United States Patent

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[54] **PUMP FOR MOLTEN METAL AND OTHER HIGH-TEMPERATURE CORROSIVE LIQUIDS**
18 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **415/131,** 415/170, 415/200, 415/214, 417/424

[51] **Int. Cl.** **F01d 5/14,** F01d 5/28

[50] **Field of Search** 417/423, 424, 321; 415/200, 201, 214, 196, 199, 131, 170

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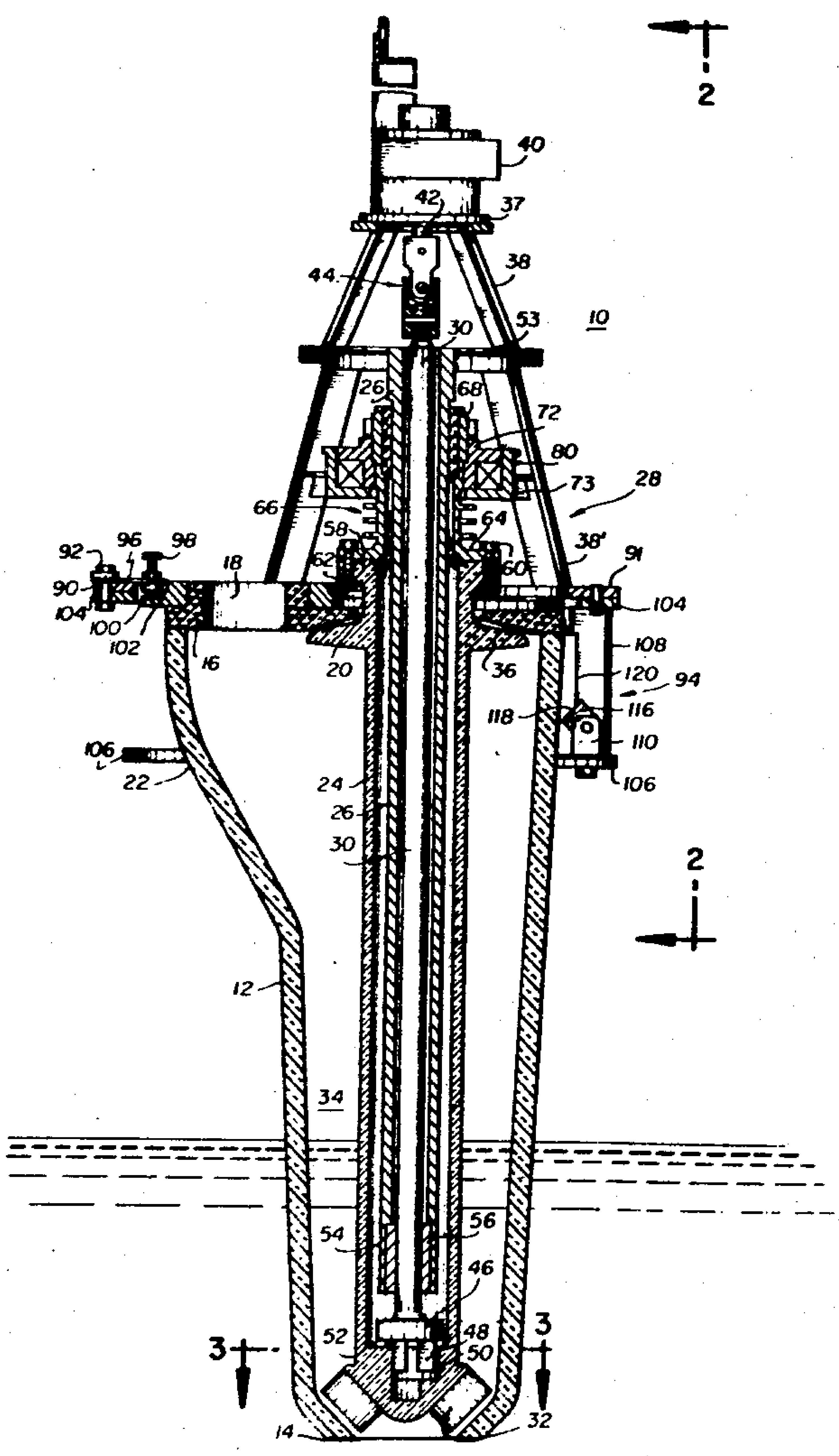
ABSTRACT: A pump for pumping molten metal and other high-temperature corrosive liquids is disclosed, which pump includes a casing constructed of refractory material and having an inlet opening at one end thereof. Pumping means are located within the casing for drawing a liquid into the casing through its inlet opening with the pumping means including: a rotatable refractory impeller; a refractory sleeve joined at one end thereof to the impeller and rotatable therewith, with the sleeve and casing defining an annular passageway through which the liquid passes; and a drive shaft located for at least a portion of its length within the sleeve, one end of the drive shaft being connected in driving relationship with the impeller. By virtue of being located within the sleeve, the drive shaft can impart rotation to the impeller and yet not be exposed to the high-temperature corrosive liquid being pumped. As an added feature, a cylindrical tube portion of the pump frame is disposed between the drive shaft and the refractory sleeve and carries a bearing for rotatably supporting the drive shaft. Since the bearing is located within the refractory sleeve, it can be positioned extremely close to the impeller, but yet never be immersed in the fluid being pumped.



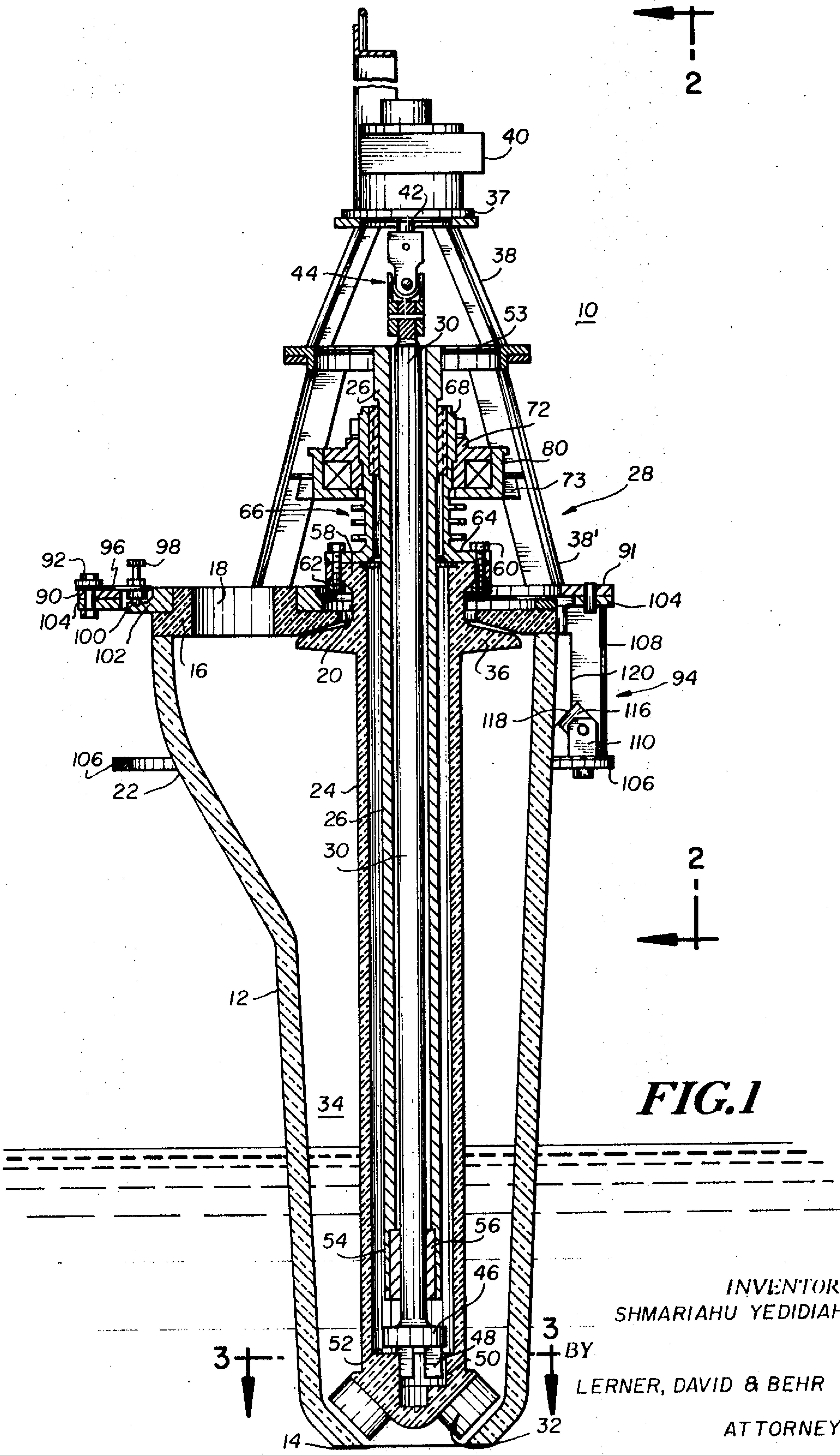


FIG. 1

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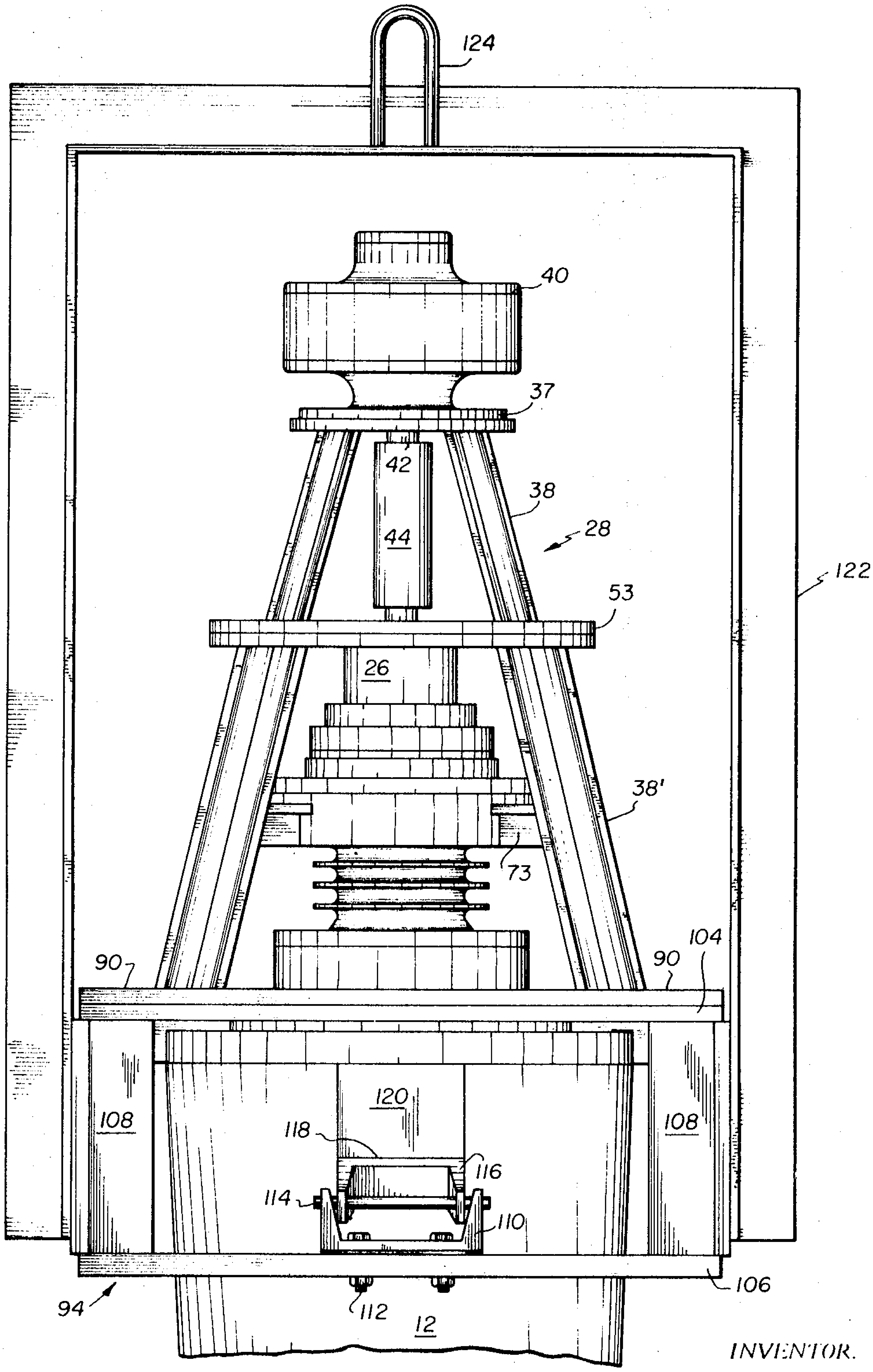

FIG.2

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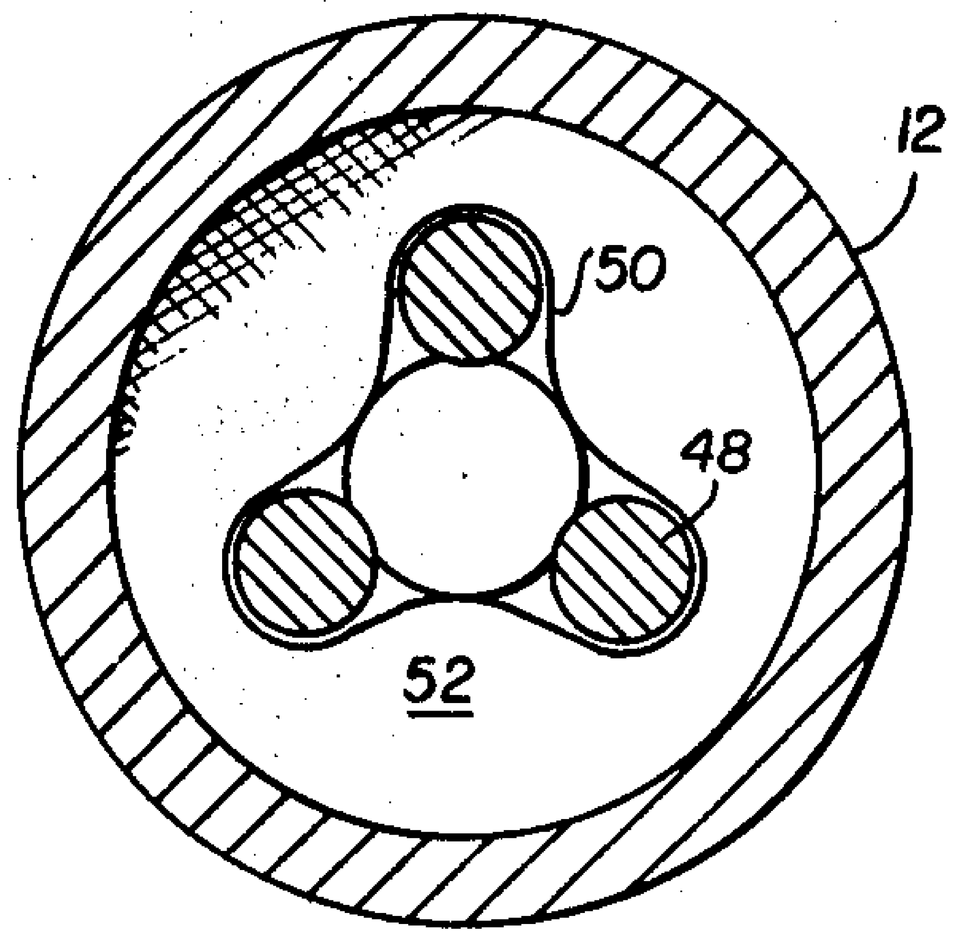


FIG.3

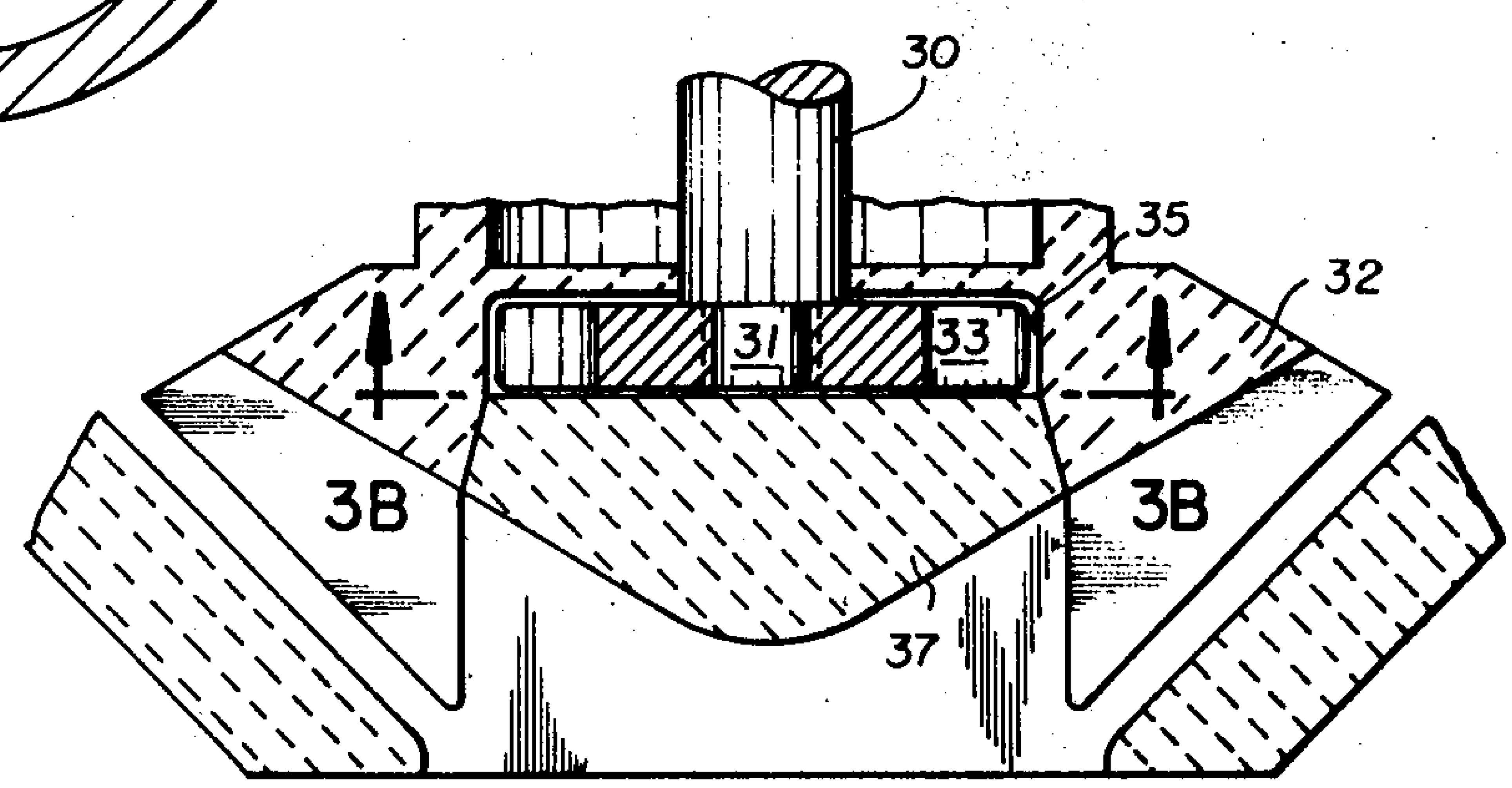
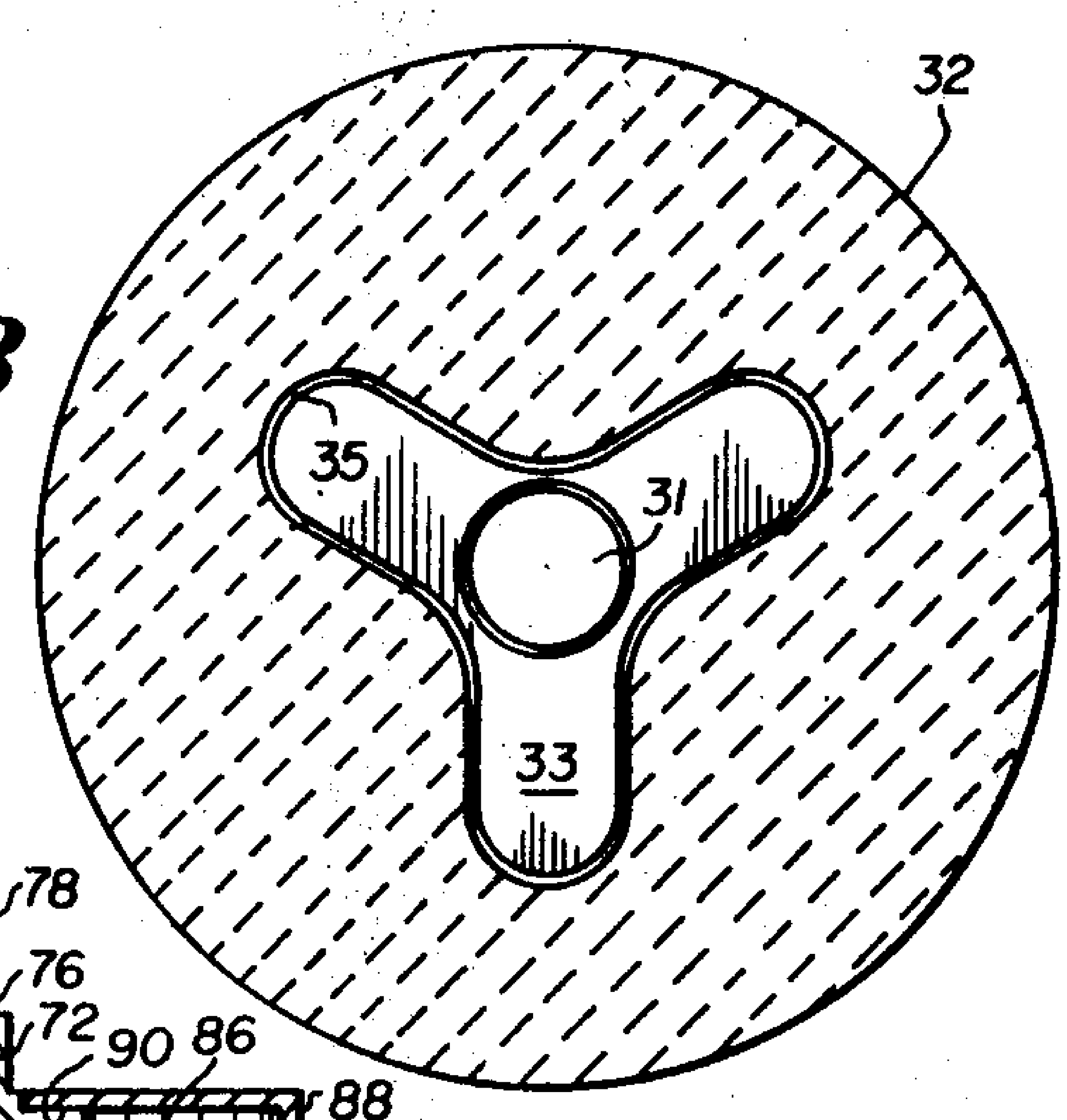


FIG.3A

FIG.3B



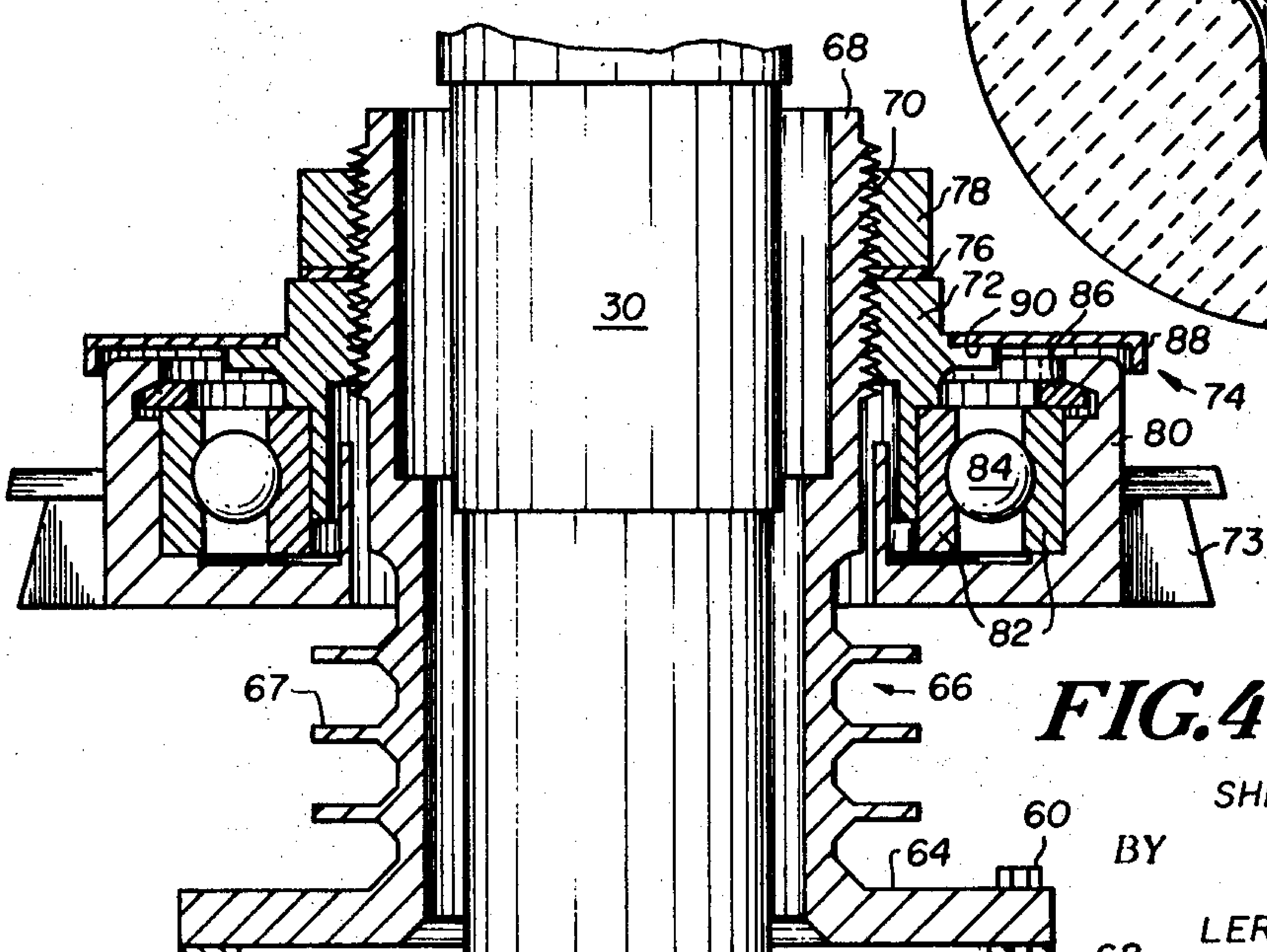


FIG.4

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PUMP FOR MOLTEN METAL AND OTHER HIGH-TEMPERATURE CORROSIVE LIQUIDS

BACKGROUND OF THE INVENTION

This invention relates to pumps, and more particularly to pumps for pumping molten metal and other high-temperature corrosive liquids.

In many fields, pumps are called upon to handle corrosive liquids at extremely high temperatures, molten metal being a typical example. In many of these situations, either the corrosivity or the temperature of the liquid (or both) precludes the possibility of using any known metal for the wetted parts of the pump. Accordingly, when dealing with such liquids, designers have turned to nonmetallic refractory materials for those parts of the pump which must come into contact with the pumped liquid. However, such materials have presented other problems.

For example, as a rule, refractory materials are very brittle and possess very low tensile and shear strength. Accordingly, when such materials are used as the driving shaft for the pump impeller, for example, the high-shear stresses applied thereto frequently result in breakdown. Additionally, because of the great difference in the coefficient of thermal expansion of refractory and nonrefractory materials, it is almost impossible to effectively support refractory parts with any metallic support structures.

An especially troublesome problem in the design of molten metal pumps concerns the location of drive shaft bearings with respect to the pumped liquid. On one prevalent prior art design, such bearings for the impeller drive shaft are located above and at a great distance from the impeller end of the drive shaft and are thereby kept out of the pumped liquid. However, with this type of construction, the great overhang of the impeller (and drive shaft) gives rise to vibration and repetitive cyclic bending stresses on the drive shaft, causing quick fatigue and frequent breakdown. In a second prior art design, this problem is eliminated by locating such bearings adjacent the impeller end of the drive shaft but immersed in the pumped liquid. However, immersing the bearing gives rise to a problem of a different nature which is particularly severe in the case of pumping molten metals. Specifically, should the molten metal solidify in the small clearances between the bearing and the shaft, subsequent attempts to remelt the metal frequently result in a breakdown. This is because of the difference in coefficients of thermal expansion causing the remelted metal to expand significantly more than the refractory part with which it is in contact.

It should be noted that, although various attempts have been made to design pumps overcoming the above noted problems, prior to the instant invention, no single pump has effectively eliminated all of these problems in a manner which is sufficiently simple and inexpensive to justify adoption or acceptance in the industry.

SUMMARY OF THE INVENTION

In accordance with the invention, a pump is provided for pumping molten metal and other high-temperature corrosive liquids, which pump includes a casing constructed of refractory material, with the casing having an inlet opening at one end thereof. Pumping means is located within the casing for drawing the liquid into the casing through its inlet opening. The pumping means includes a rotary refractory impeller; a refractory sleeve joined at one end thereof to the impeller and rotatable therewith, with the sleeve and casing defining an annular passageway through which the liquid passes; and an impeller drive shaft located for at least a portion of its length within the sleeve. In this manner, the drive shaft may be connected to the impeller for driving same, but because of its location within the refractory sleeve, it will not be exposed to the liquid drawn through the casing. Thus, and in accordance with the instant invention, the drive shaft may be a metallic member much more capable of withstanding the shear stresses involved than the ceramic driving shafts prevalent in prior art pumps of this type.

As a particularly advantageous feature of the invention, the metallic drive shaft thereof terminates in a plurality of driving pins which are loosely received in holes of greater diameter provided in the rear surface of the impeller. The clearance thereby established compensates for the differences in the coefficients of thermal expansion between the metallic drive shaft and the ceramic impeller.

As a further feature of the instant invention, a portion of the pump frame constitutes an elongated cylindrical tube portion which is disposed between the impeller drive shaft and the aforementioned refractory sleeve. The extremity of this tube portion of the frame terminates closely adjacent the impeller of the pump and carries bearing means for rotatably supporting the impeller drive shaft. It will be appreciated that because the bearing is close to the impeller, the overhand problem of the prior art has been effectively overcome, while at the same time, the bearing does not have to be immersed in the pumped liquid.

As a further feature of the invention, an upper portion of the frame comprises a bearing support portion disposed about the opposite end of the refractory sleeve (actually disposed about a metallic sleeve extension thereof) and carries second bearing means for rotatably supporting the opposite, upper end of the refractory sleeve. It will be appreciated, and become further apparent, that the aforementioned first bearing means together with the second bearing means effectively support both the impeller drive shaft and the refractory sleeve in a manner which prevents overhang and at the same time does not require either bearing means to be immersed in the pumped liquid. Additionally, and in accordance with the invention, the refractory sleeve with the impeller joined thereto, is vertically adjustable with respect to the pump casing so that various fluids may be accommodated by the pump.

Accordingly, it is an object of the instant invention to provide a pump for pumping molten metal and other high-temperature corrosive liquids which pump includes a casing constructed of refractory material and having an inlet opening at one end thereof; and pumping means located in the casing for drawing a liquid into the casing through its inlet opening; the pumping means including: a rotary refractory impeller; a refractory sleeve joined at one end thereof to the impeller and rotatable therewith, with the sleeve and casing defining an annular passageway through which the liquid passes; and a drive shaft located for at least a portion of its length within its sleeve, with one end of the drive shaft being connected to the impeller; whereby the drive shaft will not be exposed to the liquid being pumped.

Another object of the instant invention is to provide such a pump wherein, because of the above defined relationship of parts, the drive shaft may be constructed of a metallic material.

Another object of the instant invention is to provide such a pump in which drive shaft bearing means may be located extremely close to the impeller and yet not immersed in the fluid being pumped.

Still another object of the instant invention is to provide such a pump which includes upper bearing means for rotatably supporting the aforementioned refractory sleeve, and which upper bearing means together with the aforementioned drive-shaft-bearing means, effectively supports all rotating parts of the pump.

Yet another object of the instant invention is to provide such a pump wherein the aforementioned refractory sleeve and impeller joined thereto are vertically adjustable within the pump casing to accommodate a variety of liquids.

Other objects of the instant invention and a fuller understanding thereof may be had by referring to the following specification and drawings in which:

FIG. 1 is a plan view, primarily in section, illustrating a pump constructed in accordance with the instant invention;

FIG. 2 is a view taken along the arrows 2—2 of FIG. 1;

FIG. 3 is a view taken along the arrows 3—3 of FIG. 1;

FIG. 3A illustrates an alternative embodiment of the invention;

FIG. 3B is a view taken along the arrows 3B—3B of FIG. 3A; and

FIG. 4 is an enlarged sectional view of a portion of the pump illustrated in FIG. 1.

Turning to the FIGS. wherein like numerals have been used to designate like elements, there is shown the pump 10 of the instant invention which has been specifically designed for pumping molten metals and other high-temperature corrosive liquids. In the following description, certain parts of the pump 10 will be referred to as refractory material chosen for their high resistance to attack by the liquid for which the pump is designed. By way of example, but not intended as a limitation, such refractory material may comprise structural carbonaceous and siliceous refractory materials, such as graphites, graphitized carbon, clay-bonded graphite, carbon-bonded graphite, silicon carbides, aluminum silicates and other bonded refractory mixtures containing such materials.

The pump includes a refractory casing 12 at one end of which is provided an inlet opening 14 through which the pumped liquid enters the casing. At the opposite end of the casing there is provided a refractory cover 16 in which is provided a first laterally offset discharge opening 18 and a central opening 20. The central opening 20 permits a refractory sleeve 24; a cylindrical, metallic tube portion 26 of the frame broadly designated 28; and a metallic drive shaft 30 (preferably stainless steel) to be inserted into the casing 12.

As will be explained in greater detail, the refractory sleeve 24 is, in operation, a rotating member and is integrally provided at its lower end thereof with a refractory impeller structure 32 (of conventional design) by which the pumped liquid is drawn into the casing 12, up through an annular passageway 34 defined between the casing 12 and the sleeve 24, and out the discharge opening 18. Near the opposite end of the refractory sleeve 24 is provided an integrally outstanding collar 36 which centrifugally urges pumped liquid outwardly toward the discharge opening 18 and away from the central opening 20 provided in the casing cover 16.

Situated on a platform 37 above struts 38 and 38′ of the metallic frame 28 is a motor 40 the output shaft 42 of which is provided with one-half of a universal coupling 44, the second half of which is joined to the aforementioned metallic drive shaft 30. The lower end of drive shaft 30 includes an enlarged flange portion 46 having a plurality of driving pins 48 depending therefrom. The driving pins 48 fit loosely in larger diametered holes or openings 50 provided in the rear surface 52 of the refractory impeller 32.

As an alternative embodiment, illustrated in FIGS. 3A and 3B, the shaft 30 may be terminated by an externally threaded portion 31 which threadably receives a clover-shaped metallic keying member 33 which is received in a similarly shaped, but larger dimensioned cavity 35 provided in the impeller. A plug portion 37 of the impeller is removable to permit the member 33 to be secured to shaft portion 31 to thereby retain the impeller and drive shaft in nonrotative engagement with respect to one another.

It will be appreciated that the loose fit between the driving pins 48 and the openings 50 in FIG. 3, and the loose fit between the member 33 and cavity 35 in FIGS. 3A and 3B compensates for the difference in coefficients of thermal expansion between the metallic drive shaft and the refractory impeller.

To be appreciated thus far in the description, is that the liquid being pumped comes in contact only with refractory parts i.e., the impeller 32, the casing 12, the rotary sleeve 24, the casing cover 16, etc. Since the drive shaft 30 is located within the rotary sleeve 24, it never comes in contact with the high-corrosive liquids being pumped. Accordingly, the drive shaft 30 may, in accordance with the invention, be constructed of a metallic material like stainless steel much more able to withstand the shear stresses developed during the pumping operation than the refractory drive shafts prevalent in the prior art.

As noted previously, a portion of the frame 28 comprises the elongated cylindrical tube portion 26. The upper end of the tube portion 26 is rigidly secured to a transverse platform portion 53 of the frame and may be considered as part of the frame 28. The remaining portion of the tube 26 is in effect cantilevered within the rotary sleeve 24 and disposed between the sleeve 24 and the drive shaft 30. The opposite end 54 of the tubular frame portion 26 carries a cylindrical bearing member 56, preferably of carbon, by which the drive shaft 30 is rotatably supported adjacent its lower extremity thereof. Since the tubular frame portion 26 is protectively disposed within the refractory sleeve 24; like the drive shaft 30, may be constructed of a metallic material. Similarly, and in accordance with the invention, since the lower bearing 54 is disposed within the rotary refractory sleeve 24, it will never be exposed or immersed in the pumped liquid and can be located extremely close to the impeller 32 (actually below the surface level of the liquid being pumped). This arrangement eliminates the large drive shaft overhang prevalent in the prior art.

The uppermost extremity of the rotary refractory sleeve 24 terminates in an enlargement 58 which is clamped by suitable fastening means 60 between a retaining ring 62 and an outstanding flangelike portion 64 of a metallic rotary extension member 66 the central portion of which includes outstanding radiating fins 67 to help dissipate heat. With reference to FIG. 4, an upper portion 68 of the rotary extension 66 is provided with external threading 70 by which the rotary extension member 66 (and the refractory sleeve 24 secured thereto) may be vertically adjusted with respect to an inner facing member 72 of a ball bearing arrangement generally designated 74. A lockwasher 76 and internally threaded locknut 78 are provided to retain the rotary extension member 66 (and sleeve 24) in any preselected vertical position with respect to the inner facing member 72. The outer facing of the ball bearing arrangement 74 constitutes a circular, cup-shaped member 80 secured to a transverse retaining seat 73, in turn secured to the upright strut 38′ of the frame 28. The cup-shaped member 80 receives the races 82 and ball bearing 84 which in turn are held in place by a bearing-retaining ring 86. A centrally apertured bearing cover 88 is seated on a shoulder 90 defined on an outwardly extending portion of the aforementioned inner facing member 72.

It will be appreciated that should it be desired to change the clearance between the impeller 32 and the inlet end of the casing 12, one simply loosens the locknut 78 and rotates the rotary sleeve 24 (and rotary extension member 66 secured thereto) until a desired position is achieved.

In addition to the struts 38′ and the transversely oriented bearing-retaining seat 73; the frame 28 includes a relatively flat centrally apertured plate 91 secured to the lower extremity of the lowermost strut 38′. Depending from the frame plate 91 and secured thereto by suitable fastening means 92 is a casing support arrangement broadly designated 94 to be described in greater detail. Provided on the upper surface of the frame plate 91 and secured thereto by the aforementioned fastening means 92 are a plurality of leaf spring elements 96 (only one of which is visible in FIG. 1). The innermost extremities of leaf springs 96 carry vertically adjustable bolt means 98 the lower extremities 100 of which bear down on a casing cover plate 102 to urge the casing cover 16 into firm engagement with the casing 12.

The casing support arrangement 94 includes a pair of centrally apertured plates 104 and 106 respectively joined to one another by vertical plates 108 (see FIG. 2). The lower plate 106 has a plurality of upstanding generally U-shaped brackets 110 (only one of which is visible in FIG. 2) secured thereto by suitable fastening means 112. The upstanding legs of the brackets 110 carry an axle 114 on which is pivotally carried another generally U-shaped bracket 116, the face portion 118 of which supportingly engages similarly angled faces of outstanding protrusions 120 integrally provided on the casing 112, and preferably disposed thereabout at three convenient locations.

Finally, and as best illustrated in FIG. 2, a generally U-shaped hanging bracket **122** is secured by suitable fastening means provided at the extremities of the legs thereof to the aforementioned vertical plates **108**. A hook **124** is provided on the bight portion of the member **122** whereby the entire pump may be suspended in and above the liquid to be pumped.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited, not by the specific disclosure herein, only by the appended claims.

I claim:

1. A pump for pumping molten metal and other high-temperature corrosive liquids;
   said pump comprising:
   a casing constructed of end material, said casing having an inlet opening at one ed thereof;
   pumping means located within said casing for drawing a liquid into said casing through said inlet opening; said pumping means including;
   a rotatable refractory impeller;
   a refractory sleeve joined at one end thereof to said impeller and rotatable therewith, said sleeve and said casing defining an annular passageway through which said liquid passes;
   a drive shaft located for at least a portion of its length within said sleeve, one end of said drive shaft being connected to said impeller;
   whereby rotation of said drive shaft will impart rotation to said impeller and sleeve, and whereby said drive shaft will not be exposed to said liquid;
   wherein the opposite end of said casing is provided with a cover; said cover being provided with
   first opening which communicates with said annular passageway and establishes a discharge path therefore;
   a second opening through which said sleeve and shaft pass into said casing; and
   wherein said sleeve is provided with integral, outstanding collar means adjacent its opposite end thereof for centrifugally forcing said liquid away from said second opening in said cover.

2. The pump of claim 1 wherein said impeller and said sleeve are integrally joined and constitute a unitary member.

3. The pump of claim 1 wherein said drive shaft is of a metallic material.

4. The pump of claim 3 wherein said impeller includes a plurality of holes in a rear surface thereof and said one end of said drive shaft terminating in a plurality of driving pins which are received by said holes.

5. The pump of claim 4 wherein the holes in said rear surface of said impeller are greater diameter than said driving pins.

6. The pump of claim 1 wherein said casing terminates in an enlarged laterally offset arcuate portion adjacent said cover, and said first opening in said cover is laterally offset with respect to the center thereof and located generally above said offset arcuate portion of said casing.

7. The pump of claim 1 and further including:
   a frame, said frame including a cylindrical tube portion disposed intermediate said shaft and said sleeve and terminating at one end thereof adjacent said one end of said drive shaft; and
   first bearing means located adjacent said one end of said cylindrical tube portion and disposed between said tube portion and said drive shaft for rotatably supporting said drive shaft within said tube portion.

8. The pump of claim 7 wherein said frame further includes a bearing support portion disposed about said sleeve adjacent its said opposite end thereof; and
   second bearing means disposed between said bearing support portion and said sleeve for rotatably supporting said sleeve at its said opposite end thereof.

9. The pump of claim 1 wherein said impeller is vertically adjustable within said casing.

10. The pump of claim 8 wherein said sleeve includes means for vertically adjusting said sleeve with respect to said second bearing means.

11. The pump of claim 9 wherein said sleeve terminates at its said opposite end thereof in a sleeve extension portion; said second bearing means being disposed between said bearing support portion and said sleeve extension portion.

12. The pump of claim 11 wherein said sleeve extension portion is vertically adjustable with respect to said second bearing means.

13. The pump of claim 11 wherein said sleeve extension portion is of a metallic material and includes integrally outstanding heat-radiating fins.

14. The pump of claim 7 wherein said cover is removably carried on said casing and wherein said frame includes retaining means disposed thereabout for retaining said cover on said casing.

15. The pump of claim 14 and further including support means secured to said frame for supporting said casing.

16. The pump of claim 15 wherein said support means depends from said frame and includes casing supporting brackets, and wherein said casing includes integrally outstanding projections which are retained by said supporting brackets.

17. The pump of claim 16 and further including hanging means secured to said support means for suspending said pump.

18. The pump of claim 3 wherein said one end of said drive shaft carries a keying member nonrotatingly housed in a cavity provided in said impeller; said cavity being of similar shape and larger dimensions than said keying member.