Sept. 12, 1967 J. WOODBURN, JR 3,340,925

AUTOMATIC LEVEL CONTROL FOR METAL CASTING

Original Filed Dec. 5, 1963 3 Sheets-Sheet 1

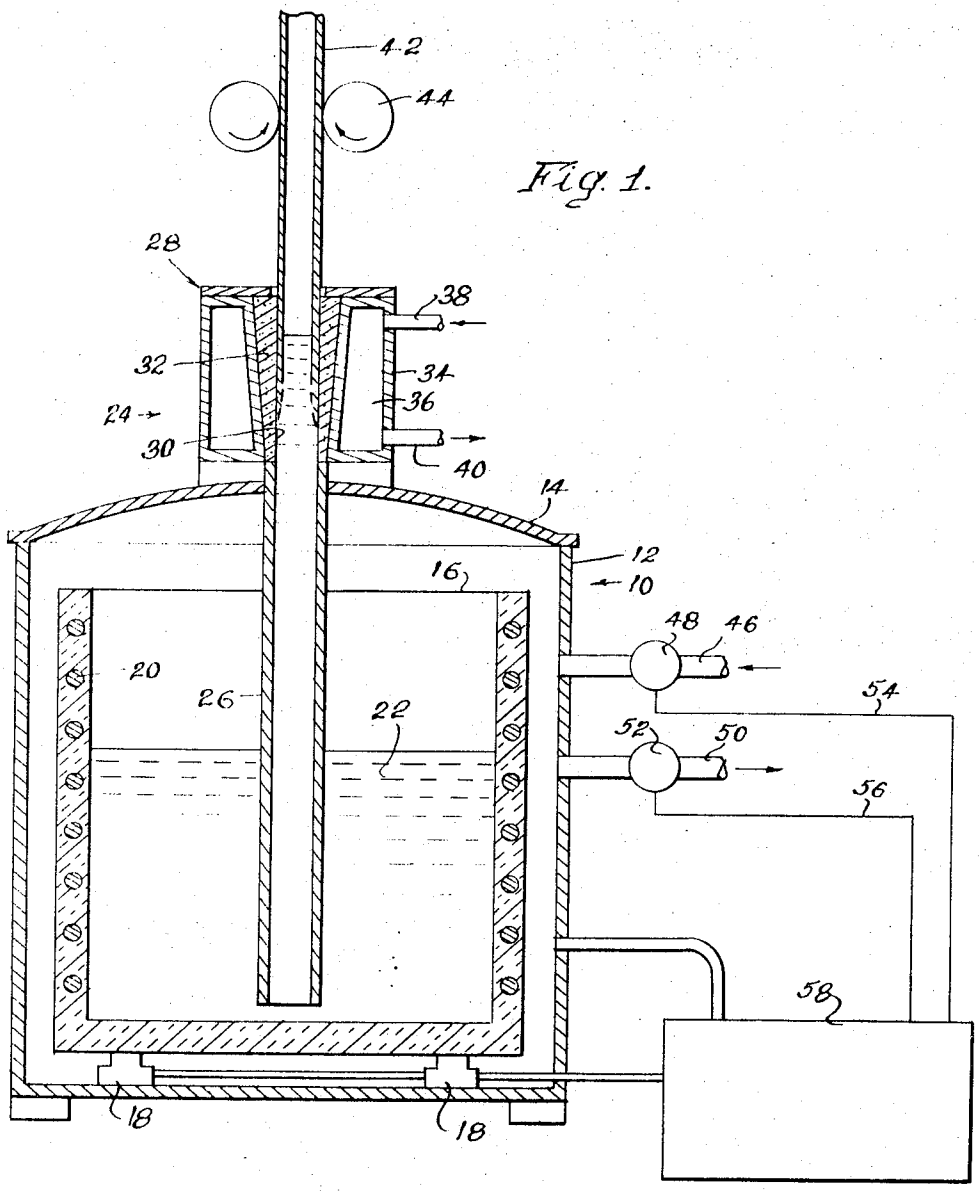


Fig. 1.

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Fig. 2.

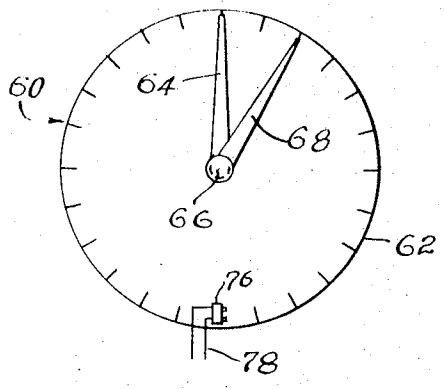


Fig. 3.

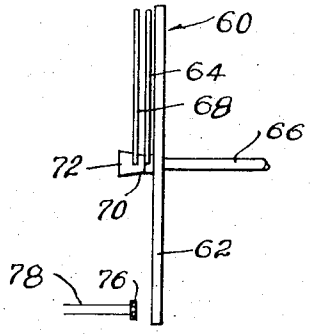


Fig. 5.

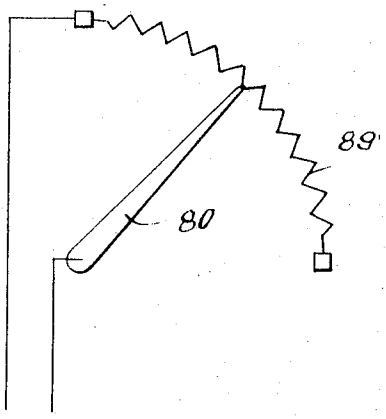
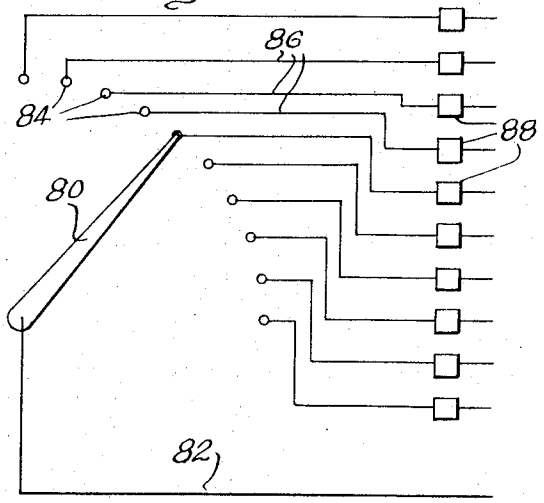


Fig. 4.



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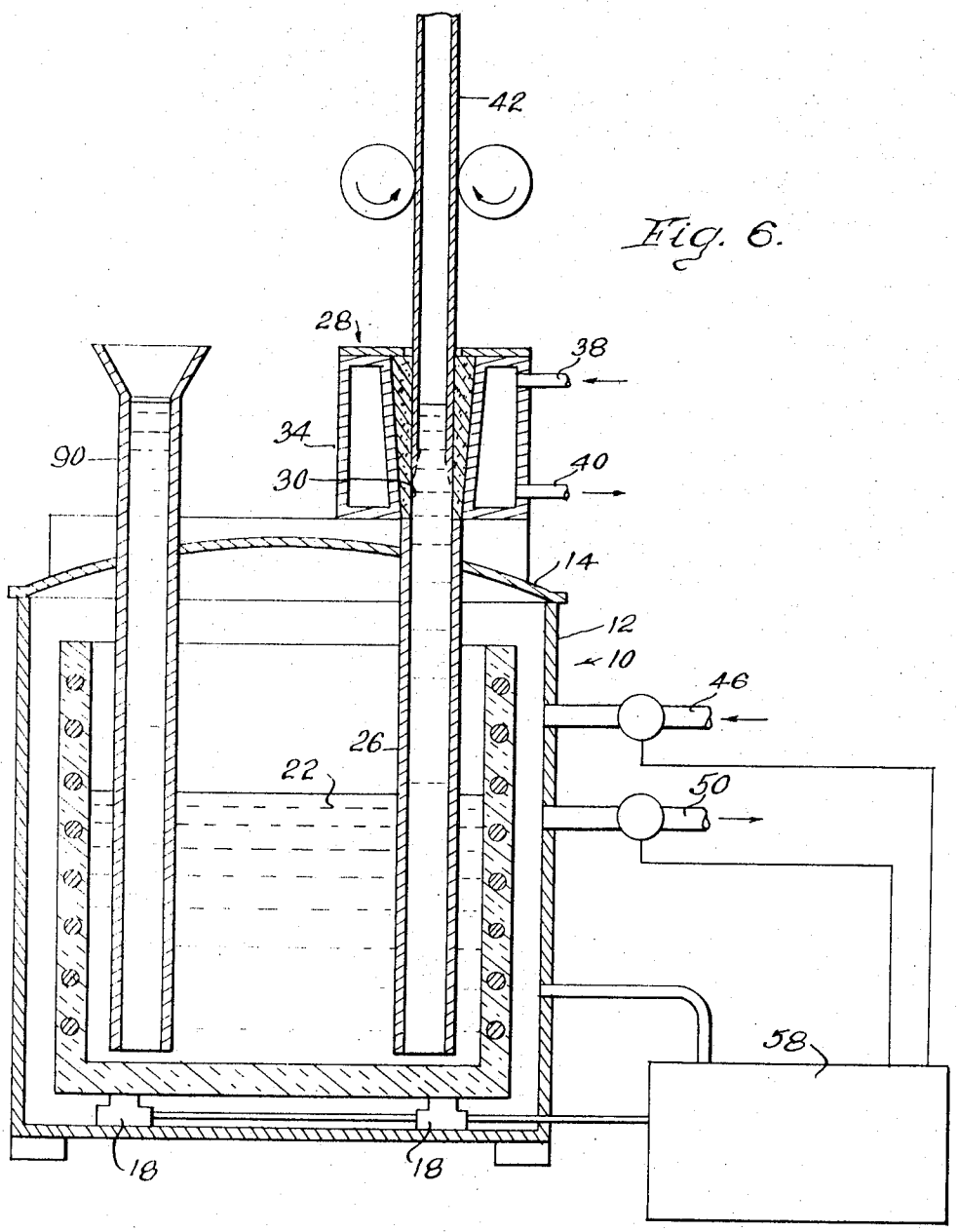


Fig. 6.

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AUTOMATIC LEVEL CONTROL FOR METAL CASTING

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Original application Dec. 3, 1963, Ser. No. 327,642, now Patent No. 3,287,773, dated Nov. 29, 1966. Divided and this application Apr. 6, 1966, Ser. No. 540,659
1 Claim. (Cl. 164—281)

ABSTRACT OF THE DISCLOSURE

In a continuous casting arrangement, a mold having a bottom opening is associated with a ladle and pressure is imposed on the molten metal in the ladle for forcing it upwardly into and through the mold. Control means is provided, responsive to the weight of the ladle and the metal in the ladle, for controlling the development of air pressure in the ladle as the molten metal is forced from the ladle through the mold.

This application is a division of my copending application Ser. No. 327,642, filed Dec. 3, 1963, now Patent No. 3,287,773.

The present invention relates generally to metal casting, and more particularly to continuous upcasting involving pressure pouring wherein a mold having a bottom pouring opening is associated with a ladle, and pressure is imposed on the molten metal in the ladle for forcing it upwardly into and through the mold.

It is, of course, desired to maintain the flow or movement of the molten metal into the mold at a certain predetermined rate to accommodate withdrawal of the cast product at a similarly constant rate. In this operation, it is desired to maintain the molten portion of the metal in the mold at a certain height relative to the freezing and casting function therein. As the cast article is withdrawn continuously, it tends to lessen the height of the molten portion of the metal in the mold, but the air pressure imposed on the molten metal in the ladle forces the molten metal into the mold and tends to raise that height, that height under ideal conditions remaining constant.

A broad object of the invention is to provide novel means for sensing the change in level of the molten metal in a ladle to enable the operator to perform corresponding manipulations, such as additional pouring, or to perform other functions and controls, either manual or automatic.

A more specific object is to provide means for sensing such level by sensing the weight of the molten metal.

Still another object is to provide a novel method of casting of the character set out above.

Other objects and advantages of the invention will appear from the following detailed description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a vertical sectional view of casting apparatus embodying the principles of the invention, certain portions thereof such as the controls being shown diagrammatically;

FIGURE 2 is a face view of one form of indicating device utilized in the apparatus;

FIGURE 3 is a side view of the apparatus of the instrument of FIGURE 2;

FIGURE 4 is a diagrammatic view of one form of control device;

FIGURE 5 is a diagrammatic view of another form of control device; and

FIGURE 6 is a vertical sectional view of a modified form of casting apparatus.

Referring now in detail to the accompanying drawings, attention is directed first to FIGURE 1 which includes a tank **10** including a receptacle **12** and a cover **14** detachably mounted thereon in sealing relation thereto to confine air pressure in the tank. The detailed structure of the tank may be as desired. A ladle **16** is mounted in the tank on load cells **18** which are weight sensing means, functioning to sense the weight of the ladle for use in conjunction with corresponding indicating means. As will be described more fully hereinbelow, the weight of the ladle and the molten metal therein can be utilized for indicating the quantity of molten metal therein by subtracting the empty weight of the ladle from the gross weight sensed by the load cells. The ladle **16** may be of conventional form, made of insulating refractory material and, if desired, may have an induction heating coil **20** embedded in the wall therein for heating the molten metal **22** or maintaining it in a molten condition.

The ladle **16** may be inserted in the tank receptacle **12**, after the removal of the cover **14** therefrom, by suitable means such as a crane, after which the cover is replaced and sealed on the receptacle. The cover **14** is incorporated in an assembly **24** which includes a pouring tube **26** and a mold **28**. The tube **26** is mounted in the cover by suitable means in sealed relation thereto, and it extends downwardly into close proximity to the bottom of the ladle. The tube extends to and communicates with the mold, the mold having a central passage **30** therein forming a cavity. This passage or cavity, as will be noted, opens through both the bottom and top of the mold, the molten metal being forced into the mold through the bottom and the cast product being withdrawn upwardly therefrom through the top opening. Preferably, the inner diameter of the pouring tube is equal to the diameter of the cavity.

The mold **28** includes a sleeve **32** forming the cavity which may be of such material as graphite. Surrounding the sleeve is a cooling jacket **34** of suitable high heat conducting material such as copper, and having an annular space **36** therein for circulation of cooling medium such as water. This cooling medium may be injected through an inlet pipe **38** from a supply source (not shown) and ejected through an outlet conduit **40**.

The cast product here indicated at **42** is in the form of a tube or pipe, and to produce such tubular product, the product is withdrawn at a predetermined rate relative to the rate of flow of the molten metal into the mold, together with other factors, e.g., temperatures involved. The cast product, after initiation of its removal, is continuously withdrawn by friction rollers **44** engaging it and rotating in the directions indicated.

The molten metal **22** is forced upwardly through the pouring tube **26** by air pressure produced in the sealed tank **10**. It will be understood that for a given pressure the molten metal will stand at a given level in the mold, and as the cast product is continuously removed, the level of the molten portion of the metal tends to lower and would lower if the pressure should remain constant. In order, therefore, to continue the pouring operation, additional pressure is produced in the tank, to maintain the level of the molten metal in the mold, because as the molten metal in the tank is depleted and the level thereof lowers, maintaining the level of the column in the mold is equivalent to raising the height of the column, i.e., the height of the column above the level in the ladle increases; hence the greater air pressure.

Air is introduced into the tank from a suitable source (not shown) through an inlet conduit **46** which includes a throttling control valve **48** of known type. Air is exhausted from the tank through an outlet conduit **50** having a control valve **52** therein of suitable and known type. The valves **48** and **52** may be controlled manually

when the apparatus is under manual operation, and controlled automatically when the apparatus is under automatic control, as described below.

As indicated above, the load cells **18** sense the weight of the ladle and the contents thereof, or the molten metal therein. This sensing operation may be utilized for use in any of a variety of different functions or control manipulations. In the simplest form of the operation of the apparatus, means utilized for indicating the weight of the ladle as sensed by the load cells, and the operator performs operations in accordance therewith. The load cells are so constructed, and the indicating means so calibrated, as to indicate the weight of the molten metal in the ladle as a resultant of effectively deducting the empty weight of the ladle from the gross weight sensed and thus indicate the quantity thereof. This indication made by the visual indicators enables the operator to determine whether to continue pouring, for example, or to replenish the molten metal, etc. For example, the operator knows the quantity of metal required for a single pouring operation, and if the visual indicating means indicates that sufficient molten metal remains in the ladle for that purpose, he can effect such a pouring operation, while on the other hand when he notes that there is insufficient molten metal for that purpose, he will arrange for another and full ladle to be put in place.

Instead of providing merely visual indications for guiding the operator, the apparatus may be used for directly effecting control operations in accordance with the conditions sensed. For example, the load cells **18** may be incorporated in an arrangement of control instruments for automatically performing the necessary or desired control operations, such as developing air pressure in the tank to raise the level of the molten metal in the mold directly proportional to the removal of the metal in the form of the cast article, whereby to automatically maintain the supply of molten metal in the mold at the desired level to enable withdrawal of the cast article at the desired rate. The principal consideration of the apparatus is that the weight of the ladle, and more specifically the weight of the molten metal therein, is utilized for determining the quantity of molten metal thereof to enable either such manual manipulations as stated or to effect any such automatic manipulations as are desired.

The load cells **18** may be in the form of mechanical scales, for example, and utilized with a visual indicator **60** (FIG. 2) in which a band or pointer **64** mounted on a shaft **66** sweeps over a dial **62** and in doing so indicates the weight and hence quantity of molten metal in the ladle.

In the case of automatic control of the apparatus, the control valves **48** and **52** are controlled respectively through suitable lines of communication **54**, **56**, which may be electrical lines or cables for controlling electric instrumentalities which, in turn, control the valves **48** and **52** in a known manner. The exact construction of the valves and their control means may be any of various kinds, whether electrical or otherwise, and may if desired be mechanically, pneumatically, or hydraulically controlled or operated, etc. All of these forms are well known, and may be selected according to the practical circumstances surrounding any given installation.

The source of control of the valves is an instrumentality **58** here designed simply a controller, itself controlled by the load cells **18**. The controller **58** is of suitable type according to the character of the valves, such as electrical, mechanical, etc.

The instrument **60** is adapted for use in automatic control, as well as manual control. An arm **68** is mounted on a sleeve **70** having a hand knob **72** friction-fitted on the shaft **66** and normally rotated with it, but capable of being manually rotated relatively to the shaft, and thereby set thereon. The arm is in position for engaging electrical contacts **76** upon swinging of the arm upon rotation of the shaft. Upon engagement of these contacts, a circuit is established through wires **78** for controlling the control apparatus which may be a shutting-off operation.

Automatic means for supplying additional air upon depletion of the liquid level may be of any suitable and known type. For example, in referring to FIGURE 4, an arm **80** is mounted on the shaft **66** for swinging movement therewith. The arm **80** is connected at one end with an electrical conductor **82**, and its other end is positioned for successively engaging contacts **84** connected with conductors **86**. The conductors lead to instrumentalities **88** which are pressure-sensitive devices operating on the basis that upon existence of a predetermined pressure, a control function will be performed. In the present instance, these pressure-sensitive devices **88** are connected with the interior of the tank so as to function in response to the pressure therein. As the arm sweeps in response to depletion of the molten metal in the ladle, as sensed through the load cells **18**, they successively put into circuit corresponding ones of the pressure-sensitive devices. These pressure-sensitive devices thereupon control one or both of the valves **48** and **52** for maintaining the pressure in the tank at the valve controlled by the characteristics of the pressure-sensitive devices.

It should be understood that satisfactory operation may be achieved by controlling the air pressure in the tank in steps, that is the air pressure may be increased in infinitely small or relatively large increments. Notwithstanding the foregoing, it is also contemplated within the scope of the invention that gradual or infinitely variable control devices may be utilized, as indicated above, instead of the apparatus illustrated in FIGURE 4. Such arrangement may include, for example, a progressively advancing device such as the rheostat **88** of FIG. 5, or a coil and armature movable therein, or other pneumatic, hydraulic, or mechanical devices.

The load cells **18** sense only the ladle and the molten metal therein below the level thereof, and not the metal in the column in the pouring tube above the level of the metal in the ladle. The air pressure in the tank is imposed on the ladle and the molten metal therein in all directions so that a pressure balance exists. As the level in the ladle lowers, the column in the pouring tube thereabove, which increases, is not sensed by the load cells, the weight of this column reacting through the metal in the ladle which in turn produces back pressure on the air in the tank. The differential in air pressure as determined by the level in the ladle is proportioned to the height of the column in the pouring tube above the level in the ladle.

The foregoing tank and ladle apparatus is designed for batch type of operation. However, the invention is sufficiently broad to cover continuous replenishment. This may be done through a filling tube **90** which is mounted in the cover **14** and extends down to a point adjacent the bottom of the ladle. This pouring tube is at least as high as the top of the mold. The molten metal rises in the filling tube to substantially the same height as that in the mold, and in the normal operation the metal does not flow out of the filling tube in response to the air pressure produced in the tank. As the molten metal is depleted in response to the casting operation, and in the absence of replenishment, the air pressure in the tank is increased in the manner described above. However, it is possible to continuously replenish the ladle by pouring into the filling tube, and in this case the air pressure may be maintained constant and the rate of filling is controlled so as to maintain the level in the mold at the desired height. It is also possible to utilize a combination of the functions, namely control the air pressure for maintaining the desired height in the mold without filling, and then when it is desired to replenish the ladle, such may be done through the filling tube and in this operation the value of the air pressure is controlled to compensate for the filling operation to maintain the level constant in the mold.

While I have disclosed certain preferred forms of the invention, it will be understood that changes may be made within the scope of the appended claim.

I claim:

Apparatus for continuous casting of metal comprising a sealed tank, a ladle in the tank adapted to contain molten metal, a mold having a bottom opening mounted on said tank, a pouring tube communicating between the ladle and the mold, the arrangement being operative in response to development of air pressure in the tank for forcing molten metal from the ladle through the pouring tube into the mold, means for developing air pressure in said tank, means for withdrawing the cast article from the mold while the molten metal is forced into the mold, and means responsive to the weight of the ladle and the molten metal therein for controlling the development of air pressure in the tank in response to depletion of the molten metal in the mold pursuant to removal of the cast article.

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