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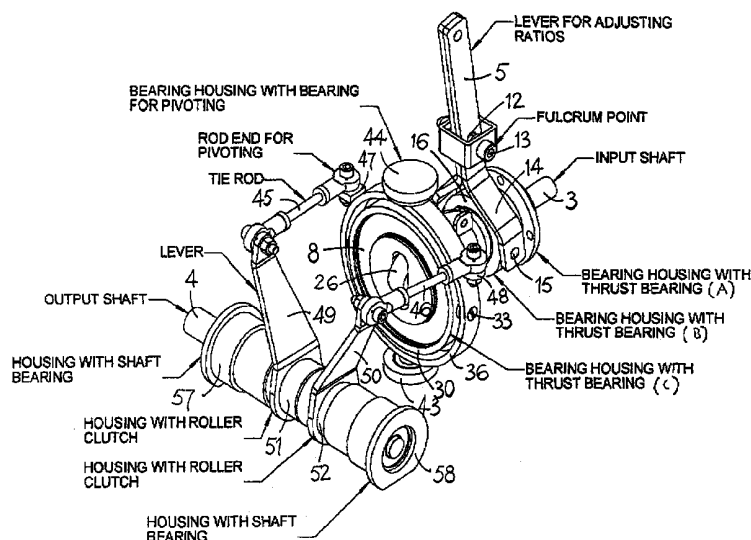
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(54) Title: VARIABLE RATIO TRANSMISSION



(57) Abstract: A drive transmission that can be used to give smoothly variable ratios over a wide range, in fixed machinery especially where soft starts and large load discrepancies are encountered and in vehicles requiring a large range of ratios and torques. The transmission has a skew drum (8) (or a type of swash plate) on an input shaft (3) with a variable angle of inclination relative to the shaft, a skew ring mounted with an interposed bearing (30) on the drum, a gimbal ring (36) pivoted at diametrically opposite pivots (34) to the skew ring and at diametrically opposite pivots (34) that are orthogonal to the first mentioned pivots to a supporting frame. Connecting rods (45, 46) are pivotally connected to the gimbal ring and to cranks (49, 56) that are in turn mounted with one-way clutches (51, 52) on an output shaft (4). Varying the angle of the skew drum varies the speed of the output shaft, smoothly variable from zero to a maximum. The angle of the skew drum to the input shaft is varied by a control, to give this variable ratio drive.



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VARIABLE RATIO TRANSMISSION

FIELD OF THE INVENTION

This invention lies in the field of drive transmissions, that is, machines for transmission of a mechanical drive from an input to an output. In particular, the invention is concerned with the provision of a variable ratio drive transmission especially a design, which can achieve a wide range of stepless ratio variation.

Applications of such transmissions lie in fields such as industrial machines of many kinds, especially where soft starts are required and where there are large load discrepancies. Vehicles such as trucks, tractors and earth moving equipment are further examples, which require a wide range of ratios and available torques.

Light industrial and agricultural vehicles can use the transmission.

Winches can advantageously use the transmission due to the wide range of torques and speeds available.

High ratio reduction gearboxes can be provided.

BACKGROUND

Mechanical variable drive transmissions – varispeed drives – have been proposed for a long time, due to the much desired objective of a mechanical varispeed gearbox with a continuously (stepless) wide range variable ratio change. For example, belt variators, chain variators, hydrostatic variators and others have been developed. Although some are ingenious devices, they are generally dependant on friction, being essentially friction drives. This imposes limits on power transmission, results in wear and heat generation and poor efficiencies. In some designs the ratio range available is limited.

THE INVENTION

The present invention works with a device that is analogous to a swash plate, but perhaps better called a skew drum, for present purposes and this term must be understood as including swash plates.

According to the present invention a variable ratio drive transmission includes an input shaft, a skew drum mounted at an end of the shaft; the plane in which the periphery of the drum lies being inclined at an angle with the axis of rotation of the shaft, means for adjusting that angle, at least one connector which is non-rotationally linked to the periphery so as to reciprocate without rotation, during rotation of the skew drum, whereby change of the angle of the skew drum varies the stroke of reciprocation accordingly, the connector connecting the reciprocating motion to a means which transmits only one direction of reciprocation to provide unidirectional rotation of an output shaft at variable speeds according to variation of the skew drum angle.

The attachment of the skew drum to the end of the shaft may be by means of a hinge structure with a control means whereby the angle of the drum to the axis of rotation of the shaft may be varied between ninety degrees (or orthogonal to the shaft axis) and an inclined (non-orthogonal) angle. When the periphery of the drum is orthogonal to shaft axis, no reciprocation and hence no rotation of the output shaft occurs. As the drum is moved to an inclined angle, the stroke of the reciprocation is increased and hence the output shaft rotational speed. The control means may be a link having a first end axially movable along the shaft and the second connected to the drum; the first end of the link may be moved by a non-rotational control means by a rotationally free connection.

The connector may take several forms and be operationally linked in several ways. One form of connector is a rod, which is pivotally connected to a crank on the output shaft. The opposite end of the rod may be operationally linked by being connected to a ring, which is held against rotation and slides against the skew drum periphery. In another arrangement the skew drum has a thrust bearing which allows the input shaft to rotate freely within, which allows the outer rim of the skew drum to stand still (not

rotate) but oscillate; the rods are connected to this. In either arrangement the oscillation is transferred via the connecting rods to the lever arms of the output shaft. The skew ring can be prevented from rotating by a pin fixed to it, which slides in a groove of a part which is fixed to the outer housing of the gearbox. Or the opposite end of the rod to the output shaft may be connected to a gimbal or other type of universal joint in which a rotationally slipping connection can be arranged to transmit only oscillation and not rotation.

More than one connector arranged to reciprocate out of phase with each other is advantageous because the impulses transmitted to the output shaft per rotation thereof can be increased, giving smoother output.

In accordance with an embodiment of the invention, a skew drum has a skew ring with a bearing interposed between the drum periphery and the skew ring, the skew ring pivotally connected by pivots at diametrically opposite positions to a gimbal ring, which in turn is pivotally connected by pivots to a non-rotational frame, the pivots being located on mutually orthogonal and intersecting axes. The connector(s), preferably in the form of rods, is/are pivotally connected to the gimbal ring. The gimbal ring may be omitted and another means of preventing rotation of the skew ring provided.

The means to transmit only one direction of reciprocation may comprise one-way clutch in a bush around the output shaft with a crank fixed to the clutch. The connector giving an angular oscillation of the crank and hence bush will transmit rotational impulses only in one direction. The clutch may be of a known kind, having a balls or rollers in a multiple tapered hub and shaft, giving a ratchet-like function.

A flywheel can if desired be provided on the output shaft to give smoother output rotational speed and torque.

In addition, an extra swash plate (skew drum) can be added to the input shaft on the opposite side of the output shaft to balance the reciprocating forces. This skew drum will also have its own set of connecting rods and levers with one-way bearings connected to the output shaft. This would also double the output torque of the gearbox.

The smoothness of power transfer from the skew drum can be improved substantially by the addition of lever arms to the output shaft and connecting rods between the levers and the outer ring of the skew drum. To make more place for the addition of the levers, a second shaft, running parallel to the output shaft and connected by two gears in mesh so that the shafts turn in opposite directions, can be added. It must be remembered that the levers must be divided equally between the two shafts. This will increase the gearboxes smoothness, output torque as well as the output speed of the box due to the fact that there are more pulses per revolution of the output shaft.

If reverse was desired, electrical clutches can be installed instead of using one way bearing clutches. The clutches would have to be controlled by CPU and engaged and disengaged at the right time to create either forward or reverse motion.

THE DRAWINGS

The invention will be more fully described by way of an examples of a drive transmission according to preferred embodiments of the invention, with reference to the drawings.

In the drawings : -

figures 1 to 13 show a first embodiment, and

figure 14 shows another embodiment;

figure 1 is an elevation showing the external casing, input and output shafts and ratio control rod,

figure 2 is an isometric view of the inner workings of the transmission,

figure 2A is a similar view to figure 2, with the output shaft sectioned,

figure 3 is a cross sectional view of the transmission, with the sectioning plane passing through the input shaft,

figures 4 to 8 are various views of components of the transmission,

and

figures 9 to 13 are views of the transmission in various settings to assist explanation of its working,

figure 14 shows another embodiment.

THE PREFERRED EMBODIMENTS

As shown in figure 1, the drive transmission 1 has the mechanism housed in a rectangular casing 2 with input shaft 3 and output shaft 4 and control handle 5. With a constant input shaft speed being maintained, the output shaft speed can be varied continuously from zero to a high speed by moving the control handle. Moved to the right 6 for higher speed and to the left 7 for lower speed. The transmission ratio and hence output speed can be varied by very small increments indeed and is essentially “infinitely” variable i.e. by infinitesimally small increments.

Figures 2 and 2A and 3 show the general arrangement of the mechanism, which is located inside the casing. The input shaft 3 has a skew drum 8 mounted on the interior end 9 of the shaft at an inclined angle 10 to the axis of rotation 11. The angle can be varied from orthogonal (at right angles or ninety degrees) to the shaft axis 11 to a maximum inclination shown in figure 3 of 53 degrees. The control of the angle of the skew drum is by means of the handle 5. This has a slotted hole 12 pivoted on a pin 13 in the casing and ending in a yoke 14, which embraces and is pivotally connected by pins 15 to a collar 16. The collar is connected by a bearing 17 to a bush 18, which allows the bush freely to rotate inside the collar but for an axial displacement of the bush to be effected by the handle. The bush is pivotally connected by means of lugs 19 and pin 20 to a link 21 whose opposite end is pivotally connected by pin 22 to lugs 23 which are fixed to the skew drum 8.

The skew drum (see also figure 6) has a slotted hole 24 in its centre and an orthogonal diametral hole 25. A disc 26 (see also figures 7 and 8) fits into the slotted hole and is held there by a pin (not shown) which passes through the diametral hole in the drum and a hole 27 in the disc. A hole 28 in the disc fits over the end of the shaft and is fixed in this position. A bearing 29 is fitted around the periphery of the skew drum and a skew ring 30 (see also figure 4) fits around the bearing. This allows the skew

drum to rotate while the skew ring remains non-rotational, but oscillating according to the inclination of the skew drum on the input shaft. The skew ring has diametral holes 31 and 32 which allow the skew ring to be connected by pins 33 to diametral holes 34 and 35 in a gimbal ring 36 (figure 5). Orthogonal diametral holes 37 and 38 in the gimbal ring allow pins 39 and 40 to be carried in bearings 41 and 42 which are mounted bushes 43 and 44 fixed in the casing of the transmission.

Two rods 45 and 46 are pivotally connected by means of pivots on lugs 47 and 48 which are fixed on the gimbal ring. The opposite ends of the rods are pivotally connected by means of pivots on cranks 49 and 50 which are fixed to bushes 51 and 52 respectively. Between these bushes and the output shaft are roller clutches 53 and 54 which transmit movement only in one direction. The resulting effect is that reciprocation of the rods provides rotational impulses to the output shaft in one direction only.

A reversing gearing (not shown) can be provided for to allow selection of a reverse direction of drive, if required.

The output shaft is held in bearings 55 and 56 in mounting blocks 57 and 58 respectively, with suitable spacers on the shaft.

When considering the operation of the mechanism it is helpful to refer also to figures 9 to 13. With the handle in the position shown in figure 9, the skew drum is in fact not inclined but is orthogonal to the input shaft and there is no oscillation of the gimbal ring and hence no oscillation of the rods. The output shaft then remains stationary at any rotational speed of the input shaft.

As the handle is moved to the right to a position shown in figure 10, the skew drum is moved into an inclined angle θ to the orthogonal. Rotation of the input shaft then causes an oscillatory movement of the gimbal ring, reciprocation of the rods and hence rotation of the output shaft. If the angle θ is small the output rotational speed is small, but the mechanical advantage is proportionally high. This provides a very high starting torque as the handle is moved towards a position which starts rotation, a significant advantage.

The rotational position of the skew plate shown in figure 10 is such that the two rods are at an intermediate position of their reciprocation, moving in opposite directions. It is helpful to visualise the oscillation imparted to the gimbal ring to refer next to figure 11 which shows the input shaft and hence skew ring having rotated through ninety degrees. In this position the gimbal has oscillated anti-clockwise if viewed from the top and the one crank is moving one way and the other the other way. The one crank is imparting a rotational impulse via its clutch to the output shaft while the other is executing a return stroke with its clutch free-wheeling.

If the control handle is moved further as shown in figure 12, the angle θ is increased and the oscillation of the gimbal ring is increased and the stroke of the rods increased, giving a higher speed at the output shaft. Figure 13 gives a further view with the input shaft having turned another 45 degrees, to give a view helpful to visualising the oscillation of the gimbal ring.

The control handle is merely exemplary and control could be by other means, including automated, feedback remote controlled actuators or logic controlled means etcetera.

The casing unit could house further gearing of various conventional kinds, for example, a differential or a brake, etcetara.

Figure 14 shows an embodiment, which is the same as the preceding one except that instead of using the gimbal arrangement to prevent rotation of the skew ring, a pin 60 is fixed to the skew ring and oscillates in an arcuate shaped slot 61 fixed in the housing. The mechanism is immersed in oil in its housing, so lubricating the action of the pin in the slot. The load on the pin is slight being the "frictional" resistance of the bearing 29. Thus the same reference numerals are used for the same parts as have been described with reference to the preceding drawings and that description is referred to. Use of this pin simplifies the mechanism and reduces the reciprocating masses.

Reference numerals : -

- 1 variable ratio drive transmission
- 2 drive casing
- 3 input shaft
- 4 output shaft
- 5 control handle
- 6 right movement for lower output speed
- 7 left movement for higher speed
- 8 skew drum
- 9 end of input shaft inside casing
- 10 angle of inclination of skew drum to axis of rotation of input shaft
- 11 axis of rotation of input shaft
- 12 slotted hole in control handle
- 13 pin in casing for slotted hole in handle
- 14 yoke at end of handle inside casing
- 15 pins pivotally connecting yoke to collar
- 16 collar axially movable by yoke
- 17 bearing (e.g. ballrace) between collar and bush
- 18 bush axially slidable on input shaft but rotating with it
- 19 lugs on bush
- 20 pin connecting from lugs to link

- 21 link from lugs on bush to lugs on skew drum
- 22 pin in lugs on skew drum
- 23 lugs on skew drum
- 24 slotted hole in skew drum
- 25 diametral hole in skew drum
- 26 disc fixed onto end of input shaft inside casing
- 27 hole in disc for pivotally fixing to skew drum
- 28 hole in disc for fixing to end of input shaft
- 29 bearing (e.g. ball race) around skew drum
- 30 skew ring around skew drum bearing
- 31 diametral hole in skew ring
- 32 diametral hole in skew ring
- 33 pins pivotally connecting diametral holes in skew ring and gimbal ring
- 34 diametral hole in gimbal ring
- 35 diametral hole in gimbal ring
- 36 gimbal ring
- 37 orthogonal diametral hole in gimbal ring
- 38 orthogonal diametral hole in gimbal ring
- 39 pin pivotally connecting gimbal ring to casing
- 40 pin pivotally connecting gimbal ring to casing
- 41 bearing around pin in casing

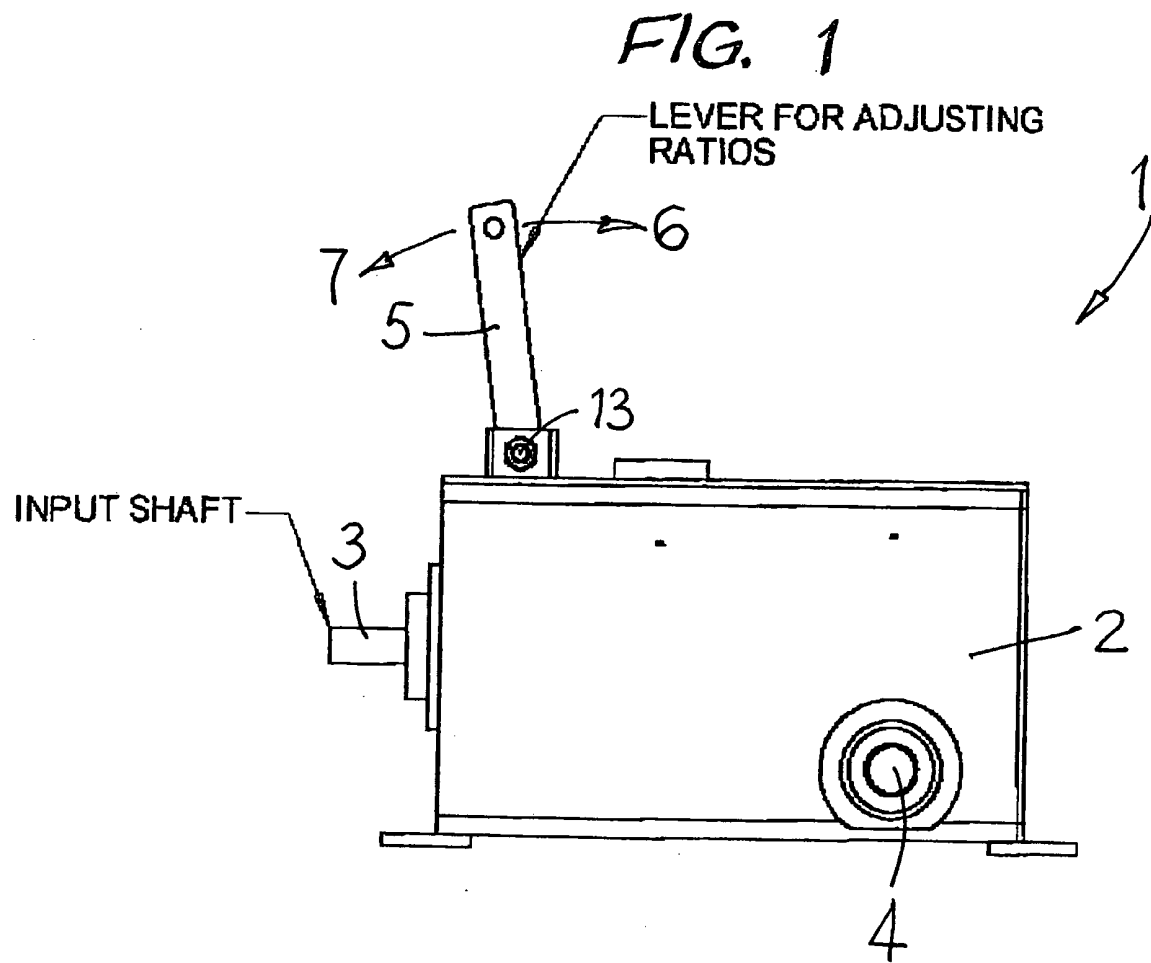
- 42 bearing around pin in casing
- 43 bush mounted in casing to hold gimbal mounting
- 44 bush mounted in casing to hold gimbal mounting
- 45 connecting rod from gimbal ring to crank
- 46 connecting rod from gimbal ring to crank
- 47 bush on gimbal ring for rod connection
- 48 bush on gimbal ring for rod connection
- 49 crank on output shaft
- 50 crank on output shaft
- 51 bush on output shaft fixed to crank
- 52 bush on output shaft fixed to crank
- 53 roller clutch on output shaft
- 54 roller clutch on output shaft
- 55 bearing for output shaft
- 56 bearing for output shaft
- 57 bush for output shaft journaling in casing
- 58 bush for output shaft journaling in casing
- 60 pin
- 61 arcuate slot

CLAIMS

1. A variable ratio drive transmission that includes an input shaft, a skew drum mounted at an end of the shaft, the plane in which the periphery of the drum lies being inclined at an angle with the axis of rotation of the shaft, means for adjusting that angle, at least one connector which is non-rotationally linked to the periphery so as to reciprocate without rotation, during rotation of the skew drum, the connector connecting the reciprocating motion to a means which transmits only one direction of reciprocation to provide unidirectional rotation of an output shaft at variable speeds according to variation of the skew drum angle.
2. A variable ratio transmission as claimed in claim 1, in which the attachment of the skew drum to the end of the shaft is by means of a hinge structure with a control means whereby the angle of the drum to the axis of rotation of the shaft may be varied between ninety degrees (or orthogonal to the shaft axis) and an inclined (non-orthogonal) angle.
3. A variable ratio transmission as claimed in claim 2, in which the control means is a link having a first end axially movable along the shaft and the second connected to the drum and the first end of the link is moved by a non-rotational control means by a rotationally free connection.
4. A variable ratio transmission as claimed in any one of claims 1 to 3, in which the or each connector is a rod, which is pivotally connected at one end to a crank on the output shaft.
5. A variable ratio transmission as claimed in claim 4, in which the opposite end of the rod is operationally linked by being connected to a ring, which slides against the skew drum periphery.

6. A variable ratio transmission as claimed in claim 4, in which the opposite end of the rod is connected to a gimbal or other type of universal joint in which a rotationally slipping connection is arranged to transmit only oscillation and not rotation.
7. A variable ratio transmission as claimed in claim 6, in which the skew drum has a skew ring with a bearing interposed between the drum periphery and the skew ring, the skew ring pivotally connected by pivots at diametrically opposite positions to a gimbal ring which in turn is pivotally connected by pivots to a non-rotational frame, the pivots being located on mutually orthogonal and intersecting axes, with the connector(s) pivotally connected to the gimbal ring.
8. A variable ratio transmission as claimed in claim 6, in which the skew drum has a skew ring with a bearing interposed between the drum periphery and the skew ring, the skew ring having a pin that oscillates in an arcuate groove, to prevent rotation of the skew ring and allow oscillation.
9. A variable ratio transmission as claimed in any one of claims 1 to 7, in which The means to transmit only one direction of reciprocation comprises a one-way clutch in a bush around the output shaft with a crank fixed to the clutch, adapted so that the connector giving an angular oscillation of the crank and hence bush will transmit rotational impulses only in one direction.
10. A variable ratio drive transmission as herein generally described.
11. A variable ratio drive transmission as herein specifically described with reference to the drawings and as illustrated.

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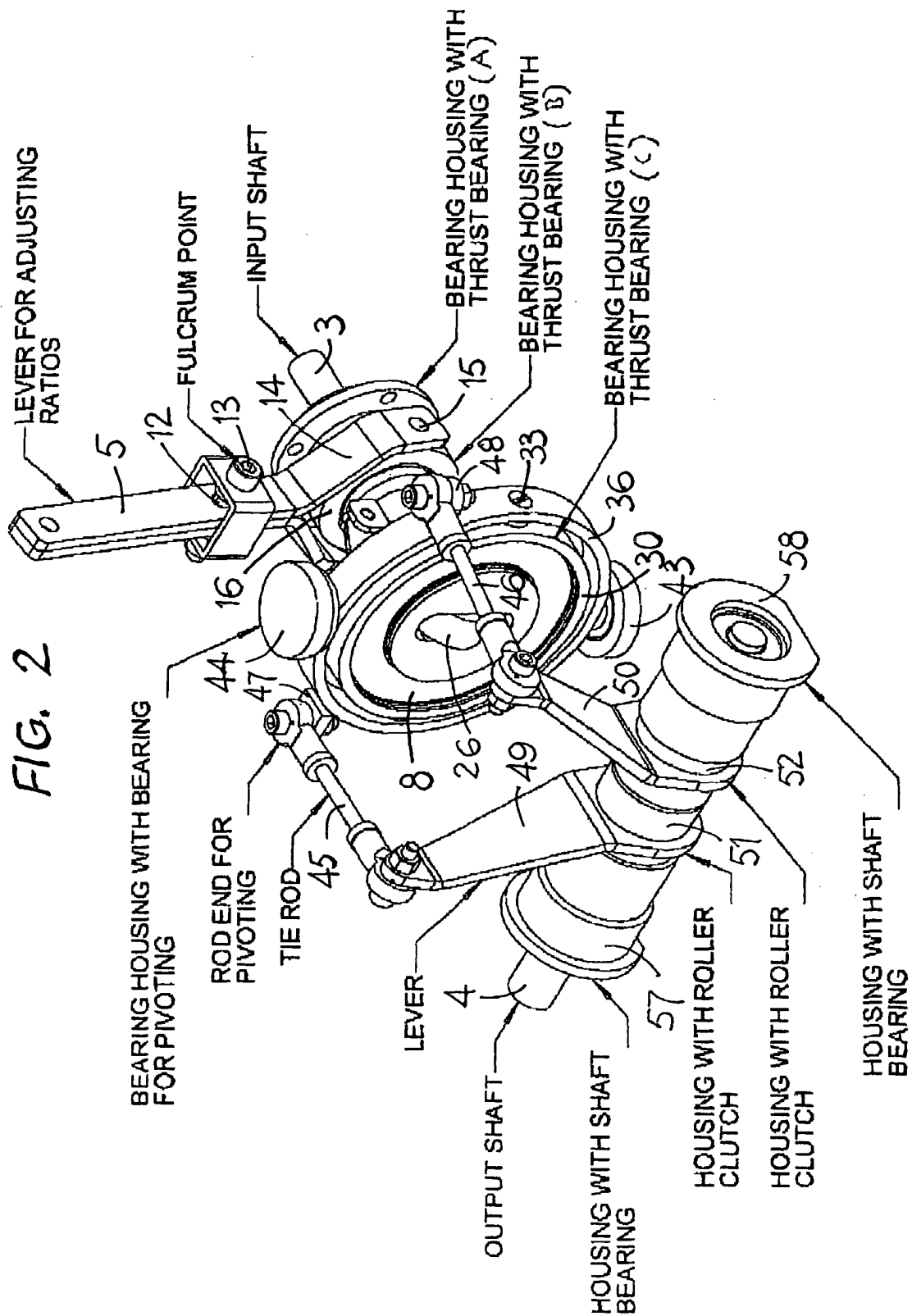
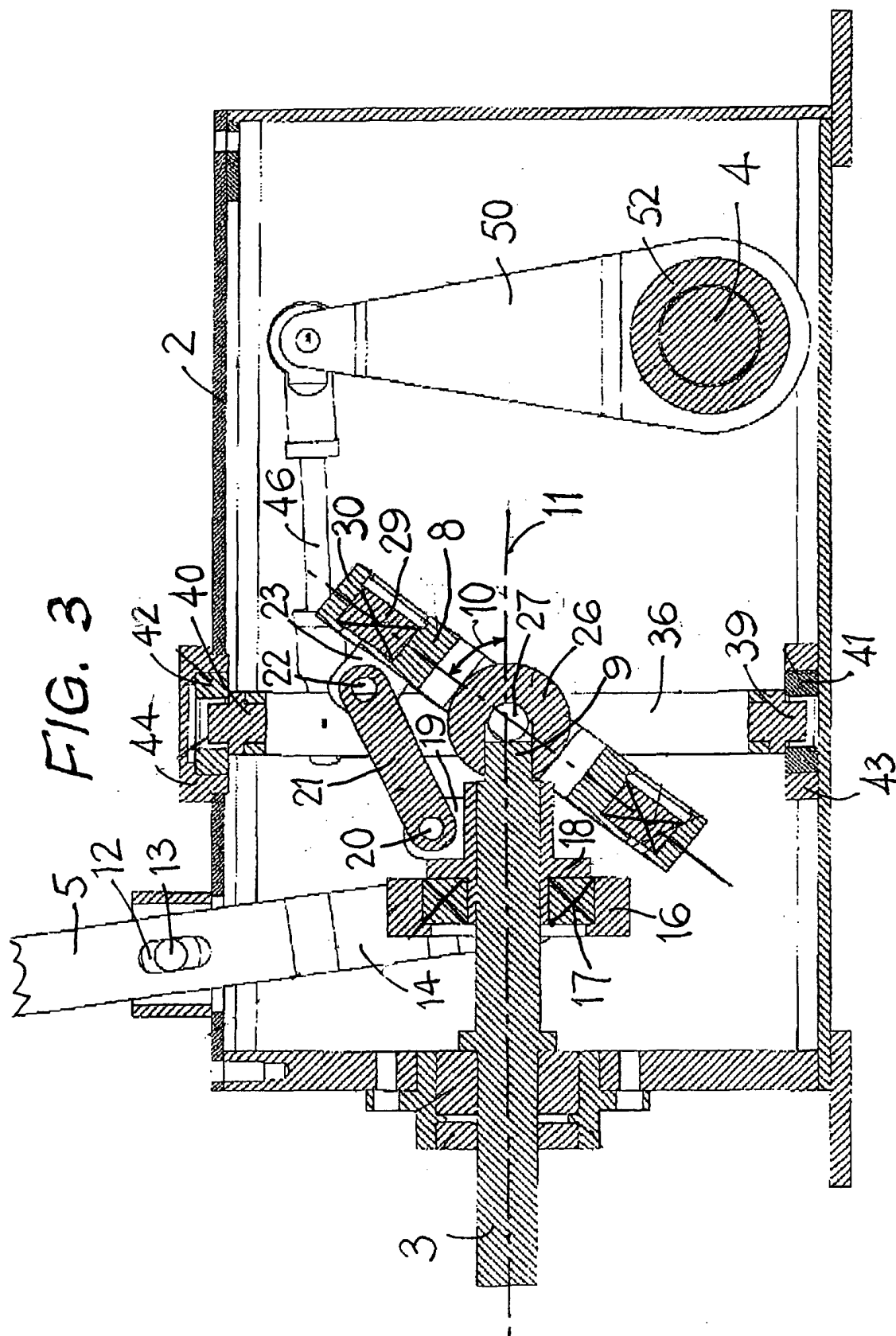


FIGURE 2



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FIG. 4

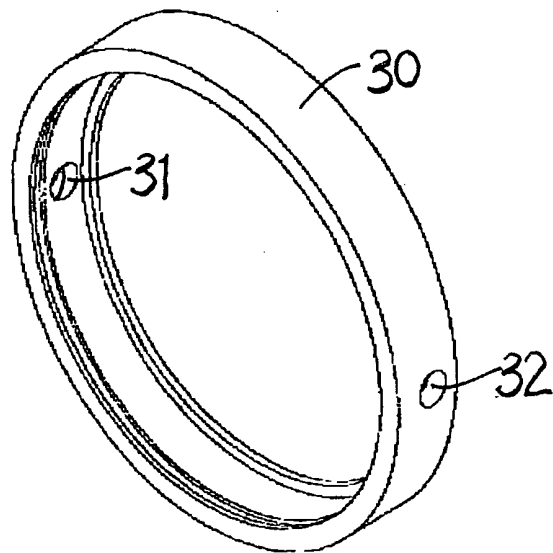
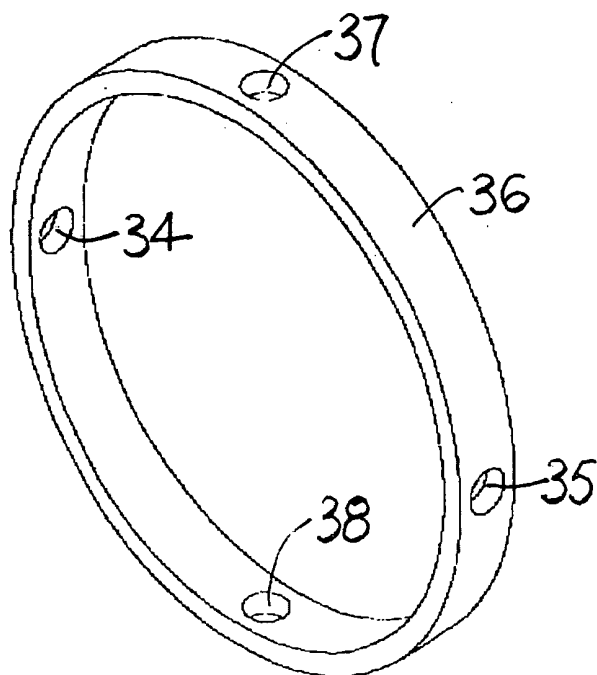
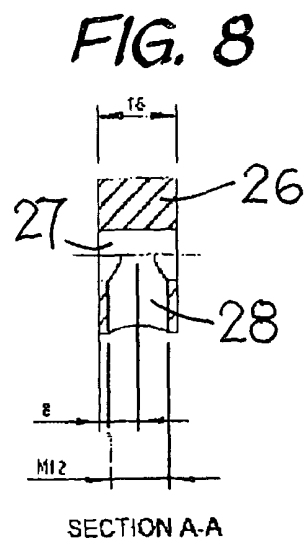
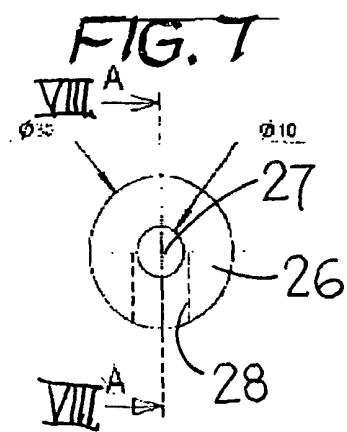
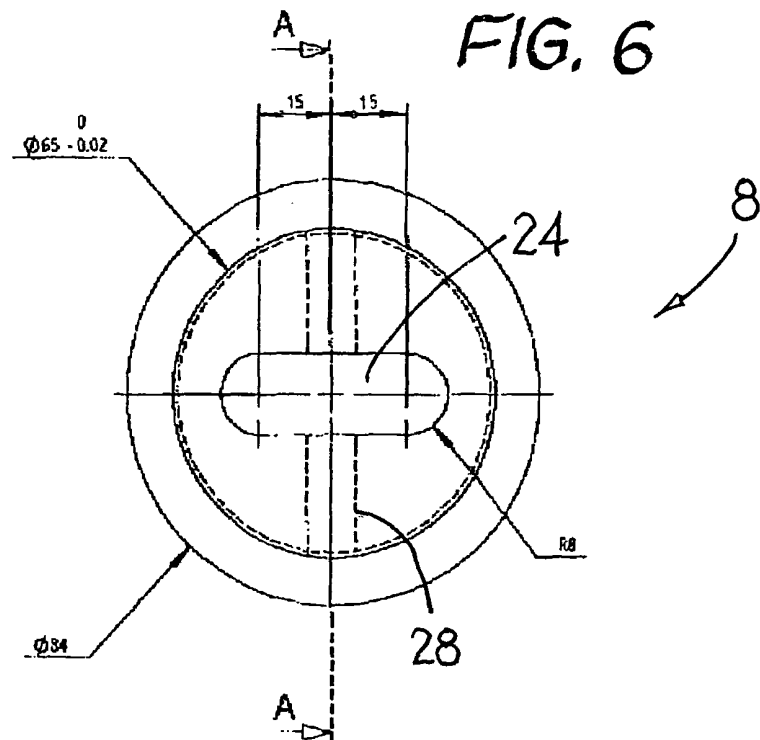
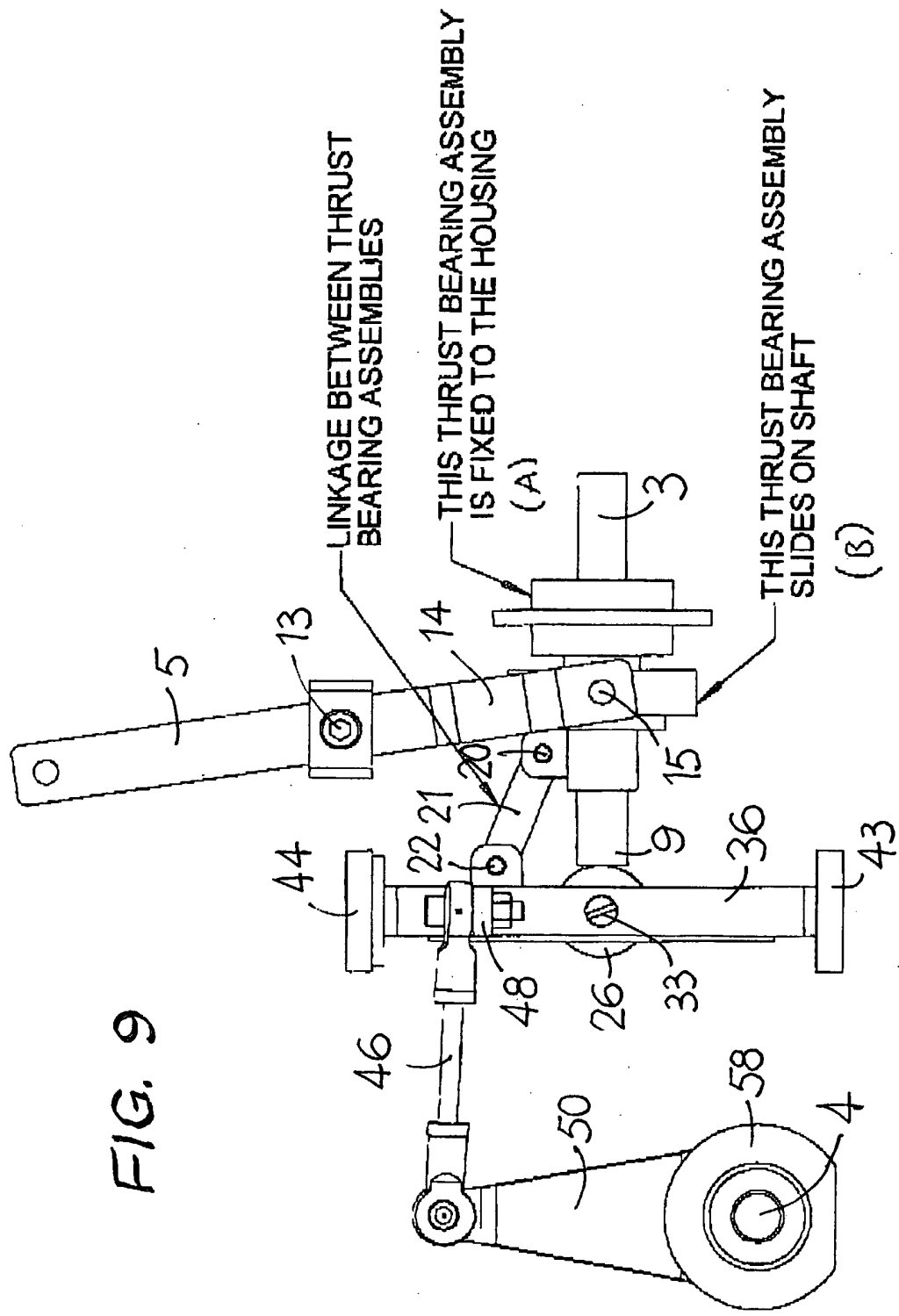


FIG. 5

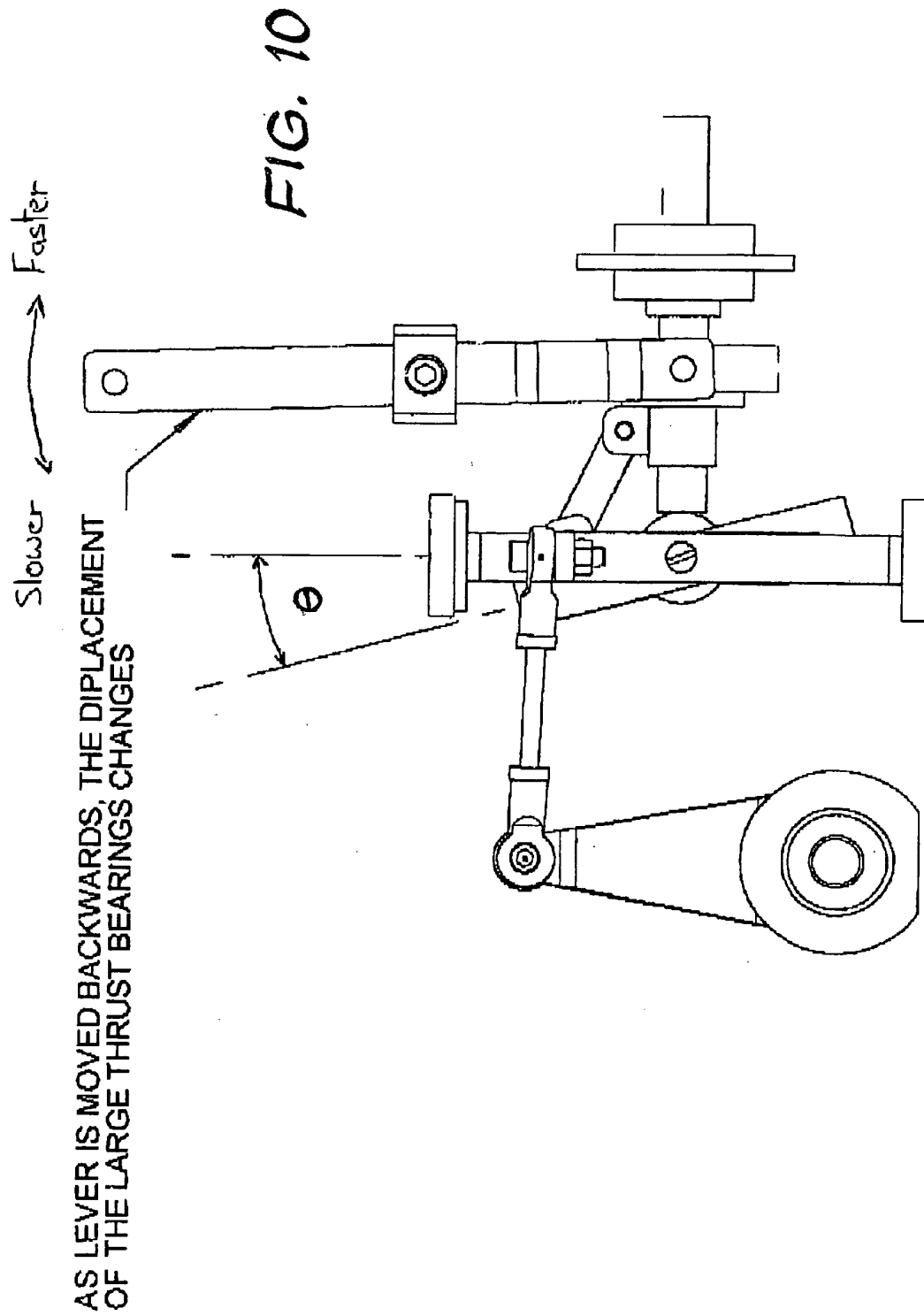


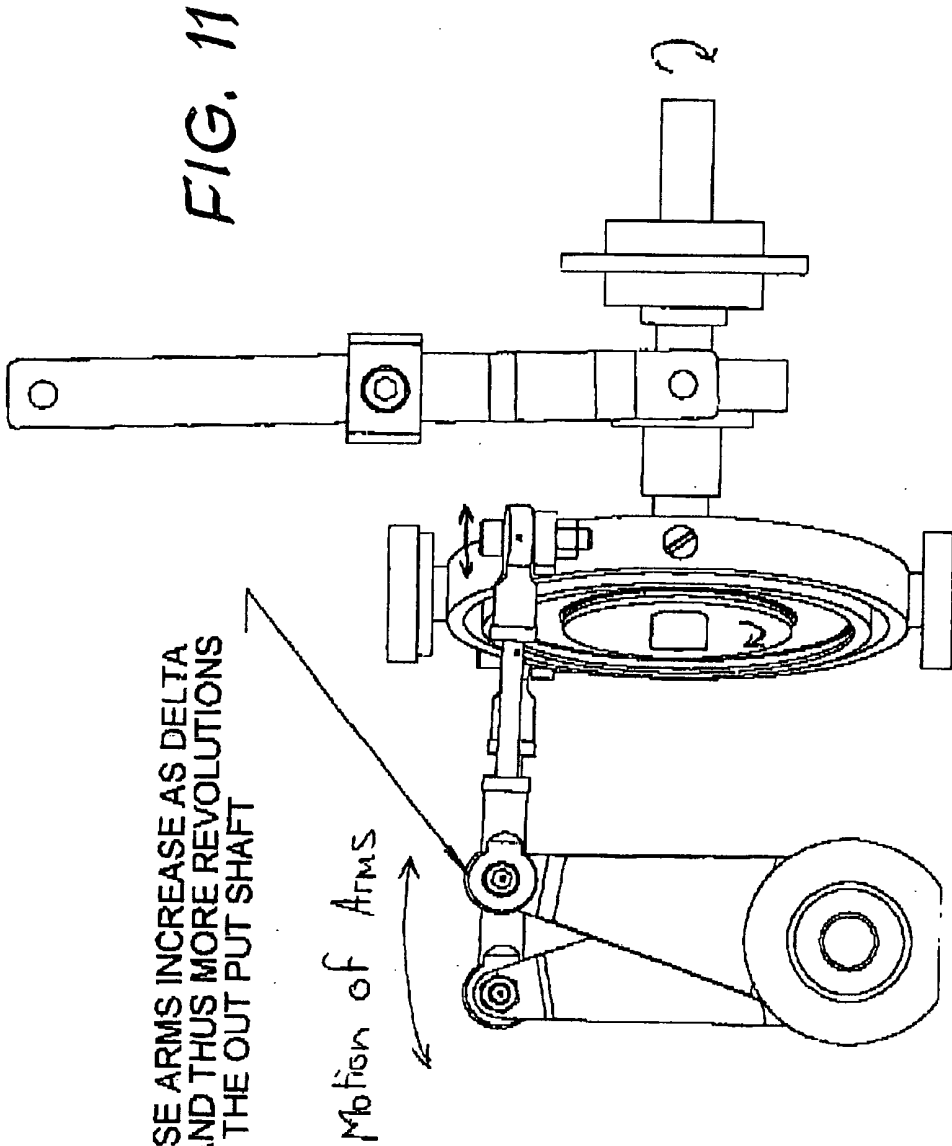
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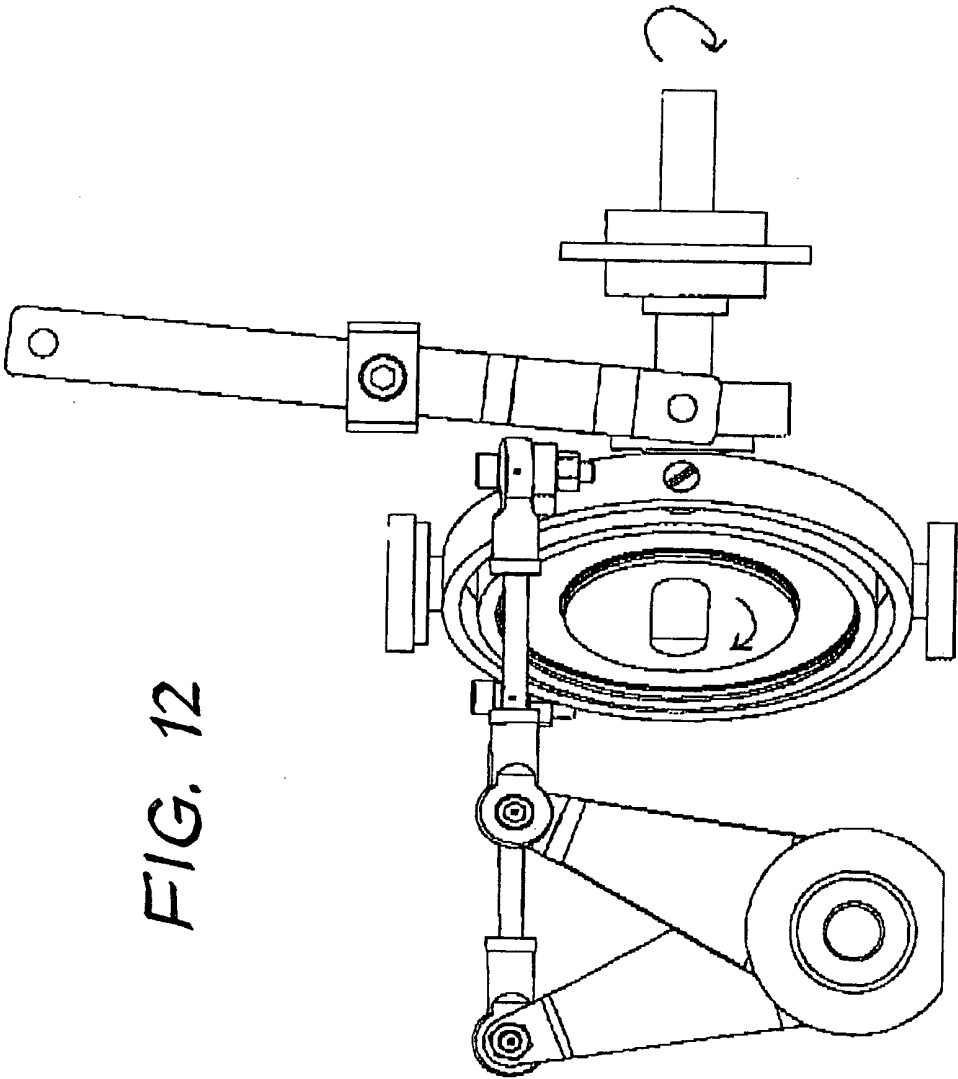


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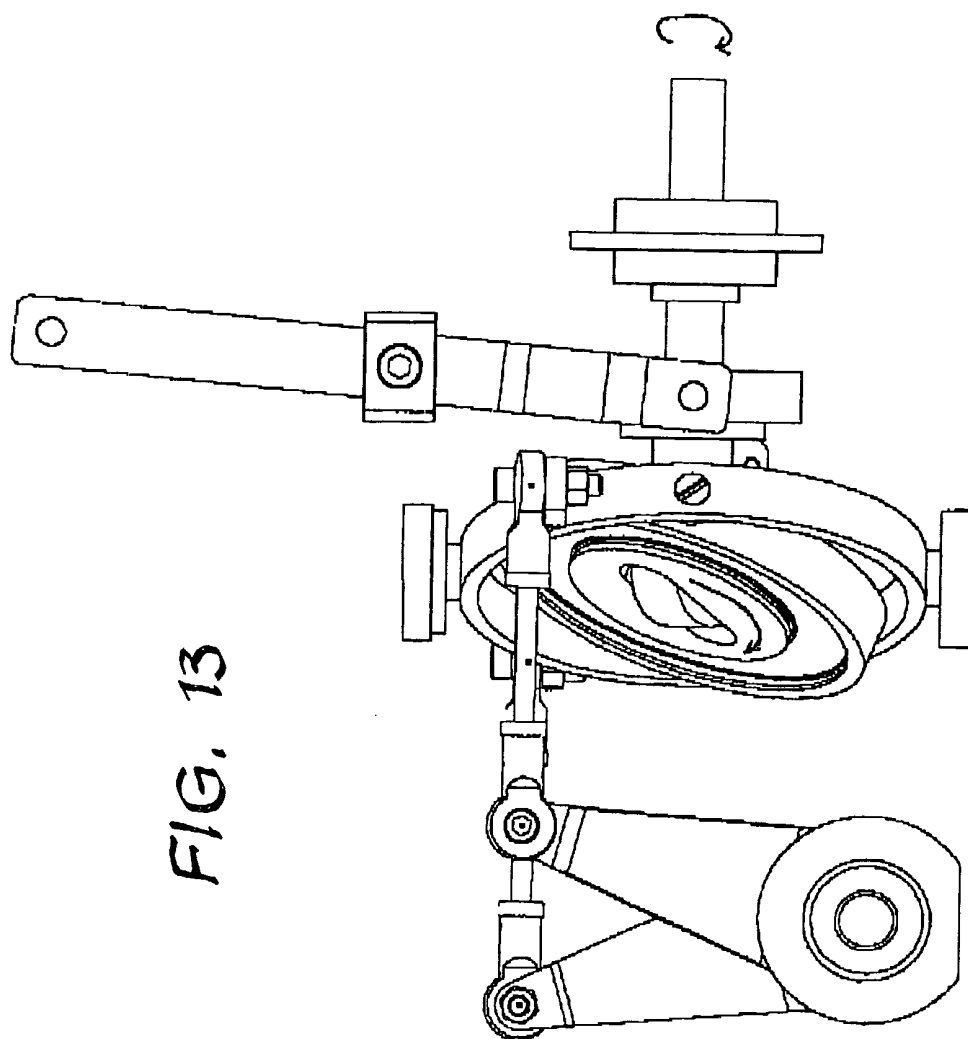




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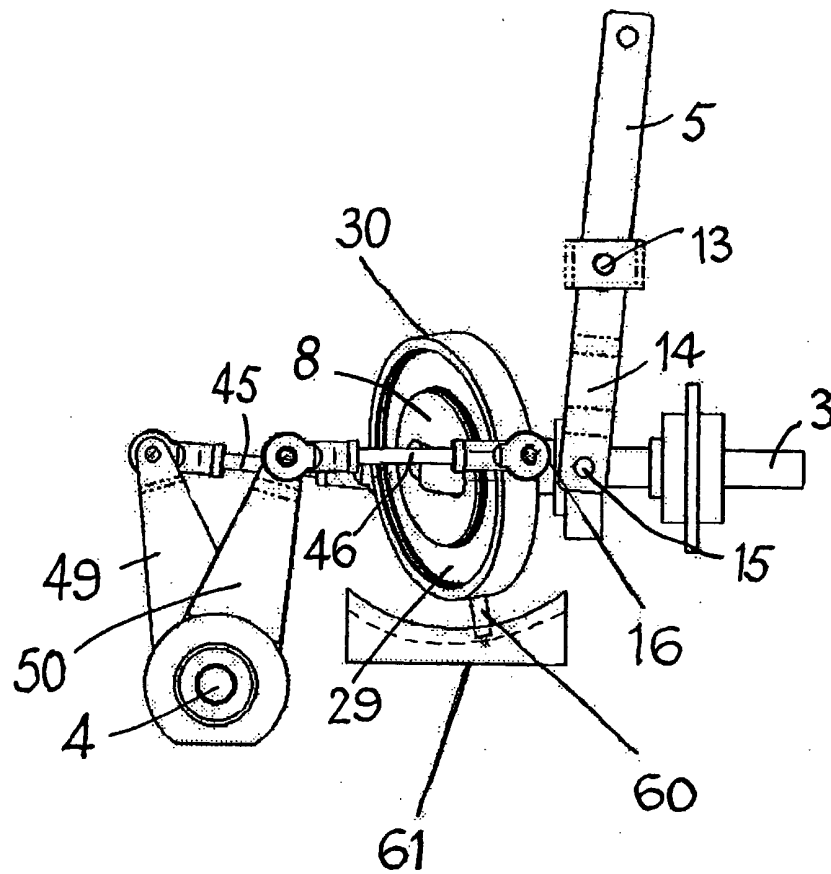


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FIG. 14



INTERNATIONAL SEARCH REPORT

International Application No

PCT/ZA 02/00026

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H29/04

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 F16H

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

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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

6 June 2002

Date of mailing of the international search report

24/06/2002

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INTERNATIONAL SEARCH REPORT

International Application No

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