United States Patent [19]

Arnold

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[45] **Apr. 30, 1974**

[54] **MECHANICAL CLAMPING DEVICE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **269/228**

[51] **Int. Cl.** **B25b 1/14**

[58] **Field of Search** 269/228

[56] **References Cited**

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Primary Examiner—Granville Y. Custer, Jr.

Attorney, Agent, or Firm—Woodhams, Blanchard and Flynn

[57] **ABSTRACT**

A vise has a slide carrying a movable jaw. Rotatably mounted in this slide is a hollow spindle which screws in the vise body and has an extension in which is screwed a driving spindle. A push rod is slidable in the hollow spindle for transmitting force from a toggle mechanism to the slide. During rotation of the driving spindle in the clamping direction a clutch between the driving and hollow spindles is first engaged so that the slide is advanced by the screwing action of the hollow spindle. Subsequently, a tapered bolt advanced by the driving spindle exerts a wedging action on the toggle mechanism which is thereby extended and applies clamping force to the movable jaw via the push rod and the slide.

12 Claims, 12 Drawing Figures

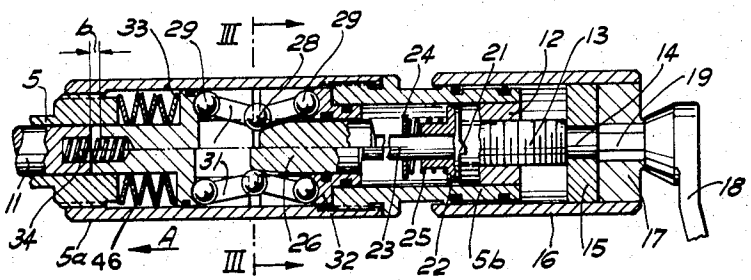

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Fig. 1

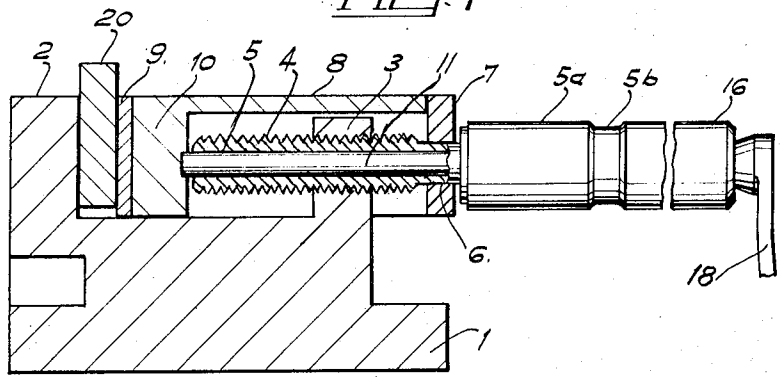

Fig. 2

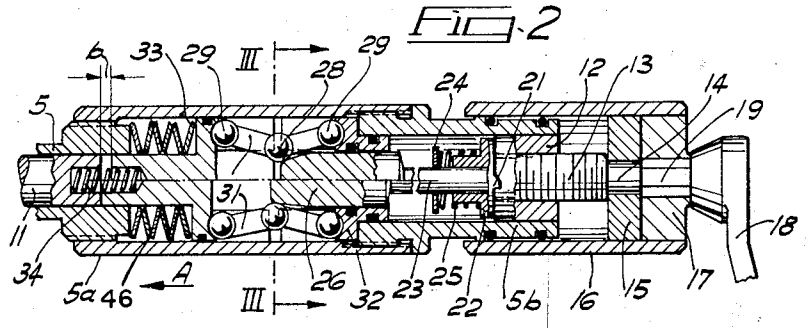

Fig. 2a

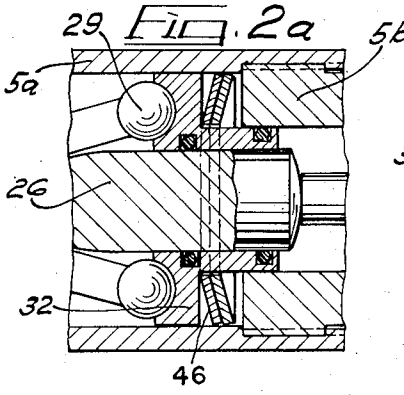

Fig. 3

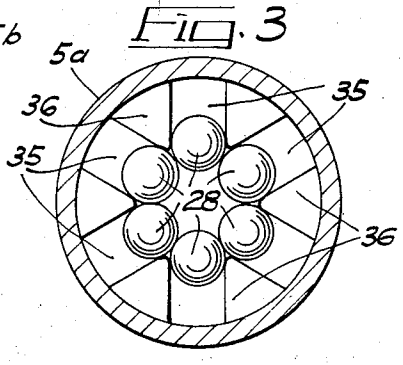

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FIG. 4

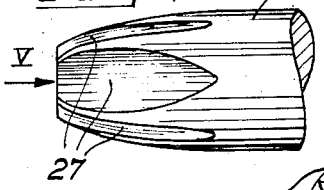

FIG. 5

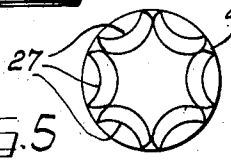

FIG. 6.

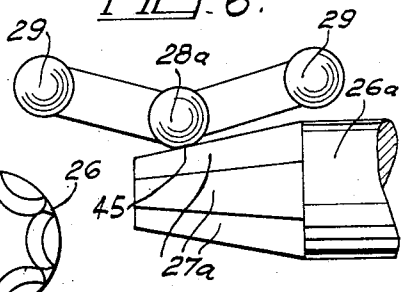

FIG. 8

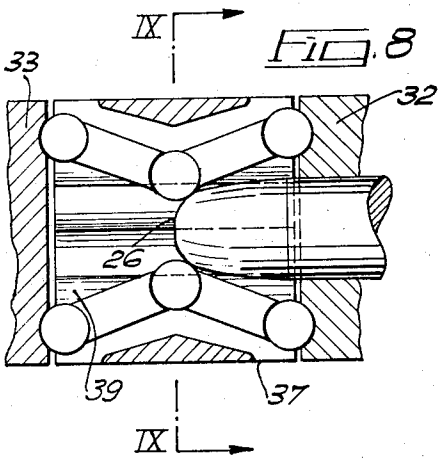

FIG. 9.

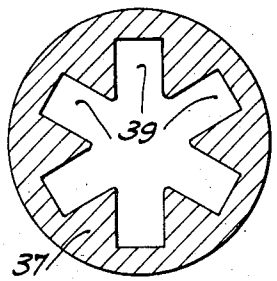

FIG. 10

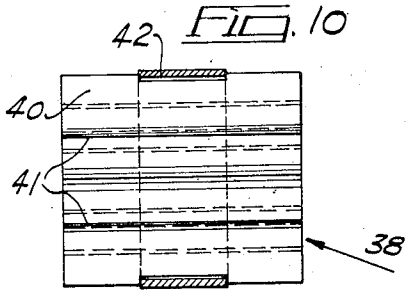

FIG. 11

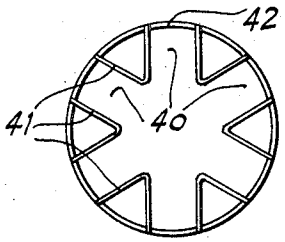

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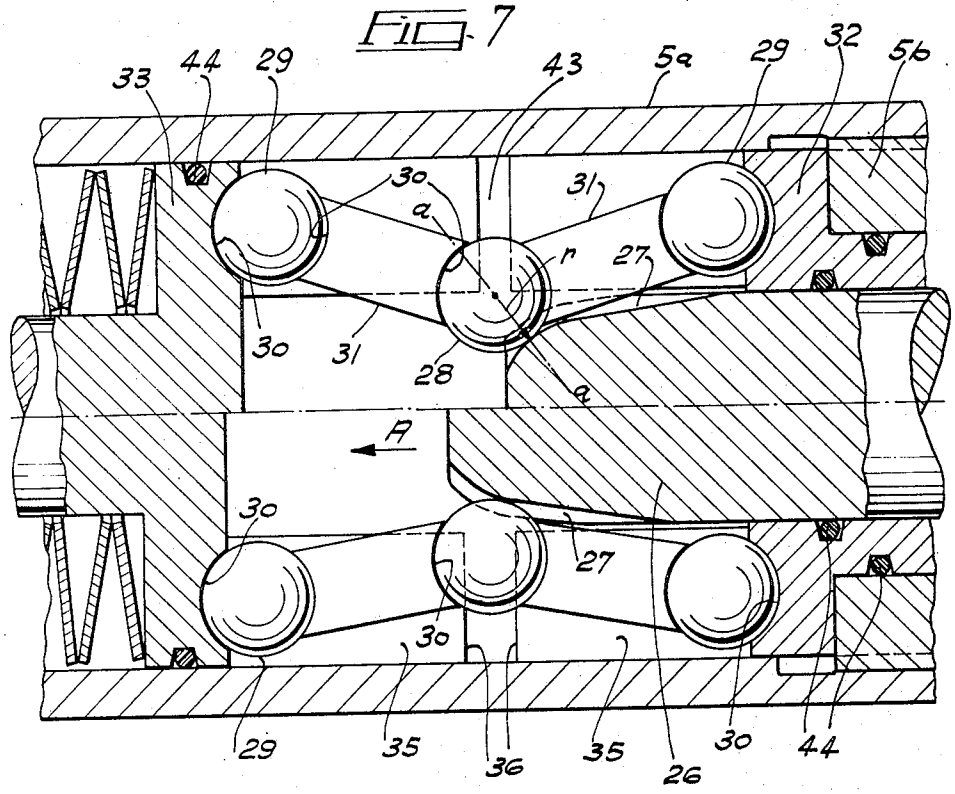
Fig. 7



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MECHANICAL CLAMPING DEVICE

The invention relates to a mechanical clamping device, more especially a vise for the clamping of workpieces, the said device having a hollow spindle which is screwable in the stationary part of the vise, a push rod which is mounted in an axially displaceable manner in this spindle and which exerts the clamping pressure, a driving spindle which is axially screwable in an extension of the hollow spindle, a torque clutch connected between the driving spindle and the hollow spindle and a toggle-lever power amplifier arranged between the driving spindle and the push rod.

In the case of a previously known vise of this construction (German Published Specification DAS No. 1,289,799) it has been proposed to provide, as the power amplifier, a pair of toggle levers, each of which consists of two compression members and a central roller, in which connection this pair of toggle levers cooperates with a longitudinally displaceable wedge acting against these rollers. In view, however, of the high clamping forces of 4 tons and above that can be exerted in the case of such a vise, this toggle-lever power amplifier is too highly stressed, so that, as a result of the resulting high frictional forces, seizing or jamming of this toggle-lever power amplifier occurs.

In this connection it is to be borne in mind that, in view of the confined space available for the pair of toggle levers in the extension of the hollow spindle, the pairs of toggle levers can have only comparatively small dimensions and that, for this reason too, the production and transmission of high clamping forces is not possible.

The object of the invention is to provide a vise having a toggle-lever power amplifier which can be accommodated in the confined space available in the extension of the hollow spindle and with which, despite comparatively small dimensions, very high clamping forces can be achieved with low stressing of the toggle-lever system and correspondingly slight wear.

With this object in view, a mechanical clamping device, more especially a vise, of the construction initially referred to is provided in which, in accordance with the invention, the toggle-lever power amplifier consists of several pairs of toggle levers arranged concentrically with respect to the spindle axis and a tapering pressure bolt which is displaceable by the driving spindle and which has bearing-surface areas corresponding to the number of the toggle levers.

The invention will now be described by way of example with reference to a number of embodiments shown in the accompanying drawings, in which:

FIG. 1 is a partial longitudinal section through a vise having a mechanical power amplifier;

FIG. 2 is a longitudinal section through a part of this vise on a larger scale. The upper half of this longitudinal section shows the moving parts in the rest position, while the lower half shows them in the clamping position;

FIG. 2*a* is a fragmentary longitudinal section of part of a vise according to another embodiment;

FIG. 3 is a cross section along the line III—III in FIG. 2;

FIG. 4 shows the top plan view of a push rod forming part of the power amplifier;

FIG. 5 is a front end view of this push rod as seen in the direction indicated by the arrow V in FIG. 4;

FIG. 6 is a fragmentary side elevation illustrating a further embodiment of a toggle-lever power amplifier;

FIG. 7 is a fragmentary longitudinal section showing part of FIG. 2 on a larger scale;

FIG. 8 shows a guide body in longitudinal section;

FIG. 9 shows this guide body in cross section; along the lines IX—IX of FIG. 8

FIG. 10 shows a further guide body in longitudinal section;

FIG. 11 shows this further guide body in cross section.

In the drawings the reference numeral 1 indicates the base plate of a vise, which base plate is formed integrally with a stationary clamping jaw 2 and a bearing support 3 in which is screwably arranged a hollow spindle 5 having an external screw-thread 4. This hollow spindle 5 is mounted by means of a neck portion 6 in the rearward part 7 of a slide 8, the front part 10 of which is provided with a movable clamping jaw 9. The front end of a push rod 11, which is mounted for axial sliding movement in the hollow spindle 5, presses against the rear face of the front part 10 of the slide 8. As shown in detail in FIG. 2, the hollow spindle 5 has extensions 5*a*, 5*b*, which form together with the hollow spindle a rigid assembly. Connected securely to the extension part 5*b* is a sleeve 12 which at the same time serves as a clutch part and in which a driving spindle 13 is screwed. The end 14 of the spindle 13 is connected securely to a head piece 15 which in its turn is connected securely to a sleeve 16 and a disc 17. A hand crank 18 is provided with a polygonal axle 19 which can be inserted into a corresponding polygonal aperture in the disc 17. For the clamping of a workpiece 20, this hand crank 18 is rotated in a clockwise direction and, for releasing the workpiece, in the counter-clockwise direction. Connected between hollow spindle 5, 5*a*, 5*b* and driving spindle 13 is a torque clutch. In the case of the embodiment illustrated in FIG. 2, to this end a dog clutch is provided, which consists of the clutch disc 22 provided with dogs 21 which are engageable in corresponding recesses in the sleeve 12. The clutch disc 22 is movable in a longitudinal direction on the extension 23 of the operating spindle, however, is secured on the spindle 23 against rotation. A disc 24 is connected to the extension 23 of the driving spindle 13. Arranged between this disc and the clutch disc 22 is a compression spring 25 which, at the beginning of the clamping operation, i.e. upon the rotation of the driving spindle 13, initially keeps the clutch members 22, 12 in engagement, so that on rotation of the driving spindle 13 the hollow spindle 5, 5*a*, 5*b* is simultaneously rotated and is screwed into the internal screw-thread of the bearing support 3. Thus, the slide 8 is advanced to the workpiece 20 by means of the push rod 11 which is displaced by the spindle 5 and which subjects the workpiece to a slight initial stressing. Upon further rotation of the driving spindle 13, the clutch disc 22 becomes disengaged from the sleeve 12 by displacement in the direction A, so that the hollow spindle 5, 5*a*, 5*b* ceases to rotate, while the driving spindle 13 is screwed further in the direction A by being rotated in the now stationary screw-threaded sleeve 12. As a result the extension 23 of the spindle 13 acts through a power amplifier so as to exert a very substantial displacing force on the push rod 11 in the direction of the arrow A, whereby the workpiece 20 is securely clamped. As is clear from the drawings, this power am-

plifier consists of three pairs of toggle levers, which are arranged concentrically with respect to the spindle axis, and a tapered pressure bolt **26** or **26***a* which is displaceable by the extension **23** of the driving spindle **13** and which has six supporting surfaces **27** or **27***a* corresponding to the number of toggle levers, in other words six in the case of the embodiment illustrated.

In the embodiment shown in FIGS. **1** to **5** and **7**, each of the toggle levers consists of three steel balls, namely a central steel ball **28** and two end balls **29**, and two compression arms **31** which are provided at their ends with bearing cups **30** and which are supported against the steel balls **28, 29** by these bearing cups. The end balls **29** are supported on the one hand against an abutment member **32** which is rigidly connected to the spindle extension **5***a* and on the other hand against an abutment member **33** which is displaceable in the direction of the spindle axis and which acts through the intermediary of a helical compression spring on the push rod **11**. Further bearing cups **30** for the end balls **29** are provided in these abutment members **32, 33**. Advantageously all the bearing cups **30** have the form of part-spherical segments the radius of curvature of which corresponds with the radius of the balls **29**, so that the high compression forces produced are advantageously transmitted via relatively large ball surface areas. In order to ensure that, when the pressure bolt **26** is displaced in the direction of the arrow A, the toggle levers will be forced outwards to a uniform extent, radial guides **35** are provided for the central balls **28** of the toggle levers or the compression members **31** thereof. In the embodiment shown in FIGS. **2, 3,** and **7**, the abutment members **32** and **33** have wedge-shaped axial extensions **36**, so that the radial guides **35** are formed between them. However, it is advantageous to provide a guide part **37** or **38**, as shown in FIGS. **8, 9** and **10**, which is loosely insertable into the spindle extension **5***a* and has the form of a cylindrical hollow body with radial grooves **39** or **40** extending throughout its entire length for guiding the central balls **28** or the compression arms **31**. This hollow body can, in the case of the embodiment according to FIGS. **8, 9**, consist of a die-casting, or else, in the case of the embodiment according to FIGS. **10, 11** consist of a sheet metal body comprising wedge-shaped sheet metal segments **41** and sheet metal ring **42** which surrounds and securely interconnects these metal segments.

In the case of the embodiment shown in FIGS. **2** to **5** and **7**, the pressure bolt **26** has a variable taper increasing towards the free end, and longitudinal grooves **27** are formed in this pressure bolt for receiving the central steel balls **28** and supporting them on a circular base line the radius of which corresponds with the radius of the balls. In FIG. **7**, the plane of contact of a central ball **28** with the pressure bolt **26** is indicated by a chain dotted line at *a, a'*. In this plane the corresponding supporting surface **27** has a radius of curvature *r* which corresponds with the ball radius. The central balls **28** thus have no point contact with the pressure bolt, but rather a circular linear contact, so that a more favorable transmission of force between pressure bolt and the six balls **28** is thus achieved. The taper angle of the pressure bolt **26** can be selected to suit working requirements or working characteristics, so that a change of the working characteristics of the toggle-lever system can only be obtained by removing the pressure bolt and replacing by one with a different taper angle.

If, as shown, the taper angle of the pressure bolt changes progressively towards the end of the latter, the result can be that, upon the clamping of the vise, i.e. upon rotation of the driving crank **18**, a constant driving moment will be obtained, although the transmission ratios in the toggle-lever system constantly change. At the start of the clamping operation, with this varying taper angle a higher rate of feed of the push rod **11** is obtained initially, which then becomes smaller as the clamping force increases. Also a saving in time is achieved, since less revolutions of the driving spindle **13** are necessary for the entire clamping procedure.

In the embodiments illustrated, the pressure bolt **26** acts with six pressure surfaces **27** on six toggle levers or three pairs of toggle levers, so that a favourable power distribution is obtained and with six toggle levers a high clamping force acting on the push rod **11** is achieved. Since each toggle-lever is loaded with only one-sixth of this clamping force, the toggle levers can be of comparatively small dimensions and the wear to which they will be subjected will be correspondingly slight. This wear is further reduced by the use of steel balls **28, 29**, as is customary in the case of ball bearings, and hardened compression arms **31** as well as a hardened pressure bolt **26**. Moreover, the space **43** containing the pairs of toggle levers, i.e. the space within the spindle extension **5***a* between the two abutment members **32** and **33** is for the most part filled with oil. For sealing this space **43**, o-rings **44** are provided between the spindle extension **5***a* and the abutment members **33** and **32** or between the pressure bolt **26** and the abutment **32**. Automatic and continuous lubrication of the pair of toggle levers and the pressure bolts is thus obtained. This lubrication is extraordinarily effective in this construction, since, when tightening and loosening the vise, the spindles **5, 5***a*, **5***b* are rotated and, as a result of this rotation, the oil is always returned to the parts which are subjected to pressure. Wear is thereby very greatly reduced.

As shown in FIG. **6**, the central balls **28***a* of the toggle levers may each be formed with a flat surface **45** by means of which it is supported upon a corresponding one of the inclined surfaces **27***a* of the pressure bolt **26***a*. This pressure bolt, by virtue of its flat inclined supporting surfaces **27***a*, has a uniform taper. It is, however, more advantageous, instead of having sliding frictional contact between the surfaces **45** and **27***a*, to provide a rolling contact between them, i.e. while retaining the uniform taper of the pressure bolt, to provide longitudinal grooves **27** instead of the flat surfaces **27***a*, in which the central balls **28** are supported on a circular base line (as previously described).

In order to be able to alter the working characteristics of the toggle-lever system at will, the several interchangeable pressure bolts may be provided with differing taper angles.

In FIG. **2***a* there is additionally shown an arrangement in which the pairs of toggle levers **29** to **32** are supported with respect to the hollow spindle **5***b* via strong plate springs **46**. The result is thereby achieved that the high tension exerted by these plate springs is also maintained when the clamping jaws of the vise somewhat compress unevennesses in the surface of a workpiece.

OPERATION

Referring to FIG. **2**, a rotation of the operating spin-

dle 13 by means of the hand crank 18 (or by rotation of the gripping sleeve 16) will cause a rotation of the clutch disc 22 and since same is engaged with the clutch sleeve 12 at 21, the clutch sleeve 12 and therewith the spindle 5*a*, 5*b* which is connected to this clutch sleeve is also rotated and screwed in the bearing block 3 and consequently, according to FIG. 1, moved leftwardly in the direction A (FIG. 2). Since the push rod 11 is supported in said hollow spindle 5 according to FIG. 2, this push rod 11 is also moved to the left and therewith, according to FIG. 1, the slide 10 is also moved. The clamping jaw 9 is thus guided to the workpiece 20 which must be clamped. As soon as a relatively small pretension is achieved, then upon further rotation of the operating spindle 13 the clutch disc 22 disengages with respect to the clutch sleeve 12. The clutch disc 22 is then not further rotated together with the hollow spindle 5, thus is stopped so that during further rotation of the operating spindle 13, the operating spindle 13 is rotated relative to the clutch sleeve 12. Thus, the operating spindle 13 and its extension 23 are moved in direction A through the threaded connection between the spindle 13 and the clutch sleeve 12 and presses the pressure bolt 26 into the same direction so that this pressure bolt presses the pairs of toggles 31 outwardly. Through this the abutment 33 is moved in direction A and thus also the push rod 11 so that said push rod then according to FIG. 1 presses the slide 10 farther in direction A. Through this a high press power is achieved and therewith the workpiece 20 is very tightly held.

In a clamping device of this type, it may happen that during an unclamping of the workpiece, that is during a turning back of the drive spindle, that same is turned back immediately through the friction moment which has been produced by the released clutch 22 so that the torque clutch dog 21 does not again engage in the recess therefor. This has the disadvantage during the next clamping operation that a tensioning power which is too little is applied on the workpiece.

In order to overcome this disadvantage, in the abovementioned clamping device or vise according to the invention, between the push rod 11 and a secondary pressure member (part of the abutment member 33) and axially acting pressure spring 34 is arranged in such a manner that in a not loaded condition between the push rod 11 and the secondary member there exists a distance (*b*) and during the pretensioning of the workpiece by a screwing of the hollow spindle said spring 34 is compressed. After this compression, the secondary member and the push rod 11 engage one another and at the start of the unclamping procedure during a counterclockwise rotation of the drive spindle through this spindle in the hollow spindle thread, a frictional moment holding said spindle is produced, which is larger than the frictional moment which is applied by the released clutch onto the hollow spindle. Thus, during a releasing of the workpiece, that is during the counterclockwise rotation of the drive spindle 13, first the hollow spindle 5, 5*a*, 5*b* is held until the torque clutch dog 21 engages again and then only during a further rotating back of the drive spindle is the hollow spindle 5, 5*a*, 5*b* turned back.

I claim:

1. A mechanical clamping device having means defining a hollow spindle means rotatably supported on a slide member, said hollow spindle means being threadably engageable in a stationary bearing block and rotatably drivable by means of a hand crank through a drive shaft and a torque coupling, an abutment member axially fixed with respect to said hollow spindle, a longitudinally movable force applying pressing rod and a plurality of toggle lever means expandable in length and being engageable with and positioned between one side of said abutment member and said force applying pressing rod, wherein the improvement comprises means defining a head on one end of said force applying pressing rod housed completely within said hollow spindle means and engaging said toggle lever means, said abutment member including means defining a surface positioned within said hollow spindle means and longitudinally movable pressure bolt means secured to said hand crank means through said torque coupling and being movable longitudinally in response to a driving of said hand crank means and a disengagement of said torque coupling, said pressure bolt means having a tapered surface portion engaging said toggle lever means which effects an expansion of said toggle lever means in response to a longitudinal movement of said pressure bolt means relative to said toggle lever means.

2. The improvement according to claim **1**, wherein said hollow spindle means includes a hollow sleeve having wall means at one end thereof, said wall means having an opening therethrough, said force applying pressing rod being slidably disposed in said opening; and

wherein said head is movable between said wall means and said toggle levers.

3. The improvement according to claim **2**, wherein each of said toggle lever means comprises a central ball and two end balls and two compression arms which have bearing cups at their ends and which are supported by said bearing cups against said balls, said bearing cups for said balls also being provided on said surface means on said abutment member and on said head.

4. The improvement according to claim **3**, wherein said plurality of toggle lever means are concentrically disposed around the axis of said hollow spindle means and are greater than two in number.

5. The improvement according to claim **4**, wherein said tapered surface portion on said pressure bolt means engages said central balls.

6. The improvement according to claim **3**, wherein each of said bearing cups has the form of a spherical segment, the radius of curvature of whichcorresponds with the radius of the balls.

7. The improvement according to claim **3**, including guide means for at least one of said central balls of said toggle lever means and for said compression arms thereof.

8. The improvement according to claim **7**, including a guide part insertable loosely into said hollow spindle means and has, for the guidance of at least one of said central balls and said compression members, radial guide grooves which extend over the entire length thereof.

9. The improvement according to claim **8**, wherein said guide part consists of wedge-shaped sheet metal segments and a sheet metal ring which surrounds and securely connects said segments.

10. The improvement according to claim **3**, wherein said pressure bolt means has means defining several longitudinal grooves therein and in which said central

balls are supported on a circular base line, the radius of which corresponds with the radius of the balls.

11. The improvement according to claim **1**, wherein said pressure bolt means includes means permitting an interchanging with several pressure bolts having a differing taper angle.

12. The improvement according to claim **1**, wherein said head is enlarged and the space between said abutment member and said enlarged head is for the most part filled with oil and is sealed by O-rings which are arranged between said abutment member, said enlarged head and said hollow spindle means.

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