine employed therewith. The second arrangement utilizes a crucible which is immersed in the molten metal and so constructed that the latter may flow into the same under certain conditions, and adapted to be forced therefrom by the introduction of air under pressure into the crucible. Due to the construction involved and the nature of the operating conditions under which it is employed, such equipment is quite costly and as it is constantly submerged in the molten metal it is usually necessary to employ specially coated parts in an effort to reduce structural deterioration.

The present invention therefore has among its objects the utilization of a novel method employing atmospheric pressure and the action of gravity for the metal transporting motivating forces and which eliminates the disadvantages of systems heretofore employed.

Another object of the invention is the production of novel apparatus for carrying out the method which is exceedingly simple in construction, inexpensive to manufacture and durable in operation.

A further object of the invention is the production of such an apparatus which may be readily adjusted to accurately measure a desired quantity of molten metal and transport the same from the supply furnace to the receiving machine.

A further object of the invention is the production of such an apparatus which may be constructed with no moving parts and which is very rapid in operation whereby maximum rates of operation may be achieved.

Many other objects and advantages of the invention will be apparent to those skilled in the art from the disclosure herein given.

In the drawings, wherein like reference characters indicate like or corresponding parts:

FIG. 1 is a semi-diagrammatic figure illustrating the details of the present invention; and

FIG. 2 is a similar type of figure illustrating a modified form of construction, particularly adapted for use where relative large amounts of metal are to be measured and conveyed.

The details of the apparatus for carrying out the method may be widely varied and FIG. 1 thus illustrates one simple example of an apparatus capable of performing the desired functions.

The apparatus illustrated is operative to transport molten metal from a supply receiver to an intermediate metering or measuring chamber from which the metal may be discharged to the die cavity, the air being exhausted from the chamber under controlled conditions to create a pressure differential, resulting in the withdrawal of molten metal from the supply and discharge thereof into the chamber, with the amount of the metal entering the chamber being controlled by control of the duration and extent of the exhausting of the air, thereby achieving a very effective and accurate control of the amount of metal which is ultimately deposited into the mold cavity.

Referring to FIG. 1 of the drawings, the reference numeral **1** indicates generally a container or hopper, illustrated as being generally cylindrical in shape, having a tubular body portion **2** closed at its upper end by a cap member **3**, illustrated as being threaded upon the body member, and a bottom member **4** which likewise may be screwed to the lower end of the body member and is provided with converging conical shaped side walls **5** terminating at their apex in a discharge port **6**.

The hopper **1** is adapted to be operatively connected with a supply of molten metal M, illustrated as being contained in a suitable receiver **7**, which normally would comprise a part of a suitable furnace, by a tube **8**, the lower end of which is immersed in the molten metal M and the upper end communicating with the interior of the hopper **1**. The tube **8** preferably is suitably threaded into a connection **9** carried by the body member **2** whereby the tube **8** may be readily replaced when necessary.

The hopper **1** may be maintained at an effective operating temperature by suitable means such as a gas burner system indicated generally by the numeral **11** which, for example, may comprise a gas and air mixing assembly **12**, the air gas mixture being distributed by a ring-shaped manifold **13** to a plurality of burner tubes **14**, with a sufficient number of tubes being employed to insure sufficiently uniform temperature of the hopper to prevent chilling of the molten metal entering the hopper. The specific details of the heating structure form no part of the present invention and any structure suitable for the purpose may be employed.

The hopper **1** preferably is positioned to dispose the discharge port **6** over the metal receiving sleeve **15** of a die casting machine, only a portion of which is illustrated in the drawing and indicated by the numeral **16**, the port **6** being aligned with the receiving opening **17** in the sleeve **15**.

Communicating with the upper portion of the hopper **1** is a conduit or line, indicated generally by the numeral **18**, arranged to connect the hopper with a reserve tank **19** which in turn is adapted to be operatively connected by a conduit or line **21** with a suitable vacuum source, as for example, a vacuum pump or ejector, the exhausting of the air in the hopper **1** being controlled by a valve **22** disposed in the line **18**. Disposed in the line **21** is a check valve **23** operative to prevent a pressure feed back in the line **21** in the event that vacuum in the tank **19** should be broken. Communicating with the upper portion of the hopper **1** is an air supply line **24** which may be operatively connected to the atmosphere through a control valve **25** disposed in series with the line **24**. Also

operatively disposed in the line 24 is a vacuum gauge 26 and a safety valve 27 which eliminates any possible build-up of vacuum in the hopper 1 to an undesirable degree.

The valves 22 and 25 may be actuated by any suitable means which will provide the desired control. Thus in the embodiment of the invention illustrated in FIG. 1, the valve 22 is illustrated as being of the pneumatic alloy actuated type, having an air cylinder 28, and the valve 25 is illustrated as being pneumatically actuated through an air cylinder 29.

Air under pressure is adapted to be supplied through a line 31 to suitable control valve means 32 and 33, associated respectively with the air cylinder 28 of the valve 22 and cylinder 29 with the valve 25, each of the valves 32 and 33 being electrically actuated and operatively connected with the air supply line 31 through pressure regulators 34 and 35, the valve 32 being connected through lines 36 to the air cylinder 28 and the valve 33 being connected to the cylinder 29 through lines 37, whereby the air pressure to the cylinders may be reversed to actuate the valves 22 and 25 from open to closed position and vice versa.

The valves 32 and 33 are adapted to be controlled by an electrical timer indicated generally by the numeral 38 which is of a type that may be adjusted to actuate the valves 32 and 33 in desired time relation and is suitably adjustable whereby the cycle of operation may be varied. Also operatively connected to the timer 38 is a suitable manually actuatable start button 39.

The electrical arrangement is such that until operation of the start button 39 the valves 32 and 33 will be in positions to maintain the apparatus inoperative and upon actuation of the button 39 the operation of the apparatus will be automatically controlled by the timer which will effect the operation of the apparatus through one complete cycle, following which the next cycle may be initiated by a subsequent actuation of the start button 39.

In operation, the air pressure to the valves 32 and 33 is suitably adjusted by the regulator valves 34–35 and the degree of vacuum in the reserve tank 19 adjusted to the desired amount by control of the vacuum pump or other vacuum producing means, or by means of a regulator valve 41 in series in the exhaust conduit 21. At the same time the hopper 1 is heated to the desired temperature, a dull red usually being satisfactory, by means of the burner system 11.

When the die casting machine 16 is ready to receive the molten metal, the button 39 is actuated, thereby initiating operation of the timer 38 which will suitably actuate the control valve 32 and applying air pressure in the proper direction to the cylinder 28 to open the valve 22. The vacuum bult up in the reserve tank 19 is operative to exhaust air from the upper portion of the hopper 1. The discharge port 6, illustrated in FIG. 1, is suitably proportioned to permit rapid discharge of the metal from the hopper 1 but at the same time is sufficiently small that it will not admit sufficient air into the hopper to prevent the desired operation of the apparatus. Consequently, a pressure differential is created between the interior of the hopper 1 and the atmospheric pressure exerted upon the top surface of the molten metal M, whereby the metal will flow into the hopper and upon accumulating at the bottom thereof will form an additional closure member for the discharge port 6.

The amount of metal drawn into the hopper 1 obviously will depend upon the degree of vacuum involved and the duration of actuation of the valve 22, so that by control by both of these variables the amount of metal drawn into the hopper may be accurately controlled. Under normal conditions the vacuum may be maintained at a suitable fixed level. I have found that a vacuum equivalent to ten inches of water produces very satisfactory results for a wide variety of applications in which any desired variation in amount of metal may be derived by change in the timing cycle, the latter being increased or reduced

to effect a similar change in the amount of metal. The gauge 26 enables the operator to determine the effective vacuum in the hopper 1 during operation and the valve 27 is provided merely as a safeguard to insure the maintenance of relative pressures in the chambers at the desired level.

The continuously open discharge port 6 not only has the advantage of eliminating movable closure members and the like, but at the same time, in permitting a small controlled amount of air to enter the hopper, tends to prevent undesired surges, etc. in the chamber during entry of the molten metal therein.

The amount of metal drawn into the hopper will also vary with the capacity of the tube 8. Thus, tests with a three-quarter inch draw tube 8 indicate that ten pounds of metal will be drawn with a timer setting of eight seconds and the vacuum at five inches, while a like amount of metal will be drawn in six seconds with fourteen inches of vacuum. Likewise, assuming a constant vacuum setting of ten inches, with one inch draw tube, the following variations in metal drawn may be achieved:

Timer Setting	Vacuum Setting	Amount of Metal Drawn
½ second	10 inches	4 pounds, 4 ounces.
1 second	10 inches	5 pounds, 7 ounces.
1½ seconds	10 inches	8 pounds, 8 ounces.
2 seconds	10 inches	10 pounds, 9 ounces.

The proportions and dimensions of the hopper 1 will of course vary with the maximum quantity of metal to be utilized, the hopper being suitably dimensioned to accommodate such amount of metal and at the same time leave an adequate working space above such metal. Likewise, the size of the discharge port 6 may be varied, depending upon the amount of metal involved and the uration of the operation cycle. For a large number of applications a discharge port of ½ inch diameter will operate every effectively.

In order for the molten metal to discharge from the hopper 1 after the molten metal has been withdrawn from the receiver 7, as described above, in predetermined measured amounts, the valve 22 in the sequence of operation is closed thereby stopping the vacuum in the hopper 1, and the control valve 25 is then open to atmospheric pressure, thereby allowing the discharge of the molten metal from the hopper 1 under the combined action of air pressure within the hopper upon the molten metal and the action of gravity upon the molten metal within the hopper.

However, various applications may require or make it desirable to increase the size of the discharge port 6, particularly to a point where the port becomes sufficiently large that insufficient vacuum will be created in the hopper interior and in such case additional valve means may be employed. FIG. 2 illustrates such a modified structure, wherein the discharge port 6′ is of considerably larger area than the port 6, rendering it desirable to provide some restriction thereof during the filling of the hopper of molten metal. Cooperable with the discharge port 6′ is a valve member 42 which is illustrated as being connected through a rod 43 with the piston of an air cylinder 44, operatively connected to the valve 33 through lines 45 connected to corresponding lines 37, whereby simultaneously with the opening of the valve 25 the valve member 42 will be drawn to the right as viewed in FIG. 2 to open the discharge port 6′. The valve member 42 and rod 43 preferably are guided by a suitable means such as a stationary guide block 46.

Referring to FIG. 2, it will be noted that the valve member 42 may be slightly spaced from the adjacent peripheral edges of the discharge port 6′, whereby a small amount of air may bleed into the hopper in a manner similar to that through the port 6 as heretofore described.

Thus, it is not necessary that the valve member 42 completely close the port 6′ but rather control the effec-

tive size of the opening thereat during the filling of the hopper to restrict such opening, to a size that will not permit an excessive amount of air to enter and thereby stop the metal movement.

Likewise, the capacity of the air intake to the top of the hopper, illustrated in FIG. 1 as comprising the line **24** and valve **25**, may be increased by employing a direct-acting type of valve mechanism, an example of which is illustrated in FIG. 2.

In the embodiment illustrated the valve member **25'** is axially movable to open or close the relatively large air inlet opening in the enlarged cap member **3'**, the valve member being actuated by an air cylinder **29'**, illustrated as being similar to the cylinder **44**, which is directly connected to the lines **37** and thus under the control of the valve **33**. Thus, simultaneously with the opening of the port **6'** by movement of the valve member **42**, the cylinder **29'** will be actuated to move the valve member **25'** to a position to open the bore **24'** permitting the direct entrance of air into the top of the hopper and thereby equalizing the internal and external air pressure. As both the valve members **42** and **25'** are simultaneously actuated to open or closed position under the control of the valve **33**, in some cases it may be desirable to operate both valve members from a single air cylinder, mechanically coupling such members.

It will be apparent that the specific details of the control valves, their actuating elements and the details of the timing structure per se form no part of the invention, there being numerous structures on the market which are suitable for the purposes here involved.

The use of the reserve tank **19** enables a plurality of units embodying the present invention to be operatively connected to a single vacuum producing source and at the same time insure that the various units will be accurately controlled. As a relatively wide variation in the amounts of metal in each unit may be readily controlled by the individual timer mechanism associated therewith, normally a regulator valve such as the valve **41** will not be required in the vacuum line. However, in the event that different units are to be operated under different vacuum conditions, a regulator valve may be installed in the line to each reserve tank.

In some cases it may be possible to operate the start button **39**, or equivalent actuating element of the starting switch may be actuated by means associated with the die casting machine whereby the feeding action is automatically controlled in synchronism with a suitable operational phase of the die casting mechanism. Thus the button **39**, illustrated in FIG. 1, could be actuated by a suitable reciprocable element **47**, associated with the die casting machine and suitably actuated thereby.

It will be noted from the above description that I have provided a novel method and apparatus for measuring molten metal and transporting the same, which is exceedingly simple, very efficient for the purposes intended and in which the apparatus will be durable and inexpensive to manufacture.

Having thus described my invention it will be obvious that various immaterial modifications may be made in the same without departing from the spirit of my invention, hence I do not wish to be understood as limiting myself to the exact form, arrangement or combination of parts or steps herein shown or described, or uses mentioned.

What I claim as new and desire to secure by Letters Patent is:

1. A method of measuring and feeding molten metal to a mold cavity in a casting operation from a supply receiver to an intermediate measuring chamber, comprising the steps of moving metal from below the molten surface thereof at an area of relatively high air pressure to an area of lesser air pressure adjacent the intermediate measuring chamber by means of the pressure differential formed, simultaneously admitting air to the area of lesser air pressure in an amount insufficient to stop such metal movement, controlling the duration of such pressure differential to limit the metal so moved to a substantially predetermined amount, and thereafter discharging the metal at said intermediate receiving chamber to the mold cavity, whereby effective and accurate control of the amount of molten metal to the mold cavity is obtained.

2. A method of measuring and feeding molten metal to a mold cavity in a casting operation from a supply receiver to an intermediate measuring chamber, comprising the steps of moving metal from below the molten surface thereof at an area at atmospheric air pressure to an area of lesser air pressure adjacent intermediate measuring chamber, creating said area of lesser pressure by exhausting the air therefrom, simultaneously admitting air to the area of lesser pressure in an amount insufficient to stop such metal movement, controlling the duration and extent of the exhaustion of air from said area of lesser pressure to limit the metal so moved to a substantially predetermined amount, and thereafter discharging the metal at said intermediate measuring chamber to the mold cavity, whereby effective and accurate control of the amount of molten metal to the mold cavity is obtained.

3. A method of measuring and feeding molten metal to a mold cavity in a casting operation from a supply receiver to a measuring chamber, comprising the steps of moving metal from below the molten surface thereof under the action of atmospheric pressure to a position above the intended measuring chamber, controlling the duration of the applied atmospheric pressure to limit the metal so moved to a substantially predetermined amount, and thereafter permitting the metal, under the action of gravity, to drop to said measuring chamber to the mold cavity, whereby effective and accurate control of the amount of molten metal to the mold cavity is obtained.

4. In an apparatus for the measuring and feeding of molten metal to a mold cavity in a casting operation, the combination of a measuring chamber, means for the passage of molten metal from a supply receiver to said measuring chamber, said measuring chamber having an outlet therein for the discharge of the metal therefrom, means for selectively reducing the air pressure in the measuring chamber below atmospheric to create a pressure differential operative to move molten metal from supply receiving into the measuring chamber, and means for effecting discharge of the molten metal from said measuring chamber to empty the same.

5. In an apparatus for the measuring and feeding of molten metal from a supply receiver to a receiving cavity, the combination of a measuring chamber, said cavity being disposed exteriorly of said chamber, means operatively connecting said measuring chamber with said supply receiver for the passage of molten metal from the supply receiver to said measuring chamber, said means operatively connecting said measuring chamber with said supply receiver constructed to initially elevate the molten metal to a point above the level thereof in said supply receiver, said measuring chamber having an outlet therein for the discharge of the metal therefrom, means for selectively reducing the air pressure in the measuring chamber below atmospheric to create a pressure differential to move molten metal from such a supply receiver into the measuring chamber, and means for effecting discharge of the molten metal from said measuring chamber to the receiving cavity, whereby effective and accurate control of the amount of molten metal to the receiving cavity is obtained.

6. An apparatus for measuring a quantity of molten metal and feeding the same into a die cavity or the like, comprising a closed hopper having downwardly converging bottom walls, the apex having a discharge portion therein, said hopper having an air exhaust port and an air inlet port therein communicating with the upper portion of the hopper, a molten metal supply tube having one end communicating with the hopper at a point below the

air inlet and outlet therein and having its opposite end arranged for immersion in a supply receiver having a supply of molten metal, air exhausting means, conduit means operatively connecting the latter and said exhaust port, valve means disposed in said conduit for controlling the exhaust of air from said hopper, the latter having an air inlet port therein arranged to supply air to the hopper interior, valve means operatively related to said inlet port for controlling the admission of air into the hopper, actuating means associated with each of said control valves, and time means operatively connected to the actuating means for controlling the same and thereby the valves in predetermined timed relation, whereby effective and accurate control of the amount of molten metal to the die cavity is obtained.

7. An apparatus for measuring a quantity of molten metal and feeding the same into a die cavity or the like, comprising a closed hopper having downwardly converging bottom walls, the apex having a discharge portion therein, said hopper having an air exhaust port and an air inlet port therein communicating with the upper portion of the hopper, a molten metal supply tube having one end communicating with the hopper at a point below the air inlet and outlet therein and having its opposite end arranged for immersion in a supply of molten metal, a vacuum reserve tank, conduit means operatively connecting the latter and said exhaust port, valve means disposed in said conduit for controlling the exhaust of air from said hopper, an air exhaust conduit having one end communicating with said reserve tank and the other arranged for operative connection to vacuum producing means, a check valve disposed in said last mentioned conduit to prevent undesired air pressure feed back to said vacuum producing means, a valve member movable relative to said hopper operable to open or close said inlet port for controlling the admission of air into the hopper, respective actuating means associated with said control valve, and said valve member and timer means operatively connected to the respective means for controlling the same and thereby control, in predetermined timed relation, the exhaust of air from and admission of air to said hopper.

8. An apparatus for measuring a quantity of molten metal and feeding the same into a die cavity or the like, comprising a closed hopper having downwardly converging bottom walls, the apex having a discharge portion therein, said hopper having an air exhaust port and an air inlet port therein communicating with the upper portion of the hopper, means for heating said hopper to a temperature above the melting point of such molten metal, a molten metal supply tube having one end communicating with the hopper at a point below the air inlet and outlet therein and having its opposite end arranged for immersion in a supply of molten metal, a vacuum reserve tank, conduit means operatively connecting the latter and said exhaust port, valve means disposed in said conduit for controlling the exhaust of air from said hopper, an air exhaust conduit having one end communicating with said reserve tank and the other arranged for operative connection to vacuum producing means, a check valve disposed in said last mentioned conduit to prevent undesired air pressure feed back to said vacuum producing means, conduit means operatively connected at one end to said air inlet port and arranged to supply air to the hopper interior, valve means disposed in said air supply conduit for controlling the admission of air into the hopper, pneumatic actuating means including air cylinders and air valves associated with each of said control valves, and timer means operatively connected to said last mentioned air valves for controlling the same in predetermined timed relation and thereby the valves associated with said exhaust conduit and said air supply conduit.

9. An apparatus for measuring a quantity of molten metal and feeding the same into a die cavity or the like, comprising a closed hopper having downwardly converging bottom walls, the apex having a discharge portion therein, said hopper having an air exhaust port and an air inlet port therein communicating with the upper portion of the hopper, a molten metal supply tube having one end communicating with the hopper at a point below the air inlet and outlet therein and having its opposite end arranged for immersion in a supply of molten metal, air exhausting means, conduit means operatively connecting the latter and said exhaust port, valve means disposed in said conduit for controlling the exhaust of air from said hopper, the latter having an air inlet port therein arranged to supply air to the hopper interior, valve means operatively related to said air inlet port for controlling the admission of air into the hopper, actuating means associated with each of said control valves, timer means operatively connected to the actuating means for controlling the same and thereby the valves in predetermined time relation, a valve member disposed at the discharge port of said hopper and movable relative thereto from an operatively open position to an operative closed position, said valve member constructed to cooperate, when in its closed position, with said discharge port to provide an air inlet of reduced area, compared with the area of said discharge port, to permit a controlled amount of air to enter the hopper during the exhaustion of air from the latter, actuating means for effecting the operation of said last mentioned valve member, and control means operatively connected to said last mentioned actuating means and said timer for effecting operation of said valve means in timed relation to said air vacuum control valves.

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