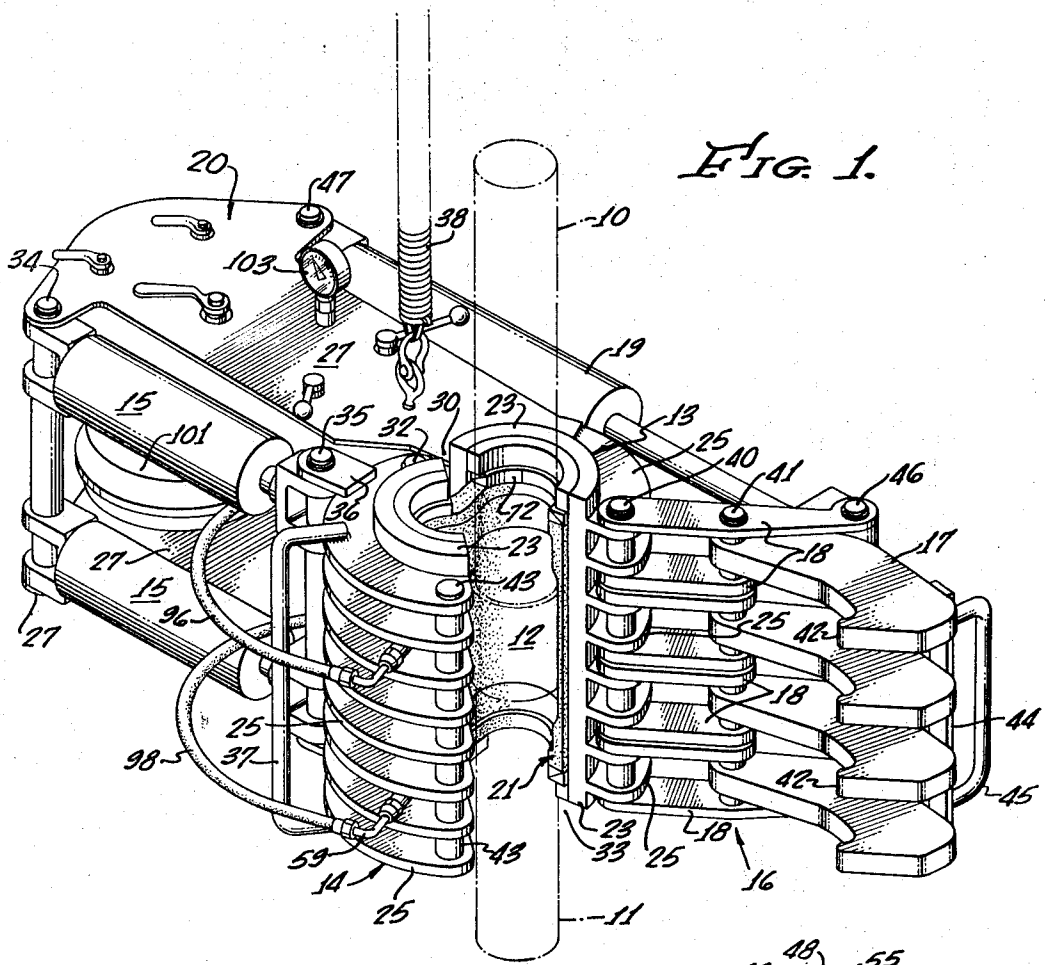
March 5, 1968 E. D. HAUK 3,371,521

LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

Filed April 1, 1966 5 Sheets-Sheet 1

FIG. 1.



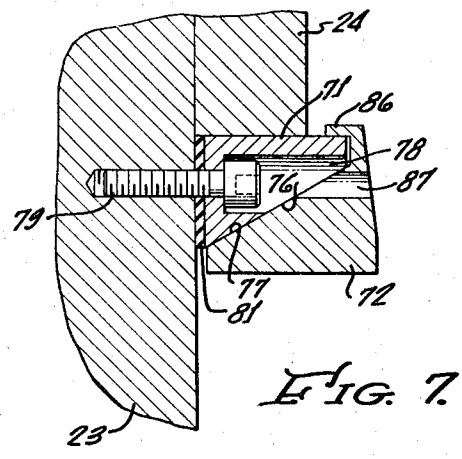


FIG. 7.

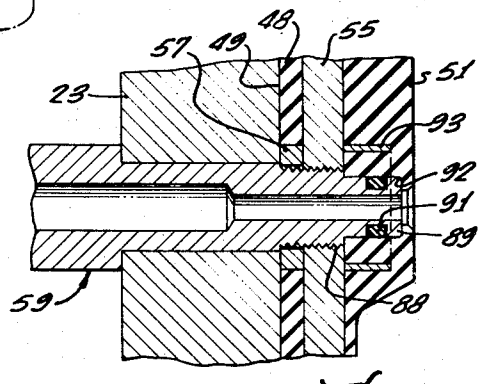


FIG. 8.

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LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

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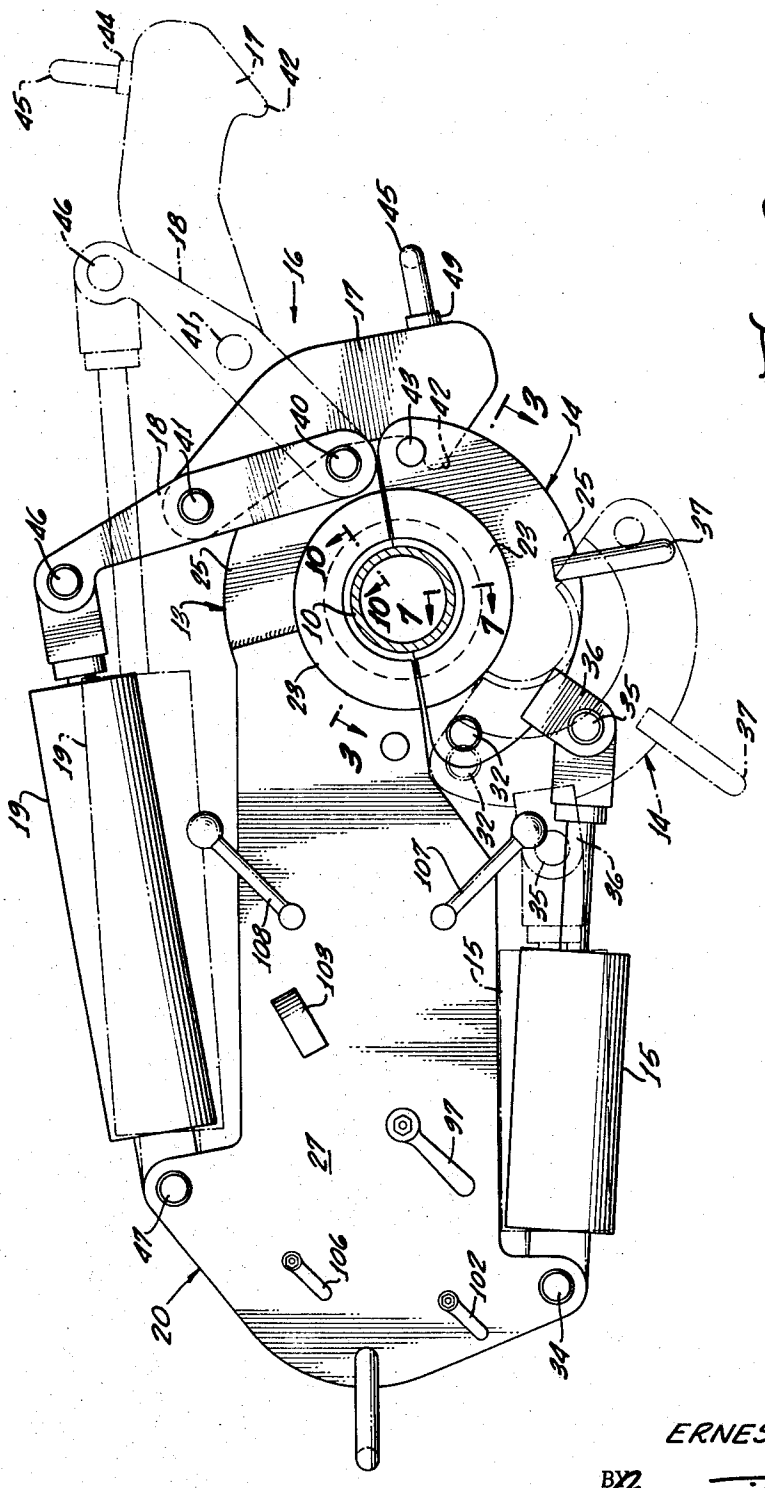


FIG. 2.

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LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

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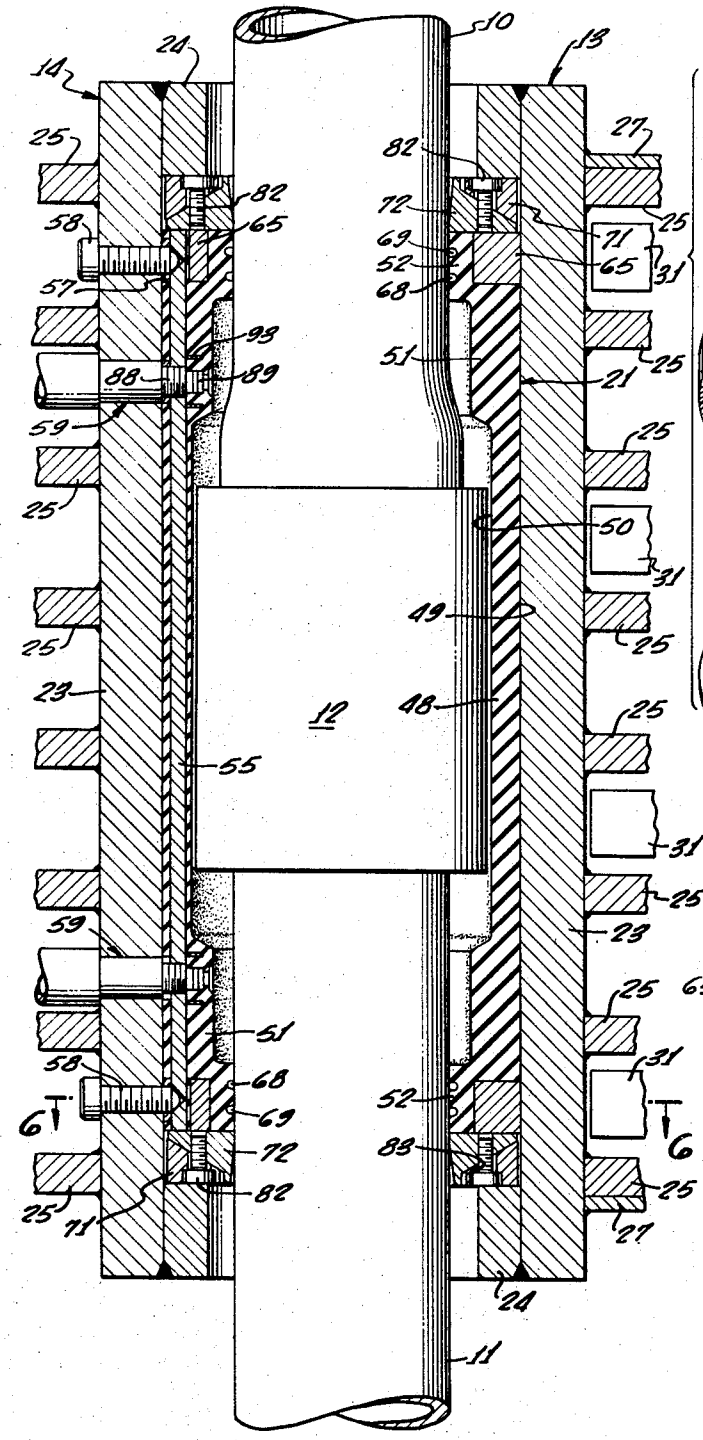


FIG. 3.

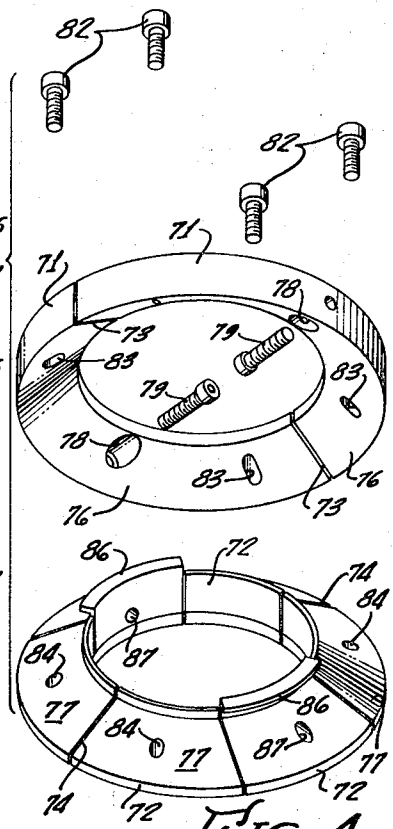


FIG. 4.

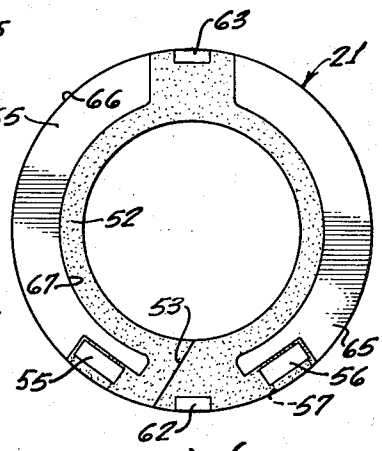


FIG. 5.

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LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

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FIG. 6.

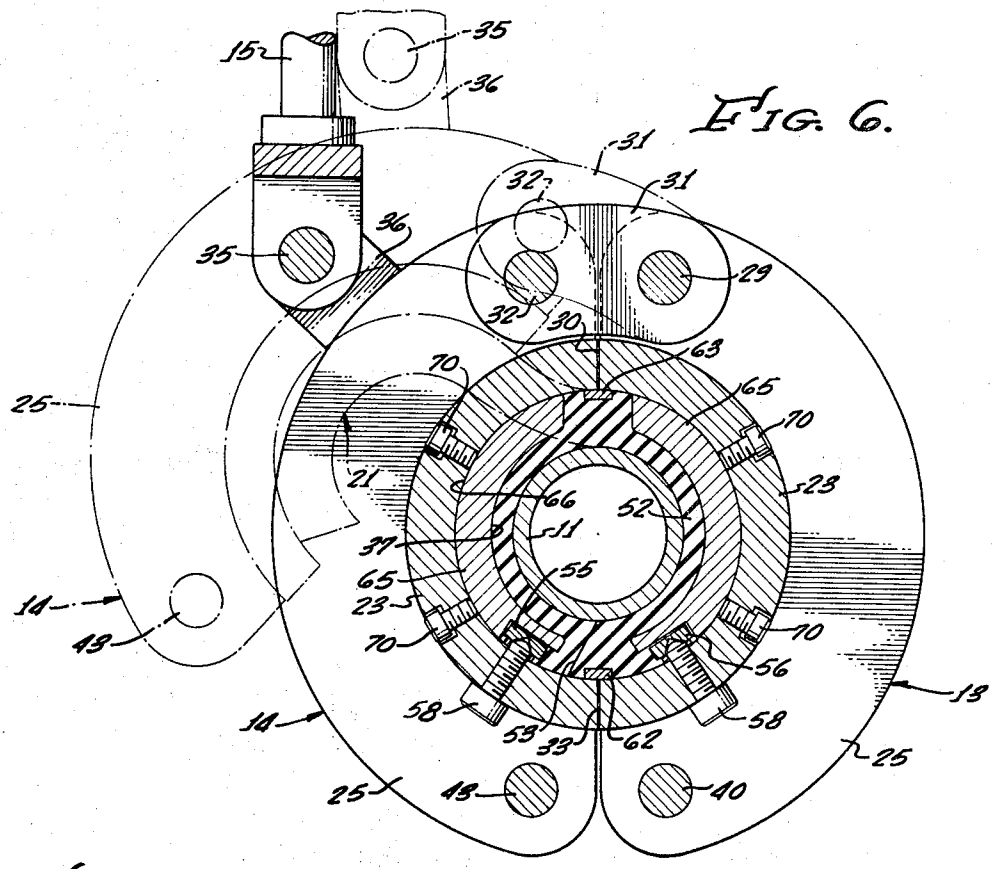
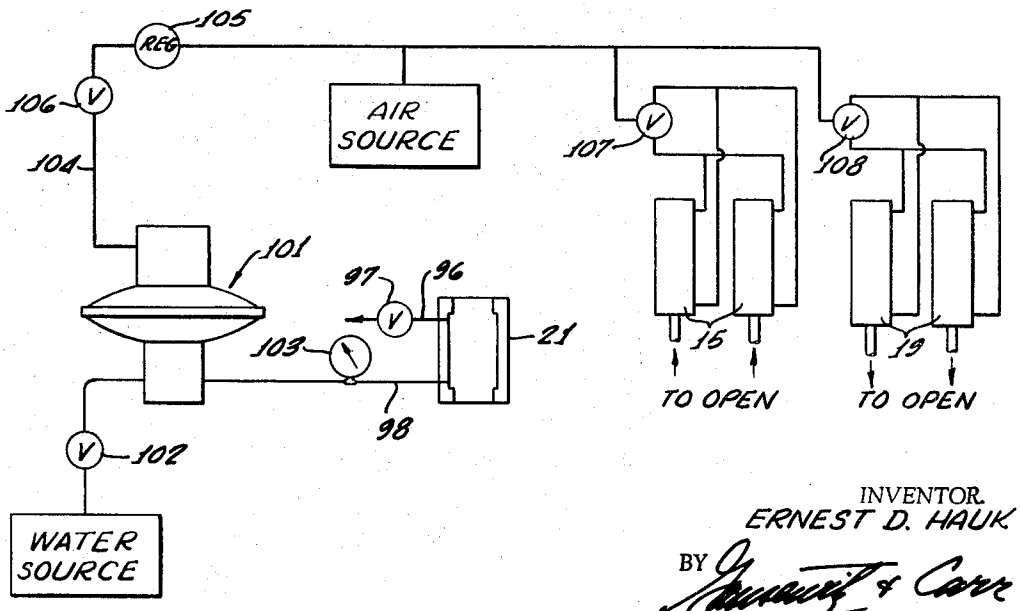


FIG. 11.



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LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

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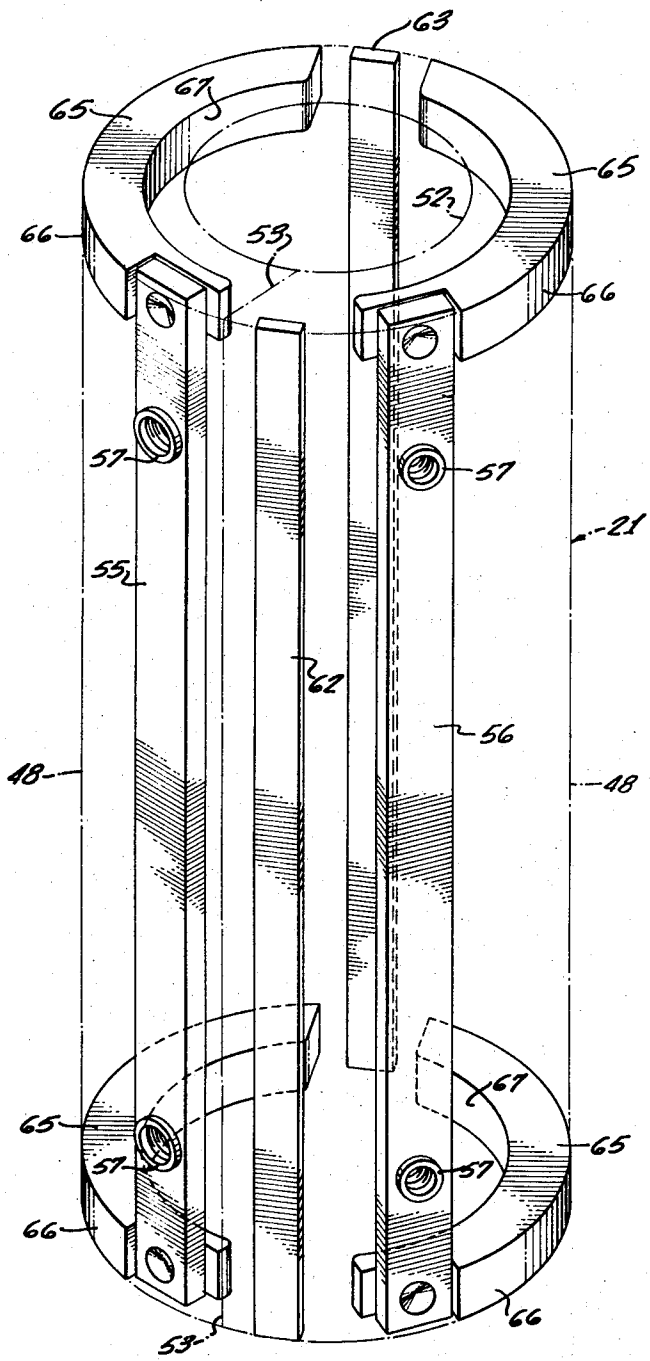


FIG. 9.

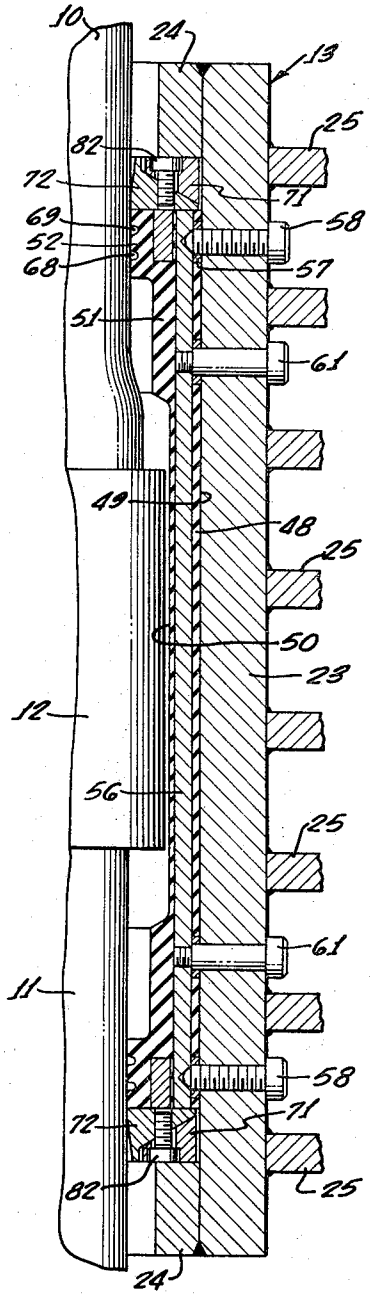


FIG. 10.

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United States Patent Office 3,371,521 Patented Mar. 5, 1968

3,371,521

LEAK-TESTING APPARATUS FOR EITHER FLUSH OR SHOULDERED PIPE JOINTS AND PACKER THEREFOR

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Filed Apr. 1, 1966, Ser. No. 539,579
31 Claims. (Cl. 73—46)

ABSTRACT OF THE DISCLOSURE

A high-pressure leak-testing apparatus for pipe joints, including joints wherein collars are present, comprising a split casing containing a rubber packer which is split correspondingly to the casing, both the casing and the packer being adapted to open up so as to receive a pipe joint in a direction lateral to the axis of the pipe. The packer contains mounting and compression means, and extrusion-prevention means, so constructed and located that the casing and packer when closed will contain fluids under pressures of thousands of pounds per square inch.

This invention relates to an apparatus adapted to test for leaks in joints betwen connected pipe sections, whether the joints be of the flush or shouldered type. The invention further relates to the packer member incorporated in such leak-testing apparatus.

The invention will be described in particular relation to the testing of collared joints between adjacent tubing sections being run into (or drawn out of) an oil well. It is to be understood, however, that the apparatus is also applicable to the testing of threaded, welded or other joints between any two connected pipe sections.

In accordance with one conventional method of testing pipe at the wellhead of an oil well, pipe sections are sealed off with internal packer means and then filled with water at high pressures. The indicated system has basic disadvantages, however, among which are the following:

(a) The water hoses connecting to the internal chamber are necessarily relatively long. Therefore, when internal pressure on the order of thousands of pounds per square inch is applied, these long hoses stretch (expand) considerably and this, in conjunction with the stretch or increase in chamber size responsive to the pressure, creates a large elastic or reserve load. The leakage of a small amount of water out of the chamber will not be sufficient to remove such elastic or reserve load, and therefore will not produce (within a reasonable time period) an appreciable change in the gauge which senses the pressure in the chamber. Accordingly, the indicated method may not practically be employed to determine small leaks but instead only relatively large ones. The determination of small leaks is vital because such leaks gradually increase (due to erosion) into large leaks and wash-outs.

(b) The use of internal packers in oil well pipe is undesirable because the scale, wax, plastic linings, etc., present in the pipe create problems relative to wear, sealing, etc.

For the above and other reasons, attempts have been made to test pipe joints by applying external fluid pressure (U.S. Patent 2,587,192, issued to H. Meyer for Leakage Tester for Threaded Pipe Couplings). Such attempts were impractical, however, for various reasons including the following:

(a) It was necessary to mount the leak-testing apparatus fixedly at the wellhead, in pipe-supporting relationship, instead of in a movable position suspended above the wellhead.

(b) The testing required relative longitudinal movement between the pipe and the leak-testing apparatus.

(c) The leak-testing apparatus could not be employed in those numerous instances when two or more strings of pipe were being run into or withdraw from a well.

(d) It was difficult or impossible to determine whether or not the lower one of the packer members was leaking, thus making it impractical to determine whether the leak was in the pipe itself or in the packer of the testing apparatus.

(e) The testing apparatus required a separate set of slips, which were normally manually operated, thus rendering usless the automatic slips already present at the wellhead.

(f) The apparatus involved the use of many parts, and was difficult and slow to put into operation and operate.

(g) It was difficult or impossible to change the packers in the field, it instead being necessary to remove the apparatus to the shop.

(i) An experienced operator was required to effect satisfactory testing operations.

(j) The apparatus was not effective in achieving sealing at very high fluid pressures, such as 6,000 pounds per square inch.

In view of the above and other factors characteristc of conventional leak-testing apparatus, it is an object of the present invention to provide a leak-testing apparatus, and packer means therefor, wherein a compact, self-contained unit is suspended in adjustable relationship above the wellhead of an oil well and is adapted to effectively and externally test pipe joints without the necessity for any relative longitudinal movement between the pipe and the tester, and without the necessity of feeding the pipe through any object whatsoever.

A further object is to provide a leak-testing apparatus which is readily and economically operated by unskilled personnel, and which incorporates a packer means which may be readily changed in the field and in a short period of time.

A further object is to provide a leak-testing apparatus which will quickly detect very small leaks, which will contain pressures of many thousands of pounds per square inch, which may be employed in conjunction with parallel strings of pipe being run into or out of a well, which is self-verifying in that any leakage therefrom may be visually observed, which may be employed in conjunction with the automatic slips already present at the wellhead, and which is not subject to the effects of the scale, wax, etc., within oil well pipe.

These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a perspective view illustrating a leak-testing apparatus, constructed in accordance with the present invention, in fully-open condition adapted to laterally receive or discharge a pipe section;

FIGURE 2 is a top plan view of the apparatus of FIGURE 1, illustrating the same in fully-closed condition in solid lines, and in fully-open condition in phantom lines;

FIGURE 3 is a longitudinal sectional view taken generally on line 3—3 of FIGURE 2;

FIGURE 4 is an exploded perspective view illustrating the upper back-up assembly for the packer (the lower back-up assembly being identical but inverted);

FIGURE 5 is a top plan view of the packer, illustrating the same in closed condition;

FIGURE 6 is a horizontal sectional view taken on line 6—6 of FIGURE 3, and showing (in phantom lines) the pivoted jaw in open condition;

FIGURE 7 is a fragmentary vertical sectional view taken along line 7—7 of FIGURE 2, and showing only the upper end region of the apparatus,

FIGURE 8 is an enlarged vertical sectional view of an area illustrated at the upper left portion of FIGURE 3;

FIGURE 9 is an isometric view illustrating the packer, the rubber portion of the packer being illustrated in phantom lines and the metal portion thereof in solid lines;

FIGURE 10 is a fragmentary sectional view taken generally along line 10—10 in FIGURE 2; and

FIGURE 11 is a schematic diagram of the pneumatic and hydraulic portions of the apparatus.

The leak-testing apparatus will be described as employed to test for leaks the threaded joints between two pipe (tubing) sections **10** and **11** and a collar **12**.

Stated generally, the apparatus comprises clamping-jaw means formed by a back-up jaw **13** and a pivoted jaw **14**, the latter being pneumatically actuated by cylinders **15**. Latch means **16** are provided to effect an additional clamping operation and also a latching or locking operation, such latch means comprising hook means **17** and cranks **18**. Cranks **18** are operated by cylinders **19** which, like cylinders **15**, are provided on a body or housing portion **20** to which the back-up jaw **13** is fixedly connected. The term "cylinders," as employed herein, denotes cylinder and piston assemblies (rams).

Very importantly, the apparatus comprises a molded rubber packer **21** having molded therein mounting, preloading (compressing), stretching and extrusion-prevention elements. A detailed description of the packer and the associated embedded elements, and also of the adjustment means and back-up elements associated with the upper and lower ends of the packer, will be given subsequently. There will also be described the means for passing water to and from the pressure chamber which is defined within packer **21** and around the pipe section.

Detailed description of the mechanical jaw and latching means 13–20, inclusive

It is pointed out that the expression "back-up jaw" is not necessarily intended to denote the absence of any movement, the expression being employed because the jaw **13** is shown as being fixedly related to the body portion **20** of the apparatus.

Each of the clamping jaws **13** and **14** is illustrated to comprise a semi-cylindrical casing member **23**, being preferably approximately one-half of a hollow cylinder. A semi-annular internal collar **24** is welded or otherwise fixedly secured at the inner surface of each member **23** at the upper and lower end thereof. When the elements **23** and **24** are in the closed positions represented in FIGURE 3, members **23** provide back-up support for the vertical walls of packer **21**, whereas the internal collars **24** provide back-up support for the extrusion-prevention retaining assemblies which form parts of the end-seal means for the packer.

A substantial number of vertically spaced, generally semi-annular exterior ribs **25** are welded or otherwise fixedly secured to each of the semi-cylindrical members **23**, providing a bracing function against the great internal pressures contained within the packer. In the illustrated embodiment, eight ribs **25** are provided on each of the casing sections **23**.

The upper and lower ribs **25** on the back-up jaw **13** have welded thereto suitable upper and lower horizontal plates **27** which form major components of the body **20** of the apparatus. Such plates **27** extend radially outwardly from the jaws and provide mounting means for the various cylinders **15** and **19** and associated valving, pumping and other means incorporated in the self-contained leak-testing unit.

There will next be described the means for effecting pivotal mounting of jaw **14** in such manner that it may be opened to a widely-spaced position relative to back-up jaw **13** in order to permit lateral reception and discharge of the tubing sections **10** and **11** and the collar **12**. Such pivotal mounting means comprises a strong vertical pin or pintle **29** (FIGURE 6) which extends through housing plates **27** and through end regions of all of ribs **25** on jaw **13** adjacent one side of what may be termed the "rear gap" **30** between the jaws. A plurality of strong, thick, short links **31** are pivotally connected to pin **29** between various ones of ribs **25** as indicated in FIGURES 3 and 6. The ends of the short links **31** remote from pin **29** extend between corresponding ribs **25** of pivoted jaw **14**, so that such link ends and the vertically adjacent regions of the ribs **25** of the pivoted jaw may receive a second vertical pin or pintle which has been given the reference number **32**. A compound pivotal movement is thus effected, upon shortening of actuating cylinders **15**, which causes a wide spacing between the jaws at the rear gap **30** and thus at the diametrically opposite "front gap" **33** through which the pipe section is laterally received and discharged.

The actuating cylinders **15** for jaw **14** are pivotally connected to a vertical pin **34** at the end of body **20** remote from the jaws. The piston-rod portions of the cylinders are pivotally connected to an additional pin **35** which is associated with the pivoted jaw **14** by means of suitable lugs **36**.

A gripping handle **37** is welded to the pivoted jaw **14**, relatively adjacent the lugs **36**, to facilitate manipulation of the leak-testing apparatus by an operator. It is emphasized that the entire apparatus is freely suspended (as from the derrick) by means of a helical spring **38** (FIGURE 1) in order to permit manual vertical (and horizontal) adjustment of the position of the apparatus to correspond with the location of the collar **12**. This is a great advantage in comparison to apparatus in which the entire pipe string, not just the tester, must be moved.

The latch means **16**, which cooperates with cylinders **19** in closing the jaws, and which also effects locking of the jaws in closed condition against the enormous forces of the contained fluid, comprises an additional vertical pin or pintle **40** which extends through all ribs **25** of back-up jaw **13** on one side of the front gap **33**. As best shown in FIGURE 1, the previously-indicated cranks **18** are pivotally connected to the pin **40** in the gaps which are provided between alternate sets of ribs **25**. Stated more definitely, one crank is located above the upper rib **25**, a second crank is located below the lower rib **25**, and two adjacent cranks **18** are located between the alternate remaining sets of ribs.

At points relatively remote from pin **40**, cranks **18** receive a further vertical pin **41** adapted to effect mounting of the above-indicated hooks **17**. Such hooks are disposed at elevations which correspond to the crank-free gaps between various ribs **25** of jaw **13**, having hook ends **42** which are shaped to fit around a vertical latch pin **43**. Pin **43** extends through the ends of ribs **25** of pivot jaw **14** (on the opposite side of front gap **33**).

The various hooks **17** are fixedly connected to each other by a vertical bar **44** having a handle **45** thereon. The upper and lower ones of cranks **18** have extension portions which extend in a direction away from pin **40** and are pivotally connected at their free ends to the piston-rod portions of actuating cylinders **19**. For the purpose of such pivotal connection, a vertical pin **46** is connected between such crank extensions.

Referring particularly to FIGURE 2, let it be assumed that the cylinders **19** are in their extended conditions illustrated in phantom lines. The operator may then readily manually (or by suitable pneumatic or hydraulic apparatus, if desired) effect clockwise pivoting of hooks **17** from the illustrated phantom-line positions to positions (unshown) adjacent latch pin **43**. The operator then causes retraction of cylinders **19** to the illustrated solid-line positions, thus effecting pivotal movement of the hooks **17** to the illustrated solid-line positions. The locations of the various pins, the sizes of the various elements,

etc., are such that the last-mentioned pivotal movement of the hooks **17** first effects an additional closing (clamping) movement of the jaws **13** and **14** and then effects a locking action.

When fully locked, as shown in solid lines in FIGURE 2, pin **41** is over center relative to a plane intersecting the axes of pins **40** and **43**, being on the side of such plane adjacent body **20**. Accordingly, the mechanism **16** will remain locked, when high-pressure fluid is present within the packer, in the absence of any fluid pressure in cylinders **19**. It will even remain locked despite an attempt made by the operator to extend the cylinders **19**. This is a safety feature since the operator may not open the jaws until the fluid pressure in the packer has been relieved.

All of the enormous pressure contained within the packer-lined casing **23** is held solely by the hooks **17**, pins **40**, **41** and **43**, the portions of cranks **18** between pins **40** and **41**, the ribs **25**, pins **29** and **32**, and short links **31**. None of the pressure is borne by the cylinders **15** and **19**, and none by the body portion of the apparatus. It is emphasized that the ribs **25**, links **31**, hooks **17** and cranks **18** form an encircling cage around the casing portions **23** of jaws **13** and **14**, such cage having great strength.

Similarly to the case of the cylinders **15**, the latch cylinders **19** are pivotally connected to the body **20** by means of a pin **47** mounted through plates **27** at a location remote from the jaws.

Detailed description of the packer 21 and associated back-up and seal-adjustment means

Packer **21** comprises, as best illustrated in FIGURE 9, a molded rubber body **48** shaped to conform to the interior wall defined by casing sections **23** and also shaped, at its ends, to conform closely to the exterior surfaces of tubing **10** and **11**. The term "rubber," as employed in the present specification and claims, denotes not only natural and synthetic rubbers but also various deformable equivalents thereof formed of suitable plastics.

It is an important feature of the invention that the entire casing **23** is lined by the rubber body **48** of the packer, the relationship being such that the pressurized fluid only "sees" rubber except at the water-inlet and water-outlet lines. The sealing means for preventing escape of water at such lines, at the longitudinal slit in the packer, and at the ends thereof, are critical to the invention and are described in detail hereinafter.

The packer has a cylindrical external wall **49** and a cylindrical internal wall **50**, as shown in FIGURE 3, the latter having sufficient diameter at its central portion to receive the collar **12**. At its upper and lower end portions, the packer is necked down at **51** for purposes including decreasing the size of the defined pressure chamber and increasing the packer wall thickness whereby fluid connections may more readily be made to the chamber. At its extreme end portions, the packer is further necked down at **52** to diameters substantially smaller than the outer diameter of tubing **10–11**.

At one point about its circumference, the molded rubber packer is slit (split) at **53**, such slit **53** being located relatively adjacent the front gap **33** (FIGURE 6) whereby the leak-testing apparatus may be opened for lateral reception and discharge of the tubing. By "lateral reception and discharge" it is meant that the tubing does not (necessarily) move axially, but instead toward and away from the longitudinal axis of the leak-testing apparatus.

Molded into the rubber body **48** of packer **21**, in spaced relationship from the slit **53** and on opposite sides thereof, are vertical bars **55** and **56** which provide extremely important functions relative to effecting compression and stretching of certain regions of the rubber and also relative to mounting of the packer in the casing sections **23**. The bars **55** and **56** should be completely embedded in the rubber body **48**, as illustrated, there being suitable washers **57** associated with the outer surfaces of the bars at apertured regions thereof. Such washers extend outwardly to, and are flush with, the external cylindrical packer surface **49**. Bars **55** and **56** are formed of steel or other suitable rigid material.

The mounting function of the bars **55** and **56** will first be described, with particular reference to index screws **58** which are provided at each end of each bar **55** and **56**. Each screw **58** extends threadedly through a casing section **23** and into a rounded or conical recess in an associated bar **55** or **56**. The inner end of each screw **58** is correspondingly rounded or conical, the relationship being such that radial-inward threading of each screw creates a cam-like indexing action which positively locates the packer **21** in the casing. Thus, after all four index screws **58** are in position, it is known that other openings in the bars **55** and **56** will be in position for reception of mounting and conduit members next to be described.

Referring particularly to FIGURES 3 and 8, combination water-conduit and mounting elements **59** are extended through openings in casing sections **23** and into packer **21** at the upper and lower neck regions **51** thereof. Such elements **59** have externally-threaded inner ends which are received in corresponding internally-threaded regions of the bar **55**. Thus, and because elements **59** have shoulders which bear against the outer casing surface, such elements **59** provide a positive mounting function relative to bar **55**. The sealing and fluid-conducting functions of elements **59** will be described hereinafter.

Referring next to FIGURE 10, upper and lower mounting screws **61** are shown as extending through a casing section **23** into bar **56**. Such screws **61** are adapted to provide the same mounting function performed by conduit elements **59**.

It is emphasized that mounting screws **61**, index screws **58**, etc., do not penetrate to the interior surface **50** of the rubber body **48** of the packer. Thus, there is no sealing problem relative to these elements. The only elements which penetrate to the interior surface of the packer are the conduit elements **59**, which should have special seals associated therewith as will be described relative to FIGURE 8.

In addition to their mounting function, the bars **55** and **56** provide very important functions relative to effecting preloading of the interfacial region at slit **53**, in order that the contained water will not commence to escape therethrough prior to the time that dynamic loading (effected by the extremely high internal fluid pressures) becomes operative. Such preloading is achieved by causing the distance between each bar and the slit **53** to be very substantially less when the apparatus is in fully-closed condition than the distance between each bar and the associated slit end (which cooperates with the other slit end to define the interfacial region) when the device is in open condition. The bars **55** and **56** are spaced sufficiently far from slit **53** to permit such preloading of the interfacial region, and are also (as will be described hereinafter) spaced sufficiently far from the packer portion diametrically opposite slit **53** to provide the optimum stretching action as the packer is shifted to open condition.

It has been found that a desired degree of preloading or compression between bars **55** and **56** and slit **53** is on the order of 25%, that is to say that the regions of the packer rubber **48** between bars **55** and **56** are compressed approximately 25% in response to shifting of the apparatus from its open condition to its closed condition. In the illustrated packer, the angle defined by adjacent surfaces of bars **55** and **56** (those bar surfaces adjacent slit **53**) is on the order of about 40 to 60 degrees when the leak-testing apparatus is fully closed.

As a specific example of one method of achieving the desired preload at the interface **53**, let it be assumed that the inner diameter of the casing **23** is, when the casing is in the fully-closed position shown in solid lines in FIGURE 2, 5⅜ inches. The packer **21** is then so molded that

its outer diameter will be, when in the closed condition shown in FIGURE 9 but prior to any compressing action, approximately 5⅝ inches. The difference between the circumference of the interior casing surface and the circumference of the exterior packer surface will then be a little more than ¾ inch. Accordingly, the bores which receive index pins 58 and mounting elements 59 and 61 are so located that all of such ¾ inch difference will be present in the lower region illustrated in FIGURES 5 and 6, that is to say in the region directly between the bars 55 and 56. Thus, when the leak-testing apparatus is shifted from its open to its fully-closed condition, such ¾ inch will necessarily be taken up in the form of compression between the bars 55 and 56, and will effect a very substantial preloading of the interfacial region 53.

The stated preloading of the interface will exist despite the fact that some stretching of the casing occurs when thousands of pounds per square inch pressure is created within the packer. It is pointed out that the precise location of the slit 53 is not of the essence, the important thing being the distance between the bars 55 and 56. It is also pointed out that the above-stated example is given by way of illustration only, and not limitation.

From the above it will be understood that the two bars 55 and 56 should lie, respectively, in the two quadrants of the circle (FIGURES 5 and 6) which are relatively adjacent the front gap 33 and remote from rear gap 30, the distance between the bars being selected to effect preloading of the packer regions therebetween. There will next be discussed the distances between bars 55 and 56 and the packer region which is adjacent rear gap 30, in particular relation to the stretching of the packer (the stretching function of bars 55 and 56) which occurs when the same is shifted from its closed position to the open position shown in FIGURE 1. It is emphasized that the bars 55 and 56 could each be located much closer to rear gap 30 than in the illustrated embodiment, but that this would produce the undesirable result of decreasing the amount of rubber which is adapted to be stretched when the packer is opened. This, accordingly, would provide additional wear in the form of strain on the bars 55 and 56, stretching of the rubber, etc., which would shorten the packer life. For these and other reasons it is desirable to locate the bars 55 and 56 in the circle quadrants adjacent slit 53, as indicated above, and as far from rear gap 30 as is commensurate with adequate preloading of the packer regions on opposite sides of slit 53.

Bars 55 and 56 should extend for the full length of the packer body, and should be at least substantially continuous.

It is pointed out that the slit 53 does not, at least at the outer region thereof, coincide with the front gap 33. Instead, an extrusion-prevention bar 62 (formed of steel or other suitable rigid material) is molded into the packer 21 at the region thereof adjacent front gap 33, the outer surface of such bar being flush with outer surface 49 of the rubber packer body. The bar 62 is sufficiently wide that its outer surface will be in bridging contact with the interior surfaces of casing sections 23 when the device is fully closed as shown in FIGURE 6. Thus, bar 62 effectively prevents extrusion of rubber through the front gap 33 despite stretching of the casing in response to insertion of fluid therein. An additional and corresponding extrusion-prevention bar 63 is molded into the packer 21 at rear gap 30, as shown in FIGURES 5, 6 and 9.

There will next be specifically described those portions of the packer 21, and cooperating elements, which relate primarily to sealing of the upper and lower packer ends as distinguished from sealing the region at the slit 53.

Arcuate compression members 65 are molded into the upper and lower packer ends on opposite sides of bars 62 and 63 (which, in turn, are located at the front and rear gaps as stated heretofore). Similarly to the case of the extrusion-prevention bars 62 and 63, and the vertical bars 55 and 56, the arcuate members 65 are formed of metal (such as steel) or other strong and rigid material. The end regions of members 65 which are relatively adjacent slit 53 are indented to receive the extreme ends of vertical bars 55 and 56. Furthermore, such end regions are spaced sufficiently far from slit 53 to permit the above-indicated preloading of the rubber at such slit. The ends of elements 65 are spaced on opposite sides of a diametral plane which contains the longitudinal axis of the apparatus, and which extends adjacent slit 53.

Members 65 are preferably rectangular in section, having outer cylindrical surfaces 66 which are flush with packer surface 49 and abut the interior surfaces of casing sections 23. Such members also have interior cylindrical surfaces 67 which are concentric with the casing 23 and are spaced radially outwardly from tubing sections 10 and 11 when the apparatus is in fully-closed condition. The precise radial distances between surfaces 67 and the extreme inner (tubing contacting) regions of the packer rubber are selected to effect preloading of the neck regions 52 in response to closing of the packer. Stated more definitely, such preloading should be on the order of about 25%.

As an example, let it be assumed that the inner diameter of each packer neck region 52 is ¼ inch less than the outer diameter of each tubing section 10 and 11. There, fore, each diametrically-opposite region of the packer will necessarily be shifted outwardly (compressed) ⅛ inch when the apparatus is closed. Since such ⅛ inch is approximately 25% of ½ inch, it follows that the radial distance between each surface 67 and the outer surface of each section 10 and 11 should be approximately ½ inch, when the apparatus is closed.

The packer neck regions 52 should have substantial axial dimensions in order to aid in prevention of extrusion of rubber in response to the extremely high pressures. Preferably, circumferential annular grooves 68 and 69 are provided in each neck region 52.

It is pointed out that substantially the same packer molds can be employed to make packers for tubing sections 11 having somewhat different diameters. For example, if the packer is to be made for tubing having a diameter larger than that of tubing 10 and 11, the inner diameters of packer necks 52 are increased accordingly. Very importantly, however, the inner diameters (surfaces 67) of preloading members 65 are also increased accordingly, to thus maintain the desired degree of rubber compression or preloading.

The above-indicated spacing of the ends of elements 65 on opposite sides of the indicated diametral plane is desirable in the achieving of preloading of the packer rubber at slit 53, and in permitting the packer to open wide to the FIGURE 1 position. Very surprisingly, it has been found that such spacing does not adversely affect the preloading of neck 52. Thus, the preloading pressure effected by elements 65 bridges the end gaps.

The amount of wear effected at the neck regions 52 is necessarily substantial, because of the thousands of pounds pressure present within the packer. It is a feature of the invention that packer life may be considerably extended by use of the adjustment means indicated in FIGURE 6. Such adjustment means comprises a plurality of circumferentially-spaced screws 70 which are threaded through internally-threaded radial bores in casing sections 23 and abut against the exterior surfaces 66. When the packer regions adjacent grooves 68 and 69 wear substantially, it is merely necessary to effect radial-inward movement of screws 70, thus increasing the amount of loading of the rubber and lengthening packer life.

Self-adjusting, self-loading, extrusion-prevention (back-up) means are provided for the neck regions 52 of the packer, and comprise outer and inner taper-related segmented rings 71 and 72, respectively. Each outer ring 71 is shown in FIGURE 4 as having two semi-circular segments or sectors, whereas each inner ring 72 is shown as having six segments or sectors. In the showing of FIG-

URE 4, the radial dividing lines **73** register, respectively, with dividing lines **74**. Each set of registered lines **73–74** is substantially registered with one of the front and rear gaps **33** and **30**.

Each outer ring **71** has a radial (horizontal) outer surface which seats against a collar **24**, and also has a generally frustoconical surface **76** (FIGURES 4 and 7) which converges in a direction away from the center of the apparatus. Each inner ring **72** has a radial inner surface which seats against the radial outer surface of neck **52** and of the associated arcuate members **65**. Each inner ring also has a frustoconical surface **77** which engages surface **76** in such manner that a limited amount of radial movement of the segments or sectors is permitted. For this purpose, the taper angle of surface **76** (relative to a horizontal plane, perpendicular to the longitudinal axis of the apparatus) should be slightly smaller (one or two degrees) than the taper angle of surface **77** relative to such horizontal plane. It is to be understood that shapes other than generally frustoconical may be employed. Thus, for example, the cooperating surfaces of outer and inner members **71** and **72** may be generally spherical.

The surface regions of each inner ring **72** adjacent tube sections **10** and **11** are also generally frustoconical, being steeply tapered relative to the above-indicated horizontal plane and converging toward the center of the leak-testing apparatus. Thus, the regions of each ring **72** closest to the adjacent packer neck **52** are caused to be in close metal-to-metal contact with the exterior tubing surface regions, despite the fact that the tubing regions more remote from neck **52** may be somewhat protuberant.

Referring particularly to FIGURE 7, the central region of each half of each outer ring **71** is provided with a horizontal bore and counterbore **78** adapted to receive a mounting screw **79** which projects horizontally into an adjacent internally-threaded region of casing **23**. A resilient element, for example a pad **81** of rubber, is interposed between the outer-central region of each sector of ring **71** and the adjacent cylindrical surface of casing **23**. Thus, such pads **81** are diametrically opposite each other, at the central regions of the sectors of ring **71**, each pad occupying, for example, approximately 20 or 30 degrees of the circle.

The two sectors of each outer ring **71** thus being mounted to the casing, such sectors may each support three sectors or segments of the associated inner ring **72**. In the case of those segments of inner ring **72** which are closest to the registered lines **73–74**, FIGURE 4, support is effected by inserting screws **82** downwardly (as viewed in FIGURE 4) through oversize holes **83** in ring **71** for threaded reception into holes **84** in ring **72**. In the case of the diametrically-opposite central sectors or segments of each inner ring **72**, which are spaced from registered lines **73–74**, support is effected by providing horizontal lips **86** on such central sectors and causing such lips to hook horizontally over inwardly-projecting regions of outer ring **71**. Two access holes **87** are provided in diametrically-opposite portions of each ring **72**, in registry with bores **78**, in order to permit threading of screws **79** into casing **23**.

With the described construction, assembly is readily effected by connecting the segments or sectors of each ring **72** to the segments of ring **71**, thereafter positioning the associated elements **71–72** in the position shown in FIGURES 2 and 7, and thereafter inserting screw drivers through access holes **87** to thread screws **79** into casing **23**.

The holes **83** are oversize in radial directions, permitting the segments or sectors of each outer ring **71** to be shifted radially through substantial distances. The thicknesses of pads **81**, the inner diameter of each ring **72**, etc., are so selected that closing of the leak-testing apparatus onto the tube sections **10** and **11** causes a very considerable radially-inwardly directed preloading of each inner ring **72** against the tubing. Such preloading may total, for example, approximately 500 or 600 pounds at each end of the packer. This provides an effective back-up for packer neck regions **52**, preventing initial extrusion thereof as the pressure within the packer builds up.

As the fluid pressure within the packer increases, strong axial pressures are exerted against the inner radial surfaces of rings **72** but this, because of the taper relationship between surfaces **76** and **77**, causes additional radial-inward movement of the segments or sectors of each ring **72**. Thus, the back-up assemblies **71–72** are self-energizing, after the initial preload is achieved, and effectively prevent extrusion of rubber from necks **52** despite the existence of thousands of pounds per square inch pressure within the packer.

The inner diameter (minimum) of each inner ring **72** corresponds approximately to the outer diameter of tubing **10–11**. The gaps between adjacent sectors of each inner ring are caused to be very small when full pressure is present within the packer.

Referring particularly to FIGURES 3 and 8, there will next be described the means for sealing the ends of conduit and mounting elements **59** to the neck regions **51** of the packer. As best shown in FIGURE 8, each conduit and mounting element **59** has a threaded portion **88** which is received in a corresponding internally-threaded opening in bar **55**. Formed adjacent such threaded portion of the conduit element is a necked-down end region (head) **89** having an annular groove therein for reception of an O-ring **91**. Head region **89** is inserted into a cylindrical opening **92** which is formed in the packer body **48**, inwardly adjacent bar **55**. Spaced radially-outwardly from opening **92**, and embedded within the packer rubber concentrically of the opening, is a metal back-up ring **93**. Such back-up ring being completely embedded in rubber, pressurized liquid may not reach any portion of the ring **93**.

In the operation of the sealing means, the outer region of O-ring **91** is caused to bear forcibly against the cylindrical wall defining opening **92**, so that the O-ring **91** is somewhat preloaded. Therefore, the combination of the O-ring and the adjacent regions of the packer rubber effectively prevent outward passage of liquid around any portion of conduit **59**. The back-up ring **93** insures that adequate radial-inward pressure will be exerted against the O-ring **91**, despite the outward forces exerted by the contained fluid.

It has been found that the O-ring **91** greatly increases the life of the sealed fluid coupling in comparison to those constructions wherein an O-ring is not employed. It is to be understood, however, that adequate sealing may be achieved, over a shorter useful life, by constructions wherein the head region **89** contacts only a necked-down region of the packer rubber.

Description of hydraulic and pneumatic circuits, and brief summary of operation

Referring particularly to FIGURES 1 and 11, the upper conduit and mounting element **59** connects through a suitable pressure-resistant hose **96** and a valve **97** to a drain or discharge region. The lower conduit and mounting element **59** connects through a hose **98** to a suitable high-pressure injection pump **101** which is supplied with water (through a valve **102**) from a suitable source. A gauge **103** communicates with line **98** and registers the pressure therein and thus within the packer. Such gauge should be capable of reading pressures in excess of 6,000 pounds per square inch.

Pump **101** may be a conventional air-operated type, known as a "Sprague pump," which is adapted to inject small amounts of liquid at very high fluid pressures in response to shifting of an air-operated piston or other element. Such piston has a large diameter, and operates a small-diameter piston in a water chamber having spring-pressed ball-check inlet and outlet means. The air side of pump **101** communicates through a line **104** and regulator

105 to a suitable source of air pressure, there being a valve 106 interposed in line 104 to control air flow. The air pressure source also communicates through a control valve 107 with cylinders 15, and through a control valve 108 with cylinders 19.

Let it be assumed that the leak-testing apparatus is suspended by spring 38 above the wellhead of an oil well, and is initially in the fully-open condition shown in FIGURE 1. Assuming, as but one of numerous examples, that the tubing sections 10 and 11 are being run into the well, such sections are lowered until the collar 12 is generally adjacent the testing apparatus. The testing apparatus is then moved laterally until collar 12 is received within packer 21, as shown in phantom lines in FIGURE 1, the spring 38 being utilized to permit the desired degree of vertical movement of the testing apparatus to permit the same to be vertically adjusted relative to the collar.

Valve 107 is then operated to extend the cylinders 15 and thus partially close the pivoted jaw 14. This effects a substantial amount of preloading engagement between the packer body sections adjacent slit 53, and between packer neck regions 52 and the external tubing surfaces. Thereafter, the operator grasps handle 45 and pivots the hook members 17 until they are shifted from the positions shown in phantom lines in FIGURE 2 to positions (unshown) at which latch pin 43 is engaged. Valve 108 is then operated to retract the cylinders 19 and thus shift cranks 18 from the positions shown in phantom lines in FIGURE 2 to those shown in solid lines therein. This effects, as described in detail, a very strong compression action between pivoted jaw 14 and back-up jaw 13, and also effects positive locking of the apparatus in closed condition. The above-indicated preloading of the packer rubber at slit 53 is thus considerably augmented, and is also substantially augmented at the neck regions 52 at opposite ends of the packer. Furthermore, and as described above relative to FIGURE 7, the assemblies 71 and 72 at opposite ends of the packer are preloaded into close pressure engagement with the external tubing surfaces. Thus, substantial seals and back-up or retaining means are provided at all points.

The operator then opens valve 102 to effect flow of water through hose 98 and the lower conduit and mounting element 59 into the lower end of the annulus (pressure chamber) defined between the tubing and packer. The pressure annulus is thus completely filled with water, the air therein discharging through the upper element 59 and through the valve 97 which is then in open condition. As soon as the operator sees water commence to discharge through the outlet from valve 97, he closes such valve and operates valve 106 to effect flow of air from the air source to the pump 101. The pump is then caused to operate until the water pressure within the packer builds up to the desired value which may be, for example, about 5,000 or 6,000 pounds per square inch. Because of the very small volume of the pressure annulus and connecting hoses, such pressure buildup occurs in only a few seconds.

After the desired operating pressure level is achieved, the operator stops operation of pump 101 and watches gauge 103 for a short period of time, such as 10 seconds. If the water pressure within the packer holds steady, it is known that there is no leak between the collar 12 and either tubing section 10 or 11. If the observed pressure commences to fall, and if the operator visually ascertains that there is no leakage of water through any of the seal points, it is known that there is a leak between collar 12 and one or both of the tubing sections. Of course, the gauge 103 may be any pressure-responsive means which visually or audibly indicates a pressure drop.

Valve 97 is then opened to relieve the fluid pressure in the packer, following which valves 107 and 108 are operated to open the clamping jaws. The apparatus is then ready for a new testing operation.

Because the volume of the chamber defined between the packer and the collar 12 is extremely small, for example one cup, and because the connecting hoses 96 and 98 are very short, the leakage of only a very small amount of water will be registered by gauge 103 as a very substantial pressure drop which is readily observable to the operator. Such leakage will, because of the extremely high water pressures employed, occur in only a few seconds. Thus, the entire testing operation for a single joint may be completed within twenty or thirty seconds.

Although the hoses 96 and 98 are shown as being flexible pressure hoses associated with pivoted jaw 14, it is to be understood that such hoses may be thick-walled metal pipes associated with back-up jaw 13. In the latter event, there is relatively little stretching or expansion of the hoses, despite fluid pressures on the order of 6,000 pounds per square inch and above.

It is desirable to maintain a coating of oil on the interfacial regions at slit 53, and on the pipe-engaging packer surfaces adjacent grooves 68 and 69.

The bars 55 and 56, elements 65 and bars 62 and 63 may each be somewhat interrupted or discontinuous, although it is greatly preferred that such elements be continuous as shown. Similarly, and although a metal such as steel is greatly preferred, the various elements molded into the rubber packer body may in some cases be nylon or other plastic.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

I claim:

1. A replaceable packer for the casing of a high-pressure leak-testing apparatus, said casing comprising jaws adapted to open for lateral reception of a pipe section, which packer comprises:

a generally cylindrical hollow body formed of molded rubber,

said body having end portions shaped to sealingly engage the exterior cylindrical surfaces of a pipe section,

the full length of said body being slit at one point about the circumference thereof whereby said body may be opened for lateral reception of a pipe section, and

mounting and compression means molded into said body on opposite sides of the slit therein,

said mounting and compression means being adapted to be connected to said jaws for opening and closing therewith,

said mounting and compression means being adapted to effect, in response to closing of said jaws,

substantial compression of the interfacial region of said body at said slit,

at least one of said mounting and compression means being spaced sufficiently far from said slit that a substantial segment or sector of said body will be compressed in response to said closing of said jaws.

2. The invention as claimed in claim 1, in which additional compression means are molded into said body at said end portions thereof, said additional compression means being adapted to effect, in response to closing of said jaws, substantial compression of the regions of said body adjacent the pipe-engaging surfaces thereof, said additional compression means being spaced a substantial distance radially-outwardly from said pipe-engaging surfaces.

3. The invention as claimed in claim 2, in which said additional compression means comprise two pairs of arcuate metal elements, one pair at each end of said body, the metal elements in each pair being generally coaxial with said body and being disposed on opposite sides of a

diametral plane containing the axis of said body and extending adjacent said slit, said elements in each pair lying generally in a plane which is perpendicular to the longitudinal axis of said body.

4. The invention as claimed in claim 1, in which extrusion-prevention means are molded into the outer part of said body, said extrusion-prevention means being located to bridge gaps between said jaws when said jaws are in closed condition.

5. The invention as claimed in claim 4, in which said extrusion-prevention means and the region of said slit relatively adjacent the exterior surface of said body are located at different points about the circumference of said body, and in which said extrusion-prevention means are relatively rigid bars.

6. The invention as claimed in claim 4, in which said mounting and compression means comprises a pair of rigid bars extending for substantially the full length of said body and embedded in said body, and in which said extrusion-prevention means comprises two rigid bars molded into said body relatively adjacent a diametral plane containing the axis of said body and extending adjacent said slit, said last-named bars being disposed on diametrically opposite sides of said body and being adjacent the exterior surface of said body, said last-named bars extending for substantially the full length of said body.

7. The invention as claimed in claim 1, in which additional compression means are molded into said body at said end portions thereof, said additional compression means being adapted to effect, in response to closing of said jaws, substantial compression of the regions of said body adjacent the pipe-engaging surfaces thereof, and in which extrusion-prevention means are molded into said body, said extrusion-prevention means being located to bridge gaps between said jaws when said jaws are in closed condition.

8. The invention as claimed in claim 1, in which said mounting and compression means comprises a plurality of elongated rigid elements extending generally parallel to the axis of said body, said elements being located in the quadrants of said body which are adjacent said slit.

9. The invention as claimed in claim 8, in which said rigid elements are embedded in said body in spaced relationship from both the interior and exterior surfaces thereof.

10. The invention as claimed in claim 8, in which said rigid elements comprise two bars each extending for substantially the full length of said body, said bars having openings therein for reception of mounting and fluid-conducting means.

11. The invention as claimed in claim 1, in which said pipe-engaging portions of said body have annular grooves, said groves lying generally in planes which are perpendicular to the longitudinal axis of said body.

12. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure, said casing means comprising two semi-cylindrical casing sections adapted to form a hollow cylindrical casing, and further adapted to be opened to laterally receive a pipe section,

each of said casing sections having a substantial number of spaced parallel ribs provided on the exterior surface thereof,

each of said sections further having a plurality of pins extending through said ribs parallel to the axis of said casing and on opposite sides of the gaps between said sections,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between said two casing sections,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid, and

actuating means to effect opening and closing of said casing means and said packer,

at least some of said pins cooperating with said actuating means in effecting opening and closing of the jaws formed by said casing sections and said ribs.

13. The invention as claimed in claim 12, in which a plurality of short connecting links are pivotally connected between two of said pins which are located on opposite sides of one of the gaps between said sections, and in which an actuating and latch means is connected between two of said pins which are located on opposite sides of the other of the gaps between said sections.

14. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure, said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

said casing means comprising two jaws pivotally connected to each other adjacent a first gap between said jaws,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a second gap between said jaws,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid, and

actuating means to effect opening and closing of said casing means and said packer,

said actuating means including:

crank means pivotally connected to one of said jaws adjacent said second gap,

hook means pivotally connected to said crank means,

latch-pin means provided on the other of said jaws adjacent said second gap and positioned to seat hooked end portions of said said hook means, and

fluid-operated cylinders connected to said crank means to pivot the same to a position at which said hook means locks said said jaws in tightly-closed positions.

15. The invention is claimed in claim 14, in which said crank means is pivoted sufficiently far, when said jaws are in said closed positions, that said jaws will remain locked even in the absence of fluid pressure in said fluid-operated cylinders.

16. The invention as claimed in claim 14, in which additional fluid-operated cylinders are provided to pivot said other jaw between open and partially closed positions.

17. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure,

said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between two casing sections,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

said packer having a molded rubber body, said packer further having mounting and compression means molded into said body on opposite sides of said slit,

said mounting and compression means being adapted to be connected to said two casing sections for opening and closing therewith,

said mounting and compression means being adapted to effect, in response to closing of said two casing sections, substantial compression of the interfacial region of said body at said slit,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid, and

actuating means to effect opening and closing of said casing means and said packer.

18. The invention as claimed in claim **17**, in which additional compression means are molded into said packer body at the end portions thereof, said additional compression means being adapted to effect, in response to closing of said two casing sections, substantial compression of the regions of said body adjacent the pipe-engaging surfaces thereof.

19. The invention as claimed in claim **17**, in which extrusion-prevention means are molded into said packer body, said extrusion-prevention means being located to bridge a gap which is present between said two casing sections when said sections are in closed condition.

20. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure, said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between two casing sections,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

an extrusion-preventing back-up assembly provided in said casing means at each end of said packer for close engagement with the exterior surface of said pipe section,

said back-up assembly comprising taper-related means to increase the radial-inward pressure against said pipe section in response to an increase in the fluid pressure contained within said pressure chamber,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid, and

actuating means to effect opening and closing of said casing means and said packer.

21. The invention as claimed in claim **20**, in which means are provided to effect preloading of said back-up assemblies in response to closing of said casing and prior to the introduction of fluid pressure into said pressure chamber.

22. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure, said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between two casing sections,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

said packer having a molded rubber body,

said packer further having compression means molded into said body radially-outward'y from said longitudinally spaced regions of said pipe sections,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid,

actuating means to effect opening and closing of said casing means and said packer, and

adjustment means provided in said casing means to augment the radial-inward shifting of said compression means in response to closing of said casing means,

said adjustment means being adjustable to increase the loading on said body and thus compensate for the effects of wear thereon.

23. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure, said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between two casing sections,

said packer being shaped to sealingly engage longitudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

said packer having a molded rubber body,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid,

said fluid inlet means comprising a rigid element inserted into an opening in said body,

said rigid element having an annular groove therein and an O-ring provided in said annular groove,

the exterior region of said O-ring contacting the rubber wall of said opening, and

actuating means to effect opening and closing of said casing means and said packer.

24. The invention as claimed in claim **23**, in which a rigid back-up ring is molded into said packer in radially-outwardly spaced concentric relationship relative to said opening.

25. The invention as claimed in claim **23**, in which said fluid inlet has a threaded portion which is threaded into a rigid insert molded into said packer.

26. A high-pressure leak-testing apparatus for pipe joints, which comprises:

casing means to contain fluid under high pressure,

said casing means being split into at least two casing sections and in such manner that said casing means may be opened to laterally receive a pipe section,

a flexible packer mounted within said casing means and slit for lateral reception of a pipe section,

the slit in said packer being generally registered with a gap between two casing sections,

said packer being shaped to sealingly engage longi-

tudinally spaced regions of said pipe section whereby to define a pressure chamber around said pipe section when said casing means is in closed condition,

said packer having a molded rubber body,

said packer further having relatively rigid mounting and compression means molded into said body on opposite sides of said slit,

fluid inlet means provided in said packer to admit fluid into said pressure chamber whereby to fill said chamber with high-pressure fluid,

said fluid inlet means including a threaded member threaded into said mounting and compression means to aid in the mounting and compressing function thereof, and

actuating means to effect opening and closing of said casing means and said packer.

27. The invention as claimed in claim **26**, in which taper-ended index screws are threaded through said casing means and into tapered recesses in said mounting and compression means to thus locate said packer in said casing means.

28. A high-pressure leak-testing apparatus, which comprises:

a metal casing having jaws adapted to be shifted between a closed condition and an open condition at which a pipe section may be shifted laterally into and out of said casing,

a molded rubber packer disposed within said casing and having a slit so located that said packer may open and close with said jaws for lateral reception and discharge of said pipe section,

said packer having necked-down end portions adapted to sealingly engage longitudinally spaced regions of said pipe section,

a set of rigid mounting and compression elements molded into said packer on opposite sides of said slit,

at least one of said mounting and compression elements being spaced a substantial distance from said slit,

means to connect said mounting and compression elements to said jaws,

said last-named means being so located that closing of said jaws effects a very substantial compression of the packer region between said mounting and compression elements whereby to preload said packer at said slit,

a set of compression elements molded into said packer at said necked-down end portions thereof,

said last-named compression elements being spaced radially-outwardly from the pipe-engaging surfaces of said end portions,

the diameters of said pipe-engaging surfaces being substantially smaller than the outer diameter of said pipe section whereby substantial compression of said end portions is effected in response to closing of said casing, and

actuating means to effect forcible closing of said casing.

29. The invention as claimed in claim **28**, in which said mounting and compression elements and said last-named compression elements are so related to said casing and to said pipe section that closing of said casing effects a compression of the associated packer rubber on the order of about 25%.

30. The invention as claimed in claim **28**, in which said mounting and compression elements are so related to said casing that said packer is stretched when said casing is shifted to open condition.

31. The invention as claimed in claim **28**, in which back-up assemblies are mounted in said casing at each end of said packer to prevent longitudinal extrusion of said end portions of said packer.

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