Aug. 28, 1956 A. K. KLINE ET AL 2,760,583

WELL PACKER AND TUBING STRING COUPLING THEREFOR

Original Filed Aug. 8, 1950 2 Sheets-Sheet 1

Fig. 1.

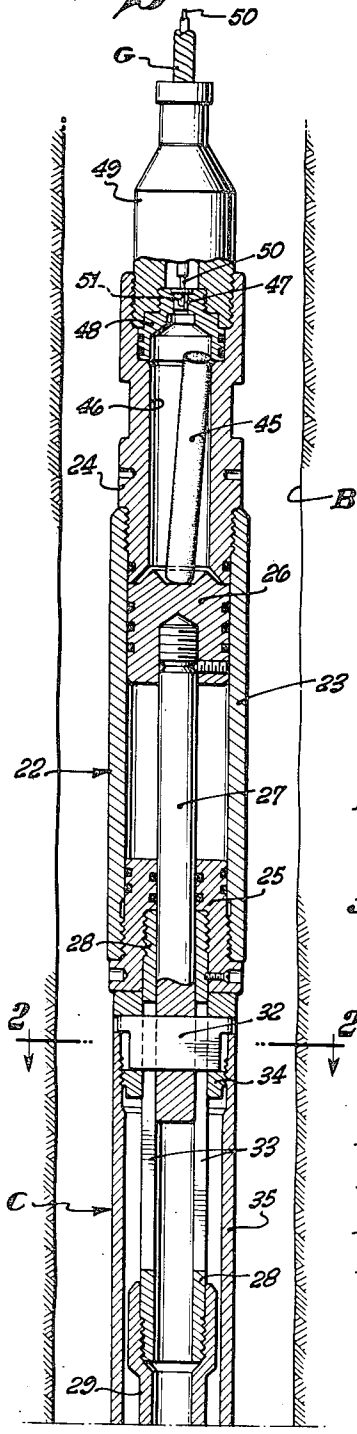


Fig. 1a.

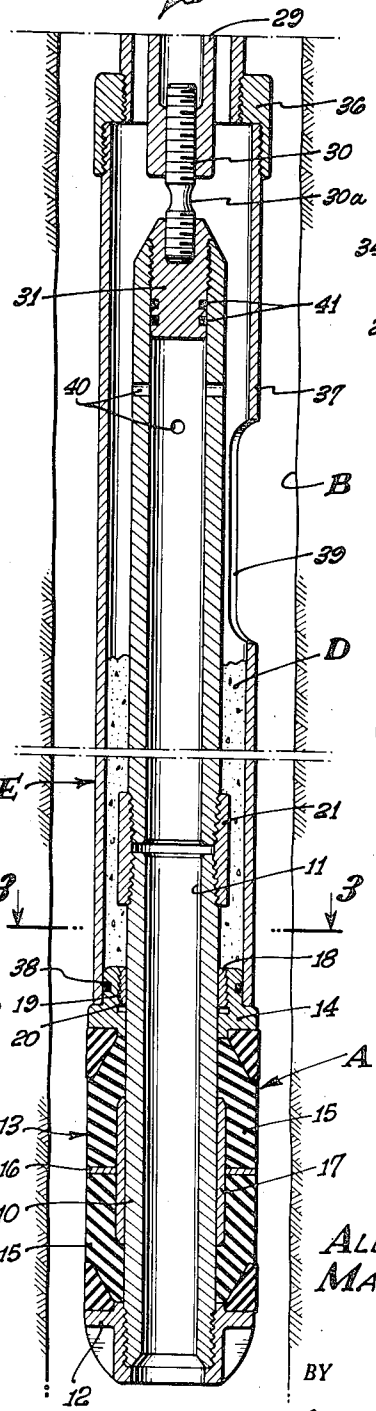


Fig. 2.

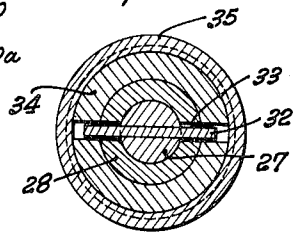
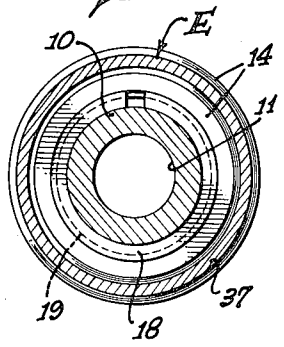


Fig. 3.



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Original Filed Aug. 8, 1950 2 Sheets-Sheet 2

Fig. 4.

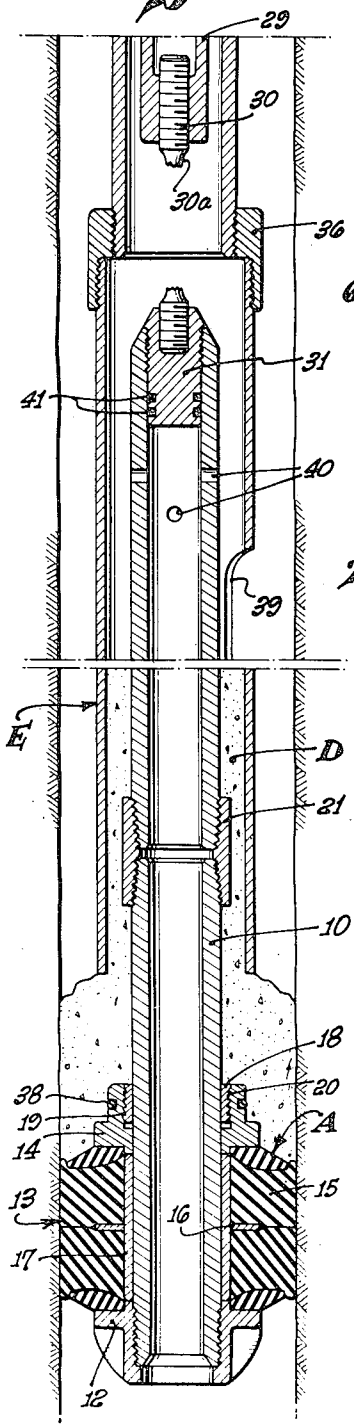


Fig. 5.

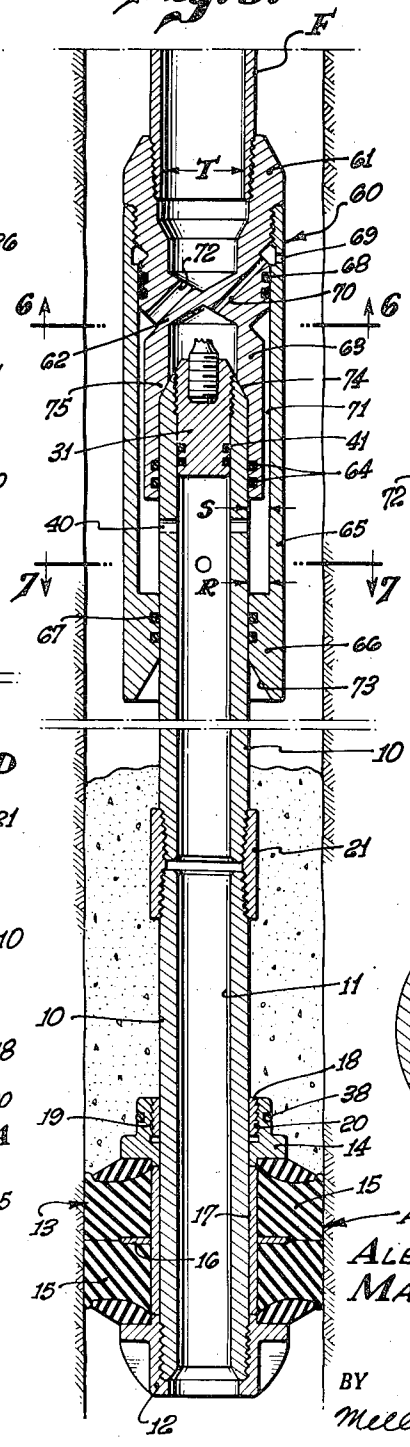


Fig. 6.

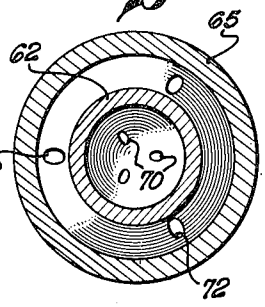
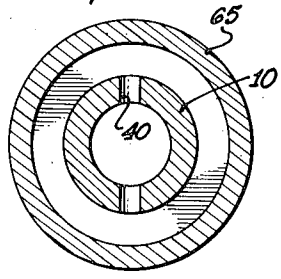


Fig. 7.



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WELL PACKER AND TUBING STRING COUPLING THEREFOR

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Original application August 8, 1950, Serial No. 178,212, now Patent No. 2,713,907, dated July 26, 1955. Divided and this application August 24, 1953, Serial No. 376,086

4 Claims. (Cl. 166—201)

The present invention relates to subsurface well tools, and more particularly to well packer apparatus adapted to be set in well bores.

This application is a division of our application for "Wire Line Packer and Tubing String Combination," Serial No. 178,212, filed August 8, 1950, now Patent No. 2,713,907.

An object of the invention is to provide a well packer having a packing element that resists buckling, especially when expanded outwardly to large extents.

Another object of the invention is to provide a well packer having a packing element that has a large extent of outward expansion, and which is capable of providing a plurality of seals against the wall of a well bore, or other confining enclosure.

A further object of the invention is to provide a well packer through which fluid can flow and having a comparatively long tubular body extension above its packing structure to enable cementitious material to be deposited around the body without plugging the body passage.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It 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:

Figures 1 and 1*a* together constitute a longitudinal section through a well apparatus disposed in an open well bore, Fig. 1*a* constituting a lower continuation of Fig. 1;

Fig. 2 is a cross-section taken along the line **2—2** on Fig. 1;

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

Fig. 4 is a view similar to Fig. 1*a*, illustrating the well packer set in the well bore and cementitious material being dumped upon it;

Fig. 5 is a view similar to Figs. 1*a* and 4, disclosing a tubing string in leakproof relation to the set well packer;

Fig. 6 is a cross-section taken along the line **6—6** on Fig. 5;

Fig. 7 is a cross-section taken along the line **7—7** on Fig. 5.

As disclosed in the drawings, the apparatus includes a well packer A adapted to be expanded to a substantial extent into leakproof engagement with the wall of an open well bore B. After having been set in the well bore by means of a setting tool C, the latter is released from the packer and cementitious material D, contained in the dump bailer portion E, of the setting tool dumped upon and around the set packer.

The cementitious material D sets and hardens in the well bore B to form a supplemental plug therein, which can also anchor the packer A in the well bore and hold

its main body portion **10** centered with respect to the well bore, in order that the subsequent leakproof association of a tubing string F with the packer can be facilitated. The well packer has a passage **11** therethrough which will communicate with the tubing string, to allow fluid to pass in both directions between the well bore B below the well packer A and the interior of the tubing string.

The well packer and setting tool combination are preferably run in the well bore on a wire line running-in string G, and after the packer has been set and the cementitious material D dumped thereupon, the setting tool C may be retrieved to the top of the well bore through elevation of the wire line.

The packer A disclosed in the drawings includes the tubular body portion **10**, which has a lower abutment and guide **12** threadedly secured on its lower end. A packing element or structure **13** surrounds the body, with its lower end resting upon the guide **12**, and with its upper end supporting an upper abutment **14** slidably mounted upon the packer body **10**. The packing element or structure **13** preferably includes a plurality of packing sleeves **15** which are separated by an intervening washer or disc **16**. Moreover, to limit the extent of outward expansion of the packing element, a tubular stop sleeve **17** is disposed therewithin, which is slidable relative to the tubular body **10**. Originally, this stop sleeve has a substantially shorter length than the distance between the upper and lower abutments **14**, **12**.

The packing element **13** is expanded outwardly into engagement with the wall of the confining well bore B by moving the abutments **14**, **12** toward one another, thereby foreshortening the packing sleeves **15** and causing the latter to bulge outwardly toward the formation. As explained hereinafter, a downward force is imposed upon the upper abutment **14** and an upward force on the tubular body **10** for the purpose of shifting the abutments toward one another. The extent of approach of the abutments is limited by their engagement with the upper and lower ends of the tubular stop sleeve **17**, which determines the maximum amount of outward expansion of the rubber packing sleeves **15** into engagement with the bore hole.

The abutments **12**, **14** are precluded from moving away from each other, thereby possibly allowing retraction of the packing sleeves **15**, by a one-way lock device of any suitable form. As disclosed, this lock device is mounted within the upper abutment **14**, consisting of a split sleeve **18** adapted to frictionally engage the exterior of the packer body **10**. This sleeve has outer downwardly inclined surfaces **19** engageable with companion inner surfaces **20** in the upper abutment **14**. It is apparent that downward movement of the upper abutment **14** along the body **10**, or relative upward movement of the tubular body within the upper abutment, is permitted by the sleeve **18**. However, movement of these parts in a reverse direction is precluded, since it effectively shifts the lock sleeve or ring **18** in a downward direction with respect to the upper abutment **14** and causes the coengaging cam faces **19**, **20** to wedge the sleeve more firmly into engagement with the packer body **10**.

The packing element or structure **13** has a comparatively long over-all initial length; so as to provide sufficient packing material for outward expansion to a substantial extent into engagement with the wall of the confining enclosure or well bore B. The making of this element as a single rubber sleeve, for example, might tend to cause its buckling during outward expansion to large extents, and an improper and inadequate pack-off against the wall of the well bore might result. Such single packing element might also become torn or ripped during the outward expansion.

It has been found that the aforenoted difficulties are minimized, if not entirely eliminated, by making the packing element **13** of the plurality of sleeves **15** separated by a spacer member **16**, such as the washer or disc. The outward expansion occurs through foreshortening each packing sleeve **15** and bulging it outwardly. The shorter sleeves tend to be anchored at each abutment **14**, **12** by frictionally engaging the latter, and their other ends also tend to be anchored by their frictional engagement against the spacer or separating washer **16**. As a result, it is the intermediate portions of each rubber sleeve **15** which moves outwardly, and, in view of the much shorter length of each sleeve, the buckling tendency is overcome and the sleeves expand outwardly uniformly around their circumferences.

In addition to preventing buckling, the plurality of bulges that are formed effectively provides individual seals of each rubber sleeve **15** against the formation wall. The plurality of seals thus provided appear to have a much greater anchoring effect against the wall of the formation, as well as a much greater sealing effectiveness, than a single rubber sleeve would have.

The packer A is of the type that will allow fluid to flow through it after it has been set in the well bore. For this reason, the body **10** is made tubular and it preferably extends to a considerable extent above the upper abutment **14**. As a matter of fact, the tubular body may be made of sections secured together through the agency of intervening couplings **21**. Such upward extension of the tubular body **10** is desired, since cementitious material D is to be deposited upon the set packer and around its upwardly extending body portion. This cementitious material, upon hardening, will form a supplemental plug in the well bore. In fact, it may well have a greater effectiveness as a plug in resisting the well pressures than the rubber packing sleeves **15**. In addition, it will serve to secure the packer body **10** firmly in the well bore by anchoring the coupling collars **21** to the cement D.

The packer A may be set and the cement D dumped upon the set packer in a single trip of the equipment in the well bore. This is accomplished by securing a combination setting tool and dump bailer C to the packer A. The lower portion of the setting tool, in effect, constitutes a dump bailer E.

The setting tool includes a power cylinder **22** consisting of a sleeve **23** threaded onto an upper cylinder head **24**, and also onto a lower cylinder head **25**. A piston **26** is slidably mounted in the cylinder and has a rod **27** secured to it, which extends downwardly through the lower head **25**.

In the operation of the equipment, a downward pressure is imposed upon the piston **26**, tending to move it downwardly in the cylinder **22**, and reactively, the cylinder tends to move in an upward direction. Since the packer A is set by moving the upper abutment **14** downwardly and the packer body **10** relatively upwardly, it is desired to transfer the upward force of the cylinder **22** to the packer body **10** and the downward force and movement of the piston **26** to the upper abutment **14**. The transfer of the upward force of the cylinder occurs by connecting the lower cylinder head **25** to a tubular mandrel **28**, whose lower end is secured onto a tension mandrel **29** threaded onto a tension stud **30**. The lower end of the stud is threaded into a plug **31** screwed into the upper end of the packer body **10**.

The piston rod **27** has a cross-piece or anvil **32** extending transversely through it, and also through a pair of opposed elongate slots **33** in the tension mandrel into a setting ring **34**. A setting sleeve **35** is threaded onto this ring and extends downwardly along the tubular mandrel **28** and tension mandrel **29**, its lower end being threaded into an adapter collar **36** screwed onto the upper end of a barrel or container **37** which actually constitutes the dump bailer portion E of the setting tool C. The lower

end of the container **37** bears upon the upper abutment **14**, leakage between the latter two parts being prevented by a suitable side seal **38** on the upper abutment engaging the inner wall of the container. The fluent cementitious material D may be introduced into the barrel **37**, and around the packer body **10**, through an upper window or opening **39** provided in the barrel.

For the purposes that will appear below, the upper end of the packer body has one or more side ports **40**, preferably disposed above the window or opening **39**, so as to prevent the cementitious material D from entering the interior of the packer body **10**, and possibly plugging it. It is also to be noted that the plug **31** carries one or more side seal rings **41** engaging the inner wall of the body **10**, to prevent leakage therealong, and that the stud **30** has an intermediate weakened section **30***a*, to enable disruption of the stud when sufficient tension is placed upon it, thereby automatically disconnecting the setting tool C from the packer A.

The piston **26** is moved downwardly within the cylinder **22** and the cylinder urged in a relative upward direction by developing a gaseous pressure in the upper portion of the cylinder. A power charge or railroad flare **45** is disposed in a combustion chamber **46** formed in the upper cylinder head **24**, this power charge being ignited by firing a cartridge **47** contained in a gun barrel **48** clamped between the upper head **24** and a cable head **49**, to which the lower end of the wire line G is secured. This latter member has a conductive core or wire **50** having an electrical connection with a heating filament **51** in the cartridge.

When current is caused to pass through the heating filament **51**, the cartridge **47** is fired; the flame issuing therefrom in a downward direction igniting the upper end of the power charge **45** and instituting its combustion. This power charge contains its own source of oxygen, and, as it burns, gas is evolved at a gradually increasing pressure. This gas under pressure forces the piston **26** downwardly in the cylinder **22**, the downward movement being transmitted through the piston rod **27**, anvil **32**, setting ring **34**, setting sleeve **35**, adapter collar **36** and container **37** to the upper packer abutment **14**. At the same time, the cylinder **22** is being urged in an upward direction, such upward movement being transmitted through the tubular mandrel **28**, tension mandrel **29**, tension stud **30** and plug **31** to the packer body **10**, which moves the lower body abutment **12** upwardly. In this manner, the upper and lower abutments **14**, **12** are shifted toward one another to bulge and expand the packing structure **13** in a lateral outward direction. Such expansion occurs progressively as the pressure in the cylinder **22** increases, due to the continued combustion of the power charge **45**. Eventually, expansion of the packing structure **13** can occur no longer because of engagement of the abutments **12**, **14** with the stop sleeve **17**. However, the gas pressure in the cylinder is continuing to increase, until the ultimate strength of the weakened section **30***a* of the tension stud **30** is exceeded, which results in a pulling apart of the tension stud and the detachment of the setting tool C from the well packer A. Following such detachment, the setting tool C can be elevated, preferably in a gradual manner, by elevating the wire line G, the lower end of the container **37** being moved upwardly off the upper abutment **14**, allowing the fluent cementitious contents D of the container to drop out upon the set packer A and around the packer body **10**. Inasmuch as the body ports **40** are above the container window or opening **39**, no cementitious material will pass through these ports during the dumping operation.

When all the cementitious material D has been emptied from the bailer E, the setting tool C can be removed from the well bore B.

The cementitious material D will set and harden in the well bore around the tubular packer body **10** and also

against the wall of the open hole. Upon hardening, an annular cement plug is formed in the well bore of extended extent, which is effectively anchored to the formation, in view of the irregularities present in the latter (Fig. 5). In addition, the coupling collars **21** in the body **10** are locked in the hardened cement, which prevents longitudinal displacement of the body in both directions. Deposit of the cement around the body **10**, particularly along an extended length of the latter, tends to maintain the body centered in the well bore, and resists its subsequent tilting or inclination.

After the cementitious material D has hardened, it is desired to relate a tubing string F to the set packer; so that any well production from below the packer A can be conducted to the top of the well bore through the tubing string. Instead of conducting well production, it is also possible to force or pump fluid down the tubing string F and through the packer body **10** to a point in the well bore below the latter.

The tubing string F has a sealing adapter structure **60** forming a part of its lower end, which is capable of being sealed off against the upper portion of the body **10** to conduct fluid between the interior **11** of the body and the interior of the tubing string F. The adapter consists of an upper head **61** threaded onto the lower end of a joint of tubing F, this upper head merging into a neck portion **62** from which an inner skirt **63** depends. This skirt has one or more side seals **64** adapted to seal off against the periphery of the tubular body **10** above its ports **40**.

The sealing adapter **60** also includes an outer sleeve **65** threaded onto the upper head **61** and extending downwardly along the neck portion **62** and inner skirt **63** to a substantial extent below the lower end of the latter. This outer sleeve has a lower head **66** provided with one or more side seals **67** adapted to engage the periphery of the tubular body below the body ports **40**.

Leakage between the neck portion **62** and the outer sleeve **65** is prevented by one or more seals **68** in the former engaging the inner wall of the latter. These seals prevent leakage in both directions and they preclude the fluid in the annulus around the tubing string F from entering the tubing string. This fluid is allowed to enter the adapter **60**, in view of the provision of a bleeder hole **69** in the outer sleeve **65** above the seals **68**, which communicates with the interior of the inner skirt **63** through a bleeder port **70** in the neck portion **62** of the device.

The inner skirt **63** is spaced from the outer sleeve **65**, forming an annular passage **71** therebetween through which well fluid can pass. The well production can flow upwardly through the tubular body **10**, thence laterally through the body ports **40** into the outer sleeve **65**, from where it will flow upwardly through the annular passage **71** between the outer sleeve **65** and skirt **63**, and thence through a fluid port **72** in the neck portion of the device, and on into the tubing string F.

The sealing adapter **60** is lowered in the well bore B on the lower end of the tubing string F. A tapered guide **73** is formed in the lower head **66**, which will engage the upper tapered portion **74** of the packer body **10**, and be centered with respect to the packer body. Such centering action properly relates the adapter **60** with the body **10**, and allows it to be moved thereover to the extent determined by engagement of a stop shoulder **75** in the inner skirt **63** with the tapered upper end **74** of the packer body. When these shoulders **75**, **74** engage, the skirt seals **64** engage the packer body **10** above the body ports **40**, and the lower head seals **67** engage the packer body **10** below the body ports **40**. While the skirt seals **64** are being moved downwardly along the body **10**, the fluid that would otherwise be trapped between the packer plug **31** and the neck portion **62** is allowed to escape through the bleeder port **70** and the bleeder hole **69** to the exterior of the apparatus.

The sealing adapter **60** is hydraulically balanced, in order that fluid pressure within the well packer A, adapter **60** and tubing string F will not tend to shift the tubing string longitudinally with respect to the packer. It is to be noted that the fluid in the annulus between the packer body **10** and outer sleeve **65** can act downwardly on the lower head **66** over the annular area R (Fig. 5). This same fluid under pressure can act in an upward direction on the adapter across the annular area S between the periphery of the packer body **10** and the inner surface of the outer sleeve. These two areas are equal; so that there is no tendency of the fluid within the apparatus to shift the adapter in either direction.

In addition, it is to be noted that the fluid under pressure within the tubing string F can act downwardly upon the neck portion **62** of the apparatus over the cross-sectional area T. But this same fluid is acting in an upward direction over the same cross-sectional area of tubing at the top of the well bore.

The foregoing comments show quite clearly that the internal pressure within the apparatus can have no tendency to shift the apparatus in either direction. As a result, there are no fluid loads due to internal pressure upon the equipment, either acting in an upward direction, which might tend to kink the tubing string F, or acting in a downward direction, that might tend to place an excessive strain on the tubing string or upon the packer itself. Moreover, in view of the hydraulically balanced condition, the tubing string F and adapter **60** can be moved easily over the packer body **10** when the equipment is being related to one another, and the adapter can be easily elevated from the packer body **10** in the event it is desired to withdraw the tubing string F.

Accordingly, subsurface well equipment has been provided which enables the well packer to be expanded to a substantial extent and anchored firmly in an open hole in such manner as to resist high pressures, and yet allow production to be had through the well packer A itself. The tubing string F can be readily placed in leakproof relation to the well packer merely by disposing its lower portion **60** along the packer.

The inventors claim:

1. In a well packer: a body; a packing structure including a plurality of elastic sleeves on said body; a stop member within said sleeves slidable on said body; a spacer member on said stop member and engaging the adjacent ends of said sleeves; upper and lower abutments on said body engaging the upper and lower ends of said packing structure; and means for exerting an upward pull on said body and a downward push on said upper abutment to longitudinally compress said sleeves and expand said sleeves laterally outward.

2. In a well packer: a body; a packing structure including a plurality of rubber sleeves on said body; a tubular stop sleeve within said rubber sleeves and slidable on said body; a rigid flat spacer disc surrounding and movable with respect to said stop sleeve and engaging the confronting ends of said rubber sleeves, said disc being movable longitudinally relative to said body; upper and lower abutments on said body engaging the upper and lower ends of said packing structure; and means for exerting an upward pull on said body and a downward push on said upper abutment to longitudinally compress said rubber sleeves and bulge said rubber sleeves laterally outward between said abutments and said disc.

3. In a well packer: a tubular body; a packing structure on said body sealed against said body; means for longitudinally compressing said packing structure to expand said packing structure outwardly; a plug rigidly secured to and closing the upper end of said body; said body extending a substantial distance above said packing structure and having an open lower end and a side port adjacent and below said plug to allow fluid to flow through said tubular body between a region below said packing

structure and a region externally of said body above said packing structure.

4. In a well packer: a tubular body; a packing structure on said body sealed against said body; means for expanding said packing structure outwardly of said body; a plug rigidly secured to and closing the upper end of said body; said body extending a substantial distance above said packing structure and having an open lower end and a side port adjacent and below said plug to allow fluid

to flow through said tubular body between a region below said packing structure and a region externally of said body above said packing structure.

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