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(54) **Hydraulic jack and method for making the same.**

(57) A hydraulic jack (10) comprises an elongated seamless body (11) composed of an impervious, flexible material inflatable with a pressurized hydraulic fluid, preferably water, from a flattened condition to an expanded condition. A first closure (12) includes elongated elastomeric seals (16) for sealing a first end of the body into a flattened form generally conforming to the composite thickness of the body and exhibiting high burst strength and sealing capabilities. A second closure (20), having at least one hydraulic fitting secured thereon, seals the second end of the body. The first closure (12) is formed by punching a plurality of arcuately disposed holes (42) through the body (11), anchoring and stretching the body (11) to dispose the holes in linear relationship, and then clamping and sealing the open, first end of the body with a pair of clamping plates (13).

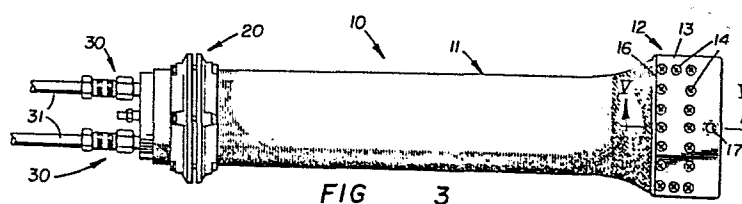


FIG 3

HYDRAULIC JACK AND METHOD FOR MAKING THE SAMETechnical Field

This invention generally relates to a hydraulic jack for moving weighty objects and more particularly to a hydraulic jack having a tubular body expandable from a flattened condition to an expanded condition in response to filling thereof with hydraulic fluid, preferably water.

Background Art

Applicant has over thirty years of experience, working as an ironworker, relating to all phases of high and heavy rigging. During such work experience, applicant has encountered many unusual emergency situations, such as fire, floods, explosions, falling material, equipment failure, and earthquakes, wherein the need for a highly portable and efficient lifting jack was needed. For example, many such emergencies resulted in the entrapment of persons under heavy objects which required expeditious and precise removal to save such persons. In addition, during applicant's work experience he encountered many problems relating to the lifting or moving of heavy objects, such as heavy machinery, buildings, bridges, airplanes, and etc.

Although there are a number of commercially available lifting jacks, they each normally require a substantial clearance, beneath the object to be moved, to accommodate the retracted jack thereunder. In addition, many such jacks do not exhibit sufficient structural integrity and lifting capacities to move immense loads efficiently and safely.

An example of the failing of the prior art to move immense loads is the absence of a jack system for saving the Leaning Tower of Pisa from

inevitable destruction. The Tower now leans approximately 16 feet from vertical at an approximate angle of 4° 35 min. with the North side of its base being approximately 3 feet higher than the diametrically opposite South side thereof. The versatility and adaptability of applicant's hydraulic jack will provide a jack system for solving this critical problem.

As suggested above, many prior art jacks that have the capability of moving very heavy loads are unduly complex and generally require special hydraulic controls and associated hardware, such as complex pumps, hoses, and valves, since they are designed to operate under pressures in the ranges of 10,000 psi. Furthermore, such prior art jacks are bulky and are incapable of being stored and transported to a job site in a compact manner. The above type of prior art jacks are exemplified by U.S. Patent Nos. 2,200,661; 2,380,152; 3,026,541; 3,521,861; 3,744,756; and 4,087,895.

Although many of the above-discussed prior art problems are solved by the type of inflatable hydraulic jack disclosed in applicant's prior publication PCT/US 78/00029, such jack exhibits other deficiencies. For example, the jack's burst strength is limited, particularly when the jack is crimped, and the clamped end thereof is prone to leakage. Other types of inflatable jacks, also exhibiting various deficiencies, are disclosed in U.S. Patent Nos. 2,976,888; 3,084,961; 3,121,577; 3,924,843; and 4,178,015.

Disclosure of Invention

An object of this invention is to provide a noncomplex and economical hydraulic jack which will exhibit a high degree of structural integrity, lifting capacity, and versatility and a method for making the jack. The hydraulic jack can be stored and transported in coiled form and uncoiled at a job site for insertion into very small clearances (less than one inch) under an object to be moved. The inflation of the jack, normally by water under a line pressure of less than 250 psi, can be closely controlled to lift, lower, or otherwise move the object in small increments, such as thousandths of an

inch. The jack can be powered by the engine-driven pump of a fire truck or the like, a hand pump, or a common garden hose.

The hydraulic jack comprises an elongated and seamless tubular body composed of an impervious, flexible material expandable from a flattened condition to an expanded condition in response to filling of the body with hydraulic fluid. A first closure means seals the first end of the body into flattened form, coextensive with and generally conforming to the composite thickness of the body when the body is in its flattened condition. A second closure means seals the second end of the body and at least one hydraulic fitting means is secured on the second closure means for attachment to a source of pressurized hydraulic fluid to selectively communicate the fluid interiorly of the body to expand it from its flattened condition to its expanded condition.

In one aspect of this invention, the first closure means comprises a pair of clamping plates having the first end of the body clamped therebetween, an elongated elastomeric sealing member positioned between each clamping plate and the body the having a lip extending over an inboard edge of the clamping plate, and fastening means for drawing the clamping plates together to precompress the sealing members under a predetermined pressure.

In another aspect of this invention, a method for making the first closure means includes the steps of forming a plurality of arcuately disposed holes through the body, anchoring and stretching the body to align the holes linearly, and clamping the open end of the body to form a sealed first closure means.

Brief Description of the Drawings

Other objects and advantages of this invention will become apparent from the following description and accompanying drawings wherein:

Figure 1 is an elevational view showing the application of the hydraulic jack of this invention to the Leaning Tower of Pisa in Italy to support, move, and properly position the same;

Figure 2 shows the hydraulic jack in its coiled form for transport and/or storage purposes;

Figure 3 is a top plan view of the hydraulic jack, shown in its uncoiled, flattened condition and readied for use;

Figure 4 is a side elevational view of the flattened hydraulic jack, taken in the direction of arrows IV-IV in Figure 3, and further showing the jack in an expanded condition by phantom lines;

Figure 5 is an enlarged sectional view through a first end of the hydraulic jack, illustrating a closure for clamping and sealing a first end of a tubular body of the hydraulic jack;

Figure 6 is an exploded view of component parts forming the closure;

Figure 7 is an enlarged sectional view through a wall of the tubular body of the jack to show the composite makeup thereof, taken in the direction of arrows VII-VII in Figure 5;

Figure 8 is an enlarged sectional view through a compression coupling for sealing a second end of the tubular body of the jack and hydraulic fittings secured on the coupling;

Figure 9 is an end elevational view showing a plurality of hydraulic jacks interconnected for simultaneous operation;

Figure 10 and 11 schematically illustrate lifting capacities of two different sized hydraulic jacks;

Figure 12 is an isometric view, illustrating a second hydraulic jack embodiment;

Figure 13 is an exploded isometric view of component parts of the jack;

Figure 14 is a longitudinal sectional view through the jack;

Figure 15 is a top plan view of an end closure of the jack, taken in the direction of arrows XV-XV in Figure 14;

Figure 16 is an enlarged sectional view of the end closure, taken in the direction of arrows XVI-XVI in Figure 15; and

Figures 17-21 illustrate method steps for making the end closure.

Best Mode of Carrying Out the Invention

Figure 1 illustrates a plurality of hydraulic jacks 10 inserted beneath the lowered side of the Leaning Tower of Pisa in Italy, to move it towards an upright position to substantially prolong its useful life. As discussed more fully hereinafter, each hydraulic jack is capable of lifting at least twenty-five (25) tons, whereby a plurality of such jacks operated simultaneously (see Figure 10) will provide infinite lifting and/or lowering capabilities. Thus, by employing a system, preferably computer-controlled, utilizing the hydraulic jack concept of this invention, the high side of the base of the Tower can be readily lowered approximately four and one-half ($4\frac{1}{2}$) inches and stabilized to restore the Tower to its 15th Century position.

To date, the heaviest lifting operation in engineering history was that of the 41,000-ton roof of the Velodrome in Montreal, Canada, in 1975. The roof was raised by sophisticated jacking apparatus, associated with high pressure hydraulic control systems, some four (4) inches to strike its centering. Applicant's relatively non-complex jacking system is readily adapted to perform lifting operations of this type at substantially less cost than conventional methods, more efficiently and expeditiously, and with a high safety factor.

The jack, of course, has many other applications wherein a closely controlled lifting, lowering, or other type of moving force is required in confined quarters. For example, the jack could be utilized to lift heavy machinery, land vehicles, or airplanes for repair or positioning purposes, free a driver subsequent to a vehicle crash wherein the steering wheel column or door has pinned him therein, and many other applications which should become obvious to those skilled in the arts relating hereto.

Referring to Figure 2, hydraulic jack 10 is adapted to be rolled-up into coiled form for storage and/or transport purposes. When the hydraulic jack is uncoiled, as shown in Figure 4, it exhibits a very narrow profile to

adapt it for insertion into a small clearance (e.g., less than one inch), under an object to be moved. As explained more fully hereinafter, the hydraulic jack is adapted to be expanded to its phantom-lined cylindrical condition from its flattened condition, as illustrated in Figure 4, in response to filling thereof with pressurized hydraulic fluid, preferably water which is readily available. For example, pressurized water could be supplied to the jack by an engine-drive pump of a fire truck or the like, a hand pump, or a common garden hose. It should be understood that the hydraulic jack is normally used in conjunction with shims, pressure plates, or other types of bearing members and will generally conform to the shape thereof to provide the desired effective surface area for lifting purposes, as illustrated in Figures 10 and 11.

Referring to Figures 3 and 4, hydraulic jack 10 comprises an elongated, woven, and seamless tubular body 11 having a composite wall thickness approximating 0.15 in. and composed of an impervious, flexible material. The body material is woven into a tube 11a (Figure 6) and coated and at least partially impregnated with a bonding and sealing agent, such as a cured plastic resin or an elastomer (e.g., nitrile rubber), to be expandable from its flattened condition to its expanded, cylindrical condition, when in free-form. The woven fabric material (e.g., a standard cross-weave with the warp ends oriented at right angles to the filling strands) composing tube 11a may comprise a standard woven firehose material, such as 1.5 inch cotton which is rubber-lined internally and externally or unlined linen. Since the material must exhibit a very high burst pressure rating and impact strength, it is preferably composed of one of the relatively new family of polyester (Dacron) or aromatic polyamide fibers, which are now commercially available, impregnated or coated internally and externally with a cured plastic resin bonded thereto by a conventional molding process.

One such fiber is Kevlar 49 aramid manufactured by E.I. DuPont Denemours and Co. (Inc.) which exhibits a tensile strength in the range of 430,000 psi and a modulus of elasticity in the range of 19,000,000 psi.

Another suitable material is Kevlar 29 which has the same high tensile strength and a modulus in the range of 9,000,000 psi. Since the Kevlar material is organic in nature, it can be combined with most commercially available resins to provide a composite structure exhibiting the desired tensile strength, modulus of elasticity, toughness for yielding good textile processability, high impact strength, good thermal stability, and chemical resistance. An example of a six-inch diameter tubular woven fabric composed of Kevlar is a 1500 denier, 2 ply warp and filling yarn having a 2 x 2 basket weave.

It is contemplated that the use of Kevlar for forming body 11 will desirably exhibit substantially less body stretch than polyester-based bodies and will substantially increase the burst strength of the jack. The reduction in stretch and increase in burst strength will provide very precise and controlled inflation of the jack at working pressures up to 1,500 psi, for example, without sacrificing workman safety.

All of the processes used for combining thermoplastic or thermosetting resins with glass fibers are adaptable to Kevlar 49 with little or no modification. For example, the thermosetting resins may be phenolics, polyesters, epoxies, polyurethanes, or any suitable mixture thereof. The thermoplastic resins may comprise polyethylene, nylon, polypropylene, rubber, or any suitable mixture thereof. The polyesters are normally utilized since they are readily available, relatively inexpensive, and are suitable for many composite structure applications. As shown in Figure 8, the cured plastic resin preferably forms an outer elastomeric coating 11b and an inner elastomeric liner 11c. Since the above types of plastic resins are well known to those skilled in the art, as well as the molding processes employing the same, further discussion thereof will not be made for sake of brevity. The chosen resin should exhibit most of the above-enumerated desirable properties, also including a high burst and crimp strengths, flexibility, and elastic memory to enable the jack to expand and contract readily without plastic deformation.

Referring to Figures 3-5, a first closure means 12 functions to seal a first end of body 11 into flattened form, coextensive with the body, as shown. Closure means 12 may comprise a pair of superimposed steel clamping plates 13 for clamping the tubular, open first end of body 11 therebetween. Plates 13 may be drawn and clamped together by fastening means 14, such as screws, bolts, or other suitable fasteners. Exposed rounded elastomeric edges 15 are preferably formed on the inboard edge of each plate 13, abutting body 11, to prevent any abrasion of the woven material composing the body, as shown in Figure 5, and to substantially increase the jack's burst strength and sealing capabilities thereat.

If so desired, a thin elastomeric rubber or plastic seal 16, formed as an elastomeric coating or separate elongated member (e.g., nitrile rubber or the rubber-like urethane Flexane 94, manufactured by Devcon Corp.), may be bonded or separately mounted on the inboard end of each plate. The seal is positioned between each plate and body 11 and has a lip extending over the inboard edge of the plate. When the plates are clamped together, the seals will be precompressed under a predetermined pressure.

A pair of aligned holes 17 may be formed through the plates to adapt the jack for attachment to a rod or cable to facilitate proper positioning of the jack in confined spaces. In addition, an annular bushing 18 may be clamped or otherwise suitably secured between the plates, in alignment with the holes. The bushing facilitates insertion of a cable or positioning tool through the holes and also provides a stop means between the plates, aiding them in precisely applying the desired clamping pressure to this end of body 11.

Figure 7 illustrates the addition of a woven sock 19 to the composite makeup of first closure means 12 to increase the structural integrity and sealing capabilities thereof. The sock may be composed of the same material composing body 11, such as polyester (Dacron) or Kevlar threads, and preferably forms a twill-weave fabric encapsulating the first end of the body, i.e., with the warp ends disposed approximately 45° relative to the filling

strands. This disposition aids in increasing the burst strength at this end of the jack since both the warp and filling strands will be placed in tension.

Sock 19 may be suitably impregnated with the same resin or elastomer impregnating body 11 to form a structurally integrated and fluid-tight composite structure of the type shown in Figure 7. The sock is preferably woven into the body to form an integral part thereof, rather than formed as a separate component as suggested by Figure 6. In fact, by weaving the body and sock end simultaneously and as an integrated, unitary composite structure, the clamping plates can be eliminated in many jack applications.

Body 11, as well as sock 19, preferably forms a composite structure comprising outer plastic (e.g., nitrile rubber) coating 11b which will exhibit a high degree of toughness to avoid potential abrasion and puncture problems and inner plastic (e.g., nitrile rubber) lining 11c which primarily functions to ensure a fluid tight seal. The composite makeup of body 11 and each end thereof, sealed by closure means 12 and 20, will exhibit an internal burst strength of at least 600 psi, and preferably much higher, depending on the particular composite makeup and application of jack 10.

Referring to Figures 4 and 8, a second open end of body 11 is closed and sealed by second closure means 20. The second closure means preferably comprises a cup-shaped head member 21 having an annular end wall 22 and a cylindrical outer wall 23 extending within the second end of body 11. A ring means, comprising a pair of outer rings 24, circumvents and clamps the second end of body 11 onto outer wall 23 of head member 21 to form an annular, static seal thereat.

In particular and referring to Figure 9, outer wall 23 of the head member has an annular ridge 25 formed circumferentially therearound to define a pair of axially spaced camming surfaces 26. Rings 24 have like-shaped annular camming surfaces 27 formed internally thereon to clamp body 11 against cam surfaces 26. A compression coupling is thus formed by second closure means 20 to effect a highly efficient static seal at this end of

hydraulic jack 10, the burst strength of which is compatible with that of body 11 and closure means 12.

Figure 8 further illustrates a pair of standard quick-disconnect couplings 30 for selectively connecting a pair of hoses or lines 31, such as a standard garden hose, to hydraulic jack 10. Each coupling includes a threaded fitting 32 secured on end wall 22 of head member 21 and a fitting 33 secured on the end of a respective hose 31. Coupling 30 is of standard design and may include a standard spring-biased or pressure responsive check valve in each fitting 32 and 33 thereof, which automatically closes upon disconnection of the fittings from each other. Standard quick-disconnect fluid couplings of this type are readily available from such well-known companies as Parker-Hannifin Corp. (Hoze-Lok type 40), Snaptite Corp., etc. In addition, a standard bleed valve 34 is preferably threadably secured on end wall 22 to selectively vent air from the working chamber of the hydraulic jack when the chamber is filled with hydraulic fluid.

In operation, hydraulic hose 10 may be stored and transported to a work site in its coiled condition illustrated in Figure 2 and quickly uncoiled and inserted, under an object to be lifted, lowered, or otherwise moved, in its flattened condition, illustrated in Figure 4. In actual practice, the overall thickness of the hydraulic jack, excepting the second end thereof which is closed and sealed by second closure means 20, exhibits an overall thickness of less than one inch. Thus, the operative portion of the hydraulic jack may be inserted into very small clearances in contrast to conventional hydraulic jacks which have enlarged fittings on each end which function on the vertically actuated piston-principle or are of the inflatable type exhibiting a substantial thickness, and thus require a substantially greater vertical height or clearance for work purposes.

As mentioned above, holes 16 (Figures 3 and 5) facilitate attachment of a cable, rigid rod, or the like thereto for the purpose of pulling or pushing the hydraulic jack into its proper position under the work object. Once the hydraulic jack has been properly positioned, one of the hoses 31

may be connected to the hydraulic jack by coupling 30 and further connected to a pressurized hydraulic fluid source, such as a standard water tap which dispenses water at an approximate water pressure of from 45 psi to 100 psi, although an operating pressure exceeding 250 psi is preferred for many applications. Alternatively, the pressurized fluid source may comprise an engine-driven or hand-operated pump for dispensing pressurized fluid from a mobile tank, such as the type employed on fire trucks and the like, or from a bucket or other convenient water source, such as a river. If so desired, a standard pressure gauge may be attached to hose 31 to permit visual observation of the hydraulic fluid pressure therein.

In addition, a flow control valve can be connected to pressurized hose 31 to closely control the volume of hydraulic fluid communicated within the hydraulic jack and, thus, the rate of expansion thereof. Alternatively, the valve, or a second valve, could be connected to the second line, constituting a drain line, to precisely control the volume of hydraulic fluid in the jack. In this manner, the rate of vertical lift or contraction may be closely controlled in sequential stages, such as stages in the thousandths of an inch. Such close control would be advantageous in many applications, such as the alignment of a drive shaft on a large seagoing vessel. It should be further understood that the employment of a hydraulic fluid, such as water, as the working fluid for expanding the hydraulic jack during operation thereof, avoids the potential explosion problem normally encountered with the use of gases, such as air. During initial filling of the hydraulic jack with water, bleed valve 34 would normally be opened to exhaust any air that may be entrapped therein in generally the same manner as one would bleed the brake lines of an automobile.

Although the material composing body 11 of hydraulic jack 10 is sufficiently tough to engage any irregular surface without causing a potential puncture therein, it may prove desirable in many applications to utilize jack aids, such as pressure plates positioned under and/or over body 11 to facilitate sequential lifting of an object in stages. For example, after an object

has been lifted five (5) inches, a support block having a vertical height of four inches could be inserted under the object, and a second deflated hydraulic jack 10 (Figure 4) could be inserted between the object and the block. Upon partial filling of the second hydraulic jack with hydraulic fluid to support the object, the first hydraulic jack could be deflated and removed, whereafter the second hydraulic jack could be expanded to further lift the object. This procedure could be continued with one or more jacks working simultaneously to lift the object to any desired height.

As shown in Figure 9, a plurality of hydraulic jacks 10 can be operated simultaneously with equalized hydraulic fluid pressure being communicated therein via interconnecting hoses 31'. The second fitting 32 secured on each end of each hydraulic jack thus facilitates such interconnection. The two fittings will also obviously provide flexibility in the communication of hydraulic fluid to the jacks, and venting thereof. For example, both fittings could be utilized to communicate hydraulic fluid to the jack to double its rate of expansion, or only one hose may be connected to the pressurized fluid source, whereas the other hose could be connected to a drain, closely controlled by a flow control valve.

The jacking system of this invention is thus adapted for many uses wherein a plurality of the jacks could be connected together in series or in tandem and simultaneously operated by a single variable control valving arrangement. The operation could be computer-controlled to ensure the maximum efficiency and control. In turn, any or all of the jacks can be disconnected and controlled separately with quick disconnect couplings 30 (Figure 9), having the above-described check valves therein. If so desired, the water contained in the expanded hydraulic jack could be replaced by a hardenable cementitious material, such as a standard Portland cement, either individually or simultaneously, to provide an in-site foundation, i.e., the jacks would not be removed.

Figures 10 and 11 schematically illustrate the lifting capacities of two sizes of hydraulic jacks 10, each mounted on a pressure plate 34 which

may be used therewith to define a flat supporting surface therefor. In accordance with the well-known formula lifting force equals pressure times area ($F=PA$), and assuming an internal hydraulic fluid pressure of 100 psi in the hydraulic jack illustrated in Figure 10, expansion of the jack to a vertical height of two (2) inches would result in a lifting force of 5664 pounds or 2.8 tons. Similarly, the larger capacity hydraulic jack illustrated in Figure 11 would provide a lifting force of 16,000 pounds or 8 tons when expanded to a vertical height of two (2) inches. Expansion thereof to a vertical height of five (5) inches would provide a lifting force of 4,700 pounds or 2.35 tons.

It can thus be seen that the length and diameter of a particular hydraulic jack can be suitably designed for a wide variety of applications. For example, it can be seen that although the overall lifting capacity of the hydraulic jack of Figure 12 was reduced when expanded from a vertical height of two (2) inches to five (5) inches, a sufficient lifting force is provided to lift an axle of a motor vehicle. This could be accomplished by laying the hydraulic jack on level ground with a second pressure plate 34 disposed over body 11 of the jack when it is maintained in its flattened condition illustrated in Figure 4. One tire of the vehicle could then be driven to rest on the upper pressure plate, whereby the jack could be thereafter expanded to lift the tire and axle five (5) inches, for example.

Figures 12-16 illustrate a second hydraulic jack embodiment 10' wherein corresponding components and structures are identified by identical numerals, but with identical numerals depicting modified components and structures of the second hydraulic jack embodiment being accompanied by a prime symbol ('). Jack 10' includes a body 11', composed of one of the types of flexible materials described above, adapted to permit the jack to be rolled-up into coiled form, a first closure means 12' for sealing a first end of the body, and a second closure means 20'. The second closure means has been modified to include the pair of outer locking rings 24' mounted on a longitudinally slotted plastic ring 4 and adapted to form a compression coupling with a head member 21'. The head member is shown in the form of

an annular plug-like manifold. The compression coupling functions to clamp this end of body 11' thereat to effect a highly efficient static seal.

One of the novel aspects of this invention resides in modified first closure means 12'. A pair of superimposed steel clamping plates 13' are adapted to clamp the tubular, open-end of body 11' therebetween by means of screws 14 which are threaded into suitably tapped holes formed in the lower plate, as more clearly shown in Figure 16. An elongated elastomeric seal 16' is positioned between each clamping plate and body 11' and has a lip 40 (Figures 15 and 16) extending over an inboard edge of the clamping plate. When the fastening means or screws are turned to draw and clamp the plates together, the seals will be precompressed under a predetermined pressure. In practice, it has been found that the elastomeric (e.g., unreinforced or Nylon reinforced nitrile rubber having a Durometer hardness in the range of 90) seal will tend to extrude slightly (e.g., 0.25 in.) when the plates are clamped together. The inherent flexure and elastic memory of the seal will allow the body to form a near natural structural transition with its connection to the clamping plates.

Testing has shown that the addition of seals 16' to closure means 12' will substantially increase the burst strength thereof, even over the burst strength (e.g., 600 psi) of body 11' proper. In fact, it has been found that the burst strength of the closure means is not reduced, even though the body is crimped or kinked during testing (most manufacturers of tubular bodies or hoses will suggest that the kink pressure rating will approximate one-half of the normal burst strength).

An analogy to the functional desiderata of improved closure means 12' may be one of equating clamping plates 13' to a tree, the roots of the tree to elastomeric seals 16', and the earth in which the roots are anchored to body 11'. In particular, when body 11 flexes under various forms and pressures during a particular lifting operation, seals 16' will provide the transitional media (i.e., "roots") to the clamping plates to provide maximum strength to the integrated components of the closure means. Carrying the

analogy one step further, should a tree, absent its roots, be stuck into the ground, it would tend to snap-off at ground level when subjected to severe winds or other transverse loads imposed thereon.

Referring to Figure 16, a seal anchoring means 36 is formed on a grooved end 15' (Figure 13) of each clamping plate 13' to lock seal 16' thereon and to prevent it from completely extruding out from between the clamping plate and the body when the clamping plates are secured together and when the jack is pressurized. As shown, such anchoring means preferably comprises an elongated recess 37 formed entirely throughout the length of an underside of the clamping plate and an elongated notch 38 formed intermediate the sides of the recess and also throughout the entire length of the clamping plate.

Seal 16' includes a body portion 39 disposed in recess 37 and a lip 40 extending over a chamfered inboard edge of the clamping plate. A rib 41 is formed on the seal and is disposed in notch 38 to prevent longitudinal movement of the seal relative to the clamping plate. As further shown in Figure 16, the inner side of each body portion 39 is substantially flush with an underside of a respective clamping plate.

Figures 17-21 illustrate method steps for making end closure means 12'. Referring briefly to Figures 13 and 21, it should be noted that a plurality of laterally spaced bolt holes 42 are formed through the double-layered open end of body 11' in an arcuate array A and transversely relative to a longitudinal axis X of body 11'. Two outer bolt holes 42a are also formed through the body, but remain in their same location after the plates have been clamped in place. Ultimately, after clamping plates 13' have been secured on the body, bolt holes 42 will be aligned in a linear relationship L (Figure 21) relative to each other, as represented by linear bolt holes 43 formed through the clamping plates in Figure 13 and the disposition of the forward row of seven screws 14 in Figure 15.

As sequentially shown in Figures 17-21, bolt holes 42 and 42a are formed through body 11 by first placing a punch die 44 over the body

(Figure 17) and then driving a punch 46 through each guide hole 45 and 45a of the punch die (Figure 18), with the seven forwardmost guide holes conforming to the arcuate configuration A of the formed bolt holes 42. A female die 47 may be positioned beneath the body and has a similar array of holes (not shown) formed therein to receive punches 46. Seals 16' are then suitably mounted between the clamping plates and body (Figure 19) in the manner described above. In particular, each seal is mounted in a grooved end 15' (Figure 13) of each clamping plate, as more clearly shown in Figure 16.

As shown in Figure 19, the subassembly is then anchored by securing only the two outer screws 14' through accommodating bolt holes 43a (Figure 13), securing the clamping plates together. A suitable jig and fixture (not shown) may be utilized to align and anchor the subassembly in place. Thus, a portion of the body between bolt holes 43a of the clamping plates and aligned bolt holes 42a of the body is compressed, but not to an extent to prevent relative longitudinal sliding movement of the body between the plates. As shown in Figures 20 and 21, the body is then stretched longitudinally to at least approximately align bolt holes 42 in linear relationship L relative to each other and in alignment with bolt holes 43 of the clamping plates. The stretching step is preferably accomplished by inflating body 11' whereby the body will tend to form semi-spherical end portions tending to pull the body in the direction of arrow X in Figure 17. Inflation pressures in the range of 20 psi have been found satisfactory to effect the stretching and alignment function. Thereafter, clamping plates 13' are clamped over the body under a clamping pressure approximating thirty-five tons whereafter the remaining seven screws 14 are installed and all nine screws are tightened under predetermined torques to retain a predetermined clamping pressure.

In the absence of utilizing the above method steps, initiated by forming the seven intermediate bolt holes 42 through the body in an arcuate array, corresponding bolt holes which are originally formed in a linear manner

would tend to elongate longitudinally when the body is filled. Such elongation not only weakens the structural integrity of the body and integrated end closure, but also renders the end closure prone to leakage after continued use. Although U.S. Patent No. 3,121,577 generally recognizes these problems, the arcuate clamping plates disclosed therein fail to provide the efficient anti-leakage and structural integrity desiderata provided by applicant's invention.

It should be noted in Figure 15, for example, that the outer two screws 14 used for anchoring purposes are positioned substantially rearwardly of seals 16' and rearwardly of the seven forwardly disposed and aligned screws 14. This arrangement tends to relieve any adverse clamping pressures that may occur adjacent to the forward corners of the clamping plates, which are points on the jack prone to leakage.

CLAIMS:

1. A hydraulic jack comprising
an elongate and seamless tubular body having first and second ends and composed of an impervious, flexible material expandible from a flattened condition, to permit said body to be rolled-up into coil form, to an expanded condition in response to filling thereof with hydraulic fluid,

first closure means for sealing the first end of said body into flattened form coextensive with and generally conforming to the composite thickness of said body when said body is in its flattened condition, said first closure means comprising a pair of clamping plates having the first end of said body clamped therebetween, an elongated elastomeric seal positioned between each clamping plate and said body and having a lip extending over an inboard edge of said clamping plate, and fastening means for drawing said clamping plates together to precompress said seals under a predetermined pressure,

second closure means for sealing the second end of said body, and hydraulic fitting means secured on said second closure means for attachment to a source of pressurised hydraulic fluid to selectively communicate said hydraulic fluid interiorly of said body to expand it from its flattened condition to its expanded condition.

2. A hydraulic jack comprising an elongated and seamless tubular body having first and second ends and composed of an impervious, flexible and woven fabric at least partially impregnated with a bonding and sealing agent and expandible from a flattened condition, to permit said body to be rolled-up into coil form, to an expanded condition in response to filling thereof with hydraulic fluid, and first closure means for closing and sealing an end of said body into flattened form coextensible with and generally conforming to the

composite thickness of said body when said body is in its flattened condition, said closure means comprising a sock composed of a woven fabric material woven and structurally integrated into said body.

3. The hydraulic jack of claim 2, wherein said sock is woven as a unitary, composite structure with said body.

4. The hydraulic jack of claim 1, 2 or 3, wherein the internal burst strength of said body and each of said first and second closure means, in response to said hydraulic fluid pressure, is at least 600 psi.

5. The hydraulic jack of any one of claims 1 to 4, wherein the material composing said body comprises plastic fibers impregnated with an elastomeric inner liner within said body.

6. The hydraulic jack of any one claims 1 to 4, wherein the material composing said body comprises aromatic polyamide fibers at least partially impregnated with a cured plastic resin.

7. The hydraulic jack of claim 6, wherein said fibers constitute Kevlar having a tensile strength in the range of 430,000 psi and a modulus of elasticity of at least 9 million psi.

8. A method for making an end closure on a double-layered open end of a tubular flexible body of an inflatable hydraulic jack comprising the steps of

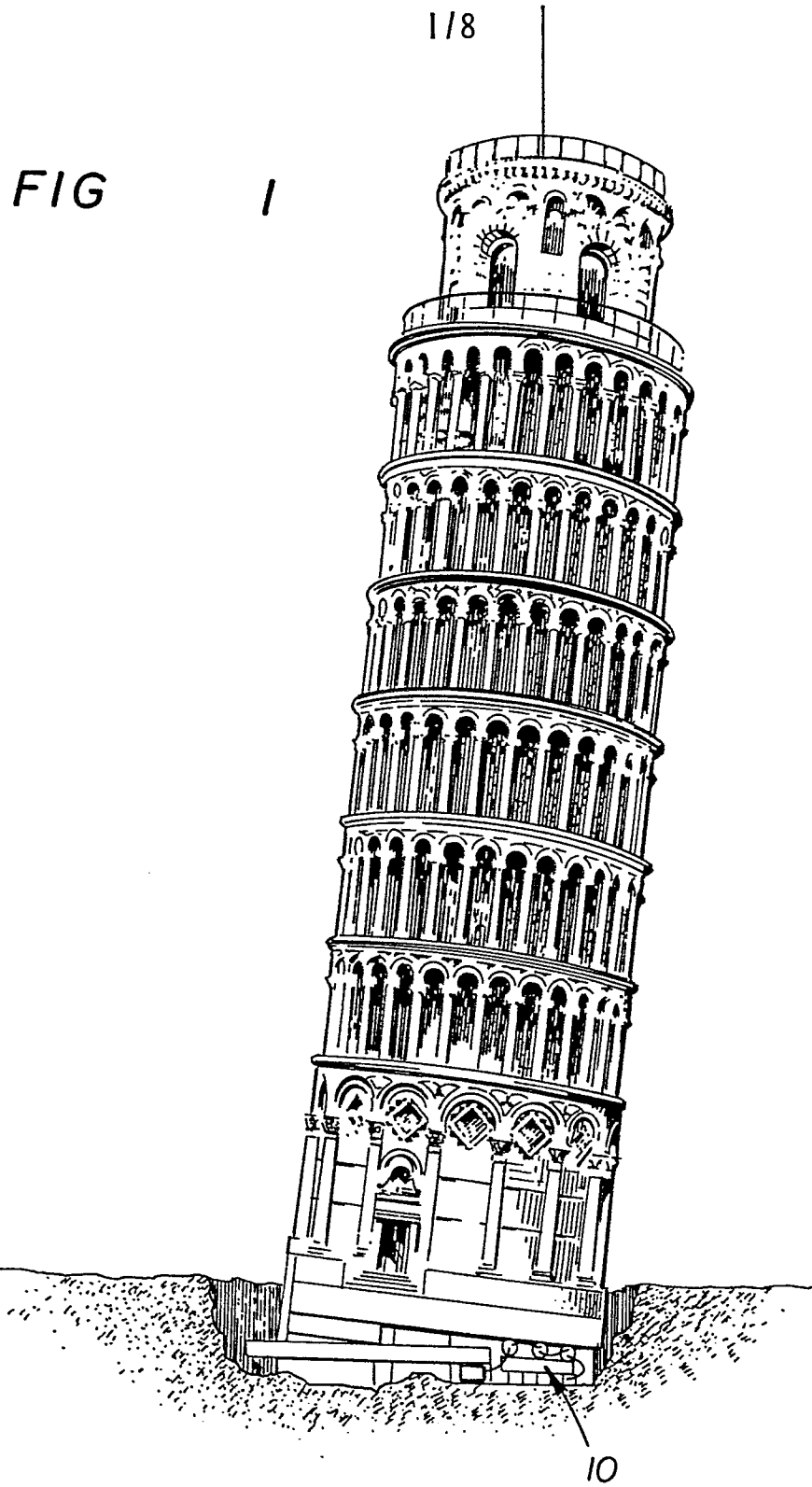
forming a plurality of spaced bolts holes through said open end in an arcuate array and transversely relative to a longitudinal axis of said body, anchoring said open end at either side of said bolt holes,

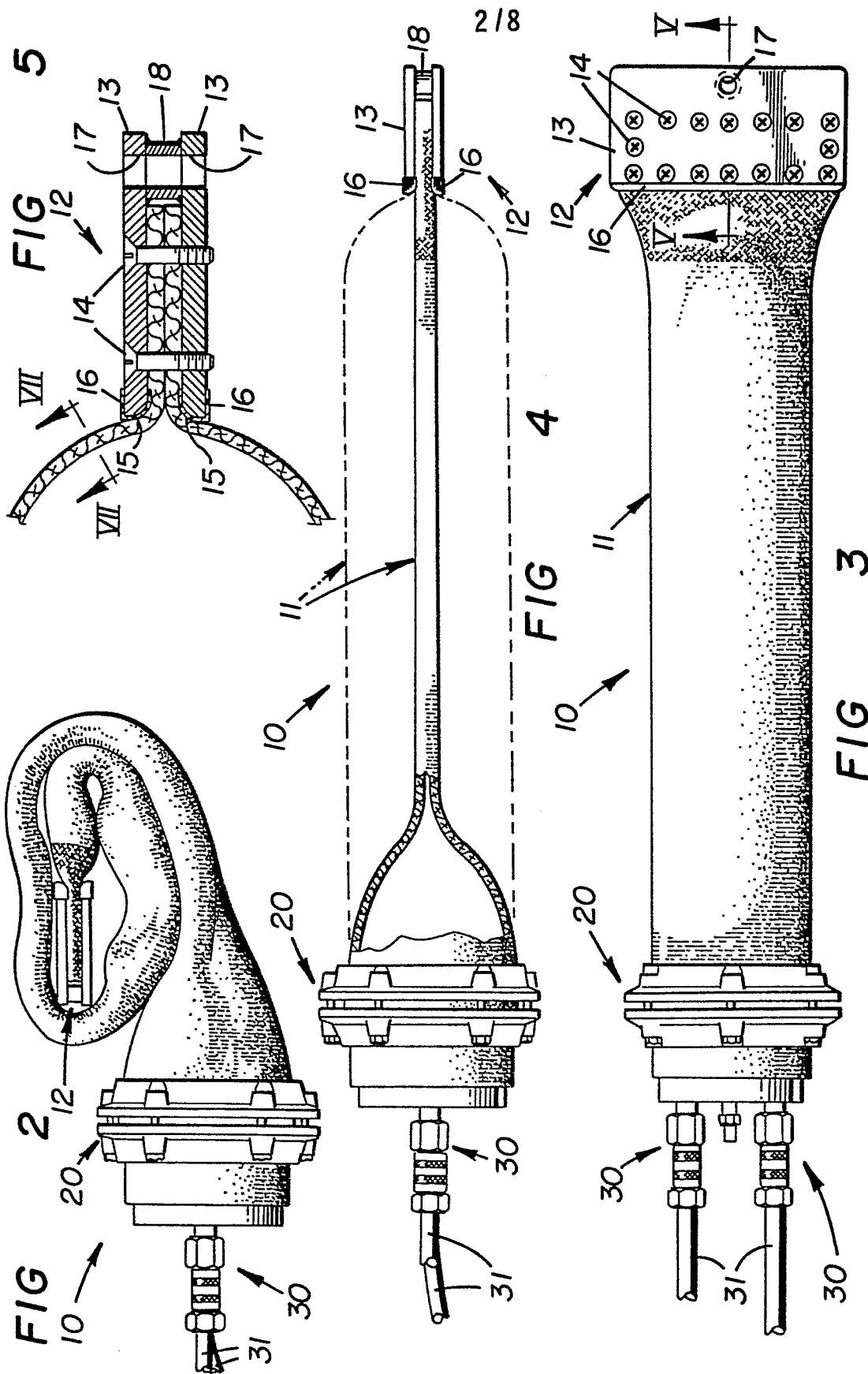
stretching said body to at least approximately align said bolt holes in linear relationship relative to each other, and

clamping said open end to form a sealed end closure thereat.

9. The method of claim 8, wherein said anchoring and clamping steps each comprise securing a pair of clamping plates over said open end.

10. The method of claim 8 or 9, wherein said stretching step comprises inflating said body with a pressurised fluid.





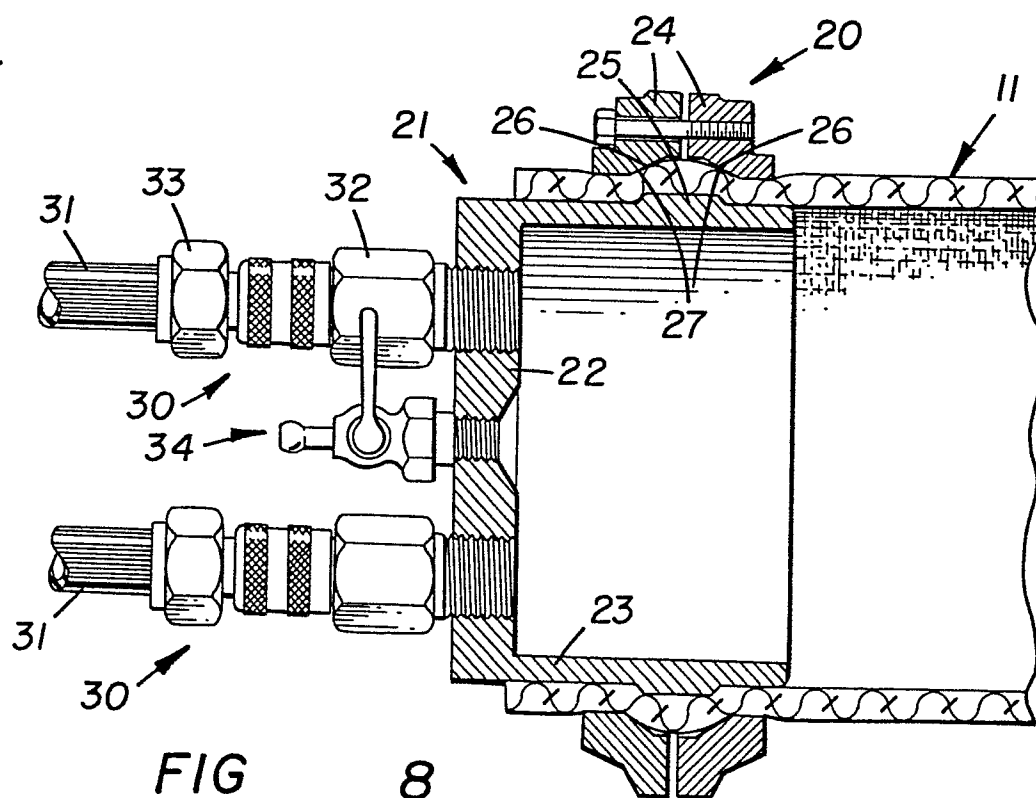
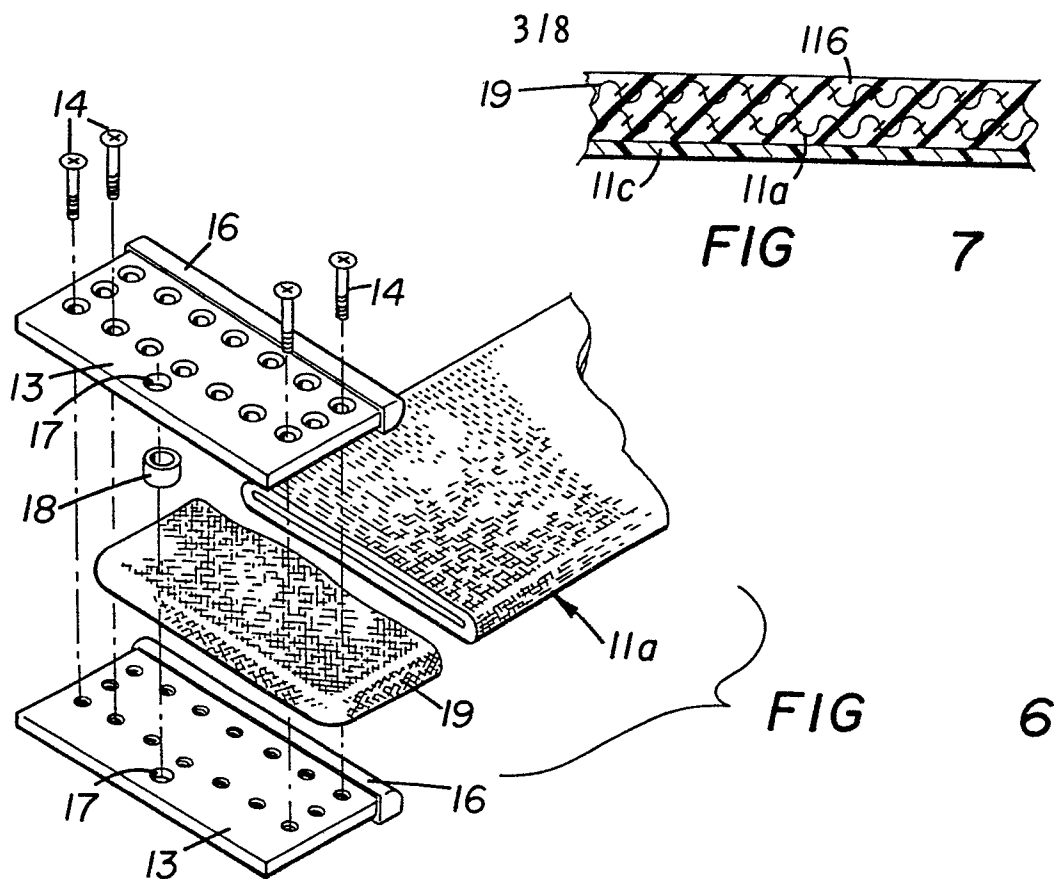
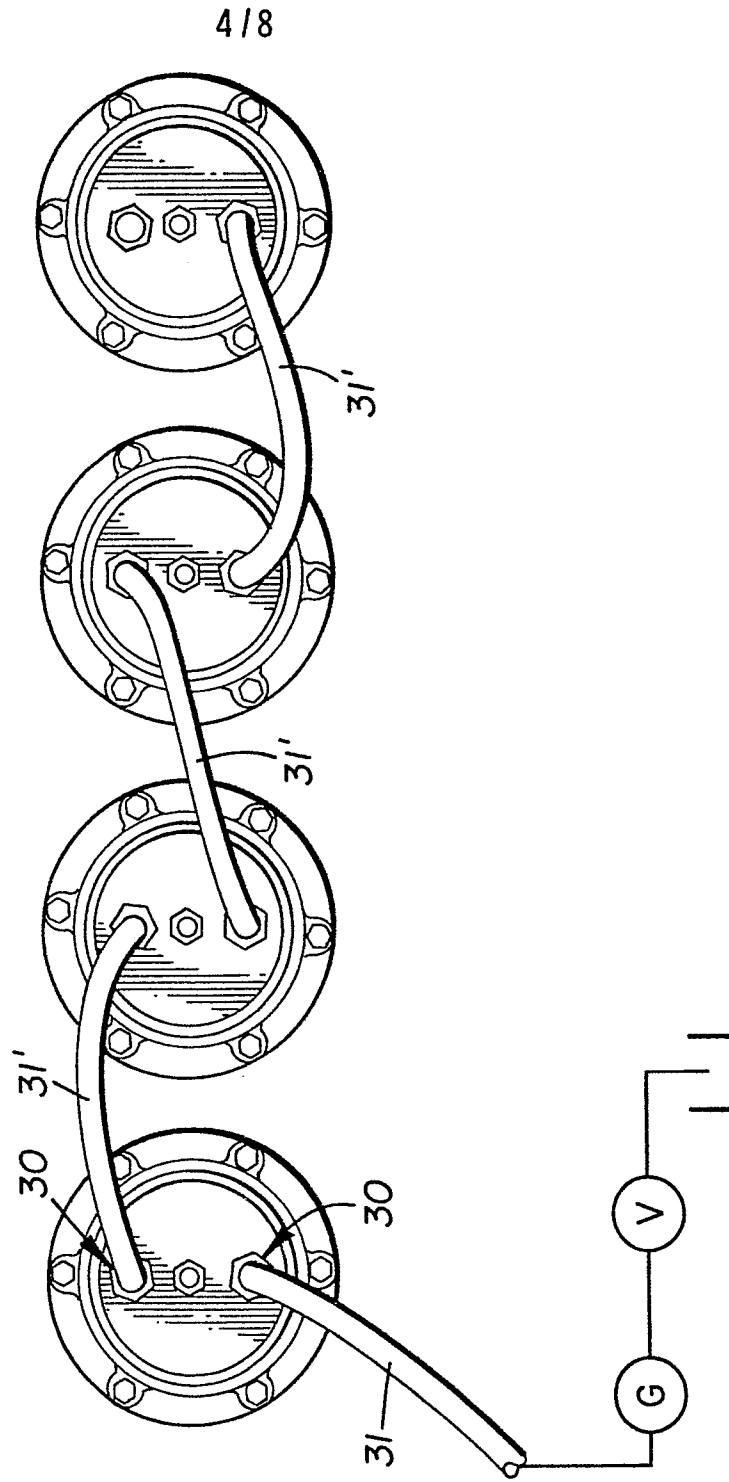
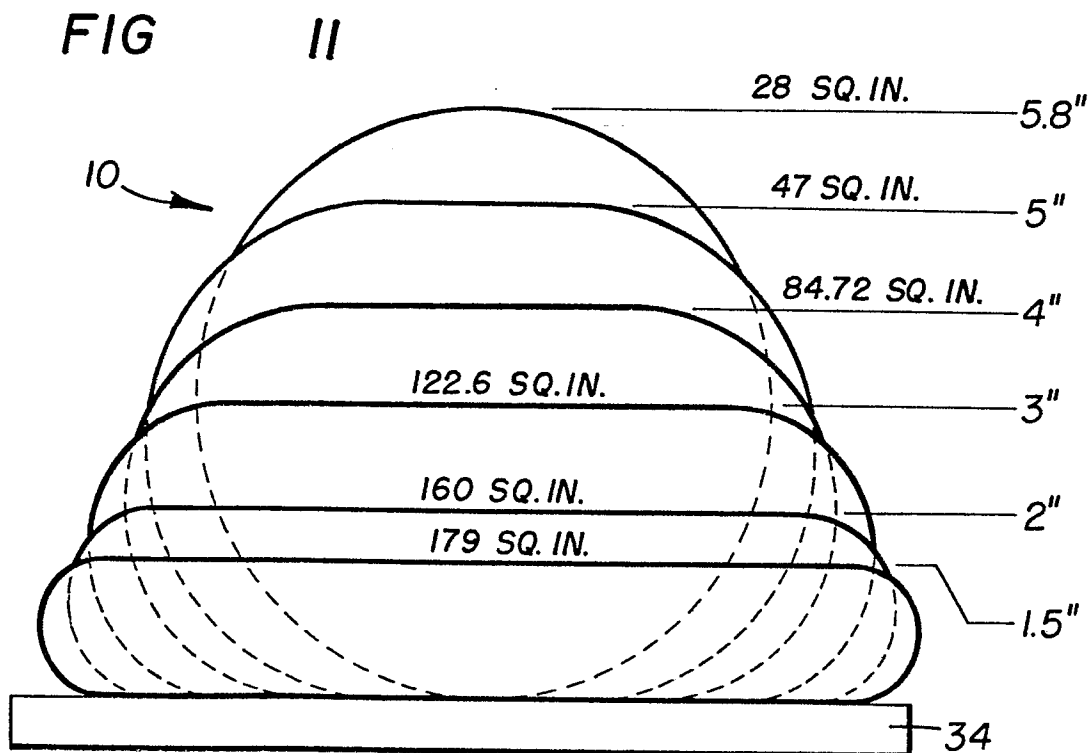
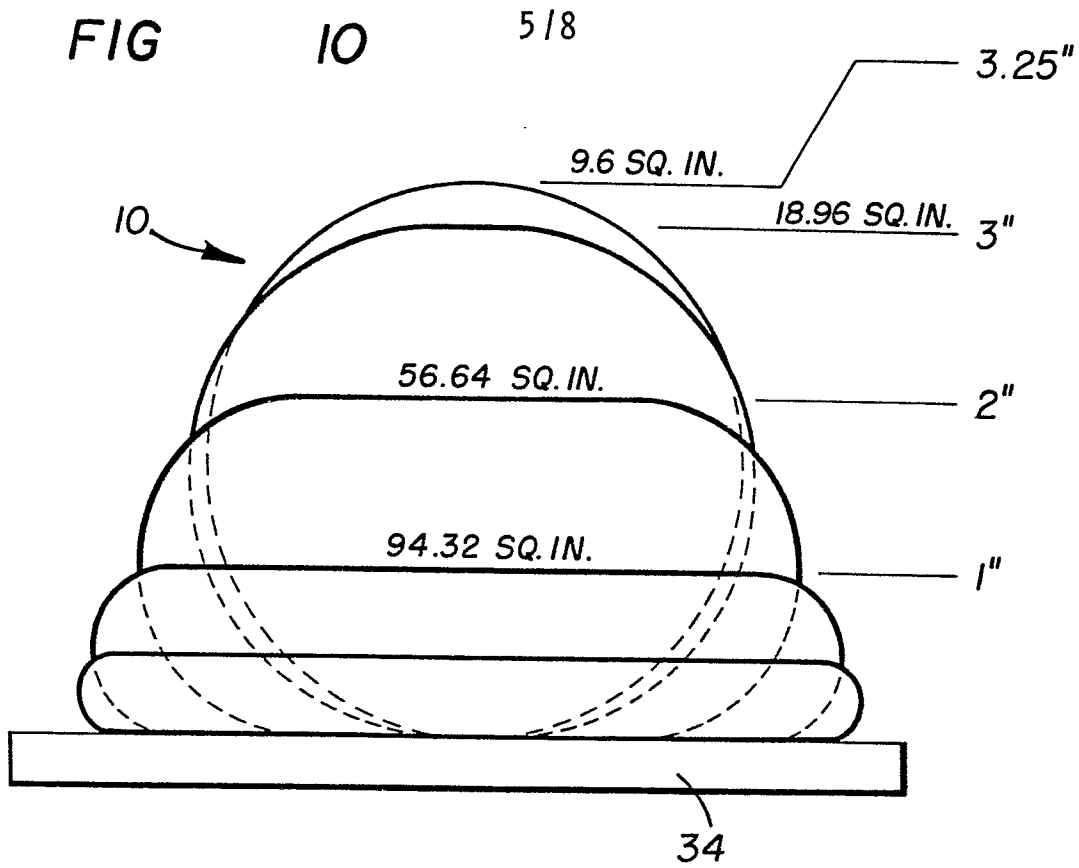
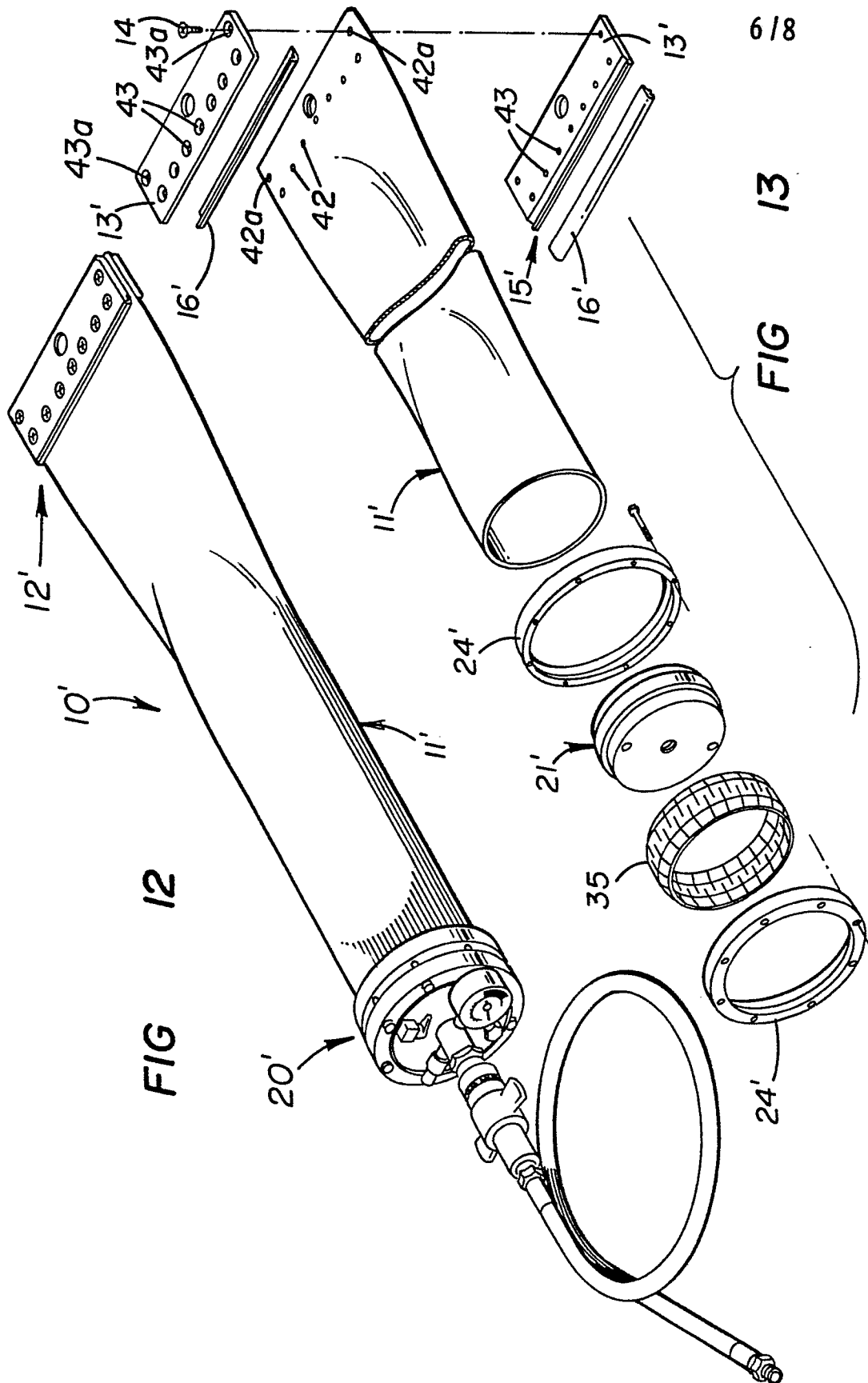


FIG 9









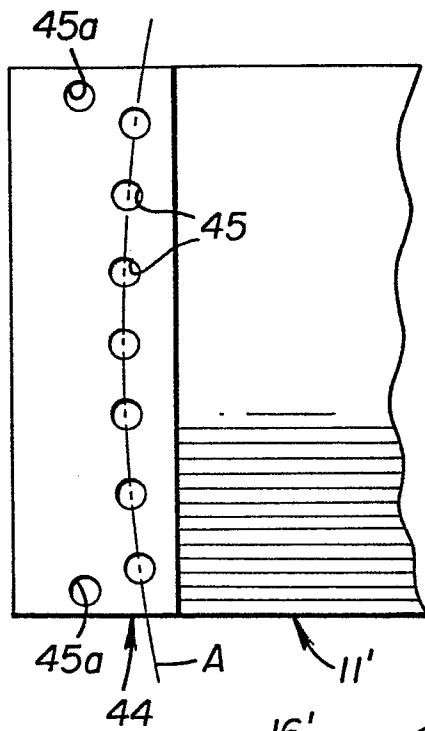


FIG 17

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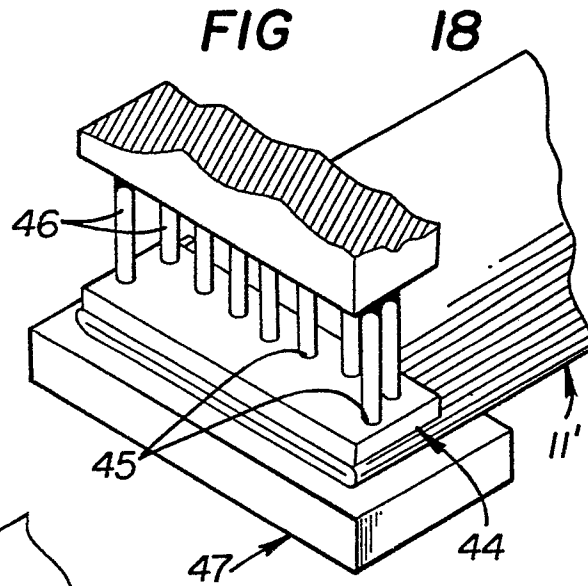


FIG 18

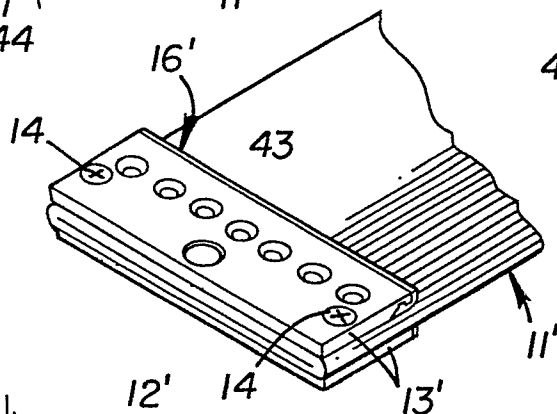


FIG 19

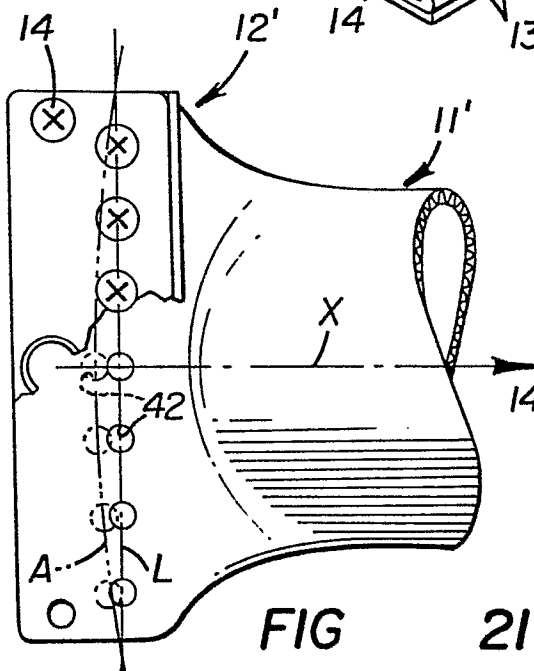
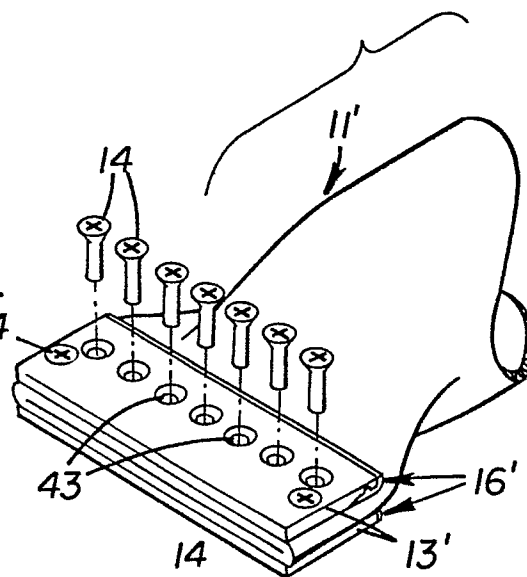


FIG 20

FIG 21





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EUROPEAN SEARCH REPORT

0115199

Application number

EP 83 30 7950

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
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Y	FR-A-2 125 216 (CAMPENON BERNARD EUROPE) * Claims 1-6; page 5, lines 4-6; figures 1-3 *	1,2	
Y,A	DE-A-2 802 716 (JANSEN) * Page 10, line 19 - page 11, line 6; claims 1, 3, 4, 11; figures 1, 14, 15 *	1,2,4-7	
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A	DE-U-7 415 621 (VETTER)		
A	DE-A-2 919 939 (RASMUSSEN GMBH)		
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The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 19-03-1984	Examiner KANAL P K
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D, A	WO-A-7 900 022 (HOLMES)		

			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 19-03-1984	Examiner KANAL P K
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