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METHOD OF AND APPARATUS FOR THE CASTING OF METAL

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2 Sheets-Sheet 1

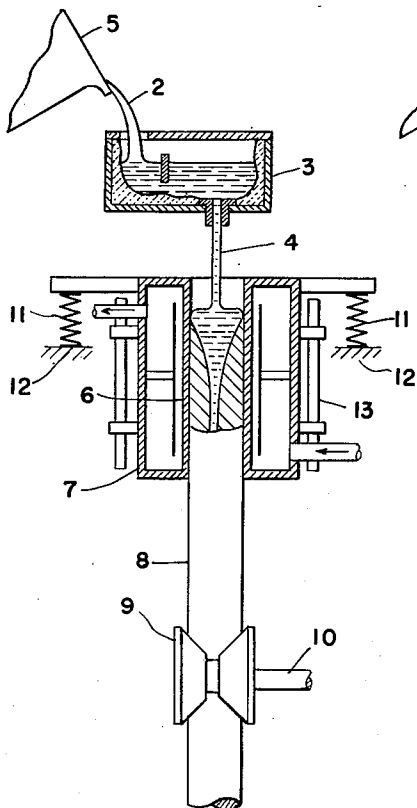


FIG. 1

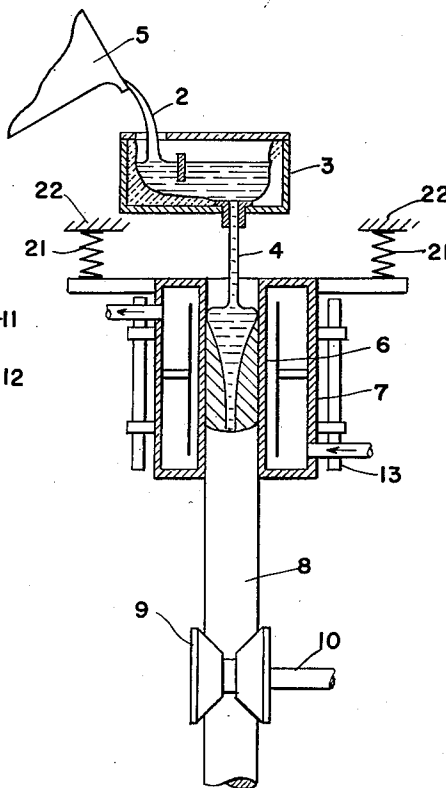


FIG. 2

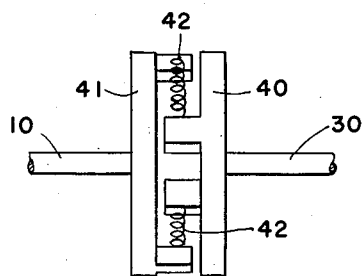


FIG. 4

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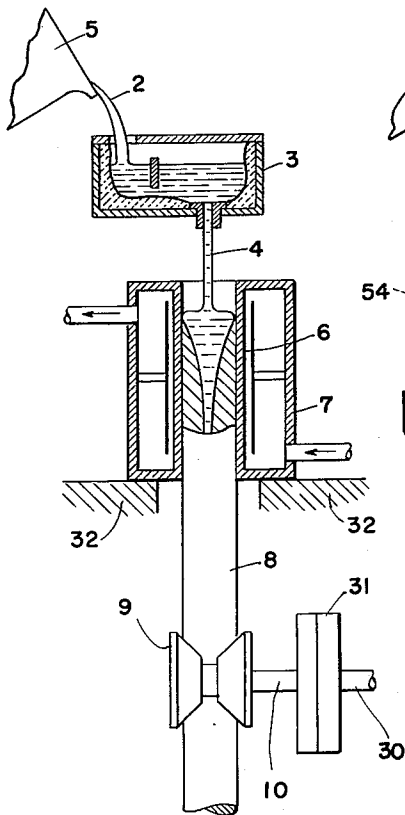


FIG. 3

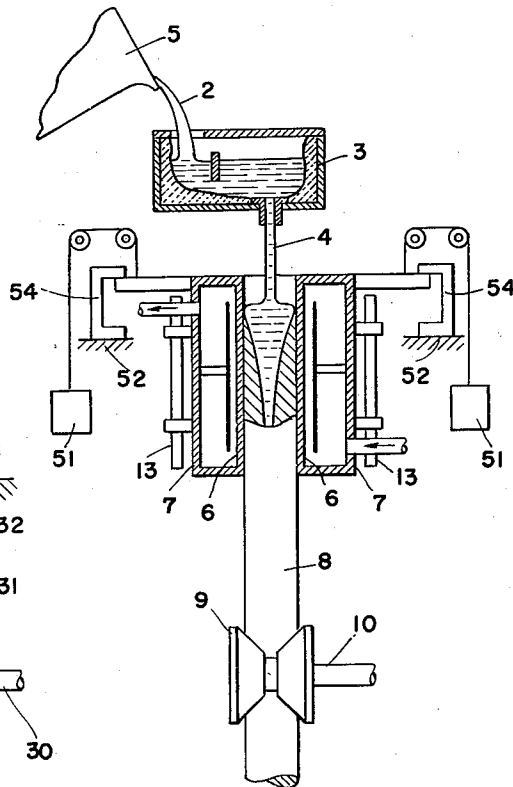


FIG. 5

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METHOD OF AND APPARATUS FOR THE
CASTING OF METAL

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8 Claims. (Cl. 22—57.2)

This invention relates to the continuous casting of metals, for example, the continuous casting of steel.

In carrying out this process it is customary to pour the liquid metal into the upper end of a vertically disposed tubular mold and to withdraw the solidified billet continuously from the bottom of the mold. In carrying out this process it has been found that the billet tends to stick to the mold and to be ruptured therein, owing to the upper section of the partially solidified billet remaining adhered to the mold while the withdrawal of the lower section of the partially solidified billet continues. The liquid metal at the interior of the partially solidified billet then escapes through the opening between the two portions of the originally solidified billet skin and forms a new skin in contact with the mold wall. This new skin, however, is thin and weak and continually ruptures in the mold until the rupture has progressed to the bottom of the mold, at which stage the liquid metal escapes from the mold, so causing a stoppage of the casting process.

In accordance with the present invention, the above-described effect is avoided by temporarily discontinuing withdrawal of the billet from the mold whenever, and for so long as, the resistance to relative movement of the metal and the mold exceeds a predetermined value, which is less than that necessary to cause rupture of the solidified skin. Otherwise expressed, withdrawal of the billet from the mold is effected by continuously applying to the billet a force tending to withdraw it from the mold, while limiting this force to a value less than the maximum resistance to movement caused by the adhesion of the metal to the mold, so that relative movement between the metal and the mold takes place only intermittently. The invention also includes apparatus adopted to operate in accordance with the above-described method.

The invention may be carried into practice by so mounting the mold that it is movable in the direction of withdrawal of the billet against the action of a restoring force. When the value of the adhesion between the billet and the mold exceeds this restoring force, the mold is pulled along with the billet, so that there is no relative movement between them. As soon as the value of the adhesion falls below the restoring force, the latter returns the mold to its original position. Alternatively, a stationary mold may be employed and a yielding connection provided between the pinch rolls, or other means which engage the billet and effect its withdrawal from the mold, and the continuously running driving means for those withdrawal means. In this case, the withdrawal means remain stationary whenever, and for so long as, the adhesion between metal and mold exceeds the force that can be transmitted by the yielding connection.

It is to be observed that proposals have already been made for withdrawing the billet from the mold only intermittently, either by effecting continuous movement of the billet and using a mold which alternately moves with the billet and returns in the opposite direction to its origi-

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nal position, or alternatively by using a stationary mold and driving the pinch rolls or other withdrawal means only intermittently. According to these previous proposals, however, the intermittent movements of the mold or of the withdrawal means were to be effected in accordance with a predetermined cycle and were not in any way dependent upon the varying strength of adhesion between the metal and the mold.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described an embodiment of our invention.

Of the drawings:

Fig. 1 is an elevation, partly in section, of continuous casting apparatus constructed in accordance with the invention;

Fig. 2 is an elevation, partly in section, of a modification of the apparatus shown in Fig. 1;

Fig. 3 is an elevation, partly in section, of a further modification of the casting apparatus;

Fig. 4 is an enlarged view of a modified portion of the apparatus shown in Fig. 3; and

Fig. 5 is an elevation, partly in section, of another modification of the apparatus of the invention.

Referring first to Figure 1, molten metal 2 is poured from a vessel 1 into a tundish 3, from which a stream 4 of the metal flows into the upper end of a vertically disposed tubular mold 6 of any desired cross-sectional form, which is surrounded by a water cooling jacket 7. The solidified or partly solidified billet 8 emerging from the lower end of the mold is engaged by a pair of pinch rolls 9, which are rotated by a continuously driven shaft 10 to effect downward movement of the billet. The mold 6, with its water jacket 7, is so mounted as to be capable of limited movement in a vertical direction, the mold being supported by compression springs 11 from a stationary member 12 and guided by stationary guide bars 13.

The downward movement of the billet produced by the action of the pinch rolls 9 exerts a frictional drag on the mold 6, which is pulled down against the action of the springs 11. If this frictional resistance to withdrawal of the billet from the mold remains substantially constant, the mold remains stationary and withdrawal proceeds continuously at a uniform rate. If the partially solidified billet sticks to the mold, the resistance to withdrawal increases above the upward force exerted on the mold by the springs and the mold is pulled down along with the billet, so that there is no relative movement between the billet and the mold. In other words, withdrawal of the billet from the mold ceases, although the billet continues to move downwardly. During such downward movement of the mold, the metal that stuck to the mold is further cooled and bends to shrink away from the mold, so that the strength of its adhesion to the mold is reduced. At the same time the skin of solidified metal increases in thickness and strength, so that it is capable of withstanding a greater pull without rupture. Downward movement of the mold also results in further compression of the springs 11, so that the restoring force which they exert on the mold increases. When the increasing restoring force exceeds the decreasing resistance to withdrawal, the springs 11 return the mold upwardly, thus effecting a relatively sudden withdrawal of the billet from the mold.

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The amplitude of the vertical movements of the mold will clearly depend upon many factors, including the characteristics of the mold and the metal being cast and the compressive force of the springs 11, which latter must be so chosen that the maximum restoring force exerted on the mold will be below that which would cause rupture of the billet to occur. When casting steel billets 3 inches in diameter in a water-cooled copper mold at speeds of up to 3 feet per minute, it was found satisfactory to limit the movement of the mold (for example by means of stops on the guide bar 13) to a maximum of 2 inches, using springs which at this maximum compression exerted a restoring force of approximately 200 lbs. The downward movements of the mold which actually occurred were usually about 1 inch in extent, lasting for periods of about 2 seconds, the restoring force of the springs at the end of the downward movement being in the neighborhood of 100 lbs.

Instead of supporting the mold 6 upon compression springs, it may, as shown in Figure 2, be suspended by tension springs 21 from a stationary member 22. This arrangement offers certain advantages in that the springs 21 may be prestressed, so that the weight of the mold produces little or no elongation of the springs and the restoring force which they exert on the mold is nearly proportional to the displacement of the mold produced by the frictional drag of the billet.

In the form of apparatus shown in Figure 3, the mold 6 is directly secured to a stationary supporting member 32 in the usual way. The drive shaft 10 of the pinch rolls is connected to a continuously driven shaft 30 through a slipping clutch 31 which is capable of transmitting only a limited torque, so that the downward force which is exerted on the billet 8 by the pinch rolls can never exceed a given value. Whenever the resistance to withdrawal exceeds this value, withdrawal ceases and shaft 10, pinch rolls 9 and billet 8 remain stationary. Shaft 30 continues to rotate, so that the downward pull on the billet is maintained at its minimum value and when the resistance to withdrawal again falls below this value, withdrawal recommences.

Instead of employing a slipping clutch, which allows unlimited relative movement between shafts 30 and 10 and maintains a constant withdrawal force on the billet when the latter is stationary, a clutch such as that shown in Figure 4 may be employed. In this clutch, the driving member 40 secured to shaft 30 is connected to the driven member 41 secured to shaft 10 by springs 42, so that continued rotation of shaft 30 after shaft 10 has been arrested will progressively increase the stress in the springs 42 and the withdrawal force which is thus exerted on the billet 8.

In the modification shown in Figure 5, the mold 6 is again mounted for vertical movement relative to the stationary supporting member 52, as in Figures 1 and 2, the maximum extent of such movement being limited by stops 54. In this case, however, the springs 11 or 21 are replaced by counterweights 51, so that the upward restoring force acting on the mold does not increase with increasing downward displacement of the mold.

It will be noted the present invention provides a novel improvement in the art of continuous casting of metal. Whenever the frictional resistance between the cast billet and its forming mold exceeds a selected value the relative movement therebetween is stopped until the resistance is below the selected value and relative movement between the billet and mold again occurs. This is accomplished by several means responsive to the frictional resistance between the mold and the cast billet. In one form of the invention the mold is so mounted as to move in concert with the billet during such periods that the resistance between the billet and mold exceeds a selected value. Under these conditions the operation of the billet withdrawal mechanism is continuous. In a modification of the invention the mold is stationary and the billet with-

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drawal stops during the period of excessive resistance between the mold and the billet. In both instances the relative movement between the billet and the mold may stop, depending upon the frictional resistance therebetween, and during the stoppage period relative motion will occur between separate relatively movable elements, i. e. between the parts 40 and 41 (Fig. 4), and between the mold 6 and the member 12 (Fig. 1).

While in accordance with the provisions of the statutes we have herein illustrated and described preferred embodiments of the invention, those skilled in the art will understand that changes may be made in the method of operation and form of the apparatus disclosed without departing from the spirit of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In the continuous casting of metal wherein molten metal is delivered to one end of an open ended fluid cooled casting mold and an at least partially solidified billet is withdrawn from the opposite end of said mold, the method of operation which comprises moving said billet in relationship to said mold so long as the resistance to relative movement between said billet and mold is below a limiting value, discontinuing the relative movement between mold and billet whenever and as long as said resistance is above said limiting value, progressively increasing the force tending to cause relative movement between said mold and billet while no relative movement therebetween occurs, and resuming said relative movement between said mold and billet when said resistance is below said limiting value.

2. Continuous casting apparatus comprising an open-ended tubular mold movable in a substantially vertical direction only, means for introducing molten metal into one end of said mold, means for cooling said mold for the solidification of metal therein, withdrawal means for engaging the at least partly solidified billet emerging from the other end of said mold, a pair of elements constructed and arranged for relative movement therebetween with one of said elements being stationary and the other element being attached to said mold, and yielding means positioned between said elements operable to stop relative movement between said elements when the resistance to relative movement between said mold and said billet is more than a predetermined value.

3. Continuous casting apparatus according to claim 2 wherein said yielding means exerts an increasing force between said relatively movable elements during downward relative movement of said mold.

4. Continuous casting apparatus according to claim 2 wherein said yielding means exerts a substantially uniform selected force between said relatively movable elements during relative movement thereof.

5. Apparatus for use in the continuous casting of metal comprising a vertically disposed and vertically movable tubular mold open at its upper and lower ends and having an outwardly extending flange attached thereto, means for maintaining the vertical alignment of said mold during vertical movement thereof, means for introducing molten metal into the upper end of the mold, means for engaging the cast billet emerging from the lower end of the mold and withdrawing it downwardly, and means for applying an upwardly directed force to the outwardly extending flange on said mold for resisting downward movement of the mold with the billet and for returning the mold upwardly after the occurrence of such movement.

6. Apparatus in accordance with claim 5, in which said last mentioned means comprise compression springs, upon which the mold is supported.

7. Apparatus in accordance with claim 5 in which said last mentioned means comprise tension springs by which the mold is suspended.

8. Apparatus according to claim 5 in which said last mentioned means include stops to limit the vertical movement of said mold, and said mold is counterweighted to exert a substantially uniform upwardly directed force on said mold.

References Cited in the file of this patent

UNITED STATES PATENTS

1,139,885	Mellen -----	May 18, 1915
2,058,447	Hazelett -----	Oct. 27, 1936
2,177,681	Anderson -----	Oct. 31, 1939
2,601,615	Jordon -----	June 24, 1952
2,709,842	Findlay -----	June 7, 1955