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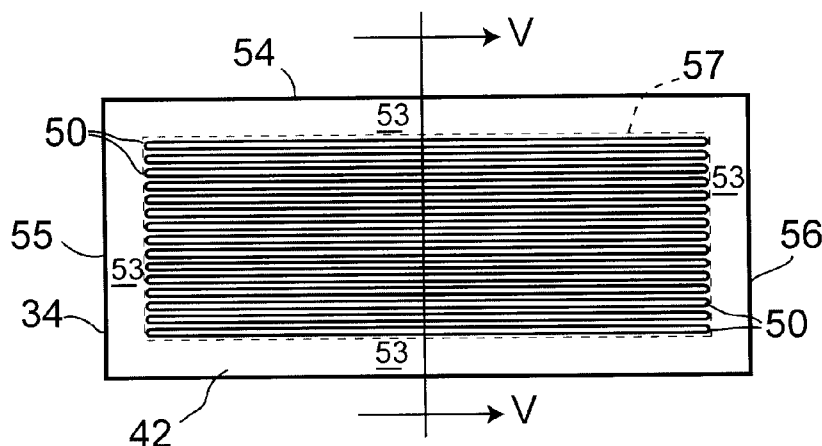


FIG. 4

(57) Abstract: Exemplary embodiments of the invention relate to a side dam block for a continuous metal caster apparatus. The block comprises a body of molten metal resistant material having a metal-contacting surface. The metal contacting surface has a plurality of indentations therein, the indentations having openings at the metal-contacting surface dimensioned to prevent penetration of molten metal into the indentations under casting conditions. Due to a smaller area of direct contact between the molten metal and the surfaces of the blocks, the blocks extract less heat from the molten metal than conventional blocks and help to reduce so-called "dog-bone" and "sink" type deformation of the cast article.

SIDE DAM BLOCKS FOR CONTINUOUS STRIP CASTERS

TECHNICAL FIELD

5 This invention relates to the casting of metal strip articles by means of continuous strip casters of the kind that employ side dam blocks to confine the molten and semi-solid metal between moving casting surfaces. More particularly, the invention relates to the side dam blocks themselves, and particularly, but not exclusively, those intended for the casting of aluminum and alloys thereof.

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BACKGROUND ART

 Metal strip articles (such as metal strip, slab and plate), particularly those made of aluminum and aluminum alloys, are commonly produced in continuous strip caster apparatus. In such apparatus, molten metal is introduced between two closely spaced (usually actively cooled) elongated moving casting surfaces and is confined until the metal solidifies (at least sufficiently to form an outer solid shell). The solidified article (often referred to as a cast slab), which may be produced in indefinite length, is continuously ejected from the space (casting cavity) between the casting surfaces as they advance. A popular form of this apparatus is the twin-belt

5 caster in which two confronting belts are rotated and circulated continuously and molten metal is introduced into a thin mold formed between the confronting regions of the belts. The metal is fed in at one end of the apparatus, conveyed by the moving belts for a distance effective to solidify the metal, and then the solidified strip emerges from between the belts at the opposite end of the apparatus. Other

0 examples include rotating block casters in which recirculating blocks are mutually aligned to form opposed casting surfaces in a casting region of the apparatus.

 In order to confine the molten and semi-solid metal to the mold cavity, i.e. to prevent the metal escaping laterally from between the casting surfaces, it is usual to provide a row or chain of blocks at each side of the casting cavity. These blocks,

5 normally referred to as side dam blocks, are trapped by and move along with the casting surfaces and are endlessly recirculated so that blocks emerging from the casting cavity exit move around a guided circuit and are fed back into the entrance of

the casting cavity. The blocks are normally guided on this circuit by a thin metal band or equivalent guide on which the blocks can slide in a loose fashion that allows for limited movement between the blocks, especially as they move around curved parts of the circuit outside the casting cavity.

The side dam blocks are usually made of metal (e.g. cast iron or mild steel) that resists attack by the molten metal being cast, and normally the blocks have substantial heat conductivity and heat capacity. The metal within the casting cavity which comes into contact with the side dam blocks tends to lose heat more quickly than metal positioned more centrally within the casting cavity, so the edge regions of the developing metal strip article (cast slab) cool more quickly than the remainder. This can result in side edges of the cast slab that are thicker than the remainder, a defect sometimes referred to as “dog-bone”, or can result in the formation of thin regions adjacent to the side edges, a defect referred to as “sinks”. Clearly, this is disadvantageous because a rectangular cross-section is optimal for subsequent rolling operations and other uses.

US patent No. 4,545,423 issued to Platek *et al.* on October 8, 1985 provides the side dam blocks with a coating or covering of non-wettable refractory ceramic material of low heat conductivity. The coating or covering reduces heat flow out of the edges of the cast article. Alternatively, such heat flow can be reduced by jiggling or rocking individual side dam blocks to break thermal contact between the blocks and the metal being cast.

Japanese patent publication No. JP 1-317657 to Yukumoto *et al.* published on December 22, 1989 discloses a method of twin-roll casting in which the metal is cooled between two counter-rotating rolls usually arranged for casting in the vertical direction. A triangular-shaped side dam is employed and is provided with a pair of grooves connected to a source of gas or lubricant. This arrangement prevents molten metal from leaking out of the gap between the dam and the edges of the rolls. The grooves do not appear to reduce heat outflow from the metal and are stated to have a size of 5mm (width) x 100mm (length) x 20mm (depth).

US patent 3,642,057 issued to Scheufele on February 15, 1972 relates to a continuous casting process for steel slab or sheet. In this process, a small slab shaped

ingot is cast and gradually bent to a horizontal orientation and may be rolled to gauge. Following casting, the slab is guided through a series of cooling rolls. The rolls may have circumferential grooves near their outer ends. The grooves reduce contact with the hot metal in these regions and help to equalize the cooling effect across the slab profile. However, the rolls do not contact molten metal as the slab has already solidified, at least at the outer surface. The rolls are not equivalent to side dams of the kind mentioned above.

There is therefore a need to address the problems mentioned above.

DISCLOSURE OF THE INVENTION

According to one exemplary embodiment of the present invention, there is provided a side dam block for a continuous metal caster apparatus, comprising a body of molten metal resistant material having a metal-contacting surface, wherein the metal contacting surface has a plurality of indentations therein. The indentations have openings at the surface dimensioned to prevent the penetration of molten metal into the indentations under casting conditions. The indentations act to reduce heat outflow from the contacting molten metal.

The indentations are preferably in the form of elongated generally parallel grooves in the metal-contacting surface, and the grooves may be generally semi-circular in cross-section, at least at inner ends thereof, or generally rectangular.

Preferably, the indentations cover a majority of the surface area of the metal-contacting surface (e.g. at least 50% and, more preferably, at least 80%).

The metal-contacting surface generally has a periphery defining a top and bottom edges and end (or side) edges, and the indentations are preferably absent in a surface region adjacent to the periphery, at least adjacent to the end edges of the block. The openings of the indentations generally have orthogonal width and height dimensions, and at least one of the width and height dimensions preferably has a maximum size of about 0.06 inch (1.5 mm), and more preferably about 0.02 inch (0.5mm).

Preferably, the indentations are separated from each other by distances no greater than five times (more preferably no more than three times, and even more

preferably no more than twice) the width dimensions of the indentations. Most preferably, the indentations are separated by distances about the same as the width dimension of the indentations (e.g. about 0.06 inch (1.5 mm) or less).

Preferably, the indentations have a depth extending into the block from the surface of 0.06 inch (1.5 mm) or less (preferably 0.02 inch (0.5 mm) or less, e.g. about 0.15mm).

The block may be made of cast iron or mild steel, and may have a generally rectangular faces. The bottom face is normally provided with a longitudinal flanged slot for loosely slidably engaging a band or the like for the block.

According to another exemplary embodiment, there is provided a continuous metal caster having a casting cavity formed between confronting moving casting surfaces, an entrance for molten metal to the casting cavity, an exit for a solidified metal slab cast within the casting cavity, and movable side dams positioned between the casting surfaces to prevent escape of molten metal at the sides of the casting cavity. At least one of the side dams is made up of movable side dam blocks having molten metal-contacting surfaces, the molten metal-contacting surface of at least one of the blocks having a plurality of indentations therein, the indentations having openings at the surface dimensioned to prevent penetration of molten metal into the indentations under casting conditions. Preferably, all of the side dam blocks of at least one of the side dams are provided with molten metal-contacting surfaces having the plurality of indentations.

According to yet another exemplary embodiment, there is provided a method of continuously casting molten metal to form a metal slab, which comprises introducing molten metal into the continuous metal caster of the kind described above, and operating the caster to cast molten metal into a metal slab while contacting the molten metal with the molten metal-contacting surface of the at least one movable side dam block to confine the molten metal to the casting cavity at the sides thereof.

Exemplary embodiments are particularly applicable to the casting of aluminum and its alloys, but may be applied to the strip casting of other metals, e.g. copper, zinc and lead, and even magnesium and steel.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are described in detail in the following with reference to the accompanying drawings, in which:

Fig. 1 is a side sectional view of a conventional twin belt caster of the kind with which the exemplary embodiments may be used;

Figs. 2A and 2B are transverse vertical partial cross-sections of lower casting belts supporting conventional side dam blocks and cast strip articles with “sinks” (Fig. 2A) and “dog-bone” (Fig. 2B) defects typical of conventional casting apparatus;

Fig. 3 is a close-up of a side dam formed of a row of side dam blocks of a kind to which the exemplary embodiments may be applied;

Fig. 4 is a view of a vertical metal-contacting surface of a side dam block according to one of the exemplary embodiments;

Fig. 5 is a cross-section taken along the line V-V of Fig. 4 of a part of the block of Fig. 4 adjacent the vertical surface shown in Fig. 4;

Fig. 6 is a close-up of the cross-section of the indentations formed in the block of Fig. 4 and corresponds to the region identified by the broken circle VI of Fig. 5;

Fig. 7 is a view similar to Fig. 6, but showing molten metal in contact with the block surface;

Fig. 8 is a cross-section similar to that of Fig. 5 showing an alternative exemplary embodiment; and

Fig. 9 is a view similar to that of Fig. 7 but showing a block having a surface indented by means of roughening.

BEST MODES FOR CARRYING OUT THE INVENTION

In order to provide context for the present invention, Figs. 1, 2A, 2B and 3 show examples of conventional apparatus with which the exemplary embodiments of the present invention may be employed. It should be realized, however, that the exemplary embodiments may be used with continuous casting apparatus of other

kinds than the one shown (e.g. rotating block casters) provided that such other kinds employ moving side dams.

Fig. 1 is a vertical section of a conventional twin belt caster 10 of the kind disclosed in US patent No. 4,061,178 issued to Sivilotti *et al.* on December 6, 1977 (the disclosure of which patent is incorporated herein by reference). The caster has an upper flexible endless metal belt 12 and a lower flexible endless metal belt 14 that rotate about rollers 16, 17 and stationary guides 18, 19. The belts confront each other for part of their length to form a thin casting cavity or mold 22 having an entrance 25 and an exit 26. Molten metal is fed into the entrance at 24 (e.g. via a metal injector nozzle or a metal launder) and a cast metal strip article (cast slab) emerges from the exit at 27 although such a strip article is not shown in the drawing. Cooling water sprays 20 are directed onto the interior surfaces of the belts in the region of the casting cavity for the purpose of cooling the molten metal as it is being cast.

In Figs. 2A and 2B, which show a casting region of the lower casting belt 14 in isolation from the remainder of the casting apparatus, side dams 28 are formed at each side of the belt to confine the metal 32 being cast. The side dams are each formed by rows of side dam blocks 34 that are trapped between the lower belt 14 and the upper belt 12 (not shown in these views) and move with the belts as casting takes place. Figs. 2A and 2B show defects (in exaggerated form for clarity) in cast article 15 produced by these conventional means. In Fig. 2A there are depressions 21 in the upper and lower surfaces of the cast article adjacent to the lateral side edges. These are referred to as "sinks". In Fig. 2B, the lateral side edges have regions 23 that are thicker than the remainder of the strip article. This defect is referred to as "dog bone". These defects are produced by uneven heat extraction from the metal as it cools.

As can be seen more clearly in Fig. 3, the blocks 34 are loosely engaged with a metal band 36 passing through a flanged slot 38 formed at the lower side of the blocks. The band 36 keeps the blocks aligned and in the correct position and, once outside the casting cavity, causes the blocks to be recirculated along a controlled path from the casting cavity outlet to the casting cavity inlet for continuous re-use. Fig. 3

shows the metal-contacting faces 42 of the blocks which, in conventional designs, are normally completely flat except for slight rounding at the extreme edges in some cases.

Fig. 4 is a side view of a block 34 according to an exemplary embodiment of the present invention showing its metal-contacting surface 42. In this embodiment, the surface is provided with a plurality of co-extensive horizontal (parallel) linear closely-spaced indentations 50 in the form of elongated grooves machined into the metal-contacting surface 42 or formed during casting of the block. These indentations 50 are shown in profile in Fig. 5, in greater magnification in Fig. 6, and with molten metal present in Fig. 7. From this, it will be seen that the indentations are generally semi-circular in cross-section (although, at the opening, the side walls in the illustrated embodiment have a contained angle Z of about 60°) and are spaced from each other by a distance X having roughly the same dimension as the width Y of the entrances of the indentations (e.g. about 0.06 inch (1.5 mm)). The openings 52 at the entrances to the indentations are made small enough in width that molten metal cannot enter and flood the indentations because of the effects of surface tension. As shown in Fig. 7, the indentations 50 reduce the area of contact between the molten metal and the block, and create insulating pockets filled with air (or parting agent, see below), thereby reducing heat transfer from the molten metal to the block. The maximum dimension that prevents such metal penetration depends on the surface tension of the metal being cast, the material of the body of the side dam block, the temperature of the metal being cast, the hydrostatic pressure of the metal at the surface, and the presence or absence of an oxide layer on the metal, etc., but it is generally constant for any particular caster used for casting a given metal. In most cases, substantial aluminum metal penetration cannot take place when the width of the indentations (i.e. dimension Y at the surface) is about 0.06 inch (1.5 mm) or less, and more preferably about 0.04 inch (1 mm) or less. The minimum dimension is governed by the limits of the manufacturing process, but for conventional machining it is about 0.02 inch (0.5 mm) or more. The general range of dimension Y is therefore preferably 0.02 inch (0.5 mm) to 0.06 inch (1.5 mm), but other ranges may be more preferable according to the metal being cast and the other factors mentioned above.

When the indentations are in the form of elongated grooves, as shown, the grooves may have any desired length (i.e. the long dimension at the surface) provided the width remains below the indicated maximum along the entire length of the grooves so that the metal bridges the grooves along their entire length and is prevented from entering and flooding the grooves.

As shown in Fig. 4, the grooves do not necessarily occupy the entire metal-contacting surface 42 of the block. There is preferably an area 53 all around the periphery 54 of the block that is free of indentations. Most preferably, even if the grooves extend to the upper and lower edges of the block, the grooves do not extend fully to the side edges 55 and 56 of the block. This is advantageous because adjacent blocks move against each other within the casting cavity and also, more particularly, as they are recirculated outside the mold. Grooves extending fully to the sides 55, 56 of the blocks could cause the blocks to bind against each other during such movement. The distance between the ends of the indentations and the side edges of the block may be quite short (e.g. up to about about 0.02 inch (0.5 mm)). The width of the region 53 along the upper and lower sides of the face 42, if present, may be the same as that at the sides. Clearly, the greater the area of the metal-contacting face 42 provided with grooves, the better the heat insulation will be, so the area where there are no indentations (grooves) should preferably be kept as small as practical. Preferably, at least 80% of the surface 42, and more preferably at least 90%, is provided with grooves or indentations (the area shown by broken lines 57 in Fig. 4). Between the grooves 50, the surface 42 forms flat lands 51 (Fig. 7). These are areas where the molten metal 32 directly contacts the block 34, thereby allowing heat to escape from the molten metal. It is therefore desirable, within the area 57 of the surface 42 containing the grooves, to make the area of the lands as small as possible (preferably 75% or less of the area 57 provided with the grooves, and more preferably 50% or less). The distance X should preferably not, however, be made so small that the web of material between the lands is unduly weakened. As noted, this dimension may be made the same as, or similar to, the width of the indentations, i.e. dimension Y, in which case the area of the lands will form approximately 50% of the total area 57.

The depth of the indentations (i.e. the distance by which they extend into the interior of the blocks) should be sufficient to avoid molten metal contact at the bottom of the indentations, bearing in mind that the molten metal bridging the indentations tends to sag towards the bottom of the indentations to a certain extent (see Fig. 7). Depending on wettability and other factors, this may for example be as little as 0.008 inch (0.2 mm). Deeper indentations not only avoid such contact but also advantageously provide a greater volume for containing air or gas-generating parting agent (e.g. oil) often sprayed onto the casting surfaces during the casting process, and this improves the heat insulating effect. Oil used as a parting agent adds further heat insulation value as it is volatilized and is usually sprayed directly onto the casting belts, but some inevitably finds its way to the side dam blocks. It is also advantageous to provide separate nozzles (not shown) that spray parting agent directly onto the inside (metal-contacting) faces of the side dam blocks before they enter the casting cavity in order to ensure that parting agent is present in the indentations before first contact with the molten metal.

Beyond a certain limit, providing the indentations with greater depths than necessary to avoid metal contact tends to weaken the web of material formed between adjacent indentations and can lead to undesirable fracture or bending of these webs. This latter effect is dependent upon the material from which the blocks are formed but, in general, the depth of the indentations may preferably be kept quite small, e.g. approximately the same dimension as the width Y of the indentations (e.g. up to about 0.06 inch (1.5 mm) or, more preferably, up to about 0.04 inch (1 mm)). It will also be seen that the indentations are preferably "blind", i.e. they are closed at the bottom ends and do not connect to other passages or structures. This helps to trap the air or gas beneath the molten metal and makes metal penetration less likely due to the increase in gas pressure that occurs when metal enters. In the embodiment of Fig. 4, the indentations are also closed at their longitudinal ends and so air or gas cannot escape at these points.

While the indentations of Figs. 5 to 7 are semi-circular in cross-section (radius R), the actual cross-sectional shape of the indentations is not critical, although indentations of this shape are especially easy to manufacture by means of machining.

In contrast, Fig. 8 shows an alternative exemplary embodiment in which the indentations are in the form of grooves of rectangular cross-section. In this case, the grooves have a width B of about 0.015 inch, a depth C of about 0.015 inch, a mutual spacing again of about 0.015 inch, and a separation of the ends of the grooves from the side edges A of the block of about 0.097 inch.

When the indentations are in the form of elongated grooves, they may be arranged horizontally (as shown), vertically, or diagonally, as desired. However, horizontal grooves are preferred because they enable the cast metal to be separated easily from the side dam blocks at the exit of the casting cavity if metal has in fact penetrated into the indentations in some areas.

It is possible to provide indentations of other kinds and shapes, e.g. dimples or holes of circular or other shapes, linear cross-hatched designs (linear non-parallel indentations set at mutual angles to intersect leaving, for example, diamond-shaped webs between the indentations), etc. However, again, the short dimension of any part of such indentations should be small enough to ensure that the molten metal bridges the indentations and does not penetrate and flood them at any point.

As an alternative to providing discrete and regular indentations as described above, randomly shaped and sized indentations may be provided, as long as they do not permit penetration by the molten metal. Indeed, the indentations may amount to a surface roughening, e.g. of the kind illustrated in Fig. 9. This figure shows random grooves 50' formed in the surface 42 by a process such as shot blasting, sand blasting or by employing an electro discharge machine. Again, the small surface dimension (width) of the grooves is such that the molten metal does not penetrate and flood them, but in this case, there may be no flat land 51 between the grooves as is the case for the embodiments of Figs. 4 through 8. The flat lands of these previous embodiments are areas where the molten metal makes full contact with the surface 42, thereby allowing heat to pass from the molten metal into the side dam block. In the embodiment of Fig. 9, the flat lands have been virtually eliminated, making the arrangement even more heat insulating. However, in embodiments of this kind, i.e. those involving surface roughening, there is less control over the widths of the indentations and therefore greater possibility of metal penetration into the

indentations in some areas of the surface. Furthermore, for hard metals such as cast iron or mild steel, it may be difficult to get the degree of indentation depth preferred to achieve the combined objectives of avoidance of metal contact with the bottom portions of the indentations and the provision of a good volume within the indentations for containing air or gas from a parting agent to provide heat insulation. Therefore, while surface roughening has advantages, the provision of discrete indentations with flat lands therebetween may be preferred in some or all cases.

For creating the surface roughness, it is preferable to use a method than tends to score the surface to form indentations that are elongated to some extent and are therefore somewhat similar to the grooves described above. For example, creating surface roughness by means of shot blasting may produce elongated indentations (pits or grooves) having a depth of about 200 micro-inches (0.0002 inch, or 5.08 μ m) to 0.04 inch (1,016 μ m), which is effective for aluminum and other molten metals.

If desired, for any exemplary embodiment, the likelihood of penetration of metal into the indentations may be further reduced by coating the surface 42 with a material that has lower wettability with the molten metal than the underlying substrate of the side dam block, but that shows resistance to attack by the molten metal. Suitable materials for this purpose include, for example, boron nitride, silicon carbide, carbon, aluminum oxide, and the like. These materials may be applied to the surface 42 by standard known coating methods. It should be noted, however, that any such coating should not fill in the indentations completely, nor reduce the depth of the grooves so that metal contact occurs. The metal-contacting surface must have the indented structure effective to reduce heat loss as described whether or not the metal of the side dam blocks contacts the molten metal directly, or via a coating layer provided on the metal contacting surface of the side dam blocks.

The effectiveness of the indentations in improving heat insulation at the sides of the strip article being cast can be assessed by measuring the temperature rise in the side dam blocks during casting and comparing this with the temperature rise of similar blocks not provided with indentations.

CLAIMS:

1. A side dam block for a continuous metal caster apparatus, comprising a body of molten metal-resistant material having a metal-contacting surface, wherein said metal contacting surface has a plurality of indentations therein, said indentations having openings at said surface dimensioned to prevent penetration of molten metal into said indentations under casting conditions.
2. A block according to claim 1, wherein said indentations are in the form of elongated generally parallel grooves in said surface.
3. A block according to claim 2, wherein said grooves are generally semi-circular in cross-section, at least at inner ends thereof.
4. A block according to claim 2, wherein said grooves are generally rectangular in cross-section.
5. A block according to claim 2, wherein said grooves are horizontal.
6. A block according to any one of claims 1 to 5, wherein an area provided with said indentations covers a majority of said metal-contacting surface.
7. A block according to claim 6, wherein said area covers at least 80% of said surface.
8. A block according to claim 6, wherein said area covers at least 90% of said surface.
9. A block according to claim 6, wherein said area has flat lands between said grooves.

10. A block according to claim 9, wherein said lands occupy 75% or less of said area of said metal-contacting surface covered by said grooves.
11. A block according to claim 1, wherein said indentations are in a form selected from the group consisting of dimples, holes and linear cross-hatch designs.
12. A block according to claim 1, wherein said indentations are in the form of irregular surface roughness.
13. A block according to any one of claims 1 to 12, wherein said metal-contacting surface has a periphery defining a top and bottom edges and end edges thereof, and wherein said indentations are absent in a surface region adjacent to said periphery, at least adjacent to said end edges of the block.
14. A block according to any one of claims 1 to 13, wherein said openings have width having a maximum size of 0.06 inch (1.5 mm).
15. A block according to any one of claims 1 to 13, wherein said openings have a width having a maximum size of 0.04 inch (1 mm).
16. A block according to claim 1, wherein said openings have orthogonal width and height dimensions, and wherein said indentations are separated from each other by distances no greater than five times the size of a smaller of said width and height dimensions.
17. A block according to claim 16, wherein said openings are separated by distances no greater than three times the size of a smaller of said width and height dimensions.

18. A block according to claim 17, wherein said openings are separated by distances no greater than twice the size of a smaller of said width and height dimensions.
19. A block according to claim 16, wherein said openings are separated by distances generally the same as a smaller of said width and height dimensions.
20. A block according to claim 1, wherein said indentations are separated from each other by a distance of 0.06 inch or less.
21. A block according to claim 1, wherein said indentations have a depth extending into said block from said surface of 0.06 inch or less.
22. A block according to claim 1, wherein said indentations have a depth extending into said block from said surface of 0.04 inch or less.
23. A block according to claim 1, wherein said indentations have a depth extending into said block from said surface of about 0.02 inch.
24. A block according to any one of claims 1 to 23, wherein said body is made of a metal selected from the group consisting of cast iron and mild steel.
25. A block according to any one of claims 1 to 23, wherein said body is generally rectangular and has a longitudinal flanged slot in a surface other than said metal-contacting surface for loosely slidably engaging a guide rail for the block.
26. A continuous metal caster having a casting cavity formed between confronting moving casting surfaces, an entrance for molten metal to the casting cavity, an exit for a solidified metal slab cast within the casting cavity, and movable side dams positioned between the casting surfaces to prevent escape of molten metal at the sides of the casting cavity, wherein at least one of said

side dams is made up of movable side dam blocks having molten metal-contacting surfaces, the molten metal-contacting surface of at least one of the blocks having a plurality of indentations therein, said indentations having openings at said surface dimensioned to prevent penetration of molten metal into said indentations under casting conditions.

27. A caster according to claim 26 wherein all of the side dam blocks of at least one of the side dams are provided with molten metal-contacting surfaces having said plurality of indentations.
28. A method of continuously casting molten metal to form a metal slab, which comprises introducing molten metal into a continuous metal caster according to claim 26 or claim 27, and operating said caster to cast said molten metal into a metal slab while contacting said molten metal with said molten metal-contacting surface of said at least one movable side dam block to confine the molten metal to the casting cavity at sides thereof.

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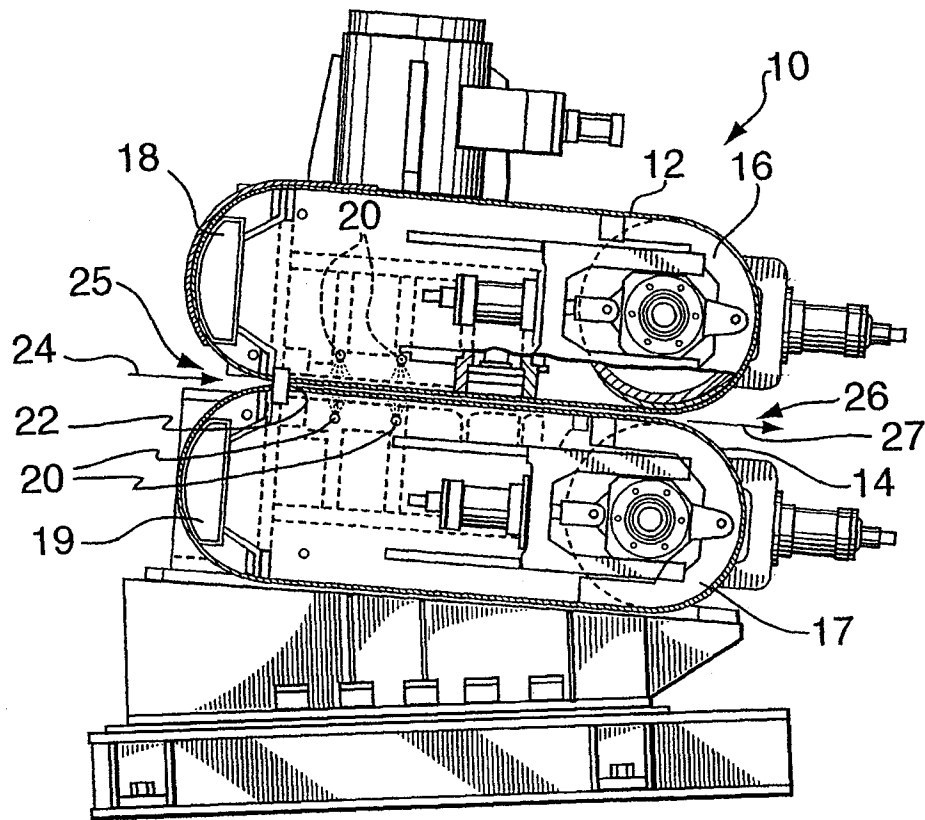


FIG. 1

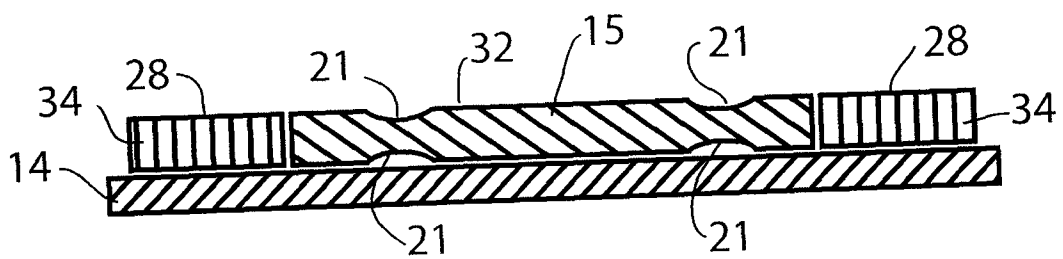


FIG. 2A

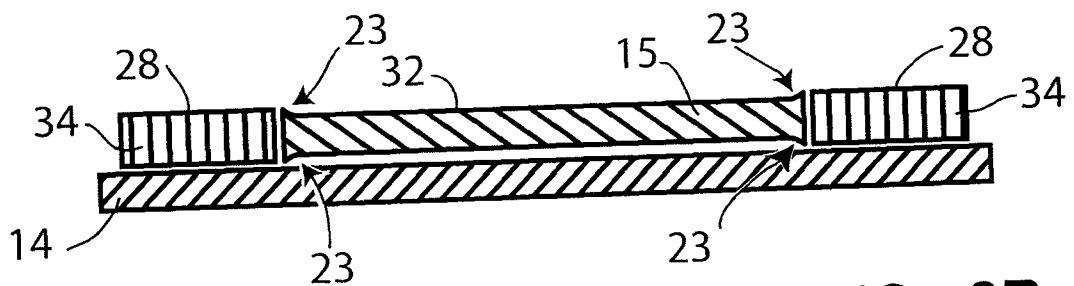


FIG. 2B

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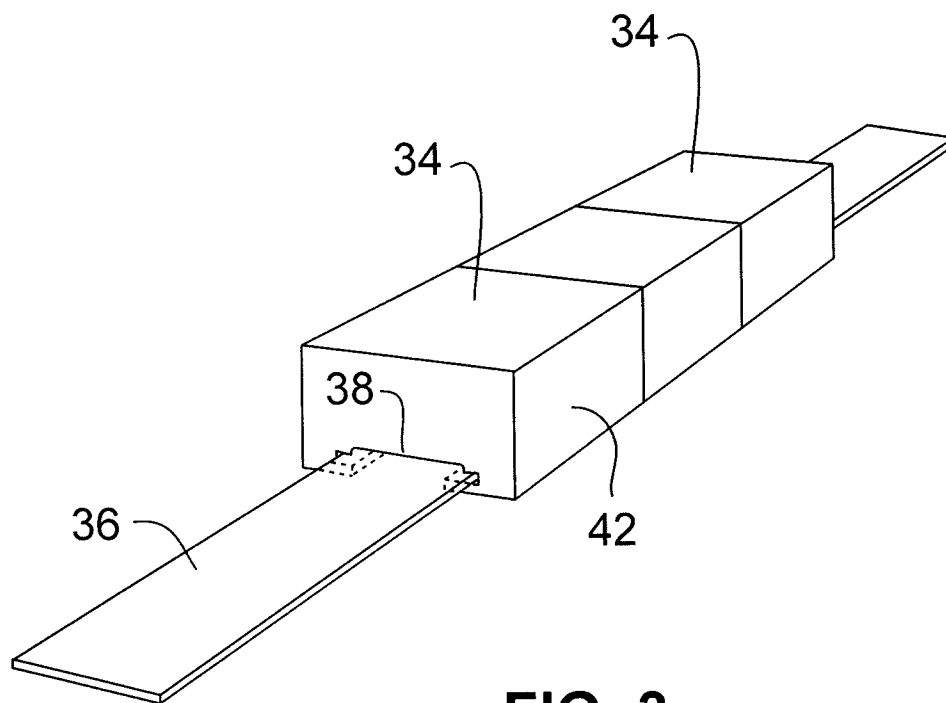


FIG. 3

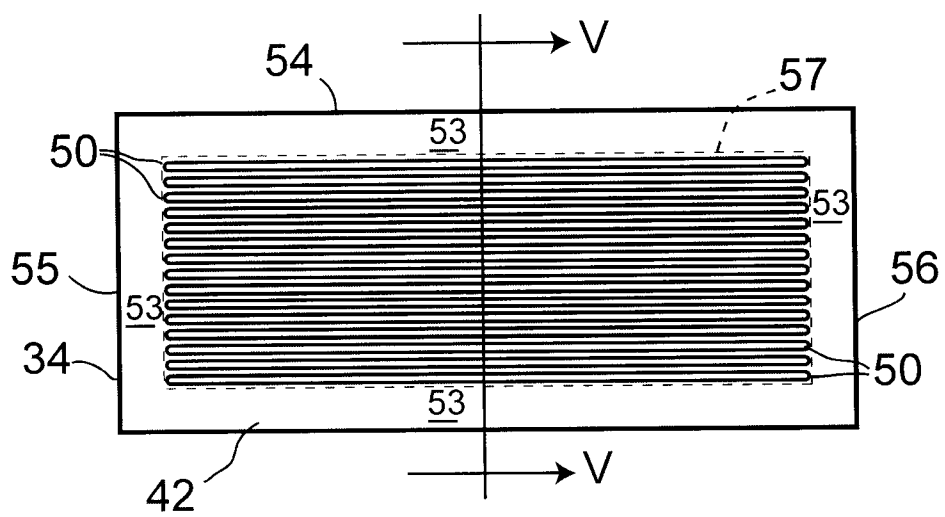


FIG. 4

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FIG. 5

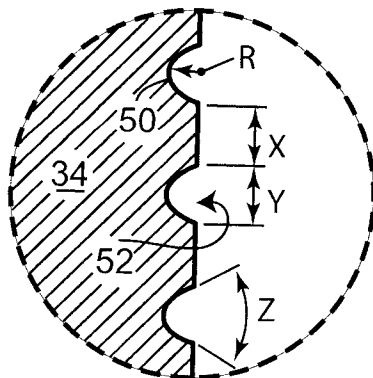
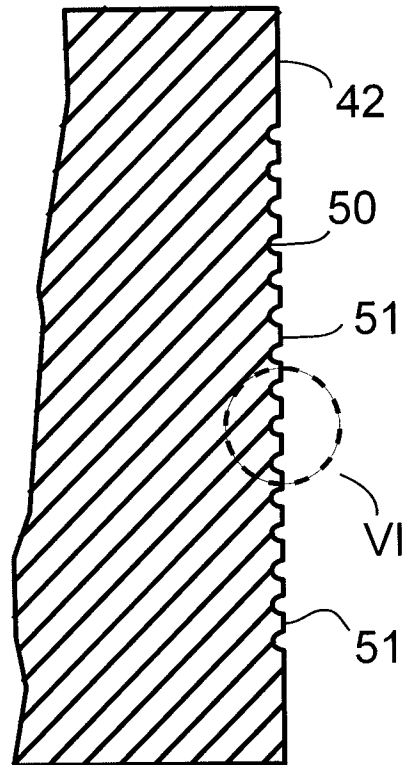


FIG. 6

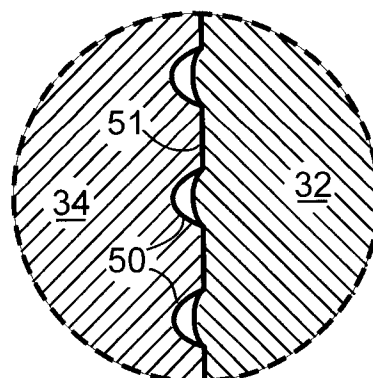
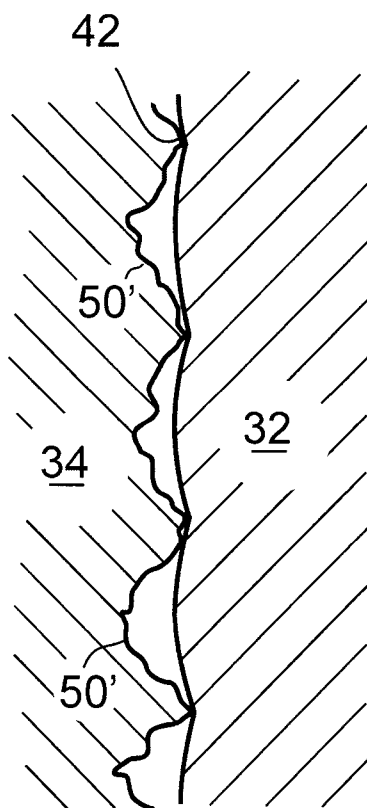


FIG. 7

FIG. 8



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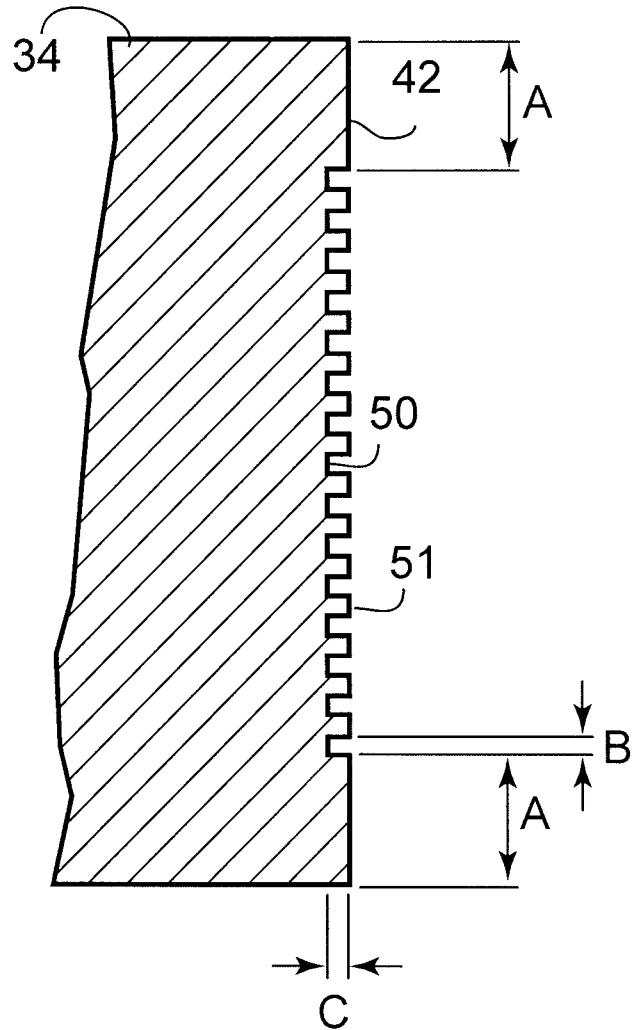


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2010/000459

A. CLASSIFICATION OF SUBJECT MATTER IPC: B22D 11/06 (2006.01) , B22D 11/08 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC: B22D 11/06 (2006.01) , B22D 11/08 (2006.01) ; ECLA: B22D 11/06L2D; USPC: 164/431		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Epoque, Esp@cenet. Keywords: cast, continuous, roll, edge, dam, surface, ridge, indent, groove.		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,250,950 A (BUXMANN, K. et al.) 17 February 1981 (17-02-1981) * the whole document *	1-3, 5-11, 14-28
Y	FR 1 364 717 A (COMPAGNIE GENERALE DU DURALUMIN ET DU CUIVRE) 26 June 1964 (26-06-1964) * the whole document *	1, 2, 5-8, 15, 20-28
Y	US 6,120,621 A (JIN, I. et al.) 19 September 2000 (19-09-2000) * figures 1a-c *	1, 6-8, 12, 20-28
Y	D4: US 4,545,423 A (PLATEK, S. et al.) 08 October 1985 (08-10-1985) * the whole document *	1-3, 5-12, 14-28
[] Further documents are listed in the continuation of Box C. [X] See patent family annex.		
*	Special categories of cited documents :	
"A"	document defining the general state of the art which is not considered to be of particular relevance	
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"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"&"	document member of the same patent family	
Date of the actual completion of the international search 3 June 2010 (03-06-2010)		Date of mailing of the international search report 14 June 2010 (14-06-2010)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476		Authorized officer Jeremy Garnet (819) 956-8721

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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