

[54] **DRIVING UNITS FOR PRODUCING A  
RECIPROCATORY AND OSCILLATORY  
MOTION SIMULTANEOUSLY**

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198/220 DC

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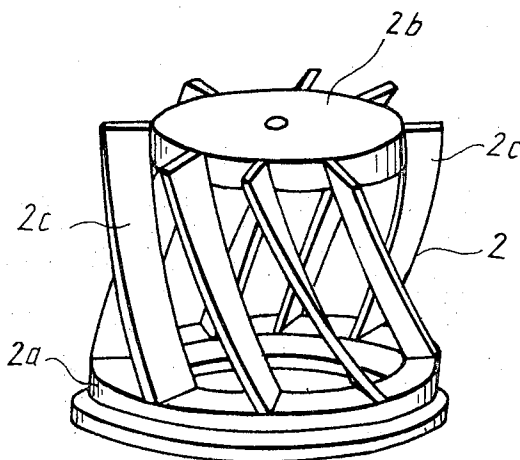
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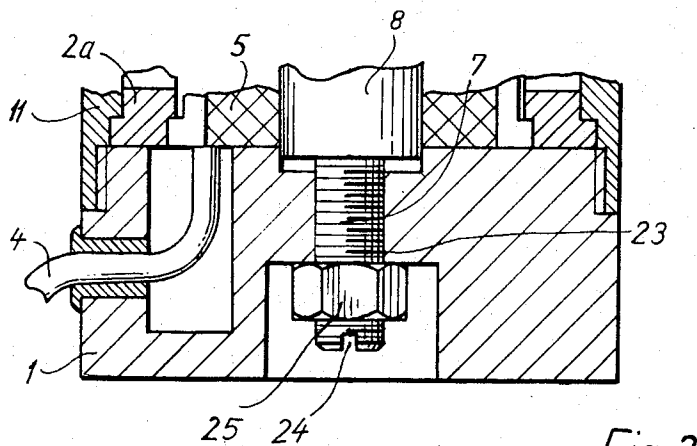
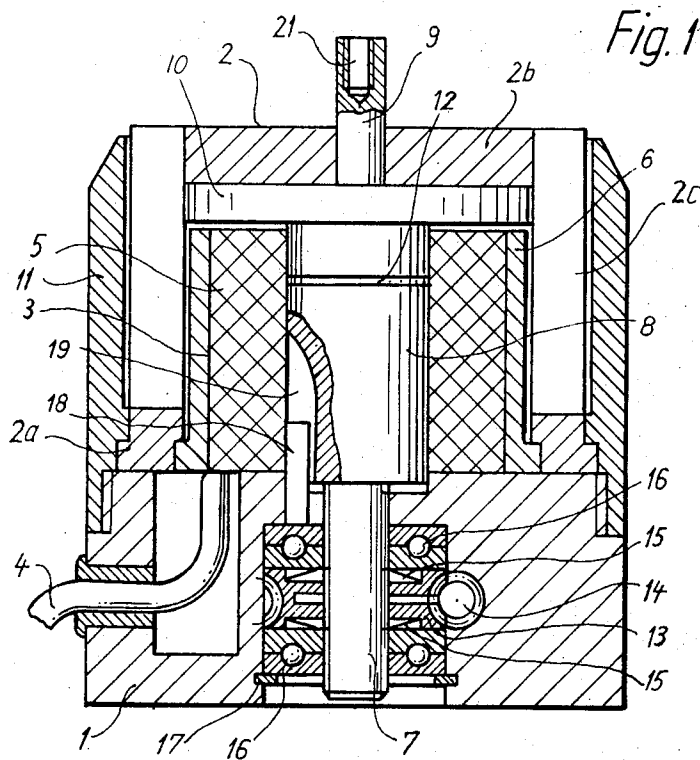
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[57] **ABSTRACT**

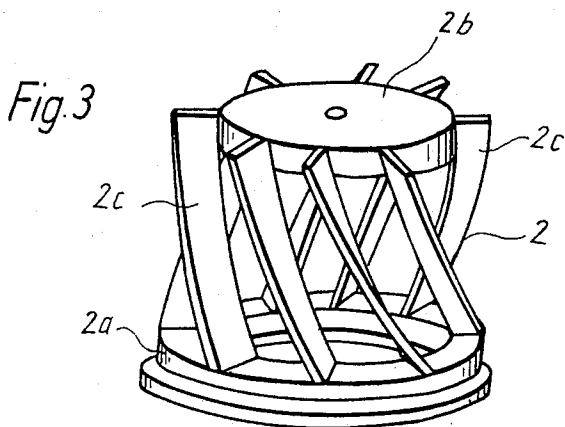
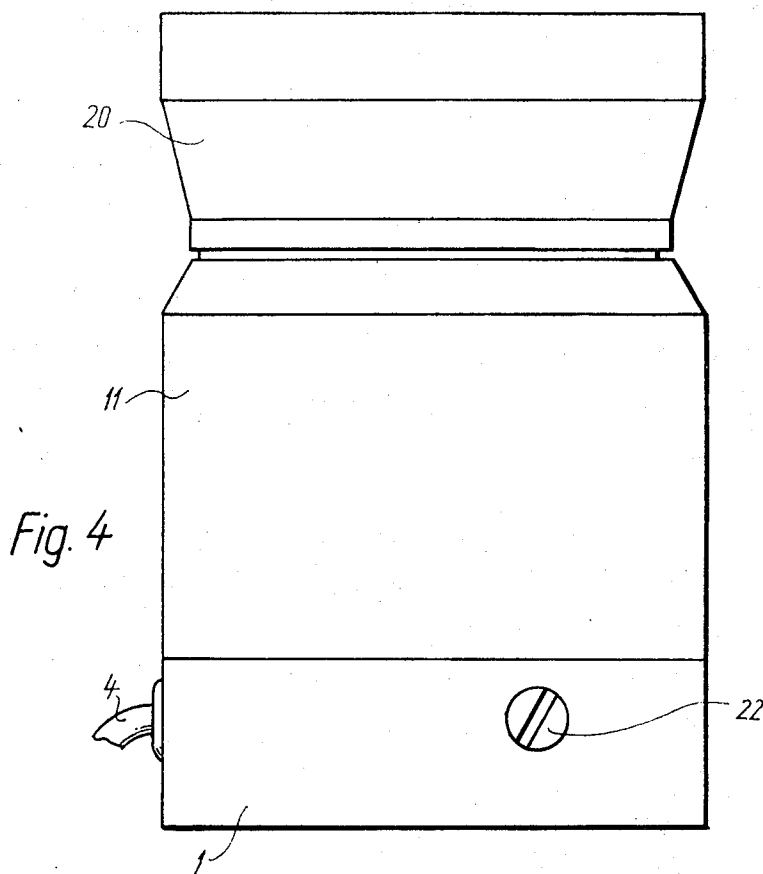
A driving unit for producing reciprocatory and oscillatory motion simultaneously comprises a pot-shaped plastics component comprising a disc-shaped part spaced from and connected to a ring-shaped part by a plurality of connected members in the form of leaf springs extending helically between the parts. An electromagnet is mounted within the component, the ring-shaped part of which is mounted on a base member and the armature of the electromagnet being rigid with the disc-shaped part. The leaf springs are substantially rigid longitudinally and flexible transversely whereby actuation of the electromagnet causes the disc-shaped part to move linearly and rotatably relative to the ring shaped part.

**5 Claims, 4 Drawing Figures**





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# DRIVING UNITS FOR PRODUCING A RECIPROCATORY AND OSCILLATORY MOTION SIMULTANEOUSLY

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to driving units for producing a reciprocatory and oscillatory motion simultaneously.

### 2. Description of the Prior Art

Driving units for producing simultaneous reciprocatory and oscillatory motion are used, for example to drive helical conveyors. Driving units proposed hitherto have been rigidly incorporated in the helical conveyor with the conveyor helix being mounted for movement relative to a chassis.

The helix is connected to the chassis by springs attached to the chassis and helix by connectors fitted to the chassis and the helix, by means of screwthreaded or other detachable connections to enable adjustment to be effected after assembly, such adjustment being necessary unless the various components are made to very fine tolerances. However, the connections often work loose when the conveyor has been in use for a certain time, readjustment then becoming necessary.

The necessity of providing connectors on the chassis and helix, and more especially the subsequent adjustment (and readjustment) or alternatively the close tolerances to be observed during production, entails a considerable increase in the production costs of the conveyor.

## SUMMARY OF THE INVENTION

According to the present invention, there is provided a driving unit for producing reciprocatory and oscillatory motion simultaneously comprising a first plastics member, a second plastics member, a plurality of elongate plastics, connecting members extending between said first and second members and integral with said first and second members, each said connecting member being substantially rigid longitudinally and flexible transversely, and electromagnetic means actuatable to move said first member towards said second member against the bias of a restoring force, said connecting members being so disposed relative to said first and second members that movement of said first member towards said second member is accompanied by rotation of said first member relative to said second member.

Further according to the present invention, there is provided a driving unit for producing reciprocatory and oscillatory motion simultaneously comprising a plastics component, said component including a first part, a second part, and a plurality of connecting members extending between said first and second parts, said connecting members being substantially rigid longitudinally and flexible transversely to permit relative movement between said parts, each said connecting member being attached to said first part at a respective point lying on a first circle and to said second part at a respective point lying on a second circle, said first and second circles lying in parallel planes and the centres of said first and second circles lying on an axis extending at right angles to said planes and the length of each said connecting member between said first and second circles being greater than the shortest distance between said circles, and electromagnetic means actuatable to

apply a periodically variable force of equal and opposite magnitude between said parts whereby one of said parts is moved relative to the other of said parts along said axis and is simultaneously rotated relative to the other of said parts about said axis.

## BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

FIG. 1 is a longitudinal section of one form of driving unit in accordance with the invention;

FIG. 2 is a fragmentary section of a modified form of the driving unit shown in FIG. 1;

FIG. 3 is a perspective view to an enlarged scale of a plastics component of the driving unit shown in FIG. 1; and

FIG. 4 is a front elevation of a helical conveyor mounted on the driving unit shown in FIG. 1.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The driving unit for producing reciprocatory and oscillatory motion simultaneously, illustrated in FIG. 1, comprises a chassis or base member 1, made of ferromagnetic material, a substantially pot-shaped integral plastics component 2 (shown in perspective in FIG. 3) which has a substantially ring-shaped part or member 2a, a disc-shaped part or member 2b and elongate connecting members in the form of leaf springs of equal lengths, extending helically between the parts 2a and 2b.

Each leaf spring 2c attached to the part 2a at a point lying on one circle and to the part 2b at a point lying on a second circle, these first and second circles lying in parallel planes and having their centres situated on an axis passing at right angles through those planes. The distance between the two points of attachment of each leaf spring 2c (that is to say the length of the latter from one point of attachment to the other) is greater than the shortest distance between the circumferences of the two circles. The driving unit also incorporates electromagnetic means in the form of an electromagnet 3 whereby equal and opposite forces and/or moments of periodically variable value can be exerted on the two parts 2a, 2b in such a way as to cause one of the parts to move in relation to the other part along the said axis and to simultaneously rotate relative to the other part about the aforesaid axis.

The points of attachment of the leaf springs 2c are distributed symmetrically round the circumference of the two circles already mentioned. As shown in FIG. 3, the leaf springs 2c are attached to the part 2b at points lying on the periphery thereof and to the part 2a at points lying a flat axial end face thereof. Although as shown the part 2b is disc-shaped, it may also be ring-shaped. The inclination of the leaf springs 2c between the parts 2a and 2b correspond substantially to that of the threads of a multi-start screw of equivalent size having as many threads as there are leaf springs and a pitch which is a multiple of the diameter of the part 2b. This construction is advantageous in that the component 2 can be produced simply and inexpensively and, in particular, that the mould for making the component 2 entails the minimum of technical effort.

At least one electromagnet 3 is mounted within the component 2 and comprises a magnetic coil 5 having

a mains lead 4, a coil casing 6, a magnetic core 8 carrying a threaded bolt 7, and an armature 10, which carries an output drive member 9 which is fixed to the disc-shaped part 2b. The axis of the bolt 7 extends in the same direction as, and preferably coincides with, the axis of the component 2. An outer casing 11 encloses the component 2 and anchors the ring-shaped part 2a and the coil casing 6 to the base member 1. Adjustment of an air gap 12 between the core 8 and the armature 1 is provided by a slotted nut 13 in the form of a worm wheel and threadably engaged with the bolt 7. A worm 14 is in mesh with the nut 13. Although as shown, the core 8 is attached to the base member 1 and the armature 10 to the part 2b, the reverse arrangement may also apply.

The mode of operation of the driving unit shown in FIG. 1 is as follows:

Alternating mains current is fed to the electromagnet 3, that is to say to its coil 5, through the mains lead 4. The result is that the armature 10 is attracted towards the core 8 at twice the frequency of the a.c. current. The armature 10, however, is fixed by the drive member 9 to the disc-shaped part 2b of the component 2. Consequently, every time the armature 10 is attracted towards the magnet core 8, the disc-shaped part 2b is pulled downwards, whereby the distance between the disc-shaped part 2b and the ring-shaped part 2a is reduced. The leaf-springs 2c are substantially rigid longitudinally but are flexible transversely, so that rotation of the part 2b in relation to the part 2a occurs, because of the obliquity of the leaf-springs 2c (FIG. 3), when the distance between the parts 2a and 2b is reduced. When this rotation takes place, the leaf-springs 2c are moved transversely, that is to say round the axis of the component 2. The component 2 is formed from a resilient plastics, for example a polyacetal, so that the transverse movement of the leaf-springs 2c produces a restoring force, by which, following upon the said rotation of the part 2b in relation to the part 2a, rotation of the part 2b in the reverse sense is brought about as soon as the armature 10 ceases to be attracted by the core 8, that is to say as soon as the alternating current flowing through the coil 5 has passed its peak and is again approaching zero. In this connection, it should be pointed out, however, that it is not entirely necessary for the restoring force to be provided by the leaf-springs 2c alone. It would be equally possible to fit, between the parts 2b and 2a or between the part 2b and the base member 1, which is fixed to the part 2a, a spring such as a coil spring, for example, to provide part of the restoring force or to produce the whole of the restoring force unaided, for example in the case when the connecting members extending between the parts 2a and 2b, although transversely flexible, are not resilient.

During every half-wave of the a.c. current, there is thus an initial attraction of the armature 10 by the core 8, and hence a vertically downward movement of the armature 10 attached to the disc-shaped part 2b, and of the drive member 9, as the current rises from zero to maximum, this movement being accompanied by simultaneous clockwise rotation (as viewed in the figures) of the part 2b, together with the armature 10 and the drive member 9. If counter-clockwise rotation of the part 2b is desired as it moves downwards, the connecting members should be inclined not as shown in FIG. 3, but in the opposite sense. When the current de-

cays from maximum to zero, the restoring forces already mentioned effect a counter-clockwise rotation of the part 2b, together with the armature 10 and the drive member 9, accompanied by simultaneous movement vertically upwards of the part 2b, together with the armature 10 and the drive member 9.

Thus, when an a.c. current is fed to the electromagnet 3, simultaneous reciprocating and rotary vibrations are set up in the drive member 9, at twice the frequency of the current. A conveyor helix 20, for example, similar to the type shown in FIGS. 17 and 18 of Swiss Pat. No. 316,008, may be fitted, as shown in FIG. 4, to the drive member 9, the longitudinal axis of the component 2 being vertical. The conveyor helix 20 has its base resting on the part 2b and has a central hole into which the drive member 9 extends. By means of a screw (not shown), which is received in a threaded hole 21 in the drive member 9, the helix 20 is secured firmly to the drive member 9. The way in which the simultaneous reciprocating and rotary vibrations transmitted by the drive 9 to the helix 20 are converted into a material-conveying action is known in the art and need not be discussed herein. The speed of the conveyor speed is determined substantially by the amplitude of the reciprocating and rotary vibrations. It is to enable the amplitude of reciprocating and rotary vibration and hence also the conveyor speed, to be adjusted while the conveyor is in operation, that the means of adjusting the air gap 12, are provided; a variation in the air gap 12 alters the force with which the armature 10 is attracted by the core 8, and this alteration in the force of attraction results in an approximately proportional alteration in the amplitude of the reciprocating and rotary vibrations carried out by the part 2b, the armature 10 and the drive member 9. To vary the air gap 12, the worm 14 is rotated by means of a screw 22 (FIG. 4), the slotted nut 13 being thereby rotated, in consequence of which the threaded bolt 7 and the core 8 are moved vertically. In order that the nut 13 is not vibrated by the forces acting on the core 8, it is held fast by two powerful cup springs 15 interposed between thrust bearings 16. The thrust bearings 16 are provided to enable the nut 13 to be turned despite this firm grip by the cup springs 15. The assembly comprising the two thrust bearings 16, the two cup springs 15 and the nut 13, is secured firmly in the base member 1 by a locking ring 17. To prevent the core 8 from rotating together with the nut 13 when the latter is rotated, an anti-rotation pin 18, is mounted in the base member 1 and extends into a slot 19 in the core 8.

Should it be possible to dispense with such regulation of the amplitude of the simultaneous reciprocating and rotary vibrations while the driving unit is in operation, then, instead of the relatively complicated means provided in the embodiment shown in FIG. 1 for varying the air gap 12, considerably simpler and accordingly less expensive means of varying the air gap 12 can be provided, as shown in FIG. 2. In this embodiment, the bolt 7 is engaged in a threaded bore 23 in the base member. A slot 24, is formed in the bottom end of the bolt 7 for the reception of a screw-driver or like tool and a locknut 25, is provided for locking the bolt 7 thereby to the gap setting. These simpler means have the advantage of being less expensive, but the disadvantage of not being able to alter the amplitude of the reciprocating and rotary vibrations produced by the driving unit during operation, which, when the unit is driv-

ing helical conveyors, for example, renders it necessary for the conveyor speed to be regulated by the use of a heavy-duty and hence also somewhat expensive series resistor inserted in the supply lead. The cost of such a series resistor far outweighs the difference in the cost of adjusting the gap 12 in accordance with the embodiment shown in FIG. 1, as compared to the embodiment shown in FIG. 2.

Preferably, the natural resonant frequency of the driving unit, that is to say of those of its parts which carry out the reciprocating and rotary vibrations, should be as nearly equal as is possible to twice the frequency of the a.c. supply to be used, because then the power consumption of the driving unit will be reduced to the minimum. The mass and inertia of the driven object, that is to say the conveyor helix 20, for instance, will affect the resonant frequency. This consideration should be taken into account when determining the dimensions of the component 2 and, in particular, the connecting members 2c thereof. However, since precise calculation of the size of the connecting members 2c from prescribed resonance frequency presents considerable difficulty, besides which the dimensioning of these connecting members 2c must be matched to the driven object if the requirement of a resonant frequency equal to twice the frequency of the a.c. supply is to be met, it is advantageous if the stiffness of the connecting members 2c and hence the restoring force exert per unit angular deflection can be varied. With plastics components constructed as shown in FIG. 3, this can be achieved by making the ring-shaped part 2a a little deeper and the connecting member 2c correspondingly shorter. In this way, it becomes possible to vary the length of the connecting members 2c and hence also the stiffness thereof, without the construction of the driving unit having to be altered in other ways.

In order to produce the component 2, a two-part mould is used, this being opened, after production of the component, by the two halves of the mould being pulled apart in an axial direction. Preferably one part of the mould is in the form of a first cylinder mounted on a plate and the other half is in the form of a second hollow, cylinder closed at one end. The inside diameter of the second cylinder is equal to the outside diameter of the first cylinder and its depth is greater, by the thickness of the part 2b, than the height of the first cylinder. The open end of the second cylinder is widened and corresponds to the shape of the part 2a. Grooves, corresponding in number to the connecting members extend from the front end of the hollow cylinder along the full length thereof. The inclination of the grooves corresponds to that of the threads of a multi-start screw of equivalent size having as many threads as there are connecting members and a pitch which is a multiple of the inside diameter of the second cylinder. When the two-part mould as described is used, the component can then be turned out of the second cylinder when the mould is pulled apart as stated or, following that action, by a simple twisting movement, equal in extent to the pitch of the grooves, in relation to the second cylinder.

Variation in the length of the connecting members 2c and at the same time in the depth of the part 2a can be achieved without difficulty, in the production method described, if that part of the mould which is in the form of a hollow cylinder be composed of three separate members, viz, a cylindrical jacket with a smooth cylin-

drical interior, the inside diameter of which is equal to the diameter of an imaginary cylindrical surface defined by the outer edges of the connecting members 2c and having a widened portion at its front end corresponding to the widened step on the part 2a; secondly, a hollow cylinder that can slide axially within this cylindrical jacket, but is secured (by key and keyway, for example) against rotation relative thereto, its outside diameter being equal to the inside diameter of the cylindrical jacket and its inner wall containing the continuous grooves described previously, the grooves extending almost to the outer wall of the hollow cylinder and also, over a front portion of its entire length, possibly reaching the outer periphery of the hollow cylinder (in other words, piercing the outer wall of the hollow cylinder); and, thirdly, a multi-start screw that fits precisely into the hollow cylinder and its grooves, having as many threads as there are grooves in the hollow cylinder. The screw is screwed into the hollow cylinder from the rear, with its head bearings against the rear end of the cylindrical jacket, its length from where it bears against the cylindrical jacket to its front end being equal to the length of the cylindrical jacket less the depth of the component 2. By rotating the screw in relation to the cylindrical jacket, the hollow cylinder can be slid axially within the cylindrical jacket, the length of the connecting members 2c and the depth of the part 2a being thereby varied.

The half-mould comprising the said three members (cylindrical jacket, hollow cylinder and multi-start screw) again forms, as such, a hollow cylindrical half-mould closed at its rear end and has the same features and advantages as the hollow cylindrical half-mould previously described in connection with the production method already referred to. The technique employed in making the component by the use of such an adjustable half-mould is therefore the same as previously described, with the sole addition that the adjustable half-mould is set to the desired length for the connecting members 2c before the component 2 is made.

The parts 2a and 2b can comprise the conveyor helix on one hand and the conveyor chassis on the other, or can, as described, be constructed to be readily attached to the chassis and to the conveyor helix which is advantageous in that manufacture of the component 2 is relatively simple and inexpensive.

The component is suitably made from a resilient plastics, preferably a polyacetal. The plastics used should preferably have a modulus of elasticity exceeding 10,000 kp./sq.cm. and a bending strength exceeding 500 kp./sq.cm.

What is claimed is:

1. A driving unit for simultaneously producing reciprocatory and oscillatory motion, comprising:
  - a plastics component; said component including,
    - a first part,
    - a second part, one of said parts being ring-shaped and having a flat axial end face and the other of said parts having an arcuate periphery,
    - a base member, said one part being rigidly mounted on said base member, and
    - a plurality of leaf springs extending helically between said first and second parts to define a housing therewith and said springs being integrally connected with said parts, said leaf springs being attached to said one part at respective points lying on said axial face and to said other

part at respective points lying on the arcuate periphery thereof, said leaf springs being substantially rigid longitudinally and flexible transversely to permit relative movement between said parts, said axial face and said arcuate periphery lying in parallel planes with their respective centers lying on an axis extending at right angles to said planes, the length of each said leaf spring between their respective attachment points being greater than the shortest distance between said respective attachment points;  
electromagnetic means located within said housing and actuable to apply a periodically variable force of equal and opposite magnitude between said parts whereby said one part is moved relative to said other part along said axis and is simultaneously rotated relative to said other part about said axis, said electromagnetic means including at least one electromagnet having a core means and armature means, one of said core and armature means being mounted on said base member, and the other of said core and armature means being rigidly attached to said other part; and  
adjustment means for adjusting the distance between said core means and said armature means.

2. A driving unit according to claim 1, in which said plastics component is formed from resilient plastics.

3. A driving unit according to claim 1, in which said leaf springs are attached to said first and second parts at said respective points distributed symmetrically about the circumference of said axial face and said arcuate periphery.

4. A driving unit according to claim 1 in combination with a

helical conveyor, said axis extending vertically and said conveyor being attached to the other of said parts, said other of said parts being disposed above said one of said parts.

5. A driving unit according to claim 1 wherein said adjustment means comprises

bolt means extending from the said one of said means in the same direction as said axis, said bolt means being mounted in said base member,

nut means engaged with said bolt means and rotatable relative to said base member,

means preventing axial movement of said nut means relative to said base member, and

means for rotating said nut means relative to said base member.

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