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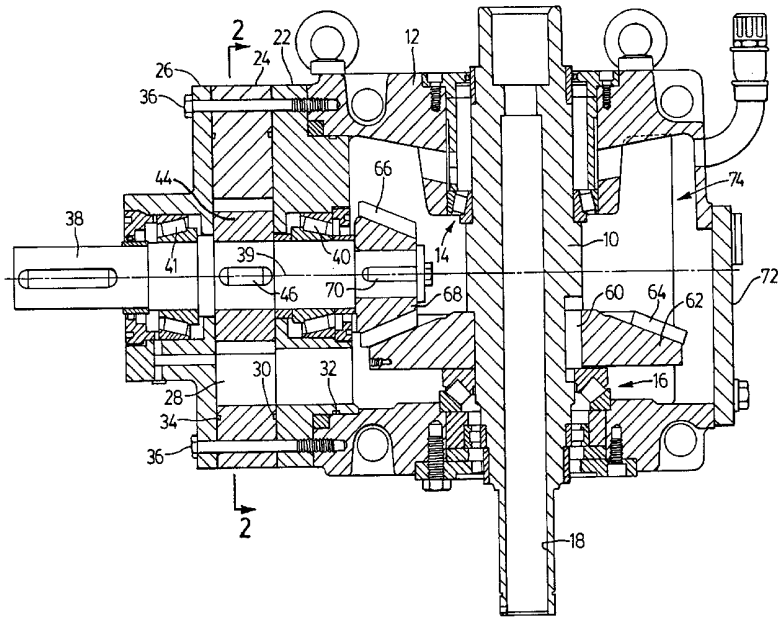
(54) Title: TRANSMISSION FOR DEEP WELL PUMP



(57) Abstract: A braking mechanism for avoiding a too sudden release of twist energy stored in a rod string on shut down or power failure, includes a gear pump which incorporates two meshing pinion gears that define a first and a second chamber within the gear pump cavity. A liquid pathway leads from the first chamber to the second chamber and contains flow-restricting means such as a nozzle or valve. The pinion gears are mounted such that pumping takes place only in one direction, namely from the first chamber, through the liquid pathway, and back to the second chamber. Reverse rotation of the pinion gears produces no pumping action.

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TRANSMISSION FOR DEEP WELL PUMP

FIELD OF THE INVENTION

This invention relates generally to the oil production industry, and has to do particularly with improving the safety of rotary downhole pumps, particularly upon shut down or power failure.

BACKGROUND OF THE INVENTION

In the past, many conventional oil wells were operated by a downhole pump at or close to the bottom of the well, the pump being of a conventional reciprocating kind actuated by a rod string, in turn reciprocated vertically by a pump jack.

Many of these older reciprocating pumps have been recently replaced by rotary-drive progressive cavity pumps. Such rotary pumps are particularly suited for the production of crude oil laden with sand and water.

However, because of the typical depth of an oil well, the torque applied at the top of the rod string, and the resistance of the pump at the bottom, can cause the rod string to wind up like a spring, thus storing the torque energy. Whenever there is a power failure or the system is shut down, this stored torque energy, along with the energy created by the fluid head on the pump, must release itself. Without any control on the rate of backspin of the rod string, serious problems have occurred. The problems tend to be as follows:

- the motor, connected to the rod string through a reducer and a sheave and pulley arrangement, may reach reverse speeds exceeding safe limits. These speeds tend to damage the motor, and can even cause it to explode.
- one or both of the sheaves can reach speeds exceeding their limits.

- on drive configurations in which the polish rod extends out the top of the drive, the projecting portion can bend and break, and the broken-off portion will then be flung away from the installation, due to centrifugal force.
- without some form of braking, the rod string could uncouple, with the result that the rod string and the pump would be lost down the hole.

BACKGROUND ART

Document WO-88/07126, filed on March 11, 1988 and published on September 22, 1988, discloses a pumping system in which a downhole pump has a rotor which is rotated by the bottom end of a rod string of which the top end is in turn rotated by torque energy derived from a prime mover, and in which twist energy is stored in the rod string during operation. A braking mechanism is provided for avoiding a too sudden release of the twist energy in the rod string on shut down or power failure. The said braking mechanism involves a complex and expensive housing holding a centrifugal brake with weight members frictionally engaging the chamber wall when the rotational speed reaches a sufficiently high level, thus retarding the rotation of the shaft.

Also of interest is U.S. patent 4,797,075, issued January 10, 1989, which discloses a progressive cavity well pump with an overspeed brake to protect the gear box during reverse rotation. A power source rotates an input shaft of the gear box, which, through a right angle drive, drives a string of rods extending down to the pump. A centrifugal brake is mounted to the input shaft. If the pump locks up, the power source will impart energy to the rods by twisting them until the power source reaches its limit. When the rods start to unwind, the centrifugal brake will engage to dissipate energy and slow the speed of the reverse rotation.

Also of interest is GB 2210931 which discloses an engine braking system having a power-absorbing gear pump which includes an outlet from

which oil passes to an outlet bore by way of an opening controlled by a piston. When braking is required, a switching valve is closed and pressure builds up in a bore behind the piston by way of the bore in the piston head. The pressure behind the piston is controlled by an adjustable pressure-setting valve and acts on a greater area of the piston than the area of the opening. Thus the opening is reduced to increase the output oil pressure and therefore the braking torque. The maximum outlet pressure is governed by a limit valve.

All of the latter mechanisms are complex, expensive and unwieldy, and there is a need for a simpler and more reliable design.

GENERAL DESCRIPTION OF THIS INVENTION

In view of the foregoing, it is an object of one aspect of this invention to provide a braking mechanism for use with a rotary pumping system.

More particularly, there is provided, for use with a pumping system in which a downhole pump has a rotor which is rotated by the bottom end of a rod string of which the top end extends substantially vertically, said top end being rotated by torque energy derived from a prime mover, wherein twist energy is stored in the rod string during operation:

a braking mechanism for avoiding a too sudden release of said twist energy in the rod string on shut down or power failure, in which the braking mechanism comprises:

a) means defining a gear pump cavity, the cavity having a periphery and being filled with a liquid,

b) two meshing pinion gears mounted for rotation about axes within said cavity, the gears acting like a gear-pump for moving liquid between a first chamber and a second chamber within said cavity,

c) a liquid pathway separate from the cavity for conducting pressurized liquid from said first chamber to said second

chamber, the pathway having flow-restricting means for restraining excessive gear speeds,

d) one pinion gear being connected to rotate with the top end of the rod string, and the other pinion gear receiving torque power directly from a source of rotary power, whereby only a single pair of pinion gears is required,

e) the pinion gears being so located with respect to each other and to the cavity periphery that the gear pump constituted by the meshing rotating gears 1) fails to pump liquid via the pathway between the chambers when the rod string rotates in the direction corresponding to normal pumping operation, and 2) pumps liquid past the flow-restricting means via the pathway from said second chamber to said first chamber when the rod string rotates in the direction opposite to that of normal pumping operation,

f) whereby if the stored energy in the rod string is suddenly released, the energy is dissipated in a controlled manner.

Additionally, this invention provides a method of operating a pumping system which utilizes a downhole pump that includes a stator and a rotor, a rod string having a top end and a bottom end, the latter being connected to, supporting and rotating said rotor, and a prime mover providing torque energy for rotating said top end, said method comprising the steps:

operating said prime mover to rotate the top end of the rod string so that said bottom end rotates the said rotor, whereby twist energy is stored in the rod string during operation, and

causing said stored twist energy to release in a slow and controlled manner upon shut down or power failure,

characterized in that:

the latter step of causing controlled release of said twist energy is accomplished by

a) rotating a pinion gear within a liquid-filled gear-pump cavity proportionately with respect to the speed and direction of rotation of the top end of the rod string, the cavity also containing a further pinion gear meshing with the first-mentioned pinion gear, the teeth of each pinion gear passing adjacent the periphery of the cavity at locations spaced from the meshing location, thereby defining first and second chambers within the cavity, the chambers being separated by the interposition of the pinion gears, the cavity and contained pinion gears constituting a partial gear pump which, due to the spacing of the pinion teeth from the cavity periphery, can pump cavity-contained liquid only into the first chamber and only when the pinion gears are rotating in the directions opposite their directions for normal operation of the down-hole pump,

b) when the rod string rotates in the direction opposite that for normal operation, causing the pinion gears to pump liquid into the first chamber,

c) passing the liquid from the first chamber along a liquid pathway back to said second chamber, the pathway being separate from the cavity and having flow-restricting means which restrains excessive gear speeds.

GENERAL DESCRIPTION OF THE DRAWINGS

One embodiment of this invention is illustrated in the accompanying drawings, in which like numerals denote like parts throughout the several views, and in which:

Figure 1 is an axial sectional view through a braking mechanism;

Figure 2 is a sectional view taken at the line 2-2 in Figure 1;

Figure 3 is a sectional view taken at the line 3-3 in Figure 2;

Figure 4 is an axial sectional view to a particular embodiment of the braking mechanism, which derives power from a hydraulic motor;

Figure 4B is a sectional view taken at the line B-B in Figure 4;

Figure 5 is an axial sectional view through a further embodiment of the braking mechanism, representing a direct drive configuration;

Figure 5B is a sectional view taken at the line B-B in Figure 5;

Figure 6 is an axial sectional view through an embodiment of the braking mechanism, representing the gear reduction configuration; and

Figure 6B is a sectional view taken at the line B-B in Figure 6.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring firstly to Figure 1, representing an earlier development, a sleeve 10 is mounted for rotation within a frame 12, by way of an upper tapered roller bearing 14 and a lower tapered roller bearing 16. The construction of the various portions associated with the mounting of the sleeve 10 is conventional, and requires no further discussion.

The sleeve 10 has an internal bore 18 adapted to receive the upper end of the polish rod, and means are supplied (not illustrated) for supporting the weight of the rod from the sleeve 10.

Leftwardly adjacent the leftward edge of the frame 12 there are provided, in sequence: a first wall member 22, a periphery member 24, and a second wall member 26. The members 22, 24 and 26 together define a gear pump cavity 28 which is sealed by virtue of annular seals 30, 32 and 34. The "sandwich" comprising the members 22, 24 and 26 is clamped together with the leftward portion of the frame 12 by virtue of a plurality of machine bolts 36.

A short shaft 38 is mounted for rotation about an axis 39 at right angles to the axis of the bore 18, through two tapered roller bearings 40 and 41, respectively in contact with the wall member 22 and the wall member 26. A first pinion gear 44 is secured to the shaft 38 by a key 46, and meshes with a smaller pinion gear 48 as clearly pictured in Figure 2. Both of the gears 44 and 48 are located within the gear pump cavity 28 which is approximately kidney-shaped.

It will be noted that the gears 44 and 48 divide the cavity 28 into a first chamber 50 and a second chamber 52. The line 54 represents a liquid pathway, separate from the cavity 28, for conducting liquid from the first chamber 50 back to the second chamber 52, and a device identified by the numeral 56 constitutes flow-restricting means for limiting the flow along the pathway 54.

Attention is now directed to the specific positioning of the pinion gears 44 and 48 within the cavity 28. Firstly, it will be noted that the two pinion gears 44 and 48 are in close mesh with each other (i.e. along the section line 3-3). However, the teeth of both gears have their crowns spaced away from the curvilinear periphery of the cavity 28, the spacing increasing with greater distance away from the first chamber. With this arrangement and spacing, it is found that the gear pump constituted by the two pinions is able to pump liquid only into the first chamber 50. They cannot, by reversing the rotational direction, pump liquid into the second chamber 52.

The apparatus just described is arranged such that, when the rod string is rotating in the normal direction for pumping oil and other liquids from the bottom of the well, the larger pinion gear 44 rotates in the clockwise direction so that no liquid is pumped into the larger chamber 52. In effect, the two pinions 44 and 48 simply rotate in their own oil, without any pumping taking place, during normal well-pumping operation. However in the event of backspin taking place, in which the rod string rotates in the opposite direction, the gear pump constituted by the pinions 44 and 48 builds up pressure within the first chamber 50, thus forcing liquid through the flow-restricting device 56, along the pathway 54, and back into the second chamber 52. This allows the rod string to unwind in a controlled way. The tolerances between the pinion gears 44 and 48 and the periphery of the cavity 28 are such as to avoid the build-up of heat.

Figure 1 illustrates the connection between the sleeve 10 and the shaft 38. Secured to the sleeve 10 by a key 60 is an annular flange 62 supporting teeth 64 which are on a sloping or bevelled surface. The teeth 64 mesh with

the teeth 66 of a further bevel gear, achieving a ratio of approximately 2:1. The bevel gear 68 is keyed to the shaft 38 by the key 70.

A door 72 allows access to the internal space 74 housing the bevel gear 62, the door 72 being secured to appropriate portions of the frame 12 which do not require any further description.

The braking mechanism described above removes stored energy built up in the rod string as a result of normal operation. The rod string tends to be very long, and during operation it coils up similar to a spring. After the initial energy release from the rod string, the fluid column in the production tubing will have built up a pressure head acting on the pump. This in turn "motors" the pump and again makes the drive string turn in reverse. Thus, under both conditions of reverse string rotation, the brake mechanism herein described will serve to control the speed.

Three further developments of the above constructions are illustrated in Figures 4, 5 and 6. In all of these embodiments, there is only a single pair of pinion gears which always mesh with each other. In Figure 4, a hydraulic motor 101 is connected to directly drive a shaft 104. In Figure 5, a direct drive configuration is shown, and in Figure 6 a gear reduction configuration is illustrated. It will be seen that the brake details for the three further developments are the same as that described with reference to Figures 1, 2 and 3. The main difference is that the drive can be used in three variations and involves only a single set of meshing gears. The gears are used to drive the main shaft and also function as the hydraulic pump, thus eliminating the gear pump in the right angled gear drive described at the beginning of this description.

While one embodiment of this invention has been illustrated in the accompanying drawings and described hereinabove, it will be evident to those skilled in the art that changes and modifications may be made therein, without departing from the essence of this invention, as set forth in the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. For use with a pumping system in which a downhole pump has a rotor which is rotated by the bottom end of a rod string of which the top end extends substantially vertically, said top end being rotated by torque energy derived from a prime mover, wherein twist energy is stored in the rod string during operation:

a braking mechanism for avoiding a too sudden release of said twist energy in the rod string on shut down or power failure, in which the braking mechanism comprises:

a) means defining a gear pump cavity, the cavity having a periphery and being filled with a liquid,

b) two meshing pinion gears mounted for rotation about axes within said cavity, the gears acting like a gear-pump for moving liquid between a first chamber and a second chamber within said cavity,

c) a liquid pathway separate from the cavity for conducting pressurized liquid from said first chamber to said second chamber, the pathway having flow-restricting means for restraining excessive gear speeds,

d) one pinion gear being connected to rotate with the top end of the rod string, and the other pinion gear receiving torque power directly from a source of rotary power, whereby only a single pair of pinion gears is required,

e) the pinion gears being so located with respect to each other and to the cavity periphery that the gear pump constituted by the meshing rotating gears 1) fails to pump liquid via the pathway between the chambers when the rod string rotates in the direction corresponding to normal pumping operation, and 2) pumps liquid past the flow-restricting means via the pathway

from said second chamber to said first chamber when the rod string rotates in the direction opposite to that of normal pumping operation,

f) whereby if the stored energy in the rod string is suddenly released, the energy is dissipated in a controlled manner.

2. The mechanism claimed in claim 1, in which the pitch-circle radius of said one pinion gear is substantially twice as large as that of the other pinion gear, and in which the axes are substantially parallel.

3. The mechanism claimed in claim 1, in which the flow-restricting means is a reduced orifice, , and in which the axes are substantially parallel.

4. The mechanism claimed in claim 1, in which the flow-restricting means is an adjustable valve, and in which the axes are substantially parallel.

5. A method of operating a pumping system which utilizes a downhole pump that includes a stator and a rotor, a rod string having a top end and a bottom end, the latter being connected to, supporting and rotating said rotor, and a prime mover providing torque energy for rotating said top end, said method comprising the steps:

operating said prime mover to rotate the top end of the rod string so that said bottom end rotates the said rotor, whereby twist energy is stored in the rod string during operation, and

causing said stored twist energy to release in a slow and controlled manner upon shut down or power failure,

characterized in that:

the latter step of causing controlled release of said twist energy is accomplished by

a) rotating a pinion gear within a liquid-filled gear-pump cavity proportionately with respect to the speed and direction of

rotation of the top end of the rod string, the cavity also containing a further pinion gear meshing with the first-mentioned pinion gear, the teeth of each pinion gear passing adjacent the periphery of the cavity at locations spaced from the meshing location, thereby defining first and second chambers within the cavity, the chambers being separated by the interposition of the pinion gears, the cavity and contained pinion gears constituting a partial gear pump which, due to the spacing of the pinion teeth from the cavity periphery, can pump cavity-contained liquid only into the first chamber and only when the pinion gears are rotating in the directions opposite their directions for normal operation of the down-hole pump,

b) when the rod string rotates in the direction opposite that for normal operation, causing the pinion gears to pump liquid into the first chamber,

c) passing the liquid from the first chamber along a liquid pathway back to said second chamber, the pathway being separate from the cavity and having flow-restricting means which restrains excessive gear speeds.

6. The method claimed in claim 5, in which the pitch-circle radius of said first-mentioned pinion gear is substantially twice as large as that of the other pinion gear, and in which the axes are substantially parallel.

7. The method claimed in claim 5, in which the flow-restricting means is a reduced orifice, and in which the axes are substantially parallel.

8. The method claimed in claim 5, in which the flow-restricting means is an adjustable valve, and in which the axes are substantially parallel.

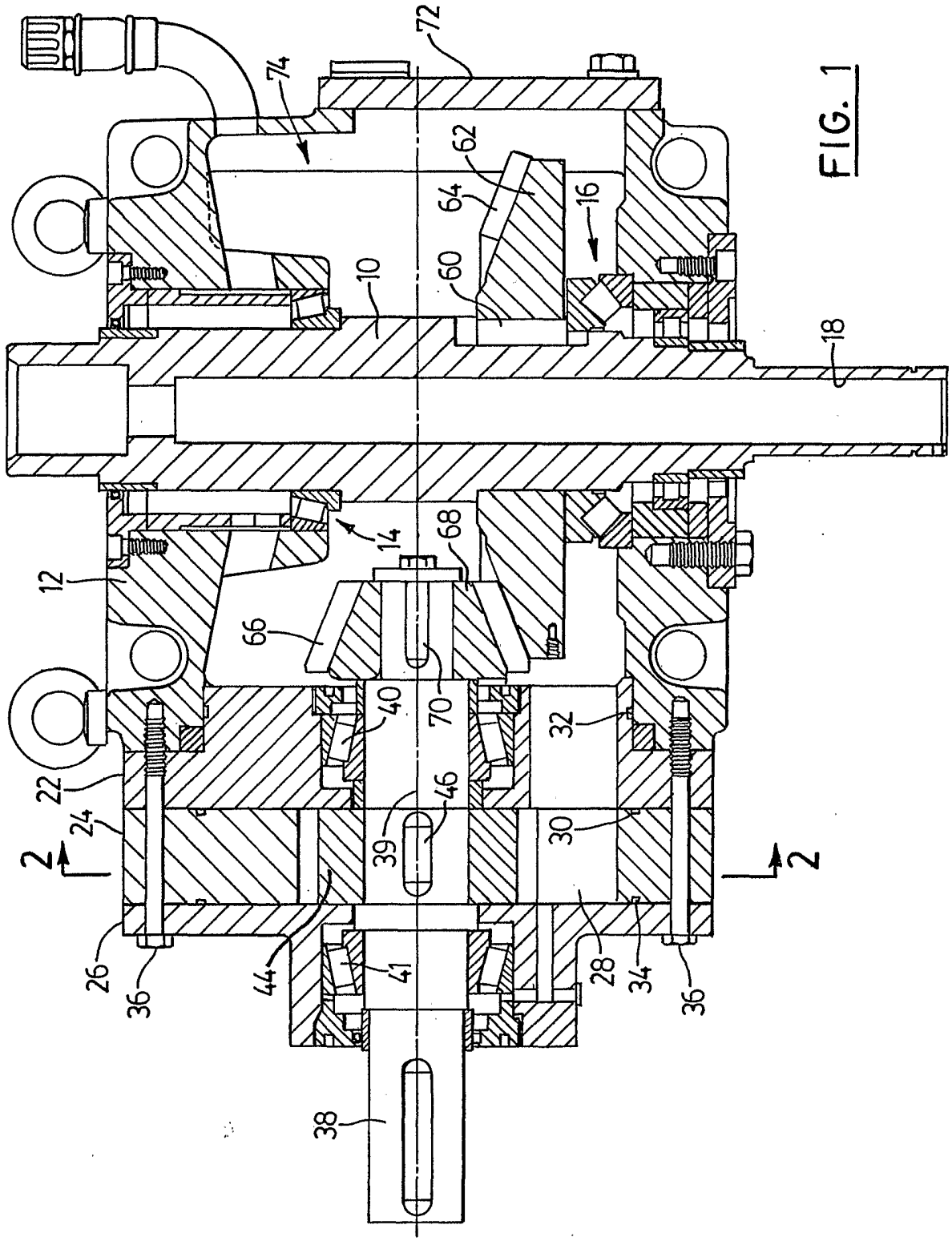
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FIG. 1

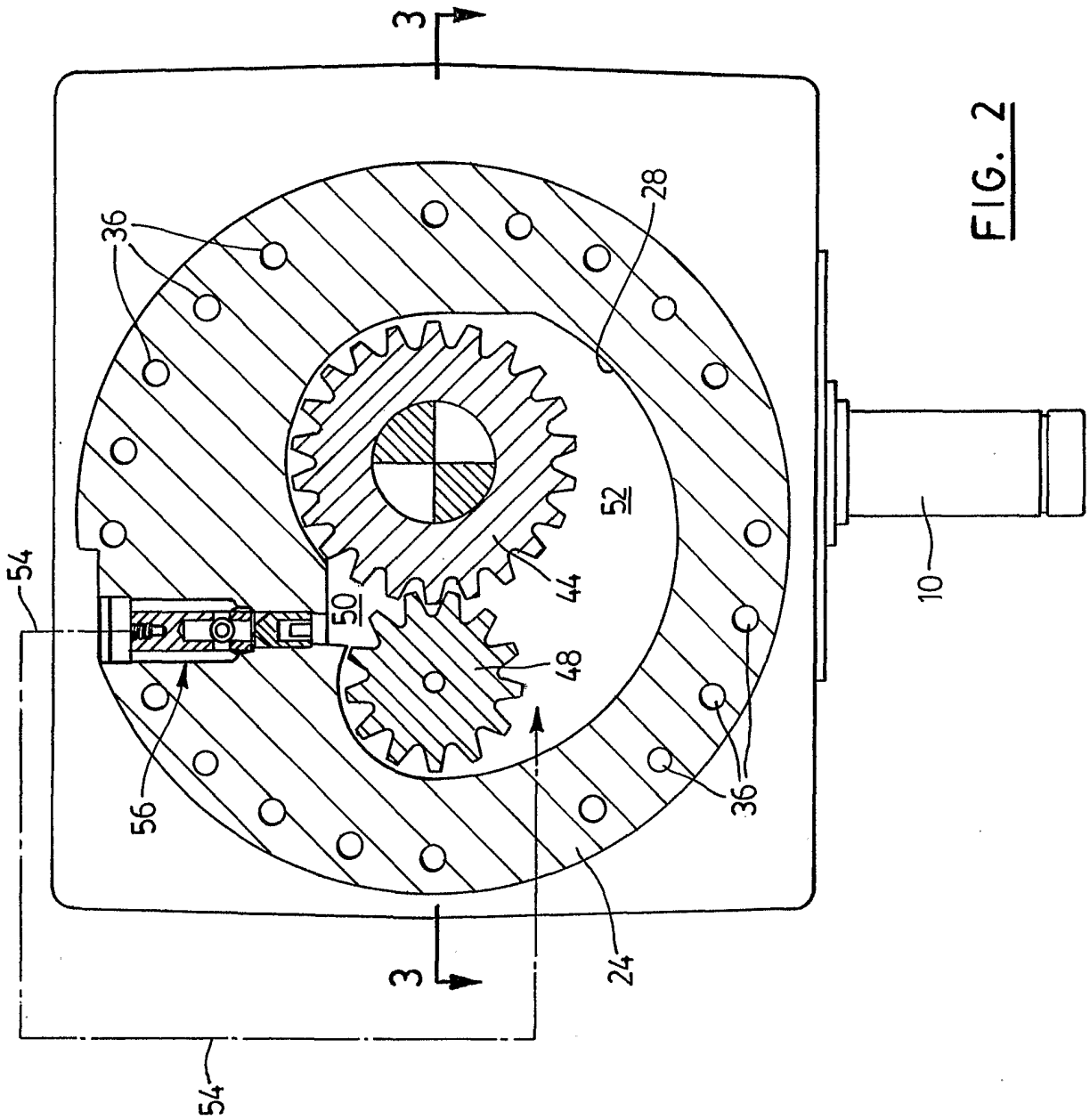

FIG. 2

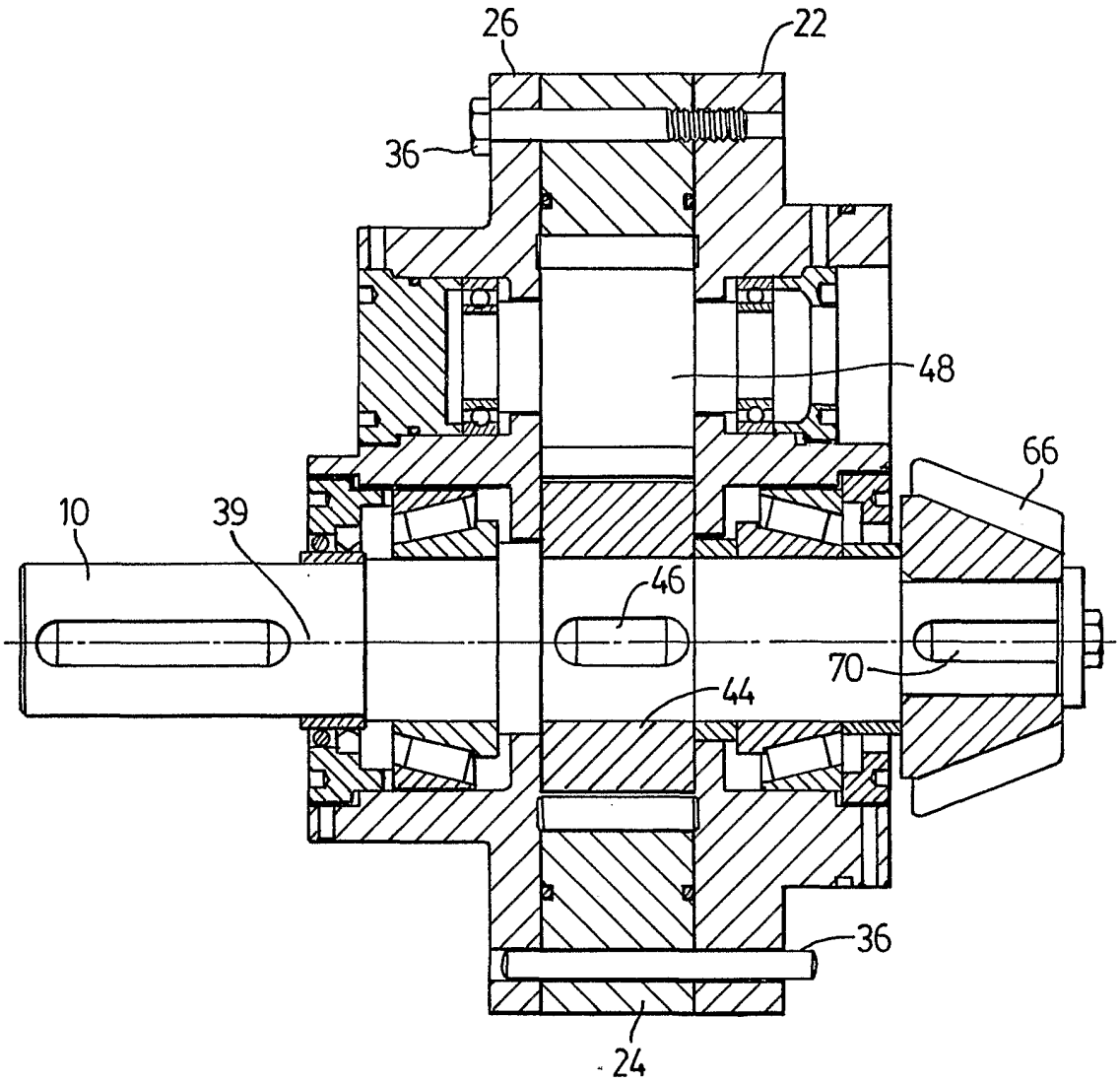

FIG. 3

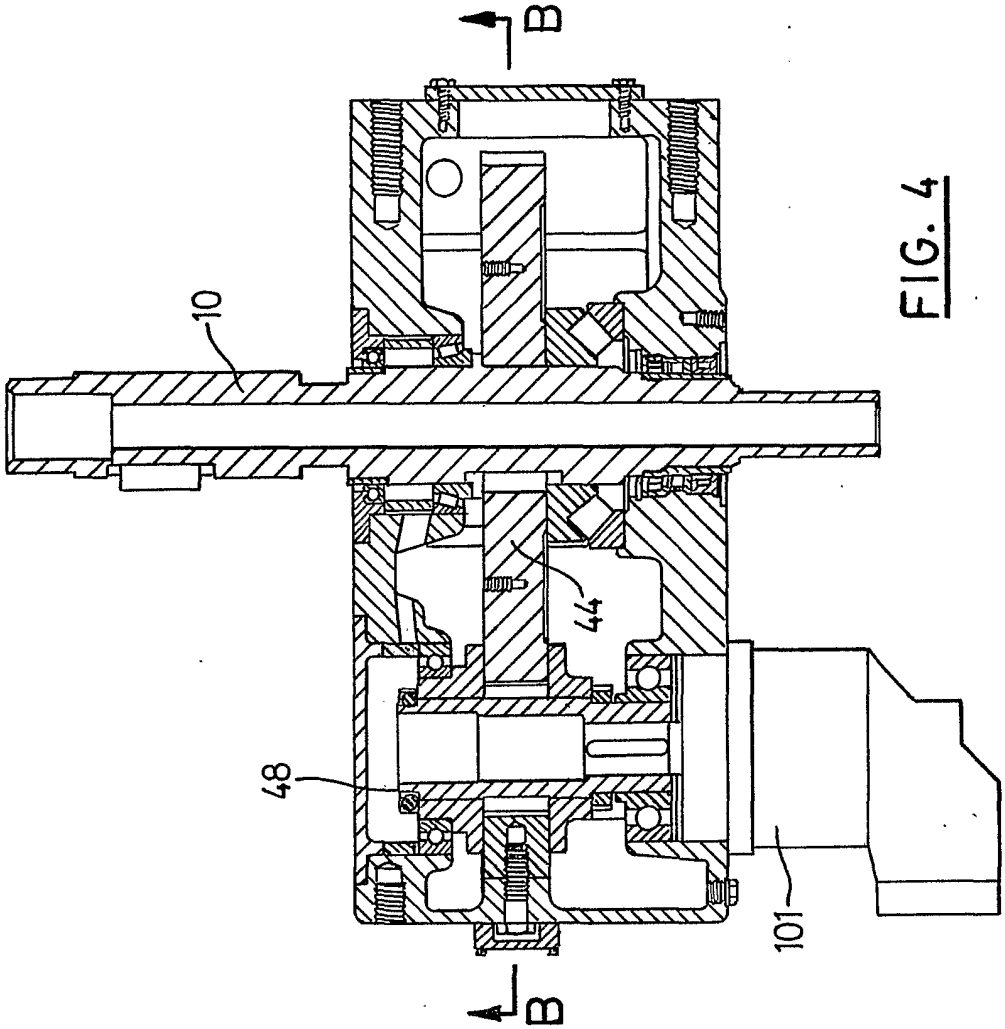

FIG. 4

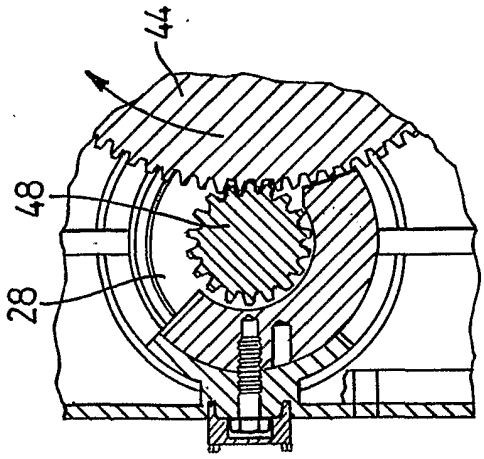

FIG. 4B

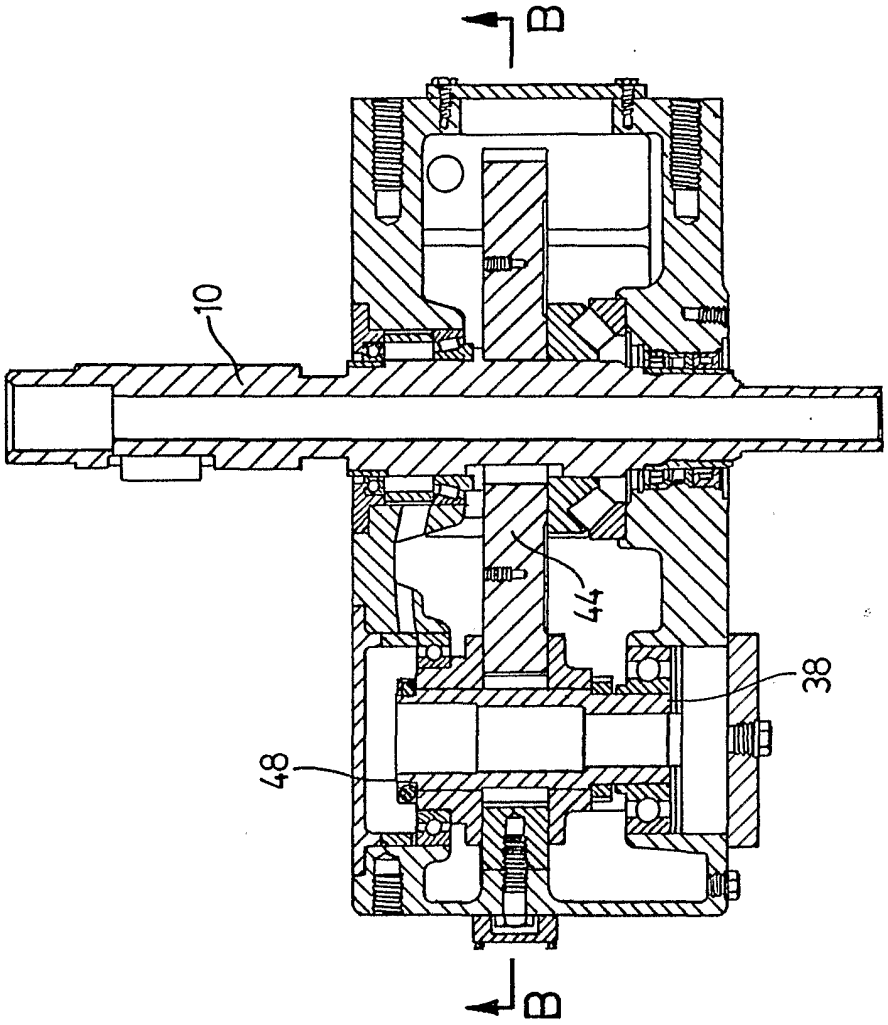

FIG. 5

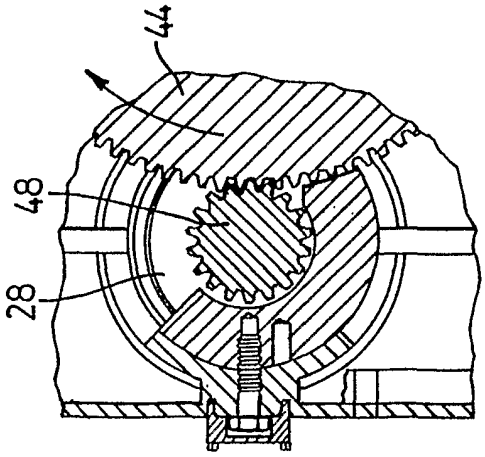

FIG. 5B

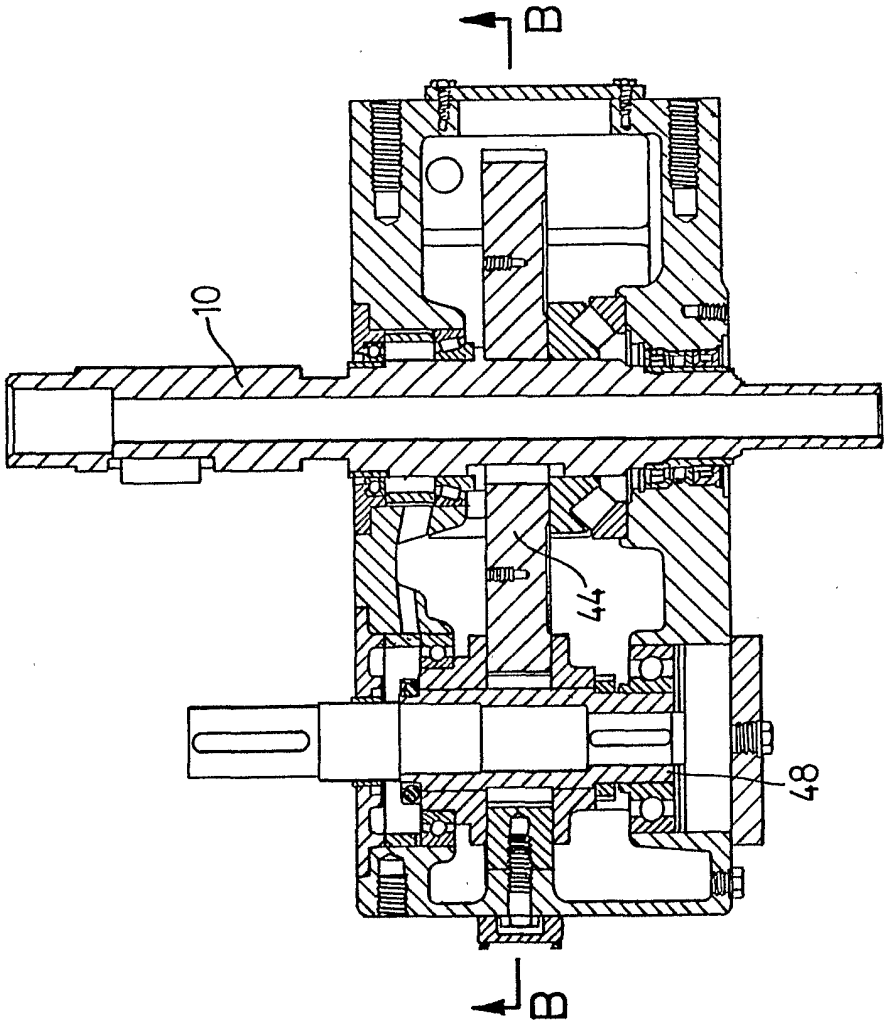

FIG. 6

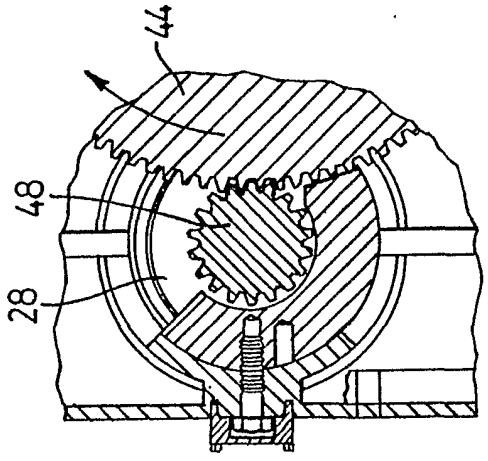

FIG. 6B

INTERNATIONAL SEARCH REPORT

	ıtional Application No
	PCT/CA 01/00839

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F04C15/00 F04C15/04 E21B43/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F04C E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	WO 88 07126 A (SUPERIOR GEARBOX CO) 22 September 1988 (1988-09-22) cited in the application claim 1; figure 1	1-8
Y	DE 534 429 C (MASCHINENFABRIK AUGSBURN-NÜRNBERG A.G.) 26 September 1931 (1931-09-26) the whole document	1-8
A	WO 97 10437 A (GRENKE EDWARD) 20 March 1997 (1997-03-20) claim 1; figures 1,2	1,5

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
1 October 2001	09/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Dimitroulas, P

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INTERNATIONAL SEARCH REPORT

nformation on patent family members

Ir tional Application No
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