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(54) **Apparatus for tensioning a threaded stud or like member.**

(57) An apparatus for tensioning a threaded stud or like member(s), which apparatus comprises a plurality of jaws (46, 48, 50 and 52) to be arrayed about said member, each of said jaws having an inner surface (56) adapted to engage the threads of said member(s), and pull means (92) for applying a force to said jaws so as to apply axial tension to said member(s), said apparatus being characterized by a rotatable actuator sleeve (36) defining an axial opening (44) within which said jaws are disposed, said sleeve defining interior cam surfaces (74, 76 and 78) so contoured as to force said jaws to move radially inwardly into engagement with said member(s) when said sleeve (36) is moved to a first rotational position and to permit said jaws to move radially outwardly out of engagement with said member when said sleeve (36) occupies a second rotational position.

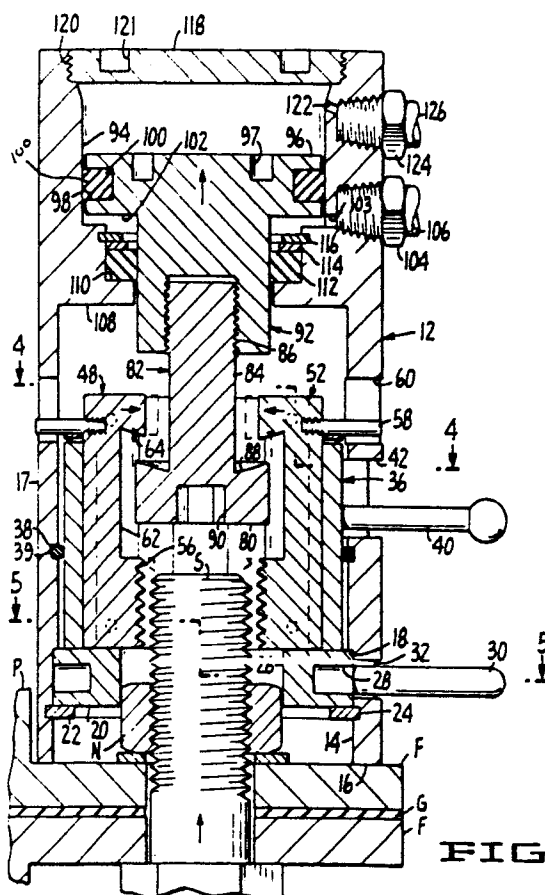


FIG. 2

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"Apparatus for tensioning a threaded stud or like member."

This invention relates to apparatus for tensioning a threaded stud or like member such as may be used in making up a flanged joint in pressure lines and pressure vessels, or other environments in which control of stress in threaded fasteners is desired.

Flanged joints in various pressure lines and pressure vessels are widely used in industry. In such joints, two parts, typically of cylindrical shape, are manufactured with annular flanges at their ends. The flanges are formed with congruent hole patterns so that the two members may be joined to one another in a pressure tight manner by first introducing a gasket between the two flanges and then by joining the flanges with threaded stud-like members, e.g., studs, bolts or stud-bolts, which extend through the holes and have nuts engaged therewith. The term "stud" is sometimes used herein for convenience to refer to the broader class of stud-like members to which the invention applies. It is important, particularly in large diameter members, that the tension in the studs be sufficient to withstand imposed forces and be uniform so as to avoid deformation of the flanges and the members to which they are fixed.

One known device for tensioning studs in the above described environment, disclosed in US-A-3,015,975, includes a hollow tubular housing that fits over the stud and the nut and rests on the surface of the flange. There is a puller bar which has at one end an interior threaded collar adapted for engagement with the portion of the stud that protrudes beyond the nut. The puller bar collar is engaged with the stud threads by rotating the puller bar, and there is a hydraulically powered mechanism to which the remote end of the puller bar is fastened. When the hydraulic mechanism is actuated, tension is applied to the stud so that the nut can be tightened, the amount of the tension being controlled by controlling the hydraulic pressure applied to the hydraulic actuator. Devices similar to that referred to above are also shown in US-A-2,866,370; US-A-3,158,015; US-A-3,162,071 and US-A-3,285,568. Substantial commerce exists in such devices, and they are widely used, particularly where flanged joints of large diameter are employed. Formation of a flanged joint using such a device is a time consuming procedure, however, because the puller bar must be engaged with and disengaged from each stud several times, and engagement and disengagement is a time consuming procedure because the puller bar must be rotated numerous revolutions each time it is engaged with or disengaged from the stud threads.

US-A-3,995,828 discloses a bolt tensioning apparatus having a segmented nut and a mechanism for moving the segments between a radially inward position, at which they engage the stud, and a radially outward position at which they are free of the stud. The apparatus disclosed in that patent eliminates the need to rotate the puller bar through numerous revolutions each time the apparatus is engaged with or disengaged from the stud. This reduces the time necessary for engagement and disengagement with a stud. However, the apparatus requires an unduly long stud because a longitudinally or axially moving sleeve is employed in moving the segments radially. Longitudinal movement of the sleeve requires substantial space between the segments and the longitudinal housing that contains the segments. Consequently, the device is useful only on unduly long studs which are undesirable as are the special studs provided with concentric grooves that are specifically disclosed in US-A-3,995,828.

It is an object of the present invention at least to mitigate the problems associated with known stud tensioning apparatus.

Accordingly, the present invention provides an apparatus for tensioning a threaded stud or like member, which apparatus comprises a plurality of jaws to be arrayed about said member, each of said jaws having an inner surface adapted to engage the threads of said member, and pull means for applying a force to said jaws so as to apply axial tension to said member, said apparatus being characterized by a rotatable actuator sleeve defining an axial opening within which said jaws are disposed, said sleeve defining interior cam surfaces so contoured as to force said jaws to move radially inwardly into engagement with said member when said sleeve is moved to a first rotational position and to permit said jaws to move radially outwardly out of engagement with said member when said sleeve occupies a second rotational position.

In one preferred embodiment the apparatus is provided within a housing having an internal bore sufficiently large to pass over the stud-like member and the nut and to rest on a flange or other surface from which the member projects. Supported within the housing bore are the jaws, for example four in number, and circumscribing the jaws is the actuator sleeve which is supported within the housing bore for rotation with respect to the central longitudinal axis thereof. The actuator sleeve has cam surfaces which cooperate with the jaws so that in one rotative position of the actuator sleeve the jaws are in their outward or disengaged position, and at

another rotative position of the actuator sleeve the jaws are moved inward into engagement with the stud threads. That the sleeve is actuated by rotation, rather than axial movement permits the jaws to be positioned so that engagement with the stud-like member is accomplished without requiring an extraordinarily long stud.

Although studs employed in forming a flanged joint typically extend perpendicularly of the flange surfaces, deformation away from the perpendicular relation usually occurs to some minor degree. Tensioning apparatus formed in accordance with one important aspect of the present invention accommodate this deformation or misalignment by providing an engaging surface between the jaws and the puller bar that is concave. Accordingly, even though misalignment occurs, apparatus of the invention can tension the stud without deforming either the stud or the apparatus.

The jaws are supported within the housing so that each can experience a moderate degree of independent axial movement. This facilitates engagement with the stud threads without requiring attention to the rotational position of the tensioning device when it is first installed on a stud and assures complete engagement between the jaws and the stud threads.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a perspective view of a typical flanged joint, illustrating an apparatus of the invention in use therewith;

FIGURE 2 is a cross sectional elevation of a stud tensioning apparatus embodying the present invention and taken along the line 2-2 of Figure 1;

FIGURE 3 is an exploded view of the apparatus of Figure 2 showing components thereof;

FIGURE 4 is a cross-sectional view taken on line 4-4 of Figure 2 and showing the jaws in a disengaged position;

FIGURE 5 is a view taken along line 5-5 of Figure 2 also showing the jaws in a disengaged position;

FIGURE 6 is a view similar to Figure 5 showing the jaws in an engaged position;

FIGURE 7 is a view similar to Figure 2 showing, in exaggerated form, engagement with a stud that is not perpendicular to the flange through which it extends;

FIGURE 8 is a fragmentary view at enlarged scale showing orientation between a modified jaw and a stud prior to engagement there-between;

FIGURE 9 is a fragmentary view showing an alternative form of driving mechanism for the nut socket; and

FIGURE 10 is a fragmentary view of still another form of driving mechanism for the nut socket.

Referring to the drawings, parts of the apparatus are contained within a housing 12. The housing 12 is typically formed of steel or a like strength material, has a generally cylindrical shape and defines interiorly thereof a bore 14 which has an inside dimension great enough so that the housing can be installed over a nut N engaged with a stud S which extends substantially perpendicularly from the surface of a flange F. The flange F is rigid with a pipe P which is typically of hollow cylindrical shape. Between two flanges as joined together by the stud S, a gasket G is usually installed. The housing 12 at its lower end, defines an annular abutment surface 16 which is normal to the longitudinal dimension of the housing and of the bore 14 and is adapted to bear on the flange surface F. The housing has an exterior chordally excised surface portion 17 which permits the apparatus to be used in environments in which there is limited space between the stud and the cylindrical pipe of which the flange is a part.

The bore 14 defines a downward facing shoulder surface 18 against which a nut engaging socket 20 bears. The socket 20 is maintained within the bore 14 by means of a retaining ring 22, the surface of the bore being provided with a groove 24 for receiving the ring 22 and maintaining the socket in place. The socket 20 defines a hexagonal central opening 26 which is dimensioned to engage nut N so that rotation of the socket imparts corresponding rotation to the nut. The external surface of the socket 20 is formed with a plurality of radially extending holes 28. The holes 28 are, preferably circular in cross-section to receive a similarly shaped Tommy bar 30 which can be introduced into one of the holes, a circumferentially extending slot 32 being provided in the housing and through which the Tommy bar can be introduced. The circumferential spacing between adjacent holes 28 is established such that at least one of the holes is always accessible through the slot 32.

Inwards of the shoulder 18 is an actuating sleeve indicated generally at 36. The sleeve 36 has an external cylindrical surface having a diameter less than that of the bore 14 so that the actuating sleeve can rotate within the bore and can skew with respect to the axis of the bore. An elastic O-ring 38 is provided for centring the sleeve 36 within the bore while permitting skewing movement of the sleeve, the bore 14 being provided with a groove 39 for retaining the O-ring in place. Secured to the external surface of the actuating sleeve 36 and extending substantially radially thereof is an operat-

ing handle 40. Housing 12 has a circumferentially extending slot 42 through which operating handle 40 extends so that actuator sleeve 36 can be rotated from the exterior of the apparatus.

The actuator sleeve 36 defines a central axial opening, indicated generally at 44, and disposed within the opening is a plurality of stud engaging jaws, there being four such jaws, indicated respectively at 46, 48, 50 and 52 in the embodiment shown in the drawings. The jaws are virtually identical and, thus, a description of one will suffice as a description of all.

Each jaw is generally sector shaped in cross section (see Figures 4 to 6) and has an arcuate outer surface 54. At the lower end of the inner surface each jaw has a threaded portion 56. The thread segments on each threaded portion 56 have the same pitch as the threads on the stud S and are sufficient in number that, when the jaws are moved inward into engagement with the threads on stud S, sufficient force can be transmitted to the stud to achieve the requisite tension thereon. The jaws are supported within the housing 12 such that the lower axial extremity of the jaws is substantially coextensive with the upper surface of socket 20 in order that a substantial portion of the threads of the stud S can be engaged. A pin 58 protrudes from the upper extremity of the exterior surface of each of the jaws, the wall of housing 12 being slotted as at 60 to admit the pin therethrough. The slot 60 is axially elongated so as to afford axial movement of the jaws and circumferentially limited to prevent rotation of the jaws when the actuator sleeve 36 is rotated. The central region of the inner surface of each of the jaws is excised at 62 thereby to define a cavity that is bounded by all four jaws. The upper extremity of excision 62 is defined by an inwardly extending abutment surface 64. The abutment surface 64 is of convex spherical shape.

The jaws 46 to 52 have, on their side surfaces, upper and lower tangentially extending holes 66 and 68. The holes in adjacent jaw surfaces form confronting hole pairs. Fitted into opposing hole pairs are tangentially extending guide pins 70, the fit between the pins and the holes being sufficiently loose that relative movement between adjacent jaws can occur. Circumscribing each pin 70 is a compression spring 72 which biases the jaws away from one another and outwards of engagement with the stud S.

The central opening 44 in actuator sleeve 36 is configured so that rotation of the actuator sleeve to one extremity of its travel urges the jaws into engagement with stud S and rotation of the actuator sleeve to its opposite extremity permits springs 72 to urge the jaws radially outwards and away from engagement with the stud. The central opening 44 in the actuator sleeve has a number of

camming surface portions equal to the number of jaws, again four in the embodiment shown in the drawings. Camming portions are disposed around the surface of the opening 44 and are positioned to correspond to the spacing of the jaws. Each camming surface portion includes a first inwardly extending surface portion 74 which is dimensioned with respect to the jaws so that when the inward extending portion contacts the jaw, the jaw is moved into engagement with the threads on stud S. Circumferentially spaced from the inwardly extending surface portion 74, each camming surface portion has a second surface 76 that is disposed radially outwardly of the inwardly extending surface portion 74. The portion 76 is so dimensioned that when the outer surface of a jaw rests against it, the jaw is disengaged from the stud. Intermediate the inwardly extending portion 74 and outwardly disposed portion 76 is a transition portion 78, which effects a smooth transition between the two extreme portions of the camming surface and facilitates movement of the actuator sleeve 36 between its two rotational extremes.

The head 80 of a puller bar 82 is disposed within the cavity defined by the excisions 62 in the jaws 46 to 52. The puller bar 82 includes an axially extending shaft 84 rigid with head 80. At the upper end of the shaft 84 is a threaded portion 86. The outside diameter of the head 80 is less than the inside diameter of the cavity formed within the jaws, when the jaws are in their inward position. Similarly, the outside diameter of shaft 84 is less than the innermost position of jaw abutment surface 64. Accordingly, a degree of skewing between the jaws and puller bar 82 can be tolerated as shown in Figure 7. In order to assure substantial contact between the head 80 and abutment surface 64 the upper surface 88 of the head is concave, having a radius of curvature equal to the radius of curvature of the convex abutment surfaces 64 on the jaws.

A hexagonal opening 90, which can be engaged with an Allen wrench to impart rotational force to the puller bar during assembly or disassembly of the apparatus, is defined in the lower end surface of the puller bar 82. As an alternative to the hexagonal opening 90 a screwdriver slot may be formed in the lower surface of the piston 92, the upper threaded portion 86 of the puller bar being received into a complementary threaded opening in the drive piston 92.

The drive piston 92 is supported in a piston chamber 94 in the housing 12, axially aligned with the bore 14. At its upper end the piston 92 is formed with an enlarged portion 96, the upper surface of the enlarged portion having spanner holes 97 for applying torque to the piston during assembly and disassembly of the apparatus. The

side wall of the enlarged portion 96 has a slot 98 in which a sealing ring 100 is disposed. The sealing ring 100 cooperates with the wall of the piston chamber 94 to afford movement of the piston within the chamber and to form a seal against leakage of hydraulic fluid therepast. The enlarged portion 96 has a lower annular surface 102 against which hydraulic pressure is applied to move the piston upwards and to effect engagement between the concave upper surface 88 of the head 80 of the puller bar 82 and the convex spherical surfaces 64 on the jaw abutments. For supplying hydraulic fluid to the lower part of the piston chamber 94, there is a port 103 formed in the wall of the housing 12. For communicating hydraulic fluid to the port, there are inlet fitting 104 and a hydraulic fluid line 106. The hydraulic fluid line is connected to a conventional source of pressurized hydraulic fluid (not shown). For preventing leakage of the hydraulic fluid downwards of the cylinder, the housing 12 is provided with an inwardly extending projection 108 in the wall of which an annular cutout 110 is formed. A hydraulic seal 112 is disposed within the cutout 110, the seal having an inner surface portion contacting piston 92 to permit the piston to move and to prevent leakage of hydraulic fluid therepast. Seal 112 is retained in place by a washer 114 and a snap ring 116 which is engaged in a groove provided in the side wall of projection 108 above the seal.

The upper end of the piston chamber 94 is closed by an impervious end closure disk 118. The disk 118 is fastened to the housing 12 via a threaded connection 120. Spanner holes 121 are provided in the upper surface of the disk 118 to facilitate its installation and removal. An inlet port 122, with which a fitting 124 is engaged to connect to the port a compressed air line 126, is provided to the upper portion of piston chamber 94, i.e. the portion between the top of the piston and the lower surface of disk 118. The disk 118 is preferably formed of aluminum or a like material that is softer than the material of which housing 12 is formed. This is desirable because, for example, where a stud fractures while it is under tension by the apparatus, the likelihood of destruction of the apparatus and injury to users are reduced because upwards movement of the piston 92 is slowed by deformation and expulsion of the end closure disk 118.

In operating a stud tensioner according to the invention, the flanged joint is first made up by installing a gasket G, aligning the flange holes with one another, and introducing studs S through aligned pairs of flange holes. Nuts N are threaded onto the studs until the nut surfaces are moved into contact with the flange surface. Next one or more stud tensioners are placed onto the protruding nut-

(s) and stud(s) as depicted in Figure 2. It will be noted that the actuator sleeve 36 is in a position so that thread portions 56 of the jaws are retracted from the threads of stud S. Additionally, the nut N resides in the central hexagonal opening of socket 20. As shown in Figure 1, it is typical practice to employ plural stud tensioners at a given time, typically spaced uniformly around a flange.

Next the actuator sleeve 36 is rotated by applying circumferential force on the operating handle 40, as indicated in Figure 4. Such movement of the operating handle 40 causes the camming transition portion 78 to traverse the outer surfaces of the jaws and eventually moves the inner camming surface 74 into contact with the outer surfaces of the jaws. This moves the thread portions 56 of the jaws into threaded engagement with the threads of the stud S as shown in Figure 6. Because the jaws are axially slidable within both the actuator sleeve 36 and the housing 12, the jaws can quickly and completely move into threaded engagement with the stud S.

Next, hydraulic pressure is applied to line 106 of each stud tensioning apparatus. The equipment for providing the pressure and adjusting its magnitude is not shown, because such equipment is well known and its operation is well understood. Suffice it to say, typical practice requires that a pressure less than the pressure to effect the final stud tensioning be first applied to all studs with the specific pressure increasing in increments until the final pressure and final stud tension is achieved. Upon entry of pressurized hydraulic fluid through line 106 and fitting 104 and through port 103, upward force is applied to the piston 92 and a corresponding force is applied to puller bar 82 until the concave surface 88 of the puller bar 82 contacts the convex abutment surfaces 64 on jaws 46 to 52. A corresponding force is thus applied to tension stud S. With the stud in the tensioned condition, the Tommy bar 30 is employed to rotate the socket 20 and the nut N until the lower surface of the nut firmly contacts the surface of flange F.

When each nut with which a stud tensioning apparatus of the invention is engaged has been tightened, hydraulic pressure on line 106 is discontinued. The actuator sleeve 36 is then rotated to a position at which the camming surface portions 76 are in rotational alignment with the outer surfaces of jaws 46 to 52. Finally air pressure is applied via line 126 which applies downward force on the piston 92 and thus the puller bar 82. Such downward force moves the puller bar surface 88 out of contact with the jaw abutment surfaces 64 so that the force of springs 70 can separate the jaws from one another and retract jaw thread portions 56 from the stud S. Removal of the apparatus from a protruding stud is then possible.

In many environments in which flanged joints are employed, the flanges tend to distort somewhat as the nuts N are tightened onto a stud S against the surface of the flange. Such distortion is particularly severe when relatively soft gaskets G are employed. For example, in Figure 7, wherein the distortion is exaggerated for clarity, it will be seen that the stud S extends from the surface of flange F at an angle other than 90 degrees. As the lower surface 16 of the housing 12 is forced against the surface of the flange, the stud S is not precisely aligned with the central axis of the passage 14. The gap between the outer surface of the actuator sleeve 36 and the inner surface of passage 14 permits the sleeve, as well as the jaws 46 to 52 within the sleeve, to move to a position askew of the central axis of passage 14 and into secure, intimate engagement with the threads on stud S. Moreover, because the upper surface 88 of the puller bar 82 is concave and because the abutment surfaces 64 on the jaws are congruently convex secure engagement between the puller bar, which remains axially aligned with the axis of passage 14, and the jaws, which skew with respect to the axis of passage 14, is achieved. The O-ring 38 serves to retain the actuator sleeve and the jaws centrally of passage 14, but because of the elasticity in the O-ring, the jaws can move to a skewed position.

A modification of a stud tensioning apparatus according to the invention is shown in Figure 8. In certain installations it is desirable to minimize the height of the apparatus as much as possible, and in the embodiment seen in Figure 8, a modified jaw 52' having an excision 62' which has a vertical dimension substantially less than that of excisions 62 to which reference has been previously made, is provided. The vertical dimension of the excision 62' is sufficiently greater than that of puller bar head 80 that skewing as described previously in connection with Figure 7 can occur. In addition, there is sufficient additional space for a wave washer 130 between the lower surface of puller bar head 80 and the upward facing surfaces of the respective excisions 62'. The wave washer 130 is formed of spring steel or a like resilient material and has upwardly extending undulations that bear against the lower surface of the puller bar and downward extending undulations that bear on the upwardly facing surfaces of the excisions 62'.

Exterior of the jaws, such as jaw 52', there is a wave washer 132 larger than wave washer 130 but otherwise of generally similar construction. Between the wave washer 132 and pins 58 there is a flat washer 134 which affords a bearing surface for the upper undulations of wave washer 132. The lower undulations of the wave washer bear against the upper surface of the actuator sleeve 86. Thus, it will be seen that the jaw 52' and its counterparts

not shown in Figure 8 are resiliently supported by wave washers 130 and 132. This assures that, irrespective of the initial relative position of the thread portion 56 and the threads on the stud S, intimate threaded engagement between each jaw and the stud is achieved upon operation of actuator sleeve 36. If the extremities of the thread portion 56 reside on the upper surface of the threads on stud S, the jaw 52' will move upwards as the actuator sleeve 36 is rotated. If the extremities of thread portion 56 reside on the lower surface of the thread studs, jaw 52' will move downwards in response to rotation of actuator sleeve 36. The coaction of the wave washers 130 and 132 permits both directions of movement. Because the operation of the embodiment of Figure 8 is otherwise identical to that previously described, no further explanation of the device is given.

The invention is not limited to stud tensioning apparatus in which the socket 20 is rotated by a Tommy bar 30. As shown in Figure 9, a socket 20', has fixed to its upper extremity a bevel gear 136. Supported within the housing 12 is a bearing 138 which supports a drive shaft 140 for rotation about an axis that extends radially of the central axis of the housing 12. Fastened to the inner end of drive shaft 140 is a bevel gear 142 which meshes with the bevel gear 136 so that upon rotation of the drive shaft 140 by a suitable handle (not shown) rotation is imparted to the socket 20' and a nut N engaged thereby.

Still another mechanism for imparting rotation to the nut N is shown in Figure 10, in which a socket 20" which has on its periphery gear teeth 144. Mounted on the exterior surface of the housing 12 and extending radially outwardly therefrom is a gear housing 146 which has a cover plate 148, that is illustrated broken away in Figure 10 to reveal internal details thereof. An idler pinion 150 is provided with teeth to mesh with the teeth 144 on socket 120". The pinion 150 is supported for free rotation on a shaft 152.

Radially outwards of the idler pinion 150 within gear housing 146 is a drive gear 154 which is supported for rotation on a vertically extending shaft 156. The drive gear 154 has teeth that mesh with the idler gear 150 so that rotation of the drive gear effects rotation of the socket 20". The shaft 156 extends above the cover plate 148 and has a radial portion 158 which enables a user to apply torque to the shaft 166 and to the drive gear 154. Thus a nut N can be tightened by the consequent torque applied to the socket 20".

Thus it will be appreciated that the invention provides a stud tensioning apparatus which affords numerous salutary advantages. The invention can be embodied in a device that consists of a small number of rugged parts. The configuration of the

actuator sleeve 36 and its actuation in a rotational direction together with limited independent axial movability of the jaws permits construction of a quick acting device that can be conveniently engaged with a stud. The gap between the outer surface of the actuator sleeve 36 and the surface of the passage 14, the presence of O-ring 38, and the spherical surfaces on puller bar head 80 and jaw abutments 64 coact to assure expeditious and accurate tensioning of studs even in the presence of deformation of the flanges. The presence of an air chamber above piston 92 assures quick release of the device from a stud, and formation of end closure disk 118 from relatively soft material protects the device and its users in the rare event that a stud fractures during tensioning thereof.

The features disclosed in the foregoing description, in the following claims and/or the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. An apparatus for tensioning a threaded stud or like member(s), which apparatus comprises a plurality of jaws (46, 48, 50 and 52) to be arrayed about said member, each of said jaws having an inner surface (56) adapted to engage the threads of said member(s), and pull means (92) for applying a force to said jaws so as to apply axial tension to said member(s), said apparatus being characterized by a rotatable actuator sleeve (36) defining an axial opening (44) within which said jaws are disposed, said sleeve defining interior cam surfaces - (74, 76 and 78) so contoured as to force said jaws to move radially inwardly into engagement with said member(s) when said sleeve (36) is moved to a first rotational position and to permit said jaws to move radially outwardly out of engagement with said member when said sleeve (36) occupies a second rotational position.

2. An apparatus according to Claim 1, further comprising nut driving means (20) for imparting rotation to a nut (N) in threaded engagement with said member(s).

3. An apparatus according to Claim 1 or Claim 2, further comprising a housing (12) in which said sleeve (36) is disposed and means (40) for selectively rotating said sleeve between said first and said second positions.

4. An apparatus according to Claim 3, wherein said housing (12) has an abutment surface (16) for engagement with a surface (F) from which said member(s) projects to apply a reaction force as tension is applied to said member.

5. An apparatus according to Claim 3 or Claim 4, wherein said housing (12) is connected to said jaws (46, 48, 50 and 52) to prevent rotation of said jaws with respect to said actuator sleeve (36).

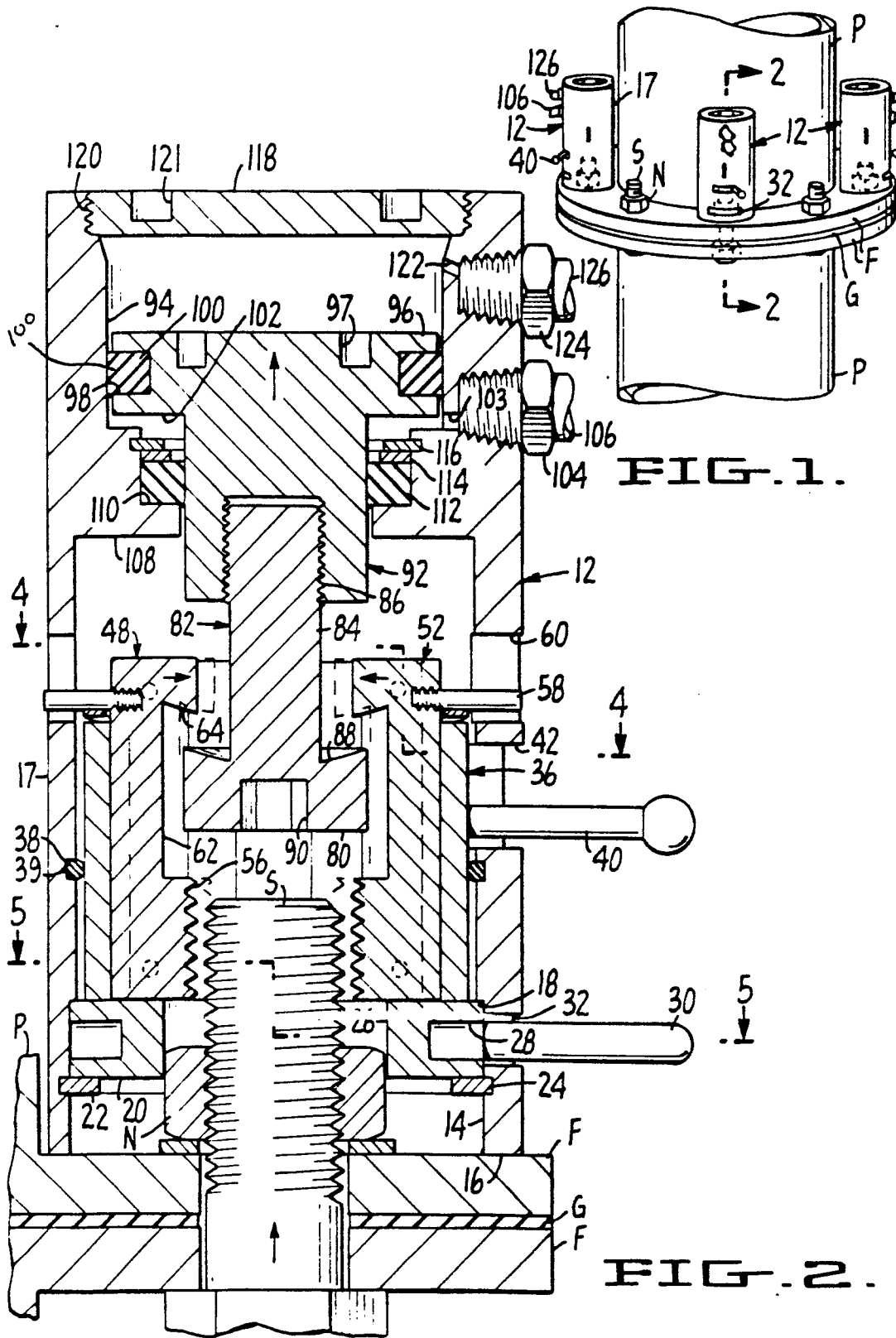
6. An apparatus according to any one of Claims 3 to 5, wherein said housing (12) defines a piston chamber (94) and said pull means comprises a piston (92) reciprocable within said chamber and connected to said jaws (46, 48, 50 and 52) to apply an axial force to said jaws and said member(s).

7. An apparatus according to Claim 6, further characterized by a puller bar (82) connected to said piston and reciprocable therewith, said puller bar having a head (80) with a concave surface (88) thereon, said jaws (46, 48, 50 and 52) having axial extensions (62) that engage said concave surface between said extensions and said puller bar irrespective of any misalignment between said puller bar and said jaws.

8. An apparatus according to any one of Claims 1 to 7, wherein said jaws (46, 48, 50 and 52) are sector shaped.

9. An apparatus according to any one of Claims 1 to 8, further characterized by means (72) for resiliently biasing said jaws (46, 48, 50 and 52) away from said member(s) and towards a position in which they do not engage said member.

10. An apparatus according to any one of Claims 1 to 9, wherein said sleeve (36) has a cam surface (74, 76 and 78) corresponding to each of said jaws (46, 48, 50 and 52), each cam surface having a first region (74) for causing said corresponding jaw to be positioned inwardly against said member(s) upon engagement of said jaw by said first region, a second region (76) disposed radially outwardly with respect to said first region for permitting said corresponding jaw to be positioned outwardly out of engagement with said member, and a third region (78) forming a transition between said first and second regions.



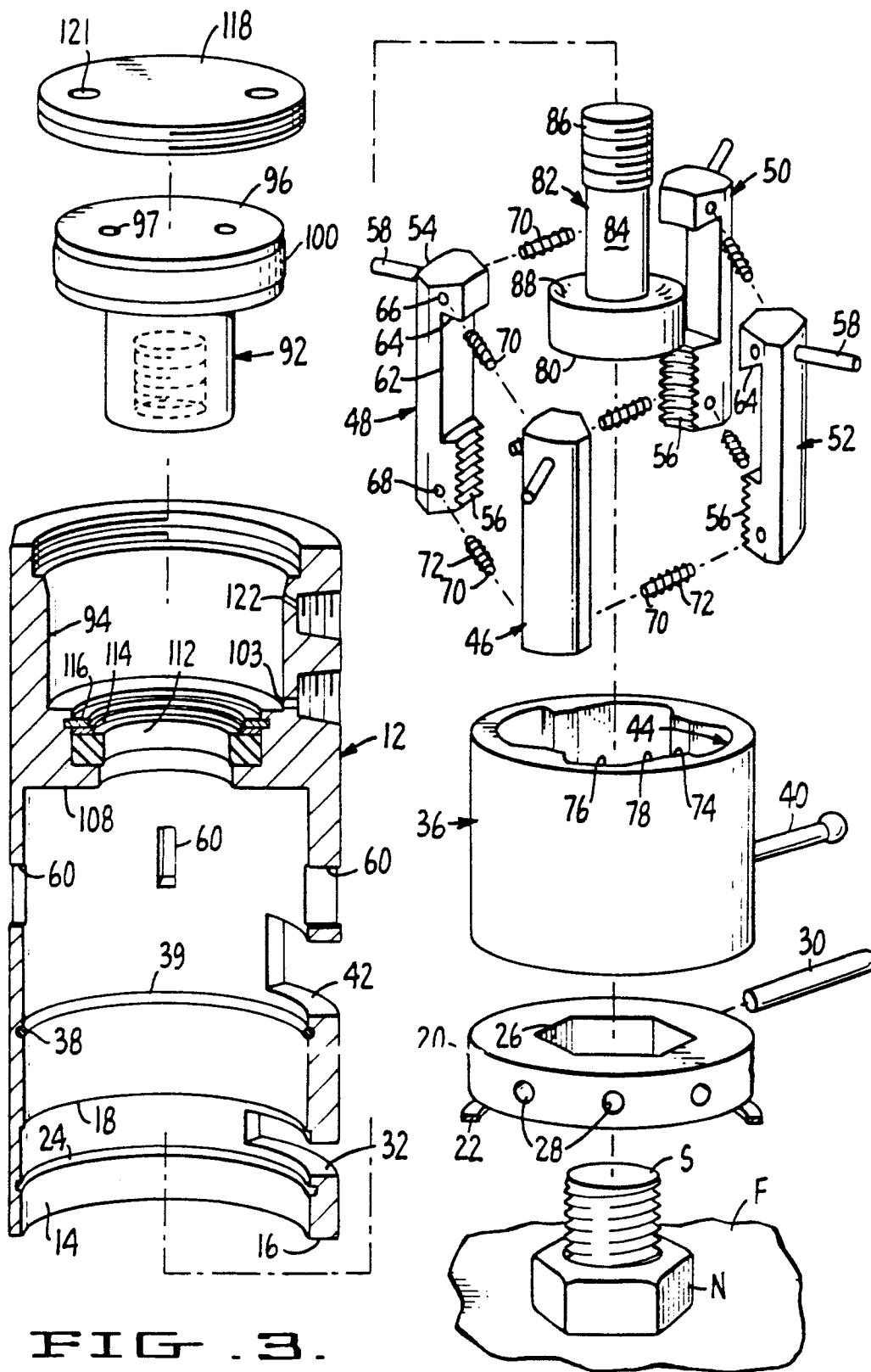


FIG. 3.

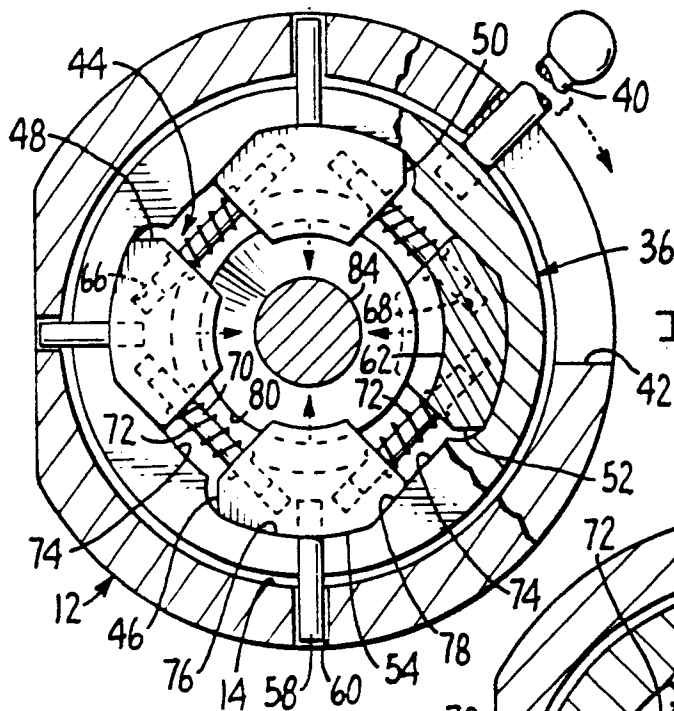


FIG. 4.

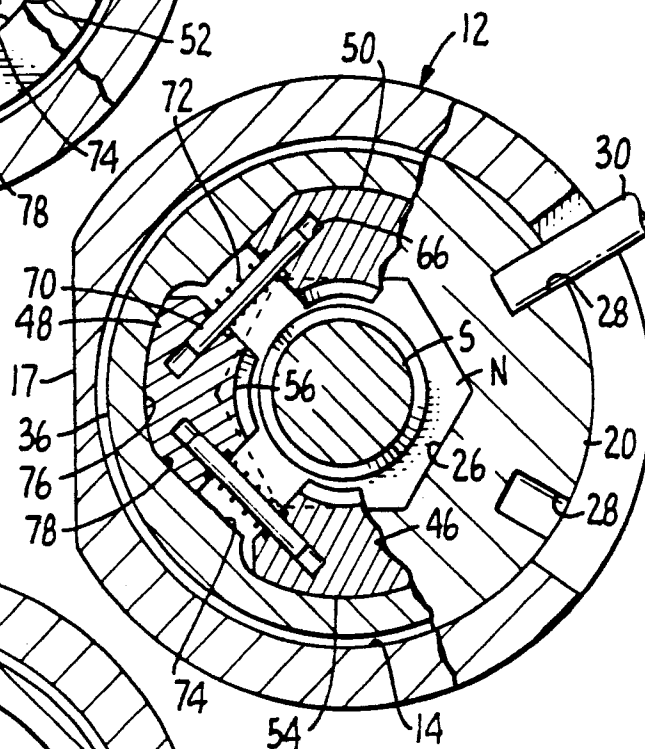


FIG. 5.

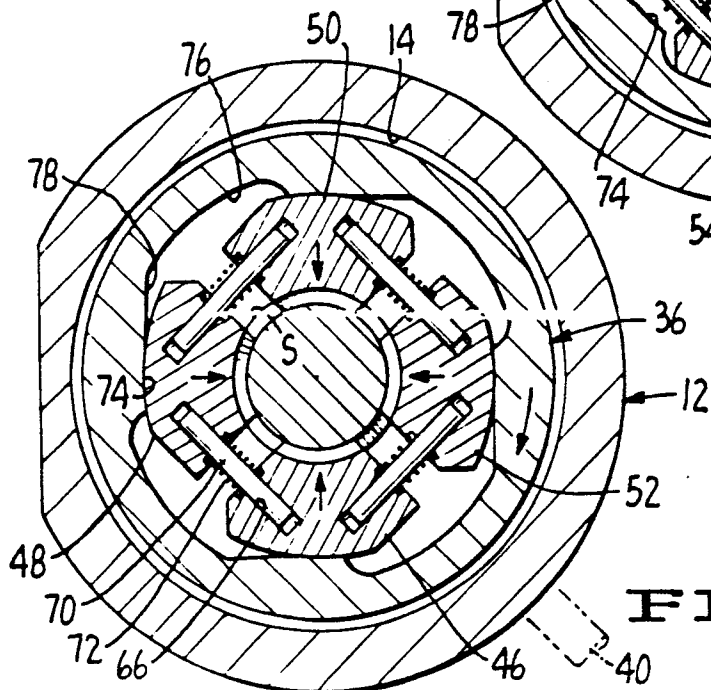


FIG. 6.

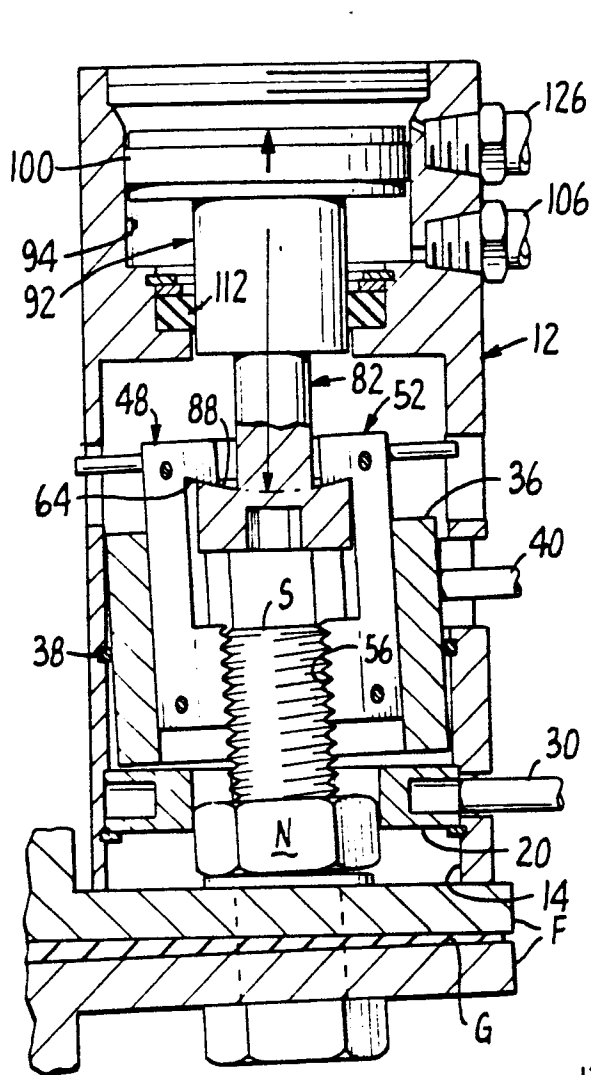


FIG. 7.

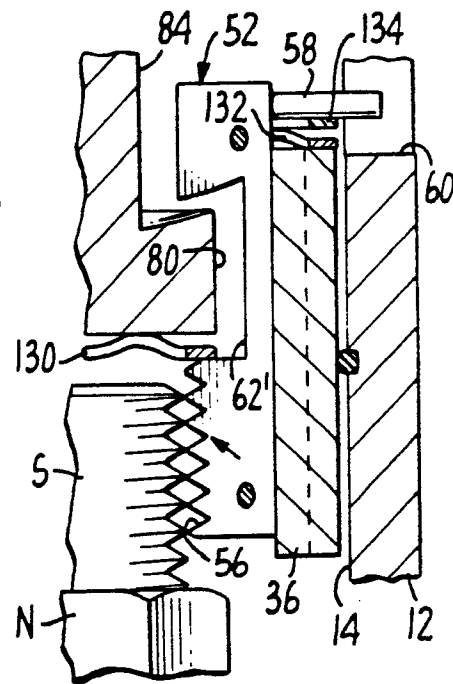


FIG. 8.

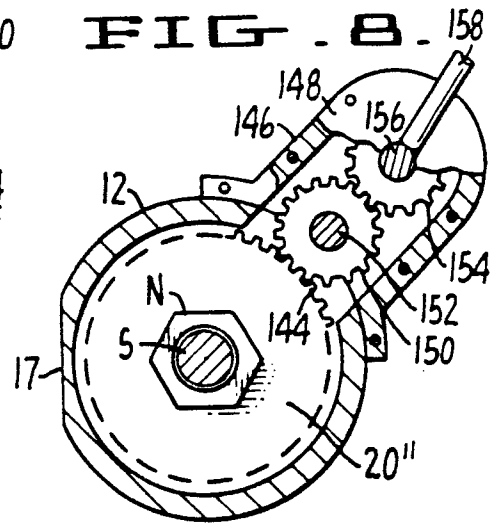


FIG. 10.

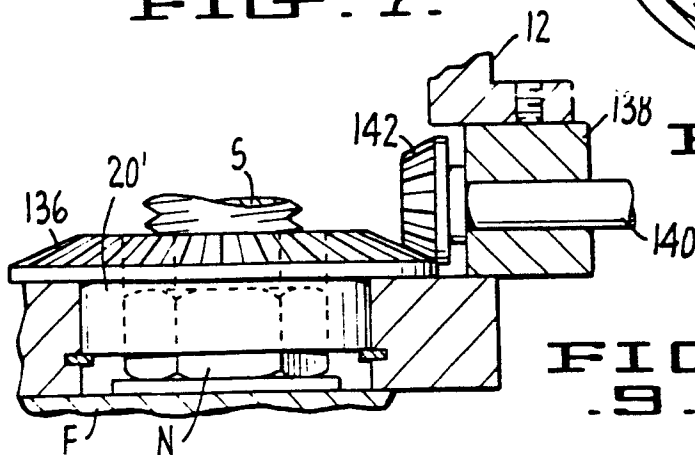


FIG. 9.