

Aug. 8, 1967

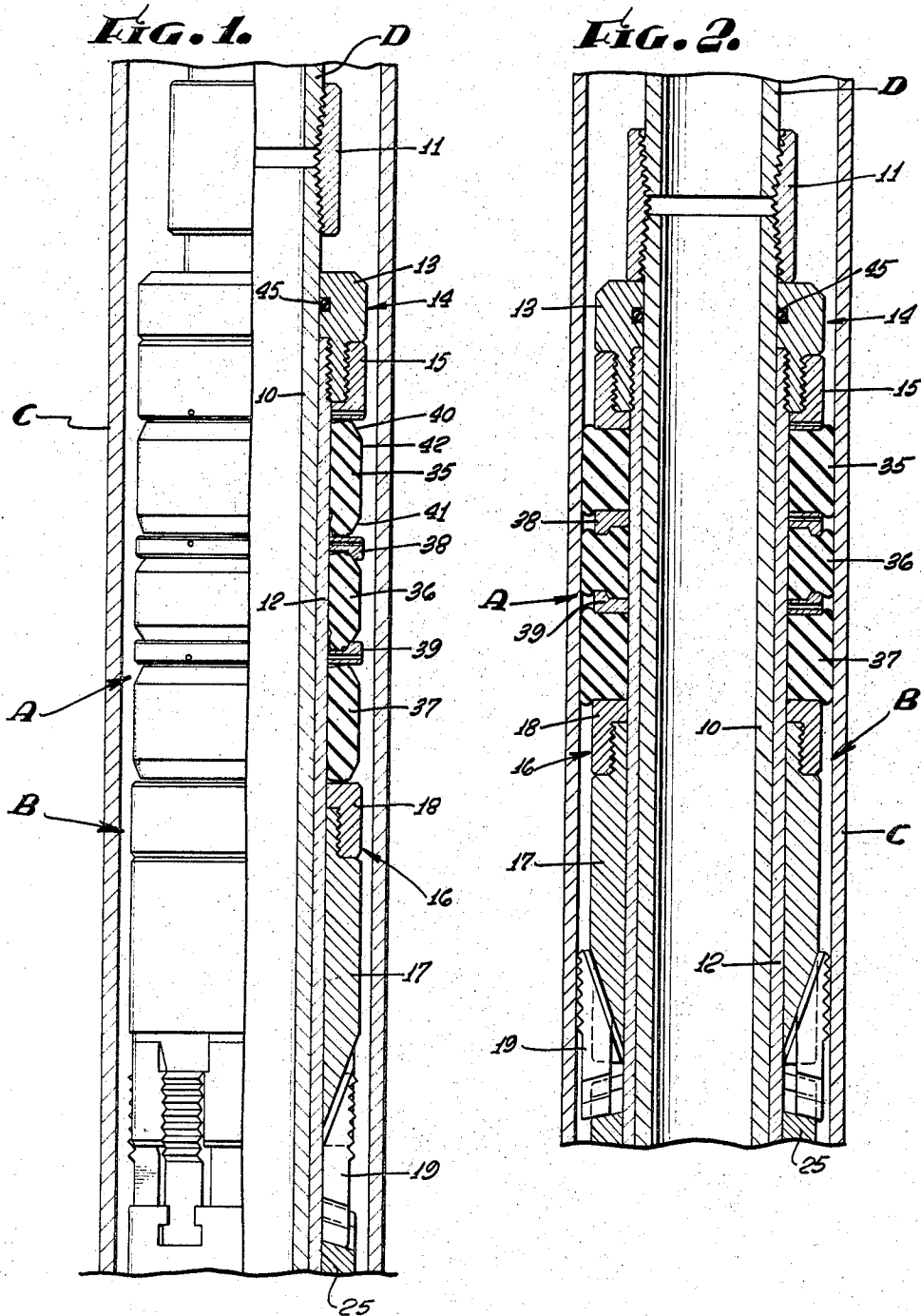
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3,334,907

PACKING STRUCTURE FOR SUBSURFACE WELL APPARATUS

Filed Aug. 24, 1964

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 3.

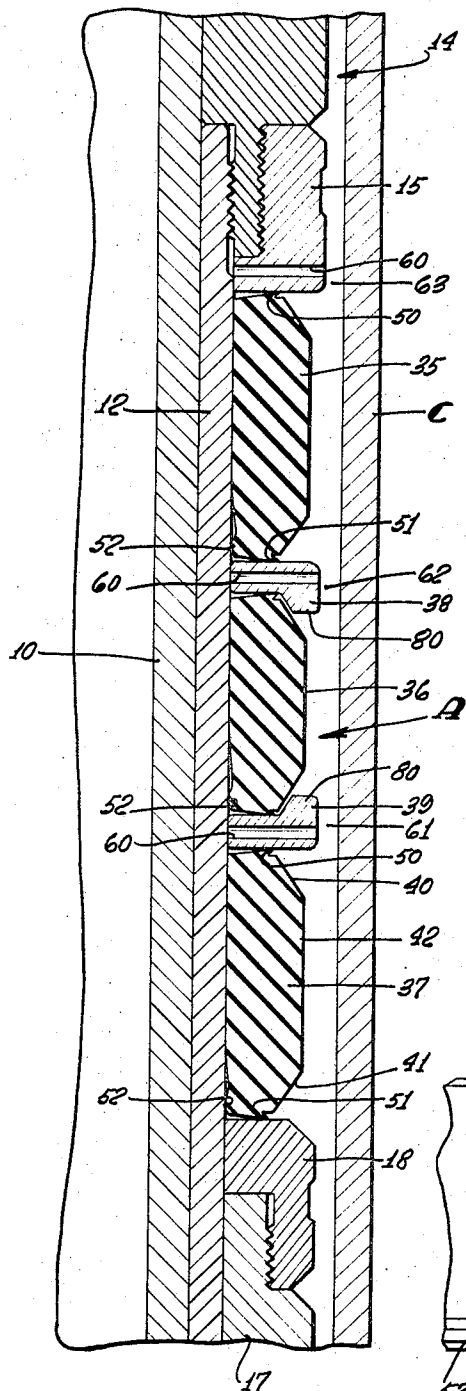


FIG. 4.

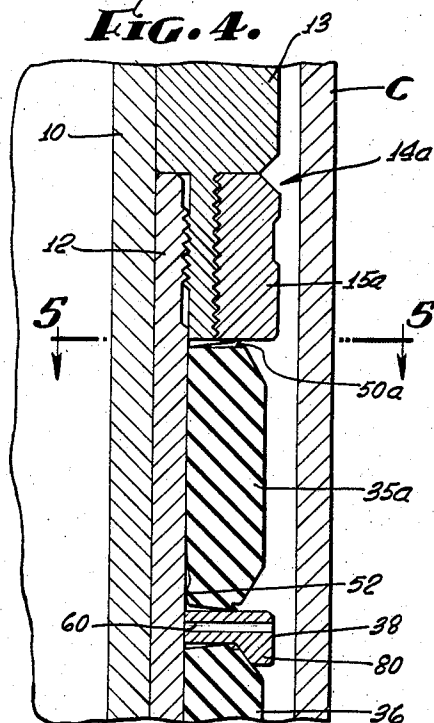


FIG. 5.

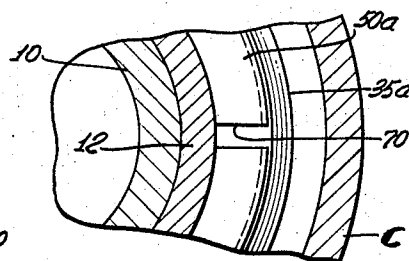
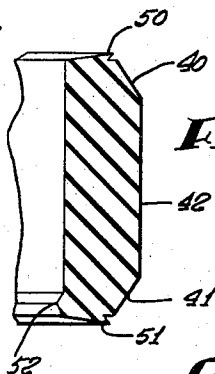


FIG. 6.



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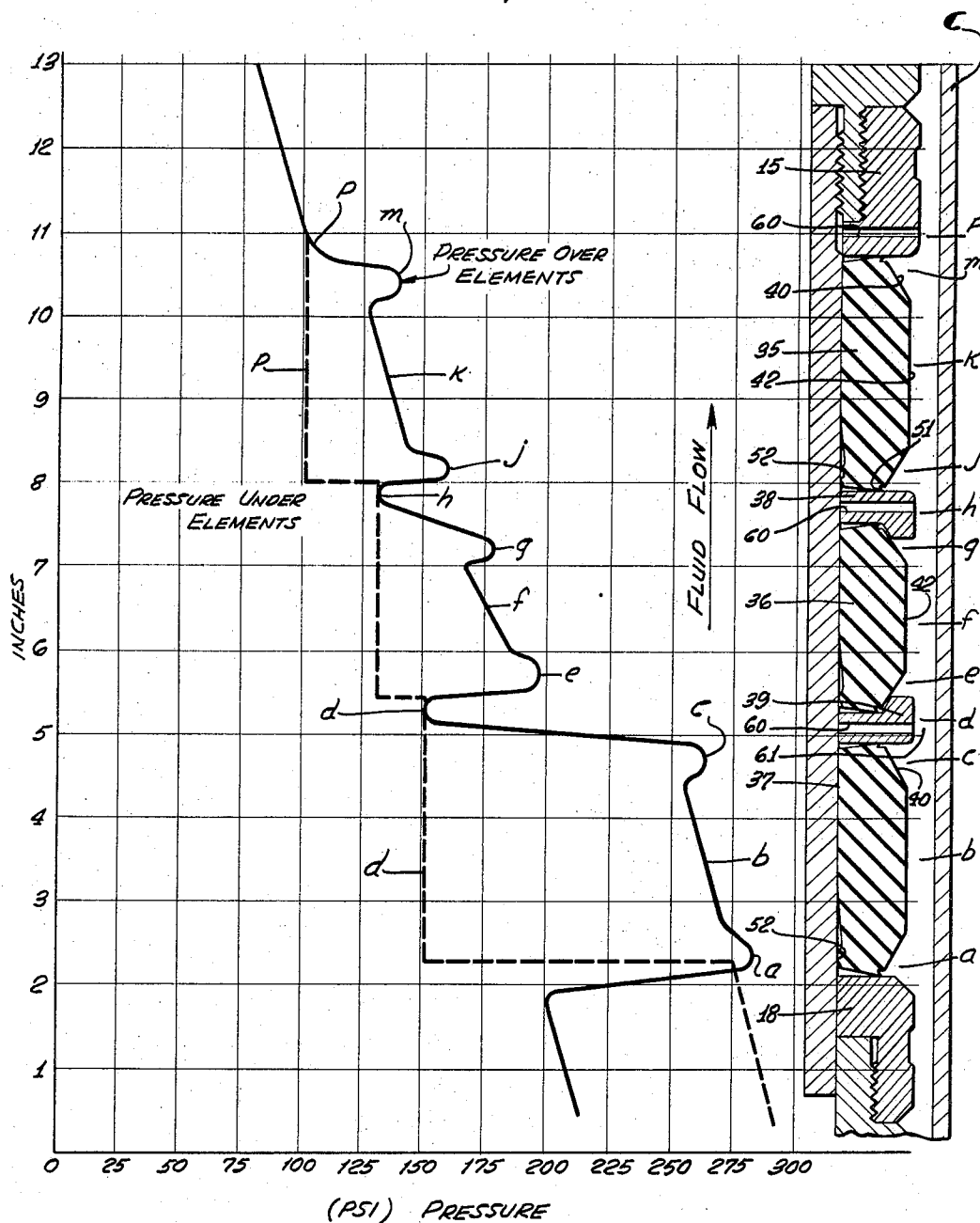
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3 Sheets-Sheet 3

FIG. 7.



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3,334,907 PACKING STRUCTURE FOR SUBSURFACE WELL APPARATUS

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Filed Aug. 24, 1964, Ser. No. 391,692
18 Claims. (Cl. 277—70)

The present invention relates to well apparatus, and more particularly to normally retracted packing or sealing structures adapted to be expanded into sealing relation with the wall of a surrounding well bore or conduit string, such as well casing.

Heretofore, subsurface well apparatus, such as packers embodying normally retracted elastic packing elements or structures, have been run in well casing to a desired setting point, after which an endwise compressive force has been imposed on the packing device to shorten it and thereby expand it into sealing relation against the wall of the well casing.

During lowering of the apparatus through fluid in the well casing or well bore, the fluid flowing relatively upwardly past the normally retracted packing structure exerts sufficient force therein, as a result of the pressure generated in the well bore fluid, to effect inadvertent outward expansion of the packing elements against the well casing. Such expansion may be due to the endwise force exerted by the fluid against the lower end of the packing element, tending to shorten it and expand it outwardly, or due to the fluid pressure passing to the interior of the packing element and ballooning it outwardly, or both.

The same inadvertent expansion has occurred in the absence of lowering the apparatus through fluid in the well casing or well bore, as for example, upon pumping or circulating fluid down through the tubular string to which the apparatus is secured, the fluid discharging from the apparatus and then flowing upwardly around the exterior of the apparatus and its normally retracted packing structure.

Accordingly, an object of the present invention is to provide subsurface well apparatus embodying a normally retracted packing structure in which the fluid pressure developed at the packing structure, as a result of lowering the apparatus through fluid in the well bore, or otherwise circulating fluid thereby, is incapable of expanding the packing structure against the wall of the surrounding well casing or well bore.

Another object of the invention is to provide subsurface well apparatus embodying a normally retracted packing structure in which a fluid pressure differential is developed at the packing structure as a result of lowering the apparatus through fluid in a well bore, or otherwise circulating fluid thereby, which tends to retain the packing structure in its retracted position rather than expanding it outwardly.

A further object of the invention is to provide subsurface well apparatus embodying a normally retracted packing structure of the type expandable outwardly by exerting an axial or endwise pack-off force thereon, in which the fluid pressure developed at the packing structure as a result of lowering the apparatus through fluid in a well bore or otherwise circulating fluid thereby is incapable of expanding the packing structure against the wall of the surrounding well casing or well bore, the axial force to effect expansion of the packing structure being relatively low when expansion is desired.

An additional object of the invention is to provide subsurface well apparatus embodying a normally retracted packing structure in which a fluid pressure differential is

developed at the packing structure as a result of lowering the apparatus through fluid in a well bore, or otherwise circulating fluid thereby, tending to retain the packing structure in its retracted position rather than expanding it outwardly, the pressure internally and externally of the packing structure being substantially equal when its outward expansion is desired, holding to a minimum the force required to effect a full and complete pack-off of the packing structure against the wall of the well bore or casing.

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 combined longitudinal section and side elevational view of an apparatus embodying the invention, with the packing structure in its retracted position;

FIG. 2 is a longitudinal section through the apparatus disclosed in FIG. 1, with the packing structure expanded against the wall of the surrounding well casing;

FIG. 3 is an enlarged fragmentary sectional view of the packing structure disclosed in FIG. 1;

FIG. 4 is a longitudinal section of a portion of a modified packing structure;

FIG. 5 is a section taken along the line 5—5 on FIG. 4;

FIG. 6 is a sectional view of a portion of a packing element embodied in and forming part of the packing structure;

FIG. 7 is a view of the packing structure disclosed in FIG. 1, with the fluid pressures imposed on the packing structure as a result of fluid flowing thereby being represented graphically.

As disclosed in the drawings, a packing structure A constitutes part of a well packer B adapted to be lowered through fluid in a well casing C by means of a tubular running-in string D extending to the top of the well bore. The packing structure can be used in a variety of well packers. By way of example, a portion of a well packer is disclosed, which includes a tubular body 10, the upper end of which is threadedly attached to a body coupling 11, which is, in turn, threadedly attached to the lower end of a tubing section D thereabove. Surrounding the body is a sleeve or outer body 12 threadedly secured to an upper head 13 forming a portion of an upper abutment 14, an upper gage ring 15 being threaded on this head. A lower abutment 16 is slidably mounted on the sleeve or body 12 and may be constituted as a lower expander 17 with a lower gage ring 18 threadedly mounted thereon. The expander 17 is adapted to move relatively downwardly within a plurality of tapered slips 19 carried by a slip ring 25 slidably mounted on the body 12 for the purpose of expanding the slips outwardly into anchoring engagement with the wall of the well casing C. The control mechanism for initially retaining the slips 19 in retracted position, or for that matter initially preventing inadvertent upward movement of the expander 17 along the sleeve 12, forms no part of the present invention, and for that reason is not illustrated. Such control mechanisms are well known, and may include, for example, a simple J-slot and pin arrangement (not shown).

The packing structure A specifically illustrated includes upper, intermediate and lower pliant elastic packing elements 35, 36, 37 made of rubber or rubber-like material,

although it is to be understood that the invention is applicable to a packing structure embodying a single packing element. The upper element 35 has its upper end engaging the gage ring 15 of the upper abutment and its lower end engaging a spacer ring 38, which, in turn, is engaged by the upper end of the intermediate element 36. The lower end of the intermediate element engages a spacer ring 39, which, in turn, engages the upper end of the lower element 37. The lower end of such element engages the lower abutment or gage ring 18.

Each packing element has its upper and lower ends 40, 41 tapered or beveled, its outer surface 42 between such beveled portions being cylindrical and having an initial diameter substantially less than the internal diameter of the well casing C in which the apparatus is run, and against which the packing elements 35, 36, 37 are to be expanded. The packing elements inherently or normally tend to occupy a retracted position, such as disclosed in FIGS. 1 and 3. They are expanded outwardly by moving the upper abutment 14 towards the lower abutment 16. As illustrated, after the setting point in the well casing is reached, the tubing string D is appropriately manipulated to release the lock or control mechanism (not shown) retaining the slips 19 in retracted position, so that the tubing string and body can be moved downwardly, a suitable device, such as friction drag springs or blocks (not shown) engaging the wall of the casing C resisting the downward movement of the slips. As the body 10 moves downwardly, its coupling 11 engages the upper abutment head 13, the packing structure A and expander 17 then being shifted downwardly as a unit, the expander moving within the slips 19 and expanding them outwardly against the wall of the well casing.

Upon anchoring engagement of the slips 19 with the casing wall, the expander 17 and the lower abutment 16 cannot move downwardly to any further extent. Accordingly, the exertion of a downward force on the tubing string D and body 10 will shift the upper abutment 14 toward the lower abutment 16, shortening the lengths of the packing elements 35, 36, 37 and expanding them outwardly into firm sealing engagement with the wall of the well casing C and also against the sleeve or body 12, the parts then being disposed in the position illustrated in FIG. 2, in which the well packer B is anchored in packed-off condition in the well casing against downward movement therewithin. As assurance that fluid leakage will not occur between the inner body 10 and the outer body 12, a suitable side seal ring 45 is mounted in the upper head 13 which seals against the periphery of the body 10.

During lowering of the well packer apparatus B in the well casing C, the fluid therein flows relatively upwardly past the packing elements 35, 36, 37, a pressure being developed in the fluid which tends to exert an upward force against the lower end of each packing element and shift it in an upward direction, to effect its shortening and outward expansion. Even a partial outward expansion restricts the annular path of the fluid flow relatively upwardly along each packing element, thereby increasing the back pressure of the fluid which additionally forces the packing elements upwardly to shorten and effect their outward expansion. In addition to the tendency of the fluid pressure developed in the fluid in the well casing to shorten the packing elements, such fluid pressure also passes to the interior of each packing element 35, 36, 37, creating a greater pressure therewithin than occurs externally thereof. Such greater pressure tends to balloon or expand the packing elements outwardly against the casing wall. As a result of the foregoing, the fluid pressure effects an undesired outward expansion of each packing element, and may cause them to slide along the casing wall, creating a swabbing action in the well casing, if not actually tearing or otherwise disrupting the packing elements themselves.

The aforementioned action also tends to occur in the event fluid is pumped down the tubing string D and out through the lower end of the body 10, then passing upwardly through the annular spaces between the packing structure A and the wall of the well casing C.

The aforementioned difficulties are overcome with a packing system, such as disclosed in the drawings. The fluid pressure is prevented from exerting a sufficient upward force on the lower ends of each packing element as to effect their shortening, and it is also prevented from passing to the interior of the packing elements and thereby expand them outwardly. Contrary to this arrangement, the fluid pressure is availed of to actually exert an inward force retaining each packing element 35, 36, 37 in its retracted position. Despite the presence of such inward force, when the packing elements are to be shortened and expanded outwardly against the wall of the well casing C, the fluid pressure is equalized around each packing element so that no increase in the compressive force is required to effect full expansion of each packing element against the wall of the well casing, as well as against the body 12 that it surrounds.

As disclosed in FIGS. 1, 2, 3, 6 and 7, each packing element has upper and lower end or lip seals 50, 51, the seals extending laterally outwardly and in a direction toward adjacent abutment 15, 18 and spacer rings 38, 39. In addition, a seal 52 is provided between the lower portion of each packing element and the sleeve or body 12 on which it is mounted. Accordingly, as the packer B is lowered through fluid in the well casing, or in the event of the circulation of fluid through the packer and upwardly therearound, any fluid pressure developed will act on the lip seals 50, 51 and urge them into sealing engagement with their companion abutments 15, 18 or spacer rings 38, 39, thereby preventing the relatively high fluid pressure externally of each packing element from passing to its interior.

The seal between the lower portion of each packing element and the body 12 is effected, as shown in the drawings, by providing an inner seal or rib 52 projecting inwardly from the main body of the packing element, which will be compressed against the periphery of the sleeve 12 when the packing element is mounted thereon, since the normal unrestrained internal diameter of the rib 52 is less than the external diameter of the sleeve or body 12. Not only is fluid pressure externally of each packing element prevented from passing to its interior, but the packing element system disclosed actually produces an external pressure differential tending to force or urge each packing element inwardly against the sleeve or body 12, by causing the fluid flowing past the packing structure A to decrease the pressure internally of each packing element.

As shown in the drawings, the spacer ring 39 above the lower packing element 37 has one or a plurality of fluid ports 60 extending therethrough establishing communication between the exterior of the ring and the interior of the lower packing element 37 above its seal rib 52. A similar fluid or vent port 60 is provided in the spacer ring 38 above the intermediate packing element 36 and in the abutment or gage ring 15 above the uppermost packing element 35. Thus, the interior of each packing element above its sealing rib 52 communicates with the exterior of the ring thereabove, so that the pressure of the fluid in the interior of each packing element above its seal rib is substantially the same as the pressure of the fluid in the annular space 61, 62 or 63 between the periphery of the ring thereabove and the wall of the surrounding well casing C. The lower or end lip seal 51 prevents the fluid pressure at and externally of the lower end of its packing element from getting under it and tending to urge the packing element axially upwardly. If any fluid does get under the lower end of a packing element, it cannot pass to its interior because of the seal provided

by the rib 52 at the lower end portion of the element and the periphery of the sleeve or body 12.

Assuming that the well packer B and its packing structure A are in their initial position, as disclosed in FIGS. 1 and 3, and that the apparatus is being lowered through the liquid or fluent material in the well casing C on the tubing string D, such fluid will flow relatively in an upward direction past the packing structure. The pressure externally of the apparatus that it develops in moving through the fluid is prevented from being exerted within the interior of each packing element by the end lip seal 51 and by the seal rib 52 sealing against the periphery of the sleeve or body 12. Similarly, the fluid pressure surrounding the upper portion of each packing element cannot pass therearound to the interior of the packing element because of the sealing effectiveness of the upper lip seal 50 against the lower end of the adjacent ring 39, 38, 15. However, the fluid flowing through the annular space 61, 62 or 63 between each ring 39, 38 or 15 and the wall of the surrounding well casing effects a decrease in the pressure of the fluid within the ports 60 and, consequently, in the interior of the packing element above its seal rib 52 that is communicating therewith.

The total fluid pressure passing the exterior of each ring is represented by the sum of its static pressure and its velocity pressure. Because of the flow velocity past the fluid ports, the static pressure within the ports 60 will be decreased much in the nature of the aspirating effect of fluid flowing past an orifice, thereby causing the static pressure of the fluid within each packing element 37, 36, 35 to be less than the static pressure of the fluid externally and surrounding the packing element. Accordingly, there is a pressure differential created on the exterior of the packing element tending to urge it and hold it inwardly in its retracted position.

The static fluid pressure internally of each packing element can be made still less than the static fluid pressure externally thereof by providing each ring above a packing element with a greater external diameter than the external diameter of the cylindrical periphery 42 of the packing element therebelow. Accordingly, the fluid flowing upwardly past a packing element at a certain velocity must accelerate in flowing through the lesser annular area 61, 62 or 63 between the ring above the packing element and the surrounding well bore. Thus, the static pressure of the fluid moving past the fluid port 60 in a ring will be substantially less than the static pressure of the fluid surrounding the packing element itself. A greater pressure differential is thereby provided externally of the packing element with respect to the pressure internally thereof than would be available in the event that the diameters of the packing elements 35, 36, 37 and rings 15, 38, 39 were made equal, or substantially so.

The provision of a greater pressure differential externally of each packing element occurs under other operating conditions in the well bore. For example, if the setting location in the well casing has been reached and fluid is circulated down through the tubing string D and the packer body 10, which will then pass upwardly around the well packer B and through the annular spaces between the packing structure A and the wall of the well casing C, the same pressure differentials noted above will be developed, tending to force and hold each packing element in its inward, retracted position, rather than tending to effect an expansion of each packing element, as by acting over its lower end area to shorten it and expand it outwardly, and by its ability to flow along the lower end of the packing element into its interior, in order to swell and balloon the packing element outwardly, because of a greater pressure being developed interiorly of the packing element than exists externally thereof, much in the nature of a downwardly facing swab cup.

When the setting location is reached in the well bore, the well packer can be set in the manner described above merely by setting down on the tubing string D and body C

to shorten the packing structure and expand its packing elements laterally outwardly. The endwise mechanical force required to shorten each packing element and expand it outwardly is held to a minimum, since the interior and exterior of each packing element are in communication with each other. After relative fluid flow past each packing element has ceased, that is, with a quiescent fluid state in the well casing C with respect to each packing element, the port or ports 60 effect communication between its interior and exterior, so that the pressures internally and externally of each packing element are equal. Accordingly, there is no fluid pressure acting on any packing element 35, 36 or 37 tending to resist its outward expansion as a result of its being shortened. If, for example, the upper and lower ends of the packing element were sealed against the body 12, air at atmospheric pressure would be trapped within the element between its upper and lower ends, and the hydrostatic head of fluid in the well casing would tend to hold each packing element laterally inwardly. The exertion of the endwise force on each packing element for the purpose of shortening it and expanding it outwardly would then have to overcome the inward holding force of the external hydrostatic head. As a result, a much greater endwise or compressive force would be required to effect outward expansion of each packing element into firm sealing engagement with the wall of the well casing than is required in the packing structure illustrated in the drawings, in which there is no hydrostatic pressure differential present when a pack-off condition is to be achieved.

Actually, in expanding each packing element 35, 36, 37 in the system illustrated in the drawings, the exertion of an endwise or axial force thereon causes each packing element to first bulge outwardly to bring its mid-portion into contact with the casing C, after which the ends of the packing element are moved toward each other until a full and solid packed-off condition, such as illustrated in FIG. 2, has been achieved. A lesser packed-off force is required because of the ability of the packing element to bulge outwardly initially. Where the hydrostatic head differential is acting on the exterior of the packing element and tending to hold it inwardly, the outward bulging tendency is severely resisted, if not prevented entirely, being a partial cause of the necessity for imposing a much greater endwise force on the packing element to effect its full expansion into sealing engagement with the wall of the well casing and also against the periphery of the sleeve or body 12 that it encompasses.

The pressure relationship externally of the packing structure and its interior is shown diagrammatically in FIG. 7, which represents actual pressure readings taken with a typical flow rate of fluid past the packing elements, which, for example, could be approximate 400 gallons per minute. Two curves are disclosed in FIG. 7, the solid line representing the pressure externally of the packing elements 35, 36, 37 and adjacent rings 15, 38, 39, 18, and the broken line representing the pressure under the packing elements.

Beginning with the lower end of FIG. 7, the fluid flowing past the lower portion of the lower packing element 37 will have a relatively high static pressure due, in part, to the increased annular area *a* surrounding the lower beveled portion of the packing element and also the fluid turbulence created in such region. The pressure of the fluid flowing past the lower abutment or ring 18 is relatively low because of the relatively high velocity of the fluid passing through the restricted annular space between this ring and the well casing C. When the fluid reaches the lower beveled or tapered region *a* of the lower packing element, the area is much greater so that the velocity pressure decreases and the static pressure increases. Thus, at the region *a*, the pressure has a value designated *a* in the pressure diagram which has been increased somewhat because of the fluid turbulence in the region *a*. As the fluid flows upwardly through the region *b*

between the periphery of the lower packing element 37 and the casing C, its velocity increases relative to the region *a* and the static pressure *b* decreases, the decrease being progressive due to the friction pressure drop as the fluid flows along the packing element. When the region *c* is reached at the upper beveled portion 40 of the lower packing element, the fluid velocity again decreases because of the increased annular area, the static pressure increasing, as represented on the graph at *c*, some of the increase in pressure being due to the turbulence of the fluid in this area.

As the fluid flows through the region *d* between the periphery of the lower spacer ring 39 and the well casing C, its velocity increases because of the reduced annular area 61 through which the fluid must flow, the static pressure dropping considerably in the region of the port 60, the great drop in pressure being represented on the curve by the letter *d*. This is the same pressure that will be present interiorly of the lower packing element 37 above its seal rib 52, since such interior of the packing element is in fluid communication with the port 60. This pressure is also represented by the letter *d* in the broken line curve. It is evident that the pressure differential tending to hold the packing element 37 inwardly is the pressure at the region *b* surrounding the packing element and the internal pressure *d*. In the example shown in FIG. 7, such differential is in excess of 100 p.s.i., as read on the abscissa scale of the inches-pressure diagram.

As the fluid continues to flow upwardly, it will leave the restricted annular area around the ring 39 at the region *d* and pass through the region *e* where the intermediate packing element 36 is beveled. As in connection with the lower element, the pressure surrounding the lower portion of the rubber or rubber-like packing element 36 will increase substantially from the pressure *d*, being designated *e* on the curve. As the fluid flows upwardly past the cylindrical portion 42 of the intermediate packing element 36 through the region *f* the pressure progressively drops until the upper beveled region *g* is reached, whereupon it increases to a slight extent. The fluid then flows through the restricted annular area *h* surrounding the upper spacer ring 38, where the fluid accelerates considerably in velocity, the static pressure decreasing to a substantial extent, as represented at *h* on the pressure curve. The same pressure *h* will be present interiorly of the intermediate packing element 36 because of the communication between the annular space *h* and the interior of the packing element through the vent or equalizer port 60 extending through the ring 38. Again, there is a substantial pressure differential between the pressure *f* externally of the intermediate packing element 36 and the pressure *h* interiorly of the packing element, which is of the order of about 50 p.s.i. as shown on the diagram by way of example.

As the fluid continues to flow upwardly past the packing structure, it will enter the region *j* of greater area adjacent to the lower beveled portion of the upper packing element 35, the pressure rising to the value *j*, as shown on the pressure diagram, after which the fluid flows upwardly through the region *k* surrounding the periphery 42 of the packing element 35, whereupon the pressure *k* progressively drops until the upper region of turbulence *m* at the upper beveled portion 40 of the upper packing element is reached, where the pressure *m* will again increase. From this region, the fluid will flow past the restricted annular space *p* surrounding the upper gage ring 15, where its velocity is increased substantially, resulting in a reduced static pressure *p* at the region of the port 60 which will result in the same pressure *p* being present in the interior of the upper packing element 35 above its seal rib 52, as designated at *p* in the broken line curve, which indicates the pressure under the packing element. As in connection with the other packing elements, a pressure differential is present externally of the packing element, tending to hold it

inwardly, such differential being shown in the graph as being about 35 p.s.i.

It is evident that the seal assembly disclosed results in the presence of a greater pressure differential externally of each packing element than exists internally thereof during the time that fluid is flowing relatively past the packing element, which will retain each packing element in its retracted position. The fluid pressure externally of and at the lower end of each packing element cannot pass inwardly thereof because of the sealing action of the lip seal 51 against its companion ring member or abutment. Moreover, the fluid pressure internally of a lower packing element cannot pass to the interior of a packing element thereabove because of the sealing action of the rib seal 52 against the periphery of the sleeve or body 12. Thus, each packing element is actually a separate hydraulic unit, in which fluid flowing past its exterior will exert a pressure differential tending to hold it inwardly.

Despite the fact that the fluid pressure developed in the well casing or well bore tends to hold each packing element inwardly, upon cessation of such fluid flow, which may result from the arresting of downward movement of the apparatus in the well casing, or as a result of the cessation of pumping of fluid down through the tubing string C and body 10 of the well packer for upward movement past a stationary apparatus B, the internal and external pressures become equalized because of the intercommunicating ports or passages 60. Accordingly, there is no fluid pressure differential acting across the packing element which, for example, might tend to hold it inwardly. Accordingly, such pressure differential need not be overcome in shortening each element 35, 36 or 37 to expand it outwardly, the expanding force being held at a minimum for effective sealing of each element against the wall of the well casing C and against the periphery of the sleeve or body 12.

In the form of invention illustrated in FIGS. 4 and 5, the upper abutment 14a may not have a port there-through. As an example, a gage ring 15a is merely threaded onto a threaded portion of the head 13. However, a low pressure interiorly of the uppermost packing element will still be obtained by cutting transverse and radial slots 70 through the upper lip sealing portion 50a of the packing element 35a, establishing communication between its interior and exterior. The pressure at the lip seal 50a will still be less than the general pressure externally of the packing element 35a therebelow, so that the pressure internally of the packing element above its sealing rib 52 will be less than the external pressure, the external pressure tending to hold the packing element in its retracted position. When fluid flow past the upper packing element ceases, the internal and external pressures will equalize because of the intercommunicating slot or port 70 through the upper lip member 50a, facilitating shortening of the packing element 35a and its outward expansion against the well casing C.

If desired, the intermediate packing element 36 may be made of a softer rubber or rubber-like material than the upper and lower packing elements 35, 37. To assist in the retention of such packing element 36 in its retracted position, the separator rings 38, 39 may have axial flanges 80 facing one another and encompassing at least partially the upper and lower beveled portions 40, 41 of the intermediate packing element. Despite the fact that the intermediate element is made of a softer packing material, the pressure of the fluid flowing past it will still be incapable of shortening it and expanding it outwardly since the external pressure will be predominant. When the intermediate packing element 36 is to be expanded, such expansion will occur with lower axial forces imposed thereon because of its lesser resistance to deformation.

ally outwardly; said packing member having an inner circumferential rib at one end portion thereof engaging and sealing against the periphery of said body; said packing member having an end seal at said one end portion sealing against an abutment at said one end portion; means providing a passage establishing fluid communication between the interior of said packing member and its exterior at its other end portion; and means for causing fluid flowing past the exterior of said packing member and said passage to produce a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

10. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said packing member having an inner circumferential rib at its lower portion engaging and sealing against the periphery of said body; said packing member having an end seal at its lower end portion sealing against said lower abutment; means providing a passage establishing fluid communication between the interior of said packing member and its exterior at its upper end portion; and means for causing fluid flowing relatively upwardly past the exterior of said packing member and said passage to produce a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

11. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; said packing member having an inner circumferential rib at one end portion thereof engaging and sealing against the periphery of said body; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said abutment at the other end portion of said packing member having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; and means for causing fluid flowing past the exterior of said packing member and said passage to produce a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

12. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; said packing member having an inner circumferential rib at its lower portion engaging and sealing against the periphery of said body; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said upper abutment having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; and means for causing fluid flowing relatively upwardly past the exterior of said packing member and said passage to produce a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

13. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic

packing member on said body having an external cylindrical surface; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; means providing a seal between said body and said packing member at one end portion thereof; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said abutment at the other end portion of said packing member having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; the diameter of said abutment at said other end portion of said packing member being substantially greater than the diameter of the external cylindrical surface of said packing member, whereby fluid flowing past the exterior of said packing member, abutment at said other end portion and passage produces a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

14. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body having an external cylindrical surface; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; means providing a seal between said body and said packing member at its lower end portion; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said upper abutment having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; the diameter of said upper abutment being substantially greater than the diameter of the external cylindrical surface of said packing member, whereby fluid flowing past the exterior of said packing member, upper abutment and passage produces a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

15. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body having an external cylindrical surface; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; said packing member having an inner circumferential rib at one end portion thereof engaging and sealing against the periphery of said body; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said abutment at the other end portion of said packing member having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; the diameter of said abutment at said other end portion of said packing member being substantially greater than the diameter of the external cylindrical surface of said packing member, whereby fluid flowing past the exterior of said packing member, abutment at said other end portion and passage produces a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

16. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body having an external cylindrical surface; upper and lower abutments on said body engaging upper and lower portions of said packing mem-

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ber, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; said packing member having an inner circumferential rib at its lower portion engaging and sealing against the periphery of said body; said packing member having upper and lower end seals sealing against said upper and lower abutments, respectively; said upper abutment having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; the diameter of said upper abutment being substantially greater than the diameter of the external cylindrical surface of said packing member, whereby fluid flowing past the exterior of said packing member, upper abutment and passage produces a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

17. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; means providing a direct seal between said body and said packing member at its lower end portion; said packing member having upper and lower end lip seals sealing against said upper and lower abutments, respectively, to prevent inward passage of fluid from the exterior of said packing member to its interior; said upper abutment having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; and means for causing fluid flowing past the exterior of said packing member, upper abutment and passage to produce a lesser static pressure in said

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passage and interior of said packing member than the static pressure externally of said packing member.

18. In a well tool adapted to be disposed in a well bore: a body; a normally retracted annular pliant elastic packing member on said body having an external cylindrical surface; upper and lower abutments on said body engaging upper and lower portions of said packing member, respectively, and movable toward each other to shorten and expand said packing member laterally outwardly; said upper and lower abutments being disconnected from said packing member; said packing member having an inner circumferential rib at its lower portion engaging and sealing against the periphery of said body; said packing member having upper and lower end lip seals sealing against said upper and lower abutments, respectively, to prevent inward passage of fluid from the exterior of said packing member to its interior; said upper abutment having a passage therethrough establishing fluid communication between its exterior and the interior of said packing member; the diameter of said upper abutment being substantially greater than the diameter of the external cylindrical surface of said packing member, whereby fluid flowing past the exterior of said packing member, upper abutment and passage produces a lesser static pressure in said passage and interior of said packing member than the static pressure externally of said packing member.

References Cited

UNITED STATES PATENTS

2,193,587	3/1940	Fortune et al.	277—34
3,120,272	2/1964	Cochran	277—102 X
3,215,208	11/1965	Tamplen	277—102 X
3,227,462	1/1966	Tamplen	277—102 X

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