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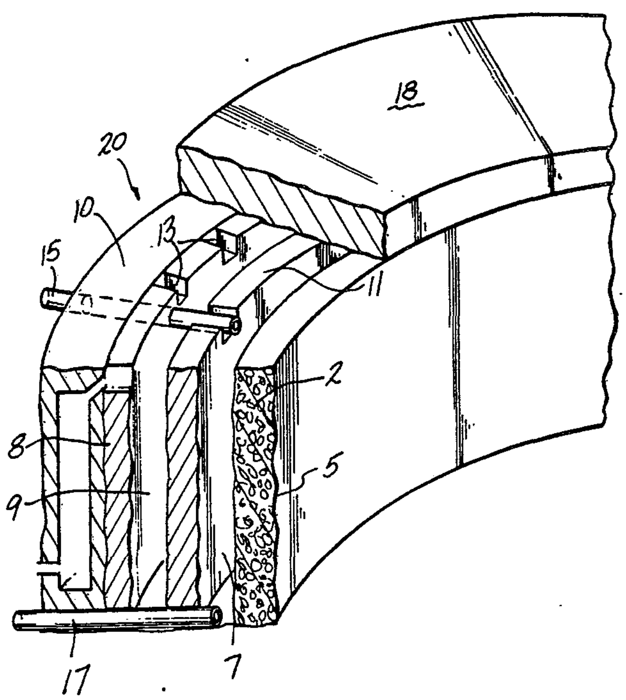
(54) **Improved continuous lubrication casting molds.**

(57) A method and apparatus for continuously casting molten metals and alloys is disclosed wherein a lubricating agent is supplied over substantially the whole of the mold surface 5 through an inner mold member 2 which extends the length of the mold and which is porous. Lubricant is fed to the porous member 2 via a lubricant plenum 7 surrounding the porous member. Coolant is fed to a coolant chamber 9 from a cooling jacket 10 to effect cooling of the lubricant by heat transfer through the dividing wall 11.



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IMPROVED CONTINUOUS LUBRICATION CASTING MOLDS

The invention relates to concepts and means for providing casting molds which permit effective heat transfer and effective lubrication over the total area of the casting mold.

Casting molds are used to shape molten metal and to extract heat from this metal to form a solid casting. These molds have two basic characteristics. The first is to extract heat to effect solidification, and the second is to provide a parting agent or lubricant to prevent adherence between the molten metal and the mold. The distribution of the parting agent or lubricant over the surface of the inner mold wall has a substantial effect on the surface quality of the solid casting, excessive amounts and concentrations of lubricant leading to pores in the surface of the casting and small amounts and concentrations of lubricant leading to a scaly casting surface.

In a continuous or semi-continuous casting the heat extraction is generally accomplished through the use of water cooling on the back side of the mold liner. The cooling water is generally applied over the complete mold surface, but can be circulated through channels machined in the body of the mold. The high thermal conductivity of the mold material provides for rapid extraction of heat from the whole internal area of the mold.

Lubrication in continuous or semi-continuous casting has been typically accomplished either by the use of mold washes or by other continuous means. The mold washes generally consist of oils or greases and contain parting agents such as graphite or other non-metallic particulate. They have a short life, and thus are generally used only in semi-continuous casting operations. The continuous lubrication means requires feeding lower viscosity oils to the molten metal meniscus. Accordingly, their effectiveness is restricted to this meniscus region. Such continuous systems have also been modified for use in hot top or closed mold casting where the lubricant is fed to the meniscus-mold region.

The above known lubrication techniques have obvious disadvantages in that they have limited life or provide lubrication only at the initial point of contact between the molten metal and the casting mold. It is well known that metal-mold contact also occurs in regions away from this initial point of contact. For instance, in the casting of long freezing range alloys the inverse segregation process provides for contact between the exuding segregate and the mold, towards the exit end of the casting mold. In such instances, which are numerous, the aforementioned lubrication techniques are clearly ineffective. Just as the heat extraction means afforded by the casting mold is generally accomplished over the full mold surface, there is also a need to provide lubrication over the total mold surface.

Various approaches have been taken in the prior art for attaining satisfactory lubrication of casting mold surfaces. One approach utilizes a supply of lubricant which is injected at the inlet end of the casting mold during the casting run. Variations of such an approach are depicted in French Patent No. 1,050,375, United States Patents 3,263,283, 4,057,100, 4,103,732, 4,157,728 and German Patent 742,771.

The French Patent '375 and the United States Patents '283, '100 and '728 generally utilize either a series of lubricant injector passages or slits to inject lubricant into the mold cavity at the inlet end thereof, while United States Patent '732 utilizes a lubricating ring which is rotably held in a recess around the upper or inlet edge of the casting mold. The ring in the '732 patent is provided with a plurality of radially inwardly directed lubricant distribution channels. During casting the ring is rotated causing lubricant to flow around the entire periphery of the inlet end of the casting mold.

German Patent 742,771 teaches supplying lubricant to an end portion of a casting mold. The lubricant is fed to the inner surface of the mold by passing it through a porous metal ring located at the end of the mold.

Another lubricating approach for continuous casting molds is depicted in United States Patent 2,825,947. This patent is primarily directed to providing a layer of a substantially liquid refractory having a high fluidity between the molten metal meniscus and the mold wall, but further discloses a ring of lubrication parts arranged at the approximate midpoint of the casting mold.

In yet another approach to providing mold surface lubrication, British Patent 1,176,139 discloses spraying the internal walls of a mold with a thin layer of metal particles welded together in a matrix. A series of lubricant passages is formed in the wall of the mold and supply lubricant to the particulate sprayed layer. The layer is penetrated through interstices between the layer particles forming a lubricant layer on the inner surface of the mold. Lubrication in this system, however, is intermittent due to carbonizing of the oil and consequent blockage of the interstices. Subsequent combustion of the carbon reopens the interstices.

In United States Patent 3,451,465 a lubricant passage is shown at the inlet end of a casting mold. Lubricant in the passage penetrates into the mold casting chamber by capillary action through a porous member located adjacent to the passage and the chamber.

Finally, United States Patent 4,044,817 teaches lubricating a casting mold by impregnating a liner with lubricant under a vacuum. The '817 patent is directed primarily to increasing the life of a graphite die or mold and notes that in some plainable manner lubrication of the cast metal interface is achieved. The graphite mold impregnation is carried out in a separate operation and is not carried out during continuous casting.

All of the aforementioned prior art patents suffer from at least two basic drawbacks. First, because the lubricant reservoir or source depends on severely limited numbers and/or geometric arrangements of lubricant supply passages, it becomes impossible to assure the desired supply along the entire length of the mold surface. Secondly, it would be highly desirable to be able to control the amount of lubricant supplied to selected portions along the length of the mold while still assuring sufficient lubrication along the entire mold length.

This invention discloses concepts and means for providing casting molds which provide improved and effective heat transfer and lubrication over the total area of the casting mold. The improved and effective heat transfer and lubrication is achieved by providing passages within or through the mold section through which lubricant can be introduced to the mold surface and by providing a lubricant source which runs along a substantial portion of the length of the mold.

One means for providing lubricant passages in accordance with this invention is to provide such passages as an intrinsic characteristic of the mold. This is readily achieved by fabricating the mold utilizing powder metallurgy techniques wherein the continuous open pore fraction present after sintering provides the routes for transmitting the lubricant to the casting face of the mold. This continuous open pore fraction is readily controlled within the powder metallurgy art by such means as control of powder particle size, distribution, compaction pressure, sintering cycle, etc. It furthermore can be supplemented by incorporation of particulate which is decomposable during the sintering cycle. Molds made by these techniques possess a characteristic permeability dependent upon the continuous open pore fraction and the mold thickness.

As an alternative, the lubricant passages may be provided in the form of discrete feed holes which may be machined into a mold after initial fabrication or which may be incorporated into the mold during fabrication, as for example by the use of wires and the like during the pressing operation when utilizing the powder metallurgy fabrication route.

In another aspect of this invention, the permeability or ability of the mold to transmit lubricant through to the internal surface of the mold is varied within the length of the casting mold. This provides for variable lubricant transfer rates to different parts of the casting surface enabling lubricant flow to be focused in those regions of molten metal-mold or ingot shell-mold contact.

The term permeability as used herein defines the ability of the mold to transmit lubricant through to the internal surface of the mold.

The invention will be further described with reference to the accompanying drawings which illustrate various embodiments of continuous casting molds according to this invention, like reference numerals being used to depict like parts.

In the drawings:

Figure 1 is a partial section in accordance with this invention, showing a porous mold wall and a peripherally continuous lubricant plenum.

Figure 2 is a view similar to Figure 1 of a mold in accordance with another embodiment of this invention, showing a porous mold wall having a plurality of distinct uniform cross-section lubricating passages therein, and further showing a substantially full height lubricant plenum having distinct lubricant supply channels along the length thereof.

Figure 3 is a view similar to Figure 1 of a mold in accordance with another embodiment of this invention, showing a porous mold wall having a plurality of distinct uniform cross-section lubricating passages of varying sizes therethrough.

Figure 4 is a view similar to Figures 1 to 3 of a mold in accordance with another embodiment of this invention, showing a porous mold wall having a non-uniform tapered cross-section.

Figure 5 is a view similar to Figures 1 to 4 of a mold in accordance with yet another embodiment of this invention, showing a porous mold wall having a non-uniform particle density or porosity along the length thereof.

Figure 6 is a sectional view in accordance with this invention, showing a porous mold wall and continuous lubricant plenum.

Figure 7 is a partial sectional view in accordance with this invention, showing a preferred embodiment of a porous mold wall and lubrication and coolant plenums.

Figure 8 is a partial sectional view of a horizontal casting apparatus employing a porous mold as in Figure 7.

Referring to Figure 1, there is shown therein a partial section of a mold in accordance with a first preferred embodiment of this invention. Casting mold 20 shown therein consists in part of a casting mold section 2 having a casting surface 5, a lubricant chamber or plenum 7, and a coolant chamber or plenum 9. Lubricant chamber or plenum 7 is formed by casting mold section 2 on one side and by lubricant chamber wall 11 on the other, and is supplied with lubricant via the lubricant supply conduit 15. Circulated lubricant is returned via return conduit 17. Coolant chamber or plenum 9 is formed on two sides by coolant wall 8 and chamber wall 11. Coolant jacket 10 is connected by plurality of coolant flow channels 13 formed in coolant wall 8 to coolant plenum 9, and supplies coolant via channels 13 to plenum 9. The entire mold wall structure is covered by the mold top plate 18.

As an alternative to providing circulation of lubricant in lubricant plenum 7, lubricant can be supplied to plenum 7 via a supply means such as supply conduit 15, but thereafter the lubricant can be retained at a desired pressure rather than being circulated. In such a case return conduit 17 is maintained closed or is not provided.

As can be seen from Figure 1, lubricant may be provided to the permeable casting mold 2 via lubricant chamber or plenum 7 which covers the total outer surface of casting mold section 2. This lubricant chamber or plenum 7 is backed by the second chamber or plenum 9 which contains the coolant, typically water. The wall between these two chambers, in this case lubricant chamber wall 11, should be solid sections of a high conductivity metal such as copper or aluminum.

In the embodiment of Figure 1 the water or other coolant used provides a means for extracting heat and solidifying an ingot shell. This water can thereafter be deflected onto the emerging ingot and be used to complete the solidification process. One of the primary benefits of the mold arrangement in accordance with this invention is that unlike other known prior art casting molds the lubricant in casting mold 20 assists in this heat transfer process along substantially the entire length of the casting mold which effects solidification of the ingot shell by filling the gap formed by shrinkage between the mold and the forming ingot with lubricant.

Another significant benefit of the casting mold 20 in accordance with the present invention is the ability of the lubricant supply system of mold 20 to supply lubricant to substantially the entire casting surface 5 quickly, continuously and efficiently, and in amounts and locations desired, as a partial result of utilizing a lubricant chamber or plenum 7 running continuously around the periphery of and substantially along the entire length of porous casting mold section 2.

It is also envisaged that the intrinsic permeability of the casting mold section 2 can be supplemented by provision of discrete parallel-sided or cylindrical feed holes 12, as depicted in Figure 2. Such holes can be machined into the mold before or after the sintering operation, or can be incorporated during the pressing operation by use of wires, fibers or other suitable media. Use of wires which are non-compressable provide for retention of good geometrical control of these passages during the pressing operation; such wires would be withdrawn from the "green" body prior to sintering. Alternatively, use of organic fibers which are decomposable during sintering may facilitate fabrication. The lubrication passages formed by these techniques may be geometrically arranged at will to supply lubricant to those regions of the mold wall where contact with the molten metal or solidifying ingot shell is found to be most troublesome.

In the case of the Figure 2 embodiment of the present invention, lubricant plenum 7 has been provided with a series of peripheral vertical ribs 16 which form a series of vertical channels 14. Lubricant plenum 7 in this embodiment is provided with a main header 19 which runs around the mold periphery. Lubricant is supplied to main header 19 and is then fed to the vertical channels 14 which run down the length of the casting mold 20 and casting mold section 2. While this lubricant plenum design can be utilized to feed lubricant to a porous casting mold section 2, as shown in Figure 1, it is particularly suitable where lubricant is to be fed to the casting mold section surface via discrete holes, in which case the vertical feed channels would provide lubricant directly into the pattern of discrete holes.

The concept of utilizing a channelled lubricant plenum wherein the channels run substantially the entire length of the casting mold section provides the same cooling benefit as discussed hereinabove with respect to the continuous lubricant plenum depicted in Figure 1. It should also be emphasized that such a channelled lubricant plenum is equally applicable when using any porous mold absent feed holes 12, inasmuch as the intrinsic permeability of the mold serves to disperse the lubricant as it flows through the mold. In other words, greater coverage is achieved on the inner mold surface even though the lubricant emanates from a narrow feed channel. Thus, the feed channels must be spaced so as to provide lubrication over the full inner mold surface. As described above, this lubrication mode with discrete feed channels rather than a full plenum can also be backed by a water cooling plenum.

Another embodiment for controlling the amount of lubricant directed to selected areas of inner mold casting surface 5 is depicted in Figure 3. The feed holes 12' are shown therein to be of varying cross-sectional dimension in traveling the length of the casting mold section 2, i.e., the feed holes 12' are largest at the top portion of mold section 2, and get progressively smaller in traveling down toward the bottom of mold section 2. It should be apparent that the number, geometrical placing, density, and cross-sectional dimensions of feed holes 12' can be arranged as desired to provide added supply of lubricant to critical areas of casting surface 5 of mold section 2. Figure 3 depicts an embodiment where larger amounts of lubrication are supplied to the upper area of casting mold 20 to overcome the effect of the vaporizing of lubricant as a result of contact with the hot molten metal as it is initially brought into contact with casting surface 5.

As stated hereinabove, molds manufactured via the powder metallurgy route possess a continuous open pore fraction that provides the routes for transmitting the lubricant to the casting face of the mold. Molds made by this process possess a characteristic permeability dependent upon the continuous open pore fraction and the mold thickness. It is this permeability which significantly determines the rate lubricant can be transferred through to the internal surface of the mold.

Figure 4 depicts a preferred embodiment of this invention wherein the rate lubricant can be transferred through to the internal surface of mold section 2" is varied by varying the thickness of casting mold section 2" along the length thereof, the rate being lower as it gets thicker, or in the case of Figure 4, in traveling down the length of the casting mold 20.

Figure 5 shows yet another preferred embodiment in accordance with this invention for varying the continuous open pore fraction and thus the permeability of casting mold section 2''' along substantially the entire length thereof. As can be seen from Figure 5, the casting mold section 2''' has an open pore fraction which decreases in travleing downwardly along the length of casting mold 20. The permeability of casting mold section 2''' thus diminishes in traveling in this direction along casting surface 5 of casting mold section 2'''. As discussed hereinabove, the continuous open pore fraction is readily controlled within the powder metallurgy art by such means as powder particle size, distribution, compaction pressure, sintering cycle, etc. It furthermore can be supplemented by incorporation of particular which is decomposable during the sintering cycle.

Accordingly, within the teachings of this invention it is clear that the permeability can be changed within the length of the casting mold to provide for variable lubricant transfer rates to different parts of the casting surface. By this means, lubricant flow can be focused in those regions of molten metal-mold or ingot shell-mold contact or other regions as desired.

Referring now to Figure 6 there is shown by way of example a casting mold in accordance with the present invention for continuously or semi-continuously casting molten materials such as metals or alloys.

Where possible the same reference numerals as described above have been employed for corresponding elements of the apparatus. The apparatus is shown in operation except that the means for pouring the metal into the casting mold and the means for withdrawing the solidified casting are not shown. The casting mold section 2 as shown can be constructed in the manner as described in reference to the prior embodiments. Surrounding the casting mold section 2 are a lubricant chamber or plenum 7 and a coolant chamber or plenum 9. Lubricant is supplied to the lubricant plenum 7 via supply conduit 15 and surrounding pressure equalization chamber 21 which is connected to the lubricant plenum 7 by means of a slot or slots 22. The lubricant travels downwardly in the lubricant plenum 7 and exits therefrom via slot or slots 23 and return conduit 17. The slots 22 and 23 are formed in the lubricant chamber wall 11. In this manner, lubricant is substantially uniformly distributed over substantially the entire length of the inner surface S of the casting mold section 2 to provide a substantially uniform flow through the porous mold section 2 emerging at casting surface 5. If desired, however, as in accordance with the previous embodiments a nonuniform flow of lubricant can be provided. For example, the lubricant flow at the upper portion of the casting mold section 2 can be made larger than the lubricant flow at the lower portion of the casting mold section 2 as shown in Figure 4.

Coolant such as water flows into the coolant jacket or pressure equalization chamber 10 via one or more fluid input conduits 24. The coolant then flows through coolant flow channels or slots 13 into the coolant plenum 9. From the plenum 9 the coolant is discharged through discharge slot 25 onto the emerging surface of the solidifying casting 27.

Cooling to solidify a shell of the molten material 28 within the mold is provided primarily by the lubricant and secondarily by the discharging coolant.

It is preferred in accordance with this embodiment that the lubricant be circulated through the lubricant plenum 7 and that at a remote location the lubricant is circulated through a heat exchanger to cool it so that it will provide appropriate cooling at the mold interface. Therefore, in accordance with this embodiment, the lubricant provides the primary coolant system for the solidifying casting and the discharging water from slot 25 provides a secondary cooling system to complete the solidification process.

It is within the contemplation of this embodiment of the invention to provide ribs 16 as in the embodiments of Figures 2 and 3 to not only direct lubricant to discharge holes which may be provided in the casting mold section but also to provide improved cooling by making direct connection between the porous mold section 2 and the water coolant plenum 9. These ribs then serve not only to distribute lubricant in the lubricant plenum 7 but also to provide improved heat transfer between the water cooled plenum 9 and the mold surface 5. However, it is not believed essential to employ the ribs in accordance with the present invention and therefore they need be used only in those cases where the added cooling or other function they can provide is required. It is apparent that feed holes 12 or 12' of varying cross section could also be employed in the mold of Figure 6. Further, the casting mold section 2 can include a varying thickness as described in reference to Figure 5 or a varying open pore fraction as described in reference to Figure 5.

Referring now to Figures 7 and 8, a still more preferred embodiment of the present invention will be described. In accordance with this embodiment, the mold can be employed for either vertical or horizontal casting in a semi-continuous or continuous manner. The vertical casting mode is shown in Figure 7 while a horizontal casting arrangement is shown in Figure 9. The mold of this invention since it provides a uniform and substantially continuous film of lubricant over the entire casting surface 5 is believed to allow more rapid casting in either the vertical or horizontal sense.

Referring now to Figures 7 and 8, the casting mold section 2 is essentially as described by reference to the previous embodiments particularly Figure 6. It has a substantially uniform wall thickness from the top of the mold top plate 30 to the bottom of the lubricant plenum 31. The wall thickness then tapers down over the length of the water or coolant application plenum 32.

It is recognized as previously described herein that there will be a certain amount of bleeding of lubricant from the lubricant plenum 31 to a portion of the casting surface 5 higher than the height of the lubricant plenum 31 and lower than the height of the lubricant plenum 31. The lubricant plenum 31 surrounds the casting mold section 33 as in the previous embodiments. Lubricant supply conduit is connected to lubricant plenum 31 via pressure equalization chamber 35 and slot or slots 36. Similarly, the lubricant plenum 31 is connected to the return conduit 37 via pressure equalization chamber 38 and slot or slots 39. In this manner a substantially uniform flow of lubricant is provided in the lubricant plenum.

The lubricant which has passed through the lubricant plenum 31 pressure equalization chamber 38 is carried by return conduit 37 to a pump 40 which pumps the lubricant into heat exchanger 41 whose purpose is to reduce the temperature of the lubricant to a temperature which will be effective for heat transfer in the mold. The lubricant is then pumped from the heat exchanger 41 by the pump 40 through the input conduit 34 back into the lubricant application system. Obviously, additional lubricant is added to the circulating flow as required from supply 42 to make up for the lubricant lost during the casting operation which flows out through the porous mold section 2.

Below the surrounding lubricant application system is a surrounding coolant application system 43. The coolant application system 43 comprises supply conduit or conduits 44 which provide a flow of coolant under pressure into pressure equalization chamber 45 through slot or slots 46 into the coolant plenum 47 and then through slot or slots 48 discharging against the solidifying casting surface via discharge slot 49. The discharge slot is formed on one side by the wall 50 and on the other side by an impervious layer 51 over the inner surface of the casting mold section 33 which tapers down in thickness over the length of the coolant application system 43. This impervious layer 51 can be a solid metal layer, a densely compacted layer or other material as desired. It is intended to prevent the coolant from passing through the porous mold surface so that lubricant from the plenum 31 can pass even to the downstream tip of the porous mold section 33. The casting is withdrawn from the mold by means of a conventional ram 52 and bottom block 53.

In Figure 7 the supply system for the molten material 28 is not shown. However, any desired system as are well-known in the art could be employed. In this mold embodiment the lubricant application system 31 and the coolant application system 43 both surround the casting mold section. However, the lubricant application system 31 surrounds a first portion of the casting mold section 2 length and the coolant application system 43 surrounds a different and downstream portion of the casting mold section 2. Therefore, primary cooling is provided by the lubricant and secondary cooling is provided by the coolant.

If desired, as in accordance with any of the previous embodiments it is possible with the embodiments of Figures 7 and 8 to employ feed holes 12 or 12' of varying cross section. Vertical ribs 16 between the plenum wall 54 and the inner casting mold section surface 55 would also be of value if desired for increasing the heat transfer by taking advantage of the heat transfer from the coolant manifold as connected via the wall 54 and walls 56 and 57 which separate the lubricant and coolant application systems. However, it is not believed that such ribs are essential in the embodiment of Figures 7 or 8. Further, varying the thickness of the casting mold section 2 or the varying the open pore fraction as in Figures 4 and 5 could also be employed in the embodiments of Figures 8 and.9.

Referring now to Figure 6, the mold is in every sense the same as described by reference to Figure 7 except it is oriented so that the casting is withdrawn horizontally. In Figure 8 the molten material supply system is shown. It comprises a partially shown furnace 60, trough 61, molten metal flow control system or valve 62 which controls the flow of molten material from the trough 61 through the downspout 63 into the tundish 64. The control system 62 controls the height of the molten material in the tundish 64 in order to control the flow rate of molten material into the mold. The molten material exits from the tundish horizontally via conduit 65 which is in direct communication with the entrance to the casting mold. The solidifying casting 27 is withdrawn by withdrawal mechanism 66. The withdrawal mechanism provides the drive to the casting 27 for withdrawing it from the mold section. Any desired withdrawal system 66 as are known in the art could be employed.

This embodiment is adapted for casting horizontally a variety of shapes including cylindrical, rectangular, strip and others as desired.

It has been found that lubricant flow rates through the permeable casting mold section are desirably in the range of about .1 to 10 $cc/in^2/min$, (0.016 to 0.16 $cc/cm^2/min$) with a preferred rate in the range of about .5 to 5 $cc/in^2/min$ (0.08 to 0.8 $cc/cm^2/min$).

While the permeability is substantially dependent upon the viscosity and temperature of the lubricant selected, where the lubricant is substantially continuously circulated through the lubricant plenum a pressure drop across the mold section from the lubricant plenum side to the casting side thereof in the range of about .01 to 5 psi (0.07 to 35 kN/m^2) is normally desirable, with a preferred pressure drop being in the range of about .1 to 1psi (0.7 to 7 kN/m^2). In the embodiment where the lubricant is not circulated through the plenum, it is desirable to maintain lubricant in the plenum at a pressure in the range of about 1 to 100 psi (7 to 700 kN/m^2), and preferably in the range of about 5 to 50 psi (3.5 to 350 kN/m^2).

It is envisaged that this invention can be used for casting all metals and alloys. Selection of the mold material, mold permeability, lubricant, etc., will be dependent upon the particular alloy or metal being cast. Accordingly, the mold material may be selected from copper, aluminum, or other metals and alloys, graphite, boron nitride or other thermally conductive materials. The lubricant may be selected from castor oil, rapeseed oil, other vegetable or animal oils, esters, paraffins, other synthetic liquids, and any other suitable lubricants typically utilized in the casting arts.

It should be a substantial advantage of the molds in accordance with this invention employing a porous casting mold section that they will be less susceptible in the casting of materials such as copper alloys to the deposition of zinc from zinc vapors on the mold wall itself. This should extend the life of the mold to a very large degree. Similar types of benefits may be provided when the mold is used with other metals or alloys.

Claims

1. Apparatus for the continuous or semi-continuous casting of metals comprising a mold to which the molten metal to be cast can be fed in a continuous or semi-continuous manner and from which a solidified ingot can be continuously or semi-continuously withdrawn, and means for supplying a lubricant to the mold surface during the casting of the metal, characterised in that the mold comprises an inner porous member 2 extending substantially the whole length of the mold and providing over substantially the whole length of the mold a porous lubricant-receiving mold surface 5, and means for supplying lubricant to said surface over substantially the whole length thereof, said lubricant supplying means comprising a lubricant chamber 7 extending substantially the whole length of said porous member 2 and defined on one side thereby, and means 15 for supplying lubricant to said chamber.

2. Apparatus according to claim 1, characterised in that means 15, 17 are provided for continuously circulating lubricant into and out of said chamber.

3. Apparatus according to claim 1 or 2, including means for cooling the lubricant.

4. Apparatus according to claim 3, characterised in that said means for cooling the lubricant comprises a coolant chamber 9 separated from the lubricant chamber 7 by a thermally conductive wall 11 and means 10, 13 for supplying coolant to said coolant chamber 9.

5. Apparatus according to claim 4, wherein said coolant chamber 9 extends substantially the whole length of the lubricant chamber 7.

6. Apparatus according to any one of the preceding claims, characterised in that said porous member 2 comprises an upstream section extending over the major part of its length and whose outer (relative to the axis of the mold) surface defines on one side said lubricant chamber 7 and a downstream section extending over a minor part of its length and projecting axially beyond said lubricant chamber 7, the said downstream section having an impervious outer surface 51, and means 43 being provided to direct coolant against said impervious outer surface thereby to cool said downstream section of the porous member.

7. Apparatus according to claim 6, characterised in that said coolant directing means 43 comprise a coolant chamber 47 surrounding said downstream section of the porous member 2, means 44 for supplying coolant to said chamber and means 48 for feeding coolant from said chamber over said impervious surface 51 and directing said coolant through nozzles 49 onto the surface of the ingot as it emerges from the mold.

8. Apparatus according to any one of the preceding claims, characterised in that the permeability of said porous member varies along the length thereof.

9. Apparatus according to claim 8, characterised in that the porosity of said porous member varies along the length thereof.

10. Apparatus according to claim 8, characterised in that the porosity of the porous member is constant and its thickness varies along its length.

11. A method for the continuous casting of metals which comprises supplying molten metal to be cast to a continuous casting mold, supplying a lubricant to said mold to lubricate the mold surface, and withdrawing the cast metal from the mold, characterised

in that the lubricant is supplied to the casting surface by means of a porous member defining on one side said casting surface and on the other a lubricant chamber and supplying lubricant to said chamber whereby the lubricant permeates through said porous member over substantially the whole length of the casting surface.

12. A method according to claim 11, characterised in that the lubricant is cooled in or before feeding to said chamber thereby to effect cooling of the porous member.

13. A method according to claim 12, characterised in that the lubricant is cooled _in situ_ in said chamber by indirect heat exchange with a coolant supplied to a cooling chamber adjacent said lubricant chamber and separated therefrom by a thermally conductive wall member.

14. A method according to claim 11, characterised in that the lubricant is circulated into and out of said lubricant chamber and externally cooled before recirculation to said chamber.

15. A method according to any one of claims 11-14, characterised in that said lubricant is applied to the outer surface of the porous member over a major upstream part of its length when considered in the casting direction, and in that a coolant is applied to the outer surface of the porous member over a minor downstream part of its length, said downstream part being provided with an impervious outer surface to prevent said coolant from permeating into the porous member.

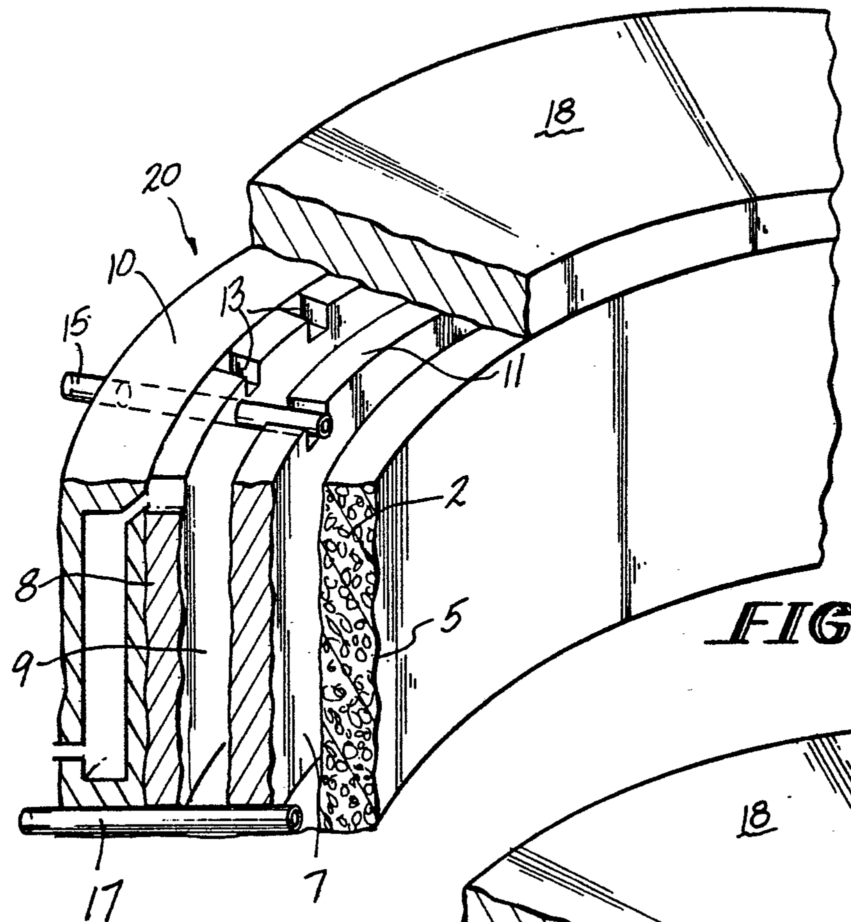

FIG-1

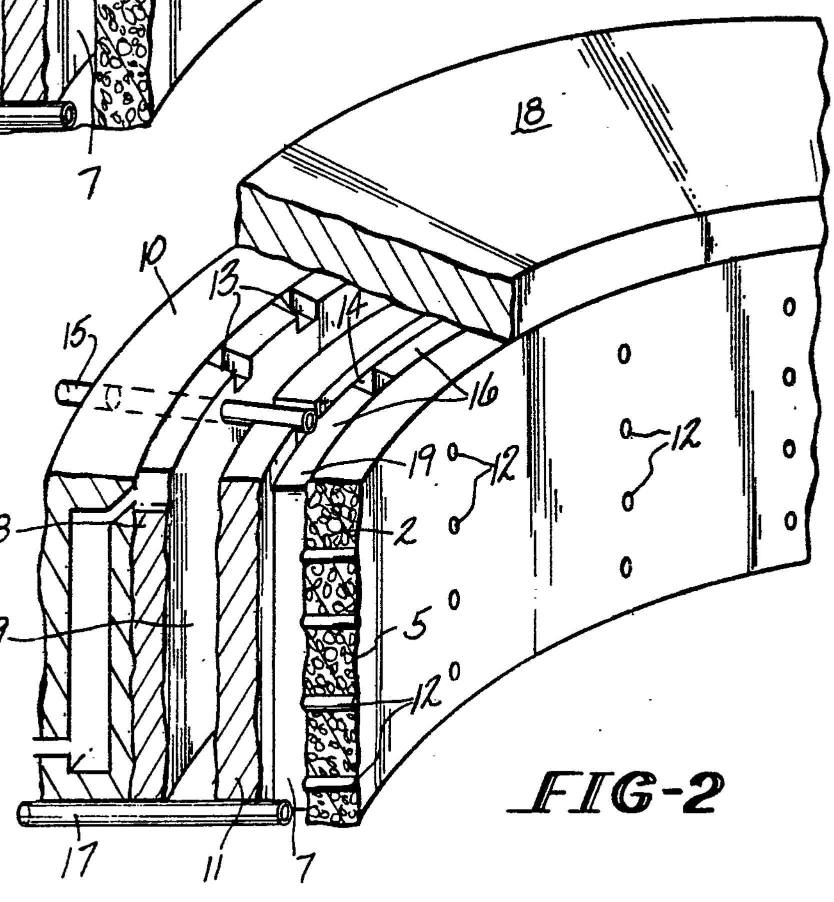

FIG-2

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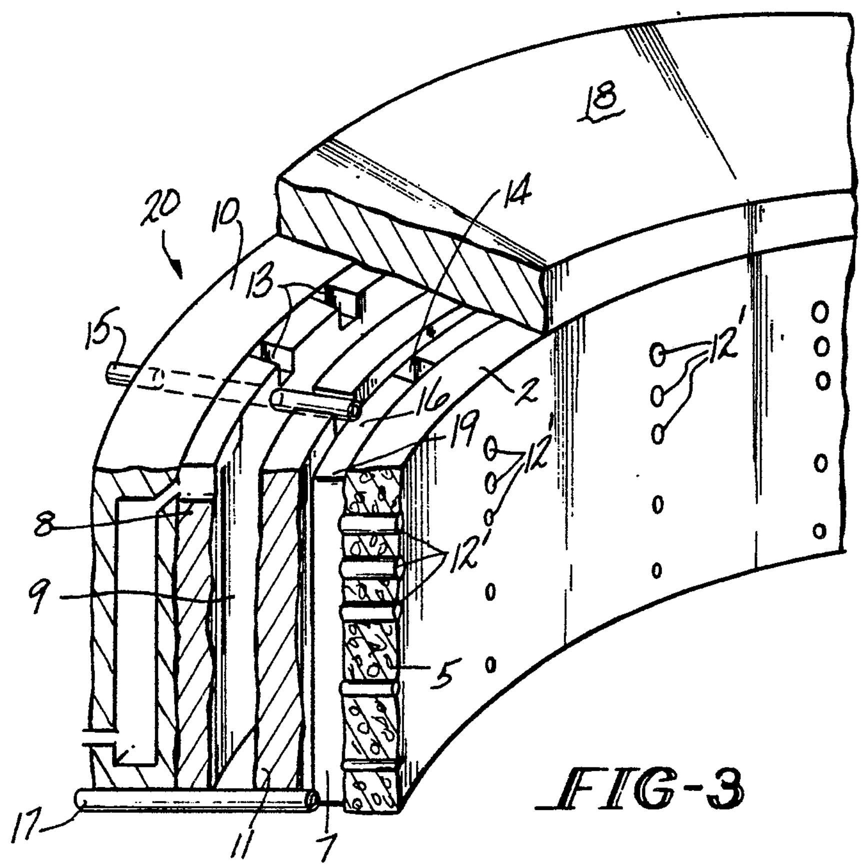

FIG-3

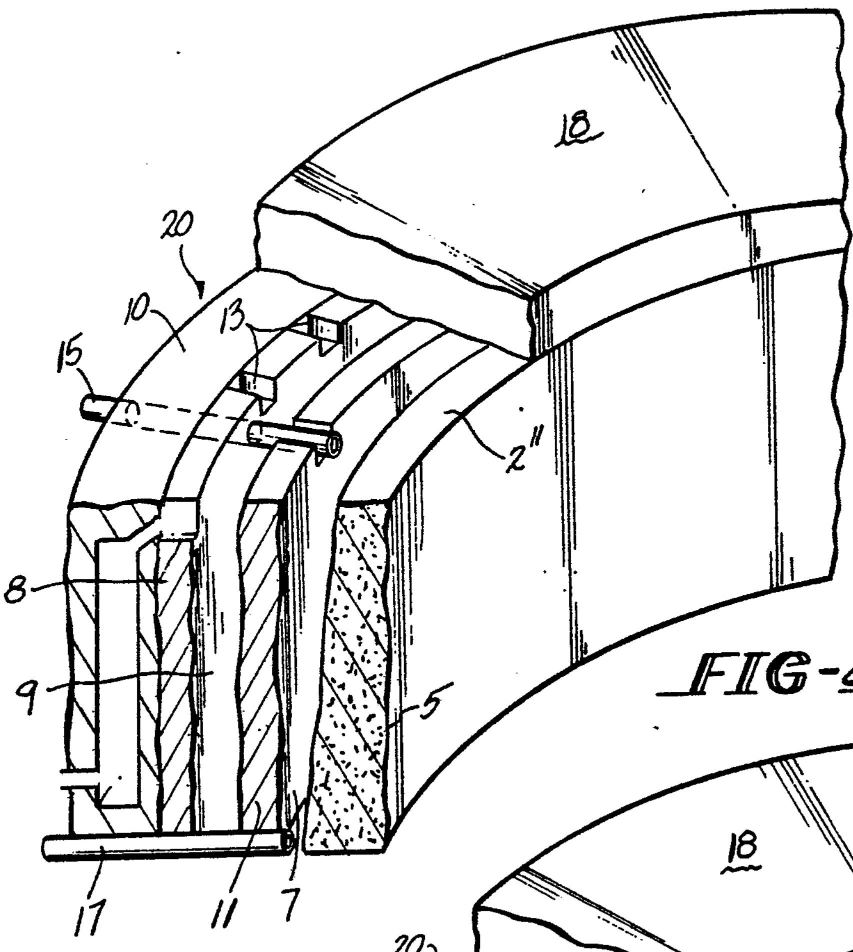

FIG-4

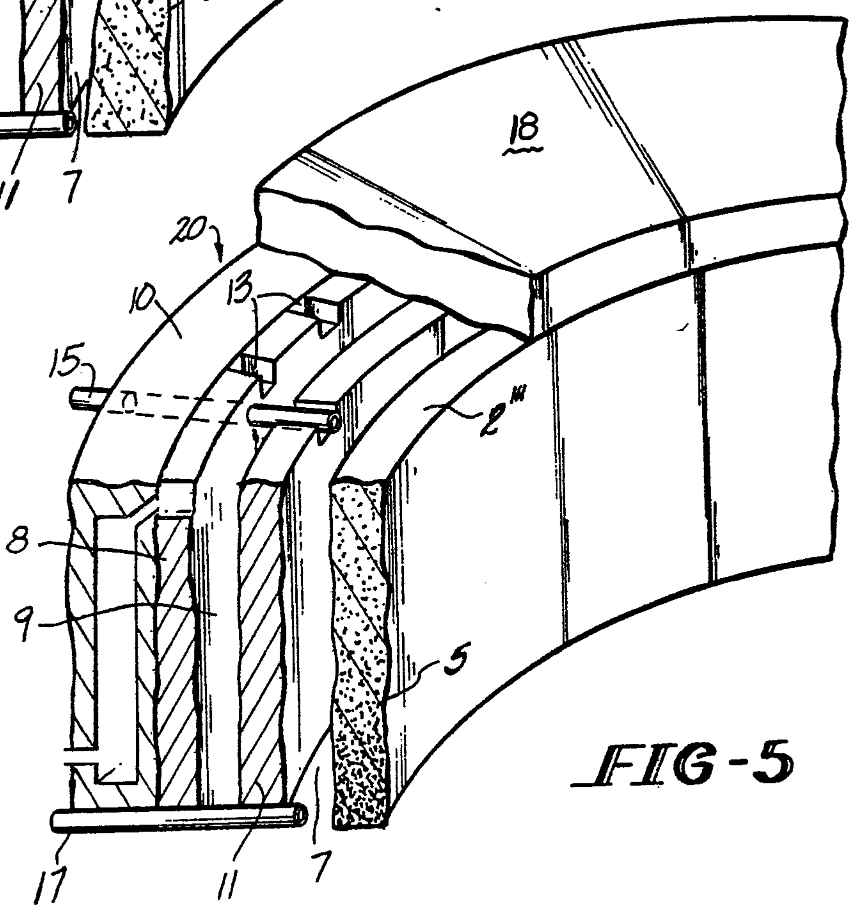

FIG-5

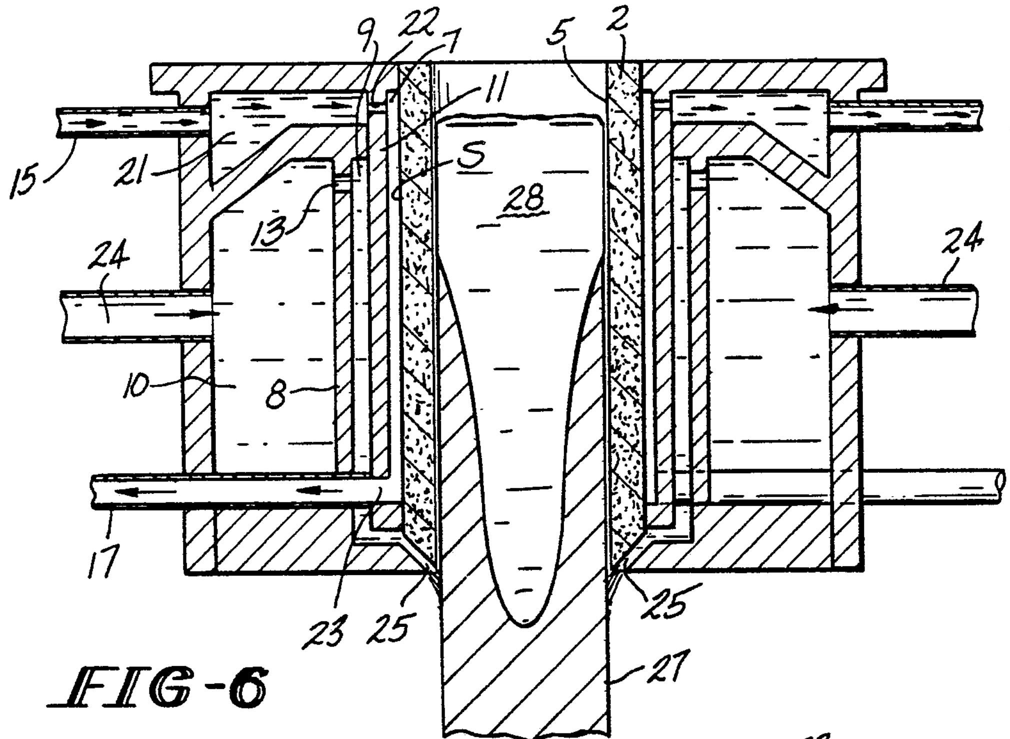

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FIG-6

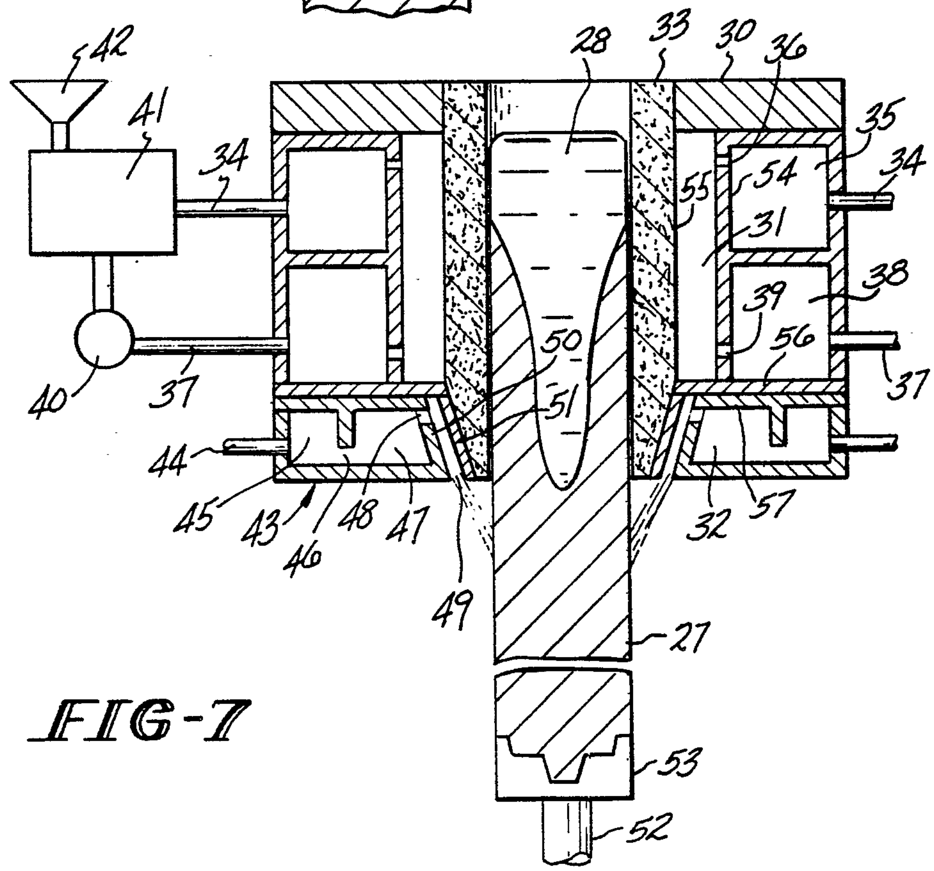

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FIG-7

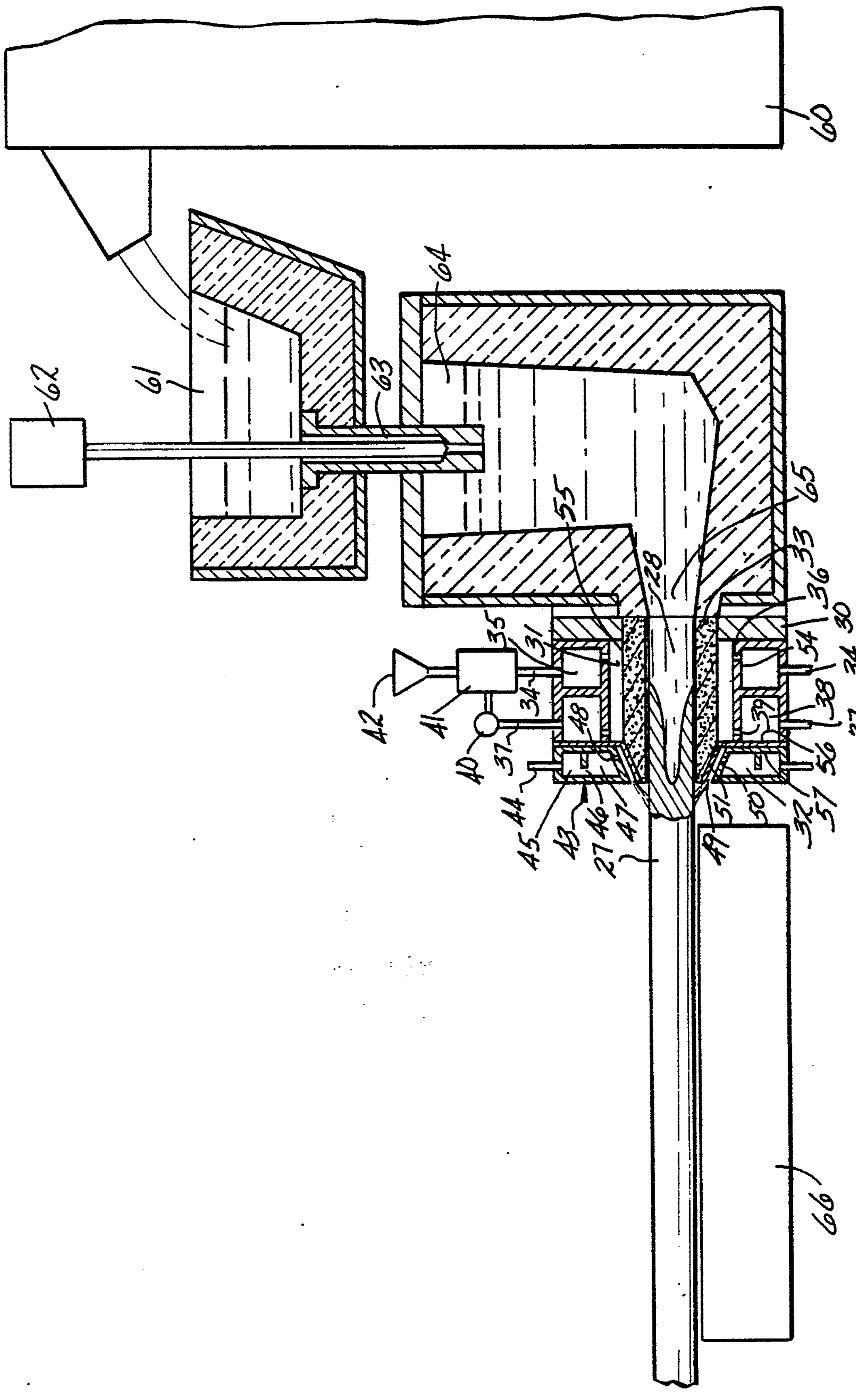
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FIG-8

European Patent Office

EUROPEAN SEARCH REPORT

0060359

Application number

EP 81 30 2993

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	DE-C- 837 589 (WIELAND) * page 2, lines 55-119 * ---	1,3,4, 5,11, 13	B 22 D 11/07 B 22 D 11/04
X	US-A-2 949 652 (HOBBS) * column 3, line 12 - column 4, line 11 * ---	1,11	
A	DE-C- 846 900 (WIELAND) * page 2, lines 25-48 * ---	6	
E	US-A-4 287 937 (OLIN CORP.) * the whole document * -----	1,2,4, 5,8,9, 10,11, 12,13	

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

B 22 D 11/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-06-1982	SCHIMBERG J.F.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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