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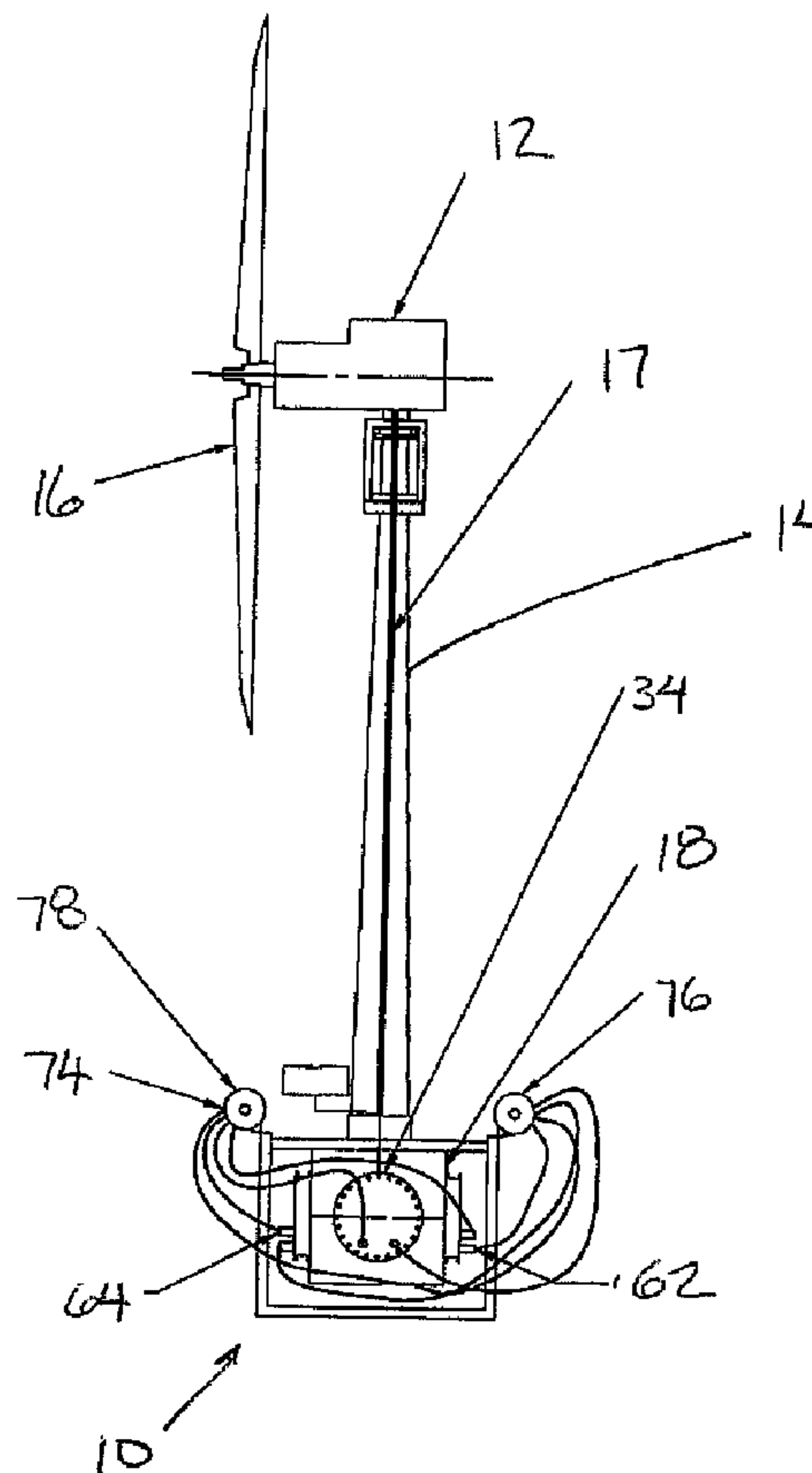
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(54) Titre : POMPE A MEMBRANE RADIALE

(54) Title: RADIAL DIAPHRAGM PUMP



(57) Abrégé/Abstract:

A pump includes a housing, an output member supported for eccentric rotation on a drive shaft of the housing, and a plurality of pumping assemblies supported on the housing about the drive shaft. Each pumping assembly includes a linear sliding pump shaft,

(57) **Abrégé(suite)/Abstract(continued):**

a diaphragm oriented transversely to the shaft in sealing engagement with the housing to define a wall portion of a respective pumping chamber, an inlet check valve, and an outlet check valve. A linkage assembly connects the output member to the pump shafts of the pumping assemblies such that the pump shafts are arranged to be reciprocated along radially oriented axes about the drive shaft in response to rotation of the drive shaft.

ABSTRACT

A pump includes a housing, an output member supported for eccentric rotation on a drive shaft of the housing, and a plurality of pumping assemblies supported on the housing about the drive shaft. Each pumping assembly includes a
5 linear sliding pump shaft, a diaphragm oriented transversely to the shaft in sealing engagement with the housing to define a wall portion of a respective pumping chamber, an inlet check valve, and an outlet check valve. A linkage assembly connects the output member to the pump shafts of the pumping assemblies such that the pump shafts are arranged to be reciprocated along radially oriented axes about
10 the drive shaft in response to rotation of the drive shaft.

RADIAL DIAPHRAGM PUMP

FIELD OF THE INVENTION

The present invention relates to a pump comprising a drive shaft and a plurality of diaphragm assemblies circumferentially spaced about the drive shaft and
5 arranged for reciprocation in a radial direction relative to the drive shaft in response to rotation of the drive shaft.

BACKGROUND

In the field of soil remediation, it is common to use a vacuum pump to extract vapours from the soil, for example hydrocarbon vapours in the soil
10 contaminated in the oil industry and the like. Because soil remediation often occurs in remote locations, it is desirable to drive the vacuum using passive means, for example solar or wind power. Attempts to drive pumps in soil remediation using wind power are described in US patent 6,109,358 by McPhee et al. The efficiency of the conversion of wind power to mechanical pumping is somewhat limited by the use of
15 conventional reciprocating pumps in the prior art.

Various improvements to pumping devices are disclosed in United States Patents 4,963,075 by Albertson and 6,574,537 by Olson; and United States Application Publication No. 2005/0271525 by Muramatsu et al. In the first two noted examples, no means are provided to directly connect the diaphragm of a diaphragm
20 pump to drive shaft which results in some losses of efficiency. In the later document, a cam drive is provided which positively drives outward reciprocation of a plurality of diaphragms, however, there is a loss in efficiency because no means are provided to positively drive the return of the diaphragms.

SUMMARY OF THE INVENTION

25 According to one aspect of the invention there is provided a pump

comprising:

a housing;

a drive shaft supported on the housing for rotation about a drive axis extending in a longitudinal direction of the shaft;

5 an output member supported on the shaft radially offset from the drive axis so as to be arranged for eccentric rotation about the drive axis;

a plurality of pumping assemblies supported on the housing, each pumping assembly comprising:

10 a pump shaft supported for linear sliding movement relative to the housing along a respective pump axis oriented in a radial direction relative to the drive axis;

a diaphragm oriented transversely to the drive axis and being joined in sealing engagement to the housing about a peripheral edge of the diaphragm so as to define a wall portion of a respective pumping chamber;

15 the diaphragm being flexible and being fixed to the pump shaft at an intermediate portion spaced from the peripheral edge such that the intermediate portion of the diaphragm is movable with the pump shaft relative to the housing;

20 an inlet check valve in communication with the pumping chamber so as to be arranged to allow air to be drawn into the pumping chamber only when the pump shaft is displaced in a first direction; and

an outlet check valve in communication with the pumping chamber so as to be arranged to allow air to be expelled from the pumping chamber only when the pump shaft is displaced in a second direction opposite to the first direction; and

25 a linkage assembly connecting the output member to the pump shafts of

the pumping assemblies such that the pump shafts are arranged to be reciprocated in response to rotation of the drive shaft.

By providing a linkage which connects pump shafts to the drive shaft where the pump shafts themselves are directly connected to a portion of the diaphragm, the diaphragms of the pumping assemblies are positively reciprocated throughout the range of motion thereof with a single input rotation of the drive shaft for converting a rotary input to an efficient multi-chamber pumping. The use of pump shafts which are supported for linear sliding movement and coupled to the diaphragms ensures that the diaphragms are isolated from the oscillating movement of the output member of the drive shaft to protect the material of the diaphragms. Any number of pumping assemblies may be provided evenly spaced about the drive axis, for example 3 to 8 diaphragm pumping assemblies can be driven from a single oscillating wheel by the drive shaft. The membranes are preferably reciprocated by floating push rods or links connecting pump shafts of the diaphragms to the oscillating wheel in which only one of the links is fixed to the oscillating wheel to adequately guide the oscillation of the wheel as the drive shaft rotates. The pump shafts act as a precise guiding system which run on ball bearings for optimal efficiency while maintaining adequate support to the membranes. The linkage can be arranged to permit a membrane working diameter in the range of 10 to 30 percent.

The membrane pump described herein comprises a simple and compact radial design with multiple chambers allowing for easy output adjustment. The pump is operable through a wide operating range of 0 – 500 revolutions per minute and through a wide temperature range of -40 to +70 degrees Celsius. The load on the pump is self-adjustable so that no safety valves are necessary. Furthermore, minimum service is required as the membrane guidance system assures longevity

and reliability while remaining environmentally friendly as no lubricants are required.

Preferably the diaphragm of each pumping assembly defines the wall portion at an inner side of the respective pumping chamber such that an exterior side of the diaphragm which faces away from the drive axis is in open communication with
5 the respective pumping chamber.

Preferably the first direction of movement of each pump shaft corresponds to a movement of the pump shaft towards the drive axis and the second direction of movement of each pump shaft corresponds to a movement of the pump shaft away from the drive axis.

10 Preferably interior sides of the respective diaphragms which face inwardly towards the drive axis communicate with a common drive chamber of the housing in which the linkage assembly is located in said common drive chamber of the housing.

Preferably each pump shaft extends radially outward from the
15 intermediate portion of the respective diaphragm to an outer end supported in a sleeve mounted on the housing for linear sliding movement of the pump shaft relative to the sleeve.

Preferably at least one roller bearing is provided in communication between each pump shaft and the respective sleeve.

20 Preferably each pump shaft extends radially outward from an outer side of the respective diaphragm and each diaphragm includes a pivot mount at an inner side of the diaphragm which is connected to the respective pivot shaft through the diaphragm.

Preferably the linkage assembly comprises an oscillating drive member
25 coupled to the output member on the shaft for rotation relative to the output member

about an offset axis of the output member which is parallel to the drive axis and a link member coupled between each pump shaft and the oscillating drive member.

Preferably each link member is pivotally coupled to the respective pump shaft about a link axis oriented parallel to the drive axis.

5 Preferably the link axes are oriented parallel to the drive axis.

Preferably only one of the link members is connected in fixed relation to the oscillating drive member.

Preferably the other link members are pivotally connected to the oscillating drive member.

10 Preferably the pump assemblies are circumferentially spaced apart about the drive axis such that the pump axes of the pump shafts lie in a generally common plane.

Preferably the linkage assembly is coupled between the output member and the pump shafts such that the pump shafts are arranged to be sequentially
15 reciprocated relative to the housing.

Preferably the housing comprises an end wall oriented perpendicularly to the drive axis and supporting the drive shaft rotatably therethrough and a plurality of side walls joined to the end wall so as to define a polygonal perimeter about the drive axis in which each side wall of the polygonal perimeter of the housing supports a
20 respective one of the pumping assemblies therein.

Preferably the pump is provided in combination with a wind turbine assembly having a turbine rotor arranged to be rotated by the wind and an output shaft mechanically coupled to the turbine rotor in which the output shaft is directly mechanically coupled to the drive shaft of the pump.

25 Preferably the turbine rotor is supported on an upright supporting

structure and the output shaft extends vertically between the turbine rotor at a top end of the upright supporting structure and the drive shaft of the pump at a bottom end of the upright supporting structure in which the drive shaft of the pump is coupled to the output shaft of the wind turbine such that the pump shafts extend radially outward
5 from a vertical axis of the output shaft of the turbine.

One embodiment of the invention will now be described in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevational view of the pump connected to a wind
10 turbine.

Figure 2 is a perspective view of a first end of a pump housing.

Figure 3 is a perspective view of an opposing second end of the pump housing with the second end wall shown removed.

Figure 4 is a perspective view of the drive shaft and linkage assembly
15 coupled to the output member of the drive shaft shown separated from the housing.

Figure 5 is a perspective view of the drive shaft and out put member.

Figure 6 is a longitudinal cross-sectional view of the drive shaft.

Figure 7 is an exploded perspective view of one of the pumping
assemblies.

20 Figure 8 is an exploded perspective view of the inlet and outlet check valves of one of the pumping assemblies.

Figure 9 is an exploded perspective view of the connection between the diaphragm and the respective pump shaft.

In the drawings like characters of reference indicate corresponding parts
25 in the different figures.

DETAILED DESCRIPTION

Referring to the accompanying figures there is illustrated a pump generally indicated by reference numeral 10. The pump 10 is well suited for being directly driven by a wind turbine 12.

5 In the illustrated embodiment, the wind turbine comprises an upright mast 14 which supports a turbine rotor 16 at the top end thereof for rotation about a horizontal axis. A vertical output shaft 17 is mechanically coupled to the turbine rotor at the top end and extends vertically the height of the mast between the rotor at the top end and the pump 10 adjacent the bottom end.

10 In an alternative embodiment, the wind turbine may comprise a vertical axis turbine in which the turbine rotor rotates about a vertical axis. The vertical output shaft in this instance is typically directly coupled for rotation together with the rotor about the vertical axis of the rotor.

The pump 10 generally comprises a housing 18 including a first end wall
15 20 formed by a flat plate having a plurality of side edges which define a polygonal perimeter of the housing. The housing 18 further comprises a plurality of side walls 22 joined to the side edges of the first end wall respectively such that the flat plates forming the side walls respectively are oriented perpendicularly to the end wall for surrounding a hollow interior of the housing. The side walls span between the first
20 end wall 20 at one end and a second wall (not shown) at the opposing end to enclose the interior of the housing. In the illustrated embodiment, the end walls are square such that there are four side walls 22 about the square perimeter of the first end wall.

The pump further comprises a drive shaft 24 which is mounted in the first end wall of the housing at a central location thereon so as to extend through the
25 end wall for rotation about a drive axis extending in the longitudinal direction of the

drive shaft perpendicularly to the first end wall and parallel to the side walls. The drive shaft is supported by a sleeve 26 extending through a respective aperture through in the end wall and which is secured to the end wall by a suitable bolt flange 28. The drive shaft 24 is supported for rotation relative to the surrounding sleeve by
5 suitable bearings 30 at axially spaced positions towards opposing ends of the sleeve.

In the illustrated embodiment, the drive shaft 24 is arranged to be directly coupled to the output shaft of the turbine to provide a direct mechanical connection between the turbine rotor and the output shaft of the turbine and in turn between the output shaft and the drive shaft 24 of the pump. In this instance, the
10 drive shaft of the pump is oriented in a vertical orientation in line with the output shaft 17 of the turbine.

Alternatively, the output shaft 17 may be coupled to the drive shaft 24 of the pump by a speed increaser or speed decreaser depending upon the expected wind conditions. In yet further embodiments, a transmission belt, for example a V-
15 belt, may be coupled between pulleys on the output shaft 17 and the drive shaft 24 respectively to transfer the rotation of the output shaft 17 of the turbine to the drive shaft 24 of the pump at a selected ratio based upon the relative diameters of the pulleys.

The drive shaft includes an output member 26 fixed to an inner end of
20 the shaft within the interior of the housing. The output member is offset in a radial direction relative to the drive axis to define an offset axis which is parallel and spaced from the drive axis. Accordingly the output member rotates eccentrically about the drive axis together with rotation of the drive shaft.

The pump 10 further comprises a plurality of pumping assemblies 34
25 which are spaced evenly in a circumferential direction about the drive axis such that

one pumping assembly is supported in each one of the side walls 22 of the housing. Each pumping assembly is arranged for reciprocating movement along a respective pump axis oriented in a radial direction relative to the drive axis such that the pump axes are all located on a common plane which is perpendicular to the drive axis.

5 Each pumping assembly includes a diaphragm 36 comprising a circular member of flexible material which is mounted to span across a respective aperture formed in the side wall 22 of the housing. A peripheral edge of the diaphragm is fixed to the housing about the perimeter of the aperture in the side wall.

 The pumping assembly further comprises an annular member 38 which
10 mounts onto the respective side wall of the housing such that the peripheral edge of the diaphragm is clamped between the annular member and the side wall of the housing about the full perimeter of the diaphragm. A pair of annular gaskets 40 are provided on opposing sides of the diaphragm for sealing between the annular member 38 and the diaphragm as well as sealing between the diaphragm and the
15 housing about the annular perimeter of the diaphragm.

 The annular member 38 defines a cylindrical wall about a central pumping chamber defined by the annular member. The pumping chamber 42 communicates directly with the exterior side of the respective diaphragm such that the diaphragm defines an inner side wall portion of the resulting pumping chamber. The
20 diaphragm spans perpendicularly to the respective pump axis of the pumping assembly.

 A circular plate 44 defines the outer side wall of the cylindrical pumping chamber. The circular plate is rigid and fastened about its periphery to the annular member and in turn to the housing by common fasteners which extend through the
25 circular plate, the annular member and the peripheral edge of the side wall of the

housing about the aperture receiving the diaphragm thereon. An additional o-ring seal 46 is secured between the circular plate and the annular member 38 for sealing engagement therebetween.

Each pumping assembly further comprises a pump shaft 48 supported
5 on the circular plate 44 by a suitable sleeve 50 slidably receiving the pump shaft 48 therein. The sleeve 50 is anchored at an inner end at a central location on the plate 44 using a suitable bolt flange. The sleeve 50 extends outwardly in a radial direction from the drive axis coaxially with the pump axis to an outer end which is enclosed by a threaded cap 52. The pump shaft extends in the longitudinal direction of the sleeve
10 and is supported for linear sliding movement therein by a plurality of roller bearings 54 at circumferentially spaced and longitudinally spaced positions on the shaft adjacent the outer end of the pump shaft. The bearings are moveable with the pump shaft for rolling movement along the inner surface of the sleeve to guide the linear sliding movement of the pump shaft relative to the housing.

15 An inner end of each pump shaft 48 is fixed to a corresponding intermediate portion of the respective diaphragm 36 at a central location thereon. A pair of circular support plates 56 having a diameter which is smaller than the diaphragm are clamped onto opposing sides of the diaphragm at the fixed connection of the pump shaft to the diaphragm to limit excessive flexing of the diaphragm relative
20 to the pump shaft adjacent the connection therebetween. A rigid fastener 58 extends through a central aperture in the diaphragm to clamp the two support plates 56 to opposing sides of the diaphragm and to clamp a rigid mount 60 at the interior side of the diaphragm to the inner end of the pump shaft located at the exterior side of the diaphragm.

25 The diaphragm is formed of flexible material such that the intermediate

portion of the diaphragm coupled to the shaft moves together with the shaft for linear sliding movement along the respective radially oriented pump axis relative to the housing while the peripheral edge of the diaphragm remains clamped in fixed relationship to the housing.

5 Each pumping assembly includes a respective inlet check valve 62 and an outlet check valve 64. Each of the check valves includes a respective valve housing 66 defining a valve chamber therein in alignment with respective openings 68 in the end plate 44 of the respective pumping chamber. A one-way flap valve member 70 overlaps the openings 68 on one side of the plate for allowing
10 communication of air or gasses between the respective valve chamber and the pumping chamber in one direction only.

At the inlet check valve 62, the flap valve member is located at the interior side of the circular plate so that gas can only enter from the valve chamber into the pump chamber but is blocked from exiting the pump chamber therethrough.
15 At the outlet check valve, the flap valve member 70 spans the outer side of the openings in the circular plate so that gas is only permitted to pass from the pumping chamber outwardly to the respective valve chamber.

Suitable o-rings 72 provide sealing engagement between each valve housing 66 and the outer side of the circular plate 44. Tubing 74 joins all of the inlet
20 check valves 62 to a common inlet manifold 76 as well as joining all of the outlet check valves 64 to a common outlet manifold 78.

A linkage assembly connects the output member on the drive shaft to the pump shafts of the pumping assemblies such that the pump shafts are arranged to be reciprocated in response to rotation of the drive shaft. The linkage includes an
25 oscillating drive member 80 which is mounted on the output member for relative

rotation therebetween about the offset axis of the output member. In this manner the oscillating drive member is suited for oscillating movement about the drive axis as the drive shaft is rotated.

5 A plurality of link members are provided in which each link member 82 is coupled between a respective pump shaft and the oscillating drive member. The link member comprises a rigid member supported by a suitable bearing 84 at an outer end for pivotal connection to the rigid mount 60 of the respective diaphragm. The bearing couples the link member for pivotal movement relative to the rigid mount about a link axis oriented parallel to the drive axis.

10 One of the link members 82 has an inner end which is fixed in position and orientation relative to the oscillating drive member. All of the remaining link members 82 have an inner end coupled by a suitable bearing 86 for pivotal movement relative to the oscillating drive member about respective axes which are also oriented parallel to the drive axis.

15 The oscillating drive member and the link members are all located within a common drive chamber defined by the hollow interior of the housing. The interior sides of the diaphragms are open to the common drive chamber as the interior sides face inwardly towards the drive axis.

Each pump shaft is supported to extend generally radially outward from
20 the exterior sides of the respective diaphragms such that each pump shaft is moveable in a first direction inwardly towards the drive axis and in a second direction outwardly away from the drive axis. When displaced in the first direction, the respective pump chamber is expanded such that air or gas is drawn inwardly through the respective inlet check valve. When displaced in the opposing second direction,
25 the corresponding pump chamber at the exterior side of the diaphragm is contracted

such that air or gas is expelled outwardly through the respective outlet check valve.

The linkage couples all of the pump shafts to the oscillating members such that as the oscillating drive member is oscillated eccentrically about the drive axis with an input drive rotation of the drive shaft, all of the pump shafts are
5 reciprocated sequentially to cause a sequential pumping of the pumping assemblies. The joining of the inlets to the common inlet manifold 76 thus provides a relatively continuous suction while the outlets joined to the outlet manifold provide a relatively continuous supply of pumped fluid under pressure.

In the field of soil remediation, one pump and turbine assembly can be
10 provided for connection of the inlet manifold to an underground suction manifold at one location while a second turbine and pump assembly can be provided for connection of the outlet manifold to an underground pressurized manifold at a second location. In this instance, vapours are drawn out at the first location while fresh air is pumped into the second location.

15 Since various modifications can be made in my invention as herein above described, and many apparently widely different embodiments of same made within the spirit and scope of the claims without department from such spirit and scope, it is intended that all matter contained in the accompanying specification shall be interpreted as illustrative only and not in a limiting sense.

CLAIMS:

1. A pump comprising:
 - a housing;
 - a drive shaft supported on the housing for rotation about a drive axis
 - 5 extending in a longitudinal direction of the drive shaft;
 - an output member supported on the drive shaft radially offset from the drive axis so as to be arranged for eccentric rotation about the drive axis;
 - a plurality of pumping assemblies supported on the housing, each pumping assembly comprising:
 - 10 a pump shaft supported for linear sliding movement relative to the housing along a respective pump axis oriented in a radial direction relative to the drive axis;
 - a diaphragm oriented transversely to the drive axis and being joined in sealing engagement to the housing about a peripheral edge of the
 - 15 diaphragm so as to define a wall portion of a respective pumping chamber;
 - the diaphragm being flexible and being fixed to the pump shaft at an intermediate portion spaced from the peripheral edge such that the intermediate portion of the diaphragm is movable with the pump shaft relative to the housing;
 - an inlet check valve in communication with the pumping chamber
 - 20 so as to be arranged to allow air to be drawn into the pumping chamber only when the pump shaft is displaced in a first direction; and
 - an outlet check valve in communication with the pumping chamber so as to be arranged to allow air to be expelled from the pumping chamber only when the pump shaft is displaced in a second direction opposite to the first
 - 25 direction; and

a linkage assembly connecting the output member to the pump shafts of the pumping assemblies such that the pump shafts are arranged to be reciprocated in response to rotation of the drive shaft.

2. The pump according to Claim 1 wherein the diaphragm of each
5 pumping assembly defines the wall portion at an inner side of the respective pumping chamber such that an exterior side of the diaphragm which faces away from the drive axis is in open communication with the respective pumping chamber.

3. The pump according to Claim 2 wherein the first direction of movement of each pump shaft corresponds to a movement of the pump shaft towards
10 the drive axis and the second direction of movement of each pump shaft corresponds to a movement of the pump shaft away from the drive axis.

4. The pump according to any one of Claims 1 through 3 wherein interior sides of the respective diaphragms which face inwardly towards the drive axis communicate with a common drive chamber of the housing, the linkage assembly
15 being located in said common drive chamber of the housing.

5. The pump according to any one of Claims 1 through 4 wherein each pump shaft extends radially outward from the intermediate portion of the respective diaphragm to an outer end supported in a sleeve mounted on the housing for linear sliding movement of the pump shaft relative to the sleeve.

20 6. The pump according to Claim 5 wherein there is provided at least one roller bearing in communication between each pump shaft and the respective sleeve.

7. The pump according to any one of Claims 1 through 6 wherein each pump shaft extends radially outward from an outer side of the respective
25 diaphragm and wherein each diaphragm includes a pivot mount at an inner side of the

diaphragm which is connected to the respective pivot shaft through the diaphragm.

8. The pump according to any one of Claims 1 through 7 wherein the linkage assembly comprises an oscillating drive member coupled to the output member on the shaft for rotation relative to the output member about an offset axis of the output member which is parallel to the drive axis and a link member coupled
5 between each pump shaft and the oscillating drive member.

9. The pump according to Claim 8 wherein each link member is pivotally coupled to the respective pump shaft about a link axis oriented parallel to the drive axis.

10. The pump according to Claim 9 wherein the link axes are oriented parallel to the drive axis.

11. The pump according to Claim 8 wherein only one of the link members is connected in fixed relation to the oscillating drive member.

12. The pump according to Claim 11 wherein the other link members
15 are pivotally connected to the oscillating drive member.

13. The pump according to any one of Claims 1 through 12 wherein the pump assemblies are circumferentially spaced apart about the drive axis such that the pump axes of the pump shafts lie in a generally common plane.

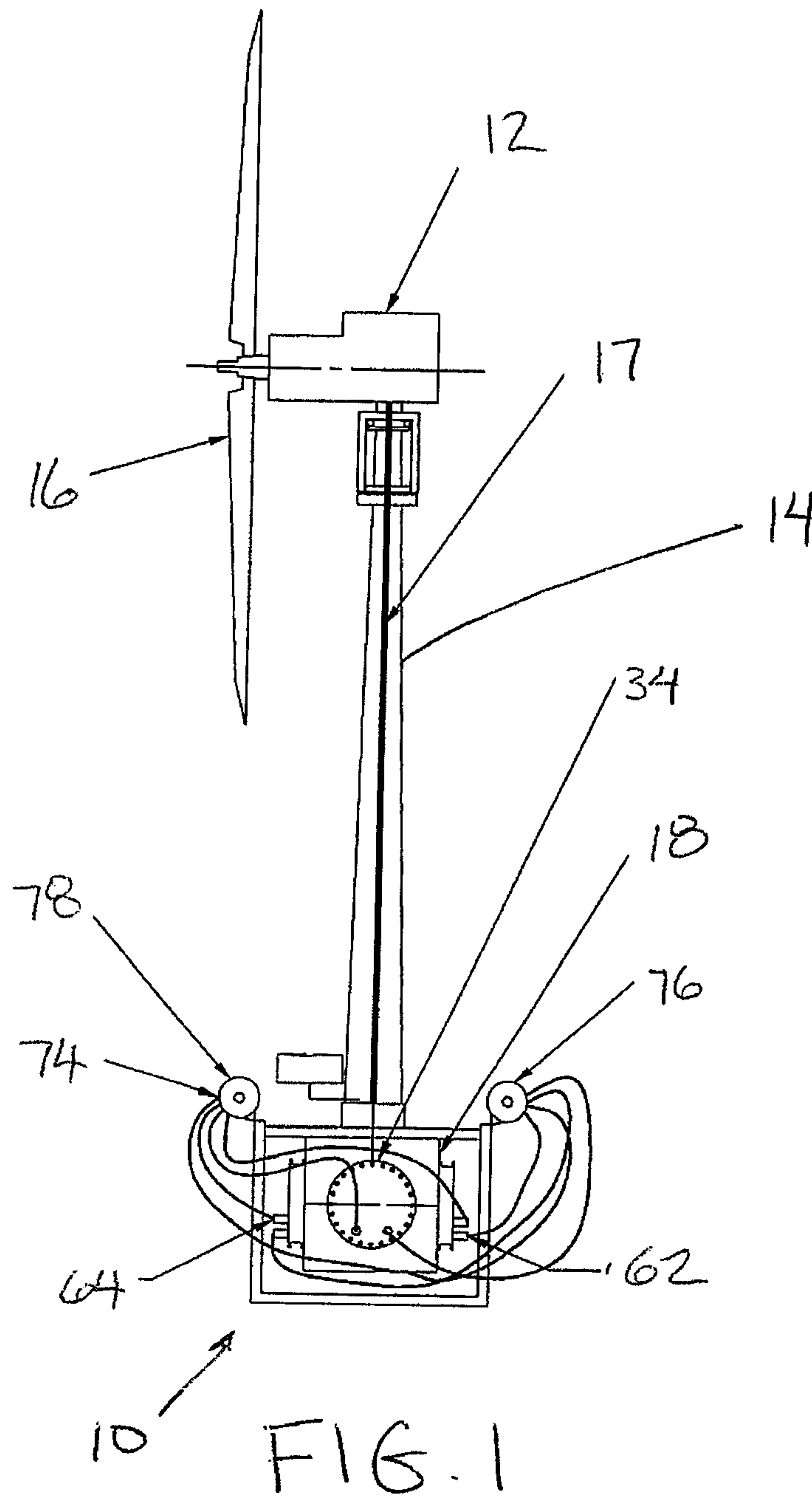
14. The pump according to any one of Claims 1 through 13 wherein
20 the linkage assembly is coupled between the output member and the pump shafts such that the pump shafts are arranged to be sequentially reciprocated relative to the housing.

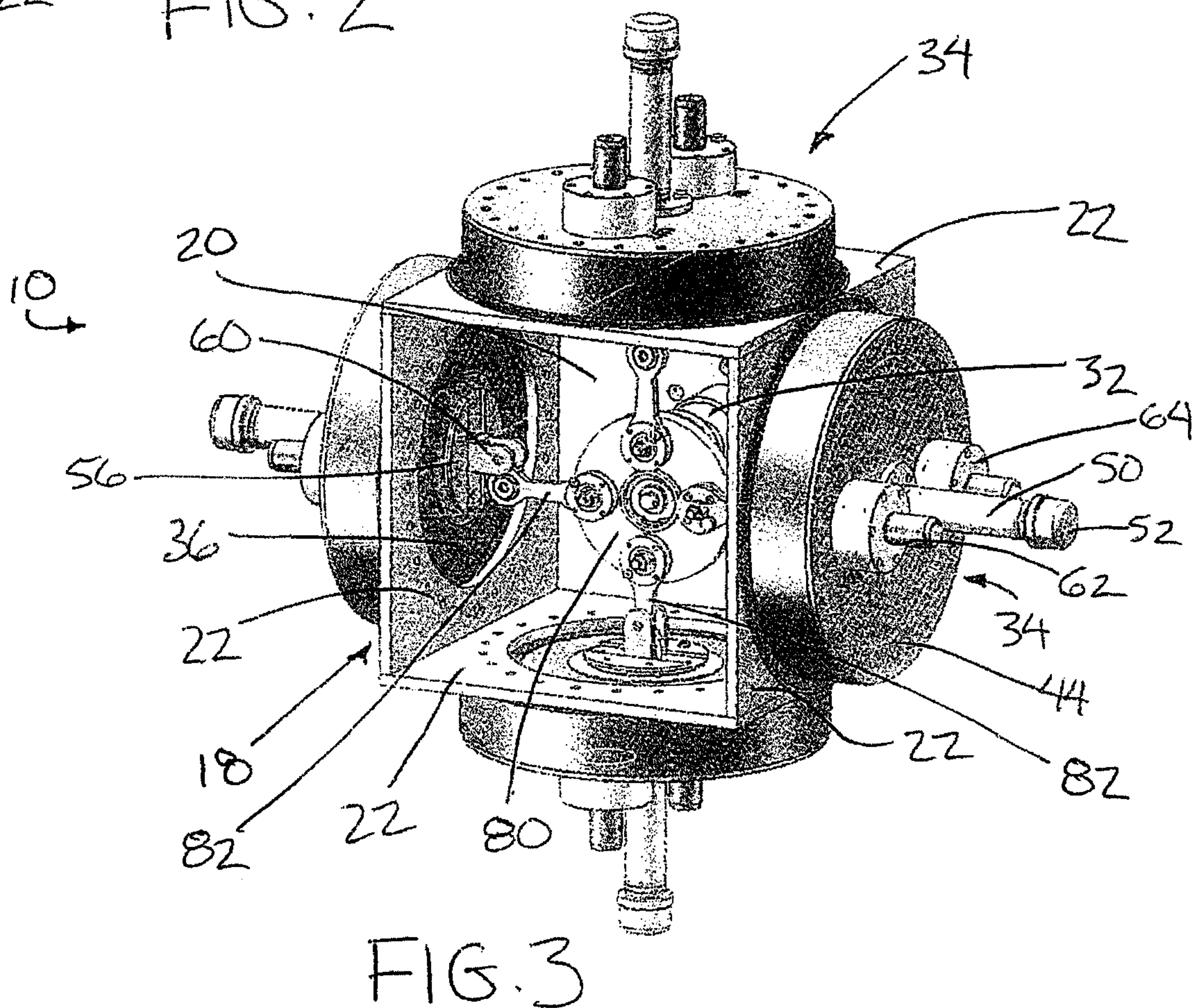
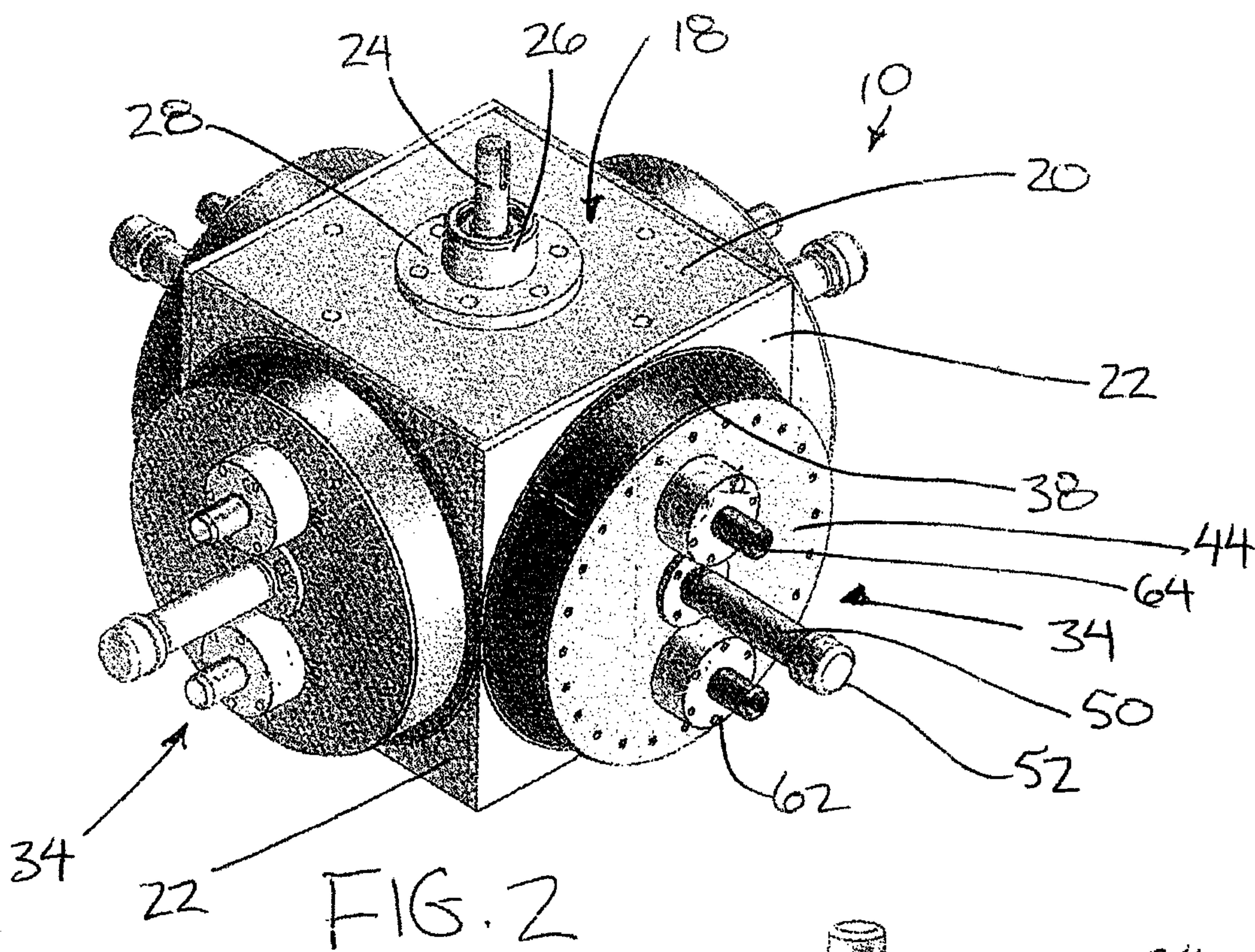
15. The pump according to any one of Claims 1 through 14 wherein the housing comprises an end wall oriented perpendicularly to the drive axis and
25 supporting the drive shaft rotatably therethrough and a plurality of side walls joined to

the end wall so as to define a polygonal perimeter about the drive axis, each side wall of the polygonal perimeter of the housing supporting a respective one of the pumping assemblies therein.

16. The pump according to any one of Claims 1 through 15 in
5 combination with a wind turbine assembly having a turbine rotor arranged to be rotated by the wind and an output shaft mechanically coupled to the turbine rotor, the output shaft being directly mechanically coupled to the drive shaft of the pump.

17. The pump according to Claim 16 wherein the turbine rotor is
supported on an upright supporting structure and the output shaft extends vertically
10 between the turbine rotor at a top end of the upright supporting structure and the drive shaft of the pump at a bottom end of the upright supporting structure, the drive shaft of the pump being coupled to the output shaft of the wind turbine such that the pump shafts extend radially outward from a vertical axis of the output shaft of the turbine.





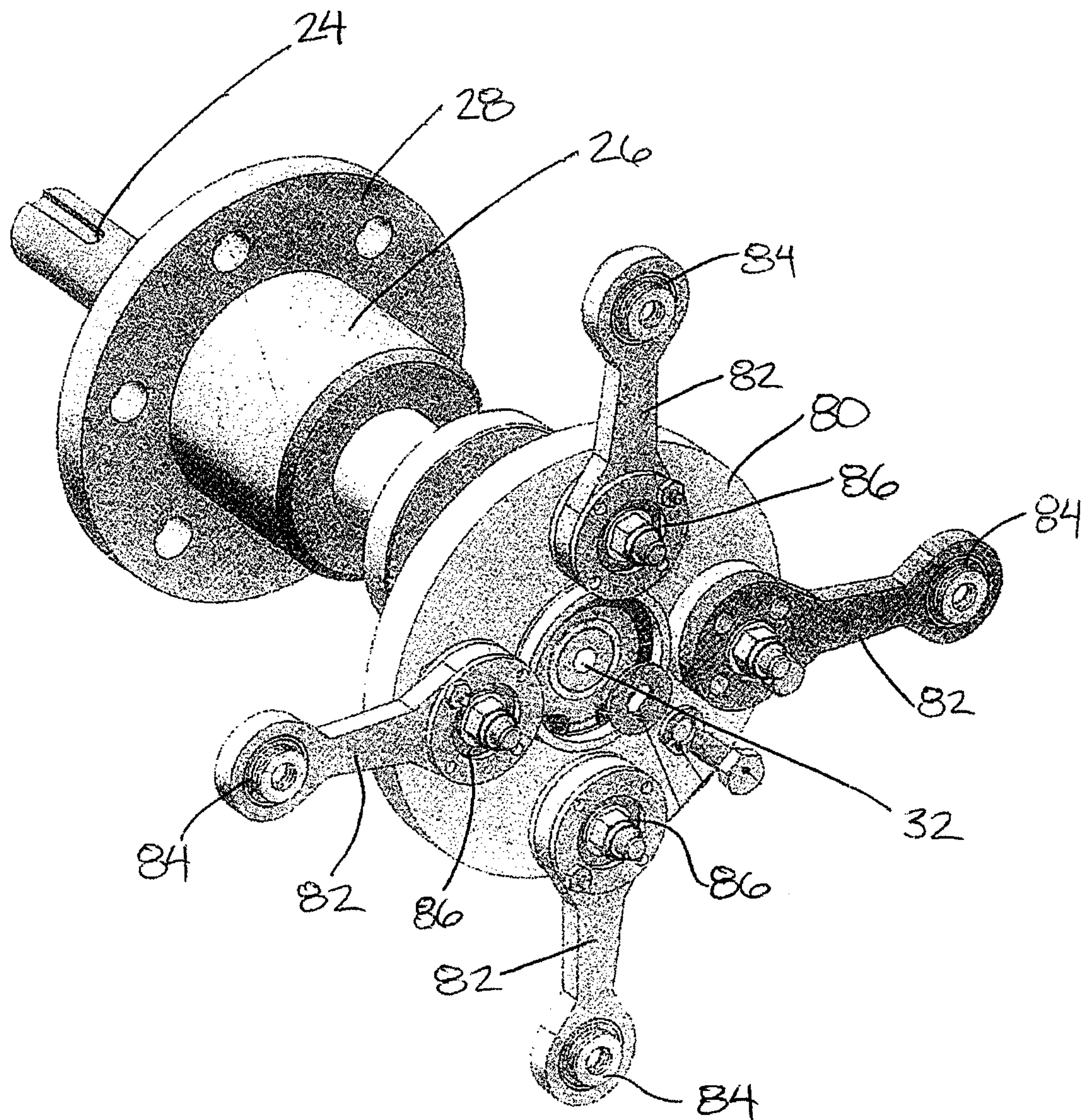


FIG.4

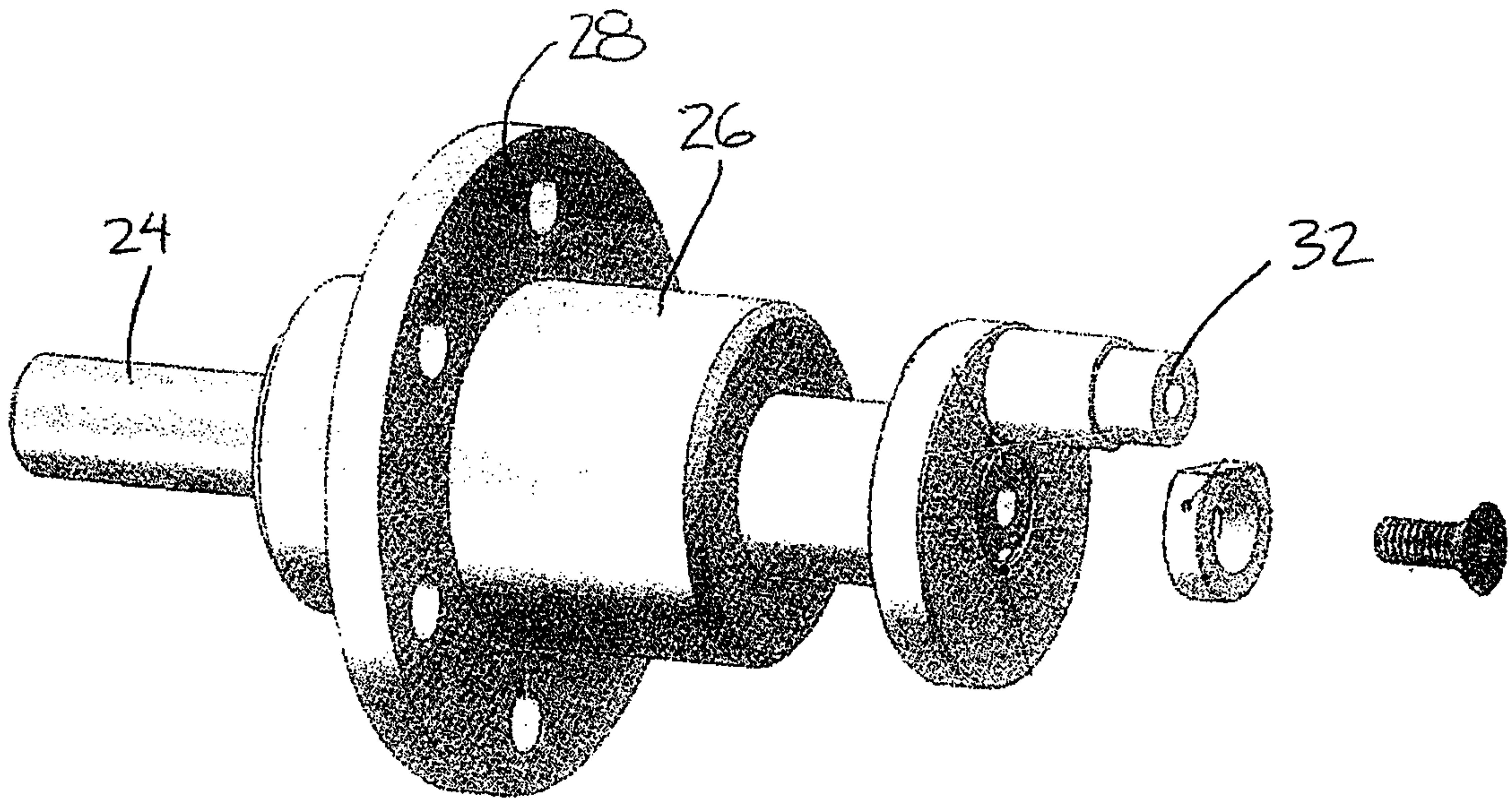


FIG. 5

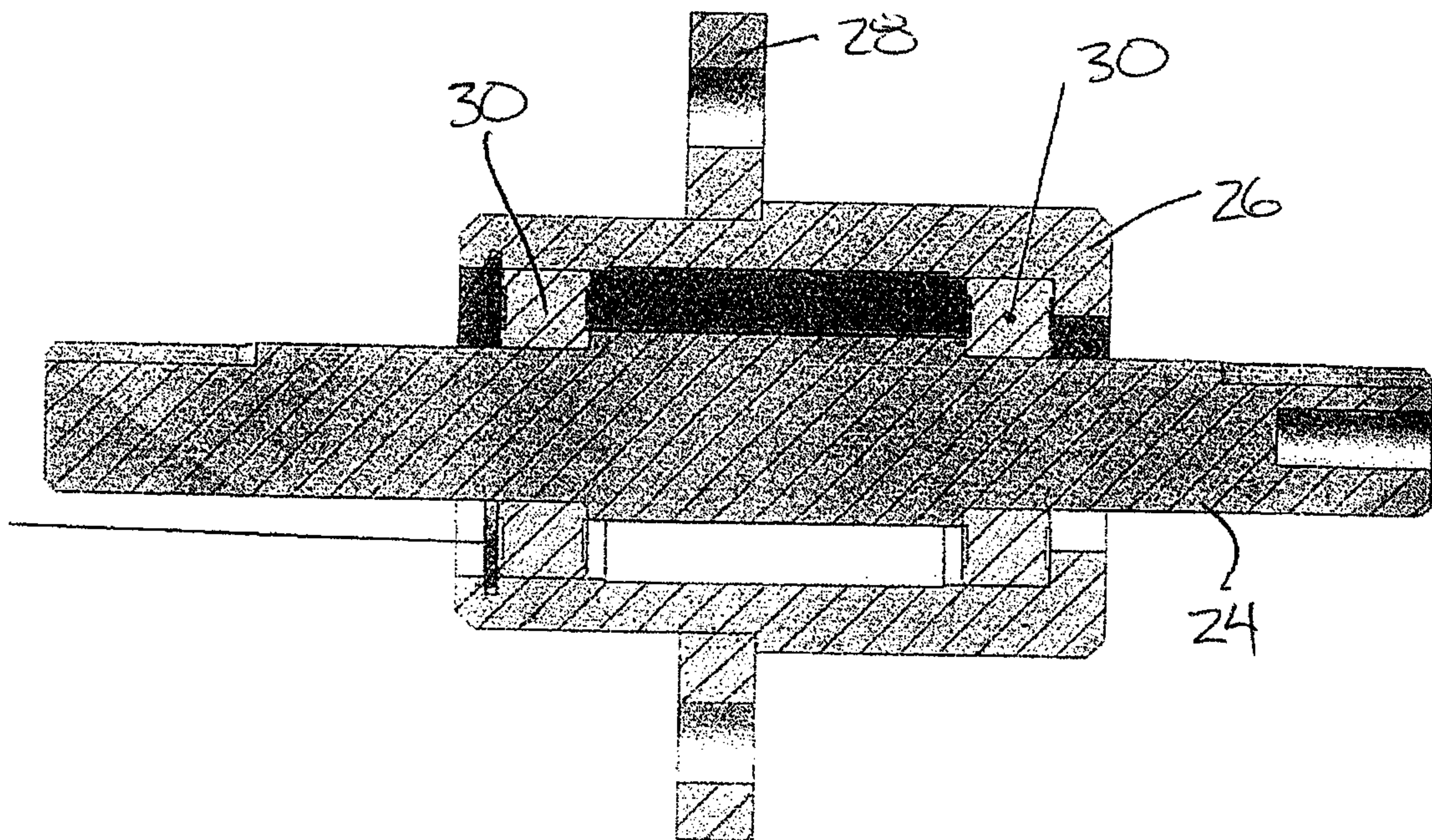


FIG. 6

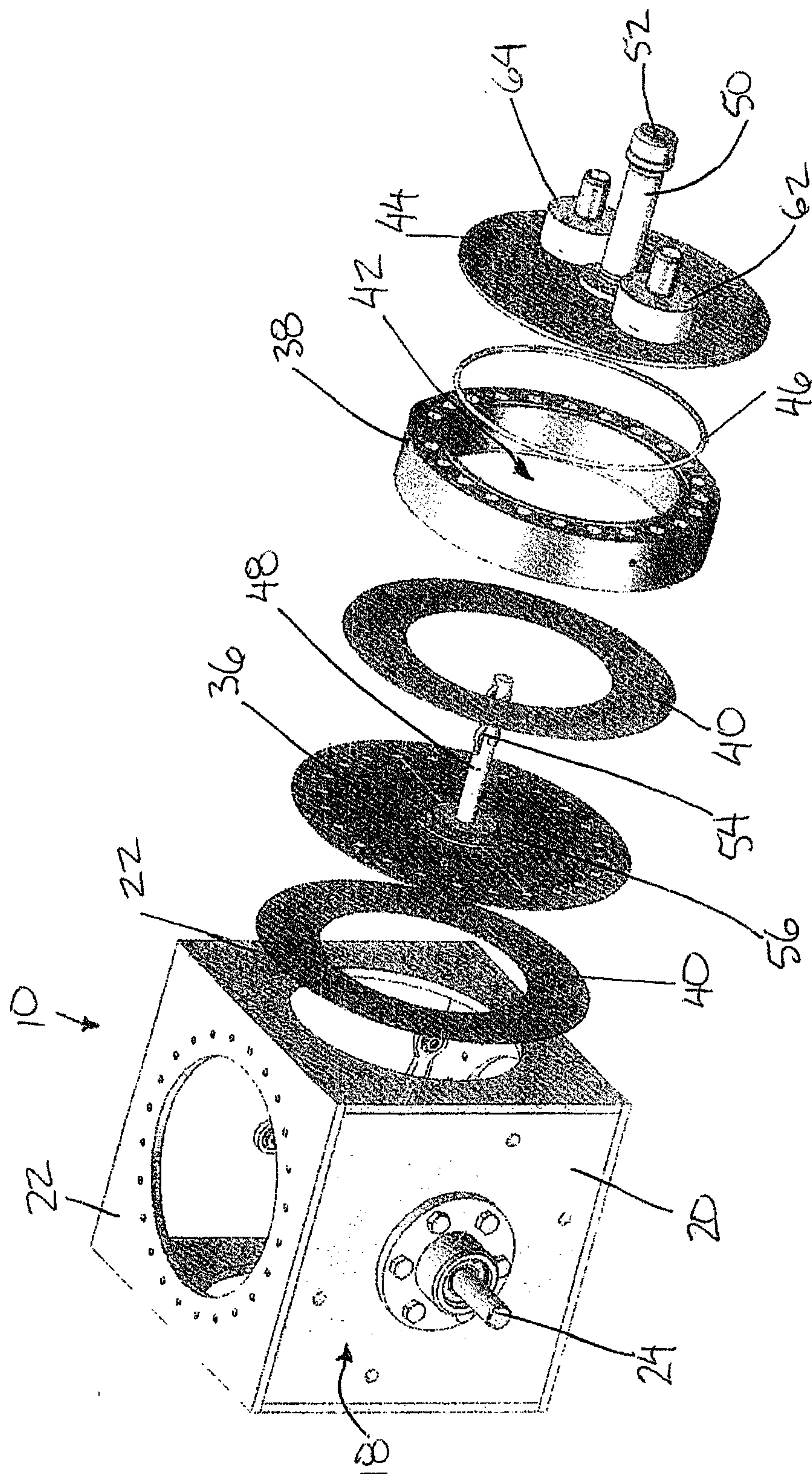


FIG. 7

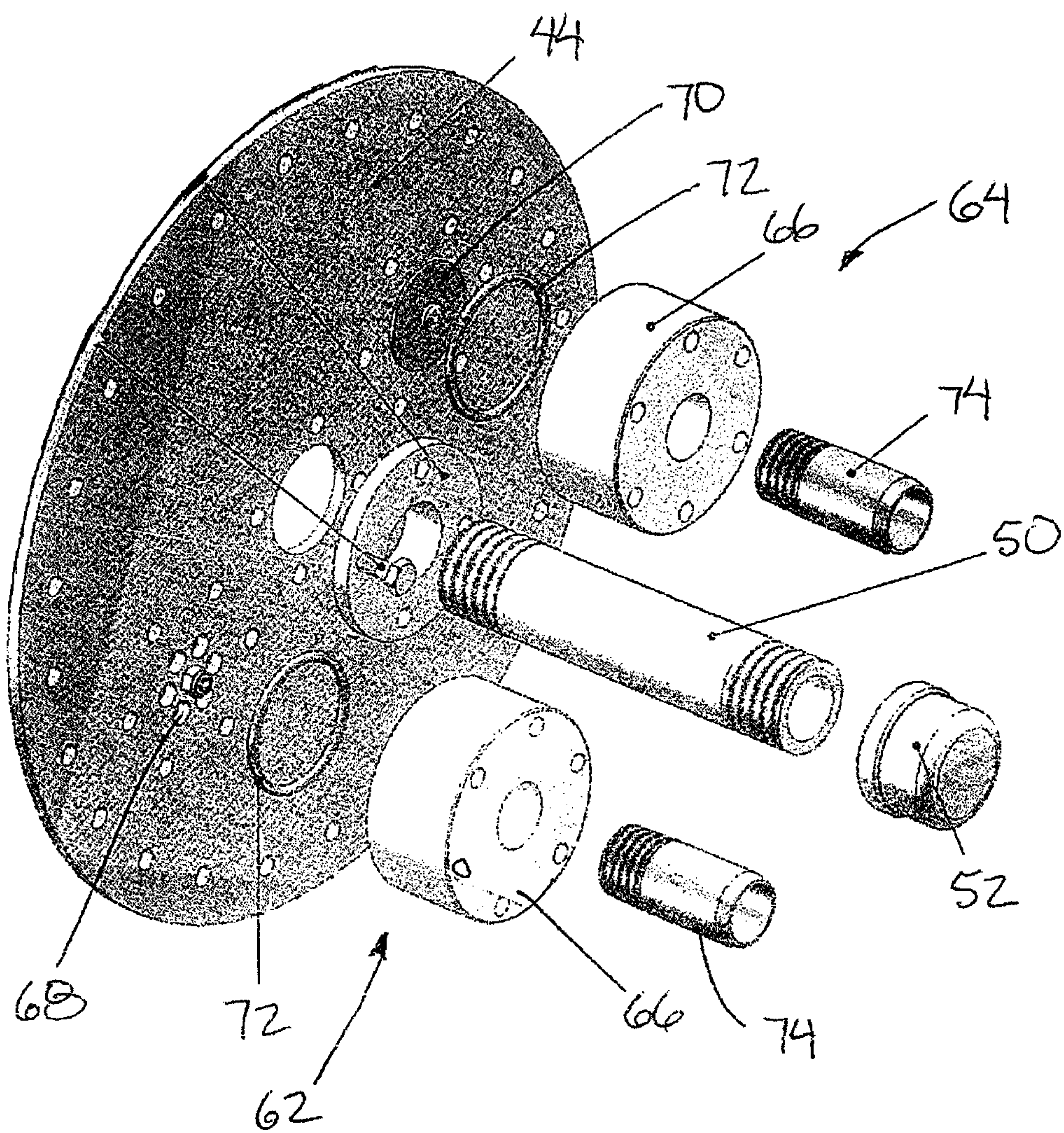


FIG. 8

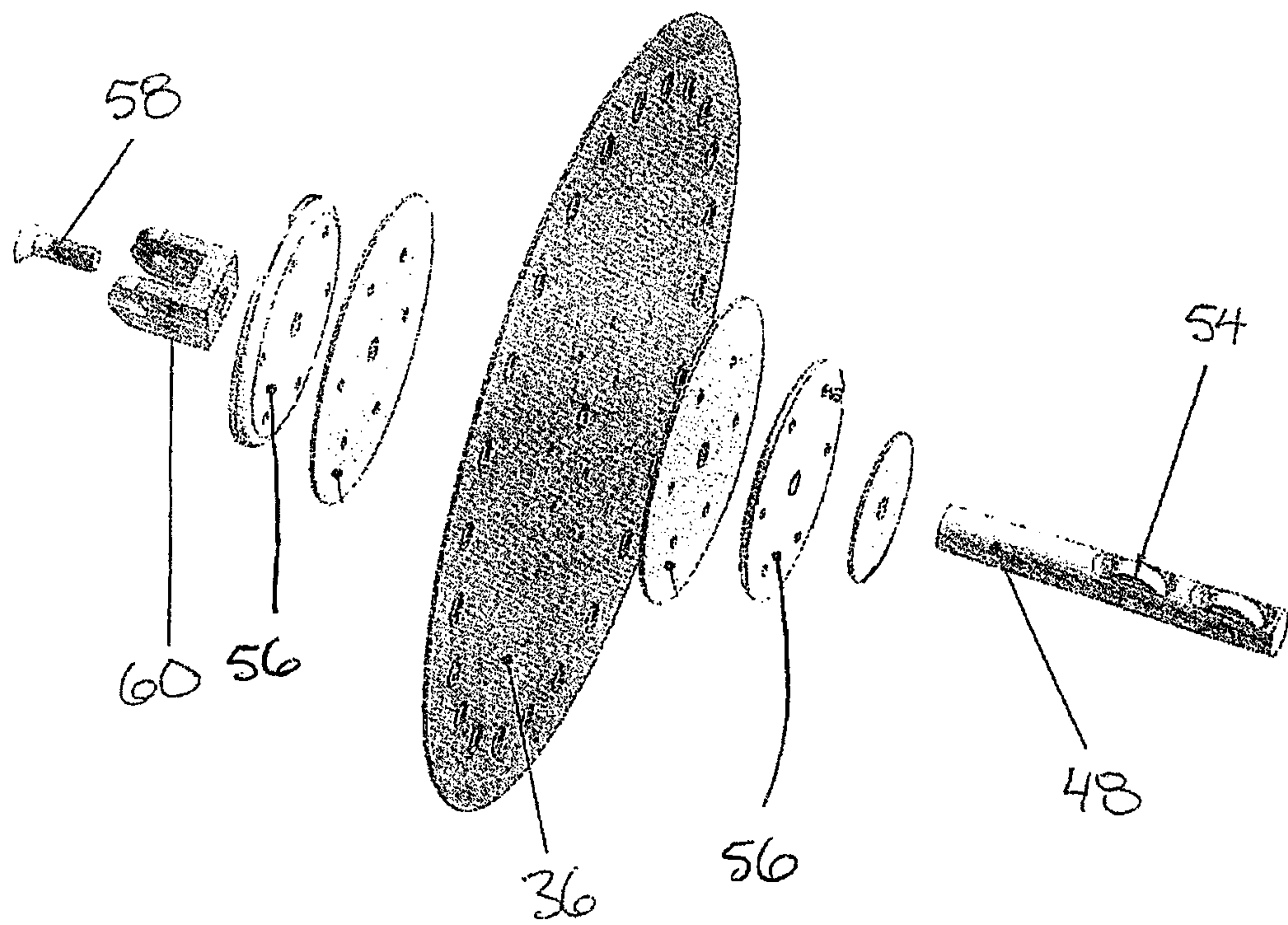


FIG. 9

