May 29, 1962 J. R. BAKER 3,036,639

EXPANDIBLE PACKING APPARATUS

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FIG. 1.

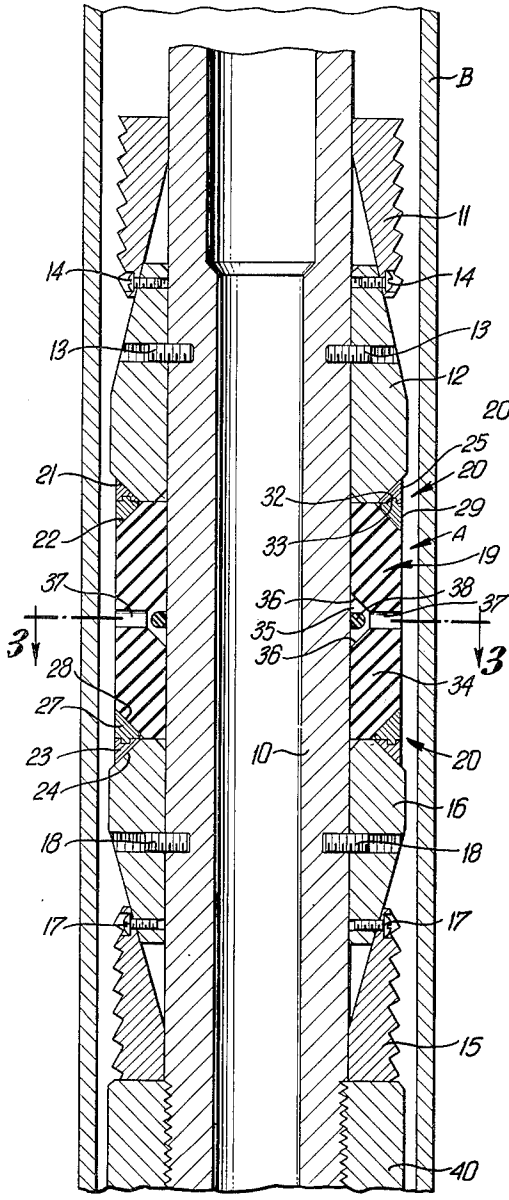
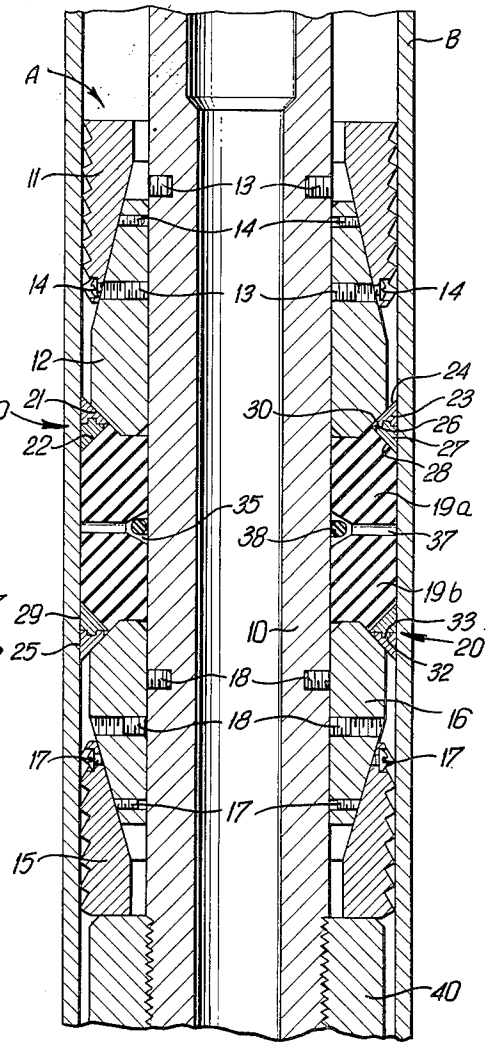


FIG. 2.



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FIG. 4.

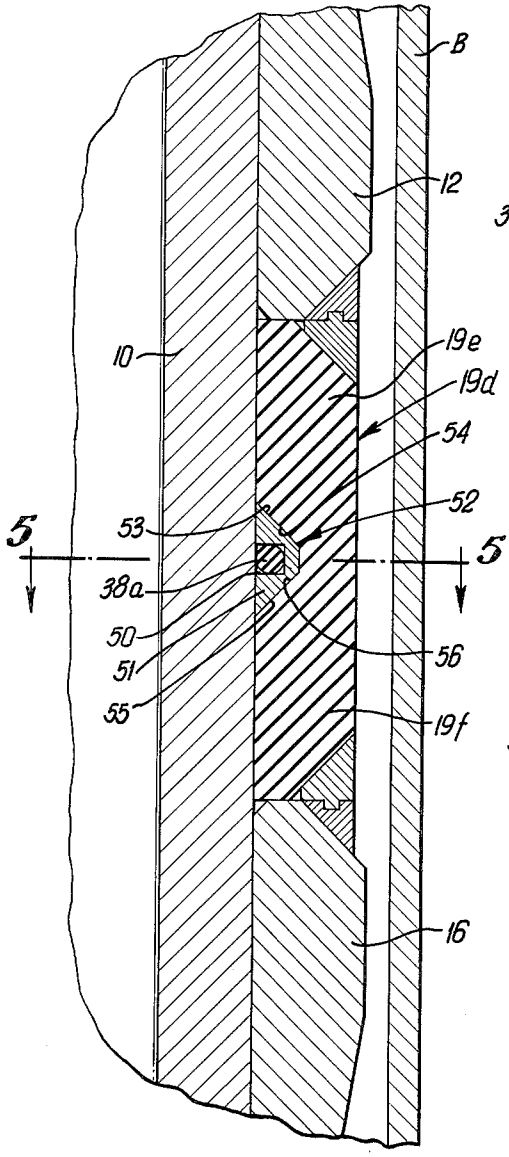


FIG. 3.

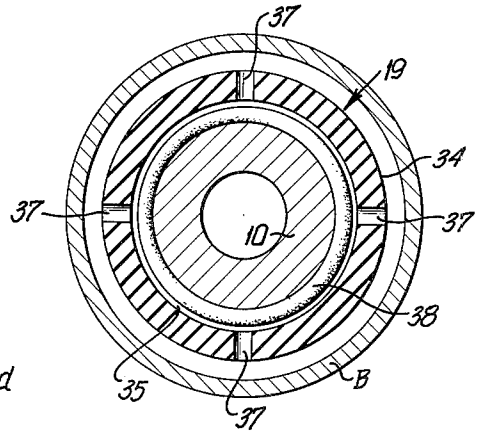
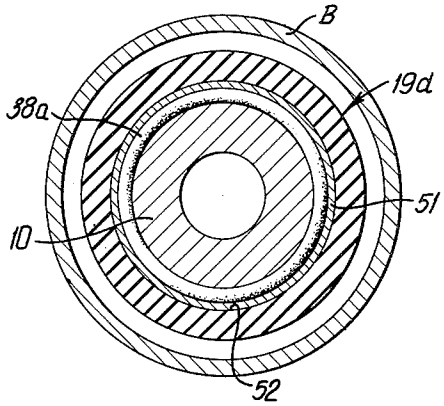


FIG. 5.



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3,036,639

EXPANDIBLE PACKING APPARATUS

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10 Claims. (Cl. 166—201)

The present invention relates to subsurface well bore apparatus, and more particularly to packing devices that are expandible outwardly into sealing engagement with a surrounding well casing, or similar conduit string, disposed in a well bore.

Packers adapted to be set in well casing, and similar conduit strings, disposed in well bores embody normally retracted packing elements or apparatus surrounding the bodies of the packers, the packing element being adapted to be expanded outwardly into sealing engagement with the well casing. At times, leakage of fluid occurs between an expanded packing element and the well casing, or between the expanded packing element and the body of the packer, or both. Such leakage has occurred at relatively low fluid pressures and has either remained fairly constant or increased as the fluid pressure increased.

An object of the present invention is to provide an expandible packing apparatus which will not leak after having been expanded against the surrounding well casing, either around the exterior or interior of the packing apparatus.

Another object of the invention is to provide a packing apparatus adapted to be expanded against the well casing and in which the fluid pressure in the casing is caused to provide a leakproof seal between the exterior of the packing apparatus and the well casing, and also between the interior of the packing apparatus and the body on which the packing apparatus is mounted.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through a well packer disposed in a well casing, with the packer parts in retracted position;

FIG. 2 is a view similar to FIG. 1, with the packer parts expanded against the wall of the well casing;

FIG. 3 is a cross-section taken along the line 3—3 on FIG. 1;

FIG. 4 is a fragmentary longitudinal section through another embodiment of the invention;

FIG. 5 is a section, on a reduced scale, taken along the line 5—5 on FIG. 4.

The packing assembly or apparatus A illustrated in the drawings is adapted to form part of a well packer to be anchored in packed-off condition within a well casing B, or similar conduit string. The well packer itself can be lowered in the well casing to the desired setting point by means of a suitable running-in string (not shown), and its parts can be expanded outwardly by a suitable setting apparatus (not shown). As an example, the well packer A may be run in the well casing on a wire line secured to a setting apparatus and appropriately related to the well packer, all as shown, for example, in U.S. Patent 2,637,402. Since the particular motive power device for setting the packer forms no part of the present invention, it has not been illustrated herein in the interest of clarity.

The packer includes a main body 10 carrying a set of upper segmental slips 11 adapted to be moved into engagement with the casing by an upper frusto-conical expander 12 which is retained initially in position by one or more shear screws 13 securing it to the body. The upper slips 11 are also retained initially in retracted position by shear screws 14 attaching them to the upper expander. A set of lower segmental slips 15 is initially held in retracted position by being attached to a lower expander 16 by shear screws 17, this expander being held in an initial position by shear screws 18, or the like, threaded into the body.

The upper and lower expanders 12, 16 are longitudinally spaced from one another and a packing assembly or apparatus A is disposed therebetween. This assembly includes a packing sleeve 19 of a pliant, elastic material, such as synthetic or natural rubber, positioned between the expanders 12, 16 and being disposed initially in a retracted position free from contact with the wall of the well casing B. Relative movement of the expanders or abutments 12, 16 toward one another will shorten the packing sleeve 19 and expand it outwardly against the wall of the well casing, as well as inwardly into firm sealing engagement with the periphery of the packer body 10.

The pliant, elastic material of the packing sleeve 19 may be prevented from cold flowing or extruding through the clearance spaces that exist between the upper and lower expanders 12, 16 and the wall of the surrounding casing B by an extrusion preventing device 20 placed at each end of the packing sleeve. As specifically shown, the end 21 of the upper mandrel or abutment 12 is tapered in an upward and outward direction, the confronting portion 22 of the packing sleeve also being tapered in a downward and outward direction, defining a generally triangularly shaped groove between the tapered surfaces 21, 22 which extend circumferentially around the abutment 12 and the confronting portion of the packing sleeve 19. An outer metallic ring 23 is positioned in the groove, having an inner tapered surface 24 engageable and companion to the tapered surface 21 on the abutment. This ring is also generally triangular in cross-section. More specifically, it is of generally right triangular cross-section with its outer surface 25 cylindrical and with its lower surface 26 flat and substantially normal to the axis of the well packer.

An inner ring 27, reversely arranged to the outer ring 23, is also disposed in the lower portion of the groove, having a tapered inner surface 28 engageable with and companion to the tapered surface 22 on the packing sleeve 19. This inner ring is also of generally triangular cross-section, specifically being of generally right triangular cross-section. Its outer surface 29 is cylindrical and forms a continuation of the outer surface 25 of the other ring 23. Its upper surface 30 is also normal to the axis of the well packer and abuts the lower surface 26 of the outer ring.

The inner and outer rings 23, 27 substantially fill the triangular groove defined by the tapered surfaces 21, 22 on the upper expander or abutment 12 and the packing sleeve. These rings are each split and normally tend to remain in a retracted position, as disclosed in FIG. 1. However, the rings 23, 27 are expandible outwardly by the packing sleeve 19 when the latter is shortened, to expand it outwardly against the well casing B so as to bring the cylindrical surfaces 25, 29 of the rings into engagement with the wall of the well casing.

To assure the same extent of outward expansion of the rings 23, 27, they are keyed to one another for circumferential slidable movement with respect to one another, with relative radial movement being prevented by an arcuate key and slot arrangement. This key and slot

arrangement consists of a circumferential rib 32 on one of the rings 27 projecting upwardly from its upper face and fitting within a companion circumferential groove 33 in the lower portion of the outer ring 23. Because of the key and keyway or slot arrangement 32, 33, the rings will expand outwardly to the same extent. However, the interconnection 32, 33 between the rings will not prevent such expansion from occurring.

A similar flow preventing device 20 is provided between the lower expander or abutment 16 and the lower confronting portion of the pliant, elastic packing sleeve 19.

The packing sleeve 19, when in a retracted position, has its exterior 34 generally cylindrical and having a substantial running clearance with the wall of the well casing B. The packing sleeve has an internal groove 35 in its mid portion extending circumferentially around the entire sleeve, this groove having tapered sides 36 that converge toward each other in a lateral outward direction. Fluid communication between a region externally of the packing sleeve 19 and the inner groove 35 is provided by a plurality of circumferentially arranged generally radial holes or passages 37 that extend from the periphery of the packing sleeve into the groove.

It is to be noted that there is a pliant, elastic seal ring 38, such as a rubber or rubber-like O ring, disposed in the internal groove 35 of the packing assembly. This O ring may snugly fit the periphery of the packer body 10 and is adapted to move upwardly into engagement with the upper tapered side wall 36 of the packing sleeve groove, and also downwardly into engagement with the lower tapered side 36 of the groove 35 for the purpose of preventing leakage of fluid between the packing sleeve 19 and the packer body 10. The inner surface of the packing sleeve on opposite sides of the groove 35 may be cylindrical and engage the periphery of the packer body 10.

Initially, the upper slips 11, packing sleeve 19 together with its extrusion preventing devices 20, and lower slips 15 are disposed in their retracted positions, such as illustrated in FIG. 1, the lower slips 15 being adjacent to a lower body member 40 suitably secured onto the body 10 itself. Through use of the wire line setting device illustrated in United States Patent 2,637,402, the well packer is lowered in the well casing to the desired setting point, at which the packer is set in the well bore, as by exerting an upward force on the body 10 and a downward force on the upper slips 11. Such setting action effects a disruption of the shear screws 14 holding the upper slips 11 to the upper expander 12, such slips moving downwardly along the upper expander and into anchoring engagement with the wall of the well casing B. The setting force also disrupts the shear screws 13 holding the upper expander 12 to the body 10, enabling the body to move upwardly relative to the upper expander and upper slips, shifting the lower expander or abutment 16 toward the upper expander or abutment 12 to shorten the packing sleeve 19 and effect its compression between the abutments 12, 16 so that it expands outwardly into engagement with the wall of the well casing. Upward movement of the body 10 can then also disrupt the shear screws 18, 17 holding the lower expander 16 to the body and the lower slips 15 to the lower expander, the lower body member 40 shifting the lower slips 15 upwardly along the lower expander or abutment 16 and outwardly into anchoring engagement with the wall of the well casing, such as disclosed in FIG. 2.

The shortening and compression of the packing sleeve 19 will also cause the packing sleeve itself, and the upper and lower abutment 12, 16 to expand the upper and lower sets of extrusion preventing rings 20 outwardly into engagement with the wall of the well casing to bridge the clearance space between the upper and lower abutments and the wall of the well casing B. Although the extrusion preventing devices 20 are disclosed, they form no part of the present invention. However, it is preferred to use them in connection with the pliant, elastic packing sleeve 19, inasmuch as they insure the maintenance of the packing sleeve material at the proper location against the well casing B and prevent their being squeezed or extruded through the clearance spaces between the upper and lower expanders 12, 16 and the wall of the well casing.

As shown in FIG. 2, the packing apparatus A is disposed against the well casing B and also against the periphery of the body 10 of the tool. The formation of the internal groove 35 in the mid portion of the packing sleeve, and also the passage holes 37 between the exterior and interior of the packing sleeve, in effect, causes the packing sleeve 19 to function as two opposed cup types of packing elements that seal against the wall of the well casing. Thus, fluid under pressure from below the apparatus can squeeze past the outer portion of the imperforate lower part 19*b* of the packing sleeve to its mid portion where it passes inwardly through the passageways 37 in the mid portion to the interior of the packing sleeve, and act on the upper tapered face 36 of the packing sleeve and tend to urge the upper portion 19*a* of the sleeve in an outward direction against the well casing, thereby precluding such fluid pressure from flowing upwardly around the exterior of the upper portion 19*a* of the packing sleeve. At the same time, this fluid under pressure tending to flow upwardly around the packing sleeve will also engage the inner seal ring 38 within the groove 35 and force it upwardly along the body 10 of the packer and against the upper tapered side 36 of the packing sleeve defining the inner groove. The engagement of the ring with this tapered side urges the ring 38 inwardly against the periphery of the body 10. In addition, the pressure of the fluid acting upwardly on the seal ring 38 causes the latter to exert a mechanical force on the upper portion 19*a* of the packing sleeve exerted partially in an outward direction, and tending to maintain the upper outer portion 19*a* of the packing sleeve sealed against the inner wall of the well casing B.

If, instead of the fluid pressure differential being present below the well packer, it is present above the packing element 19, such fluid under pressure may then pass downwardly around the exterior of the imperforate upper portion 19*a* of the packing sleeve to its mid portion, flowing inwardly through the holes or passageways 37 in the mid portion into the groove 35 and acting on the lower tapered face 36 of the groove to urge the lower portion 19*b* of the packing sleeve in an outward direction, sealing it more firmly against the wall of the well casing B, and precluding downward flow of fluid between the exterior of the lower portion of the packing sleeve and the wall of the well casing. At the same time, this fluid under pressure will also act in a downward direction on the seal ring 38, shifting it downwardly along the body 10 and against the lower side 36 of the groove, placing the seal ring in leakproof engagement with the periphery of the body and also with the lower side of the groove, thereby preventing fluid from leaking between the periphery of the body 10 and the lower, inner surface of the packing sleeve. Again, the fluid pressure acting on the seal ring 38 exerts a mechanical force on the lower portion 19*b* of the packing sleeve partially in an outward direction, to insure the maintenance of a proper leakproof seal between the lower portion 19*b* of the packing sleeve and the wall of the well casing B.

The upper and lower parts 19*a*, 19*b* of the packing sleeve are essentially two opposed cut types of packing elements, each having a base portion bearing against its adjacent abutment 12 or 16, and a lip portion at the mid portion of the packing sleeve containing the passage holes 37, the lip portions being adapted to contact the well casing B upon expansion of the packing 19.

In the absence of the lateral passages 37 through the packing sleeve, it is found that the seal ring 38 within the internal groove 35 is still effective to prevent leakage be-

tween the interior of the packing sleeve **19** and the periphery of the packer body **10**. With a pressure differential acting from below the packing sleeve, any fluid pressure that might pass between the lower portion of the sleeve and the body **10** will act upon the seal ring **38** and wedge it between the upper wall **36** and the periphery of the body **10**, to preclude leakage between the upper portion **19***a* of the packing sleeve and the periphery of the body. Conversely, with a pressure differential above the packing sleeve **19**, any fluid under pressure that would leak between the upper portion of the packing sleeve and the body acts upon the seal ring **38** and moves it downwardly into engagement with the lower tapered side **36** of the groove and the periphery of the body, precluding leakage between the lower portion **19***b* of the packing sleeve and the body of the tool. The arrangement just described prevents leakage in both directions between the packing sleeve **19** and the exterior of the body **10**, whereas the arrangement illustrated in FIGS. 1 and 2, including the passages **37**, not only prevents the aforenoted leakage, but is found to be more effective in also preventing leakage in both directions around the exterior of the packing sleeve **19**, regardless of the direction in which fluid under pressure is acting.

In the form of invention disclosed in FIGS. 4 and 5, the internal seal ring or O ring **38***a*, made of pliant, elastic material, such as rubber or synthetic rubber, is mounted in an internal groove **50** in a filler ring **51** made of cast iron, or similar material, the filler ring **51** and seal ring **38***a* slidably engaging the periphery of the packer body **10**. The filler ring **51** is of the generally triangular shape shown, conforming essentially to the shape of an internal groove **52** formed in the mid portion of the packing sleeve **19***d*. Thus, the filler ring **51** has an upper surface **53** inclined in an upward and inward direction and engaging a companion inner wall **54** of the groove **52**, the filler ring also having a lower side **55** inclined in a downward and inward direction and engaging a companion lower side **56** of the groove. As disclosed, the mid portion of the packing **19***d* is imperforate, inasmuch as radial holes or passages are omitted therefrom.

As a result of the movement of the upper and lower abutments **12**, **16** toward each other, and the shortening of the packing sleeve **19***d* and its outward expansion into engagement with the wall of the well casing B, as well as with the periphery of the body, the foregoing arrangement is found to seal effectively under low pressure differentials, as well as high pressure differentials, and also under intermediate ranges of pressure. It is believed that the metal ring **51** and the seal ring **38***a* are effective in sealing off pressure, both internally of the packing element and externally thereof, since any fluid pressure that tends to leak under the packing, as from below, acts upon the metal ring **51** and tends to shift the metal ring upwardly of the expanded packing sleeve **19***d*. Because of the tapered relationship between the upper surface **53** of the metal ring and the companion upper side **54** of the packing sleeve groove **52**, such upward movement of the metal ring tends to expand the upper portion **19***e* of the packing sleeve more firmly against the periphery of the well casing B, thereby preventing fluid from flowing upward past the exterior of the packing sleeve. The pliant, elastic seal ring **38***a* in the metal ring **51** seals against the body **10** of the packer and precludes fluid from leaking through the interior of the packing sleeve.

On the other hand, if fluid pressure is acting on the packing assembly from above, it will tend to flow between the interior of the packing sleeve **19***d* and the body **10**, shifting the filler ring **51** downwardly of the body and the packing sleeve **19***d*, causing the lower tapered side **55** of the filler ring to engage the companion side **56** of the packing sleeve groove and urge the lower portion **19***f* of the packing sleeve outwardly more firmly against the wall of the well casing B, precluding leakage of fluid in a downward direction between the exterior of the packing sleeve and the casing. Similarly, the seal ring

38*a* within the metal ring **51** is deformed by the fluid pressure against the periphery of the packer body **10** to prevent leakage of fluid between the packer body and the lower portion of the packing sleeve.

I claim:

1. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means; and means in said space movable with respect to said mounting means and packing and engageable with said mounting means and packing, said means in said space comprising a pliant, elastic annular member slidably sealing against said mounting means.

2. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means and defined by opposed side walls diverging with respect to each other in a direction toward the axis of said mounting means; and means in said space movable with respect to said mounting means and packing and engageable with said mounting means and side walls, said means in said space comprising a pliant, elastic annular member slidably sealing against said mounting means.

3. In a well tool to be lowered in a well conduit disposed in a well bore; mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abtuments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means; means in said space movable with respect to said mounting means and packing and engageable with said mounting means and packing, said means in said space comprising a pliant, elastic annular member slidably sealing against said mounting means; said mid portion having fluid passage means extending from its exterior between said imperforate portions to said space to permit fluid under pressure to pass from the exterior of said packing into said space and act on said imperforate portions to force said imperforate portions outwardly into engagement with the well conduit and also act on said means in said space to force said means in said space against said packing and its annular member against said mounting means.

4. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means and defined by opposed side walls diverging with respect to each other in a direction toward the axis of said mounting means; means in said space movable with respect to said mounting means and side walls, said means in said space comprising a pliant, elastic annular member slidably sealing against said mounting means; said mid portion having fluid passage means extending from its exterior between said imperforate portions to said space to permit fluid under pressure to pass from the exterior of said packing into said space and act on said imperforate portions to force said imperforate portions outwardly into engagement with the well conduit and also act on said means in said space to force said means in said space against said side walls and said annular member against said mounting means.

5. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means; and a pliant, elastic annular member in said space movable with respect to said mounting means and packing and engageable with said mounting means and packing.

6. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutmentss mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means and defined by opposed side walls diverging with respect to each other in a direction toward the axis of said mounting means; and a pliant, elastic annular member in said space movable with respect to said mounting means and packing and engageable with said mounting means and side walls.

7. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means; a pliant, elastic annular member in said space movable with respect to said mounting means and packing and engageable with said mounting means and packing; said mid portion having fluid passage means extending from its exterior between said imperforate portions to said space to permit fluid under pressure to pass from the exterior of said packing into said space and act on said imperforate portions to force said imperforate portions outwardly into engagement with the well conduit and also act on said annular member to force said annular member against said passage and against said mounting means.

8. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means and defined by opposed side walls diverging with respect to each in a direction toward the axis of said mounting means; a pliant, elastic annular member in said space movable with respect to said mounting means and packing and engageable with said mounting means and side walls; said mid portion having fluid passage means extending from its exterior between said imperforate portions to said space to permit fluid under pressure to pass from the exterior of said packing into said space and act on said imperforate portions to force said imperforate portions outwardly into engagement with the well conduit and also act on said annular member to force said annular member against said side walls and against said mounting means.

9. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means; a ring in said space movable with respect to said mounting means and engageable with said packing, said ring having an internal circumferential groove; and a pliant, elastic annular member in said groove slidably sealing against said mounting means.

10. In a well tool to be lowered in a well conduit disposed in a well bore: mounting means; upper and lower abutments mounted on said mounting means and movable longitudinally with respect to each other; an inherently retracted, pliant, elastic one-piece packing mounted on said mounting means between and engageable with

said abutments; said packing including upper and lower base portions engaging said upper and lower abutments, respectively, a mid portion, and an imperforate portion between said mid portion and each base portion adapted to be expanded into sealing engagement with the well conduit upon relative movement of said abutments toward each other to move said base portions toward each other, said mid portion having an internal circumferential space therewithin confronting said mounting means and defined by opposed side walls diverging with respect to each other in a direction toward the axis of said mounting means; a ring in said space movable with respect to said mounting means, said ring having tapered

sides companion to and engageable with the side walls of said packing, said ring having an internal circumferential groove; and a pliant, elastic member in said groove slidably sealing against said mounting means.

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