May 27, 1969 J. D. GRICOL ET AL 3,446,267

CONTINUOUS CASTING MOLD

Filed Sept. 7, 1966

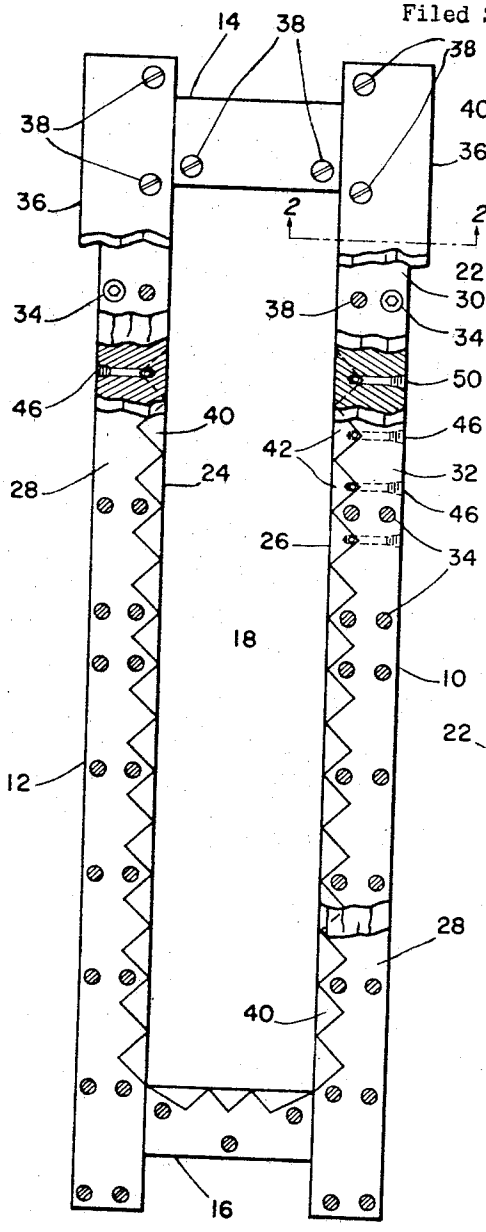


Fig. 1

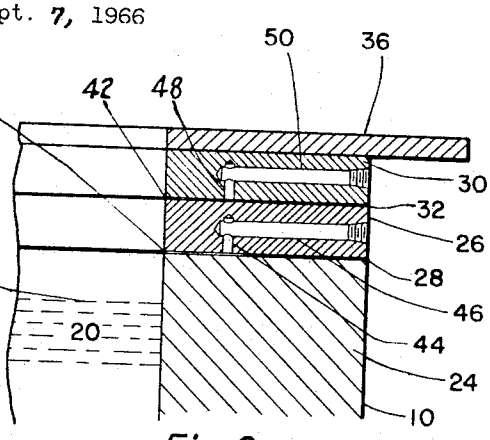


Fig. 2

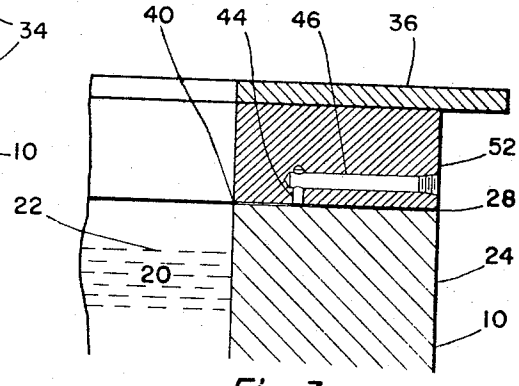


Fig. 3

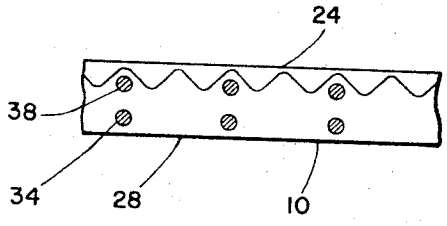


Fig. 4

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CONTINUOUS CASTING MOLD

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U.S. Cl. 164—268 3 Claims

ABSTRACT OF THE DISCLOSURE

In an open-ended continuous-casting mold, means for lubricating the surface of the mold comprises a series of metal blocks around the upper end of the mold cavity with serrated shims between the upper ends of the mold walls and the blocks. Passages in the blocks are connectible to a supply of oil and communicate with the recesses between the serrations. The shim is arranged with the recesses opening into the mold cavity along a horizontal line around the cavity so that oil passing into the mold through the recesses forms a continuous film.

A curtain of burning gas for shielding metal being poured into the mold cavity is also provided for by another series of metal blocks above the first. Similar serrated shims are placed between the lower and upper series and passages through the blocks of the upper series connect a source of a flammable gas to the recesses between the serrations of the latter shims.

This invention relates to the continuous casting of metal slabs and, more particularly, to a continuous casting mold used for casting metal slabs, especially, steel slabs.

In the continuous casting process as heretofore practiced, molten metal, for example, molten steel, is poured into a refractory-lined vessel known as a tundish. One or more spouts positioned in the bottom of the tundish direct a stream of molten metal into the top of an open ended vertical mold which, in the case of a mold for the continuous casting of steel, may have a vertical dimension of between 2 and 3 feet and an internal cavity with a length and width which correspond to the cross section of the slab to be cast therein, for example 52 inches by 10 inches. The inside surfaces of the continuous casting mold are ordinarily made of a material having a high heat conductivity, such as copper, and the walls of the mold are provided with cavities through which a coolant such as water may be circulated to provide cooling for the casting mold walls and the molten metal delivered to the mold from the tundish. In the conventional practice, the mold may be oscillated in a vertical direction, that is, in the direction of the metal movement through the mold.

At the beginning of a cast, a movable bottom piece, known as a dummy head, is positioned in the bottom of the mold to provide a surface against which the molten metal may be cast to form one end of the cast slab. As the molten metal rises in the mold, the portion of the molten metal adjacent the relatively cool dummy head and walls of the mold is chilled and begins to form a shell of solidified metal. The dummy head is then lowered at a controlled rate, for example about 1.9 feet per minute in the case of continuously cast steel slabs, and molten metal is added to the top of the mold so that the level of molten metal in the mold is maintained at a relatively constant level throughout the cast. At the point within the mold where the molten metal first begins to solidify and form a shell the shell wall will be very thin, but as the slab passes downwardly through

the mold, the thickness of the shell will gradually increase until, at the bottom of the mold, the thickness of the shell may be on the order of ½ to 1 inch thick. Thus, during its passage through the mold the cast slab comprises a relatively thin wall of solidified metal surrounding a core of molten metal. After leaving the casting mold, the cast slab passes through a slab guiding and cooling apparatus which provides sufficient cooling to solidify the molten metal remaining within the slab.

As noted above, the shell of solidified metal which forms the surface of the slab within the mold is relatively thin and weak and therefore there is a possibility that the metal shell may be ruptured within the mold. In the event that the thin shell of solidified metal is ruptured molten metal from the interior of the slab may escape and damage the casting mold and the slab guiding and cooling apparatus positioned immediately below the casting mold. Such a rupture of the slab, known as a "breakout," may involve amounts of metal varying from a few pounds up to several tons or more and may result in a serious delay in the casting process. One of the major causes of breakouts within the casting mold is the temporary adhesion of the slab to the wall of the mold or tearing of the shell of the slab by particles of steel or slag which may have adhered to the mold wall.

In the continuous casting process as practiced heretofore, one means employed to attempt to avoid such adhesion of metal or slag to the mold walls and consequent breakouts has been to apply a film of oil, such as rape seed oil, along the inner walls of the mold so as to lubricate the mold walls. To be effective, the oil must form and maintain a substantially continuous film on the mold walls. Heretofore, a series of spaced ports or holes was provided in the upper portion of the mold walls above the level of molten metal in the mold through which oil was delivered so as to form a series of descending streams of oil on the inner walls of the mold. This method of mold lubrication, however, has not been satisfactory for several reasons. Difficulty was encountered in causing the discrete descending streams of oil to coalesce into a single, substantially continuous sheet covering the whole inside surface of the mold wall. Moreover, this difficulty was compounded by the necessity of providing oil ports of substantial size in the mold wall since such ports frequently become clogged and therefore inoperative as a result of splashes of metal or slag. In addition to the difficulties involved in cleaning and maintaining the oil ports, even a temporary clogging of one or more oil ports resulted in a disruption of the oil film on the mold wall and this, in turn, often resulted in a breakout within the mold.

In some continuous casting operations, it has been found desirable to shield the molten metal in the casting mold from contamination by the atmosphere. Heretofore this has been accomplished by providing a second series of spaced ports or holes in the upper portion of the casting mold above the oil ports referred to above through which a gas, such as natural gas, may be passed. The gas issuing from the gas ports was then ignited to form a sheet or curtain of burning gas which shielded the molten metal in the mold from the atmosphere. However, as with the oil ports previously referred to, the gas ports often became clogged by splashes of molten metal or slag and the effectiveness of the curtain of burning gas was seriously diminished.

It is an object of the present invention to provide an improved apparatus for applying lubrication to the walls of a continuous casting mold.

Another object of the invention is to provide an improved apparatus for delivering a curtain of gas to the upper portion of the continuous casting mold.

A further object of the invention is to provide means whereby a film of lubricating oil may be formed and maintained on the walls of the casting mold.

A still further object of the invention is to provide means whereby a curtain of gas may be formed above the molten metal in the continuous casting mold.

Another object of the invention is to provide means for delivering gas and oil to the upper portion of a continuous casting mold wherein the possibility of plugging or clogging from splashes of metal or slag has been minimized.

Generally, the above objects of the present invention are accomplished by the provision of a novel form of a casting mold wherein a series of narrow elongated recesses are located above the level of molten metal in the mold through which oil or gas may be delivered to the upper portion of the casting mold.

The above objects and others will be apparent to those skilled in the art from the following description of the invention and drawings in which:

FIGURE 1 is a top plan view, partly broken away of a continuous casting mold incorporating the apparatus of the present invention.

FIGURE 2 is an enlarged view taken in section along line 2—2 of FIGURE 1.

FIGURE 3 is an enlarged sectional view similar to FIGURE 2 showing a modification of the invention wherein means are provided only for delivering oil to the walls of the casting mold.

FIGURE 4 is a fragmentary top plan view showing a modification of the apparatus according to the present invention.

Referring now to the drawings, and particularly to FIGURE 1, the continuous casting mold of the present invention includes two side portions, designated generally at **10** and **12**, and two end portions, designated generally at **14** and **16** connected together in a conventional manner, not shown, so as to form a cavity **18**, open at the top and bottom. Molten metal **20** may be delivered to the mold from a tundish, not shown, and is maintained at an approximately constant level **22**, within the mold as shown in FIGURES 2 and 3. The molten metal first begins to solidify along the mold walls at a point somewhat below the surface **22** of the molten metal.

The present invention relates to the upper portion of the casting mold and more particularly to the portion of the mold above the surface of the molten metal. Each of the side portions **10** and **12** which form the walls of the continuous casting mold comprise main mold walls **24** which are preferably water cooled and made of copper. An oil block member **26**, also preferably made of copper, and having a length equal to the length of the mold wall is positioned at the top of the mold wall and spaced from the top surface of the mold wall by a shim **28**. A gas block member **30**, also preferably made of copper, and similar in form to the oil block member **26** is positioned above the oil block member **26** and spaced therefrom by a shim **32**. The block members **26** and **30** and the shims **28** and **32** are fastened to mold wall **24** by a series of cap screws **34** which are preferably countersunk into the upper surface of the block **30** and spaced on about 6 inch centers. A plate **36**, also preferably made of copper is preferably attached to the upper surface of the block **30** by a series of machine screws **38**. Plate **36** serves to protect the upper portions of the mold from damage as a result of splashes of molten metal or slag.

The shims **28** and **32** are similar in form and have a length and width corresponding to the length and width of the block members **26** and **30** and a thickness on the order of 0.010 inch. While the long edge of the shims **28** and **32** which is adjacent the outer side of the blocks **26** and **33** respectively may be straight, the long edges of the shims **28** and **32** adjacent the mold cavity **18** are serrated so as to form a first series of V-shaped recesses **40** between the oil block **26** and the mold wall **24** and a second series of V-shaped recesses **42** between the oil block **26** and the gas block **30**. The shims **28** and **32** may be made from any suitable material, for example, steel, copper or aluminum. While the size and shape of the serrations may be varied, it has been found desirable to space the serrations on about 3-inch centers so that the recesses **40** and **42** form a substantially continuous opening along the inside wall of the casting mold. In order to prevent the tips of the serrations on the shims **28** and **32** from extending into the mold cavity **18**, it may be found desirable to round off the tips of the serrations as shown in FIGURE 4.

A series of intersecting passageways **44** and **46** are formed within the oil block **26** as shown in FIGURE 2. Vertical passageway **44**, bored from the bottom of the oil block **26** communicates, at its lower end, with the recess **40** formed between the oil block **26** and the mold wall **24** and at its upper end with the inner end of horizontal passageway **46** which is bored from the outer side of the oil block **26**. Preferably, the outer end of passageway **46** is threaded so as to provide a convenient connection with an external oil supply source, not shown. As shown in FIGURE 1, a set of intersecting passageways **44** and **46** is provided for each recess **40** formed by the shim **28**.

A similar series of intersecting passageways **48** and **50** are formed within the gas block **30**. Vertical passageway **48**, bored from the bottom of the gas block **30** communicates, at its lower end, with the recess **42** formed between the oil block **26** and the gas block **30** and at its upper end with the inner end of horizontal passageway **50** which is bored from the outer side of the gas block **30**. Preferably, the outer end of passageway **50** is threaded so as to provide a convenient connection with an external gas supply source, not shown. A set of intersecting passageways **48** and **50** is provided for each recess **42** formed by the shim **32**.

In casting operations where there is no need to provide a protective curtain of flaming gas, it may be desirable to omit the gas block **30**. In this event, as shown in FIGURE 3, an oil block **52** may be provided which has a thickness equal to the combined thickness of the oil block **26**, the shim **32** and the gas block **30** in order that the overall height of the casting mold may be maintained constant.

The construction of the oil and gas blocks with interposed shims required for the ends of the casting mold may be identical with the construction described above for the sides of the casting mold. In this connection, it has been found that for a mold capable of handling a slab 10-inches thick, it is sufficient to provide three oil or gas recesses for the end portion of the mold.

In operation, natural gas may be introduced through the passageways **50**. The gas flows from the passageways **50**, through the passageways **48**, through the recesses **42** and forms a horizontal, substantially continuous curtain of gas which, when ignited, forms a continuous flame across the cross section of the mold and effectively prevents outside atmosphere from entering the mold cavity **18**. In a similar manner, oil may be pumped through the passageways **46** and **44** and into the recesses **40**. The oil emerging from the recesses **40** forms a film along the surfaces of the mold cavity at and below the level of the recesses **40**. Since the recesses **40** and **42** form a substantially continuous line along the inner surface of the mold walls, and the height of the recesses is very small, i.e. on the order of 0.010 inch, splashes of metal or slag do not tend to penetrate into and clog the recesses **40** and **42**. The uniformity and continuity of the oil film is enhanced by the provision of the substantially continuous recesses according to the present invention for emission of the oil and, at the same time, the possibility of plugging or clogging the oil ports and the

effect of any obstruction that may occur is substantially reduced.

In the practice of the present invention, it has been determined that about 5 to 6 ounces of oil per ton of steel cast should be delivered to the oil recesses **40** in order to form and maintain a substantially continuous film of oil on the mold walls. Heretofore, rape seed oil has often been used for mold lubrication due to its relatively high flash point (485° F.) and fire point (515° F.). While rape seed oil may be used in the practice of the present invention, it is preferable to use a vegetable oil known as Crambe oil which has a lower viscosity than rape seed oil and a higher flash point (650° F.) and fire point (687° F.). The lower viscosity improves the wetting ability of the oil, i.e. the ability to form an oil film over the mold wall while the higher flash and fire points assists in maintaining the oil film on the mold wall despite the relatively high temperatures which exist at the walls of the mold.

The terms and expressions which have been employed are used as terms of description and not of limitation and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A mold for the continuous casting of metal slabs having a pair of oppositely disposed vertical end members, said side and end members being joined together to form a mold cavity open at the top and bottom, means on said side and end members adjacent the top of said cavity for delivering oil to said cavity comprising a first set of metal blocks positioned above each said side and end member of said mold, each block of said first set of metal blocks having a plurality of passageways formed therein, a first serrated shim interposed between each of said blocks in said first set of metal blocks and said side and end members of said

mold, each of said passageways in each of said first set of metal blocks communicating with a recess formed between adjacent serrations of said first shim, said block of said first set of metal blocks and said mold member, and means for delivering gas to said cavity comprising a second set of metal blocks positioned above said first set of metal blocks, said second set of metal blocks having a plurality of passageways formed therein, a second serrated shim interposed between each of said blocks of said first and said second set of metal blocks, each of said passageways in said second set of metal blocks communicating with a recess formed between adjacent serrations of said second shim and said first and second sets of metal blocks.

2. A mold for the continuous casting of metal slabs, as recited in claim **1**, in which the side and end members of said mold and each block of said first and second set of metal blocks are copper.

3. A mold for the continuous casting of metal slabs, as recited in claim **2**, in which copper plates are fastened to the upper surfaces of said second set of metal blocks.

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U.S. Cl. X.R.

164—259

IN THE UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,446,267 Dated May 27, 1969

Joseph D. Gricol
George E. Schmidt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, (claim 1) line 29, after "disposed" there should be inserted -- vertical side members and a pair of oppositely disposed --,

Column 6, (claim 1) line 1, after "passageways in each" the word -- block -- should be inserted.

SIGNED AND
SEALED
MAR 10 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents