Jan. 6, 1959 I. HARTER, JR., ET AL 2,867,018

CONTINUOUS CASTING MOLD

Filed July 19, 1955 3 Sheets-Sheet 1

FIG. 1

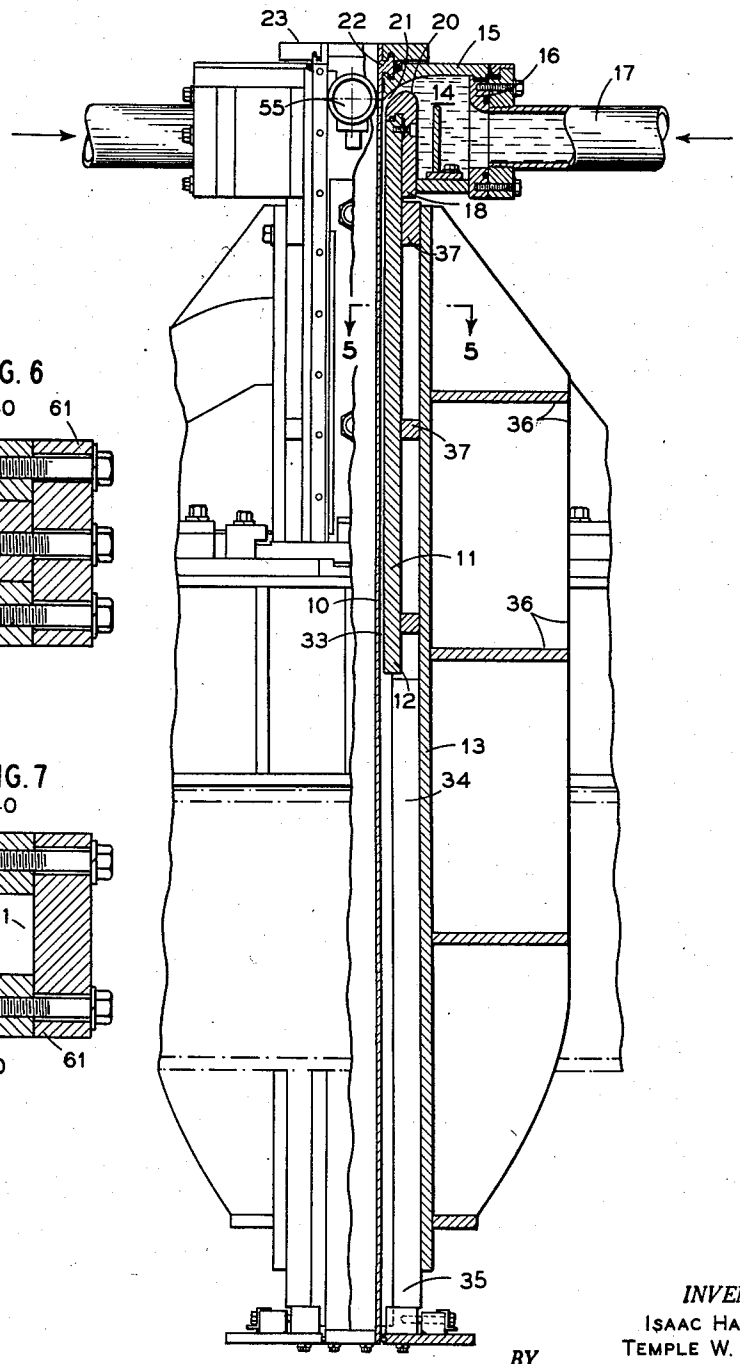


FIG. 6

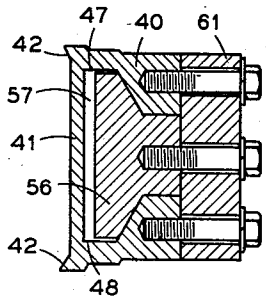
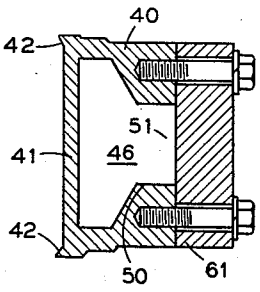


FIG. 7



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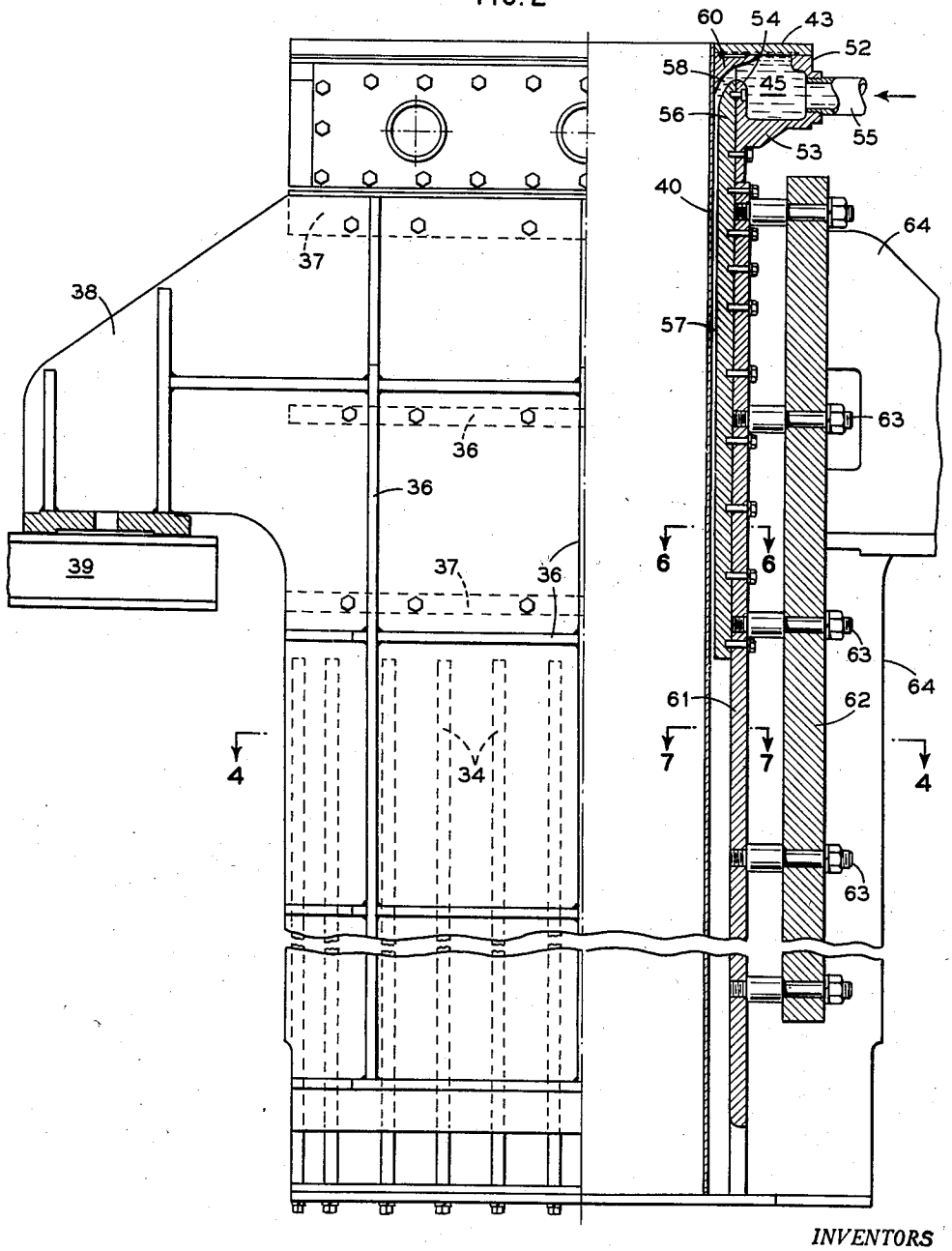
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CONTINUOUS CASTING MOLD

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FIG. 2



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CONTINUOUS CASTING MOLD

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FIG. 3

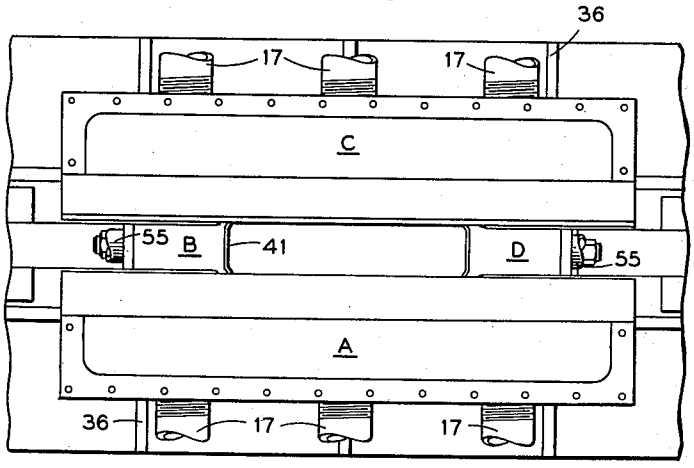


FIG. 4

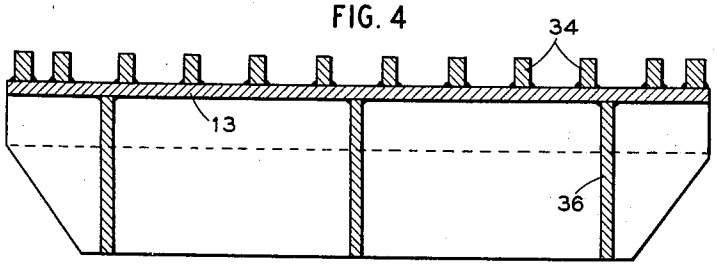
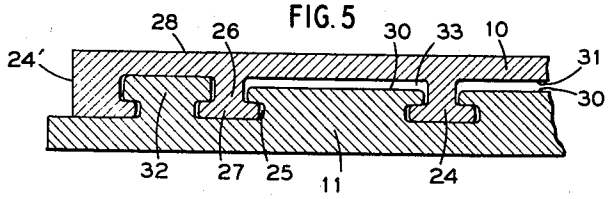


FIG. 5



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United States Patent Office

2,867,018

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CONTINUOUS CASTING MOLD

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Application July 19, 1955, Serial No. 522,914

10 Claims. (Cl. 22—57.2)

The present invention relates to the continuous casting of high melting temperature metals, and more particularly to a novel construction of a sectional continuous casting mold where the joint between the sections is vertical and the sections are separately supported to avoid distortion of the mold surfaces during the casting process.

In the continuous casting of metals, molten metal is delivered to one end of a mold, the molten metal is at least partially solidified in the mold to form a casting and the casting is withdrawn from the opposite end of the mold for further cooling and solidification. In a commercial unit of the type described large amounts of heat must be withdrawn from the molten metal so that a self-sustaining skin or shell of solidified metal may be formed on the ingot before withdrawal from the mold. When ferrous metals are cast in a continuous casting mold the entering metal temperature will be of the order of 2900° F., and when the mold is constructed as shown in U. S. Patent 2,590,311 the flow of high velocity cooling water along the exterior of the mold liner cools the mold wall so that the face of the mold in contact with the molten metal might be of a temperature of the order of 400° F. Under the same conditions, the temperature of the cooling water in contact with the exterior surface of the mold liner might be at a temperature of the order of 50° F. With these circumstances the differential thermal forces acting on the mold will tend to distort the mold walls and lead to difficulties in maintaining continuity of casting operations. Such distortion becomes aggravated with increases in the horizontal cross-sectional dimensions of the mold cavity.

Heretofore many expedients have been used to reinforce and rigidly support the mold liner so that it will not be distorted during the casting operation, as a result of the differential temperature conditions existing in the mold wall. All of the constructions known in the art disclose rigid means for supporting the mold liner wall. With increased dimensions encountered, for example, in the casting of a polygonal shape, the support of the mold liner surfaces heretofore in use is inadequate to compensate for the differential expansion of the mold wall, resulting in either mold wall failure or sufficient distortion of the mold to injure the casting and eventually interrupt the continuity of the casting operations.

In accordance with our present invention we provide a mold construction and arrangement which is effective in overcoming mold distortion in the casting of polygonal shapes. This is accomplished by providing a plurality of mold wall panels or liner sections which are assembled with longitudinally abutting edges to form the desired mold cavity and casting cross-sectional shape. The liner sections are each provided with rigid support means and separate cooling fluid flow passageways whereby movement of the casting confining mold wall is substantially avoided in a direction normal to the axis of the casting mold. However, the mold wall panels or liner sections of large dimensions are permitted to expand and contract in the plane of the liner or wall so that the mold wall in

contact with the metal being cast expands and contracts under the influence of thermal forces without distorting the casting surfaces.

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 a continuous casting mold constructed in accordance with the present invention;

Fig. 2 is an elevation, partly in section, of the mold shown in Fig. 1 as viewed from one end;

Fig. 3 is a plan view of the continuous casting mold shown in Figs. 1 and 2;

Fig. 4 is a section of a portion of the apparatus shown in Fig. 2, taken at the elevation 4—4;

Fig. 5 is an enlarged section taken on the line 5—5 of Fig. 1;

Fig. 6 is an enlarged section taken on the line 6—6 of Fig. 2; and

Fig. 7 is an enlarged section taken on the line 7—7 of Fig. 2.

In general the present invention provides a continuous casting mold which is constructed in a plurality of mold wall panels or liner sections where the sections are joined along abutting surfaces to form the confining walls of the mold. Each of the sections is constructed with individual provisions for cooling the section and each is provided with a separate support means to avoid distortion of the casting confining surface of the liner.

In the illustrated embodiment of the invention the continuous casting mold is shown with a generally rectangular horizontal cross-section for the production of slabs or castings of elongated cross-section. The mold is so constructed that the cross-sectional length or lateral dimension of the mold may be changed between convenient limits such as, for example 15 to 30". In a similar manner the transverse width of the mold may also be changed by substitution of replaceable end sections so that this dimension may be changed, for example, from 3 to 5". With certain limits the mold may be used with the usual accessory equipment, such as an ingot withdrawal mechanism, without major change in accessory equipment, but by mere adjustment thereof.

As shown in Fig. 3, the mold is formed from four sections; namely, A, B, C, and D, where the sections A and C contain the side walls of the mold and the sections B and D contain the end walls of the mold. The opposite longitudinal edges of the end wall sections B and D bear upon the facing surfaces of the side wall sections A and C. It is desirable to maintain the junctures between the wall sections tight so as to avoid leakage of molten metal therebetween even though the adjoining surfaces have sufficient cooling effect to prevent molten metal escape from within the mold cavity. Any fins of frozen metal formed between the edges of the mold sections jam and lead to surface defects on the cast ingot.

Referring to Fig. 1, it will be noted that the upright side wall or mold liner **10** for the section C is formed from a sheet of metal. In the embodiment shown the side wall has a length of 76" and a width of 36". With dimensions of this order it is essential that the mold liner should be rigidly supported to prevent either inward or outward movement of the mold wall toward or away from the casting within the mold while expansion and contraction due to temperature changes should be guided to prevent buckling or distortion of the mold wall.

The mold liner **10** is supported by a skirt or weir plate **11** which is also formed of brass and extends from a position downwardly adjacent the upper end of the mold liner **10** to a lower position **12** intermediate the length of the mold liner. As hereinafter described, the weir plate **11** is attached to the mold liner so that guided thermal movements of the liner can occur in transverse and longitudinal directions. The weir plate is reinforced and backed up by a reinforcing structure which includes a plate **13** formed of steel and extending substantially the full length of the mold liner **10**. The plate **13** is supported directly upon the structural steel work of the casting unit and is arranged for lateral adjustment, as desired, for selected width dimensions of the ingot to be cast.

A fluid inlet chamber **14** is formed at the upper end of the mold liner **10** for the introduction of a cooling fluid, such as water, and the discharge from the chamber into a cooling fluid passageway formed between the mold liner and the skirt. The inlet chamber is provided with a horizontally disposed top plate **15** which abuts the upper end of the mold liner **10** at the upper end thereof and is attached to an upright plate member **16** through which the cooling fluid inlet ducts **17** are connected. A plate **18** is attached to the upper end of the weir plate **11** and forms one side of the cooling fluid inlet chamber. The plate **18** is formed with a rounded upper end portion **20** which cooperates with a curved portion of the plate **15** to form a converging inlet **21** to the cooling water flow passageway formed between the weir plate **11** and the mold liner **10**.

The mold liner **10** is provided with an integrally formed horizontally disposed key **22** adjacent its upper end which fits into a keyway formed in the top plate **15** and a retainer plate **23**. The key and keyway combination described rigidly supports the mold liner against vertical movement and movement normal to the plane of the casting. However, sufficient clearance is provided between the key and keyway to permit movement of the mold liner in a horizontal direction in the plane of the mold liner as such movement may be occasioned by temperature changes.

The mold liner **10** below the horizontally disposed key **22** is provided with a spaced series of longitudinally extending keys **24** which are formed integrally with the liner and engage corresponding keyways formed in the weir plate **11**. The construction is shown in Fig. 5. The keys extend vertically, i. e. longitudinally of the mold liner **10**, and are constructed and arranged to allow vertical movement of the mold liner relative to the weir plate **11**, as such movement may be occasioned by differential temperature expansion therebetween, while at the same time movement of the mold liner **10** normal to the face of the liner is avoided. In the embodiment shown, the key **24** is shaped as a T in horizontal section, with the shank **26** projecting normal to and outwardly of the liner, and the head **27** arranged parallel to the liner surface or hot face **28** of the liner. The corresponding keyways **25** in the weir plate **11** are finished to a dimension so that both the recess accommodating the shank **26** and the slot accommodating the head **27** are elongated in a direction parallel to the face **28** of the liner. In the direction perpendicular to the face of the liner **10**, the slot width is gerater than the thickness of the ends of the head **27** for sliding clearance. The weir plate **11** is formed in one piece, and by means of the keys and keyways, its surface **30** is uniformly spaced from the cold face **31** of the liner **10** to define parallel cooling fluid flow passages **33**. One-half a key **24'** is formed at each of the opposite edge portions of the mold liner, and the portion **32** of the weir plate **11** between the key **24'** and the adjacent key **24** is finished to bear upon the surface **31** of the mold liner. The key and keyway assembly is such as to allow some longitudinal movement of the liner **10** with respect to the weir plate **11** and some horizontal movement in the plane of the hot face **28**, as such movement may be occasioned by thermal changes in the parts. However, movement in a direction normal to the face **28**, between the liner **10** and weir plate **11** is substantially avoided.

Below the lower end of the weir plate **11** the keys **24** of the mold liner **10** bear directly upon reinforcing webs **34** of the structural support plate **13** of the mold assembly. This construction increases the cross-sectional area of the cooling fluid flow passageways **33** with the mold liner and plate **13** cooperating to confine the flow of the cooling water to a bottom discharge opening **35** at the lower end of the mold assembly. The ribs **34** also provide a support for the lower end portion of the mold liner, permitting movement in both vertical and horizontal directions in the plane of the hot face **28** while substantially preventing movement in a direction outward with respect to the mold cavity.

The upright steel plate **13** is provided with reinforcing ribs **36** on the exterior side thereof. These ribs are shown in Figs. 1, 2, 3, and 4, and are welded to the plate **13** to form a rigid structural assembly. The plate **13** is bolted to the weir plate **11** with spacer bars **37** positioned between the plates **11** and **13** so that the proper positional relationship between the ribs **34** and the keys of the mold liner **10** in the lower portion of the assembly is maintained. As shown in Fig. 2, the side wall assembly of the mold is attached to the supporting frame work of the unit through bracket extensions **38** bearing on a surface **39** upon which it can be moved for size adjustment. The connection between the bracket **38** and the surface **39** may be of a rigid bolted type or means such as a slotted connection between the bracket **38** and surface **39** and may be provided for adjusting the position of the side walls through, for example, ratchet and gear means.

With the construction described the mold liner **10** is rigidly fixed at its upper end against vertical movement longitudinally of the axis of the mold. The upper end portion of the mold liner is likewise restrained against movement normal to the axis of the mold, but transverse movement of the mold liner, as occasioned by thermal expansion and contraction, can occur in a horizontal direction. Below the upper end of the mold liner **10** the liner is restrained against movement normal to the mold axis by the key and keyway construction described, with movement of the liner permitted longitudinally of the mold axis. The lower end of the mold is provided with a splash plate, below the opening **35**, which is constructed and arranged to engage the keys **24** of the liner so as to restrain inward or outward movement normal to the mold cavity longitudinal to the axis thereof. In effect the construction described provides a floating face for the mold wall or face **28** defining the marginal surface of the mold cavity. Thus the mold liner will not be distorted either by reason of temperature changes, by ferrostatic pressure imposed thereon from the molten metal within the mold, or by reason of the hydrostatic pressure imposed thereon by the flow of cooling water along the exterior surface of the mold liner.

The mold end sections B and D may be constructed in the same manner as that previously described for the side sections A and C, particularly when the face width dimension of the mold end sections is relatively short. The magnitude of thermal movement is dependent upon the dimensions of the part subject to thermal changes. When the cross-section dimensions of the mold cavity are such as to encounter appreciable horizontal movement in the plane of the mold wall from temperature changes, the end sections B and D are constructed in the same manner as the side sections A and C. Under these circumstances each of the sections A, B, C, and D is assembled with only one longitudinal edge abutting the face of an adjoining section while the opposite edge is free to move in a horizontal direction. When the width of a mold part

is of the order of 3 to 5", as in the embodiment of the invention illustrated, the movement of the mold liner in a horizontal direction parallel to the hot face thereof can be generally ignored.

As shown in Figs. 2, 3, 6, and 7, the end sections B and D are formed from an elongated mold liner or hollow member **40**, where the hot face **41** is provided with edge portions **42** tapering toward the side wall sections of the mold. The hollow member **40** extends the full longitudinal length of the mold and is supported at its upper end position by a heavy plate **43** which forms the upper boundary of a cooling fluid inlet chamber **45**. The hollow member **40** is shown in cross-section in Figs. 6 and 7 and is constructed to form an internal recess **46** the spaced side walls **47** and **48** of which are normal to the hot wall face **41** and extend away from the face for a short distance and converge toward a neck portion **50** having parallel sides with an opening **51** on the rearward side of the mold liner. The thickness of the elongated member **40** adjacent the hot face **41** is substantially equal to the thickness of the liner described for the side wall sections A and C of the mold.

The cooling fluid inlet chamber **45** includes an external upright wall **52**, a horizontally disposed floor section **53** and an upright inner wall **54** which terminates at its upper end at a position spaced from the top plate **43**. The outer wall, the bottom and inner wall of the inlet chamber are integral, with the assembly bolted to the top plate **43** to form the chamber **45**. A cooling fluid, such as water, is introduced to the chamber through a fluid inlet connection **55** which receives cooling fluid from an external manifold or the like. The chamber **45** is bolted to weir plate **56** which cooperates with the inlet chamber and the elongated hollow member **40** to define a cooling fluid flow passageway **57** longitudinally of the member **40**. The inner wall **54** of the cooling fluid inlet chamber is rounded to cooperate with a shaped end of the weir plate to form a fluid distributing opening **58** to the cooling fluid flow passageway **57** where the flow entrance is of the converging type to minimize pressure drop and will afford equal distribution of cooling fluid to the passageway **57**. The top plate **43** of the inlet chamber **45** is provided with an insert section **60** which is bolted thereto and likewise attached to the upper end of the member **40** to cooperate with the rounded end of the weir plate extension **56** to form the converging inlet **58**.

As shown in Figs. 2 and 6, the weir plate **56** is formed from an elongated bar having diverging edges matching the edges **47** and **48** within the elongated member **40**, and to define one wall of the fluid flow passageway **57**. This weir plate extends downwardly from the cooling fluid flow inlet **58** to a position intermediate the height of the member **40**.

The weir plate **61** is bolted to the weir plate **56** and the elongated member **40**, and rigidly connects the parts of the mold sections B and D. The weir plate **61** extends from a position upwardly adjacent the lower end of the elongated member **40**. Beneath the lower end of the weir plate **56** the elongated member is supported against horizontal movement by attachment to the weir plate **61**. This construction is shown in Fig. 7 where the cross-section flow area of the flow passageway is increased by the omission of the weir plate **56**.

As shown in Fig. 2 the plate **61** is securely and rigidly attached to a structural plate member **62** extending substantially the full length of the plate. The plate and the structural member are connected by means of stud bolts **63** with the structural support member **62** in turn mounted upon outwardly extending webs **64** which rest upon the structural steel work supporting the mold (not shown).

In assemblying the mold for the desired cross-section dimensions the opposite edges of the end wall sections B and D are coated with an initially plastic sealing material and the side wall sections A and C are forced

against the sealing material with excess material being forced out of the joints. The excess material is cleaned from the mold walls. A preferred form of sealing material consists of a mixture of graphite and cooked starch, where the material is dried in position by the application of heat or by the first metal cast. This general type of sealing material has proven satisfactory since it does not introduce moisture or hydrocarbons into the metal being cast, and retains a tight seal between the surfaces of the mold sections.

While in accordance with the provisions of the statutes we have illustrated and described herein a preferred embodiment 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 our 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. A substantially upright open ended fluid cooled mold comprising a plurality of separate plates defining the walls of said mold, the vertical edge of at least one plate abutting the face of an adjoining plate, and means for separately supporting each of said plates for operational thermal movement in the plane of the inner surface of each of said plates only and simultaneously defining separate cooling fluid flow passageways along the exterior surface of each of said plates.

2. A substantially upright open ended fluid cooled mold comprising horizontally spaced plates defining the side walls of a casting mold, plates defining the end walls of said casting mold, the opposite vertical edges of said end wall plates bearing upon the inner faces of said side walls to define a mold of selected horizontal cross-section, means for separately supporting each of said plates for operational thermal movement in the plane of the inner surface of each of said plates only and simultaneously defining separate cooling fluid flow passageways along the exterior surface of each of said plates, and means for changing the horizontal spacing between said end wall plates.

3. A substantially upright open ended fluid cooled mold comprising horizontally spaced plates defining the side walls of a casting mold, upright plates defining the end walls of said casting mold, the opposite vertical edges of said end wall plates bearing upon the inner faces of said spaced side walls to define a mold of selected horizontal cross-section, means for separately supporting and guiding each of said wall plates for operational thermal movement in the plane of the inner surface of each of said plates only and simultaneously defining cooling fluid flow passageways along the exterior surfaces of said plates including weir plates supporting each of said mold wall plates and forming a plurality of said fluid flow passageways, and means for changing the horizontal spacing between said wall plates.

4. A substantially upright open ended fluid cooled mold comprising spaced plates defining the side walls of a casting mold, plates defining the end walls of said casting mold, the opposite vertical edges of said end wall plates bearing upon the inner faces of said spaced side wall plates to define a mold of selected horizontal cross-section, means forming a plastic seal between said plates, said means including graphite and starch, and means for separately supporting each of said plates.

5. A substantially upright open ended fluid cooled mold comprising spaced upright plates defining the side walls of a casting mold, upright plates defining the end walls of said casting mold, the opposite vertical edges of said end wall plates bearing upon the inner faces of said spaced side walls to define a mold of elongated horizontal cross-section, and means for separately supporting each of said plates for operational thermal movement in the plane of the inner surface of each of said plates only

including a weir plate for each of said wall plates, horizontally spaced key and keyway connections between each of said wall plates and a companion weir plate, and a rigid structural support for each of said weir plates.

6. A fluid cooled mold comprising horizontally spaced substantially upright plates defining the walls of a casting mold, means for joining at least one of the edges of each of said wall plates with the inner faces of an adjoining wall plate to define a mold of selected horizontal cross-section, and means for separately supporting each of said plates for thermal movement only in the plane of the inner surface of each wall plate and simultaneously defining cooling fluid flow passageways along the exterior surfaces of said plates including a weir plate for each of said wall plates, horizontally spaced key and keyway connections between each of said wall plates and a companion weir plate, and a rigid structural support for each of said weir plates.

7. A fluid cooled mold comprising a plurality of substantially upright mold liners positioned in abutting relationship to define an open ended continuous casting mold, walls including a horizontally positioned plate member adjacent the upper end of each of said mold liners and defining a cooling fluid inlet chamber at the upper end portion of each of said mold liners, means for pendently supporting each of said mold liners from one of said plate members, a weir plate exteriorly spaced from each of said mold liners to form a cooling fluid flow passage between said liner and weir plate, the upper end portion of said weir plate projecting into said fluid inlet chamber to a position spaced from said horizontal plate member and cooperating therewith to define a converging entrance to said cooling fluid flow passage, the lower end of each of said weir plates terminating at a position intermediate the vertical length of said mold liner, and a support member rigidly positioning each of said weir plates and the lower end of each mold liner against movement in a direction normal to the plane of said weir plate.

8. A fluid cooled mold comprising plate members defining upright walls of a casting mold, said walls adapted to define a casting mold of polygonal horizontal section, a horizontally disposed key member formed integrally with and extending from the upper end portion of the exterior surface of each of said wall plates to engage a keyway formed in a structural support member whereby the upper end portion of said side plates are restrained against vertical movement and restrained against horizontal movement normal to the interior surface of said mold side wall, a plurality of horizontally spaced keys formed integral with and extending outwardly and vertically of the exterior surface of said wall plates, a weir plate having a plurality of keyways in one side thereof to engage the keys in said side wall plate, said keyways having a transverse dimension larger than the corresponding key for thermal movement therebetween in the plane of the plate, and means for rigidly supporting said weir plate in a fixed position.

9. A fluid cooled mold comprising plate members defining upright transversely spaced side walls of a casting mold, upright plates forming the end walls of said mold, the longitudinal edges of said end wall plates bearing upon the inner faces of said spaced side walls, said side and end walls defining a casting mold of polygonal horizontal section, a horizontally disposed key member formed integrally with and extending from the upper end portion of the exterior surface of each of said side wall plates to engage a keyway formed in a structural support member whereby the upper end portion of said side plates are restrained against vertical movement and restrained against horizontal movement normal to the interior surface of said mold side wall, a plurality of horizontally spaced keys formed integral with and extending outwardly and vertically of the exterior surface of said side wall plates, a weir plate having a plurality of keyways in one side thereof to engage the keys in said side wall plate, said keyways having a transverse dimension larger than the corresponding key for thermal movement therebetween in the plane of the plate, a weir plate secured to each of said end wall plates, and means for rigidly supporting said weir plates in a fixed position.

10. A fluid cooled mold comprising plate members defining upright transversely spaced side walls of a casting mold, upright plates forming the end walls of said mold, the longitudinal edges of said end wall plates bearing upon the inner faces of said spaced side walls, said side and end walls defining a casting mold of polygonal horizontal section, a horizontally disposed key member formed integrally with and extending from the upper end portion of the exterior surface of each of said side wall plates to engage a keyway formed in a structural support member whereby the upper end portion of said side plates are restrained against vertical movement and restrained against horizontal movement normal to the interior surface of said mold side wall, a plurality of horizontally spaced keys formed integral with and extending outwardly and vertically of the exterior surface of said side wall plates, a weir plate having a plurality of keyways in one side thereof to engage the keys in each of said side wall plates, said keyways having a transverse dimension larger than the corresponding key for thermal movement therebetween in the plane of the plate, said end wall plates constructed with a longitudinally extending recess therein having converging sides, a weir plate having diverging sides inserted in said recess, and means for rigidly supporting said weir plates in a fixed position.

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