

Filed Nov. 17, 1959

BOLT-TENSIONING APPARATUS

4 Sheets-Sheet 1

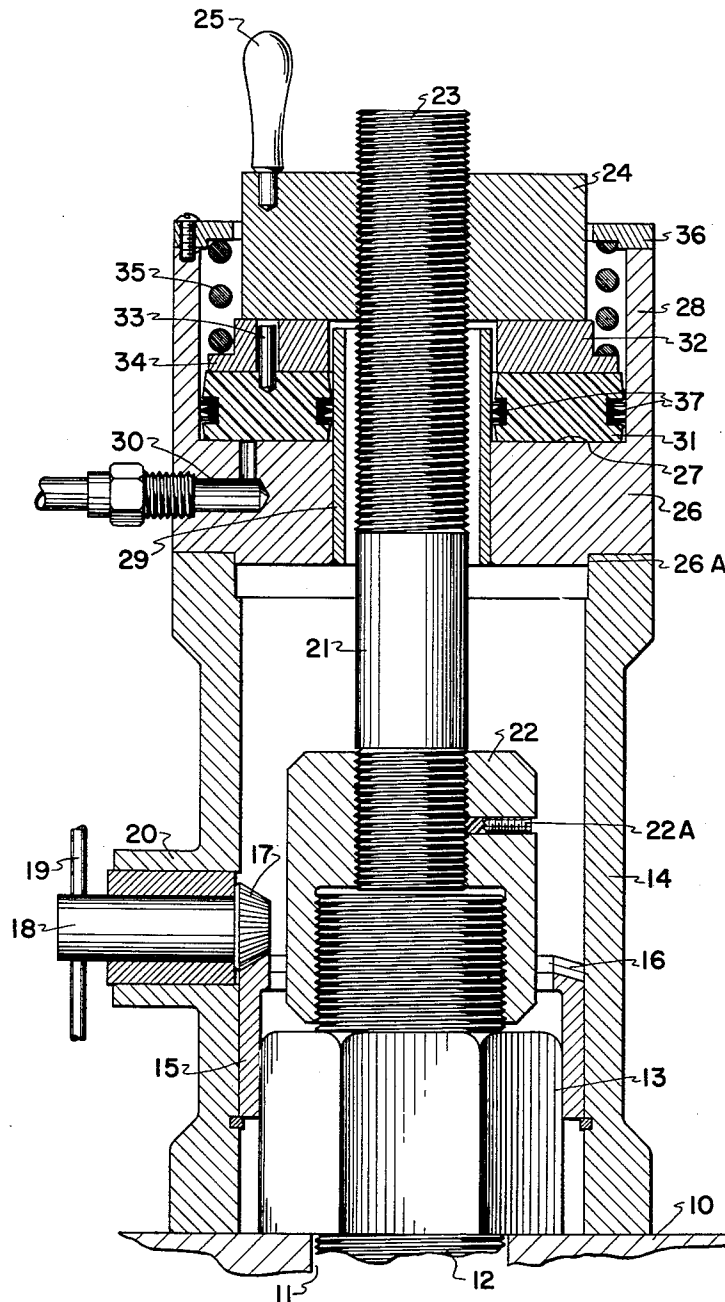


Fig. 1

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Jan. 9, 1962

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4 Sheets-Sheet 2

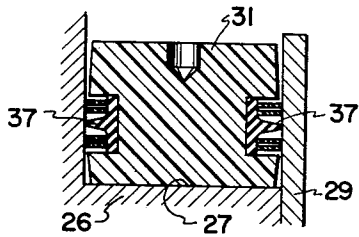


Fig. 2

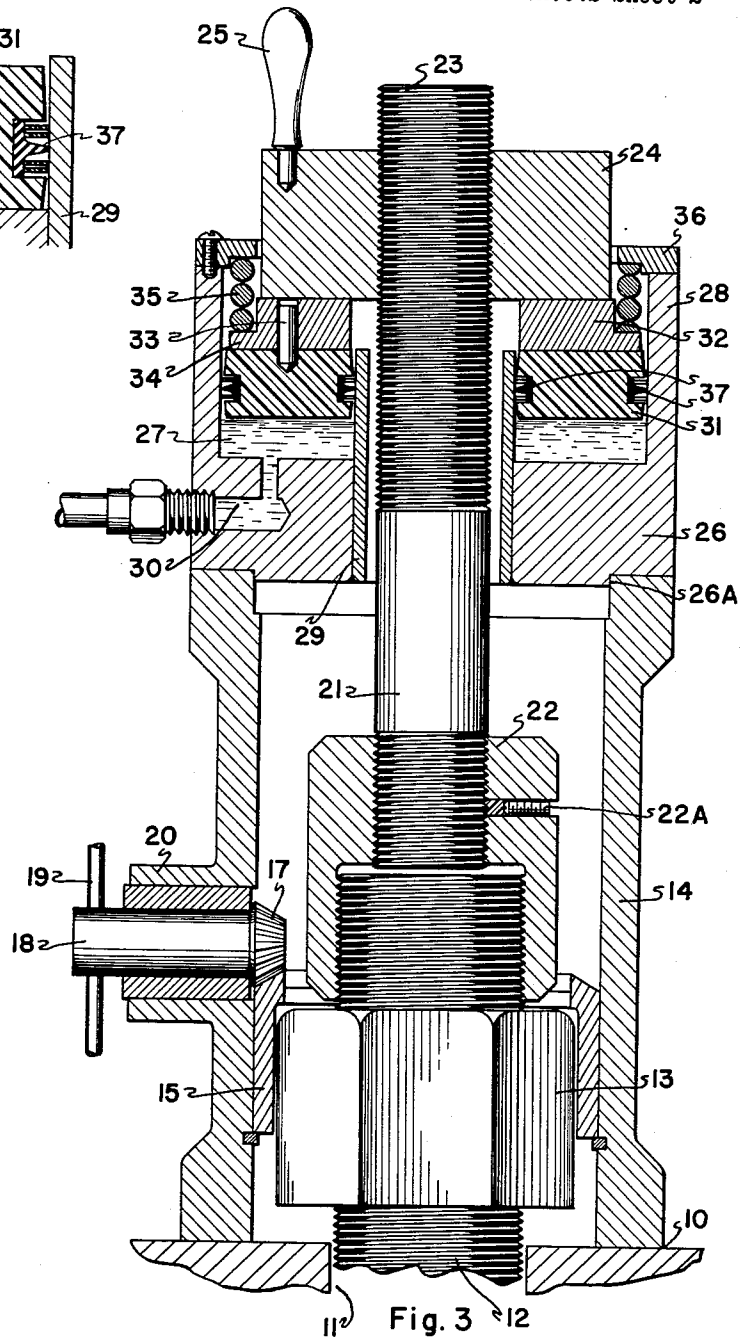


Fig. 3

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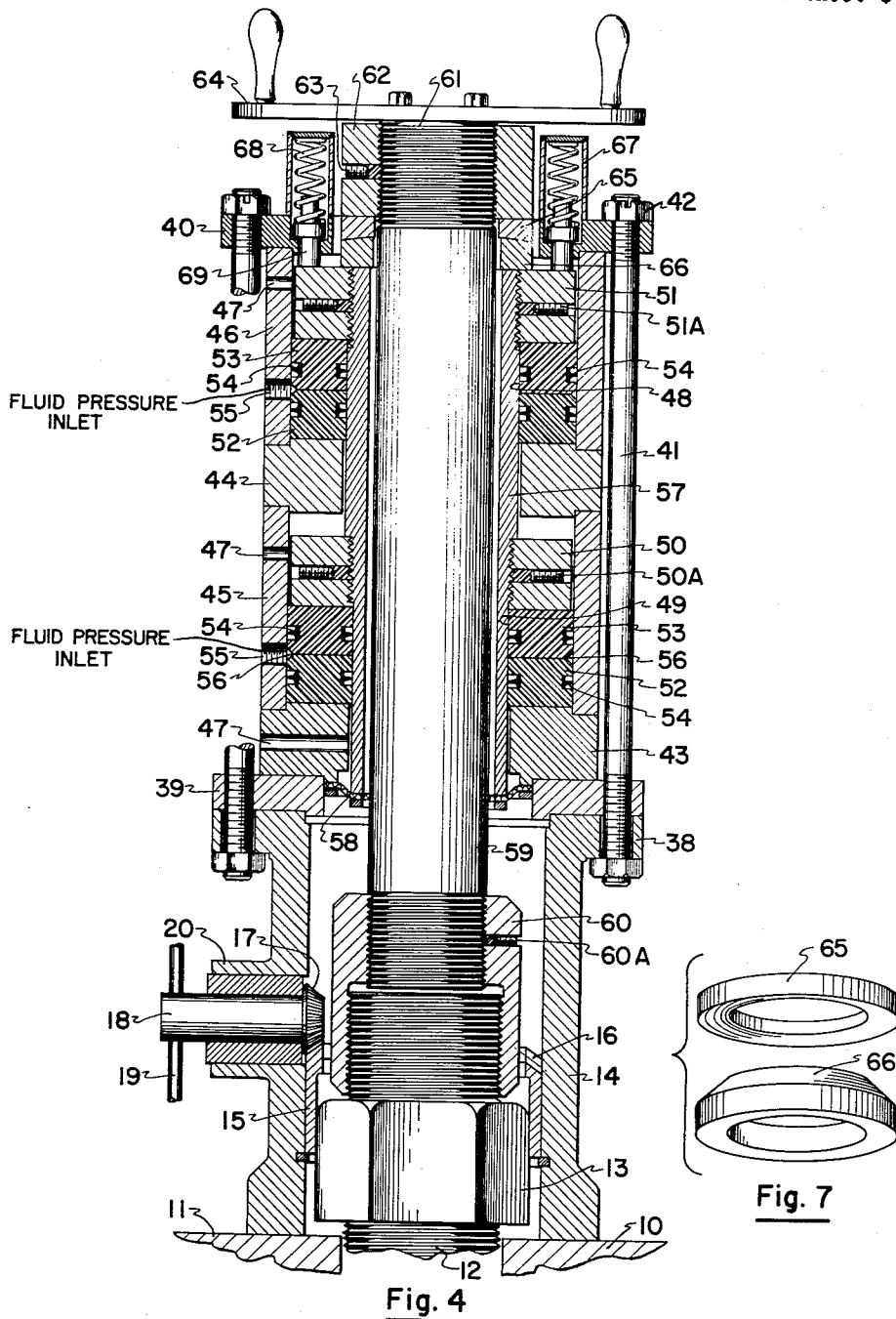
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

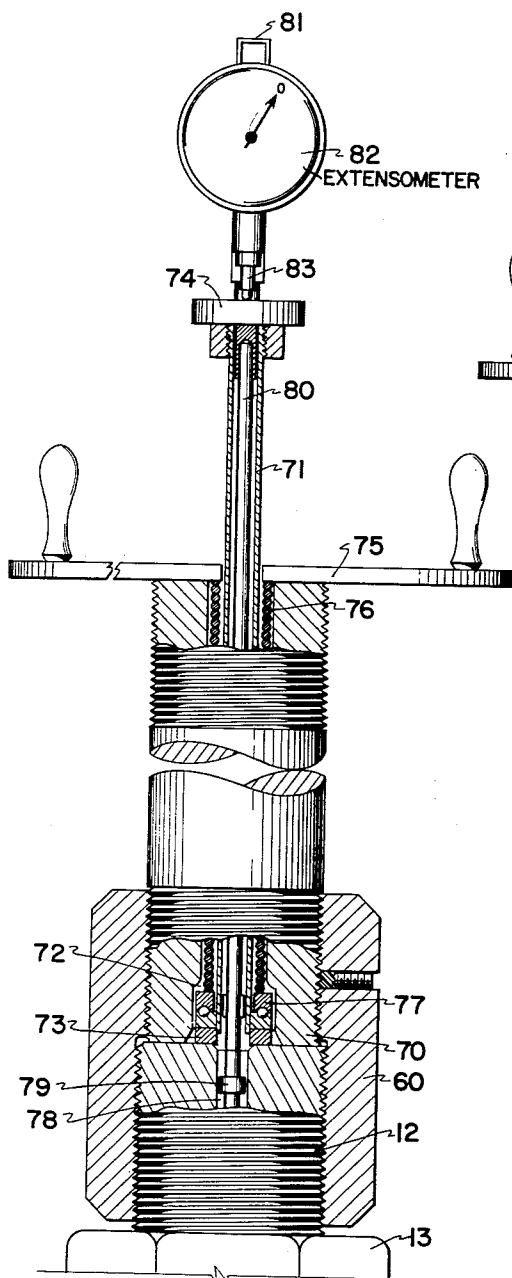


Fig. 5

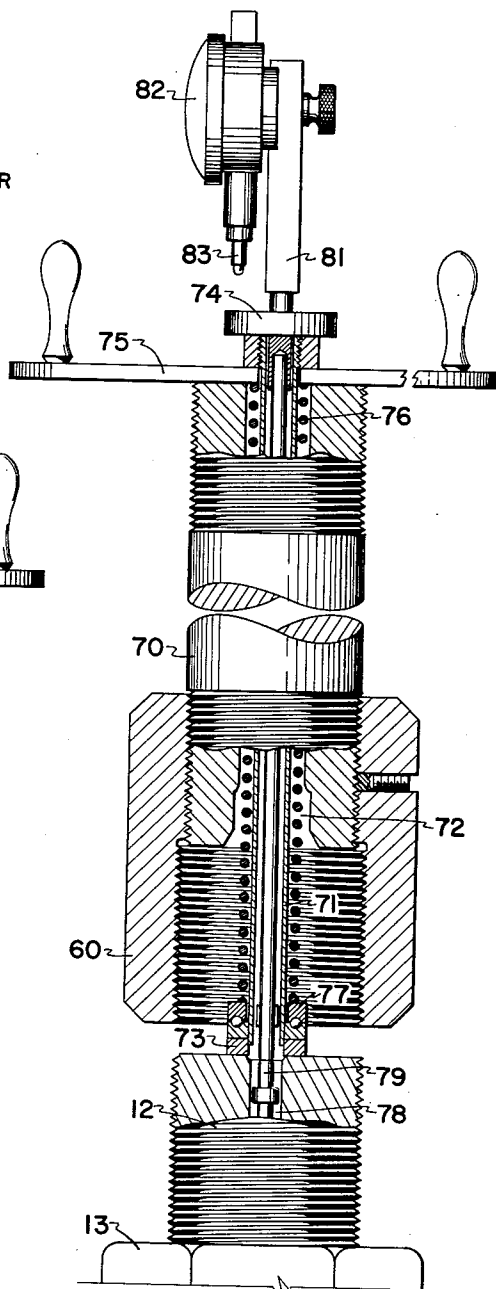


Fig. 6

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3,015,975

BOLT-TENSIONING APPARATUS

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Filed Nov. 17, 1959, Ser. No. 853,554
11 Claims. (Cl. 81-54)

This invention relates to a structurally and functionally improved bolt-tensioning apparatus, and in its more specific aspects, has as its primary object the provision of an alternative and/or more desirable design of mechanism over that disclosed in my United States Patent 2,866,370 dated December 30, 1958.

A further object of the present invention is that of providing an apparatus which will be capable of exerting tension on a bolt or equivalent member, which tension will have a value substantially in excess of the tension value or strain capable of being exerted by an apparatus as disclosed in my aforesaid prior patent.

An additional object is that of designing a mechanism for tensioning a bolt in which no damage will occur to the mechanism even although the parts be slightly out of alignment; the strain and tensioning effect being of desired value, despite such misalignment.

Still another object resides in a mechanism which will be capable of exerting a tension of high value; the apparatus, despite its relatively large mass, cooperating with the bolt and associated parts without damage to either the latter or the tensioning mechanism.

A still further object includes the provision of structure whereby an operator may precisely determine the response of a bolt or similar unit to a tensioning strain, and thus conclude whether the parts have been stressed to a degree sufficient to assure an end result in accordance with the requirements of any particular installation.

Among other objects is that of furnishing a mechanism which will include relatively few parts, each individually simple and rugged in construction, and these parts being readily combinable to furnish a mechanism operating over long periods of time with freedom from all difficulties.

With these and other objects in mind, reference is had to the attached sheets of drawings illustrating practical embodiments of the invention, and in which:

FIG. 1 is a sectional view of one form of apparatus; FIG. 2 is a fragmentary sectional side view, in enlarged scale, of a preferred design of piston structure to be included in assemblies of the type herein illustrated;

FIG. 3 is a view similar to FIG. 1, but showing the parts of the mechanism shifted to a different position;

FIG. 4 is a view again similar to FIG. 1, but showing an alternative form of assembly;

FIG. 5 is a fragmentary view of certain of the elements of the mechanism, embodying a provision whereby an operator may evaluate the tension exerted upon a bolt or stud;

FIG. 6 is a sectional side view of the mechanism as shown in FIG. 5, with the parts occupying different relative positions; and

FIG. 7 is a perspective view of the elements of a washer assembly providing a centering structure for the mechanism as illustrated in FIG. 4.

Referring primarily to FIGS. 1 and 3, the numeral 10 indicates a flange or supporting structure formed with an opening 11 through which a stud or bolt 12 extends. The latter, in accordance with conventional practice, is threaded and serves to mount a correspondingly threaded nut 13, which bears against the flange or structure 10 in order to secure the parts in fluid-tight relationship. As will be understood, gaskets, lock rings and other auxiliary structures may be associated with the parts to be

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sealed or units effecting that seal. These structures in many instances will not be employed, however, and for the purpose of avoiding unnecessary illustrations in the present drawings, have not been included in the views.

A suitable number of assemblies of the type illustrated are employed in a given installation so that, with an annular flange or similar unit being involved, desired pressures for effecting proper sealing may be created at a number of spaced points throughout an annular series of bolts or units defining the sealing structure. In this manner a proper tensioning of the bolts or their equivalents is assured throughout the entire circumference of the assembly, even if the tensioning apparatus is caused to cooperate initially with only certain of these bolts to tension them and thereafter is shifted to cooperate with other bolts; this operation being repeated until the entire series of bolts are under substantially even tension, to thus assure a seal which will be leakproof even under conditions of high pressure within a given vessel or tube.

As will also be understood, the tensioning apparatus is preferably connected to mechanism which will establish proper pressures for its operation, as especially shown in and described in connection with FIG. 1 of my afore-identified United States patent.

With the foregoing in mind, and returning to a consideration of FIGS. 1 and 3, it will be seen that numeral 14 indicates a suitable housing bearing against the flange 10 or equivalent structure and rotatably supporting a wrench 15 of the socket type, which will receive nut 13 to turn the latter in engagement with the threads of the stud or bolt 12. If a socket wrench 15 is employed, then it is conveniently provided with gear teeth 16 which mesh with the teeth of a bevel gear 17 secured to a shaft 18 provided with a manipulating unit 19. The latter has rotatable bearing within a lateral extension 20 of housing 14. Accordingly, with the nut 13 ensleeved within wrench 15, that nut may readily be rotated with respect to the stud or bolt 12 by simply turning shaft 18. This will bring nut 13 to a position at which it bears against the flange or reaction surface 10.

A puller bar 21 has secured to its lower end a nut or sleeve 22, which is internally threaded to engage with the threads of the stud or bolt 12. This sleeve is adjustable along bar 21, but is normally locked against movement with respect thereto by a nylon plug and set screw assembly 22A. The upper end of this bar is also threaded, as indicated at 23. These latter threads are engaged by the bore threads of a holding nut 24 conveniently having associated with it a handle 25 by means of which it may be manually rotated. As such rotation occurs, and with the puller bar stationary, nut 24 will shift axially of this bar.

Disposed above housing 14 is a body 26 which presents an upwardly facing ring-shaped cavity 27, which in cross section is in the form of a channel. This space, as hereinafter brought out, provides the cylinder for the apparatus. The desired configuration is included in this cylinder by having wall 28 of body 26 extend upwardly to thus furnish the desired outer cylinder surface. The inner wall surface of the cylinder is provided by a separate tube 29, conveniently formed of alloy, is pressed into the bore of body 26 and welded along the bottom of this body to furnish a fluid-tight structure. That tubing (whether it is integral or separate from body 26) furnishes, in conjunction with wall 28, the desired channel-shaped space. The puller bar 21 extends through the bore of body 26, preferably to a point above the latter.

Body 26 is formed with a fluid passage 30 extending through to the cylinder defined by the space 27. A suitable fitting may be connected to the outer end of this passage to thus couple the cylinder with a source of liquid

under pressure. Within the cylinder, a ring-shaped piston 31 is disposed for upward and downward movements. Above this piston a backing plate or ring 32 is supported; a suitable number of dowel pins and openings 33 being provided for the proper positioning of this plate with respect to the piston. The plate is interposed between the holding nut 24 and the piston, and preferably includes a flange portion 34 against which one end of a spring 35 bears. That spring is conveniently enclosed within the wall 28 of the cylinder and has its opposite end bearing against a retaining ring 36 suitably secured against detachment from body 26 and concentrically disposed with respect to the holding nut 24. Thus, this spring normally urges and retains piston 31 in the position shown in FIG. 1.

While piston 31 may be formed of various materials, it is preferred that it be made of a suitable phenolic resin. It embraces a ring-shaped body which will have a clearance of several thousandths of an inch from the opposed surfaces of the inner and outer cylinder walls 29 and 28 respectively. For purposes hereinafter brought out, it is tapered toward both its upper and lower faces. The backing plate or ring 32 has an internal diameter substantially in excess of the exterior diameter of member 29 defining the inner cylinder wall. The external diameter of plate 32 should be several thousandths of an inch less than the internal diameter of the bore defined by part 28. In fact, as shown, it may have an inside diameter $\frac{1}{16}$ inch more and an outside diameter $\frac{1}{16}$ inch less than the corresponding diameters of piston 31. If cylinder body 26 is not integral with housing 14, then it may include an extension or boss portion 26A extending within an enlarged upper bore portion of the housing for the purpose of properly locating these components one with respect to the other. Also, as shown, the outer and inner edges of piston 31, at points substantially midway of its upper and lower surfaces, is provided with grooves within which packing rings 37 are disposed. These rings are preferably of T-shaped configuration, which will assure a fluid-tight seal even where clearances of around $\frac{5}{1000}$ or $\frac{9}{1000}$ inch exist. This is in contradistinction to packing such as O-rings, the operating efficiency of which is not of a high order where clearances in excess of $\frac{1}{1000}$ inch are present.

As will be understood, by using a piston, preferably of phenolic material, with ample clearances, all danger of scoring of either the inner or outer cylinder surface is prevented. No sealing contact between those surfaces and the piston occurs; this being provided for solely by the packing 37. Such slight rubbing contact as occurs actually results in a polishing of the cylinder walls, so that their surfaces are improved with use of the apparatus. The undersurface of the piston, as shown in FIGS. 1 and 2, does not have to be reinforced, because the hydraulic pressure will be evenly distributed in contact with that surface. The extent of coverage of the upper piston face by the backing plate or ring 32 is adequate to prevent it cracking under the pressures which are created. As will be noted, ample clearance is provided between the bore of portion 29 and the pulling bar 21 so that these parts will not contact.

By having the head portion of the piston tapered, misalignment between the stud 12 and the flange or other portion 10 is provided for. This condition of the parts has been illustrated in somewhat exaggerated form in FIG. 3. The misalignment comes into being largely because of machining errors, which in practice may not be avoided. However, the bolt 12 must be subjected to tension without any bending of that bolt or stud. The actual misalignment is rarely more than a few minutes, although a possible misalignment has been provided for in the apparatus, as shown, ranging from 30 minutes to 1 degree. The taper on the piston head is on the order of 2 degrees, and consequently, the piston is free to tilt by a small amount. With such misalignment present, and after the tensioner has been disposed in operative position with respect to and connected with the bolt or stud, the holding nut 24 will

contact the back-up plate or ring with a part of its outer edge, depending on the direction in which the misalignment occurs. For example, if the stud is extending to the left of a properly aligned position, the left-hand edge of the holding nut will engage this plate, and the right-hand edge of that nut will be free. This holding nut is never tightened beyond so-called "finger tight" or less. Accordingly, there is no real clamping action. If fluid is pumped into the cylinder through duct 30, the right-hand portion of the piston will move initially and will tilt until it bears against the bottom surface of element 24. As further fluid enters the cylinder under pressure, it will proceed to lift the puller bar and in turn apply tension to the stud or bolt.

As aforementioned, the motion illustrated in FIG. 3 has been exaggerated, the tilt rarely being more than a few minutes and the total motion rarely more than $\frac{1}{32}$ to $\frac{1}{16}$ inch. The clearance between the cylinder walls and the piston allows the piston to tilt. However, due to the type of packing employed (preferably Greene, Tweed T), the change in the actual packing diameter is less than $\frac{1}{1000}$ inch. This packing follows the resultant motion and remains fluid-tight. After the bolt or stud 12 has been tensioned and nut 13 or its equivalent brought from the position shown in FIGS. 1 and 3 down to a point where it firmly contacts the surface of part 19, the coupling between the source of liquid pressure and conduit 30 is interrupted. Thereupon, the liquid within the cylinder 27 is allowed to return. This will be assured by spring 35 acting against piston 31 to urge it toward the base of the cylinder and thus expel the liquid. Under these circumstances, the piston will seat against the base surface of cylinder 27, and the apparatus may thereupon be removed from association with a given bolt and applied to another one to duplicate the afore-described operation. With that further bolt, misalignment in a quite opposite direction may occur. However, due to the construction employed, the parts of the tensioner will adapt themselves and correct for the misalignment.

As will be understood, a tensioning apparatus embracing the characteristics of the mechanism shown in FIGS. 1 and 2 may include a number of different stages. By resorting to such a structure, a desirable and compact mechanism will be furnished which will be capable of exerting any required tension on the puller bar. In order to avoid unnecessarily involved illustration, merely a two-stage tensioner has been shown in FIG. 4. In common with the earlier views, the reference numerals 10 to 20 inclusive designate in FIG. 4 parts functionally and/or structurally identical with those heretofore described. The upper end of housing 14, however, terminates at a lower level, in the form of a flange 38. The cylinder body supported upon the housing for manufacturing purposes involves a number of parts. These parts are conveniently maintained in proper positions with respect to each other by including in the cylinder assembly a lower plate 39 and an upper plate 40, having diameters substantially equal to the diameter of flange 38, and in common with the latter, being provided with openings. These openings are aligned, and rods 41 extend through them. The ends of these rods are conveniently threaded and mount nuts 42 which, when tightened, serve to retain the parts between plates 39 and 40.

The cylinder assembly proper conveniently includes ring-shaped plates 43 and 44 retained in spaced relationship to each other by an intervening collar portion 45. A second collar portion 46 is interposed between ring 44 and plate 40. These collar portions provide on their inner faces the outer surfaces of the cylinders. Each of the members 45 and 46 may be provided with a vent opening 47. A similar opening may be included in plate 43. A tube 57 provided with smooth exterior surface portions 48 and 49 is disposed within the tube defined by collars 45 and 46. These portions of the tube provide the inner cylinder surfaces. Rings 50 and 51 are con-

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nected to this tube, conveniently by screw threads and nylon plugs and set screw assemblies 50A and 51A. Therefore, as this tube shifts axially, rings 50 and 51 will move in synchronism therewith.

It is preferred to dispose within each of the cylinders a pair of pistons 52—53. These pistons are formed of phenolic resin and are provided with grooves in their outer and inner side faces which receive T-shaped packings 54 corresponding to the packings 37 afore-described. Collars 45 and 46 are formed with openings 55 providing liquid passages. With the parts in positions of rest, as shown in FIG. 4, the edges of pistons 52—53 of each pair will preferably be in line with the openings 55. Adjacent their meeting surfaces, these pistons may provide a groove 56, so that liquid may readily flow around the pistons and between their abutting surfaces. As will be observed, the packings carried by each pair of pistons 52—53 are in proper sliding engagement with the adjacent cylinder surfaces of collars 45—46 and the faces 48 of the tube defining the inner cylinder walls. The bore or opening of plate 43 is substantially larger than the exterior diameter of this tube, so that contact between these parts will not occur. Likewise, the external diameters of plates 50 and 51 are substantially smaller than the internal diameters of collars 45 and 46, to again avoid rubbing engagement between these parts. Therefore, there will never be any danger of seizing or galling of the cylinder walls, in that they are merely engaged by the pistons of phenolic material and their packings. At the lower end of tube 57, a flexible partition member 58 may be mounted to extend across the space between this tube and the adjacent plate 43.

Thus, in common with the structure shown in FIGS. 1 and 2, cylinder assemblies are present which are ring-shaped and in section present a channel configuration. Also, the pistons are ring-shaped. Plates 50 and 51 serve as backing plates or cylinder heads, and the lower piston 52 of each pair serves as the base part of the cylinder. However, one of these pistons will react against the upper surface of plate 44, while the other reacts against the corresponding surface of plate 43.

The puller bar 59 forming a part of this assembly has attached to its lower end, by a nylon plug and set screw 60A, a nut 60 or similar unit for engagement with the threads of the bolt or stud 12. Its upper end is threaded, as at 61, and as shown, extends above the cylinder assembly. This threaded end portion is engaged by the threads of a holding nut 62. The latter, when once properly adjusted with respect to the puller bar, may be secured against movement relative thereto by means of a set screw and nylon plug 63. A manual actuator 64 is attached to the upper end of the bar and serves to rotate it. This will present no difficulties, in that the diameter of the puller bar is sufficiently small so that it substantially clears the bore surface of the tube 57. So rotated, the puller bar will effect rotation of nut 60 or its equivalent to suitably interengage with the threads of the bolt or stud 12.

A set of spherical washers, shown to best advantage in FIG. 7, is interposed between the holding nut 62 and the upper edges of plate 51 and tube 57. These washers include bodies 65 and 66 formed with interengaging surfaces defining a common curvature, so that a centering structure is presented. In the case of misalignment, the puller bar will lean to one side or the other, depending on the direction and the amount of misalignment of the parts. The actual misalignment which has to be corrected for is rarely as much as 10 minutes. As afore brought out, substantial clearance exists between the inner sleeve or tube 57 and the puller bar. Therefore, these parts will not interengage. The center of curvature of the set of spherical washers is toward the bottom of the apparatus. Accordingly, misalignment due to shifting of flange 10 can be partially corrected. As the stud or bolt is tightened, the flange will tend to bend slightly under

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the load. As the spherical washer center corresponds more or less to the center of flange rotation, the washers will shift while the loading is continuing and will align the puller bar. Even if a full correction is not accomplished in this manner, any bending load applied to the bolt in tension will be negligible. Also, if desired, spherical washers may be interposed between other surfaces of the assembly.

In common with the construction described in connection with FIGS. 1 and 2, spring pressure may be resorted to in order that the parts may assume desired initial positions, as shown in FIG. 4. Conveniently, this is achieved by forming plate 40 with a series of openings, in line with which it mounts housings 67. The latter enclose springs 68 thrusting at their upper ends against the closure portions of the housings. At their opposite ends they thrust against pins 69. The pins bear against plate 51 providing the head portion of the upper cylinder. As liquid under pressure is admitted into this cylinder and simultaneously into the lower cylinder, plate 44, through sleeve or tube 45, will exert pressure on plate 43. The latter will transmit this reaction pressure through plate 39 and housing 14 to the surface of the member 10. Simultaneously, tube 57 will elevate, carrying with it head 51. This will result in a compression of the springs 68. Those springs are of course preferably pre-tensioned in the initial conditions of the parts. Therefore, when pressure within the cylinders is relieved, springs 68 will expand, thus lowering tube 57 to a point where substantially no liquid is present in the cylinders, as shown in FIG. 4.

In the case of tensioning apparatus of relatively large size, there exists the danger of damaging contact occurring between the bolt or stud to be tensioned and the parts of the apparatus. More particularly, considering the structure as shown in FIG. 4, as the apparatus is lowered into position over the stud or bolt, the puller bar and its associated parts will be freely suspended from the top of the assembly. With continued lowering, the socket or nut 60 will contact the end of the bolt, and the motion of the puller bar will be stopped, although the housing and its associated parts will be further lowered until contact is established with the flange or its equivalent. Under this condition, the next operation will be that of coupling nut 60 with the threads of the bolt or stud. Obviously, as contact is established between the top of the bolt and the nut or its equivalent, the entire weight of the puller bar and its associated parts is behind this contact. Therefore, in effect a blow results which may readily cause deformation of the entrance portion and/or the first thread at the upper end of the bolt or stud. This would make it very difficult to properly apply the puller bar to the stud, and even more difficult to uncouple these parts after tensioning has occurred.

It is feasible to overcome this by resorting to the teachings as in FIGS. 5 and 6. In those views it will be observed that merely the puller bar and parts associated therewith have been illustrated, it being understood that the piston and cylinder assemblies, as shown, for example, in FIG. 4, have been omitted so as to avoid confusing illustration.

Thus, in those views, the numerals 10, 12 and 13 again represent flange, stud and nut elements respectively. The puller bar is designated by the reference numeral 70 and corresponds to the bar 59, except for the fact that it is formed with an axially extending bore. Disposed within this bore and projecting beyond the ends of the same is a tube 71. The lower end of the puller bar mounts a nut 60 or equivalent element, as afore described. Adjacent its lower end the bore of that bar may be enlarged, as indicated at 72. A ring 73 is welded or otherwise suitably affixed to the lower end of tube 71 and has a diameter such that it may be freely accommodated within the enlargement 72, but may not

pass into the bore. The upper end of this tube has attached to it a cap or head portion 74 positioned at a point beyond the actuator 75 for rotating the bar. The diameter of part 74 is such that it will not pass through the opening in this actuator or its equivalent. A spring 76 has its upper end bearing against a convenient surface such as will be afforded by the actuator. Its lower end bears against the upper member of an anti-friction bearing assembly 77, in turn resting against the upper surface of ring 73. Accordingly, under the action of gravity and the thrust exerted by spring 76, ring 73 will normally tend to project beyond the lower edge of nut 60 or its equivalent.

The value of the spring is calculated, and when it is assembled on the tube, the initial tension of this spring will be slightly in excess of the weight of the puller bar and its associated parts. It is apparent that as the apparatus is lowered (see FIG. 6), ring 73 will contact the upper surface of the bolt or stud 12, with the lower edge of nut 60 spaced above that surface a distance of around $\frac{1}{4}$ to $\frac{1}{2}$ inch. With the tension of the spring existing as afore defined, there will be no danger of the nut 60 striking against the upper end of the bolt. Rather, as the mechanism is lowered to the position shown in FIG. 5, the housing may be brought into contact with flange 10 or its equivalent while maintaining the spacing of the nut 60 above the stud. Having completed the foregoing operations, the mechanic will now grasp the crank or plate 75 and exert a downward push thereon. This will require a force of only around 2 to 3 pounds. Under these circumstances, he will readily perceive when nut 60 contacts the upper end zone of the bolt, and thereupon will engage the threads of the latter with the threads of the nut. He will now continue to thread the nut onto the bolt until the latter is fully inserted into the nut bore. Under these conditions, tube 71 will remain stationary, even although spring 76 will rotate. This will be of no consequence, because of the provision of bearings 77, so that little turning effort will be required. Obviously, as the nut 60 is disengaged from the threads of bolt 12 by an unthreading of the parts, equally small effort will be necessary.

It is desirable that the actual elongation of the stud under tension be determinable while the tensioning apparatus is still in position. In this manner, an independent check is provided indicative of the force exerted on the stud. With this thought in mind, the present invention contemplates that the bolt 12 will be provided with a drilled center hole which will extend through to a point just short of the lower end of the stud. This hole has been indicated by the reference numeral 78. A measuring rod is disposed within this hole and bears against the bottom surface of the same. This rod 79 conveniently extends to a point just short of the upper stud surface. By measuring the position of the rod relative to the top of the stud before and after the tensioning of that member, the actual elongation of the latter may be determined. As shown in FIGS. 5 and 6, the apparatus may provide for this measurement at a point convenient for observation by the operator.

To achieve this, a center rod 80 extends through the bore of tube 71. The upper end of this rod mounts a dial support 81. Secured to the latter is a gauge 82 embracing a dial, indicia and a pointer, as well as a contacting element 83. The surface of cap 74 is of ample area so that under all conditions it will be engageable with the actuator 83. The parts will initially be in the positions shown in FIG. 6. With the nut 60 or its equivalent engaging the top surface of the stud or bolt 12, actuator 83 is brought to a position at which it contacts the upper surface of cap 74. The indicating mechanism of the gauge is then set so that it will read with a zero registration.

Cap 74 is mounted to be movable with tube 71. That tube provides an independent point of reference with

the top of the stud. Rod 80 provides an independent means of reference to the bottom of the stud. As tensioning proceeds, it will therefore be obvious that the indicating mechanism will register the elongation of the stud or bolt, since the dial will directly indicate the increase in the distance between the lower and upper ends of that bolt. The operator may discontinue the action of the tensioning apparatus when the desired degree of elongation has been reached. Thereupon, a nut 13 is turned with respect to the threads of the bolt until it engages flange 10 or its equivalent. With the relief of pressure within the cylinder or cylinders, there will be some loss of tension as the stud nut takes over the load. This can be allowed for by the operator.

Briefly to recapitulate the functional characteristics of the mechanism of FIGS. 1, 2 and 3, a number of tensioning apparatus may be applied at equally spaced points to bolts included in an annular series. This application will involve disposing the housing 14 in contact with the supporting surface 10 and the threading of the nut 22 onto the bolt 12, as shown in FIG. 1. Prior to this action, the nut 13 will have been threaded onto that bolt, and if desired, a washer (not shown) will have been interposed between that nut and surface 10. Now, by admitting fluid under suitable pressure through passage 30 into cylinder 27, piston 31 will elevate within that cylinder. In such elevation it will carry with it the backing plate or ring 32 and the holding nut 24. The latter being connected to the puller bar 23, that bar will be elevated, carrying with it nut 22, and due to the reaction zone provided by the cylinder assembly and housing 14, will tension the bolt or stud 12. This condition of the parts has been illustrated in FIG. 3. Any misalignment will be compensated for due to the structure and cooperation of the elements of the assembly, as previously described. With bolt 12 under proper tension, nut 13 may be turned down from the position shown in FIG. 3 to a point where it thrusts against the surface of part 10, as in FIG. 1. The pressure within the cylinder may now be relieved, and the hydraulic liquid will flow back from the cylinder through conduit 30 incident to the action of the spring 35. Nut 22 is now disengaged from bolt 12, and the apparatus is applied to the next stud to be tensioned.

Similar application and removal of the apparatus to and from a stud is achieved with the assembly as shown in FIG. 4. In that assembly, during tensioning, fluid under pressure will be admitted through ports 55. This will thrust the body parts of the cylinder assembly and the housing 14 supporting them against the surface of unit 10. Simultaneously, it will cause the rings 53 defining the upper pistons to bear against the piston heads provided by plates 50 and 51. Those plates or rings being secured against movements with respect to tube 57, it follows that this tube will be elevated. With such elevation, it will raise backing nut 62 and the upper end of puller bar 59. Any misalignment of the parts will be compensated for by the spherical washer assembly interposed between the holding nut and cylinder head 51 together with the attached tube 57. After proper tensioning has been achieved and the stud nut 13 tightened, the pressure within the cylinders is relieved. Under these conditions, springs 68 will return the parts to their initial positions.

Thus, among others, the several objects of the invention as specifically aforementioned are achieved. Obviously, numerous changes in construction and rearrangements of the parts may be resorted to without departing from the spirit of the invention as defined by the claims.

I claim:

1. A bolt tensioner including in combination a body providing a plurality of cylinders, said body having passages for liquid flow into such cylinders, pistons movable within said cylinders, a pulling bar connected with the pistons of the different cylinders to move with such pis-

tons and bolt-engaging means connected to move with said bar.

2. In an apparatus as defined in claim 1, said cylinders being disposed one above the other, a member common to said pistons to receive thrust from the latter and centering means interposed between such member and said pulling bar to compensate for misalignment of a bolt to be tensioned.

3. A bolt-tensioning and nut-seating apparatus including in combination a housing to be applied to a mounting member from which a bolt supporting a nut extends, a rod disposed within and extending above said housing, tube means defining a pair of cylinders and bearing against the upper end of said housing, said cylinders having openings for the passage of fluid into their interiors, pistons reciprocable within said cylinders and formed with openings through which said rod extends, means above the pistons and bearing against an upper surface contiguous with one of the same for connecting the rod with said pistons and a nut carried by said rod within said housing and connectible with a bolt for tensioning the latter as said pistons and rod are moved.

4. A bolt tensioner including in combination a tubular body having an axially extending ring-shaped recess of channel-shaped cross section and facing in an upward direction, said recess providing a cylinder and said body being formed with a fluid passage communicating with said cylinder, a ring-shaped piston reciprocable and wholly confined within said cylinder, a pulling bar extending through the bore of said body, means carried by said bar at a point below said piston and connectible with a bolt to be tensioned, a holding nut connecting said bar for movement with said piston, said body being formed with a further recess providing a second cylinder, a piston also within said latter cylinder, and means common to both said pistons for connecting said rod with said bar.

5. A bolt-tensioning apparatus including in combination a body providing a cylinder having a fluid passage communicating with it, a piston movable within said cylinder, a pulling bar, means coupling said bar with said piston, means movable with respect to said bar in response to elongation of a bolt under tension, registering means forming a part of the apparatus and connected to said elongation-responsive means for indicating the amount of such elongation, said elongation-responsive means comprising a member movably disposed within a longitudinal bore formed in said bar and extending beyond such bore to connect with a part of a bolt to be tensioned and said registering means being connected to said member and disposed at a point adjacent that end of the bar opposite said bolt-engaging means.

6. A bolt-tensioning apparatus including in combination a housing having an upper end, a body supported upon that end, outer and inner annular walls extending upwardly from said body and in spaced relationship to each other to provide between them an upwardly facing channel furnishing a cylinder, a ring-shaped piston within said channel, a puller bar extending upwardly from within said housing through the opening defined by said inner wall to a point above the latter, the upper end of said bar being formed with threads, a holding nut mounted upon said threads and thrusting against said piston, and a bolt-engaging means carried by the lower end of said bar within said housing.

7. In an apparatus as defined in claim 6, a spring having its lower end thrusting against said piston, and means connected to said body and providing bearing means overlying and engaged by the upper end of said spring.

8. In an apparatus as defined in claim 6, said bar having a diameter such that it may assume an angular position within the space defined by said inner wall, and aligning means interposed between said holding nut and piston to correct stresses which would result in a bending of the puller bar.

9. In an apparatus as defined in claim 6, said bar being formed with a bore, a tube extending through said bore, a rod slidable within said tube and having its lower end connectible with a surface of a bolt, the lower end of said tube being connectible with a different bolt surface, indicating means connected to the upper ends of said rod and tube and visible above said bar for registering the distance between said bolt surfaces.

10. In an apparatus as defined in claim 9, a spring acting against said tube to urge the same in a downward direction.

11. In an apparatus as defined in claim 9, rotatable bolt-engaging means carried by the lower end of said tube.

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