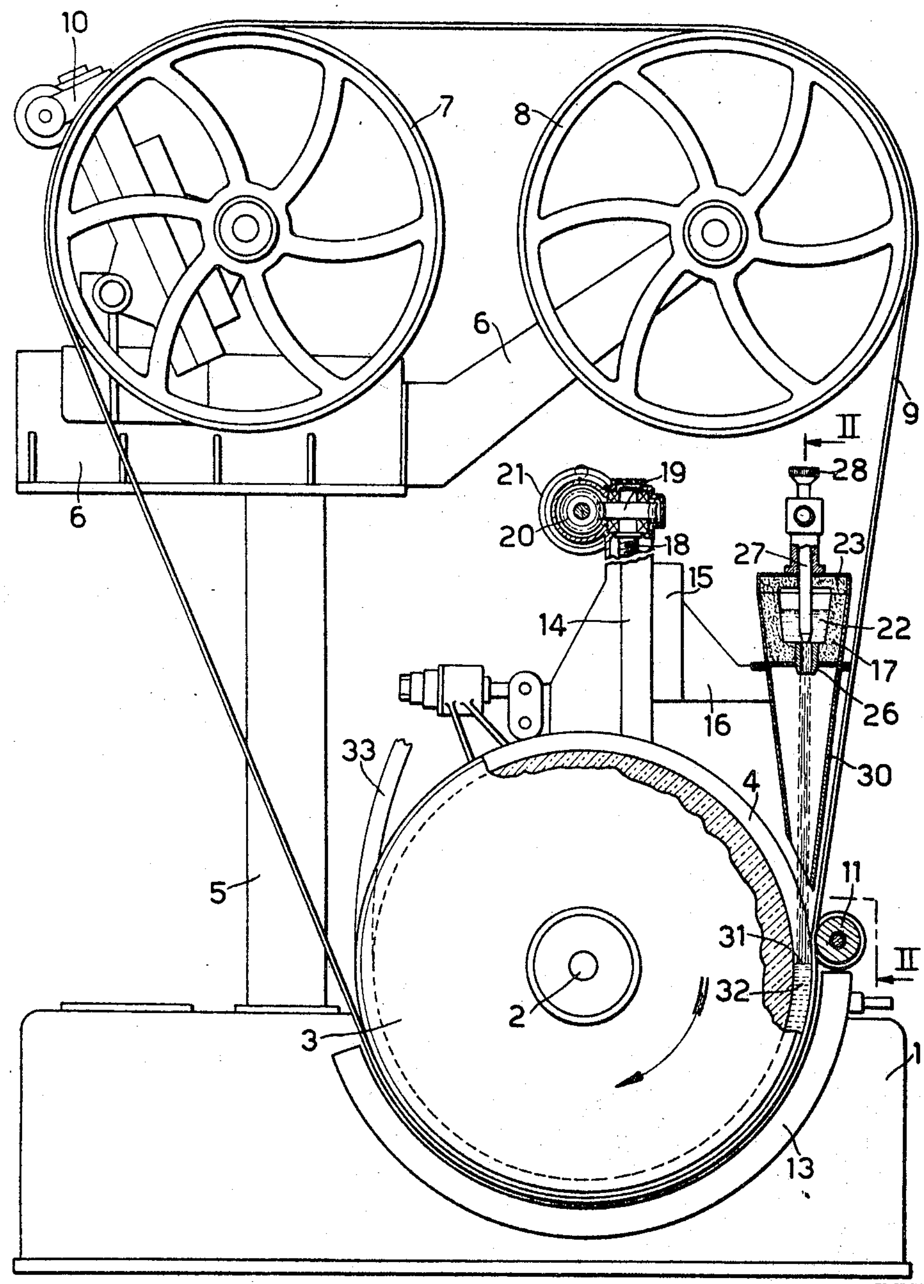
DEVICE FOR FEEDING MOLTEN METAL TO A CONTINUOUS CASTING DEVICE

Filed Aug. 3, 1966 Sheet 1 of 2

Fig.1



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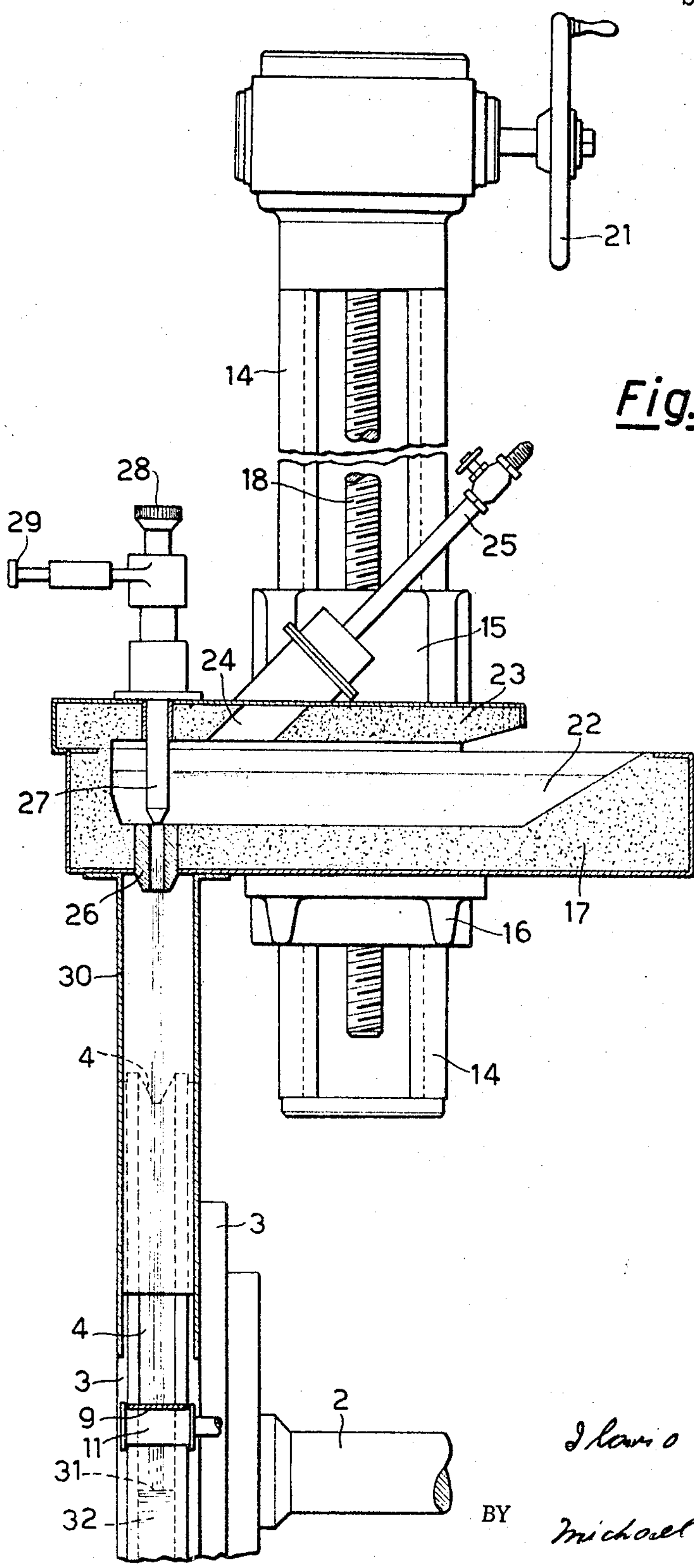

Fig. 2

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3,452,808

DEVICE FOR FEEDING MOLTEN METAL TO A CONTINUOUS CASTING DEVICE

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Filed Aug. 3, 1966, Ser. No. 569,889
Claims priority, application Italy, Aug. 5, 1965, 17,673/65
Int. Cl. B22d *11/06, 11/10*
U.S. Cl. 164—278 5 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure is of a wheel type continuous casting mold having a molten metal feed means which is is adjustable both in distance from the mold and in aperture for creating turbulent molten metal conditions at the mold entrance.

This application relates to a device for feeding molten metal to a continuous casting device.

Devices for the continuous casting of metals are known, wherein molten metal is continuously cast and wherefrom said metal is fed out, usually in the form of a continuous section or molten bar.

Embodiments of such devices can be seen, for example, in my co-pending U.S. Patent application No. 243,087 now U.S. Patent No. 3,261,059, and British Patent No. 1,014,449.

Rods, tapes or round bars obtained with such devices are, however, exposed to the drawback of showing structural defects or even segregation of the components of a metal alloy if a metal alloy is being cast. It has been possible to ascertain that the aforementioned short-comings are essentially a result of the fact that the cooling or solidification of the liquid metal take place with said liquid metal in an "at rest" condition in general, so that the solidified metal exhibits as has been viewed both in macrographic and micrographic plates, a crystalline structure which is somewhat coarse and is accompanied by separation of components.

The defects thus discovered induce serious troubles in the ensuing processing steps of the obtained bar or section which usually is directly fed in still hot state to a rolling mill to undergo suitable mechanical operations therein, such as repeated considerable reductions of the cross-section. By this the coarse crystalline textures are broken with the danger of causing fissures which do not always weld themselves again under the influence of the heat and pressure imparted by the rolling mill cylinders; as a result flaws are formed in the rolled metal.

To obtain a fine-grained structure while avoiding the segregation of the constituents of the alloy in the solidified metal obtained from a continuous metal casting device, it has been recently suggested, as is for example, disclosed in my now abandoned U.S. patent application No. 404,815 to feed at a considerable speed the molten metal from the crucible to the meniscus or liquid plane of the continuous casting device. The effect of such a speed is that of inducing an energetic whirling motion within the liquid metal which is being rapidly cooled and solidified within the device, the result being that the formation of coarse crystalline textures and the segregation of constituents of an alloy are prevented, if the metal is alloyed. By restricting, for the sake of simplicity, the discussion to the case in which a pure metal is melted and a rod is being obtained, it has been ascertained that the obtained rod has an extremely fine and regular crystalline structure, as disclosed in the U.S. patent application No. 404,815 and thus it can be rolled or otherwise processed without any trouble whatsoever.

It has been possible to ascertain, however, that, even

holding entirely valid the principle of impeding the formation of coarse crystalline textures by inducing a vigorous whirling motion within the liquid metal being cooled in the continuous casting device, the means suggested for achieving said result in the above mentioned U.S. patent application No. 404,815 are not entirely satisfactory and are possessed of certain defects that it is highly desirable to eliminate, as will clearly appear in the following.

According to said U.S. patent application No. 404,815, the crucible which contains the molten metal is affixed to the framing of the device above the liquid meniscus of said device, and the molten metal reaches said meniscus by flowing within a nozzle having the shape of an elongate conduit which is sloping with respect to a vertical line, projects from the crucible's bottom and extends up to the immediate vicinity of said meniscus. The molten metal flows with a considerable momentum from the nozzle and induces a whirling motion within the liquid metal being cooled within the device: to obtain the desired grain size in the crystalline structure of the metal which is being solidified within the device, the turbulence of the liquid metal being cooled should obviously have a predetermined value, and this means that the molten metal should be fed out of the outlet nozzle of the crucible at a determined speed.

According to the aforementioned U.S. patent application No. 404,815 the rate of flow of the molten metal from the nozzle is determined by the head of molten metal in the crucible, that is, by the level differential between the outlet orifice of the nozzle and the level of molten metal within the crucible.

In order that the rate of flow of molten metal from the nozzle may be varied, it is necessary that the so-called "head" be varied, and this result is obtained by causing the level of the molten metal within the crucible to vary.

At this stage, it is fitting to note that, in order that the advantages obtainable with a continuous casting device embodying the teaching of the aforementioned U.S. patent application No. 404,815 may be achieved along with the improved results thereof, the necessity is often felt, during a casting operation, of causing the turbulence conditions of the metal being cooled in the device to be frequently varied, thus causing also a variation of the rate of flow of the molten metal out of the outlet orifice of the crucible nozzle. Very often said variations of turbulence and speed should be obtained within the shortest possible time interval so as to avoid the formation of large areas of coarse crystalline texture within the solidified metal such areas may be readily spotted, for example, by examining the metal coming out of the rolling mill which is coupled to the continuous casting device.

Let it be assumed, for simplicity, that the continuous casting device also includes a wheel having a peripheral groove, driven to a continuous and constant rotary motion, of the kind disclosed in the U.S. patent applications No. 243,087 and No. 404,815 and in the British Patent 1,014,449.

The rate of flow of the molten metal from the crucible should have, under steady operative conditions, a well defined and constant value so as to give rise to the desired turbulence rating. It may occur that the temperature of the molten metal in the crucible undergoes even considerable variations as a consequence of corresponding variations taking place in the oven and that the efficiency of the metal cooling system within the device is varied for example due to pressure differentials of the coolant water. To make the problem quite clear, let it be assumed that during casting the temperature of the molten metal within the crucible undergoes a sudden increase, or that the efficiency of the cooling is decreased due to a decrease of the pressure of the water which feeds the cooling system, the latter being for example of the kind disclosed in the U.S. patent application No. 243,087 and in the British Patent No. 1,014,449, aforementioned. Under these conditions, the total solidification of the metal within the device will take a longer time interval and could be regarded as having been completed in correspondence with a section of the peripheral groove of the casting wheel placed at a distance from the liquid meniscus within the same groove, which is greater than the distance at which it took place before the assumed variation. It is thus obvious that, for maintaining the grain size of the crystalline structure of the solidified metal equal to the values prior to the variation, it is necessary that the turbulence of the liquid metal being cooled be increased and, therewith, the rate of flow of the molten metal coming from the crucible nozzle.

The reverse is true whenever the temperature of the liquid metal within the crucible undergoes a decrease and that the efficiency of the cooling system is increased: if so, the turbulence of the molten metal being cooled can be decreased.

It has also been said that, in many cases, the device, or wheel for the continuous casting is coupled to a rolling mill so as to form a unit for continuous casting and rolling wherein the conditions of the unit could frequently demand variations in the speed of rotation of said wheel. If, still maintaining the efficiency of the cooling system constant, the wheel should increase its rotational speed so as to increase the solidified metal output, one has obviously to increase the amount of molten metal delivered by the crucible so as to keep at a constant level the liquid meniscus, that is the liquid plane within the peripheral groove of the wheel. This increased delivery of molten metal obviously requires an increase of turbulence of the metal being cooled so as to avoid the formation of coarse crystals.

The contrary is true if the wheel should be rotated at a lower angular velocity.

It has been found, in practice, that it is very difficult rapidly to increase or decrease, according to the teaching of the U.S. patent application No. 404,815, the level of the molten metal within the crucible since considerable amounts of metal should be varied and this variation cannot be obtained, in any case, with the rapidity which is necessary for the requirements of the continuous casting process. It has also been found that the molten metal, while passing through the long nozzle underlying the crucible, meets with a considerable attrition which hinders and partly annuls the effect of the variations in the level of the molten metal in the crucible, and said level should be brought considerably higher than it would be necessary according to theoretical considerations. Another shortcoming of the prior art as disclosed by the U.S. patent application No. 404,815 lies in that, if it is necessary to slow the rotation speed of the wheel in which the cooling of the metal takes place and it thus becomes necessary to diminish the flow of molten metal from the crucible, the molten metal stream flowing within the nozzle and whose cross-section becomes thinner and thinner towards the outlet bore of the nozzle due to the speed increase, may split into droplets in its lowermost portion, thus giving rise to gaseous occlusions. A further drawback is the difficulty of making long nozzles of a refractory material, adapted to convey liquefied metals at a high temperature, such as steel, copper and their alloys. Another shortcoming is the fact that the molten metal by falling along the nozzle in contact with the refractory material walls moves with a substantially laminar flow, so that, when it comes out of the nozzle outlet (said outlet is positioned in the neighborhood of the liquid meniscus of the casting wheels) it produces in the liquid metal being cooled a turbulence which is diminished with respect to that which one would experience if the falling motion along the nozzle had been a non-laminar flow.

It should be borne in mind, lastly, that the nozzle undergoes quick alterations as to its liquid flow diameter and abrasion of the material forming said nozzle could occur, and particles of said material could be occluded in the solidified metal with ensuing detrimental consequences.

All the above enumerated drawbacks are overcome with the device according to the present invention, an object of which is that of providing a quick and easy variation of the speed at which the molten metal coming from a crucible comes into contact with the liquid meniscus which is formed in the casting device to originate rapid variations of turbulence in the liquid metal being cooled with said apparatus.

Another object is to cause the molten metal to go from the crucible to the liquid meniscus in a vertical casting by freely falling from said crucible, thus doing away with the necessity of having nozzles for conveying said molten metal. The additional advantage is thus achieved that the liquid meniscus in the groove of the casting wheel on which the molten metal coming from the crucible falls has a minimum area which substantially corresponds to a section of the groove taken with a horizontal plane containing the axis of the wheel; the cooling of the liquid metal in the vicinity of the meniscus is thus more regular than it would be in the case in which the casting takes place through the long nozzle of the prior art with which a liquid meniscus having a larger area was obtained, corresponding to a section of the wheel groove still taken with a horizontal plane but not containing the axis of the wheel. These and other objects are achieved with the device according to the invention comprising supporting members which can be vertically moved and parallel to themselves and supporting a crucible containing the molten metal to feed the continuous casting device and means for controlling the vertical displacement of said members, the crucible bottom being fitted with a perforation positioned on the vertical line of the liquid plane of the molten metal being cooled within the device.

To make the structural features of the device more clearly understandable, an embodiment thereof will be illustrated in the following, by way of example only and without any limitation, reference being made to the accompany drawings, wherein:

FIGURE 1 is a diagrammatical elevational view, partly in section, of a continuous casting machine, and

FIGURE 2 is illustrative of an enlarged detail of the device, taken along the line II—II of FIG. 1.

FIGURE 1 is illustrative of a continuous casting machine for metals which is very similar, the device for feeding in the molten metal being excepted, to the machines described in the above mentioned U.S. copending patent applications No. 243,087, No. 404,815 and in the British Patent No. 1,014,449.

Said device comprises a baseplate **1** which freely and rotatably supports the shaft **2** of a casting wheel **3** which is rotatable about its own axis and has a peripheral casting groove **4**. To the baseplate **1** is affixed a pillar **5** which supports an arm **6** carrying two wheels, **7** and **8**, respectively, which freely rotate about their axes. A flexible endless metal tape **9** is held taut between the casting wheel **3** and the wheels **7** and **8**: the tension of the tape is obtained through a device diagrammatically shown in FIG. 1 and connoted by the numeral **10**, which is not illustrated in detail for simplifying the showing in that it is of known and conventional construction and is adapted to transfer displacements to the wheel **7** in the sense of bringing it towards and away of the wheels **3** and **8**. The endless tape **9** is moved solidly with the casting wheel **3** in the direction indicated by the arrow in FIG. 1 and confines, with the peripheral groove **4** of said wheel a so-called casting area which is extended along an arc of circle defined by the periphery of the rotary casting wheel: more precisely, said arc goes from that point of the periphery of the wheel **3** in which the tape **9** is kept pressed against said wheel by an idle roller **11** to the point at which the tape parts off said wheel. The casting wheel is internally cooled and is also cooled from its outside by a device **13** simply and diagrammatically shown in FIG. 1 since the cooling system is not disclosed in detail herein and is not shown in the drawings in detail inasmuch as it is of a kind very much the same as that disclosed in the U.S. patent application No. 243,087 and British Patent No. 1,014,449.

Above the casting wheel a device is provided for feeding the molten metal to said wheel, said device comprising a vertical guiding member **14** affixed to the machine baseplate in which a vertical groove, in the shape of a dovetail, has been formed; said groove houses and guides a slide which is movable and to whose body **15** (FIGS. 1 and 2) are solidly affixed bracket-like members **16** which carry a crucible **17**. In the slide **15** a vertical screw-threaded bore is formed (not shown in the drawings), in which a long threaded shaft **16** is engaged. At the top of said shaft is affixed a wheel **19** having a helical thread engaging a worm-wheel **20**, placed horizontally and rotated whenever a rotational drive is imparted to a handwheel **21** affixed to the shaft of said screw. It is apparent that a rotation in either direction of the handwheel **21** caused a corresponding rotation of the threaded shaft **18** and thus a lifting or a depression in vertical direction of the slide **15** and thus also of the crucible **17**. The crucible **17** holds molten metal **22** which continually pours out of a melting furnace in a manner known per se and not shown for the sake of simplicity. In FIG. 2 the crucible has been shown partially shielded by a vault **23** lined with a refractory material through which a perforation **24** (see also FIG. 1) has been formed, a flame being passed through said hole so as to sweep the liquid plane of the molten metal held in said crucible, a fuel for the heating flame being fed in a conventional way through a blowpipe **25**.

On the crucible bottom a member **26** is provided through which a bore is formed, exactly positioned on the vertical line of the section of the groove **4** which is substantially defined by a horizontal plane passing through the axis of the wheel **3** and is near the roller **11**. Above the bore formed through the member **26** of a rod **27** is provided, which is vertically movable and whose displacement can be controlled through manually actuable members **28** and **29**. For example, the member **28** can simply consist of a head shaped as a handle, solid with the rod **27** which in a portion intermediate its length can be screw-threaded screwably to engage a nut affixed to the machine baseplate. By rotating the member **28** the rod **27** would be either lifted or depressed according to the direction of rotation. The member **29** could, in turn, be the head of a screw which is intended to lock the rod **27** by impeding the displacements thereof.

As can be seen more particularly on FIG. 2 the lower portion of the rod **27** is shaped as a conical surface so that, by displacing the rod **27**, it is possible to vary the flow area of member **26** from a condition of complete closure to a condition of total aperture, thus varying the rate of flow, or flow in the unit of time of molten metal from the crucible.

To the bottom of the crucible **17**, around the member **26**, is affixed a tubular member **30**, for example a stainless steel tube, having the shape shown in the drawings and extending downwardly towards the casting wheel **3**.

During the operation of the device the hole of the member **26** is at least partially left free by the rod **27** and the metal held in the crucible, for example steel or copper or their alloys, freely falls from said hole into the groove **4** of the casting wheel. Under normal steady operative conditions, the groove **4**, in correspondence with the casting area, is filled with metal which, in the right side of FIG. 1 is liquid and is solid in the left portion of said figure, the cooling and subsequent solidification of the metal taking place due to the effect of the cooling system which is an integral part of the casting machine.

The liquid plane or meniscus **31** of the molten metal **32** in the casting wheel is kept at a constant level substantially contained in a horizontal plane passing through the axis of the casting wheel, and that means, as outlined above, that said meniscus has an area corresponding to the minimum area of the cross-section of the casting groove, the result being that the cooling of the liquid metal in the neighborhood of the meniscus **31** takes place under conditions of utmost uniformity. The liquid metal coming out of the hole of member **28** freely and directly falls onto the liquid meniscus in the casting wheel.

The metal solidified in the casting wheel continually emerges from said wheel in the form, for example, of a continuous rod **33** and is removed for the subsequent uses.

It should be noticed that, since the tubular member **30** has an opening which communicates with the ambient atmosphere only at its lowermost end, no air renewal takes place therewithin, so that the liquid column falling from the crucible is practically submerged by an inert gas atmosphere. The tubular member **30** also fulfills the function of avoiding that possible droplets or spatters of molten metal falling from the crucible may be a hazard for people standing near the machine, said drops being conveyed into the groove **4**. The molten metal falling from the crucible comes into contact with the meniscus **31** of the liquid metal being cooled in the casting area of the wheel **3** at a speed which is essentially a function of the distance of the crucible from said meniscus **31**, the level of the liquid plane of the molten metal within the crucible being kept constant during the continuous casting operation.

The kinetic energy of the metal falling into the casting area of the wheel **3** originates a vigorous turbulence of the metal being cooled in said area, coarse crystalline formation being thus prevented along with segregations of the constituents of an alloy, if the metal being cast is in alloy form.

The speed at which the molten metal falling from the crucible comes into contact with the liquid meniscus **31** can be varied very quickly and simply manipulating the handwheel **21** so as to lift or depress the crucible: it is thus possible readily to obtain a solidified metal having a uniform crystalline structure of the desired grain size.

It is thus apparent that if, as outlined in the opening portion of this specification, the temperature conditions of molten metal in the crucible, or the efficiency of the cooling system are varied, the turbulence of the liquid metal being cooled can be easily and correspondingly varied.

Similar considerations apply to the case in which the production of solidified metal should be increased or decreased.

The fact that the adjustment of the falling speed of molten metal in the point in which it comes into contact with the liquid meniscus **31** is obtained through a variation of the height of the crucible is of particular advantage since it is possible, inter alia, to effect a very accurate adjustment which can be varied within a wide range: the means which allow the achievement of said variations are very simple and practical both as to their constructional and operational features.

Extremely advantageous, as outlined above, is also the feed of the casting wheel with molten metal freely falling from the crucible, inasmuch as by so doing one avoids the use of a refractory material tube or nozzle through which the molten metal is caused to fall, a nozzle which would undergo rapid alterations under the action of the molten metal which is at a high temperature, thus avoiding also that the solidified metal may occlude traces of the material of which the nozzle is made of, thus jeopardizing the favorable properties of the solidified metal, but it is not excluded that, for low-melting metals, a nozzle can be adopted to convey the liquid directly to the cavity and still along a vertical direction which is the one permitting the best utilization of the gravity pull converted into kinetic energy so as to induce a turbulence during the cooling stage.

I claim:

1. In a continuous casting machine, the combination comprising a rotatable casting wheel having a circumferential edge face provided with a circumferential casting groove therein; an endless travelling belt looped about the circumference of said wheel and having an inner surface engaging said edge face over a portion of arc for closing a corresponding portion of said groove and defining a travelling mold cavity therewith; supply means arranged to introduce molten metal into said travelling mold cavity for undergoing cooling and solidification therewithin; a crucible having an outlet aperture located upwardly spaced from the upstream end of said travelling mold cavity; first means operative for varying the rate of flow of molten metal through said outlet opening and second means operative for varying the spacing of said outlet aperture from the level of molten metal in said travelling mold cavity, whereby to vary the kinetic energy with which molten metal issuing from said outlet aperture impinges upon and mixes with the molten metal in said mold cavity.

2. In a machine as defined in claim **1**, said outlet aperture having a predetermined cross-sectional area, and said first means being operative for varying the effective cross-section of said outlet aperture between two conditions in which the effective cross-section respectively corresponds to 100% and to 0% of said predetermined cross-sectional area.

3. In a machine as defined in claim **1**, said second

means being operative for varying the spacing of said outlet from said level of molten metal in said casting groove in a direction substantially vertical to said level.

4. In a machine as defined in claim **1**, said supply means further comprising a tubular member carried by said crucible and extending from said bottom wall towards said travelling mold cavity in registry with said outlet aperture, so that molten metal issuing from the latter passes through said tubular member prior to entering into said mold cavity.

5. In a machine as defined in claim **4**, said tubular member being imperforate and having an upper open end rigid with said bottom wall and a lower open end proximal to the upstream end of said travelling mold cavity, so that molten metal passing from said outlet aperture into said mold cavity is surrounded by said tubular member over substantially the entire distance between the former and the latter.

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U.S. Cl. X.R.

164—281