United States Patent

Schwartz et al.

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[54] DEVICE FOR STRESSING TENSIONABLE ARMATURES

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[52] **U.S. Cl.** ....**254/29 A**

[51] **Int. Cl.** **E21b 19/00**

[58] **Field of Search**....................254/29 A

[56] **References Cited**

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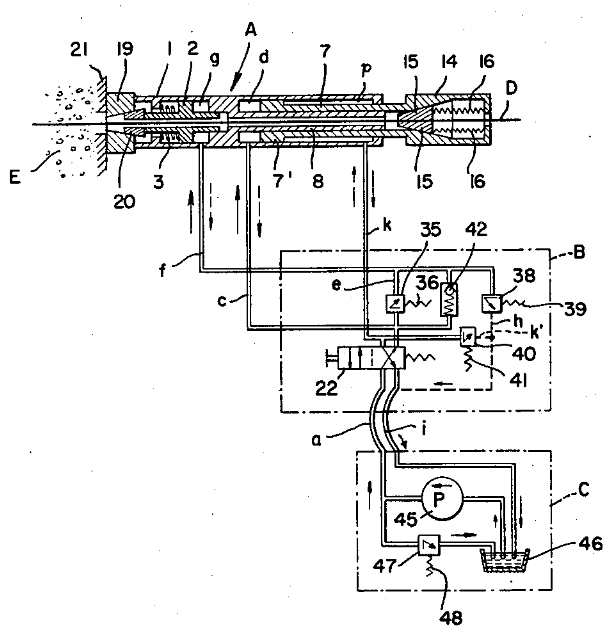
[57] **ABSTRACT**

A tensionable armature passes axially through a jack comprising a hydraulic cylinder in which two pistons are slidable. The first piston projects from one extremity of the cylinder and carries a spring-loaded chuck for gripping the free end of the armature upon outward movement thereof, this piston being of the double-acting type and coacting with a fixed stem for positively disengaging the associated chuck from the armature upon inward retraction. The second piston, which is spring-loaded, bears upon another chuck at the opposite cylinder extremity on being urged outwardly against the spring force, thereby causing that chuck to hold the armature in its stressed position against the shell of a concrete casing. A distributor, comprising a set of four valves controlled by a common handle, has an operating position and a release position; in the former, an outward movement of the first piston to stress the armature is followed by a loading of the second piston to clamp the armature in place, whereas in the latter the first piston is retracted and the second piston is unloaded preparatorily to a new tensioning stroke.

10 Claims, 11 Drawing Figures



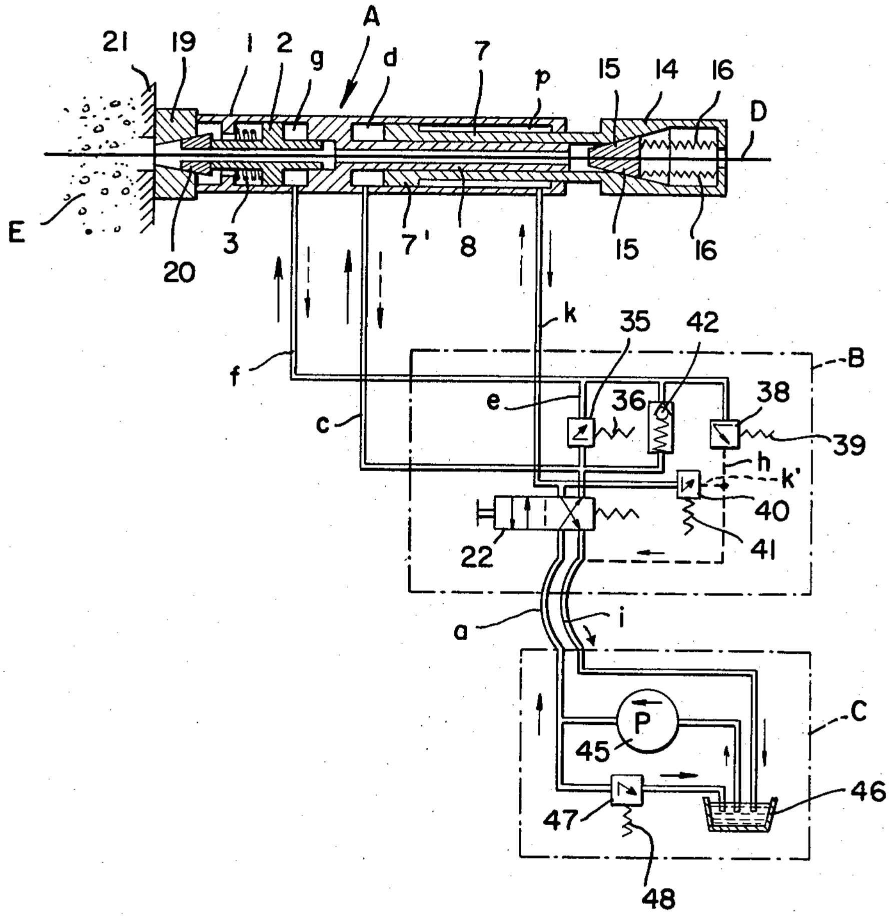


FIG. I

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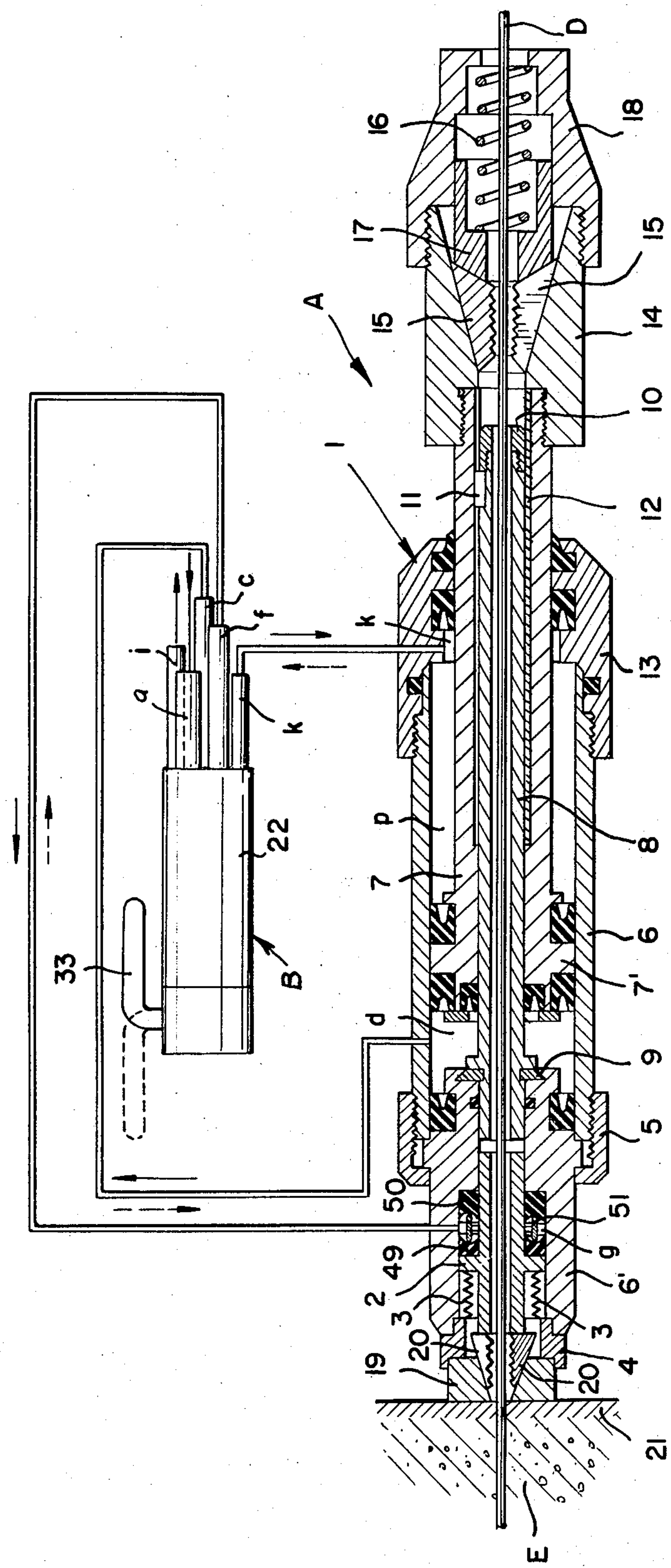

FIG. 2

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FIG. 4

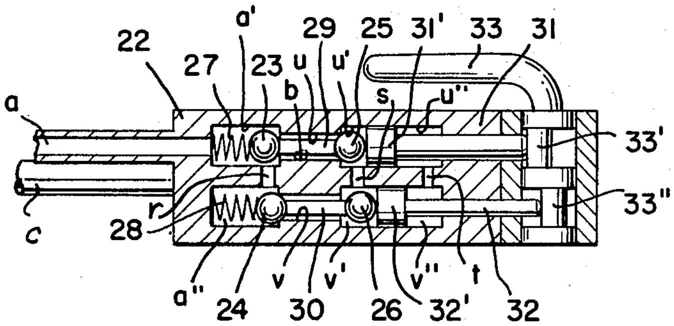


FIG. 3

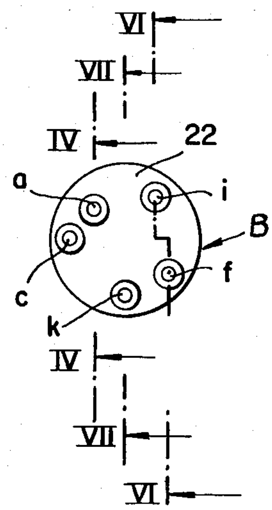
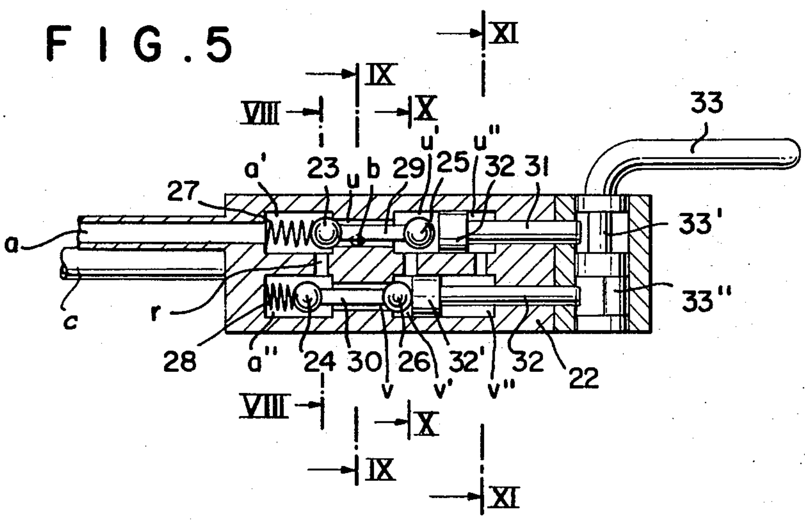


FIG. 5



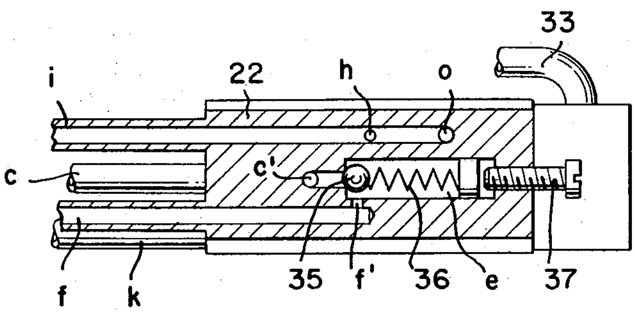


FIG. 6

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FIG.7

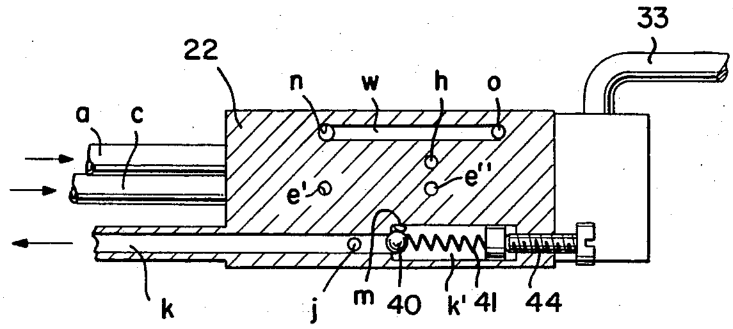


FIG.8

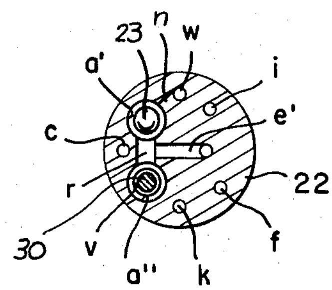


FIG.9

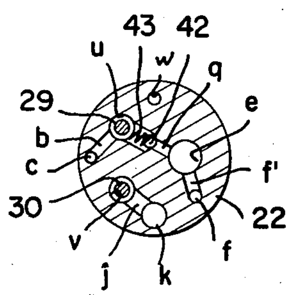
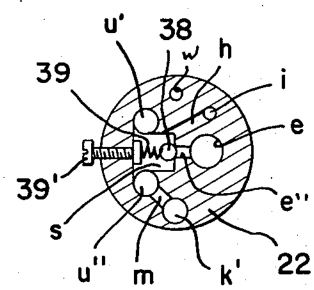


FIG.10



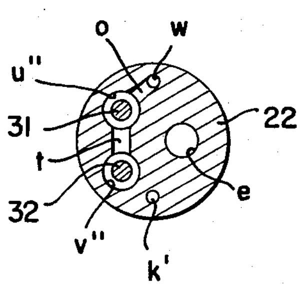


FIG.11

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DEVICE FOR STRESSING TENSIONABLE ARMATURES

Our present invention relates to a device for the stressing of tensionable armatures, such as rods or cables, embedded in a freshly poured or precast concrete structure and projecting endwise therefrom.

The tensioning of such concrete armatures usually proceeds in stages, with alternate stressing and holding steps until the desired tension has been achieved. Frequently, a hydraulic or pneumatic jack is used to pull the free end of the armature or reinforcing element for a distance determined by the working stroke of the jack, this free end being then clamped under stress while the jack is retracted for subsequent re-expansion and further tensioning.

The general object of our invention is to provide automatic or semiautomatic means for carrying out these stressing and clamping operations in a predetermined sequence and over as many cycles as is necessary to impart a desired tension to the cable or other element to be stressed.

More particularly, our invention aims at providing a compact distributor for hydraulic or pneumatic fluid to be used in operating a jack for the stressing of such a rod or cable in one or more steps until the desired tension has been reached.

In accordance with this invention we provide a jack which includes a pair of pistons coaxially disposed at opposite extremities of a cylinder, the element to be stressed being received in aligned axial bores of these pistons; a projecting end of one of these pistons, which will be referred to hereinafter as the tensioning piston and preferably is of the double-acting type, carries a movable chuck with a first set of clamp jaws engageable with the free end of the tensionable element for stressing same upon an outward movement of that piston from a retracted to an extended position. A fixed chuck with a second set of clamp jaws is disposed adjacent the other extremity of the cylinder in the path of the other piston, which will be referred to as the locking piston and is preferably spring-biased in a direction away from that chuck, the application of fluid pressure to the latter piston driving these second clamp jaws into locking engagement with the tensionable element to hold it in position while the tensioning piston is retracted preparatorily to another outward stroke. A distributor inserted between the jack and a source of oil or other high-pressure fluid has two alternate positions for outwardly extending and inwardly retracting the tensioning piston; in the first of these distributor positions, a threshold valve responsive to a predetermined back pressure from the jack opens to admit fluid to the clamping cylinder for locking the tension element in place, whereas in the second distributor position the locking piston is unloaded concurrently with the withdrawal of the tensioning piston. The jaws of the fixed chuck, however, continue to hold the tension element until its free end is again pulled outwardly by the next working stroke of the tensioning piston; a fixed stem rigid with the cylinder housing, extending axially within the tensioning piston, insures the positive release of the mobile chuck upon retraction of that piston. In this released condition, the jack may be removed from the stressed structure while leaving the fixed chuck in position to keep the rod or cable under tension.

If the tension element remains relatively slack during a stressing operation, the threshold valve does not open until the double-acting piston comes to rest against a part of the housing in its limiting outermost position; if, however, this element reaches its predetermined maximum stress in the course of a tensioning stroke, the resulting opening of the threshold valve not only actuates the locking piston but also provides a bypass preventing the buildup of substantial further pressure on the tensioning pistons so that no appreciable further stressing takes place. This bypass may include an additional threshold valve responding to the buildup of back pressure from the cylinder compartment containing the locking piston. Upon the subsequent switching of the distributor to its alternate position, a check valve effectively in parallel with the first threshold valve enables the rapid discharge of fluid from that compartment to a region of low pressure such as an oil sump or the atmosphere.

The distributor, according to another feature of our invention, comprises a channeled body with an inlet port connected to the high-pressure side of the fluid supply, a discharge port leading to the aforementioned region of low pressure, and three further ports communicating with respective compartments of the jack cylinder. Several threshold and check valves are accommodated within the channels of that body, as are two pairs of ganged blocking valves controlled by a common actuator which alternately opens and closes one valve of each pair.

The actuator may be a manually or automatically operable cam shaft with relatively offset eccentrics acting by way of respective plunger rods upon the two valve pairs against the force of associated biasing springs; each valve pair may comprise two advantageously spherical heads confronting respective valve seats at opposite ends of a restricted passage whose length is less than the spacing of these heads whereby only one of them can come to rest against its seat at any given time.

The above and other features of our invention will be described in detail hereinafter with reference to the accompanying drawing in which:

FIG. 1 is an overall view of a stressing device according to our invention, including a hydraulic jack shown in longitudinal section and a distributor illustrated only diagrammatically;

FIG. 2 is a view similar to FIG. 1 but showing details of the jack drawn to a larger scale;

FIG. 3 is an end view of the distributor illustrated in FIGS. 1 and 2;

FIG. 4 is a longitudinal sectional view through the distributor taken on the line IV — IV of FIG. 3;

FIG. 5 is a view similar to FIG. 4, showing the distributor in an alternate position;

FIG. 6 is a longitudinal sectional view taken on the line VI — VI of FIG. 3;

FIG. 7 is another longitudinal sectional view, taken on line VII — VII of FIG. 3; and

FIGS. 8, 9, 10 and 11 are cross-sectional views of the distributor taken on lines VIII — VIII, IX — IX, X — X and XI — XI, respectively, of FIG. 5.

In FIGS. 1 and 2 we have shown a hydraulic jack, generally designated A, to which oil under pressure is delivered by a distributor B from a source C for the controlled tensioning of a prestressing cable D whose end remote from the jack is anchored to a concrete structure E wherein the greater part of this cable is embedded. Concrete structure E is bounded by a mold or falsework 21 against which a chuck 19 rests under pressure from jack A whose cylinder 1 bears coaxially upon that chuck. Several clamp jaws 20 are disposed about cable D within the frustoconical throat of chuck 19 in the path of a single-acting piston 2 movable in a compartment *g* of cylinder 1 and biased inwardly, i.e. away from the structure E, by loading springs 3. Another piston 7, of the double-acting type, has a head 7' dividing the interior of the housing 1 into two compartments *d* and *p*, compartment *d* being separated from compartment *g* by the left-hand end of a tubular stem 8 integral with housing 1. Piston 2 and 7 are both hollow and coaxially disposed in the cylindrical housing 1, with stem 8 nested in piston 7; the free end of cable D passes centrally through piston 2, stem 8 and piston 7 into another chuck 14 which is integral with the right-hand end of piston 7 projecting from cylinder 1. Chuck 14 has a frustoconical throat diverging in the same direction as that of chuck 19, i.e. to the right in FIGS. 1 and 2, and accommodates a set of clamp jaws 15 under pressure of springs 16; in the fully retracted position of piston 7, i.e. with compartment *d* reduced to its minimum volume, the free end of stem 8 bears upon the jaws 15 to disengage them from the cable D which they normally grip under pressure of springs 16.

As more fully illustrated in FIG. 2, housing 1 comprises two parts 6, 6' held together by a clamping nut 5, part 6 being a sleeve closed at its left-hand end by the part 6' and at its right-hand end by another clamping nut 13. A longitudinally slitted bushing 12 nonrotatably received in piston 7 coacts with a key 11 on stem 8 to prevent relative rotation of the piston and the stem, key 11 being held in position by a nut 10 threaded onto stem 8 and being received in the slit of bushing 12. In contrast to the more schematic showing of FIG. 1, FIG. 2 illustrates the stem 8 as secured to housing part 6' by a laterally inserted locking fork 9 with beveled prongs. FIG. 2 also shows a stepped collar 4 embracing the chuck 19 and entering the housing part 6' for positively locating the jack A with reference to that chuck. Furthermore, this Figure shows a socket 17 for biasing spring 16 and an end cap 18 threadedly engaging the chuck 14 to compress the spring 16, the socket having a beveled surface bearing upon the outer edges of the wedge-shaped clamp jaws 15.

Fluid supply C includes a pump 45, a sump 46 and a relief valve 47, controlled by a spring 48, which opens a bypass for excess oil if the load pressure exceeds a certain maximum.

The distributor B, as schematically indicated in FIGS. 1 and 2, has an inlet port *a* connected to the high-pressure side of pump 45, an outlet port *i* returned to the sump 46 and three further ports *c*, *f* and *k* respectively communicating with compartments *d*, *g* and *p*. For convenience, the lines serving these ports will be referred to hereinafter by the same designations as the ports themselves. The distributor also includes a valve structure, generally designated 22, which in its illustrated position connects the inlet *a* and the outlet *i* with ports *c* and *k*, respectively, and in its alternate position reverses these connections. A threshold valve 35, normally held closed by an adjustable spring 36, is inserted in a connection *e* between the fluid lines *c* and *f*, a check valve 42 in parallel with threshold valve 35 serving to drain the compartment *g* in the alternate position of distributor body 22. Two further threshold valves 38 and 40, normally held closed by respective adjustable springs 39 and 41, connect ports *f* and *k* with two passages *h* and *k'* merging into the outlet *i*.

The switching of the distributor between its two alternate positions is carried out manually with the aid of a handle 33 which projects from the body 22 and is rotatable through 180° as illustrated in FIG. 2. In the full-line position of this handle, corresponding to the distributor position of FIG. 1, oil under pressure flows from inlet *a* via port *c* into compartment *d* and is drained from compartment *p* via port *k* into outlet *i*, thereby displacing the piston 7 toward the left and entraining the free end of cable D gripped by the clamp jaws 15 of chuck 14. The back pressure thus developing in line *c* progressively increases and, before or when the piston arrives in its outermost (right-hand) position, reaches a critical level which unblocks the threshold valve 35 and causes the fluid to enter the line *f* so as to load the piston 2, moving it toward the left into contact with the clamp jaws 20 which are thus pressed into firm locking engagement with cable D. The system remains in this position until the distributor handle 33 is turned into its alternate position (dot-dash lines, FIG. 2) whereupon the pressure in line *c* is relieved so that piston 7 is retracted by the simultaneous pressurization of line *k*; cable D, whose free end is now disengaged from the jaws 15, elastically draws the jaws 20 deeper into the chuck 19 so as to remain securely clamped even as piston 2 is restored to its normal right-hand position by the pressure of its springs 3 as compartment *g* is drained through check valve 42. It will be noted that, in the construction specifically illustrated in FIG. 2, compartment *g* includes a pair of annular gaskets 49, 50 of elastic material spread apart by a ring 51 of T-section, this assembly cushioning the return stroke of piston 2; the stroke of this piston being relatively short, ring 51 may remain in continuous contact with the expanding and contracting gaskets.

The aforedescribed sequence of operations may be repeated any number of times by the alternate reversal of handle 33. During the next tensioning stroke, with the projecting portion of cable D again stressed by the advancing piston 7, the clamp jaws 20 are unseated by the slight relative motion between the cable and the chuck 19 so as not to interfere with the further tensioning. When the cable tension rises sufficiently to exert upon the fluid in line *c* a reaction force equaling the threshold level of valve 35, this valve opens to actuate the piston 2 and to operate the locking jaws 20 so that the advance t of piston 7 is halted by the deviation of fluid from line *c* to line *f*. As the back pressure from compartment *g* reaches a predetermined value, which may be substantially less than the threshold level of value 35, threshold valve 38 also opens to create a bypass path via outlet *i* back to the sump 46. Thus, no substantial increase in the tension of cable D occurs after the limit established by the setting of valve 35 has been reached.

After a reversal of handle 33 to the release position (dot-dash lines), piston 2 and 7 are once more retracted whereupon jack A can be bodily removed from cable D and chuck 19, with the adapter 4 preferably remaining on the jack.

The two chucks 14 and 19 as well as their clamp jaws 15 and 20 could be made similar in size so that only one set of spare parts need be available for the two sets of jaws.

Reference will now be made to FIGS. 3 – 11 for a more detailed discussion of the construction of distributor B.

As best shown in FIG. 3, ports *a*, *c*, *f*, *k* and *i* are peripherally spaced on a rear face of the generally cylindrical distributor body 22 which carries the handle 33 and is formed with a multiplicity of internal channels leading to and from these ports. Thus, port *a* opens into a pair of valve chambers *a'*, *a''* which are interconnected by an orifice *r* and communicate by way of restricted passages *u* and *v* with other valve chambers *u'* and *v'* respectively aligned therewith and interconnected by an orifice *s*. Passage *u* is traversed, with considerable clearance, by a pin 29 whose ends are secured to a pair of spherical valve heads 23 and 25 in chambers *a'* and *u'*, respectively; the ends of passage *u* opening into these chambers form respective valve seats adapted to be alternately blocked by the heads 23 and 25 whose spacing, as determined by the length of pin 29, is greater than the length of the passage. In an analogous manner, two spherical valve heads 24 and 26 in chambers *a''* and *v'* are interconnected by a spacing pin 30 traversing the passage *v* with substantial clearance. Two springs 27 and 28 in chambers *a'* and *a''* bear upon the heads 23 and 24 to urge them into contact with their respective valve seats. The other two heads 25 and 26 confront a pair of plungers with rods 31, 32 and heads 31', 32', the plunger heads 31' and 32' forming annular shoulders which separate the chambers *u'* and *v'* from chambers *u''* and *v''* interconnected by an orifice *t*. The free ends of plunger rods 31 and 32, remote from the two valve pairs 23, 25 and 24, 26, bear upon respective crank portions 33' and 33'' constituting diametrically offset extensions of handle 33. In the position of this handle illustrated in FIGS. 4 and 6, which is the same as that shown in FIG. 2, eccentric 33' thrusts the plunger 31 to the left against the force of spring 27 so that head 23 is lifted off its valve seat whereas head 25 blocks the passage *u;* at the same time, spring 28 is free to press head 24 against its valve seat to block the passage *v* whose other end is unblocked by the head 26. In the alternate handle position (FIGS. 5 and 7), the relative position of the two pairs of valve heads is reversed.

Axially extending passage *u* opens into a transverse channel *b* which, as best seen in FIG. 9, leads into port *c;* the orifice *s* interconnecting chambers *u'* and *v'* is open toward channel *h* which in turn empties into outlet *i* as best seen in FIG. 10. Thus, port *c* communicates via channel *b* in the working position (FIGS. 4 and 6) with inlet *a* and in the release position (FIGS. 5 and 7) with outlet *i*. Similarly, axially extending passage *v* opens into a transverse channel *j* (best seen in FIG. 9) leading to port *k* which therefore receives fluid from inlet *a* in the release position and discharges into outlet *i* in the working position. At the junction between port *k* and its extension *k'*, FIG. 7, threshold valve 40 is located; this valve comprises a ball loaded by the spring 41 whose pressure is adjustable by a screw 44. Channel *k'* is connected through a transverse conduit *m* with chamber *v'*, as best seen in FIG. 10, and thus also communicates via orifice *s* and channel *h* with outlet *i*. Thus, excess pressure in port *k* is relieved by the yielding of valve 40.

Channel *e*, extending axially within body 22 in transversely offset relationship with port *f* with which it is connected by a conduit *f'*, has an extension *e'* which opens into the orifice *r* between *a'* and *a''* (see FIG. 8); the junction between channels *e* and *e'* is normally blocked by the valve 35 which also is shown as a spherical head under pressure from its spring 36 which can be adjusted by a screw 37. As seen in FIG. 10, channel *e* also has a transverse connection *e''* leading to the space *s*, *h*, this connection being normally obstructed by the valve 38 whose loading spring 39 can be adjusted by a screw 39'. Thus, valve 38 normally blocks the connection between channels *e* and *h* as diagrammatically indicated in FIG. 1.

As seen in FIG. 9, passage *u* is connected with channel *e* by conduit *q* forming a seat for the weakly spring-loaded check valve 42.

The physical arrangement shown in FIGS. 3 – 11 differs from the schematic hydraulic circuit of FIG. 1 in that threshold valve 35 is always subjected to the full fluid pressure prevailing in inlet chambers *a'* and *a''*, regardless of the position of valves 23 – 26. It is to be understood, however, that supply line *a* has an elevated flow resistance (a throttle valve could be inserted therein if necessary) so that a considerable pressure drop exists between pump 45 and chambers *a'*, *a''* as long as oil streams to either port *c* or port *k*. In the release position, the pressure in line *k* opens the valve 40 before reaching the threshold of valve 35 so that the latter remains ineffectual as though it were in fact cut off from the supply.

A further channel *w* extends axially through body 22 and communicates via transverse ducts *n* and *o* with chambers *a'*, *a''* and with chambers *u''*, *v''*, respectively, thereby reducing or eliminating the pressure differential across valves 23 – 26 and plunger heads 31', 32''; owing to the presence of this equalizing channel *w*, therefor, the operator reversing the handle 33 need only overcome the pressure of springs 27, 28.

Naturally, the handle 33 could also be replaced by the shaft of a servomotor actuated by remote control or automatically to carry out a succession of reversals; it will also be apparent that the handle 33 need not be swung back and forth but could be rotated unidirectionally to switch the distributor between its two alternate positions.

We claim:

1. A device for stressing an elongate tension element projecting from a structure, comprising:

a fluid-actuatable jack including a cylinder and a pair of pistons within said cylinder coaxially disposed at opposite extremities thereof, said pistons being provided with aligned axial bores for receiving a tension element to be stressed;

first clamp means at one of said extremities on a projecting end of one of said pistons engageable with said element for stressing same upon an outward movement of said one of said pistons from a retracted position to an extended position;

second clamp means at the other of said extremities juxtaposed with the other of said pistons for locking engagement with said element upon a stressing of said element by said one of said pistons and upon outward displacement of said other of said pistons with said other of said extremities bearing on a structure to which said element is anchored;

a source of high-pressure fluid for said jack;

and a distributor for said fluid disposed between said source and said jack for successively applying fluid pressure to said pistons in an outward direction in a first distributor position to stress and to lock said element and for inwardly retracting said pistons in a second distributor position, said distributor including a pressure-responsive threshold valve biased to actuate said other of said pistons in said first distributor position upon a rise in back pressure of fluid from said jack to a predetermined level following outward movement of said one of said pistons.

2. A device as defined in claim 1 wherein said cylinder forms a first compartment for exerting outward fluid pressure upon said one of said pistons, a second compartment for exerting inward fluid pressure upon said one of said pistons, and a third compartment for exerting outward fluid pressure upon said other of said pistons, the latter being spring-biased in an inward direction, said distributor being provided with a first, a second and a third port respectively communicating with said first, second and third compartments, said distributor further having an inlet port connected with said source and communicating with said first port in said first distributor position and with said second port in said second distributor position, said distributor also having a discharge port communicating with said second port in said first distributor position and with said first port in said second distributor position, said threshold valve being interposed between said inlet port and said third port for establishing communication therebetween.

3. A device as defined in claim 2, further comprising a check valve disposed between said first and third ports for enabling the discharge of fluid from said third compartment in said second distributor position.

4. A device as defined in claim 3, further comprising a second and a third threshold valve leading from said second and third ports, respectively, to said discharge port.

5. A device as defined in claim 4 wherein said distributor comprises a channeled body provided with said ports and accommodating all said valves in the channels thereof, two pairs of ganged blocking valves in said channels, and actuating means common to said blocking valves for alternately opening and closing one valve of each pair.

6. A device as defined in claim 5 wherein two of said channels form constricted passages each terminating in a pair of valve seats, each pair of blocking valves comprising two interconnected heads confronting the valve seats of a respective passage, the spacing of said heads being greater than the length of the respective passage whereby only one head can engage its valve seat at any time.

7. A device as defined in claim 6 wherein said actuating means comprises spring means urging one head of each pair of blocking valves against its valve seat, a pair of rods in respective extensions of said two of said channels respectively juxtaposed with the other head of each pair, and cam means for alternately advancing said rods to move said other head of either pair onto its valve seat against the force of said spring means.

8. A device as defined in claim 7 wherein said cam means comprises a shaft journaled in said body for rotation through at least 180° and provided with a pair of diametrically opposite crank portions respectively bearing upon said rods.

9. A device as defined in claim 7 wherein said rods are provided with plunger heads in said extensions, said body being provided with an equalizing duct extending from said inlet port to sections of said extensions behind said plunger heads.

10. A device as defined in claim 1 wherein said jack comprises a tubular stem rigid with said cylinder extending coaxially through said one of said pistons for engagement with said first clamp means to release same from said element in said retracted position.

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