

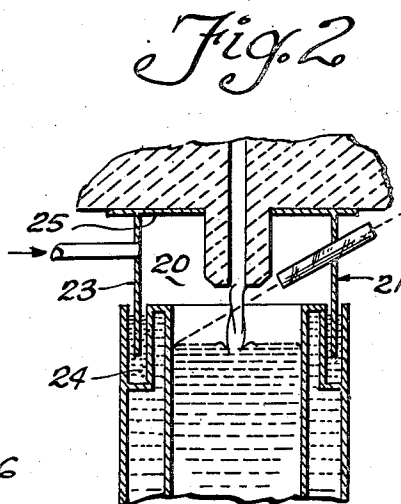
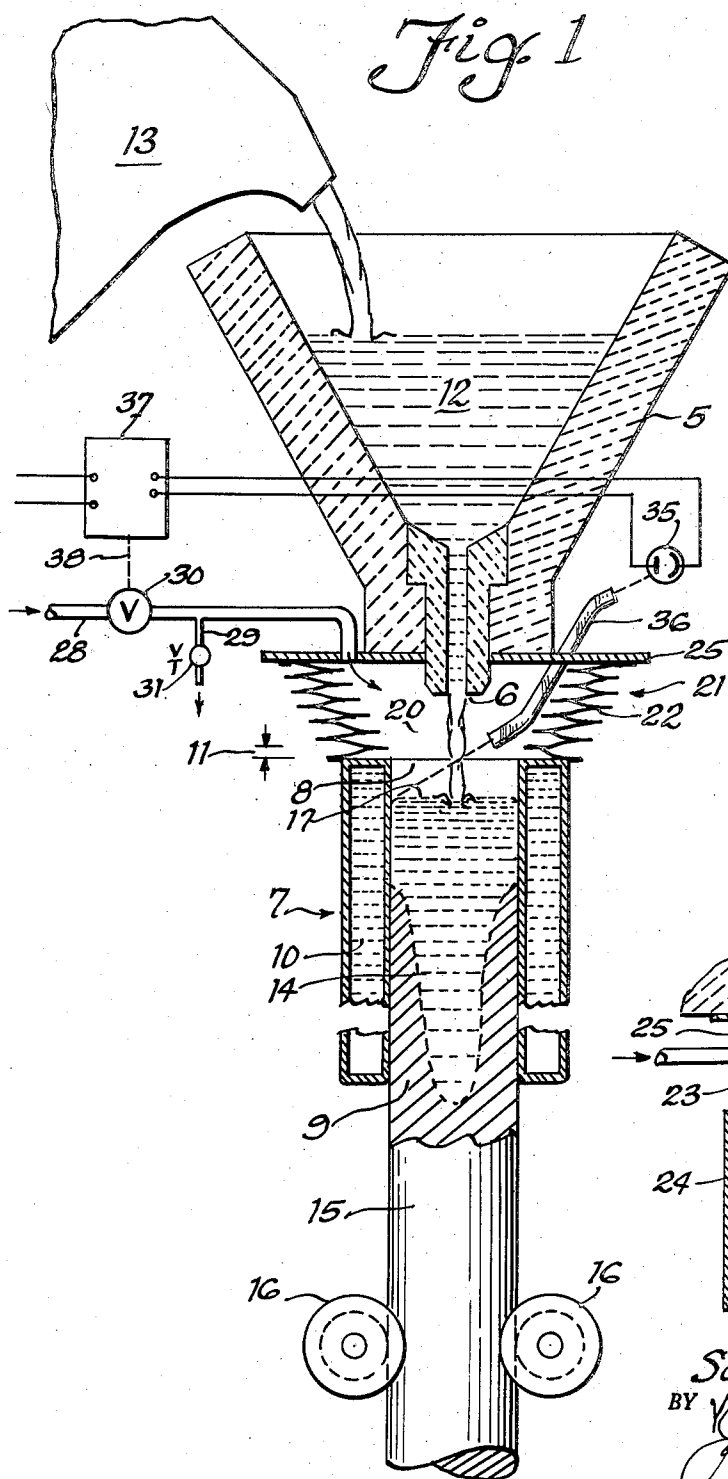
March 4, 1958

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METHOD AND APPARATUS FOR CONTROLLING GRAVITY
LIQUID FLOW, AND FOR CONTINUOUS
METAL BILLET CASTING

2,825,104

Filed March 16, 1954

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

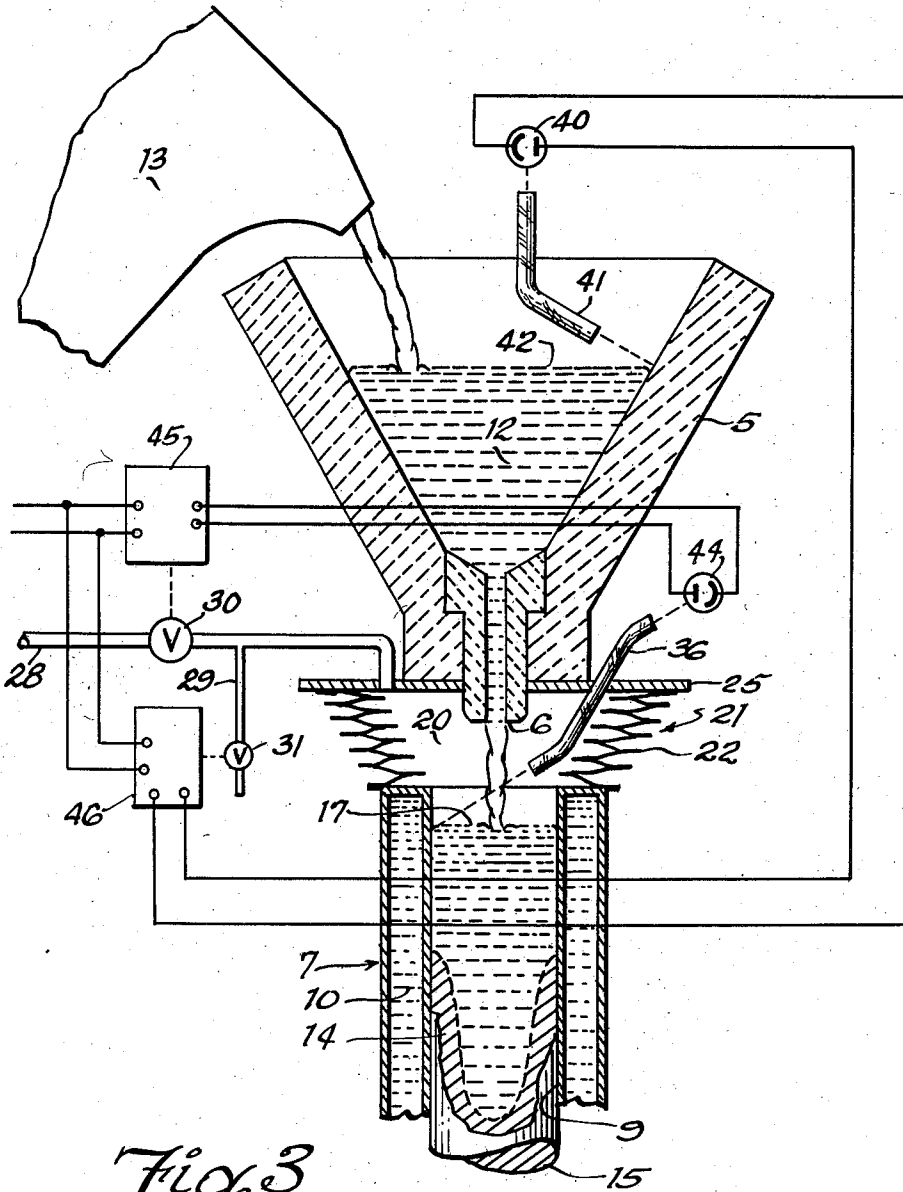


Fig. 3

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METHOD AND APPARATUS FOR CONTROLLING GRAVITY LIQUID FLOW, AND FOR CONTINUOUS METAL BILLET CASTING

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18 Claims. (Cl. 22—57.2)

In its broadcast application the present invention relates to regulation of the volume rate of gravity flow of a liquid material, from an upper, supply body of liquid contained in a first and higher receptacle, through an orifice that is located below the surface of that body of liquid material, and to a receiving body thereof contained in a lower receptacle disposed to receive the liquid discharged through the orifice.

A typical field of utility of the invention is in a situation wherein the material is continuously withdrawn from the lower receptacle, at a volume rate which may vary, in which case the invention may be used to maintain the volume rate of fluid discharge through the orifice substantially equal to the rate of withdrawal, and/or a situation wherein the supply body of liquid material in the upper receptacle is periodically replenished by added batches, whereby the liquid at the orifice is subject to periodically varying head pressures. In the latter case the invention may be either or both used to maintain the volume rate of discharge through the orifice constant under the varying head, and/or again made to substantially equal the volume rate of withdrawal of the material from receiving body contained by the lower receptacle.

A very important field of application of the invention, and which has been selected for purposes of disclosure, is that of continuous metal casting, for example, the continuous casting of molten metal into an open top and open bottom mold, wherein the metal continuously moves downward through the mold, solidifying from molten condition at the top to solid condition at the bottom of the mold, and being continuously withdrawn therefrom in the form of solid, elongate billet stock.

While this continuous billet casting is being commercially worked, it has, prior to the present invention, presented such serious problems as to place it on the border line between practical and impractical operation.

Reference is made to United States Patent to Webster, No. 2,246,907, dated June 24, 1941, which enumerates certain of the difficulties and problems of continuous billet stock casting. For example, the rate of withdrawal of solidified billet stock from the mold bottom may have to be varied by reason of variation in temperature of the molten metal, its rate of solidifying, etc. In continuous casting, as generally practiced at the present time, the metal is cast from a supply body that is contained in a pour box, having a relatively low level discharge orifice, and the supply body is periodically replenished by ladle batches that are rapidly poured or dumped into the pour box, to be thereafter discharged gradually through the pour orifice to the mold. This periodic replenishment provides periodically varying head of molten metal above the pour box discharge orifice, a varying pressure at the orifice, and a variation in volume rate of discharge of the metal. Also variation in the gravity rate of flow of the molten metal may be caused by varying viscosity of the molten metal.

The present invention affords a novel means and method of overcoming such factors as tend to result in uncon-

trolled variation in rate of discharge by gravity of molten metal through an orifice, and also permits that rate to be maintained practically equal to a variable volume rate of withdrawal of metal from the lower, receiving body of metal.

In the accompanying drawings:

Fig. 1 is a somewhat schematic vertical section, showing a continuous billet casting assembly including one embodiment of the invention.

Fig. 2 is a fragmentary detail section showing a minor modification of structural arrangement for practicing the invention.

Fig. 3 is a view similar to Fig. 1, showing a more complex embodiment of the invention.

Referring to Fig. 1, the continuous billet casting apparatus therein shown includes a stationarily mounted pour box 5, having at its bottom a discharge orifice 6 that overlies a mold 7 that has an open top 8, an open bottom 9, and double walls providing space 10 for circulation of a cooling medium. As is the general practice, mold 8 is mounted for vertical vibration through a distance indicated at 11, which in practice is of the order of three-quarters of an inch, and is vibrated by suitable mechanism, not shown. For continuously supplying molten metal to mold 8, pour box 5 periodically has poured into it batches of molten metal, which forms therein a supply body 12 of metal in molten, liquid condition. This periodic replenishment may be accomplished by batches of molten metal poured into box 5 by a ladle 13, at such intervals as to maintain continuous discharge of metal through orifice 6 and to the open top 8 of mold 7. This metal forms in mold 7 a body 14 that is molten at the top of the mold, that continuously moves downwardly through the mold and solidifies therein, being withdrawn continuously from the bottom of the mold as elongate, solid billet stock 15. This billet stock is withdrawn by a suitable driving mechanism, such as that shown by the above-identified patent, and including a pair of motor driven gripper wheels, herein designated 16, and, as also set forth in that patent, these wheels may be driven at selectively variable speed to permit adjustment of the travel time of metal through mold 7.

It will be readily apparent that such factors as viscosity of molten metal forming the supply body 12, and varying depth of that body which provides a varying head at orifice 6 will tend to vary the volume rate of discharge of the liquid, molten metal through that orifice, additionally, that any variance between volume rate of that discharge and volume rate of withdrawal of metal from the mold, as solid billet stock 15, will result in variation of the level of the top surface 17 of the body 14 of metal in the mold, which may cause overflowing of the mold, or insufficient travel time of the metal within the mold for solidification, depending on the sense of such variance.

In conformance with the more general aspects of the invention, regulation of the volume rate of flow of metal in molten condition, from the supply body 12 contained by pour box 5, and by gravity discharged through orifice 6 to the receiving body of molten metal comprising the upper portion of the body 14 of metal in mold 7, a chamber or space 20, containing the discharge side or outlet of orifice 6 and the open top 8 of mold 7, and overlying the top surface 17 of the receiving body 14 of metal, is enclosed in a gas tight wall structure 21. As shown in Figs. 1 and 3, this wall structure, to accommodate vertical vibration of mold 7 relative to the stationary pour box 5, may be of the axially semi-collapsible or other flexible formation, similar to the wall of an expansible bellows structure, shown at 22 in Figs. 1 and 3, or, as shown in Fig. 2, it may comprise a rigid cylindrical wall 23, depending from the pour box bottom and entered into an

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annular trough 24 carried by the top of the mold and containing a liquid sealing medium, such as mercury. In either case, a gas tight seal is provided at the top of wall structure 21, as by joining it with a plate 25 secured to the pour box bottom, and at the bottom, either by sealing the flexible wall 21 to the top of mold 7, or by the sealing trough arrangement 24 of Fig. 2.

Provision is made for varying the magnitude of pressure of a gaseous medium filling chamber 20 within wall structure 21, thereby to increase and decrease rate of discharge of molten metal through orifice 6, respectively by decreasing and increasing the pressure of that medium. Additionally, and as shown, such gas pressure variation may be accomplished automatically, as to maintain volume rate of metal discharge constant in spite of periodic head variations caused by periodic replenishment of the supply body 12, and/or to maintain the volume rate of molten metal pouring substantially equal to the volume rate of withdrawal of metal from mold 7 in the form of solidified billet stock.

As a means of selectively varying the pressure of the gaseous medium that is maintained under pressure in chamber 20, there is shown in Figs. 1 and 3 a supply line 28 that communicates with chamber 20 for thereto supplying a suitable gaseous medium delivered by a source at some suitable preselected maximum pressure. A suitable system for selecting the pressure exerted in chamber 20, is one that varies the ratio between volume rate of supply of the gaseous medium to chamber 20 and the volume rate of exhaust of the medium from the chamber. In Figs. 1 and 3, a bleed or exhaust line 29 serves to exhaust the gas from the chamber, and either or both a flow rate regulating valve 30 in supply line 28 and/or a flow rate regulating valve 31 in the exhaust line 29, may be employed to adjust that ratio. Thus valve 30 may be opened and closed respectively to increase and decrease pressure in chamber 20 by increasing and decreasing the ratio of volume rate of supply to that of exhaust, and/or valve 31 may be opened or closed to decrease and increase pressure in chamber 20, also by decreasing and increasing the ratio of volume rate of supply to that of exhaust.

The automatic control system of Fig. 1, by means of which rate of molten metal discharge through orifice 6 may be maintained substantially equal to rate of billet stock withdrawal is shown as including means, closely resembling those of the above-identified patent, for detecting the level of the top surface 17 of the receiving body 14 of metal in mold 7, and generating a signal of a magnitude corresponding to that level and varying in proportion to changes therein. Such means may include a photosensitive cell 35 to which light emitted by the surface 17 of the molten body of metal in the mold is conducted by a quartz rod 36, in such fashion that intensity of illumination of cell 35 increases and decreases with rise and descent of surface 18. The electrical signal output of cell 35, increasing and decreasing with intensity of illumination of cell 35, is imposed on a servomotor system 37, the output element 38 of which is connected to the control element of valve 30, in such fashion as to open that valve more widely when the level of surface 17 rises, thereby increasing the ratio of volume rate of supply to that of exhaust of the gaseous medium correspondingly raising the pressure in chamber 20, and decreasing the rate of molten metal discharge through orifice 6, by increasing the resistance thereto exerted by the gaseous medium. Opposite operation occurs upon a descent of surface 17. Thus, by suitable circuitry and arrangements of servomechanism 37, output element 38 and valve 30, the level of surface 17 can be made to remain quite constantly at a preselected level during changes of rate of billet stock withdrawal, and/or changes of such factors as may affect the rate of metal discharge through orifice 6, as variation in head provided by body 12, or viscosity of the molten metal.

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In some cases it may be desirable to provide for an auxiliary control effect, somewhat of the nature of an anticipatory regulating operation, that acts rapidly upon replenishment of the upper, supply body 12 of molten metal, to increase the gas pressure in chamber 20, independently of the level of surface 18 of the lower, receiving metal body. Fig. 3 shows an arrangement for providing such control.

This arrangement comprises means for detecting the magnitude of the head of molten metal that is effective at the entrance or upper side of discharge orifice 6, producing a signal of a magnitude that is proportional to that head, and utilizing that signal to vary the relative rates of volume supply and exhaust rates of the gaseous medium to and from chamber 20, to increase and decrease the ratio of supply to exhaust respectively with increase and decrease of the head of metal in pour box 5. Since the gaseous medium supply and exhaust rate ratio is also subjected to control from the lower metal body surface 17, such control by head or depth of the supply body 12 may not result in actual increase or decrease of pressure in chamber 21, but may result only in a tendency toward such an increase or decrease.

Conveniently, as shown in Fig. 3, the device for measuring the depth of supply body 12, or of the head thereby provided, comprises a second surface level detector, including a photosensitive cell 40 and a quartz tube 41 in an arrangement to vary intensity of illumination of cell 40 by light emitted from the top surface 42 of the supply body of molten metal in pour box 5, with rise and descent of that surface 42. The system is so arranged that the pressure of the gaseous medium in chamber 20 is proportional to an algebraic summarization of components respectively proportional to the magnitudes of signal outputs of cell 40, and a second cell 44 that is arranged to detect the level of the top surface 17 of the receiving body 14 of metal in mold 7, in an arrangement similar to that of Fig. 1. Conveniently, and as shown, such summarization may be accomplished at chamber 20 itself, by the very simple expedient of operating the valve 30 that controls volume rate of gas supply by a servomechanism 45 that is controlled by the output of one cell, shown as 44, while the exhaust rate control valve 31 is operated by a second servomechanism 46 that is controlled by the other cell, here 40.

By such an arrangement, while the pressure in chamber 20, exerted against discharge of molten metal through orifice 6, primarily and inherently is under control of cell 44 and changes in the level of surface 17, the replenishment of supply body 12 tends to provide a rapid increase in the ratio of rate of gaseous medium supply to rate of exhaust, by reduction of the latter rate, thus minimizing the lagging effect that may occur if the change in rates of gas supply and exhaust are delayed until rise of surface 17 as a result of increased head of molten metal above orifice 6.

From the above it will be evident that there are certain basic concepts of method and apparatus presented by the invention herein disclosed, and that many variations from the specific embodiments above described in an exemplary way may be resorted to within the limits of the invention, which limits are to be ascertained solely from the appended claims.

I claim:

1. In the continuous gravity casting of molten metal from an intermittently replenished molten supply body in a pouring box, through an orifice therein, and to a receiving body of molten metal in an open bottom billet mold wherein said metal continuously solidifies and from the bottom of which the solidified metal is continuously withdrawn as an elongate billet, the method of maintaining the volume rate of molten metal flow through said orifice substantially equal to the volume rate of withdrawal of solidified metal from said mold, said method comprising supplying to and exhausting from a confined

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space located at the discharge side of said orifice and overlying said receiving body, a gaseous medium under pressure, detecting and developing a first control signal from the level of the top surface of said receiving body of metal, by said signal varying the relative volume rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said surface level, detecting and developing a second control signal from the level of the top surface of said intermittently replenished supply body, and by said second control signal varying the ratio between said volume flow rates of supply and exhaust of said gaseous medium to increase the ratio of supply rate to exhaust rate in respective response to rise and descent of said supply body top surface level.

2. In apparatus for continuous casting of molten metal, which includes a pour box for containing a supply body of the molten metal and having therein an orifice for gravity flow of metal from said body, a molding device comprising a receptacle disposed beneath said orifice for receiving molten metal, therefrom and means for continuously withdrawing metal from said receptacle; means for detecting the volume rate of withdrawal of metal from said receptacle and generating a signal of a magnitude proportional thereto, means for maintaining volume rate of flow of molten metal through said orifice substantially equal to said volume rate of metal withdrawal, comprising gas tight structure enclosing a space surrounding said orifice and the top of said receptacle, a body of gas under pressure enclosed by said structure, and means responsive to magnitude of a signal developed by said detector and signal generating means for increasing and decreasing the pressure of said gas respectively in response to decrease and increase in said withdrawal rate and in a range of pressure of sufficient magnitudes to correspondingly vary the rate of metal flow through said orifice.

3. In apparatus for continuous casting of molten metal, which includes a pour box for containing a supply body of molten metal and having therein an orifice for gravity flow of metal from said body, a molding device comprising a receptacle disposed beneath said orifice for receiving and containing a body of molten metal therefrom and means for continuously withdrawing metal from said receptacle; means for detecting and generating a signal of a magnitude that varies with the level of the top surface of a body of molten metal in said receptacle, means for maintaining the volume flow rate of molten metal through said orifice substantially equal to said volume rate of metal withdrawal, comprising gas tight structure enclosing the discharge side of said orifice and the top of said receptacle, means for introducing gas under pressure to the interior of said receptacle, means for exhausting gas therefrom, and means responsive to magnitude of a signal developed by said detector and signal generating means for varying the relative volume rates of gas flow through said supply and exhaust means to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said level, and in a range of magnitudes of pressure sufficient to correspondingly affect rate of flow of the metal through said orifice.

4. In apparatus for continuous casting of molten metal, which includes a pour box for containing a supply body of molten metal and having therein an orifice for gravity flow of metal from said body, and a molding device comprising a receptacle disposed beneath said orifice for receiving and containing a body of molten metal therefrom and means for continuously withdrawing metal from said receptacle; means for detecting the level of the top surface of a supply body of molten metal contained by said pour box and generating a signal of a magnitude that varies with change of said level, gas tight structure enclosing the discharge side of said orifice and the top

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of said receptacle, and means operative in response to variation in magnitude of said signal for increasing and decreasing pressure of a gaseous medium contained by said structure in respective response to rise and descent of said level, and in a range of magnitudes of pressure sufficient to correspondingly affect rate of flow of the metal through said orifice.

5. In apparatus for continuous casting of elongate billet stock, and which includes a stationary pour box for containing a supply body of molten metal and having an orifice for discharging metal from said body, molding means comprising a vibratory, open bottom mold having a top opening disposed to receive molten metal from said orifice and adapted to contain a continuously downwardly moving body of metal that is molten at the top and solid at the bottom of the mold and means for continuously withdrawing solidified metal as elongate billet stock from the open mold bottom, and means for detecting and generating a signal of a magnitude varying with the volume rate of solid metal withdrawal from said mold bottom; means for maintaining the volume rate of molten metal discharge through said orifice substantially equal to said volume withdrawal rate, comprising gas tight structure having a wall connected with said mold and pour box, enclosing the discharge side of said orifice and said mold top opening, and arranged to permit vibration of said mold relative to said stationary pour box, and means responsive to said signal for increasing and decreasing the pressure of a gaseous medium enclosed by said structure respectively in response to decrease and increase in said withdrawal rate, and in a range of magnitudes of pressure sufficient to correspondingly affect rate of flow of the metal through said orifice.

6. In apparatus for continuous casting of elongate billet stock, and which includes a stationary pour box for containing a supply body of molten metal and having an orifice for discharging metal from said body, molding means comprising a vibratory, open bottom mold having a top opening disposed to receive molten metal from said orifice and adapted to contain a continuously downwardly moving body of metal that is molten at the top and solid at the bottom of the mold and means for continuously withdrawing solidified metal as elongate billet stock from the open mold bottom, and means for detecting and generating a signal the magnitude of which varies with rise and descent of the level of the top surface of a body of metal contained by said mold; means for maintaining the volume rate of molten metal discharge through said orifice substantially equal to the volume rate of withdrawal of solid metal from said mold bottom, comprising gas tight wall structure attached to said pour box and mold, enclosing the discharge side of said orifice and said open mold top, and arranged to permit vibration of said mold relative to said pour box, means for supplying to and exhausting from the interior of said wall a gaseous medium under pressure, and means responsive to the magnitude of said signal for varying the relative volume rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said level, and in a range of magnitudes of pressure sufficient to correspondingly affect rate of flow of the metal through said orifice.

7. The method of controlling flow rate of liquid through an orifice of constant effective cross sectional area, that comprises maintaining a confined body of a gaseous medium at the delivery side of said orifice under pressure of sufficient magnitude to affect rate of liquid flow through said orifice by counter-pressure resistance exerted by said medium, and adjusting the pressure of said body inversely with required changes in said flow rate and independently of changes in pressure of said liquid.

8. The method of controlling gravity flow rate of liquid through an orifice, that comprises maintaining a con-

finer body of a gaseous medium at the delivery side of said orifice under pressure of sufficient magnitude to affect rate of flow through said orifice by counter-pressure resistance exerted by said medium, developing independently of the pressure of said gaseous medium a control signal of magnitude proportional to magnitude of variance between said flow rate and a required flow rate, and by said control signal increasing and decreasing pressure of said medium respectively as said flow rate exceeds or is less than the required flow rate.

9. The method of controlling gravity flow rate of material in liquid form through an orifice and to a body from which said material is removed continuously, said method comprising maintaining an enclosed gaseous medium in a confined space at the discharge side of said orifice and overlying said body of material under pressure of sufficient magnitude to affect rate of flow of the liquid through said orifice by counter-pressure resistance exerted by said medium, detecting and developing a control signal from changes in the level of the top of said body of material and independently of the magnitude of pressure of said medium, and in response to variation in said control signal increasing and decreasing the pressure of said gaseous medium respectively when said top level rises and descends and as the sole means of controlling said flow rate.

10. The method of controlling gravity flow of material in liquid form from an upper body the depth of which is variable, through an orifice spaced below the surface level of said body and providing a flow path of constant effective cross sectional area, whereby a variable head exists above said orifice, and to a second body of said material below said orifice and from which said material is withdrawn continuously, said method comprising, maintaining a confined body of a gaseous medium at the discharge side of said orifice and overlying the surface of the said lower body under pressure of a magnitude sufficient to affect rate of flow of the liquid through said orifice by counterpressure resistance exerted by said medium, detecting and developing a control signal from changes in the level of the upper surface of at least one of said bodies and independently of magnitude of pressure of said medium, and by said control signal increasing and decreasing the pressure of said gaseous medium respectively in response to rise and descent of a surface level so detected as the sole control of said flow rate.

11. The method of controlling gravity flow of liquid from a body of varying depth, and through an orifice spaced below the surface of said body, whereby a variable head is provided, said method comprising, maintaining a confined body of gaseous medium at the discharge side of said orifice under pressure within a range of magnitudes sufficient to affect rate of flow of the liquid through said orifice, detecting and developing a control signal from variations in the level of the surface of said body of liquid, and increasing and decreasing the pressure of said gaseous medium respectively in response to variations in said control signal responsive respectively to rise and descent of said level.

12. The method of controlling flow rate of liquid through an orifice that comprises maintaining constant the effective cross sectional area of the flow path provided by said orifice, supplying to and exhausting from a confined space at the discharge side of the orifice a gaseous medium under pressure of magnitude sufficient to affect flow rate of the liquid through said orifice by counter-pressure resistance exerted by said medium, and as the sole control of said flow rate varying the relative volume flow rates of supply and exhaust of said medium to vary the pressure thereby exerted in said space and that opposes flow of liquid through said orifice, inversely with required changes in rate of flow of said liquid through said orifice.

13. The method of controlling gravity flow rate of

liquid from an upper, supply body of varying depth, through an orifice spaced below the surface of said body, whereby a variable head is provided, and to a lower, receiving body from which said material is drawn continuously, said method comprising continuously supplying to and exhausting from a confined space enclosing the delivery side of said orifice and the upper surface of said lower body a gaseous medium under pressure of magnitude sufficient to affect rate of flow of the liquid through said orifice, detecting and developing from the level of the top surface of the said receiving body and independently of the magnitude of pressure of said medium a first control signal and by said signal varying the relative volume flow rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said level, detecting and developing a second control signal from the level of the top surface of said upper supply body, and by said second control signal varying the relative volume flow rate of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said upper, supply body top surface level.

14. In the continuous gravity casting of molten metal from a molten supply body in a pouring box, through an orifice therein and to a receiving body of molten metal in a molding device wherein said metal solidifies and from which solidified metal is continuously withdrawn, the method of maintaining volume flow rate of molten metal through said orifice substantially equal to the volume rate of withdrawal of solidified metal from said molding device, said method comprising supplying to and exhausting from a confined space located at the discharge side of said orifice and enclosing the top surface of said receiving body of molten metal, a gaseous medium under pressure of a magnitude sufficient to affect rate of flow of the metal through said orifice, developing independently of the magnitude of pressure of said gaseous medium a control signal having a magnitude proportional to the volume rate of withdrawal of solidified metal from said molding device, and by said control signal varying the relative volume rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate of said gaseous medium in respective response to decrease and increase in said volume rate of withdrawal.

15. In the continuous gravity casting of molten metal from a molten supply body in a pouring box, through an orifice therein and to a receiving body of molten metal in an open bottom billet mold wherein said metal continuously solidifies and from the bottom of which the solidified metal is continuously withdrawn as an elongate billet, the method of maintaining the volume rate of molten metal flow through said orifice substantially equal to the volume rate of withdrawal of solidified metal from said mold, said method comprising supplying and exhausting a gaseous medium to and from a confined space located at the discharge side of said orifice and above said receiving body of metal in the mold and at respective rates to maintain said medium within said space at a pressure of sufficient magnitude to affect rate of flow of the metal through said orifice, detecting and developing from the level of the top surface of at least one of said bodies and independently of the magnitude of pressure of said gaseous medium a control signal, and in direct response to said control signal varying the relative volume rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of a said top surface level so detected.

16. In the continuous gravity casting of molten metal from an intermittently replenished molten supply body in a pouring box, through an orifice therein, and to a receiving body of molten metal in an open bottom billet

mold wherein said metal continuously solidifies and from the bottom of which the solidified metal is continuously withdrawn as an elongate billet, the method of maintaining the volume rate of molten metal flow through said orifice substantially equal to the volume rate of withdrawal of solidified metal from said mold, said method comprising supplying and exhausting a gaseous medium to and from a confined space located at the discharge side of said orifice and overlying said receiving molten metal body at respective rates effective to maintain pressure of said medium in said space at a magnitude sufficient to affect rate of flow of the metal through said orifice by counter-pressure resistance exerted by said medium, detecting and developing from the level of the top surface of the latter said body and independently of magnitude of the pressure of said medium a control signal, and by said control signal and as the sole means of controlling said flow rate varying the relative volume flow rates of supply and exhaust of said gaseous medium to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said surface level.

17. In the continuous gravity casting of molten metal from an intermittently replenished molten supply body in a pouring box, through an orifice therein, and to a receiving body of molten metal in an open bottom billet mold wherein said metal continuously solidifies and from the bottom of which the solidified metal is continuously withdrawn as an elongate billet, the method of maintaining the volume rate of molten metal flow through said orifice substantially equal to the volume rate of withdrawal of solidified metal from said mold, said method comprising supplying and exhausting a gaseous medium to and from a confined space located at the discharge side of said orifice and overlying said receiving body respectively at rates maintaining said medium within said space under pressure of a magnitude to affect rate of flow of the metal through said orifice, detecting and develop-

ing a control signal solely from the level of the top surface of said intermittently replenished supply body of molten metal and independently of the pressure of said gaseous medium, and by said control signal varying the relative volume rates of supply and exhaust of said gaseous medium, to increase and decrease the ratio of supply rate to exhaust rate in respective response to rise and descent of said top surface level.

18. In apparatus for continuous casting of molten metal, which includes a pour box for containing a supply body of the molten metal and having therein an orifice for gravity flow of metal from said body, and a molding device having a receptacle disposed below said orifice for receiving metal discharged therefrom; means for regulating the volume rate of discharge of molten metal through said orifice comprising gas tight structure enclosing the discharge side of said orifice and the top of said receptacle, means for maintaining within said structure a gaseous medium under pressure within a range of sufficient pressure magnitudes to affect the rate of discharge of metal through said orifice by counter-pressure resistance exerted by said medium, and control means for adjusting the pressure of said gaseous medium within said range.

References Cited in the file of this patent

UNITED STATES PATENTS

1,139,888	Mellen	May 18, 1915
2,140,607	Thompson	Dec. 20, 1938
2,246,907	Webster	June 24, 1941
2,354,400	Percy	July 25, 1944
2,371,604	Brennan	Mar. 20, 1945
2,457,083	Jordan	Dec. 21, 1948
2,544,837	Jordan	Mar. 13, 1951

FOREIGN PATENTS

891,444	Germany	Sept. 28, 1953
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