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APPARATUS FOR CONTINUOUS CASTING OF METAL

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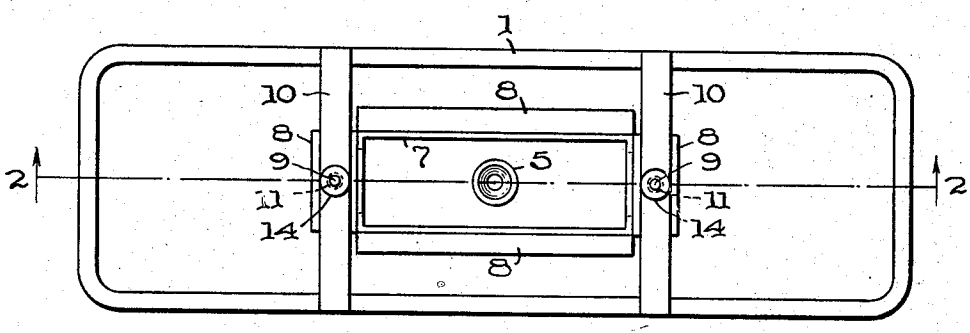


FIG. 1.

FIG. 2.

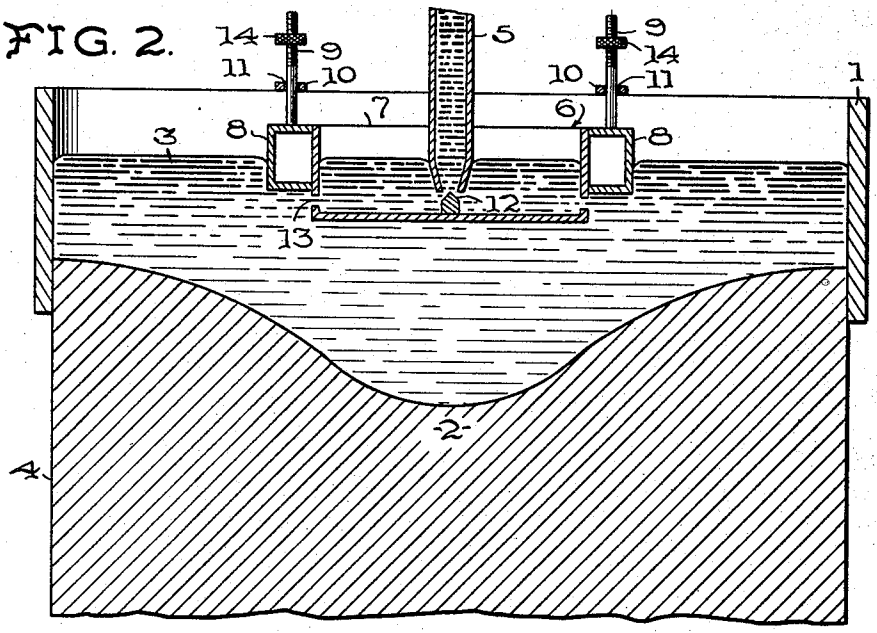
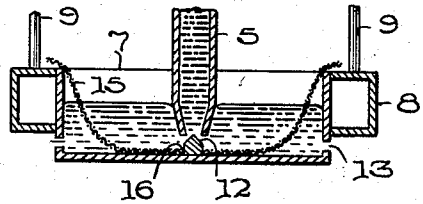


FIG. 3.



INVENTOR.
OWEN M. GARDNER
BY James E. Toomey
ATTORNEY

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APPARATUS FOR CONTINUOUS CASTING OF METAL

Owen M. Gardner, Opportunity, Wash., assignor to Kaiser Aluminum & Chemical Corporation, Oakland, Calif., a corporation of Delaware

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7 Claims. (Cl. 22—57.2)

This invention relates to the continuous casting of metal ingots, billets and the like. More particularly, this invention relates to apparatus for the continuous casting of metal ingots, billets and the like wherein a substantially uniform rate of flow of molten metal into the mold is maintained.

In the art of continous casting of metals, the general practice is to allow a vertical open-ended mold shell, to feed molten metal continuously into the top of the mold shell through suitable metal delivery means such as a standpipe or pouring spout and continuously withdraw solid casting from the lower end of the mold; and to supply a cooling fluid continuously to the mold and/or to the solid casting as it emerges from the mold. The metal may or may not be completely solidified in the mold; thus, the casting at the point where it emerges from the mold may contain a core or crater of molten metal, which is solidified by cooling the casting below the mold. The cooling fluid may be a liquid, preferably water, or a gas, such as air. Cooling of the mold, and of the casting below the mold, may be accomplished either by the use of a cooling jacket, such as a water jacket, or by delivering coolant directly to the mold or casting, as by means of spray pipes or a perforated tank. Where ingots, billets and the like of relatively large cross-section are to be cast, a baffle or distributor is generally provided beneath the lower or exit end of the pouring spout or standpipe for the purpose of causing the incoming molten metal to be directed outwardly thereby reducing undesirable turbulence of the molten metal in the mold shell and reducing the tendency toward an excessively deep molten metal crater. The casting procedure may be a strictly continuous process (in which the casting is cut to length without interruption of the casting procedure) or it may be semi-continuous; i. e., a casting of desired length may be cast, the flow of metal stopped, the casting removed and the procedure commenced anew. "Continuous" casting as herein used refers to either type of operation.

It is recognized, in the continuous casting of metal, that it is highly desirable that the rate of flow of molten metal into the mold be uniform or substantially uniform during the casting operation. Variations in the rate of flow may lead to thermal cracks, shrinkage cracks, cold shuts, and other serious defects which render the casting unsuitable for subsequent fabricating operations. Non-uniformity in rate of flow of molten metal can be caused by various factors. For example, in any given casting operation the level of the molten metal in the holding hearth of the furnace, or any other container for holding the body of molten metal, necessarily continues to fall thereby decreasing the pressure of the metal passing into the pouring spout or standpipe and thus decreasing continuously the rate of flow of molten metal into the mold shell. The rate of flow can also be altered by other factors among which may be mentioned obstructions in the path of flow of the metal from the main

body of metal to the mold shell and changes in temperature of the metal which affects the viscosity thereof.

Various proposals have been made heretofore for ensuring proper control of the rate of flow of molten metal, but for one or more reasons have not been found to be commercially practicable. One such proposal involves the use of a plurality of pipe lines of relatively small cross-section for supplying molten metal to the mold shell under pressure. The use of such plurality of pipes of small cross-section gives rise to the problem of clogging of the pipes. Moreover, such apparatus is expensive in first cost and in maintenance. Another proposal has been to make use of intermediate containers or receptacles for molten metal between the casting station and the main furnace and wherein means are provided for maintaining a given level of metal in the intermediate container. Such apparatus makes the process of supplying molten metal complicated and costly.

According to the instant invention, uniformity of the rate of flow of molten metal into the mold is accomplished by means of a novel regulator which is adapted to float on the body of molten metal within the mold shell. The regulator generally comprises a receptacle provided with suitable float means and is adapted to float on the body of molten metal contained in the mold beneath the metal delivery means, e. g. pouring spout or standpipe, through which the molten metal is fed to the mold. The receptacle of the regulator is adapted to co-act with the exit or lower end of the metal delivery means to automatically control the rate of flow of the molten metal from the delivery means such that the molten metal level in the mold shell is substantially constant at all times. The receptacle is provided adjacent the bottom thereof with apertures to give a predetermined flow of metal outwardly into the body of molten metal. The regulator means of the instant invention is simple and relatively inexpensive and yet is very efficient in maintaining proper control of the rate of flow of molten metal into the mold shell. Moreover, this apparatus is automatic in its operation or coaction with respect to the pouring spout, thereby eliminating the necessity of manual control.

Accordingly, the primary purpose and object of the instant invention is to provide a novel regulator means for maintaining uniformity of metal flow rate in the continuous casting of metals which overcomes many of the disadvantages attendant in the use of means as heretofore known.

Another object of this invention is to provide a novel regulator for maintaining uniformity of molten metal feed in the continuous casting of metals wherein said regulator is simple, inexpensive and automatic in its operation.

Another object of this invention is to provide a novel regulator for maintaining uniformity of molten metal feed in the casting of metals which compensates for factors affecting flow rate such as pressure, temperature, and obstructions to the path of metal flow.

Another object of this invention is to provide a novel regulator for maintaining uniformity in rate of molten metal feed into the mold of continuous casting machines wherein the regulator additionally has means provided for controlling the path of flow of molten metal into the body of molten metal contained in the mold.

Other objects and advantages of the invention will be apparent from the following description, taken in conjunction with the drawings, and wherein:

Figure 1 is a plan view showing one form of continuous casting apparatus embodying the principle of the invention with parts removed for purpose of clarity, and

Figure 2 is a vertical, sectional view taken along line 2—2 of Figure 1.

Figure 3 is a fragmentary vertical, sectional view of the regulator shown in Figure 2 and includes the provision of a screen for treating molten metal.

With further reference to the drawings which illustrate one preferred embodiment of the invention as applied to the casting of rectangular or sheet ingots of aluminum or aluminum alloys, a relatively short open-ended mold shell 1 is suitably mounted over a casting pit (not shown) by any of the conventional means. Within the mold shell 1 and extending therebelow is an embryo ingot 2 comprising a pool of molten metal 3 and solidified casting 4, the pool 3 extending downwardly and forming a molten metal crater or core within the ingot. The molten metal is continuously fed into the mold by the use of a suitable delivery means or pouring spout 5.

Positioned within the mold shell 1 and floating on the pool of molten metal is a regulator assembly 6. The regulator comprises a rectangular receptacle or box-like member 7. On each side of receptacle 7 is a float chamber 8 suitably secured to the receptacle. It will be seen that the float means provide sufficient buoyancy to the receptacle to maintain the entire upper edge portion thereof above the surface of the body or pool of molten metal 3. The float chambers are generally air-containing and can either be made separately from the receptacle and thereafter joined thereto or can be made such that one wall of the chamber is formed by the side of the receptacle, as illustrated. Moreover, the float chambers can be made integral with the receptacle. The receptacle and float chambers are made from a suitable material such as stainless steel. Mounted on the top of the float members at the ends of the receptacle 7 and extending vertically therefrom is a rod 9. Suitably mounted across the top of mold shell 1 are a pair of elongated bar-like members 10 each having an aperture 11 therein. The rods 9 are slidably positioned within apertures 11 in bars 10. By this means the regulator assembly 6 is prevented from drifting or moving laterally with respect to mold shell 1 and spout 5 while allowing vertical movement thereof relative to the pouring spout 5. Alternatively, only one elongated cross member 10 may be used and in such cases more than one rod 9 is mounted on a given float chamber. Although the float chambers as illustrated in Figures 1–3 are closed at the top, it is to be understood that this is not necessary to the satisfactory operation of the invention. It is preferable, however, to use closed chambers to prevent any tendency of foreign material getting into the chambers, e. g. molten metal, and altering the desired operating level of the regulator.

Secured to the inner surface of the bottom of receptacle 7 is a throttling member 12 which cooperates with the exit or lower end of pouring spout 5 in controlling the rate of flow of molten metal entering receptacle 7. This member can be made of any suitable material such as nodular cast iron, silicon carbide or ceramic coated steel. As illustrated in Figure 2, throttling member 12 projects upwardly from the bottom of receptacle 7 and the upper portion thereof is of conical configuration. The lower or exit end of spout 5 is adapted, when necessary, to closely seat on throttling member 12 when it comes in contact therewith thereby effectively interrupting the flow of molten metal into receptacle 7.

For purposes of allowing molten metal passing into receptacle 7 to flow out into molten metal pool or body 3, there is provided one or more horizontal elongated slots 13 on either end of receptacle 7 adjacent the bottom thereof and wherein the slots are positioned below the bottom of float chambers 8. In the application of casting sheet or rectangular ingots as shown in Figures 1 and 2, it has been found desirable to provide slots or other form of apertures only at the ends of the receptacle. By this means, a relatively small regulator can be used which will give the proper distribution of molten metal within the mold shell. In the casting of sheet or rectangular ingots, using a central pouring spout, the edges and corners of the ingots are subjected to a greater rate of heat abstraction than in the case of the ingot faces and it is, therefore, desirable to direct the incoming flow of molten metal in the direction of the edges and corners in order to minimize undesirable temperature differentials in the ingots.

In a continuous casting operation utilizing the regulator of the instant invention, the regulator is first positioned slightly spaced from the top of a conventional bottom block (not shown) of the casting apparatus which is within the mold shell in its uppermost position. In order to accurately position the regulator relative to the bottom block prior to the entry of molten metal, suitable means such as nuts 14 may be provided in threaded engagement with the upper portion of rods 9. Nuts 14 are adapted to contact members 10 thereby limiting the downward movement of the regulator. These nuts also function to prevent the regulator from passing down and freezing in the ingot at the end of the casting operation. The upper portion of each rod 9 is threaded for a predetermined distance to thereby allow adjustment of the regulator to various metal head levels. It will be understood that means other than nuts 14 can be provided for limiting the downward movement of the regulator as, for example, suitable arms mounted on the regulator which are adapted to contact members 10 or the top of mold shell 1 at the desired regulator position. The regulator is generally heated by any suitable means prior to positioning within the mold shell to avoid possible freezing of molten metal feed upon contact with the regulator with the undesirable results of clogging of the flow apertures or slots and freezing of the regulator to the bottom block. After the heated regulator has been positioned within the mold shell, bars 10 are placed over the mold shell such that rods 9 of the regulator pass through apertures 11 in the bars. The ends of these bars are suitably secured to the mold shell to thereby prevent lateral movement of the regulator when in a floating position. Immediately thereafter, molten metal is caused to pass down through spout 5, into receptacle 7 and out through slots or apertures 13 into the area defined by the mold shell and the top surface of the bottom block. When molten metal first passes into and out of the receptacle the throttling member 12 will be spaced away from the lower end of the spout 5 such that there is substantially no throttling of the metal flow passing down the spout. After a predetermined amount of molten metal has passed into the mold shell, however, the regulator will begin to float and move upwardly. At such time as the desired metal head is reached as determined by the co-action of the throttling member 12 with the exit or lower end of spout 5, the bottom block is caused to move downwardly thereby withdrawing solidified ingot from the mold shell. Should any variations in the metal flow occur during the casting operation, regulator 6 will automatically compensate for same and maintain the rate of molten metal flow into the mold shell substantially uniform. For example, in any given casting operation wherein the drop rate of the bottom block and ingot is constant, should the pressure of molten metal passing down spout 5 be reduced and the rate of flow be necessarily decreased, the metal head level will drop and the regulator will move downwardly thereby moving throttling member 12 away from the exit end of spout 5. This, in turn, will result in a greater flow of metal into the mold shell to compensate for the reduction in pressure. Conversely, should the pressure increase too great an amount, the metal head level will increase and regulator 6 will be caused to move upwardly and throttling member 12 will move closer to the exit end of spout 5 to reduce the volume or rate of flow of incoming metal to substantially that of the rate of withdrawal of solidified ingot from the mold shell. It will thus be seen that by use of the regulator of the instant invention, variations in rate of flow of molten metal passing into the mold shell are automatically and

rapidly compensated for thereby ensuring substantially uniform rate of metal flow at all times with the obvious attendant advantages resulting therefrom.

It is desirable casting practice to provide a screen member through which the molten metal passes prior to entrance into the mold in order to prevent impurities in particulate form which might be present from entering the mold. It is conventional practice to provide a screen in the metal transfer trough leading from the furnace or other molten metal holding means to the mold. Such positioning of the screen member in the molten metal transfer system, however, does not prevent impurities or foreign matter in particulate form from getting into the molten metal stream subsequent to passage through the screen member and becoming entrapped in the casting being produced. In the instant invention it has been found desirable to provide the screen member in the regulator as shown in Figure 3 such that all the molten metal feed will be screened immediately prior to passage into the metal head within the mold shell. As illustrated in Figure 3, screen member **15** is of dish-shaped cross-section with the edge of same projecting above the top of the regulator for ease of removal. A suitable opening **16** is provided in the bottom of the screen member such that throttling member **12** projects therethrough. By this means the coaction between the throttling member and the metal delivery means is not affected. Moreover, the screen member is maintained in proper position within the regulator. The screen member can be made of any suitable material, e. g., black iron screen provided with a refractory coating.

Although the embodiment of the invention described above in conjunction with Figures 1–3 of the drawings as applied to rectangular or sheet ingots utilizes a float chamber on each side of the receptacle, it is to be understood that a lesser number of chambers can be used as, for example, two chambers, one on either end or short side of the receptacle. The use of float chambers on each side of the receptacle is preferably to ensure against undue rocking of the regulator when in operative position and to give additional strength thereto against warpage. Additionally more than one pin or rod **9** on at least two sides of the receptacle can be used to prevent any tendency toward rocking. The throttling member **12** may take various shapes other than that shown in Figures 2 and 3, as, for example, spherical, conical, frusto-conical, etc., the primary consideration being that the seating of the exit end of the spout **5** on the throttling member be such as to accurately control the rate of metal flow and to effectively stop the flow of molten metal into the receptacle and mold shell, if necessary, although in practice it is generally found that increases in flow of molten metal are not so great as to necessitate completely stopping the metal flow. It is to be noted that although the throttling member preferably is in the form of a vertical projection as shown in Figures 2 and 3, it is contemplated, within the scope of the invention, that the bottom of the receptacle may perform this function. In such case the shape of the exit end of spout **5** would be made to conform to that portion of the receptacle bottom with which it would contact when the regulator was in its uppermost position. The bottom of receptacle **7** can be substantially flat, as shown in Figure 7, or it can be of other configuration such as curved, etc. Additionally, the receptacle bottom can be suitably insulated for purposes of preventing excessive heat transfer to the central portion of the molten crater and retention of heat in the upper portion of the metal head. Various means other than that disclosed for maintaining alignment of the regulator with respect to the molten metal delivery means can be used, as, for example, suitable arms mounted on the mold shell engaging suitable guide means provided on the regulator.

It is also to be understood that although the embodiment of the instant invention above described in conjunction with Figures 1–3 pertains to regulators for use in casting rectangular or sheet ingots, the invention is equally applicable to the casting of circular, square or other polygonal shaped ingots, billets and the like. In such cases the float means can be in the form of a continuous chamber around the periphery of the receptacle or, alternatively, can be in the form of separated spaced float chambers. In the casting of ingots, billets and the like of various configurations by the instant invention the metal flow passages provided in the lower portion of the receptacle adjacent the bottom thereof may take the form of a plurality of apertures, so positioned and designed that the desired distribution of the incoming molten metal within the molten metal head is obtained.

Various changes, omissions and additions may be made to this invention without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator being movable relative to said delivery means, said regulator comprising a receptacle for receiving molten metal from said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, float means affixed to the side of said receptacle and adapted to contact the body of molten metal, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within said mold shell, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal below said float means and below the surface of said body of molten metal, said regulator being adapted to move vertically relative to the lower end of said delivery means upon change in the level of said body of molten metal to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal.

2. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator comprising a receptacle for receiving molten metal from said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, float means affixed to the side of said receptacle and adapted to contact the body of molten metal, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within the mold shell, means for maintaining said receptacle in vertical alignment with said molten metal delivery means, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal and below the surface of said molten metal body, and said receptacle being provided with throttling means in alignment with the lower end of said delivery means, said regulator being adapted to move vertically relative to said delivery means upon change in the level of said body of molten metal whereby said throttling means coacts with said lower end of the delivery means to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal.

3. An apparatus according to claim 2 wherein said throttling means in said receptacle comprises a vertically extending projection affixed to the bottom of said receptacle and wherein the lower end of said delivery means possesses a configuration which conforms to the configu-

ration of said throttling means such that contact of said delivery means with said throttling means is effective in stopping further flow of metal into said mold shell.

4. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator comprising a receptacle for receiving molten metal from said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, float means affixed to the side of said receptacle and adapted to contact the body of molten metal, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within the mold shell, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal below the surface of said body of molten metal, and means provided within said receptacle for screening the molten metal feed passing into said body of molten metal, said regulator being adapted to move vertically relative to said delivery means upon change in the level of said body of molten metal to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal.

5. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator being movable relative to said delivery means, said regulator comprising a receptacle for receiving molten metal from said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, float means affixed to said receptacle and adapted to contact the body of molten metal, said float means comprising at least one air-containing chamber affixed to the side of said receptacle, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within the mold shell, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal below said float means and below the surface of said molten metal body, said regulator being adapted to move vertically relative to the lower end of said delivery means upon change in the level of said body of molten metal to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal.

6. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell having a substantially rectangular configuration adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator being movable relative to said delivery means, said regulator comprising a receptacle of substantially rectangular configuration for receiving molten metal from the lower end of said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, a float chamber affixed to each side of said receptacle and adapted to contact the body of molten metal, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within said mold shell, means for maintaining said receptacle in vertical alignment with said delivery means, said alignment means comprising a pair of spaced elongated bars passing across and affixed to the upper end of said mold shell such that each bar overlies a float chamber affixed to the short sides of said receptacle, said bars each being provided with a vertical aperture therein, and a pair of vertically extending rods each of which is affixed at its lower end to the top of one of said float chambers affixed to the short sides of said receptacle and wherein the upper end thereof is positioned in sliding relation within the aperture of the horizontally positioned bar thereabove, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal and below the surface thereof comprising a horizontally extending elongated slot provided in the lower portion of each of the short sides of said receptacle adjacent the bottom thereof, said slots being below the bottom of said float chambers, throttling means provided within said receptacle in alignment with the lower end of said delivery means, said throttling means comprising a projection extending vertically from the bottom of said receptacle, the upper portion of said projection being of conical configuration, said throttling means adapted to move vertically relative to and co-act with the lower end of said delivery means upon change in the level of said body of molten metal to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal, means for limiting the downward movement of said regulator, and means provided within said receptacle for screening the metal feed passing into said molten metal body from said receptacle, said throttling means projecting upwardly through said screening means.

7. In apparatus for the continuous casting of metal bodies, the combination of an open mold shell adapted to contain a body of molten metal, downwardly directed delivery means for feeding molten metal into said mold shell, a regulator positioned beneath said delivery means and adapted to float on said body of molten metal, said regulator being movable relative to said delivery means, said regulator comprising a receptacle for receiving molten metal from said delivery means and wherein the lower end of said delivery means is adapted to extend downwardly into the chamber defined by said receptacle, float means affixed to the side of said receptacle and adapted to contact the body of molten metal, said float means providing sufficient buoyancy to said receptacle to maintain the entire upper edge portion thereof above the surface of the body of molten metal contained within said mold shell, said receptacle being provided with means for passage of molten metal from said receptacle to said body of molten metal and below the surface of said molten metal body, said regulator being adapted to move vertically relative to the lower end of said delivery means upon change in the level of said body of molten metal to alter the rate of flow of molten metal from said delivery means thereby compensating for such change in level of the body of molten metal.

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