



(11) **EP 2 811 166 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
15.08.2018 Bulletin 2018/33

(51) Int Cl.:
F04D 7/06 ^(2006.01) **F04D 29/046** ^(2006.01)
F04D 29/18 ^(2006.01) **F04D 29/42** ^(2006.01)

(21) Application number: **14171529.2**

(22) Date of filing: **06.06.2014**

(54) **Molten metal pump and emergency pump-out of molten metal**

Metalschmelzpumpe und Notfallabpumpen von Metallschmelze

Pompe de métal en fusion et vidange par pompage de métal en fusion en urgence

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **07.06.2013 US 201361832376 P**

(43) Date of publication of application:
10.12.2014 Bulletin 2014/50

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EP 2 811 166 B1

Description

BACKGROUND

[0001] The present exemplary embodiment relates to a molten metal pump. It finds particular application as a pump suitable for emergency pump out situations, and will be described with particular reference thereto. However, it is to be appreciated that the present exemplary embodiment is also amenable to other like applications.

[0002] Molten metals such as aluminum, brass, bronze and zinc are commonly used. Of course, to be placed in a molten state, the metal must be exposed to elevated temperatures. A variety of types of furnaces and other devices are used for this purpose, including smelting furnaces for aluminum production, induction furnaces for metal processing, and refractory furnaces for metal recycling. The following paragraphs describe several varied systems in which a molten metal exists.

[0003] For example, Hall-Heroult® manufactures aluminum smelting pots consisting of a rectangular steel box insulated with fire bricks along the bottom and the sides. Carbon blocks containing conductor rods are attached to the bottom brick lining, with the rods protruding from the cell structure. The sides of the cell are lined with carbon on top of the firebricks. Square anode blocks constructed from compressed petroleum, coke and coal tar are fixed to rods and suspended from two beam-like busbars attached to the cell structure, which as well as supplying electric current can lower or raise the anode blocks. Alumina is provided to the cell through an ore bin located above the cell and a portable fume extraction hood covers the cell. Aluminum is derived from the added aluminum within the melting pots via an electrolytic process.

[0004] As another example, induction furnaces employ electromagnetic energy to induce electrical currents within a charge of metal or metal alloy. The electrical resistance of the metal produces heat as a natural consequence of the induced currents flowing in the metal. The combination of applied electrical power and frequency can be chosen to induce sufficient heat within the metal to cause it to melt, providing a molten liquid which can be poured into molds or otherwise used to produce a wide variety of metal products. The basic elements of an induction furnace include an electromagnetic induction coil, a vessel having a lining of refractory material, and a support structure for the coil and vessel.

[0005] As a further example, metals may be melted in reverberatory furnaces. In a reverberatory furnace direct flame and radiation from hot refractory linings heat the metal. At its simplest, such a furnace is a steel box lined with alumina or other refractory brick having a flue at one end and a generally vertically lifting door at the other end closing a main entrance for the furnace through which a metal is directly charged into the furnace. The charge of molten metal may be introduced through the main entrance and lies in a shallow hearth having a relatively low

roof so that flame passes across the surface of the charge. Conventional oil or gas burners are usually placed on either side of the furnace to heat the refractory lining and to melt the metal. The resulting molten metal is then transferred to a casting machine to produce metal ingot.

[0006] In the hot-dip galvanizing of an object, for example of iron, steel etc., the object is immersed in a bath of molten zinc, the iron and zinc forming alloys with one another. The molten zinc is typically housed in a refractory container during this process.

[0007] Each of these systems - and equipment not mentioned herein - is capable of failure. For example, within each of these systems a refractory lined vessel designed to withstand the extreme temperatures associated with molten metals may be employed. In operation, the interior surface of the refractory lining that contacts the molten metal can become sintered and brittle because of the extreme temperatures to which it is exposed. As the device is used repeatedly, the refractory expands and contracts in response to the heating and cooling cycles. Cracks form in the refractory, permitting small amounts of molten metal to migrate into the granular material. Failure can result in a dangerous situation where molten metal could escape containment.

[0008] Furthermore, each system requires the introduction of energy (e.g. heat or electricity) to keep the metal in a molten state. If the heating system were to fail (or for example power to the system is lost), the molten metal could solidify and ruin the system.

[0009] Accordingly, a means for rapid pump-out of molten metal would be advantageous should one of the failure situations described above, or a similar situation, be encountered (condition precedent to emergency pump out).

[0010] DE 10 2004 009 546 A1 discloses a pump for pumping molten magnesium. The pump comprises a steel base including mated steel plates defining a pumping chamber and a motor mount comprising a motor. An impeller is located in said pumping chamber and at least one stainless steel post extends between said steel base and said motor mount. A stainless steel shaft extends between said motor and said impeller. Furthermore, at least one bearing ring engages the impeller and a stainless steel riser tube is in fluid communication with the outlet. The pump lacks a robust structure.

[0011] US 3 776 660 A concerns a pump for molten salts and metals and teaches a top retainer plate and a bottom retainer plate. The pump chamber is contained by the plates but the pump chamber within which the impeller is rotated is comprised of housing components, whereby the housing components are made of refractory material such as silicon carbide.

[0012] US 6 439 860 B1 teaches a chambered vane impeller molten metal pump comprising a drive means, a motor mount, a coupling with a taper facilitating shaft removal, a shaft with a tapered top and a bottom with dovetail mating grooves for accepting impeller vanes, a bear-

ing supporting the shaft, tapered support sockets, supports comprising a tapered end, an aperture, and groove, a laminated base, and a fabricated chambered van impeller.

[0013] As those skilled in the art understand, molten metal pumps already exist that can remove molten metal from vessels. However, because of the high temperature environment in which these pumps operate, the pumps are constructed of a refractory material. Unfortunately, because of thermal expansion problems, a refractory pump cannot be immersed in molten metal without a relatively lengthy pre-heating process. Accordingly, a traditional refractory pump is unsuitable for emergency pump-out situations.

BRIEF DESCRIPTION

[0014] Various details of the present disclosure are hereinafter summarized to provide a basic understanding. This summary is not an extensive overview of the disclosure and is neither intended to identify certain elements of the disclosure, nor to delineate scope thereof. Rather, the primary purpose of this summary is to present some concepts of the disclosure in a simplified form prior to the more detailed description that is presented hereinafter. The scope of the invention is solely defined by the appended claims.

[0015] To overcome the above-mentioned drawbacks, the present invention suggests a molten metal pump with the features of claim 1 and a method for emergency pump out of a molten metal from a vessel according to claim 10. In accordance with one aspect of the present exemplary embodiment, a molten metal pump comprised of a metal base defining a pumping chamber is provided. The pump further includes a motor mount adapted to receive a motor, at least one metal post extending between the base and the motor mount, and a metal shaft disposed between the motor and an impeller disposed in the pumping chamber. A bearing ring engages the impeller. The pumping chamber will include an inlet and an outlet and a metal riser tube in fluid communication with the outlet is also provided.

[0016] According to a further exemplary embodiment, a method for emergency pump out of a molten metal from a vessel is provided. The method comprises identifying a condition precedent which requires rapid removal of the molten metal from the vessel, and then introducing a pump including at least a metal base, a metal post and a metal riser tube into the molten metal. By rotating a shaft and impeller combination with a motor, the impeller being disposed within the base and configured to direct molten metal into the riser tube, molten metal is transferred through the riser tube into a second vessel. The present pump, constructed primarily from metal, does not require preheating and can be introduced into a molten metal even when the pump components are at a temperature below about 100°C.

[0017] A molten metal pump comprised of a metal base

having a plurality of mated plates is provided. The base defines a pumping chamber. A motor mount adapted to receive a motor is also provided. At least one metal post extends between the base and the motor mount. A metal shaft extends between the motor and a refractory impeller located in the pumping chamber. A refractory bearing ring engages the impeller. The pumping chamber includes an inlet and an outlet. A metal riser tube is provided in fluid communication with the outlet. A gasket material is disposed between each pair of adjacent metal plates. A gasket material is disposed between each bearing ring and a surface of the metal base adjacent to the bearing ring. A metallic coupling joins the impeller to the metal shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention consists in the novel parts, construction, arrangements, combinations and improvements, shown and described. The accompanying drawings, which are incorporated in and constitute a part of the specification illustrate one embodiment of the invention and together with the description, serve to explain the principles of the invention.

FIGURE 1 is a perspective view of a molten metal pump;

FIGURE 2 is a rear elevation view of the pump of FIG. 1;

FIGURE 3 is a side elevation view of the pump of FIG. 1;

FIGURE 4 is a top plan view of the pump of FIG. 1; FIGURE 5A, 5B and 5C are representative of the pump base of FIG. 1 in various phases of assembly (FIG. 5A is fully exploded, FIG. 5B is partially exploded by part grouping, and FIG. 5C is assembled);

FIGURE 6 is a cross-sectional view of a pump base; and

FIGURE 7 is the molten metal pump of FIG. 1 including an outlet conduit adapter attached to the riser.

DETAILED DESCRIPTION

[0019] The exemplary embodiment has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding this description. It is intended that the exemplary embodiment be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

[0020] Turning now to the molten metal pump as shown in the figures, a motor 111 is attached to a rotatable shaft 113 by a coupling assembly (not visible). The shaft 113 is attached at its lower end to a rotatable impeller 117 which rotates within a pumping chamber 118 defined by base 119. A birdcage impeller of the type disclosed herein is suitable but alternative impeller embod-

iments are envisioned to work equally well. The impeller 117 and pumping chamber 118 are in fluid communication with an inlet 134 and an outlet 133 of the base 119. The use of a graphite or ceramic (refractory materials) impeller can advantageously minimize thermal expansion issues.

[0021] A first bearing ring pair 121 and a second bearing ring pair 122 are provided to allow proper rotation of the impeller 117. The bearing rings advantageously prevent erosion so that flow can be maintained. The motor 111 is supported and connected to the base assembly 119 by a pair of posts 125 which are attached to a motor mount platform 129 via bolt assemblies 131.

[0022] A riser tube 132 has a first end disposed in fluid communication with the outlet 133 in the base 119 and is secured at a second end to the motor mount platform 129 via a coupling adaptor 137. The shaft, posts and riser tube can be constructed of any high temperature resistant metal, such as stainless steel.

[0023] The base assembly is comprised of steel plates 140, 141, 142, 143 and 144. Of course, it is envisioned that more or fewer than five plates can be used to assemble the base. Three plates is considered to be the most likely minimum number. Interposed between each of the plates is sealing gasket 145, 146, 147 and 148 which can be constructed of Graphoil. The plates can be constructed, for example, from 304, 316 and/or 330 stainless steel. Silicon carbide bearing rings, particularly outer bearings 121 and 122 are seated within recesses in the base and are similarly surrounded by expansion gaskets (which can be constructed of FryeWrap XFP® expanding paper from Unifrax Corporation) 150, 151, 152 and 153, forming an interface between the silicon nitride bonded silicon carbide bearing ring and the adjacent metal surfaces on the outside edge and outer wall. The expanding gaskets keep bearing rings aligned notwithstanding dissimilar thermal expansion. Additionally, sealing gaskets 154 and 155 seal the inside edge of the bearing rings.

[0024] Shaft 113 is secured to the impeller 117. Particularly, graphite impeller 117 can be machined with a quadralobal extension 160. Extension 160 can be shaped in the same manner as the shaft which is described in U.S. Patent 5,634,770. Moreover, the quadralobal mating allows for dissimilar thermal expansions and high torque transfer. A cap member 170 having a cooperatively formed internal surface for receiving the extension 160 is positioned there over. Metal cap 170 includes a threaded head end 171 suitable for receiving a cooperatively threaded end of shaft 113. The male thread connection allows for field modification to the shaft. A bore 180 through impeller 117 is designed to receive a bolt 181 having a threaded end to receive nut 183. Tightening of nut 183 draws impeller 117 and cap 170 into a mated relationship.

[0025] A gasket material 190 (eg. Grafoil®) can be positioned between the interface with shaft 113 and cap 170. Furthermore, a gasket 193 can be provided at the interface between cap 170 and a surface of impeller 117.

A graphite plug 191 can be inserted into the bore 180 of the impeller 117 to seal the bolt 181 from exposure to molten metal.

[0026] Plates 140-144 are equipped with aligned passages 200 designed to receive bolt and nut assemblies 201 suitable for simultaneously mating the plates 140-144 together to form base 119 and attaching posts 125 to the base 119. Posts 125 can include cross members 210 which include alignment passages 211 (optionally with bearing rings) serving as a guide for shaft 113. The pump can generally be approximately at least 3 meters long and maintain its functional stability because of the steel superstructure.

[0027] Plate 142 can include a plurality of tap holes 220 designed to receive screws 221 suitable for joining riser tube 132 to the base 119 adjacent outlet 133. Hook elements 230 are secured to the motor mount 129 to facilitate the lifting of the pump assembly into the desired location.

[0028] The present pump provides a suitable emergency pump out apparatus. More particularly, because thermal expansion mismatches are minimized via the pump design, no preheating is required. Accordingly, the pump can be immediately disposed within a body of molten metal when required. The pump is particularly advantageous because of its steel construction it can be readily disposed within molten aluminum and molten zinc (and other molten metals) whereas a traditional graphite pump requires a super structure above the furnace to keep the pump in place because of its comparatively high buoyancy.

[0029] As articulated above, it may be desirable for the pump to be at least 3 meters in length, in which case each of the shaft 113, posts 125 and riser tube 132 will be at least 3 meters in length. Moreover, this length is anticipated to be sufficient to allow the base to be deployed adjacent a lower portion of the molten metal containment vessel, wherein molten metal is lifted via riser tube 132 above the height of a sidewall of the containment vessel. Of course, in certain situations, a taller system may be desired.

[0030] Furthermore, in certain environments, it may be desirable for the riser tube to have a length greater than the post/shaft elements. For example, with reference to Figure 7, it may be desirable to provide the riser tube 132 with height extending conduits 229 and 231 and generally u-shaped elbow 233 in fluid communication with an outlet conduit 235. This allows safe discharge into a holding unit.

[0031] As noted previously, since base 119 may be disposed on a bottom floor of the vessel being evaluated, it may be exposed to dross and other occlusions. Accordingly, in selected embodiments, it may be advantageous to provide a steel basket 249 (or screen) surrounding the inlet 134. Moreover, the basket 249 can define a plurality of relatively smaller openings 251 that can discourage large dross pieces or inclusions from entering and damaging the pump (see Figure 6).

Claims

1. A pump for pumping molten metal such as aluminium comprised of a metal base (119) defining a pumping chamber (118),
a motor mount (129) comprising a motor (111), an impeller (117) located in said pumping chamber (118),
at least one metal post (125) extending between said metal base (119) and said motor mount (129), a metal shaft (113) extending between said motor (111) and said impeller (117),
at least one bearing ring (121; 122) engaging the impeller (117), the pumping chamber (118) including an inlet (134) and an outlet (133),
a metal riser tube (132) in fluid communication with the outlet,
wherein said base is comprised of a plurality of mated steel plates (140; 141; 142; 143; 144)
characterized in that
the base comprises at least an inner most plate of a greatest thickness, two outermost plates of the thinnest thickness, and two intermediate plates of intermediate thickness and wherein the pumping chamber (118) is defined by the inner most plate, wherein the shaft (113), post (125) and riser tube (132) are constructed of any high temperature resistant metal.
2. The pump of claim 1, wherein said impeller (117) is comprised of a refractory material.
3. The pump of one of claims 1-2, wherein at least two plates include recesses receiving the bearing rings.
4. The pump of one of claims 1-3, wherein a thickest of said steel plates (140; 141; 142; 143; 144) defines the outlet (133).
5. The pump of claim 4, wherein an expansion gasket is disposed between a radial edge of each bearing ring and an associated plate.
6. The pump of one of claims 1-5, wherein a gasket (145; 146; 147; 148) is disposed between adjacent plates.
7. The pump of claim 1, further including a sealing gasket (154; 155) disposed on an inboard horizontal face of each bearing ring (121; 122).
8. The pump of one of the preceding claims, further comprising a coupling joining the shaft (113) and the impeller (117), said coupling comprising a metal cup having a chamber configured to receive a portion of the impeller (117) and a projection configured to mate with said shaft (113), a passage extending through a wall defining the cup and through said projection, said passage receiving a bolt (181) such that

said bolt (181) passes through an opening in said impeller (117) and is received in said passage through the coupling, a nut (183) being provided on the bolt (181) to secure the coupling to the impeller (117).

9. The pump of claim 8, wherein said projection includes external threads configured to receive an internally threaded end of the shaft (113).
10. A method for emergency pump out of a molten metal from a vessel, said method comprises identifying a condition precedent which requires rapid removal of the molten metal from the vessel, and then introducing a pump of one of the preceding claims including at least a metal base (119), a metal post (125), a shaft (113), an impeller (117), a motor (111) and a metal riser tube (132) into the molten metal, rotating the shaft (113) and the impeller (117) combination with the motor (111), said impeller (117) disposed within said metal base (119) and configured to direct molten metal into said riser tube (132), and introducing metal from said riser tube (132) into a second vessel.
11. The method of claim 10, wherein the pump temperature of said pump is below 100°C, when introduced into said molten metal.

Patentansprüche

1. Pumpe zum Pumpen von geschmolzenem Metall wie zum Beispiel Aluminium, gebildet aus einer Metallbasis (119), die eine Pumpkammer (118) definiert, einem Motoranbau (129), umfassend einen Motor (111), ein Antriebsrad (117), das sich in der Pumpkammer (118) befindet, mindestens einem Metallpfahl (125), der sich zwischen der Metallbasis (119) und dem Motoranbau (129) erstreckt, einem Metallschaft (113), der sich zwischen dem Motor (111) und dem Antriebsrad (117) erstreckt, mindestens einem Lagerring (121; 122), der das Antriebsrad (117) einschaltet, wobei die Pumpkammer (118) einen Einlass (134) und einen Auslass (133) enthält, einem Metallsteigrohr (132) in fluider Kommunikation mit dem Auslass, wobei die Basis aus einer Vielzahl zusammengepasster Stahlplatten (140; 141; 142; 143; 144) gebildet wird,
dadurch gekennzeichnet, dass
die Basis mindestens eine innerste Platte einer größten Dicke, zwei äußerste Platten der dünnsten Dicke und zwei mittlere Platten mittlerer Dicke umfasst und wobei die Pumpkammer (118) durch die innerste Platte definiert wird, wobei der Schaft (113), Pfahl (125) und Steigrohr (132) aus jeglichem Metall

mit hoher Temperaturbeständigkeit hergestellt sind.

2. Pumpe nach Anspruch 1, wobei das Antriebsrad (117) aus einem hochschmelzendem Material besteht. 5
3. Pumpe nach irgendeinem der Ansprüche 1-2, wobei mindestens zwei Platten Aussparungen enthalten, die die Lagerringe aufnehmen. 10
4. Pumpe nach irgendeinem der Ansprüche 1-3, wobei eine dickste der Stahlplatten (140; 141; 142; 143; 144) den Auslass (133) definiert. 15
5. Pumpe nach Anspruch 4, wobei eine Expansionsdichtplatte zwischen einem radialen Rand jedes Lagerrings und einer assoziierten Platte angeordnet ist. 20
6. Pumpe nach irgendeinem der Ansprüche 1-5, wobei eine Dichtplatte (145; 146; 147; 148) zwischen benachbarten Platten angeordnet ist. 25
7. Pumpe nach Anspruch 1, ferner enthaltend eine verschließende Dichtplatte (154; 155), die auf einer horizontalen Innenfläche von jedem Lagerring (121; 122) angeordnet ist. 30
8. Pumpe nach irgendeinem der vorherigen Ansprüche, ferner umfassend ein Verbindungsstück, das den Schaft (113) und das Antriebsrad (117) verbindet, wobei das Verbindungsstück eine Metallschale mit einer Kammer, die dazu ausgelegt ist, einen Abschnitt des Antriebsrades (117) aufzunehmen und einen Überstand, der dazu ausgelegt ist, zu dem Schaft (113) zu passen, umfasst, einen Durchgang, der sich durch eine Wand, die die Schale definiert, und durch den Überstand erstreckt, wobei der Durchgang einen Bolzen (181) derart aufnimmt, dass der Bolzen (181) eine Öffnung in besagtem Antriebsrad (117) passiert und in die Passage durch das Verbindungsstück aufgenommen wird, eine Mutter (183), die auf dem Bolzen (181) bereitgestellt ist, um das Verbindungsstück auf dem Antriebsrad (117) zu sichern. 35 40 45
9. Pumpe nach Anspruch 8, wobei besagter Überstand Außengewinde enthält, die dazu ausgelegt sind, ein Ende des Schaftes (113) mit Innengewinde aufzunehmen. 50
10. Verfahren, um im Notfall geschmolzenes Metall aus einem Gefäß zu pumpen, wobei das Verfahren das Identifizieren eines vorangehenden Zustandes, der ein schnelles Entfernen des geschmolzenen Metalles aus dem Gefäß erfordert, und das anschließende Einführen einer Pumpe nach einem der vorherigen Ansprüche, enthaltend mindestens eine Me-

tallbasis (119), einen Metallpfahl (125), einen Schaft (113), ein Antriebsrad (117), einen Motor (111) und ein Metallsteigrohr (132), in das geschmolzene Metall, das Rotieren der Schaft-(113) und der Antriebsrad(117)kombination mit dem Motor (111), wobei das Antriebsrad (117) innerhalb der Metallbasis (119) angeordnet ist und dazu ausgelegt ist, geschmolzenes Metall in das Steigrohr (132) zu lenken, und das Einführen von Metall aus besagtem Steigrohr (132) in ein zweites Gefäß umfasst.

11. Verfahren nach Anspruch 10, wobei die Pumpentemperatur der Pumpe unter 100°C ist, wenn diese in das geschmolzene Metall eingeführt wird.

Revendications

1. Pompe pour pomper du métal en fusion tel que de l'aluminium, constituée d'une base métallique (119) définissant une chambre de pompage (118), un support de moteur (129) comprenant un moteur (111), une turbine (117) située dans ladite chambre de pompage (118), au moins un montant métallique (125) s'étendant entre ladite base métallique (119) et ledit support de moteur (129), un arbre métallique (113) s'étendant entre ledit moteur (111) et ladite turbine (117), au moins une bague de roulement (121 ; 122) engageant la turbine (117), la chambre de pompage (118) comprenant une entrée (134) et une sortie (133), un tube ascendant métallique (132) en communication fluide avec la sortie, ladite base étant constituée d'une pluralité de plaques d'acier appariées (140 ; 141 ; 142 ; 143 ; 144) caractérisée en ce que : la base comprend au moins une plaque la plus interne de plus grande épaisseur, deux plaques les plus externes de moindre épaisseur, et deux plaques intermédiaires d'épaisseur intermédiaire, et la chambre de pompage (118) étant définie par la plaque la plus interne, l'arbre (113), le montant (125) et le tube ascendant (132) étant constitués de tout métal résistant à des températures élevées.
2. Pompe selon la revendication 1, dans laquelle ladite turbine (117) est constituée d'un matériau réfractaire.
3. Pompe selon l'une des revendications 1 et 2, dans laquelle au moins deux plaques comprennent des évidements recevant les bagues de roulement.
4. Pompe selon l'une des revendications 1 à 3, dans laquelle la plus épaisse desdites plaques d'acier (140 ; 141 ; 142 ; 143 ; 144) définit la sortie (133).
5. Pompe selon la revendication 4, dans laquelle un

joint d'expansion est disposé entre un bord radial de chaque bague de roulement et une plaque associée.

6. Pompe selon l'une des revendications 1 à 5, dans laquelle un joint (145 ; 146 ; 147 ; 148) est disposé entre des plaques adjacentes. 5

7. Pompe selon la revendication 1, comprenant, en outre, un joint d'étanchéité (154 ; 155) disposé sur une face horizontale côté intérieur de chaque bague de roulement (121 ; 122). 10

8. Pompe selon l'une des revendications précédentes, comprenant, en outre, un accouplement raccordant l'arbre (113) et la turbine (117), ledit accouplement comprenant une coupelle métallique comportant une chambre configurée pour recevoir une partie de la turbine (117) et une saillie configurée pour s'emboîter avec ledit arbre (113), un passage s'étendant dans une paroi définissant la coupelle et à travers ladite saillie, ledit passage recevant un boulon (181) de manière que ledit boulon (181) passe par une ouverture dans ladite turbine (117) et soit reçu dans ledit passage traversant l'accouplement, un écrou (183) étant prévu sur le boulon (181) afin d'assujettir l'accouplement à la turbine (117). 15
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9. Pompe selon la revendication 8, dans laquelle ladite saillie comprend des filetages externes configurés pour recevoir une extrémité taraudée de l'arbre (113). 30

10. Procédé pour le pompage d'urgence d'un métal en fusion depuis une cuve, ledit procédé consistant à : identifier une condition impérative qui requiert un enlèvement rapide du métal en fusion de la cuve, puis introduire une pompe selon l'une des revendications précédentes comprenant au moins une base métallique (119), un montant métallique (125), un arbre (113), une turbine (117), un moteur (117) et un tube ascendant métallique (132) dans le métal en fusion, faire tourner l'arbre (113) et la turbine (117) en combinaison avec le moteur (111), ladite turbine (117) étant disposée au sein de ladite base métallique (119) et configurée pour diriger le métal en fusion jusque dans ledit tube ascendant (132), et introduire le métal depuis ledit tube ascendant (132) jusque dans une seconde cuve. 35
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11. Procédé selon la revendication 10, dans lequel la température de pompe de ladite pompe est inférieure à 100°C, lorsque introduite dans ledit métal en fusion. 50

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FIG. 1

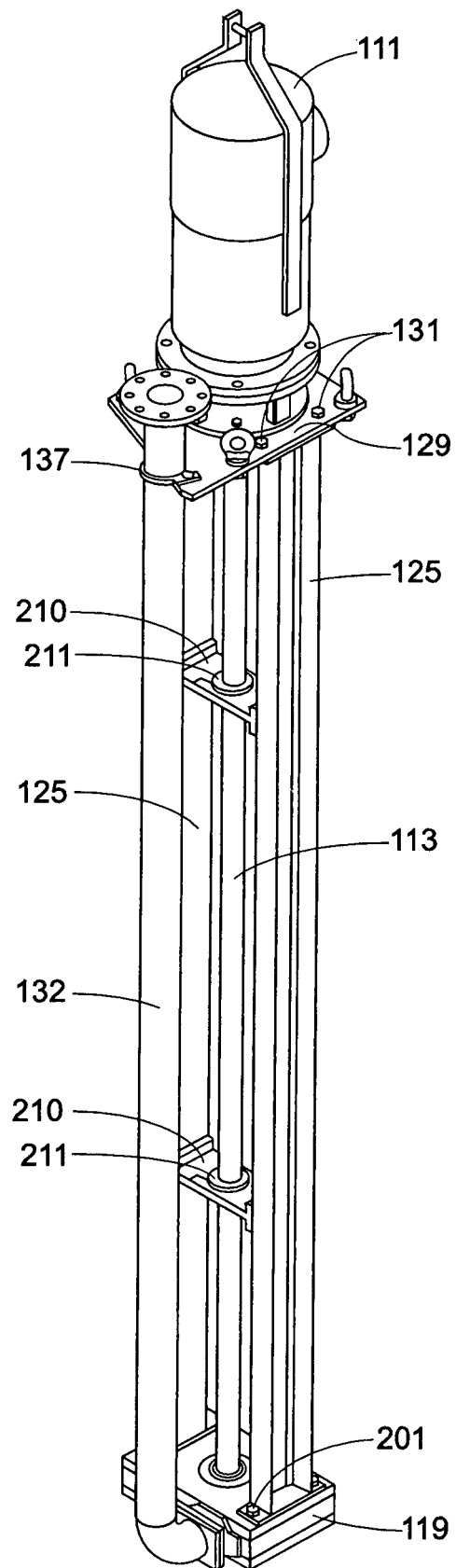


FIG. 2

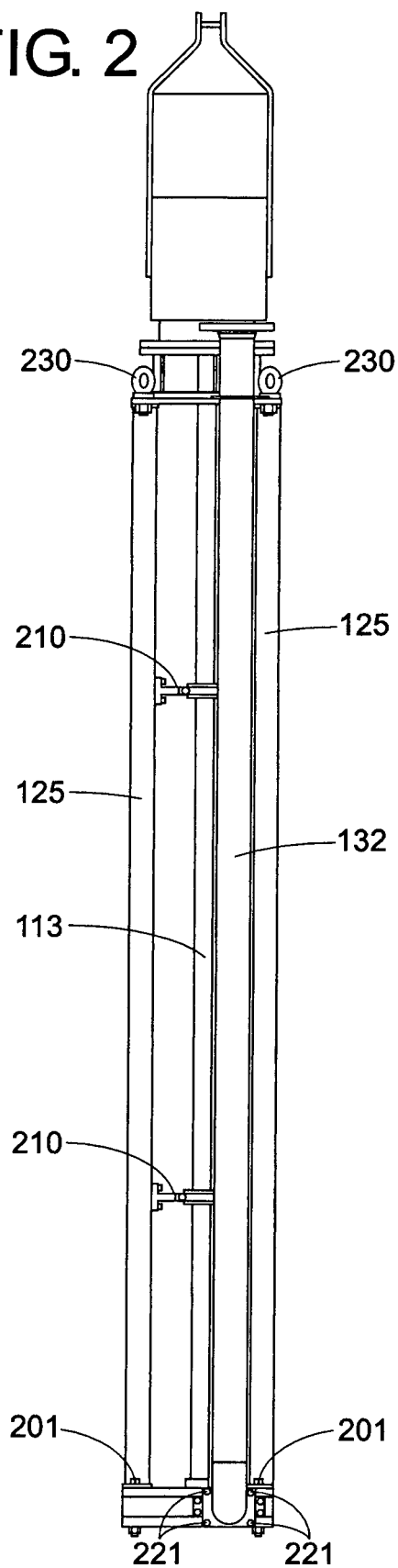


FIG. 3

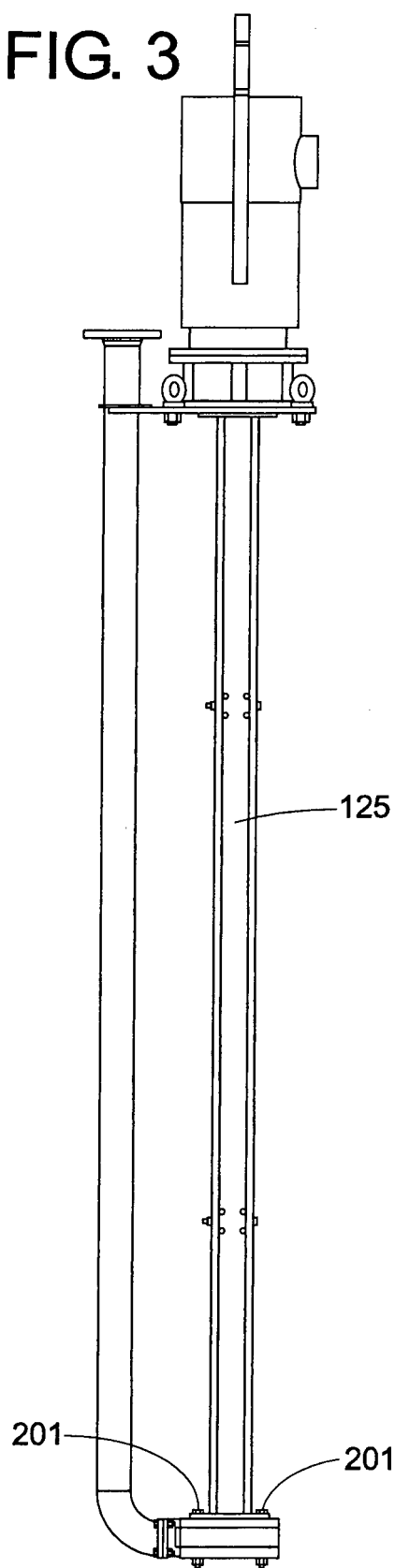
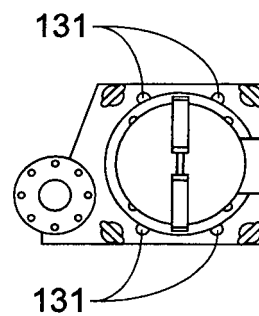


FIG. 4



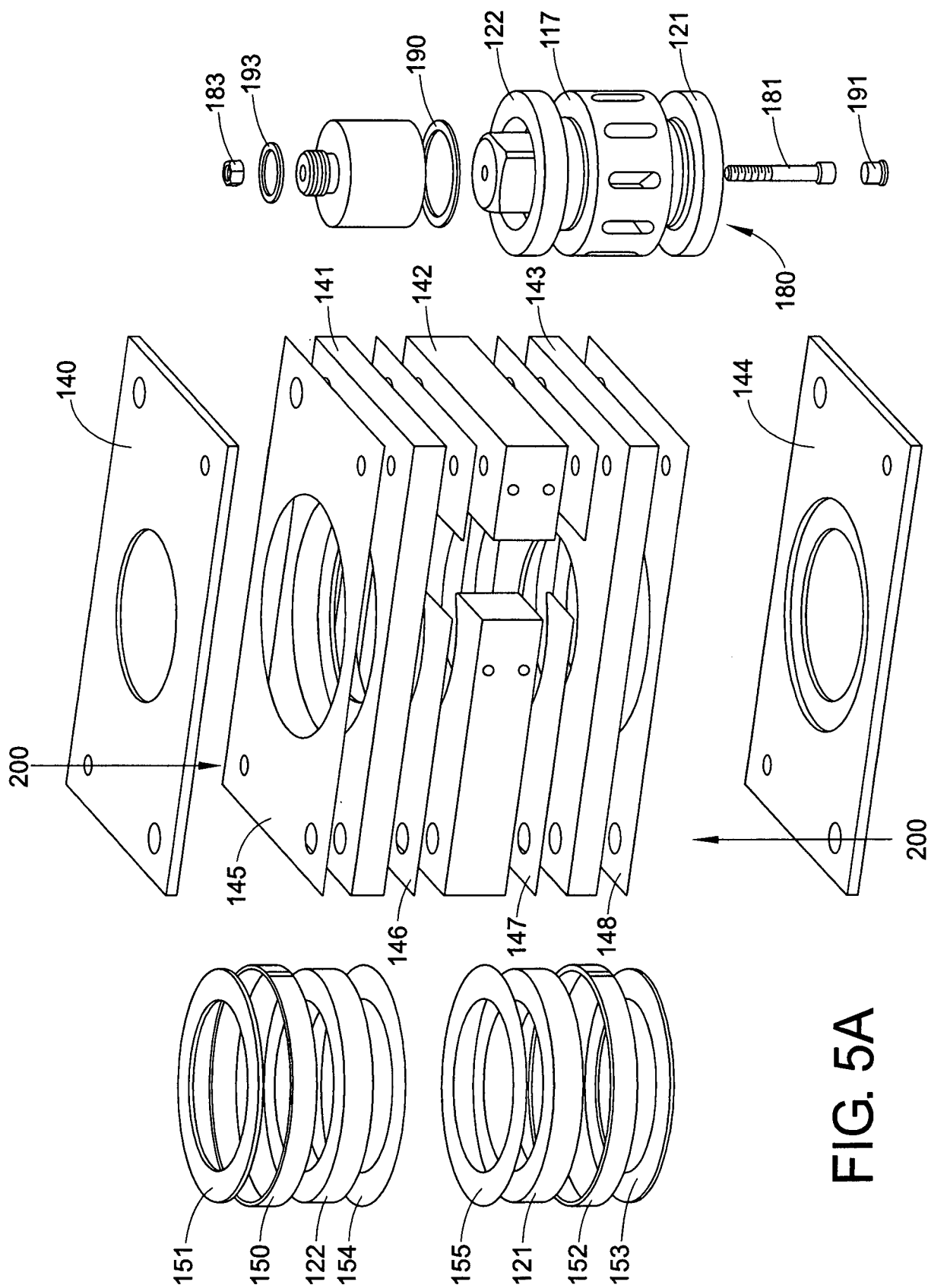


FIG. 5A

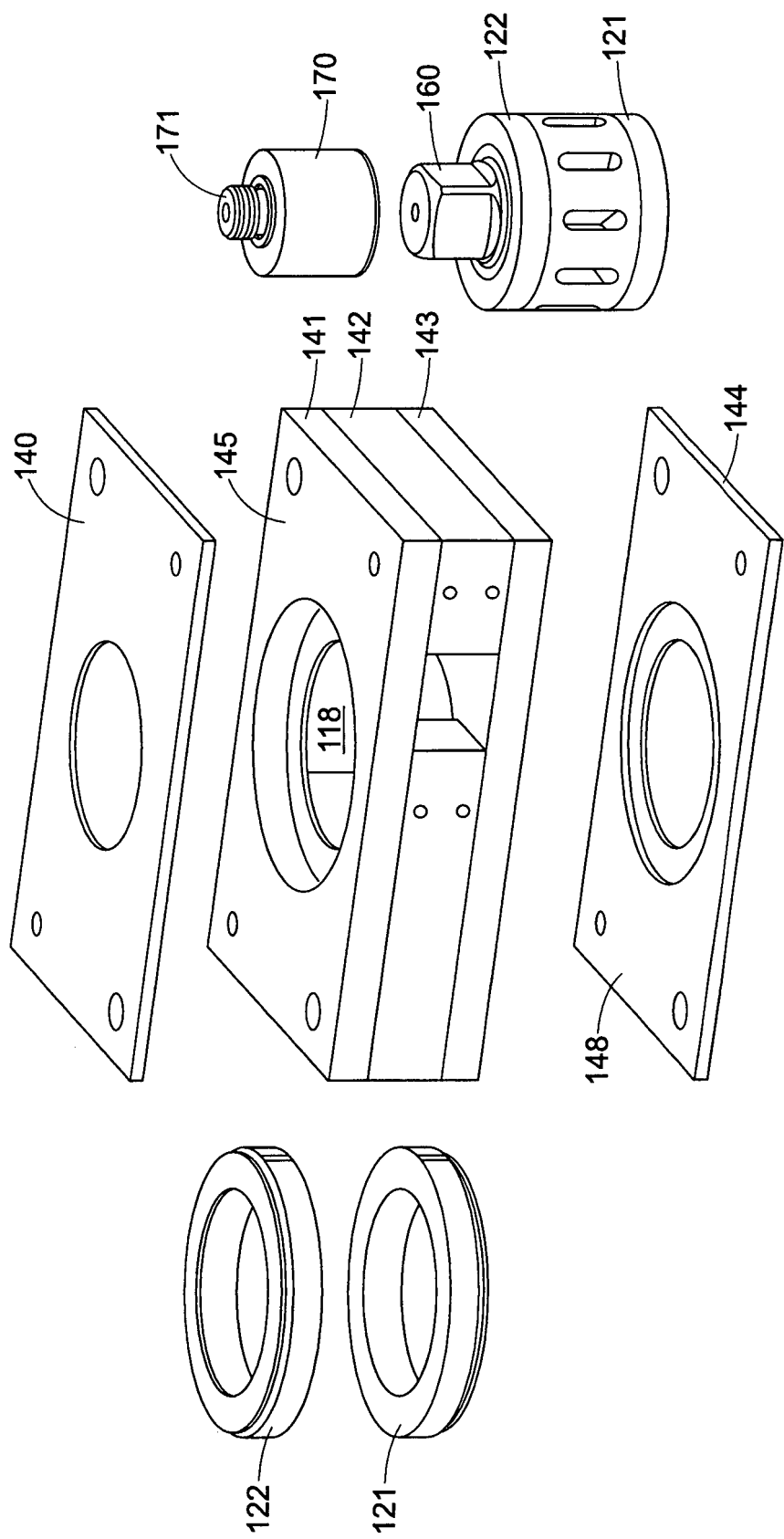


FIG. 5B

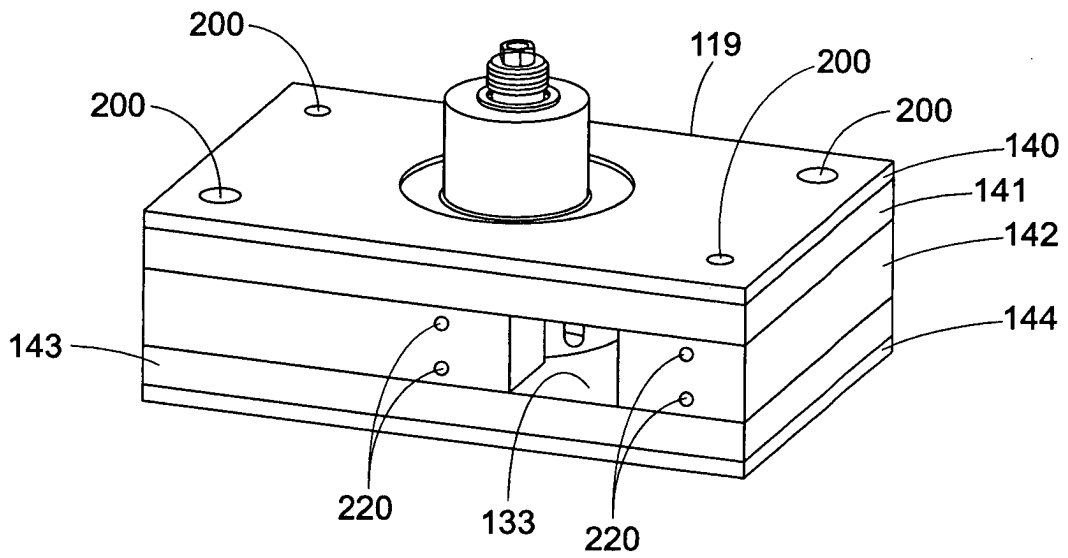


FIG. 5C

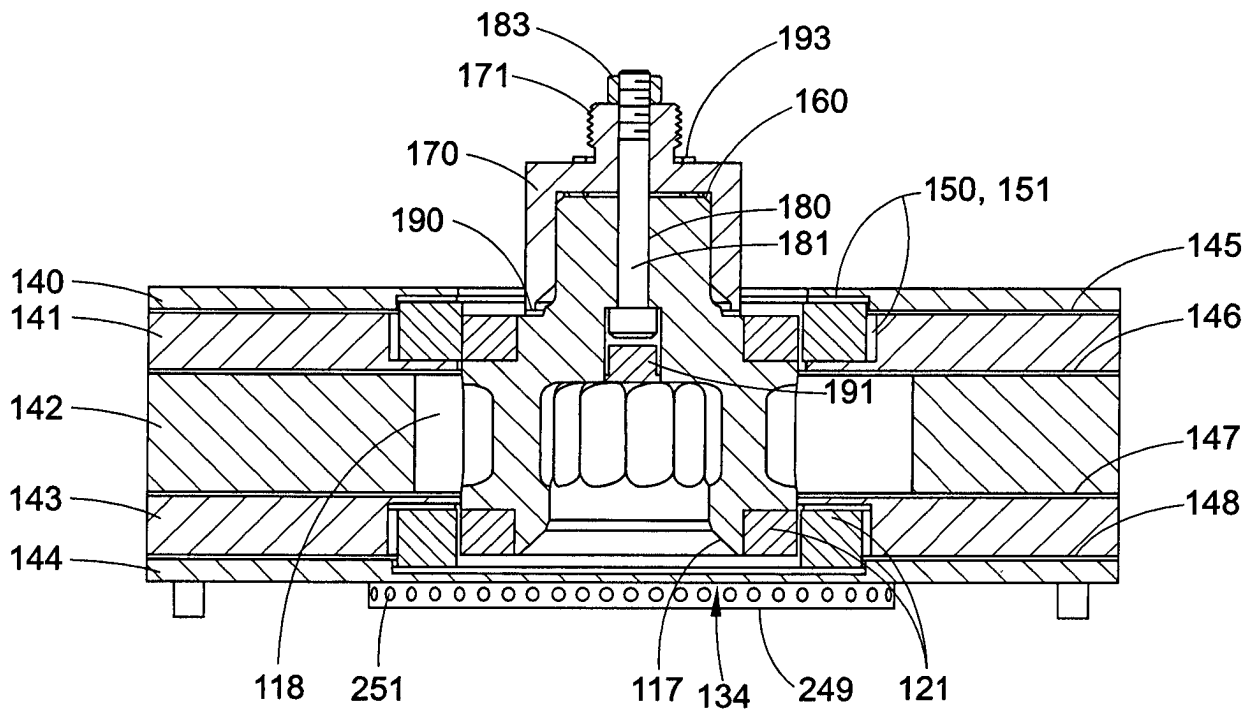


FIG. 6

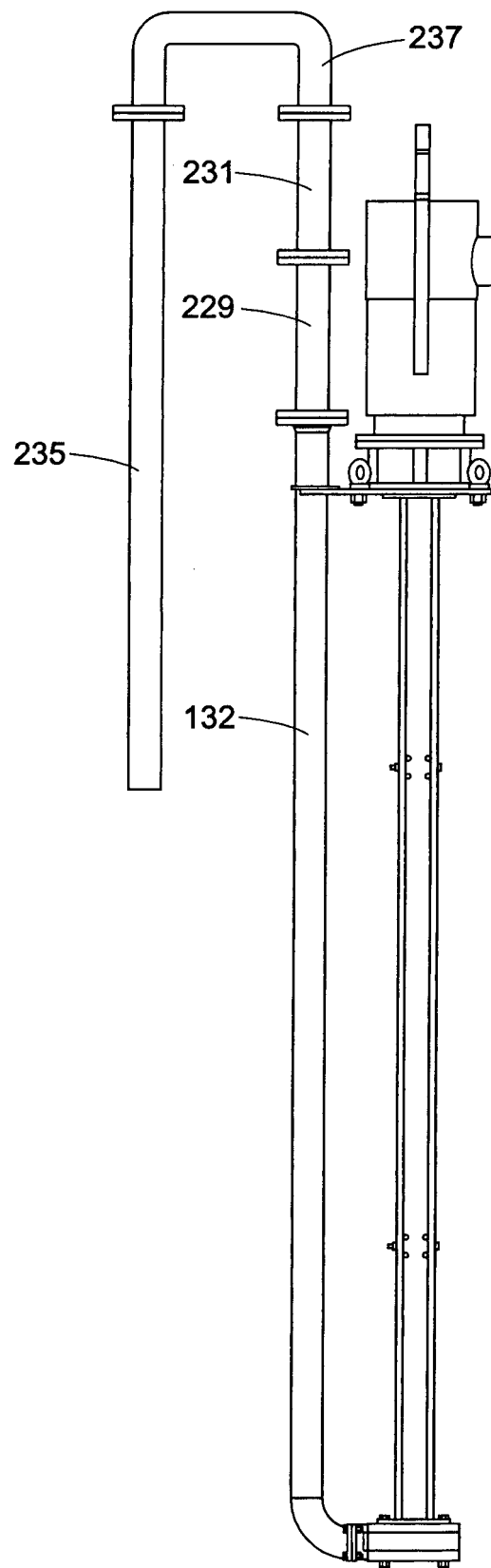


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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