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(54) Braking device for toggle-lever drive apparatuses

(57) The braking device (15, 16) for braking a rocking work arm (12) in toggle-lever drive apparatuses (10), comprises a hydraulic decelerator (17', 17") operating in correspondence with an operative position of the work arm (12), which is provided with a control rod (18) movable according to a longitudinal axis (A); the braking device (15, 16) further comprises an actuating arm (19', 19") connected to the rotatable drive shaft (13) of the work arm (12) and designed to act on the control rod (18) of the hydraulic decelerator (17', 17"). The control rod (18) of the decelerator (17', 17") and the actuating arm (19', 19'') have arched contact surfaces (20, 21) shaped and disposed in such a way that the actuating arm (19', 19") exerts a thrust force on the control rod (18) which remains substantially coaxial to the longitudinal axis (A) of the decelerator (17', 17").

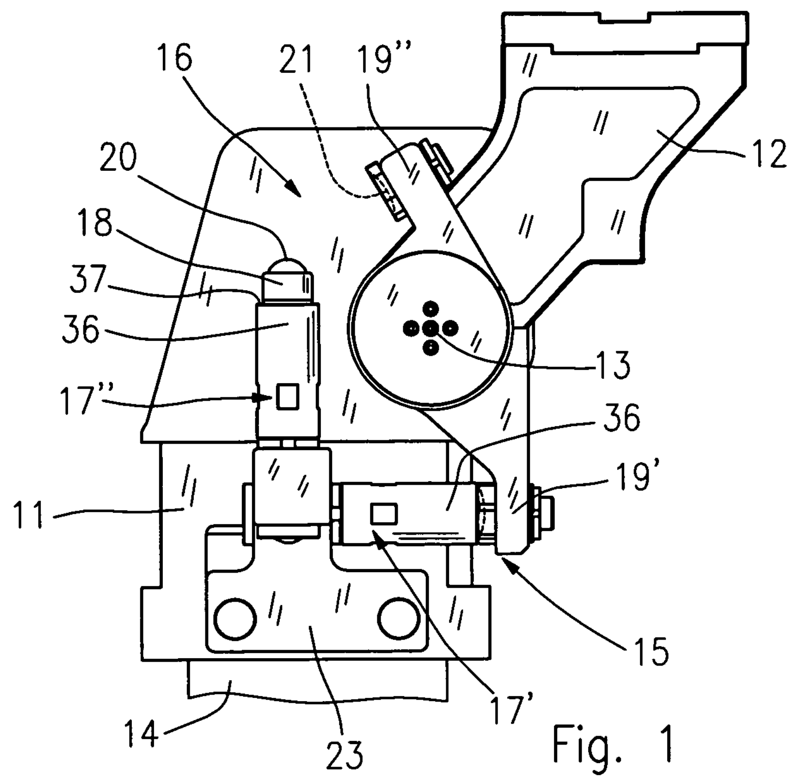

Fig. 1

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Description

BACKGROUND OF THE INVENTION

[0001] This invention concerns a braking device for a toggle-lever drive apparatus having a rocking work arm, the braking device being particularly suitable for braking the work arm in correspondence with an operative position; this invention also concerns a toggle-lever drive apparatus comprising at least one braking device for braking the rocking work arm.

STATE OF THE ART

[0002] In general, drive apparatuses having a rocking work arm are known and used for example in the motor vehicle manufacturing field, along the bodywork assembly lines, for driving heavy support structures for supporting a plurality of clamping and/or centring devices for sheet metal parts to be assembled with one another.

[0003] A drive apparatus of this kind, known for example from EP-A-1 300 625, conventionally comprises a box-shaped body having a pivotally connected work arm which is angularly movable between a first and a second operative position, and a pneumatic linear actuator operatively connected to the work arm by means of a toggle lever connecting link assembly housed in the box-shaped body of the device.

[0004] In general, in drive apparatuses of this kind, in which the rocking arm have to support and move heavy loads, there is a need to control the movement of the same rocking arm, in an even and extremely precise way, maintaining an accurate control of the positions, in particular during the transient stopping period of the movement in correspondence with the operative positions.

[0005] For such purpose it is possible to make use of pneumatic damping and braking devices associated with the linear actuator of the apparatus, as for example illustrated in EP-A-1 199 480 and DE-A-3307584.

[0006] In particular, EP-A-1 199 480 illustrates a pneumatic actuator comprising a piston chamber closed by a front head and by a rear head, each having an inlet-outlet opening for the inlet and outlet of air under pressure, which opens out into a cavity which is coaxially arranged to and communicating with the piston chamber.

[0007] The actuator also comprises pneumatic braking means whereby it is possible to control the movement of the piston at the end of its stroke, which comprise for each head a narrowed air venting passage and a sleeve secured on one piston surface facing towards the head itself, the sleeve being designed to penetrate tightly into the cavity in the head, thereby closing the air inlet-outlet opening; in this way, the residual air contained in the chamber is forced to escape in a controlled manner from the narrowed passage, decelerating the stroke of the piston at the end of its stroke.

[0008] The use of braking means of this kind in the aforesaid drive apparatuses, however, implies various problems of a functional nature, in that the use of a compressible fluid, like compressed air, does not allow a precise control of the position and the movement of the work arm, and moreover involves the possible onset of parasitic vibrations and oscillations of the work arm itself which induce overstresses in the drive apparatus.

[0009] In addition, braking means of this kind prove to be inadequate whenever the work arm must be moved at high speeds, for example imposed by specific manufacturing requirements, in that they are unable to absorb the high kinetic energy values that are generated, thereby jeopardising the operation and the general reliability of the drive apparatus.

[0010] One possible solution would be to make use of conventional hydraulic braking means, possibly compatible with the linear actuator, which however would give rise to a considerable increase in structural complexity, together with a consequent increase in costs and greater risks related to the reliability of the apparatus.

OBJECTS OF THE INVENTION

[0011] The main object of this invention is to provide a braking device for a toggle-lever drive apparatus, which is structurally simple and inexpensive, and which allows to efficiently decelerate the work arm also in the presence of high kinetic energy values for the arm itself.

[0012] Another object of this invention is to provide a braking device of the aforementioned kind, whereby it is possible to exert a controlled braking action having a constant value on the work arm, thus allowing the precise control of the position and of the movement of the work arm.

[0013] A further object of this invention is to provide a braking device of the aforementioned kind, which possesses easily adaptable structural and mechanical features, both for allowing its installation on different types of drive apparatuses, and for allowing the correct positioning of the work arm also in the presence of backlash inside the drive apparatus.

[0014] A still further object of this invention is to provide a toggle-lever drive apparatus which is structurally simple, and which allows the work arm to perform a rapid movement, while at the same time maintaining perfect control of the movement of the arm itself, in particular in correspondence with the operative positions.

BRIEF DESCRIPTION OF THE INVENTION

[0015] According to a first feature of the invention, the above can be achieved by means of a braking device for a toggle-lever drive apparatus having a rocking work arm connected to a rotatable drive shaft, in which said braking device comprises braking means operating in correspondence with an operative position of the work arm, characterised by comprising:

a hydraulic decelerator in correspondence with said

operative position, having a control rod movable according to a longitudinal axis; and
an actuating arm connected to the rotatable shaft of the work arm and designed to act on the control rod of the hydraulic decelerator,
the control rod of the decelerator and the actuating arm having arched contact surfaces shaped and disposed in such a way that the actuating arm exerts a thrust force on the control rod itself which remains substantially coaxial to the longitudinal axis of the decelerator.

[0016] According to a further feature of the invention, a toggle-lever drive apparatus having a rocking work arm is provided, of the type comprising:

a box-shaped body;
a work arm connected to a rotatable drive shaft operatively connected to a linear actuator, the work arm being angularly movable between a first and a second operative position; and
braking means operating in correspondence with at least one of said first and second operative positions of the work arm,

characterised in that said braking means comprise:

a hydraulic decelerator on at least one side of the box-shaped body, in correspondence with at least one of said first and second operative positions of the work arm, each decelerator having a control rod movable according to a longitudinal axis; and
an actuating arm for each hydraulic decelerator, connected to the rotatable shaft of the work arm and designed to act on the control rod of the hydraulic decelerator itself,
the control rod of each decelerator and the relevant actuating arm having arched contact surfaces shaped and
disposed in such a way that the actuating arm exerts a thrust force on the control rod which remains substantially coaxial to the longitudinal axis of the decelerator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and further features according to this invention, will be more clearly evident from the following description with reference to the accompanying drawings, in which:

Fig. 1 shows a side view of a drive apparatus comprising a first and a second braking device according to this invention, in which the work arm is in a first operative position;
Fig. 2 shows a side view of the drive apparatus of Fig. 1, in which the work arm is in a second operative position;
Fig. 3 illustrates a braking device according to this invention;
Figs. 4 to 7 show enlarged details illustrating the contact surfaces of the braking device of Fig. 3, in different operative positions;
Fig. 8 shows an exploded perspective partial view of the apparatus of Fig. 1;
Fig. 9 shows a longitudinal cross-sectional view of the hydraulic decelerator of the braking device of Fig. 3; and
Fig. 10 shows a longitudinal cross-sectional view of the toggle-lever drive apparatus according to this invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The general features of this invention will be illustrated hereunder by means of several embodiments.

[0019] Figures 1 and 2 illustrate a toggle-lever drive apparatus provided with a first and a second braking device according to this invention.

[0020] In particular, the drive apparatus according to the invention, indicated as a whole by reference number 10, comprises a box-shaped supporting body 11 for supporting a work arm 12 connected to a rotatable drive shaft 13, in turn operatively connected to a pneumatic linear actuator 14, as explained further on.

[0021] The work arm 12 is angularly movable according to a rocking movement between a first operative position, illustrated in Fig. 1, and a second operative position, illustrated in Fig. 2, which can be modified in relation to the operative requirements, as explained further on.

[0022] As mentioned previously, the apparatus 10 in this case comprises a first braking device 15, acting in correspondence with the first operative position of the work arm 12, and a second braking device 16, acting in correspondence with the second operative position of the work arm 12.

[0023] However, it cannot be excluded that the apparatus 10 may comprise only one braking device acting in correspondence with only one of said first and second operative positions of the work arm.

[0024] The first braking device 15 comprises a hydraulic decelerator 17' acting in correspondence with the first operative position of the work arm 12, the decelerator 17' having a control rod 18 movable according to a longitudinal axis A.

[0025] In turn, the second braking device 16 comprises a hydraulic decelerator 17" acting in correspondence with the second operative position of the work arm 12, the decelerator 17" having its own control rod 18 movable according to a respective longitudinal axis A.

[0026] As can be seen in the figures, the longitudinal axes A of operation of the decelerators 17', 17" are disposed in angularly spaced apart positions from each other in a plane orthogonal to the drive shaft 13.

[0027] The first braking device 15 also comprises an actuating arm 19' for the first hydraulic decelerator 17', while the second braking device 16 comprises an actuating arm 19" for the second hydraulic decelerator 17"; the actuating arms 19', 19" are connected to the rotatable shaft 13 of the work arm 12, in angularly spaced apart positions from one another in the aforesaid orthogonal plane, to rotate with the work arm 12 according to said plane between the first operative position, in which the first arm 19' operates the rod of the first hydraulic decelerator 17', and the second operative position, in which the second arm 19" operates the rod of the second hydraulic decelerator 17" , along a preestablished rotational angle.

[0028] As illustrated in the figures 4 to 7, the control rod 18 of each decelerator 17', 17" and the relevant actuating arm 19', 19" have arched contact surfaces 20, 21 shaped and disposed in such a way that the actuating arm 19', 19" exerts a thrust force F on the control rod 18 itself which remains substantially coaxial to the longitudinal axis A of the decelerator 17', 17" .

[0029] This occurs in particular along the entire angle of rotation in which each actuating arm 19', 19" acts on the control rod 18 of the relevant decelerator 17', 17".

[0030] For the purposes of this description, the expression "thrust force substantially coaxial to the axis of operation" is understood to mean that the thrust force F is coaxial or at the most can be slanted by an angle α ranging from 0° to 3° compared to the longitudinal axis A of operation of the decelerator, in any case passing through the axis A itself.

[0031] Thanks to a measure of this kind, the thrust force F exerted by each actuating arm 19', 19" on the control rod 18 of the relevant decelerator 17', 17'' does not have significant force components acting in a transversal direction to the control rod 18, thereby drastically limiting the breakage risks of the rod 18 itself, and obtaining force values F which have a component in an axial direction that remains virtually constant along the entire angle of operation of the decelerator, with significant advantages in terms of control of the braking of the work arm 12.

[0032] To achieve this, the actuating arm 19', 19" comprises a concave thrust surface 21, on a side facing towards the decelerator 17', 17", while one end of the control rod 18 of the decelerator 17', 17" is provided with a convex reaction surface 20.

[0033] The concave thrust surface 21 provided on each actuating arm 19', 19" has, in the plane of oscillation of the arm 19', 19" itself, a curved profile having one or more radiuses of curvature; preferentially, as in the case illustrated, the concave surface 21 is defined by an arc of a circumference having a single radius of curvature R1.

[0034] Likewise, the convex reaction surface 20 provided on the control rod 18 of each decelerator 17', 17" has, in the plane of oscillation of the actuating arm 19', 19", a curved profile having one or more radiuses of curvature.

[0035] In the case illustrated, the convex reaction surface 20 is defined on a contact head 22 disposed at the end of the control rod 18 of the decelerator 17', 17''; preferentially, the contact head 22 provided on the control rod 18 is in the form of a spherical bearing comprising a contact ball 22 freely rotatably supported on a plurality of supporting balls, which has a single radius of curvature R2.

[0036] Preferentially, the concave surface 21 has a centre of curvature C1 which, during contact with the convex reaction surface 20, lies on the longitudinal axis A of operation of the decelerator, and has a radius of curvature R1 equivalent to at least twice the radius of curvature R2 of the contact head 22.

[0037] The hydraulic decelerators 17', 17" can be supported on at least one side of the box-shaped body 11 of the apparatus 10, in particular on one side or, alternatively, on the opposite side of the box-shaped body 11 itself, by means of an appropriate bracket 23 securable by means of bolts or other removable fastening means.

[0038] In relation to the side on which the decelerators 17', 17" are fitted, the actuating arms 19', 19" are consequently provided or connected to the rotatable shaft 13 of the work arm 12 on the same side of the box-shaped body 12.

[0039] Each decelerator 17', 17" is supported on the bracket 23 to be adjustable in position according to the direction of the longitudinal axis A of operation of the decelerator 17', 17'' itself.

[0040] As illustrated in Fig. 9, preferentially each decelerator 17', 17" comprises a cylindrical body 24 provided with an external screw thread 25 engageable in a respective threaded hole 26 provided in the bracket 23, in such a way as to allow a simple axial adjustment of the decelerator 17', 17" by screwing.

[0041] A nut 27, that can be tightened against the bracket 23 for locking the decelerator 17', 17" in position, is also screwed onto the screw thread 25.

[0042] Preferentially, the second actuating arm 19" , which, as mentioned previously, acts in correspondence with the second operative position of the work arm 12, is connected to the drive shaft 13 in an angularly adjustable way with respect to the drive shaft 13 itself, in the plane of oscillation of the actuating arm 19''.

[0043] In particular, as illustrated in Fig. 8, the actuating arm 19" comprises an annular body 28 which is removably connected to the drive shaft 13, the body 28 of the arm 19" having a hole 29 provided with a radially internal toothing 30 selectively engageable in an adjustable way with a radially external toothing 31 provided on the drive shaft 13.

[0044] It cannot be excluded however that the angular adjustment of the actuating arm can be achieved by other suitable means, for example by means of pins, not shown, that can be inserted into appropriate holes provided in the actuating arm and/or in the drive shaft.

[0045] Moreover, a graduated rim 32 is provided or fitted concentrically onto the drive shaft 13 for indicating the angular position of the actuating arm 19" with respect to the drive shaft 13, which defines a check for a reference notch 33 peripherally provided on the annular body 28 of the actuating arm 19" .

[0046] The removable fastening of the actuating arm 19" can for example be achieved by means of an appropriate retaining disc plate 34 which maintains the annular body 28 of the arm 19" anchored to the drive shaft 13 by means of one or more fastening screws 35 which engage in the shaft 13 itself.

[0047] The drive apparatus 10 according to this invention also comprises stop means for stopping the actuating arms 19', 19" of the decelerators 17', 17" in the respective operative positions of the work arm 12.

[0048] Preferentially, said stop means are associated with or included in each braking device 15, 16 according to this invention, and in particular, as illustrated in figures 1, 2 and 9, comprise a stop sleeve 36 coaxially fitted to each hydraulic decelerator 17', 17", peripherally around the control rod 18 of the decelerator itself; each stop sleeve 36 has an end defining a respective stop surface 37 against which the actuating arms 19', 19" are designed to stop in order to define the respective operative positions of the work arm, at the end of the rotational angle along which each actuating arm 19', 19" acts on the respective decelerator 17', 17".

[0049] Preferentially, each stop sleeve 36 is axially adjustable with respect to the relevant hydraulic decelerator 17', 17", for example by providing an appropriate internal screw thread 38 that can be screwed onto the external screw thread 25 of the body 24 of the decelerator 17', 17", the sleeve 36 being lockable in position against the nut 27, or by providing a further check nut, not shown, on the body 24 of the decelerator 17', 17" .

[0050] The stop sleeve 36 also comprises a cylindrical internal guiding and sliding surface for the control rod 18 and/or for the contact head 22 of the decelerator 17', 17", for example defined by a cylindrical guide bearing 39 housed in an appropriate seat in the stop sleeve 36.

[0051] Thanks to the braking devices with integrated stop means as described above, the drive apparatus according to this invention allows to efficiently decelerate the work arm also in the presence of high kinetic energy values, and to stop the work arm itself in correspondence with operative positions which can be adjusted and/or modified.

[0052] In particular, in the event of use of the drive apparatus along an assembly line in the motor vehicle manufacturing field, the first braking device 15 conventionally acts in correspondence with a first fixed operative position of the work arm 12, illustrated in Fig. 1; therefore it is not necessary to provide for the angular adjustment of the actuating arm 19', which would enable the macroscopic modification of the operative position of the work arm 12.

[0053] However, the axial adjustment provided for the decelerator 17' and for the relevant stop sleeve 36 of the braking device 15 allows to micrometrically compensate for any mechanical clearances and thus accurately define the first operative position of the work arm 12.

[0054] Conversely, the second braking device 16 acts in correspondence with a second operative position of the work arm 12, illustrated in Fig. 2, which, in relation to requirements of use or of operative speed of the drive apparatus, must allow to be modified each time; in this case, as mentioned previously, consequently the angular adjustment of the relevant actuating arm 19" is provided, whereby it is possible to macroscopically modify the second operative position of the work arm 12.

[0055] Preferentially, the second operative position of the work arm 12 can be adjusted discontinuously by a preestablished angle, for example 15°, to vary from a minimum angular value of 15° to a value of 120° with respect to the first operative position of the work arm 12.

[0056] An adjustment of this kind is achieved by providing that the internal radial toothing 30 of the actuating arm 19" and the external radial toothing 31 of the drive shaft 13 have teeth spaced apart by the chosen angle of 15°, so that, with the help of the graduated rim 32, the actuating arm 19" can be secured in an angular position corresponding to the operative position established for the work arm 12.

[0057] Here too, the axial adjustment for the decelerator 17" and for the relevant stop sleeve 36 of the braking device 16 is provided, so as to allow the micrometric compensation of any mechanical clearances, for accurately defining the second operative position of the work arm 12.

[0058] Moreover, the numerous possibilities of adjusting the braking device according to the invention, enable it to be installed on different types of drive apparatuses, without the need for substantial structural modifications.

[0059] In addition, it cannot be excluded that both the actuating arms 19', 19" can be provided with an angular adjustment with respect to the drive shaft 13, in relation to specific operative requirements.

[0060] To increase the possibilities of adjustment, preferentially the concave thrust surface 21 is made on a striking member 40 adjustably fitted onto each actuating arm 19', 19" transversally to the arm itself.

[0061] The hydraulic decelerator chosen for the braking device according to this invention is of a type commonly available on the market, comprising a chamber for containing a dense hydraulic fluid, and a piston tightly housed in the chamber and connected to the control rod of the decelerator, the piston being movable within the containing chamber to force the hydraulic fluid itself through a narrow passage orifice provided in the containing chamber.

[0062] The decelerator also comprises adjusting means for regulating the braking force, acting on the narrow orifice for passage of the dense fluid.

[0063] A decelerator of this kind is particularly suitable for this invention, in that it is capable of absorbing high kinetic energy values, as well as ensuring excellent movement control of the load associated with the work arm 12, preventing the onset of oscillations and vibrations of the load itself.

[0064] However, it cannot be excluded that other types of hydraulic and non-hydraulic decelerators, that prove to be suitable for the purpose, may be used.

[0065] Lastly, Fig. 10 illustrates a schematic cross-sectional view of a drive apparatus 10 having a first and a second braking device 15, 16 according to this invention, in which the same numerical references have been used to indicate similar or equivalent parts.

[0066] The drive apparatus 10 of Fig. 10, comprises a pneumatic actuator 14 and a self-locking braking device 41, which will be described further on, capable of locking the work arm 12 and maintaining it locked in any position, when the pneumatic actuator 14 is not fed with air under pressure, for example at the end of its operation, or for accidental reasons.

[0067] The drive apparatus 10, as mentioned, comprises a box-shaped body 11 provided with a rotatable arm 12 designed to be connected to a load to be moved.

[0068] The pneumatic actuator 14 has a tubular rod 42 which is operatively connected to a lever arm 43, integral with or mechanically connected to the drive shaft 13, by means of an intermediate connecting link 44, the intermediate link 44 being elastically yieldable in an axial direction, and articulated in 45 and 46 to its ends. The elastic connecting link 44 forms part of a known type of toggle-lever mechanism, whereby it is possible to achieve a condition of irreversibility of the motion of the work arm 12 in correspondence with the first operative position, illustrated in Fig. 10, with particular reference to the case in which the work arm is subjected to external stresses which tend to make it rotate.

[0069] The self-locking braking device 41, provided at one end of the actuator 14 opposite the box-shaped body 11, comprises an axle 47 operatively connected to the rod 42 of the actuator by means of a nut-screw mechanism 48; the tubular rod 42 slides axially along the box-shaped body 11 between a forward position and a backward position, coaxially to the axle 47, causing the lowering or the raising of the rocking arm 12 and the simultaneous rotation of the axle 47.

[0070] The pneumatic actuator 14 comprises a tubular body 49 closed by a front head 50 and by a rear head 51 onto which the self-locking braking device 41 is mechanically secured.

[0071] Reference number 52 has been used to indicate a piston, connected to the tubular rod 42, which is reciprocably movable within the chamber of the actuator 14 between a backward position against the rear head 51, and a forward position against the front head 50.

[0072] Reference number 53 has been used to indicate a flow passage duct for the feeding and discharge of the air under pressure, formed in the front head 50, while reference number 54 has been used to indicate a flow passage duct for the air in the rear head 51.

[0073] The piston 52 has a front tubular nose 55, coaxial to the tubular rod 42, and a rear tubular nose 56 coaxial to the previous one.

[0074] The two noses 55 and 56 form part of a pneumatic damping device for damping the movement of the piston 52 at the two ends of its working stroke, which can be used in combination with the braking devices 15 and 16 according to this invention, or in place of one of them, whenever, in correspondence with an operative position of the work arm 12, a high absorption of kinetic energy of the arm 12 itself is not required.

[0075] As schematically indicated in figure, the nose 55 has a slightly conical end surface, to penetrate into a cavity coaxial to the axle 47, having an end open towards the chamber of the actuator 14; a lip seal 58 tightly closes the cavity as soon as the conical end of the nose 55 begins to penetrate, closing the air passage towards the duct 53.

[0076] In this condition, the air under pressure which remains in the chamber of the actuator can be discharged through a throttle valve 59, into a duct made in the head 50, between the chamber of the actuator and the duct 53 for feeding and discharging the compressed air.

[0077] The damping device of the rear head 51 is wholly identical to the damping device of the front head 50, to which reference is made.

[0078] Returning to the self-locking braking device 41, it comprises braking means which can be operated to lock and, respectively, free the rotation of the aforesaid axle 47 connected to the rod 42 of the actuator 14.
The braking devices comprise a rigid braking disk 60, which rotates with the axle 47 itself, supported floating in an axial direction between two friction members 61, 62, one 61 of which is secured to a support body 63 supporting the axle 47, while the other friction member 62 is supported by a plate 64 biased by springs 65 against the braking disc 60 and operatively connected to a pneumatic cylinder 66 for disengagement of the brake.

[0079] From the foregoing it will be evident that the drive apparatus according to this invention is structurally simple, and allows the work arm to perform a rapid movement, and at the same time maintaining perfect control of the movement of the arm itself, in particular in correspondence with the operative positions.

[0080] What has been described and shown with reference to the accompanying drawings, has been given purely by way of example in order to illustrate the general features of the invention, and of its preferential embodiments; therefore, other modifications and variations to the braking device for a toggle-lever drive apparatus, and to the drive apparatus itself are possible, without thereby deviating from the scope of the claims.

Claims

1. Braking device (15, 16) for a toggle-lever drive apparatus (10) comprising a rocking work arm (12) connected to a rotatable drive shaft (13), in which said braking device (15, 16) comprises braking means operating in correspondence with an operative position of the work arm (12), **characterised by** comprising:

a hydraulic decelerator (17', 17") in correspondence with said operative position, having a control rod (18) movable according to a longitudinal axis (A); and
an actuating arm (19', 19") connected to the rotatable shaft (13) of the work arm (12) and designed to act on the control rod (18) of the hydraulic decelerator (17', 17"),
the control rod (18) of the decelerator (17', 17") and the actuating arm (19', 19") having arched contact surfaces (20, 21) shaped and disposed in such a way that the actuating arm (19', 19") exerts a thrust force on the control rod (18) which remains substantially coaxial to the longitudinal axis (A) of the decelerator (17', 17").

2. Braking device (15, 16) according to claim 1, **characterised in that** said arched contact surfaces (20, 21) of the actuating arm (19', 19") and of the control rod (18) of the decelerator (17', 17") are shaped and disposed to define a thrust force passing through the longitudinal axis (A) of the decelerator (17', 17") and slanting by an angle ranging from 0° to 3° with respect to the axis (A).

3. Braking device (15, 16) according to claim 1 or 2, **characterised in that** said contact surfaces (20, 21) of the actuating arm (19', 19") and of the control rod (18) of the decelerator (17', 17") comprise a concave thrust surface (21) provided on said actuating arm (19', 19") and a convex reaction surface (20) provided at one end of the control rod (18) of the decelerator (17', 17'').

4. Braking device (15, 16) according to claim 3, in which the actuating arm (19', 19") is movable in a plane of oscillation, **characterised in that** said concave thrust surface (21) provided on the actuating arm (19', 19") has, in said plane of oscillation, a curved profile having one or more radiuses of curvature.

5. Braking device (15, 16) according to claim 4, **characterised in that** said concave thrust surface (21) is defined by an arc of a circumference having a single radius of curvature.

6. Braking device (15, 16) according to claim 3, in which the actuating arm (19', 19") is movable in a plane of oscillation, **characterised in that** said convex reaction surface (20) provided on the control rod (18) of the decelerator (17', 17") has, in said plane of oscillation of the actuating arm (19', 19"), a curved profile having one or more radiuses of curvature.

7. Braking device (15, 16) according to claim 6, **characterised in that** said convex reaction surface (20) is defined on a contact head (22) disposed at the end of the control rod (18) of the decelerator (17', 17"), the contact head (22) having a curved profile having a single radius of curvature.

8. Braking device (15, 16) according to claims 5 and 7, **characterised in that** said concave thrust surface (21) has a centre of curvature which, during contact with the convex reaction surface (20), lies on the longitudinal axis (A) of operation of the decelerator (17', 17"), the concave thrust surface (21) having a radius of curvature equivalent to at least twice the radius of curvature of the contact head (22) defining said convex reaction surface (20).

9. Braking device (15, 16) according to claim 7 or 8, **characterised in that** the contact head (22) provided on the control rod (18) of the decelerator (17', 17") is in the form of a spherical bearing comprising a freely rotatably supported contact ball (22).

10. Braking device (15, 16) according to any of the previous claims, in which the drive apparatus (10) comprises a box-shaped support body (11) for supporting the rotatable shaft (13) of the work arm (12), **characterised in that** said hydraulic decelerator (17', 17") is supported on one side of the box-shaped body (11) of the drive apparatus (10), the actuating arm (19', 19") being connected to the rotatable shaft (13) of the work arm (12) on the same side of the box-shaped body (11).

11. Braking device (15, 16) according to claim 10, **characterised in that** the decelerator (17', 17") is adjustably supported in position in the direction of the longitudinal axis (A) of the decelerator (17', 17") itself.

12. Braking device (15, 16) according to any of the previous claims, in which the actuating arm (19', 19") is movable in a plane of oscillation orthogonal to the drive shaft (13) of the work arm (12), **characterised in that** said actuating arm (19', 19") is angularly adjustably connected to said drive shaft (13) with respect to the drive shaft (13), in said plane of oscillation.

13. Braking device (15, 16) according to claim 12, **characterised in that** the actuating arm (19', 19") is removably connected to said drive shaft (13), the actuating arm (19', 19") having a hole (29) provided with a radially internal toothing (30) selectively engageable in an adjustable way with an radially external toothing (31) provided on said drive shaft (13).

14. Braking device (15, 16) according to any of the previous claims, **characterised in that** said concave thrust surface (21) is made on a striking member (40) adjustably fitted on said actuating arm (19', 19") transversally to the arm (19', 19") itself.

15. Braking device (15, 16) according to any of the previous claims, **characterised by** comprising stop means (36) for stopping the actuating arm (19', 19") of the decelerator (17', 17") in said operative position for the work arm (12).

16. Braking device (15, 16) according to claim 15, **characterised in that** said stop means comprise a stop sleeve (36) coaxially fitted to the hydraulic decelerator (17', 17"), peripherally around the control rod (18) of the decelerator (17', 17") itself, said stop sleeve (36) having an end defining a stop surface (37) for stopping said actuating arm (19', 19") in said operative position of the work arm (12).

17. Braking device (15, 16) according to claim 16, **characterised in that** said stop sleeve (36) is axially adjustable with respect to the hydraulic decelerator (17', 17").

18. Braking device (15, 16) according to claim 16 or 17, in which one end of the control rod (18) of the decelerator (17', 17") is provided with a contact head (22) for the actuating arm (19', 19"), **characterised in that** said stop sleeve (36) comprises a cylindrical internal guiding and sliding surface for said contact head (22) of the decelerator (17', 17").

19. Braking device (15, 16) according to any of the previous claims, **characterised in that** said hydraulic decelerator (17', 17") is of the type comprising a chamber for containing a dense hydraulic fluid, and a piston tightly housed in said chamber and connected to said control rod (18), the piston being movable within the containing chamber to force the hydraulic fluid itself through a narrow passage orifice provided in said containing chamber.

20. Toggle-lever drive apparatus (10) having a rocking work arm (12), of the type comprising:

a box-shaped body (11);
a work arm (12) connected to a rotatable drive shaft (13) operatively connected to a linear actuator (14), the work arm (12) being angularly movable between a first and a second operative position; and
braking means operating in correspondence with at least one of said first and second operative positions of the work arm (12),

characterised in that said braking means comprise:

a hydraulic decelerator (17', 17") on at least one side of the box shaped body (11), in correspondence with at least one of said first and second operative positions of the work arm (12), each decelerator (17', 17") having a control rod (18) movable according to a longitudinal axis (A); and an actuating arm (19', 19") for each hydraulic decelerator (17', 17"), connected to the rotatable shaft (13) of the work arm (12) and designed to act on the control rod (18) of the hydraulic decelerator (17', 17"),
the control rod (18) of the decelerator (17', 17") and the relevant actuating arm (19', 19") having arched contact surfaces (20, 21) shaped and disposed in such a way that the actuating arm (19', 19") exerts a thrust force on the control rod (18) which remains substantially coaxial to the longitudinal axis (A) of the decelerator (17', 17").

21. Drive apparatus (10) according to claim 20, **characterised by** comprising:

a first hydraulic decelerator (17') for said first operative position and a second hydraulic decelerator (17") for said second operative position of the work arm (12), each of said first and second hydraulic decelerators (17', 17") having a control rod (18) and being supported by said box-shaped body (11) in such a way as to have respective longitudinal axes (A) of the control rods (18) disposed in angularly spaced apart positions from one another in a plane orthogonal to the drive shaft (13) of the work arm (12); and a first and a second actuating arm (19', 19") for said first, respectively said second hydraulic decelerators (17', 17"),
said first and said second actuating arm (19', 19") being connected to the drive shaft (13) of the work arm (12) in angularly spaced apart positions from one another in said orthogonal plane, to rotate with the work arm (12) between said first operative position, in which said first arm (19') operates the rod (18) of the first hydraulic decelerator (17'), and said second operative position, in which said second arm (19") operates the rod (18) of the second hydraulic decelerator (17").

22. Drive apparatus (10) according to claim 20 or 21, **characterised in that** said arched contact surfaces (20, 21) of each actuating arm (19', 19") and of the control rod (18) of the relevant decelerator (17', 17") are shaped and disposed to define a thrust force passing through the longitudinal axis (A) of the decelerator (17', 17") and slanting by an angle ranging from 0° to 3° with respect to the axis (A).

23. Drive apparatus (10) according to claim 22, **characterised in that** said contact surfaces (20, 21) of each actuating arm (19', 19") and of the control rod (18) of the relevant decelerator (17', 17") comprise a concave thrust surface (21) provided on said actuating arm (19’, 19") and a convex reaction surface (20) provided at one end of the control rod (18) of the decelerator (17’, 17").

24. Drive apparatus (10) according to claim 23, in which the actuating arm (19’, 19") is movable in a plane of oscillation, **characterised in that** said concave thrust surface (21) and said convex reaction surface (20) have, in said plane of oscillation of the actuating arm (19’, 19"), a curved profile having one respective radius of curvature.

25. Drive apparatus (10) according to claim 24, **characterised in that** said concave thrust surface (21) has a centre of curvature which, during contact with the convex reaction surface (20), lies on the longitudinal axis (A) of the decelerator (17’, 17"), and has a radius of curvature equivalent to at least twice the radius of curvature of said convex reaction surface (20).

26. Drive apparatus (10) according to claim 20, **characterised in that** each decelerator (17’, 17") is adjustably supported in position in the direction of the longitudinal axis (A) of the decelerator (17’, 17’’).

27. Drive apparatus (10) according to any of the previous claims from 20 to 26, in which each actuating arm (19’, 19") is movable in a plane of oscillation orthogonal to the drive shaft (13) of the work arm (12), **characterised in that** at least one of said actuating arms (19’, 19") is angularly adjustably connected to said drive shaft (13) with respect to the drive shaft (13), in said plane of oscillation.

28. Drive apparatus (10) according to any of the previous claims from 20 to 27, **characterised by** comprising stop means (36) for stopping each actuating arm (19’, 19") in said first and/or said second operative position for the work arm (12).

29. Drive apparatus (10) according to any of the previous claims from 20 to 28, in which the linear actuator (14) comprises a pneumatic cylinder having a piston (52) operatively connected to a rotating axle (47), **characterised by** comprising a self-locking braking device (41) for said rotating axle (47), said self-locking braking device (41) comprising a rigid braking disk (60), rotating with said axle (47), supported floating between a first and a second friction members (61, 62), one (61) of said friction members being fixed, the other (62) of said friction members being supported by a plate (64) elastically biased against the braking disc (60) and operatively connected to a pneumatic cylinder (66) for disengagement of the self-locking braking device (41).

30. Drive apparatus (10) according to claim 29, **characterised in that** said actuator (14) comprises pneumatic damping means (55, 56, 59) on at least one of its ends.

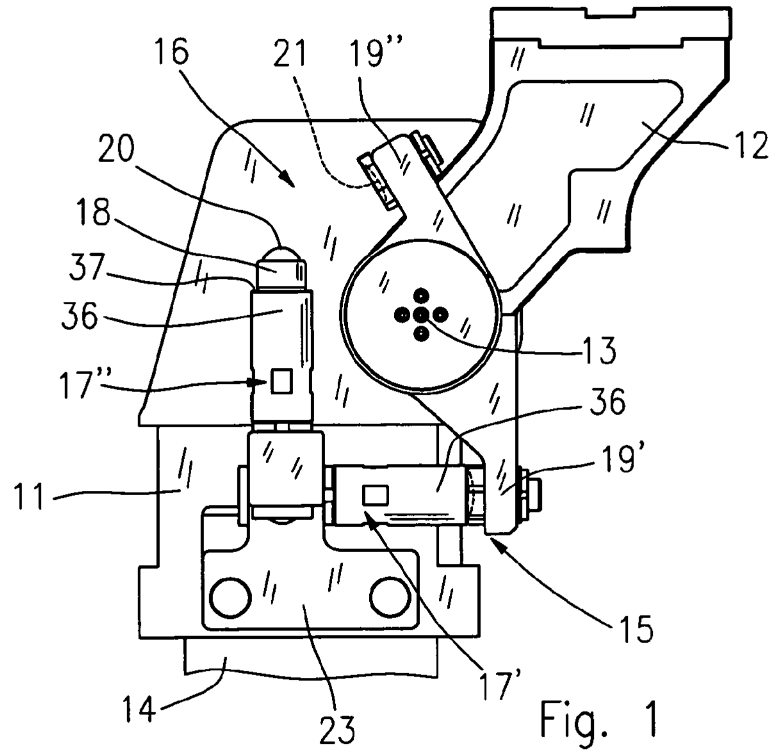
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Fig. 1

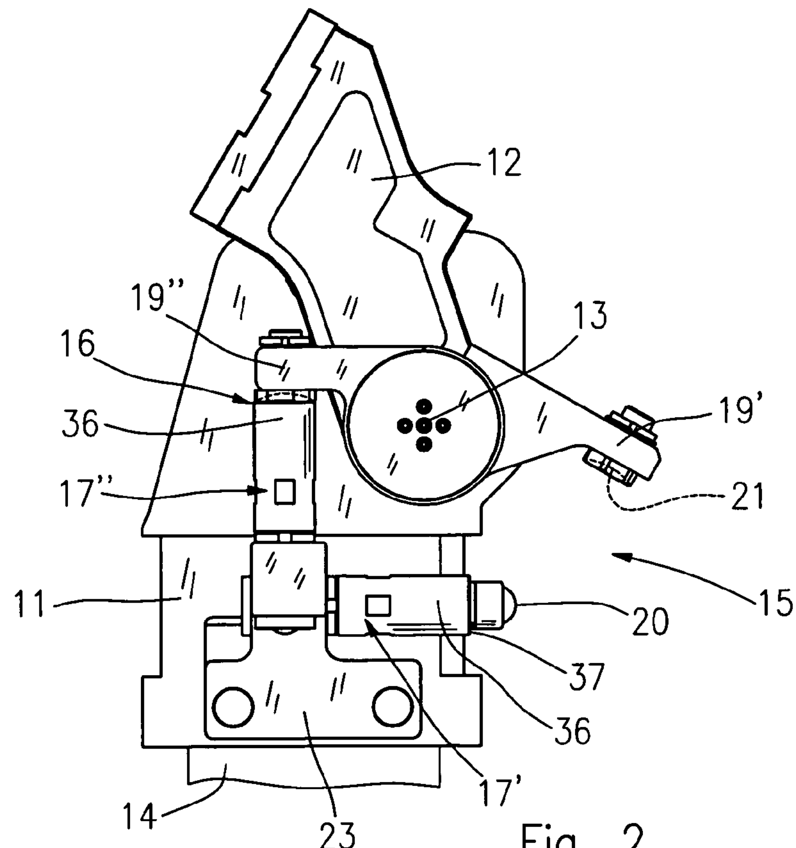
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Fig. 2

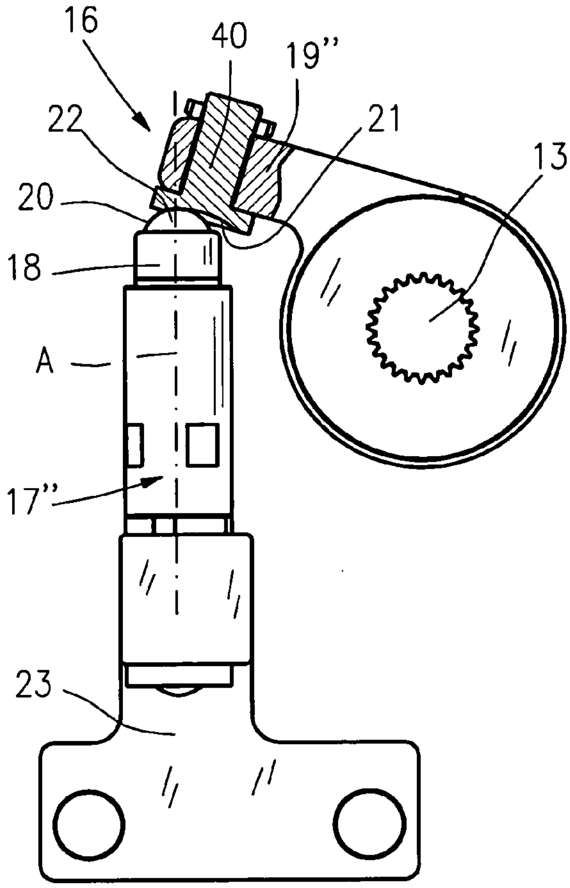

Fig. 3

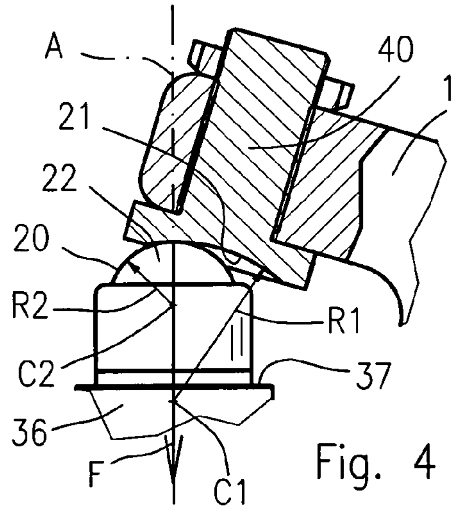

Fig. 4

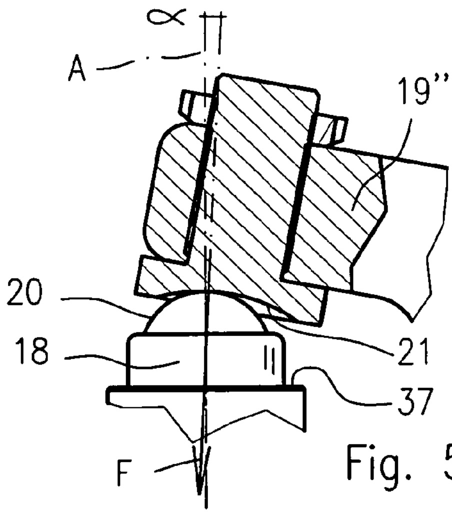

Fig. 5

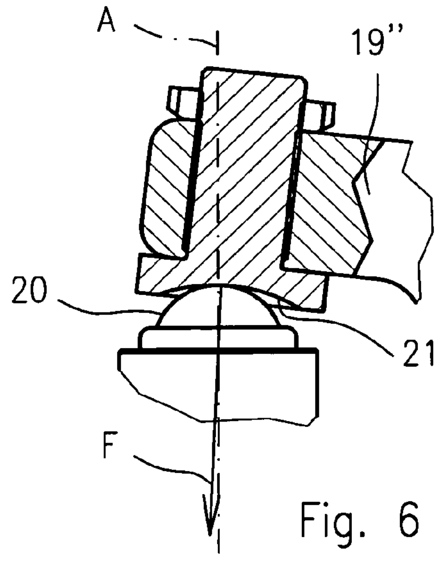

Fig. 6

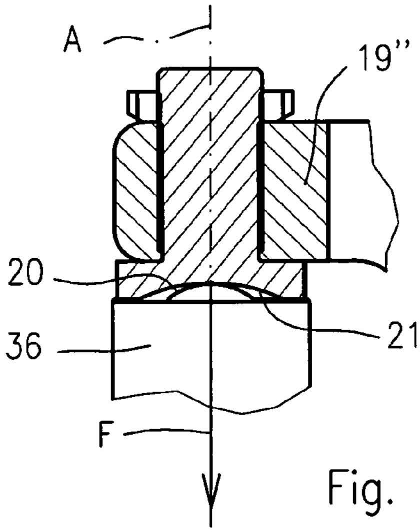

Fig. 7

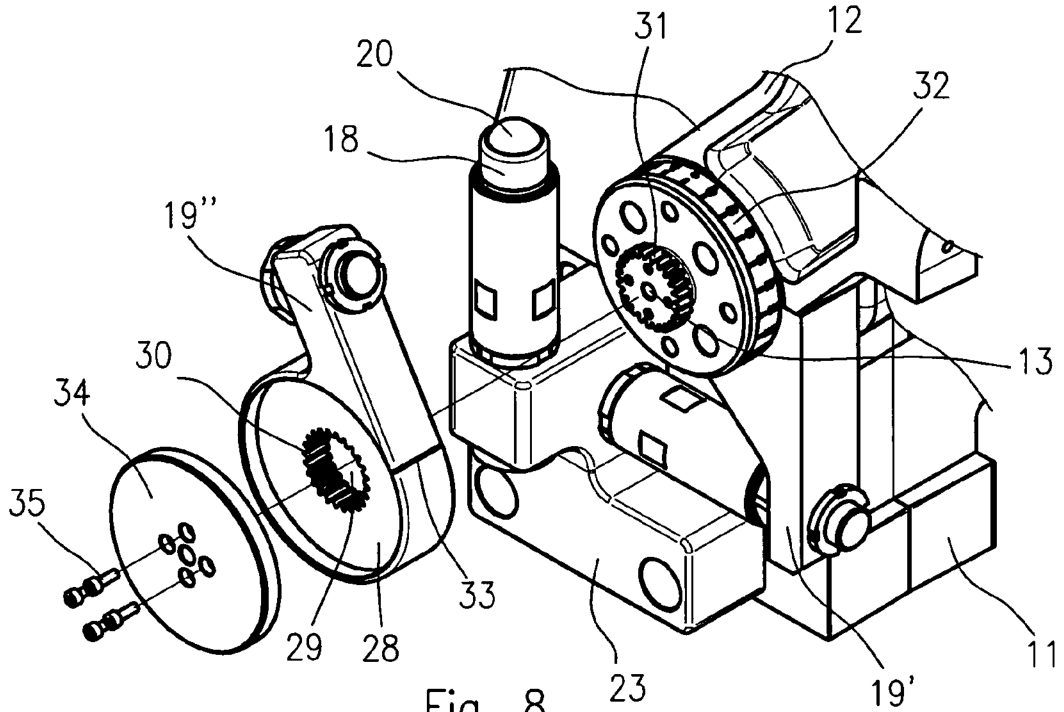
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Fig. 8

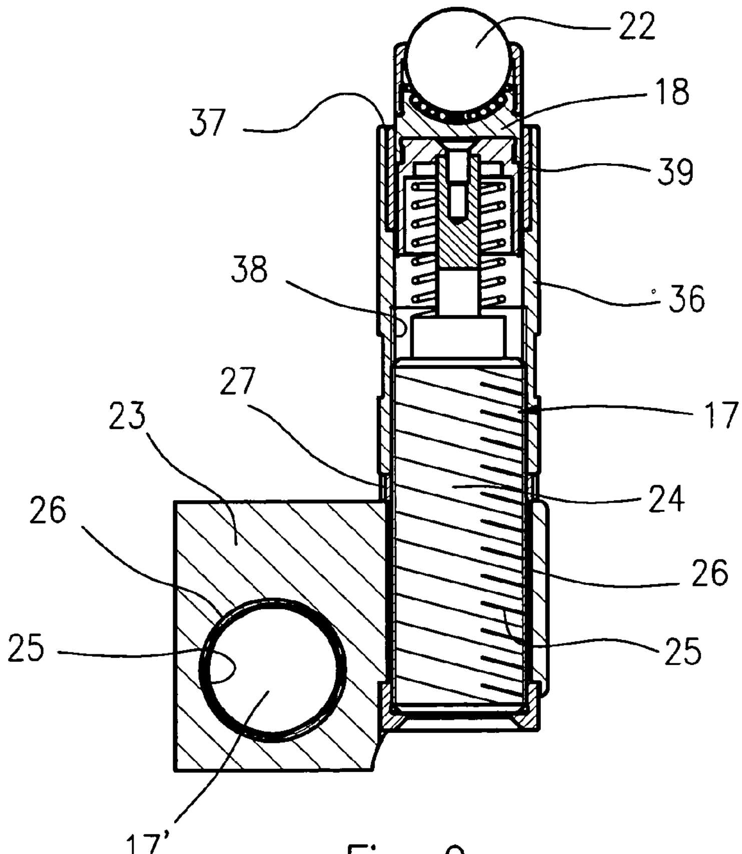
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Fig. 9

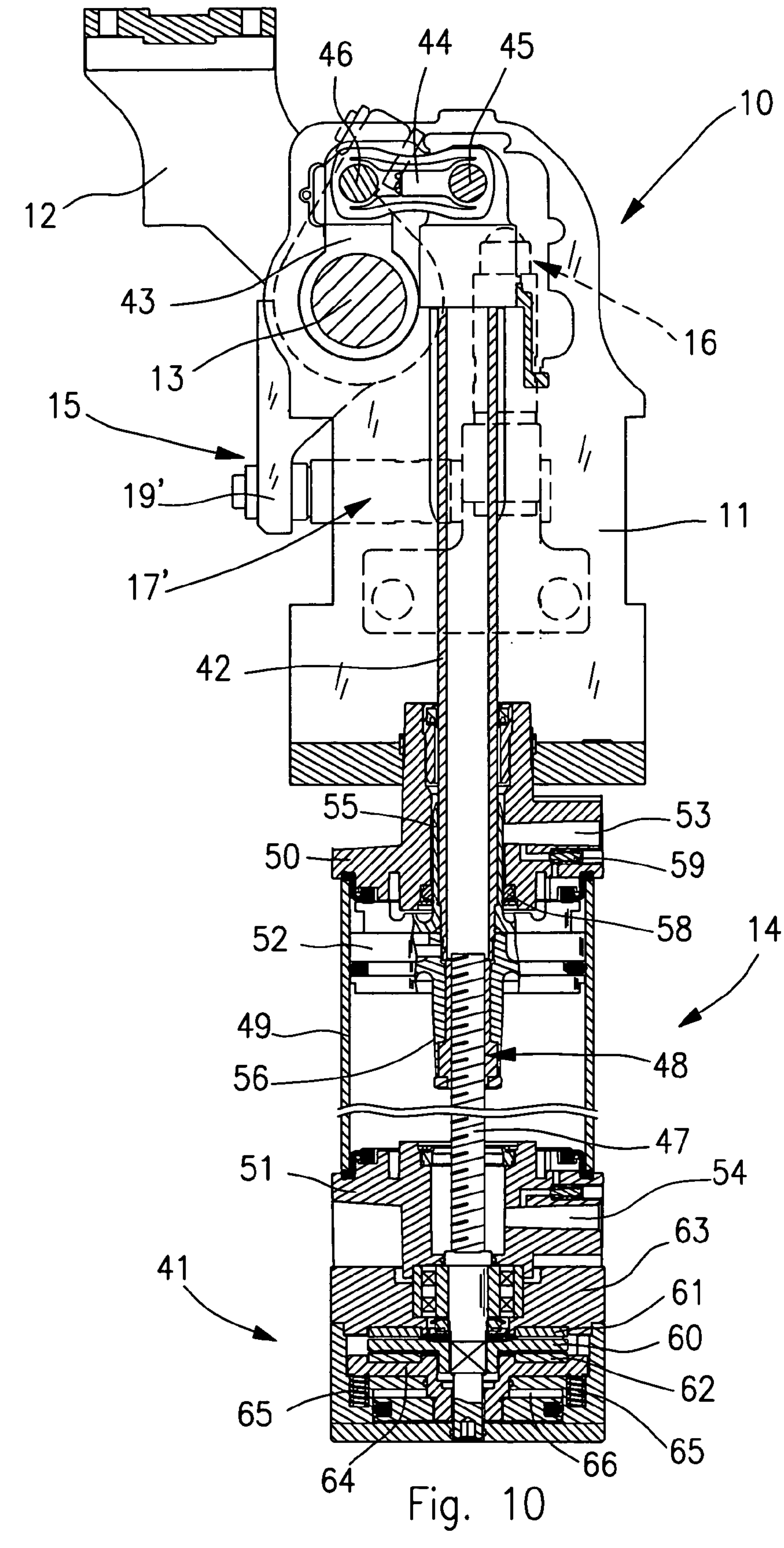
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Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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