Dec. 16, 1969 J. N. WOGNUM 3,483,918

CONTINUOUS CASTING

Filed Dec. 14, 1966 2 Sheets-Sheet 1

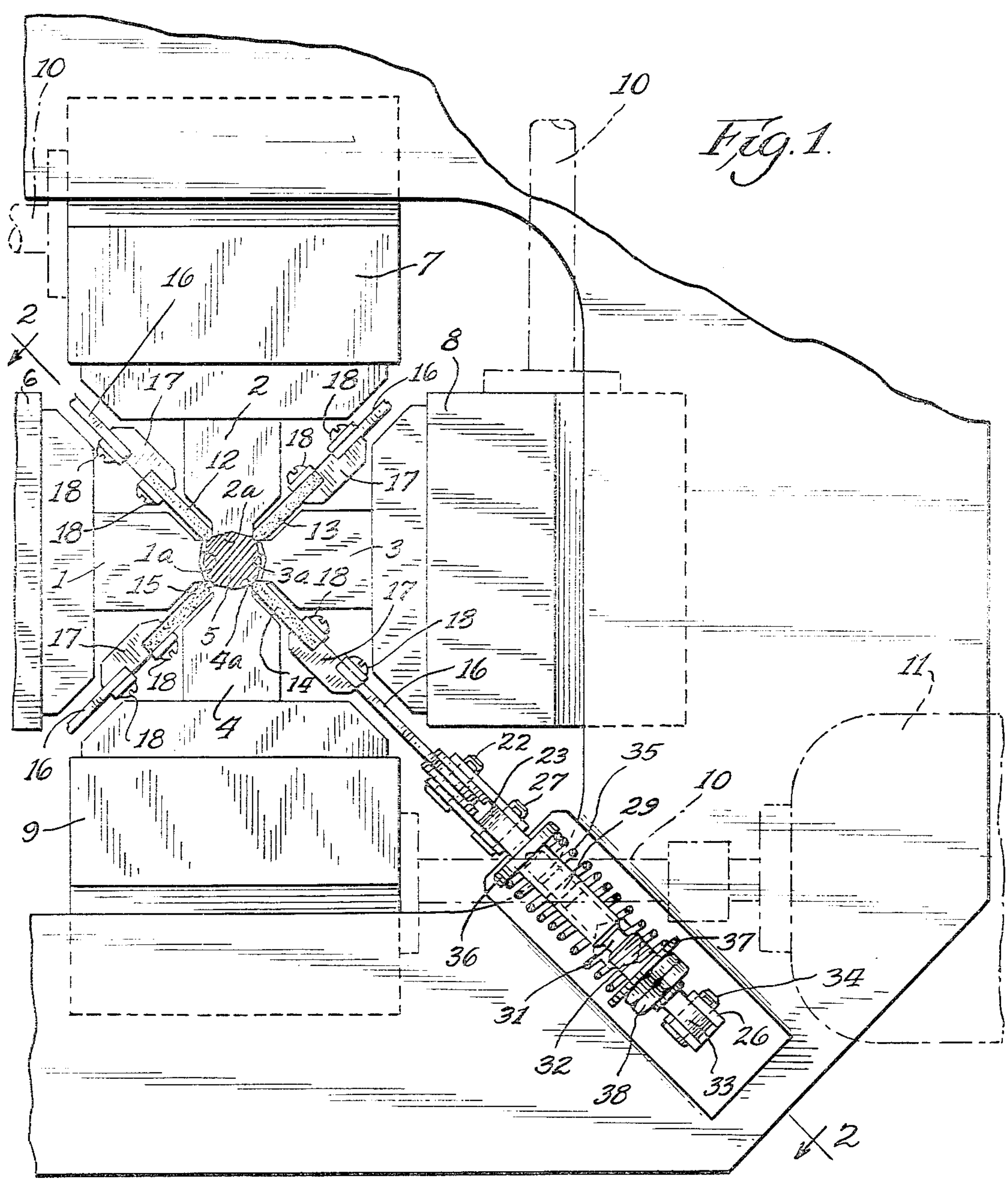

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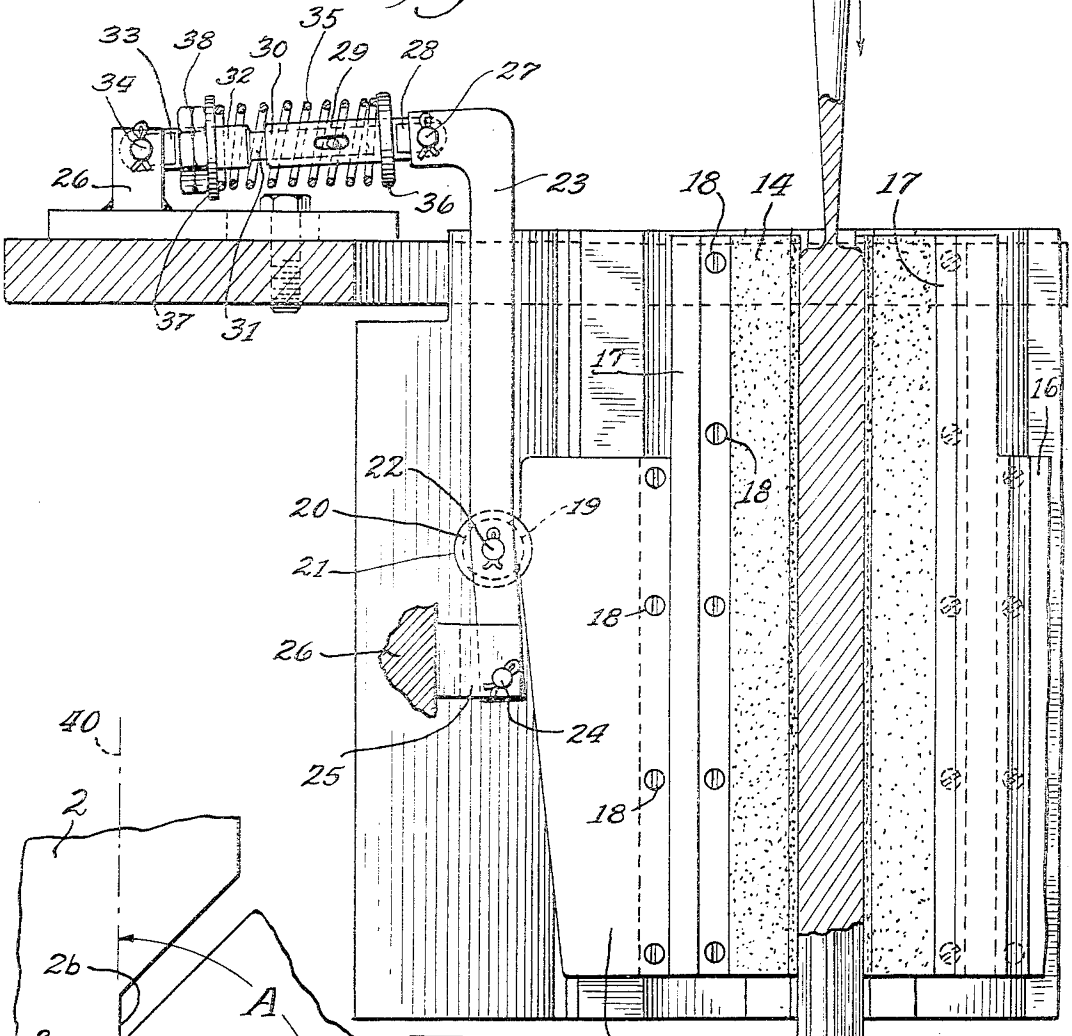
Fig. 2.



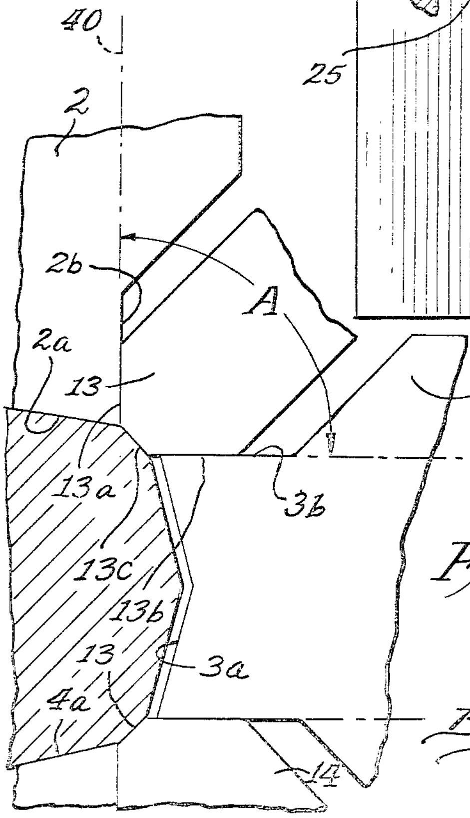


Fig. 3.

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CONTINUOUS CASTING

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ABSTRACT OF THE DISCLOSURE

Apparatus for continuous casting of metal of a type having vibrating mold sections arranged wtih the inside surfaces of the mold sections forming a cavity into which the molten metal is received. The mold sections are bridged with corner inserts at the regions of abutment of adjacent mold sections for the purpose of minimizing leakage of molten metal between the mold sections.

This invention relates to the art of continuous casting and particularly relates to improvements in a continuous casting machine of the vibrating mold type as, for example, shown in U.S. Patent No. 3,075,264 issued in my name.

The type of continuous casting machine is one having a cavity extending longitudinally through it, the cavity being open at its opposite ends and formed by the inside surfaces of a plurality of vibrating mold sections located around the cavity, one of the open ends of the cavity being the receiving end through which molten metal can be introduced into the cavity and the other end being for discharge of the metal after it is solidified as a casting as it passes through the cavity. The mold sections may be vibrated in closed orbital paths to drive the casting being formed in the cavity through the cavity.

One of the characteristics associated with this type of machine is that the corner surfaces of adjacent mold sections must be maintained in close proximity at all times during the operation of the machine in order to preserve a fluid tight corner and thereby prevent leakage of the molten metal out between adjacent mold sections. In order to do this, the corner surfaces of the mold sections are arranged at angles to the plane of orbital movement of the mold sections and certain mold sections travel in their orbits toward the longitudinal center of the mold while alternate mold sections travel in their orbital paths away from the longitudinal center of the mold. By proper timing and amplitude of the orbital paths, the side surfaces of the mold sections will remain in sliding contact with each other without any separation.

With this type of structure, a problem exists if the mold sections are not properly phased in their movements. Without proper phasing, there is a risk of interference of adjacent mold sections at their side surfaces which can result in jamming or breakage of the mold parts. Therefore, it is essential that proper synchronization of the orbital paths of the mold sections is set accurately prior to initiation of operation of the mold.

Because accurate synchrnization is troublesome to achieve ahead of time and because of the possibility of losing synchronization, it is desirable to have a design of apparatus which will function without interference of the mold sections even when proper synchronization does not exist. It is the principal object of this invention to provide such a machine design which will permit the functioning of the mold sections regardless of whether or not they are in proper phased relationship in their orbital movements. In providing such an apparatus, it is another object of the invention to provide a structure which can be properly synchronized after the machine is initiated in its operation.

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It is another problem with this type of machine when bowing of the mold sections, which is ordinarily possible because of uneven thermal expansion of the mold sections, occurs because it accentuates the corner leakage condition. The bowed mold sections remain in contact at corner portions along only small areas of contact in the regions of the apices of the bowing and are separated from each other above and below these apices. It is another object of this invention to provide improved corner construction which overcomes this problem of corner separation due to the bowing of the mold sections by employing corner inserts which have sliding contact with the mold sections in planes corresponding to the possible bowing direction of the mold sections so that the contacting corner portions of the mold sections with the corner inserts are always along full flat regions, rather than face to face along regions which may become bowed.

It is another object of this invention to provide corner inserts having means for urging them into continuous intimate contct with the contacted portions of the mold sections continually through the full movement of the mold sections. This has the advantage of not only minimizing molten metal leakage, but provides substantially gas tight contacts between the inserts and the mold sections to minimize leakage of the atmosphere into the mold at the corners of the hot casting to prevent an undesirable oxidized condition of the casting at the corners.

With the ordinary mold of the type mentioned, even though full flow leakage of molten metal may not occur at the corners, the tendency to leak partially has oftentimes resulted in undesirable flash extending from the corners of the final casting. It is another object of this invention to provide an improved corner construction for the casting machine which not only minimizes the leakage problem, but also minimizes the partial leakage problem resulting in flash.

Although the invention has been suggested, by way of example, as having particular advantages with a mold having mold sections which are vibrated in orbital paths, it similarly has advantages when applied to such a mold wherein the vibratory motion of the mold sections has only rectilinear components of motion, rather than orbital.

Other objects and advantages of the invention should be apparent upon reference to the accompanying drawings in which

FIG. 1 shows a top plan view of a main fragmentary portion of a continuous casting machine embodying the improvements of this invention;

FIG. 2 shows a sectional view along the line 2—2 of FIG. 1 to particularly show the internal portions of the machine and the manner of supporting the corner inserts; and

FIG. 3 shows a top plan view of a fragmentary portion of portions of the casting machine immediately surrounding the mold cavity.

Although the invention can be applied to vibratory molds of the type described having more than four separate mold sections, for illustrative purposes by way of example, only a four sectioned mold is shown.

In FIG. 1, the four mold sections **1**, **2**, **3** and **4** are arranged around a cavity **5** which is formed by the inner surfaces *1a*, *2a*, *3a* and *4a* of the mold sections. Each of the mold sections is suitably secured to a corresponding support member **6**, **7**, **8** and **9**, respectively. These support members **6**, **7**, **8** and **9** are provided with means contained therein for causing the individual mold sections to vibrate in orbital paths. The means can be of the same type as described in said patent or of any other type to provide the proper orbital movement described in the patent. Each of the support members is provided with a shaft **10** which can each be coupled to a drive motor **11**. As described in said patent, the motors can be of a synchronous type to insure proper synchronous movement of the mold sections in proper phased relationship.

It is essential that the mold sections 1, 2, 3 and 4 closely abut each other at their corners to prevent leakage of molten metal and to minimize the amount of incoming atmosphere. With previous devices, a miter joint was provided at the corners with the corner contacting surfaces between adjacent mold sections extending along a line bisecting the angle of the junction. With the four sectioned machine, such a mitered joint has an angle of junction of 45 degrees, although different angular relationships can be employed.

Regardless of which angular relationship is established, with the use of a miter type joint, paths of orbital movements of the mold sections must correspond accurately with each other and their phase relationships must be very accurate in order to even approximate a leakage free condition or a non-interference condition between the mold sections. By employing the corner inserts, as hereinafter described, the problem associated with the angular relationship between mold sections and the phasing of their orbital paths is eliminated.

As particularly shown in FIG. 1, there are four mold inserts 12, 13, 14 and 15 positioned in the corner regions between the mold sections 1, 2, 3 and 4. Each of the mold inserts 12, 13, 14 and 15 are of identical construction, just as each of the mold sections 1, 2, 3 and 4 are of identical construction, although neither the inserts nor the mold sections need be identical. Each mold section is secured to a carrier 16 through an intermediate connecting plate 17 which is coupled between a corner insert and the carrier 16 by means of screws 18. Each carrier 16 is provided with a rounded notch 19 along its rear surface which acts as a detent to engage the circular surface 20 of a roller 21. The roller 21 is pivoted on a shaft 22 journaled in an arm 23 which has its lower end journaled on a shaft 24 secured in an anchor member 25 suitably secured to the fixed frame 26 of the machine. The upper end of the arm 23 is journaled in a shaft 27 to the outer end 28 of a sleeve plunger 29 having an inner end 30 telescoping over the outer end 31 of a stem 32 which is journaled at its inner end 33 by means of a shaft 34 to another portion of the frame 26. The engaged stem 32 and the sleeve plunger 29 are encircled with a compression type coil spring 35 which reacts at its ends against flanges 36 and 37 on the sleeve plunger 29 and the stem 32, respectively. The stem 32 is threaded and provided with an adjustable nut 38 which provides for adjustment of compression of the spring 35.

In operation, the pressure of the spring 35 urges the arm 23 and its roller 21 toward the carrier 16 which in turn urges the corner insert it supports snugly into the corner regions between two adjacent mold sections. This is sufficient for purposes of retaining the corner inserts in place. When it is desired to remove a corner insert for examination, repair or replacement, it is only necessary to press the arm 23 in a direction away from the center of the mold cavity in order to release the contact between the roller 21 and the carrier 16. The corner insert is then free to be withdrawn from the machine with its carrier 16.

As particularly shown in FIGS. 1 and 3, two adjacent mold sections, as for example mold sections 2 and 3, have no actual contact with each other. Instead, they have side surfaces 2*b* and 3*b* which extend at right angles to each other as indicated by the angle A. As viewed from the top of the mold, as in FIGS. 1 and 3, each mold section, for example mold section 3, follows an orbital path consisting of two distinct portions of movement, the first portion of movement involving moving its inside surface 3*a* toward the longitudinal axis of the cavity 5 and forward toward the discharge end of the cavity to provide a driving force on the metal casting to propagate it through the cavity, and the second portion of movement involving moving the inside surface 3*a* in restriction away from

the longitudinal axis and in return movement toward the receiving end of the cavity 5. With prior devices having angular surfaces of contact between the mold sections at a corner, such angular relationship required, as mentioned, accurate orbital paths and accurate phasing of the movements. With the arrangement shown in FIGS. 1 and 3, the components of the movement of the mold section 3 toward and away from the longitudinal axis of the mold cavity are parallel to the line 39 extending perpendicular to line 40 forming the angle A. Because the side surface 3*b* of the mold section 3 is in alignment with the line 39, there is no in and out movement of an angular side surface which is or could be in interference with another angular surface on an adjacent mold section. Similarly, the side surface 2*b* of the mold section 2 follows an in and out path along the line 40 and it is evident that it likewise has no angular surface which can move in interference with any other angular surface.

Each of the corner inserts, corner insert 13 as an example, is provided with two leading surfaces 13*a* and 13*b* which also extend at right angles to each other and are urged against the side surfaces 2*b* and 3*b* of the mold sections, respectively. Because there is no tendency for movement of the mold sections to urge the corner insert 13 into any type of movement, as the mold sections 2 and 3 follow their original paths, there is only sliding contact between the side surfaces 2*b*, 13*a* and 3*b*, 13*b*. In addition, the end surface 13*c* of the corner insert 13 is broad which minimizes any tendency for a sharp corner to be formed on the casting which was possible with the prior machines without corner inserts.

Although the characteristics of only two mold sections 2 and 3 and one corner insert 13 have been described, the remaining corner inserts 12, 14 and 15 and mold sections 1 and 4 have identical characteristics.

From what has been described, it should be apparent that the mold sections can orbit through their paths with any phase relationship without causing binding of the machine due to interference of the mold sections with each other at their adjacent corner portions. Regardless of the phase relationship of the mold sections, they will still continue to follow paths corresponding to the lines 40 and 39. Therefore, it is possible to start operation of the mold sections prior to initiation of casting and adjust the motors or other drive mechanisms for the mold sections into the desirable phase relationship for proper operation of the machine while the machine is operating. In the ordinary use of the four section mold, as shown, mold sections 1 and 3 are operated 180 degrees out of phase with mold sections 2 and 4. In this way, alternate mold sections opposite each other move toward the cavity while the other two mold sections move away from the cavity.

By having the corner inserts 12, 13, 14 and 15 constantly urged into the corner regions, the corners are substantially leakproof and gas tight. Further, if bowing of the mold sections 1, 2, 3 or 4 occurs due to uneven thermal expansion of the inside surfaces 1*a*, 2*a*, 3*a* and 4*a* relative to the more remote regions of the mold sections, the bowing occurs in directions along corresponding lines 10 and 39, rather than laterally thereof. With such bowing, there is no tendency for a gap to form between the corner inserts and the mold sections. With the prior devices having the mitered joint type connections, bowing of the mold sections created gaps at the corners which emphasized the possiblity of leakage and gas influx.

Although it is possible to employ many materials for the composition of the corner inserts 12, 13, 14 and 15, a desirable material is graphite because it substantially retains its shape without distortion or bowing when heated. Further, it does not tend to stick to the casting passing through the mold to counteract the driving force of the mold sections. This is important because the corner inserts are stationary as the mold sections vibrate. In addition, it has a high melting temperature. Other suitable materials with like characteristics are certain copper alloys and stainless steels which can also be used in place of graphite.

Although the invention has been particularly shown and described for a mold having mold sections with orbital types of motion, the invention can also be applied to a mold in which the mold sections 1, 2, 3 and 4 are provided with a rectilinear motion rather than the orbital motion. For example, although the corner sections 12, 13, 14 and 15 remain stationary, it is possible to apply a well-known driving mechanism to the mold sections 1, 2, 3 and 4 to provide them with rectilinear motion toward and in retraction away from the longitudinal axis of the mold cavity without any component of motion parallel to the longitudinal axis. This type of mold does not have the full advantages of the orbital vibratory type, but it is a type which has been used.

In another type of mold, the cavity is the central portion of a mold sleeve which is a single section mold. Oftentimes, with this type, the sleeve is reciprocated in directions parallel to the longitudinal axis of the cavity. Although there has been no tendency to divide this single section mold into a plurality of sections, for the sake of easily obtaining special contours to the cross-section of the cavity so that different cross-sectional shapes can be readily cast, the single sectional mold can be divided into a plurality of mold sections, such as sections 1, 2, 3 and 4 and the corner inserts can also be used. The mold sections are then necessarily provided with suitable driving mechanism for causing their reciprocating motion in directions parallel to the longitudinal axis of the cavity.

In all three cases mentioned, whether orbital or rectilinear motion is provided, the corner sections 12, 13, 14 and 15 can remain stationary and provide adequate leakproof corners between the adjacent mold sections.

Although only a single embodiment of the invention has been shown and described, it should be apparent that the invention can be made in many different ways without departing from the true scope of the invention defined by the appending claims.

I claim:

1. Apparatus for continuous casting of metal of a type having a cavity extending longitudinally therethrough open at its ends and formed by the inside surfaces of a plurality of mold sections located around the cavity with said inside surfaces disposed substantially parallel to the longitudinal axis of the cavity, one of said open ends of said cavity being a receiving end through which molten metal can be introduced into said cavity and the other of said open ends of said cavity being a discharge end through which said metal can be progressively discharged from said cavity, vibrating means connected to vibrate said mold sections to cause a plurality of opposed surfaces of said inside surfaces of said sections to vibrate in closed loop paths, the first portion of movement involving moving each of said opposed inside surfaces of the sections toward said longitudinal axis of said cavity and forward toward the discharge end thereof to provide a driving force on the metal casting to propel it through the cavity, the second portion of movement involving moving each of said opposed inside surfaces in retraction away from said longitudinal axis and in return movement toward the receiving end of said cavity while said metal is in said cavity so that resistance to the forward movement of the metal by the inside surfaces of the sections is minimized, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed inside wall of the cavity, said corner sections being mounted substantially stationary relative to the mold sections.

2. Apparatus as defined by claim 1 characterized by, the corner sections having bias means urging them into tight engagement with the mold sections in the region of the cavity to provide and maintain substantially liquid tight engagement between the corner sections and the adjacent edges of the mold sections they contact during the vibratory movement of the mold sections.

3. Apparatus as defined by claim 1 characterized by, said corner sections being provided with bias means urging them into substantially liquid tight contact with the mold sections.

4. Apparatus as defined by claim 1 characterized by, said corner sections being provided with resilient bias means urging them into substantially liquid tight contact with the mold sections.

5. Apparatus for continuous casting of metal of a type having a cavity extending longitudinally therethrough open at its ends and formed by the inside surfaces of a plurality of mold sections located around the cavity with said inside surfaces disposed substantially parallel to the longitudinal axis of the cavity, one of said open ends of said cavity being a receiving end through which molten metal can be introduced into said cavity and the other of said open ends of said cavity being a discharge end through which said metal can be progressively discharged from said cavity, vibrating means connected to vibrate said mold sections to cause a plurality of opposed surfaces of said inside surfaces of said sections to vibrate in closed loop paths, the first portion of movement involving moving each of said opposed inside surfaces of the sections toward said longitudinal axis of said cavity and forward toward the discharge end thereof to provide a driving force on the metal casting to propel it through the cavity, the second portion of movement involving moving each of said opposed inside surfaces in retraction away from said longitudinal axis and in return movement toward the receiving end of said cavity while said metal is in said cavity so that resistance to the forward movement of the metal by the inside surfaces of the sections is minimized, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed inside wall of the cavity, the contacts between the corner sections and the adjacent edges of the mold sections they bridge being along abutting surfaces on the corner sections and the mold, the abutting surfaces between a mold section and its adjacent corner section extending in planes parallel to the direction of movement of the mold section toward and in retraction away from the longitudinal axis of the cavity of the mold.

6. Apparatus as defined by claim 5 further characterized by, said corner sections being mounted substantially stationary relative to the mold sections.

7. Apparatus for continuous casting of metal of a type having a cavity extending longitudinally therethrough open at its ends and formed by the inside surfaces of a plurality of mold sections located around the cavity with said inside surfaces disposed substantially parallel to the longitudinal axis of the cavity, one of said open ends of said cavity being a receiving end through which molten metal can be introduced into side cavity and the other of said open ends of said cavity being a discharge end through which said metal can be progressively discharged from said cavity, vibrating means connected to vibrate said mold sections to cause a plurality of opposed surfaces of said inside surfaces of said sections to vibrate in closed loop paths, the first portion of movement involving moving each of said opposed inside surfaces of the sections toward said longitudinal axis of said cavity and forward toward the discharge end thereof to provide a driving force on the metal casting to propel it through the cavity, the second portion of movement involving moving each of said opposed inside surfaces in retraction away from said longitudinal axis and in return movement toward the receiving end of said cavity while said metal is in said cavity so that resistance to the forward movement of the

metal by the inside surfaces of the sections is minimized, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed inside wall of the cavity, said corner sections being mounted substantially stationary relative to the mold sections and the bridging portions of the corner sections being made of graphite.

8. Apparatus for continuous casting of metal of a type having a plurality of mold sections arranged around a longitudinal axis with their inside surfaces forming a cavity into which molten metal can be poured for casting metal into the cross-sectional shape of the cavity, said mold sections being provided with means for vibrating them with motion tending to cause them to drive the casting metal through the cavity in the direction of said longitudinal axis, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed inside wall of the cavity, said corner sections being mounted substantially stationary with respect to the mold sections.

9. Apparatus for continuous casting of a metal of a type having a plurality of mold sections arranged around a longitudinal axis with their inside surfaces forming a cavity into which molten metal can be poured for casting metal into the cross-sectional shape of the cavity, said mold sections being provided with means for vibrating each mold section with a component of motion in a direction toward and in retraction away from said longitudinal axis of the mold, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed wall of the cavity, the contacts between the corner sections and the adjacent edges of the mold sections they bridge being along abutting surfaces on the corner sections and the mold, the abutting surfaces between a mold section and its adjacent corner section extending in planes parallel to the direction of motion of the mold section toward and in retraction away from the longitudinal axis of the cavity of the mold.

10. Apparatus for continuous casting of metal of a type having a plurality of mold sections arranged around a longitudinal axis with their inside surfaces forming a cavity into which molten metal can be poured for casting metal into the cross-sectional shape of the cavity, said mold sections being provided with means for vibrating each mold section with a component of motion in a direction toward and in retraction away from said longitudinal axis of the mold, corner sections mounted to contact and bridge between adjacent edges of the inside surfaces of the mold sections, the inside surfaces of the mold sections and the corner sections thereby collectively providing a substantially closed wall of the cavity, the mounting for each corner section being a latch and detent means engaged between the corner section and an arm pivotally secured to the frame of the apparatus, a resilient means reacting to maintain the latch and detent means releasably engaged and to urge the corner section into its contact with adjacent edges of the inside surfaces of the mold sections.

11. Apparatus for continuous casting of metal of a type having at least four mold sections arranged around a longitudinal axis with their inside surfaces forming a cavity into which molten metal can be poured for casting metal into the cross-sectional shape of the cavity, said mold sections being provided with means for vibrating each of the four mold sections with a component of motion in a direction toward and in retraction away from said longitudinal axis of the mold, a corresponding number as the number of mold sections of substantially stationary corner sections each mounted to contact and bridge between adjacent edges of the inside surfaces of two adjacent mold sections, the inside surfaces of all the mold sections and all the corner sections thereby collectively providing a substantially closed wall of the cavity.

12. Apparatus for continuous casting of metal of a type having a plurality of mold sections arranged around a longitudinal axis with their inside surfaces forming a cavity into which molten metal can be poured for casting metal into the cross-sectional shape of the cavity, said mold sections being provided with means for vibrating each of the mold sections with components of molten parallel to said longitudinal axis of the mold, a corresponding number as the number of mold sections of substantially stationary corner sections each mounted to contact and bridge between adjacent edges of the inside surfaces of two adjacent mold sections, the inside surfaces of all the mold sections and all the corner sections thereby collectively providing a substantially closed wall of the cavity.

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