

Jan. 7, 1958

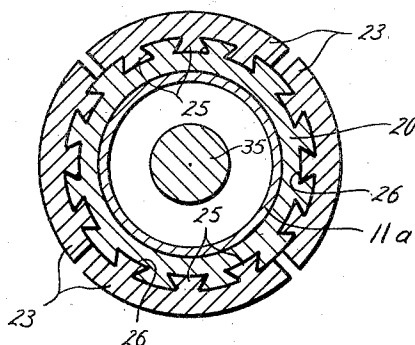
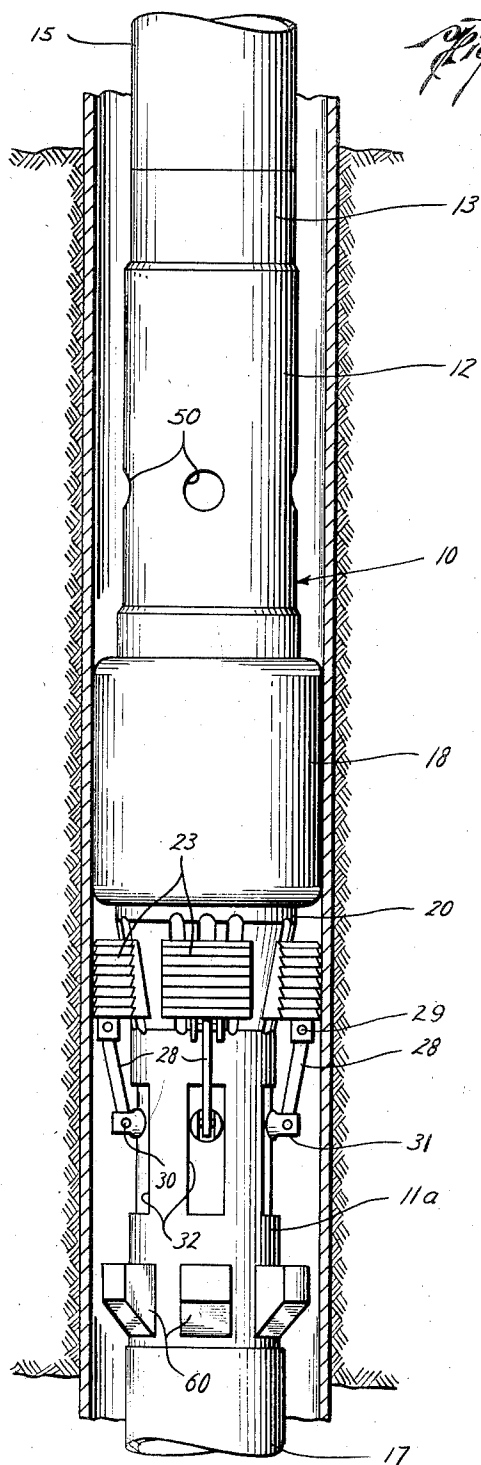
H. U. GARRETT ET AL.

2,818,925

WELL APPARATUS

Filed Aug. 13, 1954

3 Sheets-Sheet 1



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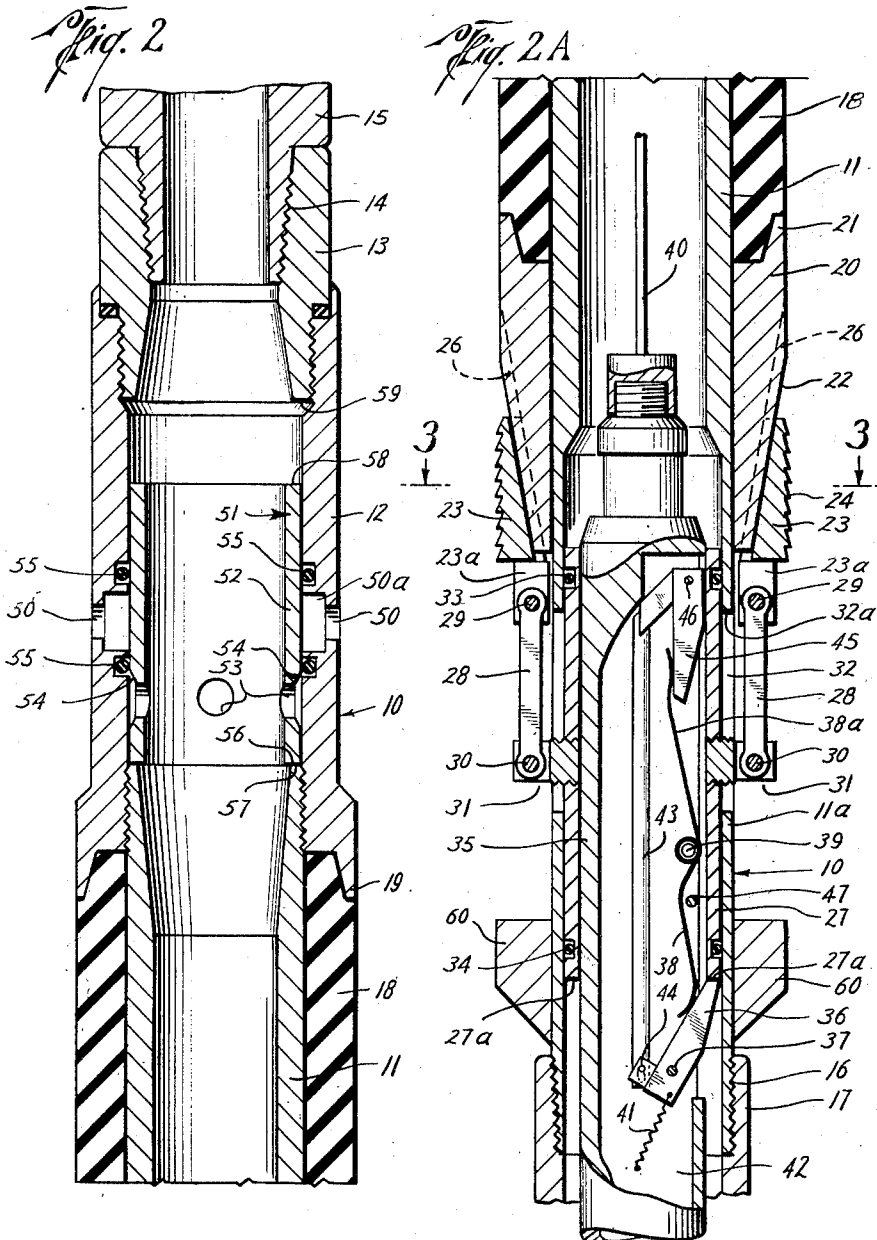
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WELL APPARATUS

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3 Sheets-Sheet 2



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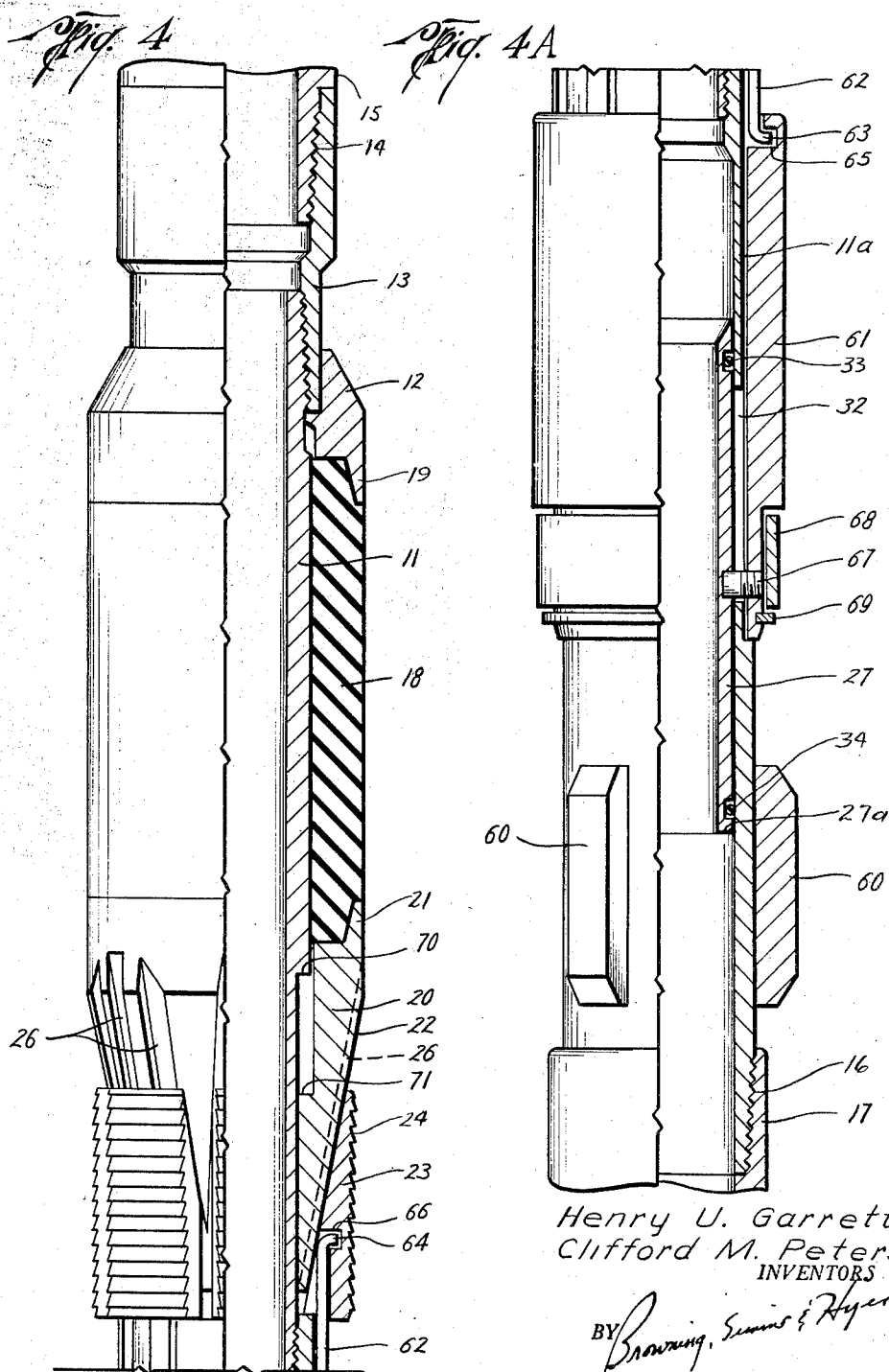
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WELL APPARATUS

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WELL APPARATUS

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Application August 13, 1954, Serial No. 449,632

1 Claim. (Cl. 166—131)

This invention relates to a well apparatus of the type having an expansible gripping means, such as slips, for anchoring one well conduit to another while in the well or for setting a packer or the like. In another of its aspects, the invention relates to a combination packer-circulating valve assembly adapted to be made up as a part of a tubing string in a well.

Well packers, tubing anchors, and the like are employed for performing many operations associated with the completion and production of oil, gas, water and other wells. In some instances, it is highly desirable that the packer be set accurately at a predetermined depth but this is impractical where substantial manipulation of the tubing is necessary in order to set the packer. Thus in many types of packers, it is necessary in order to set the same that the tubing be raised or lowered or rotated or both in order to release slips and then to move the tubing either upwardly or downwardly until the slips are set and then to further move the tubing until the packer element is expanded. In such an arrangement, the manipulation of the tubing not only makes it difficult to set a packer accurately at a predetermined depth but there is no assurance that the slips will always engage the casing at the point desired. Other types of packers, commonly termed "disc well packers," are set by breaking a frangible element extending across the bore of the packer so as to release the slips for setting with the casing. While this type of packer can be set without extensive tubing manipulation and can achieve delayed action setting, it is not possible to run tools through it without breaking the frangible element so that it must always be set before performing wire line operations through it. Still another type of packer employs fluid pressure to set the same but this is sometimes undesirable because of the necessary pressure manipulations. It would therefore be highly desirable to possess a packer or tubing anchor which could be set with substantially no tubing manipulation, would always have an unobstructed full-opening bore therethrough, and which would not require pressure manipulations to set the same.

It is therefore an object of this invention to provide an apparatus in which a retractable gripping means carried by one well conduit can be expanded into gripping relationship with another well conduit by a wire line manipulation controlled from the earth's surface thereby minimizing necessary manipulation of the well conduit, permitting a full-opening bore through the apparatus and avoiding the use of pressure manipulations to set the same.

Another object is to provide a well packer which can be set at any desired depth in a well by a wire line tool so that manipulation of the tubing can be substantially eliminated in setting the packer thereby increasing the accuracy in setting the packer at a preselected depth and also without necessarily employing fluid pressure to set the packer.

Another object is to provide a packer or the like including pipe gripping means settable by a wire line tool, the packer having a full-opening bore unobstructed and

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open at all times so that wire line or other operations can always be performed through the tubing both before and after the gripping means are set and yet the gripping means can be set at any time by a simple wire line operation.

Another object is to provide apparatus in which retractable pipe gripping means are set by wire line operation positively controlled from the earth's surface after the apparatus has been positioned at a predetermined depth in a well thereby avoiding premature setting of the gripping means while the apparatus is being run into the well or while tubing carrying such apparatus is being manipulated for various purposes.

Another object is to provide apparatus adapted to be made up as a part of a well conduit and carrying expansible gripping means exteriorly thereof, the apparatus having a part interiorly thereof adapted for manipulation by a wire line tool lowered through the interior of the conduit to control the exterior gripping means.

Another object is to provide a well packer which can be accurately set at a preselected depth in a well through a wire line manipulation and then released by a simple tubing movement, withdrawn from the well, or re-set without such withdrawing at a lesser or greater depth by again using a wire line tool.

In some well operations, particularly completion and work-over operations where a permanent type completion installation is employed, it would be desirable to possess a combination packer and circulating valve assembly permitting opening and closing of the circulating valve and passage of wire line tools or others through the assembly both before and after the packer is set and it is therefore another object of this invention to provide such a packer-circulating valve combination selectively manipulatable by a wire line tool so that operation of each of the packer and valve can be selectively controlled from the earth's surface to permit, for example, circulation downwardly through the tubing and then up the casing-tubing annulus, or vice-versa, before the packer is set or circulation through the casing-tubing annulus into the tubing, or vice-versa, or circulation through the casing-tubing annulus into a stinger tube-tubing annulus and thence up the tube and tubing, or vice-versa, after the packer is set.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon a consideration of the written specification, the appended claim, and the attached drawings wherein:

Fig. 1 illustrates a preferred embodiment of the packer-circulating valve combination of this invention installed in a well with the packer in expanded position;

Figs. 2 and 2A are vertical cross-sectional views of the packer-circulating valve arrangement of Fig. 1 except that the packer is shown in a retracted position and in Fig. 2A, one form of a wire line tool is shown positioned for manipulation of the combination, it being understood that Fig. 2A is a lower continuation of Fig. 2;

Fig. 3 is a cross-sectional view taken on the line 3—3 of Fig. 2A;

Figs. 4 and 4A are vertical views, partially in section and partially in elevation, showing another embodiment of the packer apparatus of this invention.

In general, the apparatus of this invention includes expansible pipe gripping means mounted exteriorly on a body with provision of means interiorly of the body which means are manipulatable by a wire line or other tool inside the body in order to actuate the pipe gripping means exteriorly of the body. Thus when the apparatus is made up as a part of a well tubing, it is possible to control a function exteriorly of the tubing by a manipulation performed interiorly of the tubing. In another of its aspects, the invention contemplates combining with the

foregoing apparatus a circulating valve which likewise is subject to being opened and closed by manipulation of a wire line tool interiorly of the body or tubing and arranged so that the valve and gripping means can be selectively operated to permit various well operations to be conducted.

Thus referring to Figs. 2 and 2A, there is shown a hollow or tubular body, designated generally by the numeral 10, comprising an inner mandrel 11, an outer housing 12 and an upper sub 13. Upper sub 13 and mandrel 11 are each provided with means for connecting body 10 as a part of a well conduit, such as through threads 14 permitting attachment of pin 15 of a tubing string and threads 16 permitting attachment of a coupling 17.

Disposed around inner mandrel 11 is an expansible resilient packing 18, made of rubber or the like, and adapted to be expanded outwardly into sealing engagement with a well casing. One (e. g. the upper) end of packing 18 is fixed against movement relative to body 10 as by being maintained in place by an annular lip 19 depending from housing 12. The other (or lower) end of the packing is fixed to an expander 20 (as by being bonded to lip 21), expander 20 being movable upwardly and downwardly relative to mandrel 11 in order to expand packing 18. Expander 20 is provided with an outer inclined or wedge surface 22 which diverges from the longitudinal axis of mandrel 11 and upon which is slidably supported a plurality of slips 23 each having teeth or wickers 24 for firm engagement with a well casing. The slips can be maintained in operative position with respect to expander 20 by any suitable means such as by the dovetail keys 25 on each of the slips fitting into corresponding dovetail keyways 26 in expander 20 (Fig. 3). With this arrangement, slips 23 are maintained adjacent surface 22 while sliding both upwardly and downwardly therealong to be expanded and retracted, respectively. The combination of expander 20 and slips 23 can be termed expansible pipe or casing gripping means to broadly designate the illustrated structure as well as others serving a similar ultimate function.

In accordance with this invention, the expansible pipe or gripping means is set by the wire line or other manipulation of a part situated interiorly of body 10 and linked to the gripping means so that setting or releasing of the gripping means is responsive to such manipulation of the part. Such part is illustrated in the drawing as a sleeve 27 shiftable longitudinally along a depending portion 11a of mandrel 11, portion 11a preferably being of increased internal cross-sectional area in order to accommodate sleeve 27 thereby permitting the latter to have substantially the same internal diameter as the bore tubing 15. This provides a full-opening bore through the apparatus to freely accommodate wire line tools or the like at all times.

A linkage is provided between sleeve 27 and slips 23 and such linkage can be in the form of link pins 28 each of which are pivoted at one end, as by pivots 29, to ears 23a on slips 23 and at their other end, as by pivots 30, to ears 31 carried by sleeve 27. Ears 31 of the sleeve extend through slots 32 in mandrel portion 11a and fluid can be prevented from flowing through these slots or openings by providing suitable seal means therefor. Thus O-rings 33 and 34 can be provided above and below the slots, as on the upper and lower ends of the sleeve, to form a sliding seal between the sleeve and the inner wall of mandrel portion of 11a to always seal the slots against fluid flow therethrough despite longitudinal shifting of the sleeve.

Part or sleeve 27 is provided with a portion engageable with a wire line tool such as the lower end 27a thereof, to thereby permit movement of the sleeve in such direction as to cause slips 23 to be expanded.

Any suitable wire line tool can be employed to effect this movement of the sleeve and in Fig. 2A is illustrated

a preferred type of such tool, one form of which is described and shown in greater detail in our co-pending application Serial No. 330,294, filed January 8, 1953. Briefly, the tool comprises a housing 35 adapted to be inserted into the bore of the assembly of Figs. 2 and 2A and having an opening in one side thereof permitting dog 36 to pivot outwardly around a shear pin 37 and to be urged to such outward position by a spring portion 38 carried on a pin 39 connected to body 35. With this arrangement, body 35 can be lowered through the well tubing as by wire line 40 with dog 36 riding on the interior of the tubing until the dog is positioned below end 27a of sleeve 27. Then an upward pull on wire line 40 will cause the dog to engage this lower end and move the sleeve upwardly to expand slips 23. When the sleeve is thus moved to its uppermost position, an additional pull on the wire line will cause pin 37 to shear thereby permitting spring 41 to pull dog 36 downwardly into recess 42. This movement also causes retaining rod 43 to move downwardly since this rod is connected to dog 36 by a lost motion connection such as by pin 44, carried by dog 36, working in a slot in the lower end of rod 43. This frees an upper dog 45 for outward movement about pivot pin 46 under the urging influence of spring portion 38a. The spring portion 38 is prevented from moving out of housing 35 by a pin 47. The function of dog 45 will be made more apparent hereinafter.

As one feature of this invention, a circulating valve is combined with the packer in order to permit certain well operations to be performed under the control of a wire line tool. Thus housing 12 can be provided with ports or fluid passageways 50 which include an annular portion 50a on the interior of housing 12. A valve member, here illustrated as sleeve 51, is movably positioned within housing 12 so that it can be shifted to open and close passageways 50. Thus the sleeve can be provided with an imperforate portion 52 adapted to be positioned across passageway 50 to close the same and with a plurality of ports 53 and narrow longitudinal slots 54 adapted to be placed in register with fluid passageways 50 to permit communication between the interior and exterior of the tubing string. Suitable seals, such as O-rings 55, can also be provided to seal around passageways 50 and prevent fluid flow through the passageways when the sleeve is in closed position. Slots 54 prevent O-rings 55 from being pressured into ports 53 with resultant pinching of the O-rings, the slots acting in effect as relief passages permitting pressure to be equalized on the O-ring before it can be pressed into ports 53.

The sleeve is shown in Fig. 2 in closed position with its lower end 56 in abutment with the upper end 57 of inner mandrel 11 thereby providing stop parts limiting movement of the sleeve in one direction. The upward movement of the sleeve is limited by its upper end 58 abutting the lower end 59 of sub 13 when ports 53 register with passageways 50. It should be noted that whether the sleeve 51 is in its upper or lower position, there will always be a part thereof, e. g., a part of its upper and lower ends, exposed for engagement by the wire line tool. Thus dog 36 can be made to engage lower end 56 of sleeve 51 to move the same upwardly to open position or dog 45 made to engage the upper end of the sleeve to move it downwardly to closed position.

With the foregoing arrangement, the assembly can be made up as a part of a tubing string and lowered into the well with the packing 18 in collapsed position. During such lowering into the well, slips 23 and ears 31 are prevented from catching on the casing which would prematurely set the slips, by means of spacer lugs 60, one of which is spaced below each ear 31 and extends far enough outwardly from body 10 to prevent the ears or the slips from rubbing on the sides of the casing.

If the packer is to be set and then the circulating valve opened, the wire line tool shown in Fig. 2A is lowered through the tubing until dog 36 can engage the lower

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end of sleeve 27. An upward pull on the wire line moves the slips 23 outwardly into engagement with the casing after which a slight lowering of the tubing causes the slips and expander 20 to move relative to mandrel 11 (mandrel 11 actually moving downwardly relative to the casing) thereby causing packing 18 to be expanded into sealing engagement with the casing. An additional upward pull on the wire line causes pin 37 to shear and the dog 36 to drop downwardly. The wire line tool can then be withdrawn, shear pin 37 replaced and the tool again run into the hole until dog 36 engages lower end 56 of sleeve 51 to raise the sleeve to open position after which the tool can be withdrawn from the hole.

On the other hand, it may be desirable to open the circulating valve before the packer is set in which case the wire line tool can be lowered into the hole until dog 36 engages sleeve 51 to raise the latter to open position. The tool can then be lowered an additional increment until the dog 36 engages sleeve 27 to set the slips. Pin 37 can then be sheared and the tool removed from the tubing.

When it is desired to close sleeve 51, the wire line tool can be lowered into through the tubing until the dog 36 engages the lower end of this sleeve and then pin 37 is sheared thereby releasing dog 45. This dog is then engaged with the upper end 58 of the sleeve and the latter moved or jarred downwardly to closed position. When it is desired to retract slips 23, the tubing can be merely raised which will permit the slips to retract and the packing to be collapsed to the position shown in Figs. 2 and 2A. The packer can then be withdrawn from the hole or reset without withdrawing the same at a greater or lesser depth than that at which it was originally set merely by properly positioning the tubing and again using the wire line tool to set the slips.

Since the slips are initially set without any movement of the tubing, and the only movement of the tubing which might be employed is that which is sufficient to expand packing 18, it will be apparent that the depth at which the packer is set can be accurately controlled since the only variables which need be considered are the stretch in the tubing and the distance which the tubing must move to expand packing 18. Each of these can be relatively accurately calculated from data known to those skilled in the art.

From the foregoing, it will be apparent that the arrangement of Figs. 2 and 2A can be run into the hole and then fluid circulated downwardly through the tubing to the bottom of the hole and upwardly through the tubing-casing annulus before the packer is set or the circulating valve opened. Contrariwise, reverse circulation can also be employed. On the other hand, the packer can set and the circulating valve opened permitting reverse circulation through the circulating valve into the tubing or downwardly through the annulus between the tubing and an extension tube or stinger tube landed in the tubing (not shown), as in permanent completion operations well known to those skilled in the art. If desired, fluid can also be passed down through the tubing and the stinger tube and thence out the circulating valve back up through the casing-tubing annulus. The operation contemplated with this tool are thus very flexible since each of the packer and circulating valve can be selectively operated to perform their various functions.

Another embodiment of the packer is shown in Figs. 4 and 4A, the principal difference between this embodiment and that of Figs. 2 and 2A being in the arrangement of the linkage between the sleeve and the slips. For this reason many of the parts in Figs. 4 and 4A bear numerals identical to those in Figs. 2 and 2A to designate parts having similar functions. In this embodiment, the linkage between sleeve 27 and slips 23 is provided by an external sleeve 61 slidably mounted upon mandrel portion 11a and connected to the slips by spacer links 62. Spacer links 62 have outturned ends 63 and 64 respectively disposed in an annular slot 65 in sleeve 61 and a slot

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66 in the slips. Slots 66 are made slightly wider than spacer links 62 to hold the spacer links in proper circumferential and longitudinal alignment. It will be noted that each of slots 65 and 66 are somewhat oversize relative to the ends of spacer links to permit the latter to pivot in these slots as the slips move inwardly and outwardly along the outer surface 22 of expander 20.

Means are also provided for holding the slips in engagement with the surface and can comprise the dovetail slide arrangement 25 and 26 as illustrated in Fig. 3.

External sleeve 61 is connected to the inner sleeve 27 by one or more studs 67 threaded through the outer sleeve and extending into the inner sleeve via slot 32. Stud 67 can be prevented from disengaging the inner sleeve by means of an annular ring 68 held in place by snap ring 69.

It is desirable that suitable stops be provided to prevent excessive endwise force being applied to packing 18 when the tubing is lowered to expand the same. There are several ways that such stops can be provided and in Fig. 2A, such stops can be provided by making the upper end of 32a of slot 32 to be in a vertical position such that ear 31 engages the upper end of this slot when packing 18 is expanded to its desired maximum. Another type of stop is provided in Fig. 4 in which opposing shoulders 70 and 71 are respectively provided on mandrel 11 and expander 20 for engagement when the packing 18 is at its maximum expanded position.

The circulating valve shown in Fig. 2 has not been illustrated in conjunction with the embodiment of the packer shown in Fig. 4 and 4A but it will be understood that it can be incorporated in this latter structure. Also, the circulating valve can be omitted from the structure shown in Figs. 2 and 2A.

The packer shown in the drawings is of the hook-wall type in which downward movement of the tubing tends to expand packing 18. It will be understood that this arrangement can be reversed so that upward movement of the tubing urges the slips outwardly and causes the packing to expand and downward movement of the tubing releases the slips. Such can be accomplished either by inverting the structure shown in Figs. 2-2A, and 4-4A, or by placing the pipe gripping means at the top of packing 18 and making the bottom of the packing fixed with respect to the inner mandrel.

It should also be apparent that packing 18 can be eliminated and expander 20 fixed relative to the tubing (as by welding, pinning or the like) to provide a tubing anchor for anchoring or securing tubing within the casing or the like. Further, it is contemplated that in some instances it will be possible for the wire line tool to be employed to not only move slips 23 outwardly into engagement with the casing but also to apply sufficient force to move the expander sufficiently to expand packing 18 into sealing engagement with the casing so that the tubing need not be lowered to effect this seal or if it is lowered, the lowering will be only to more firmly set slips 23 in the casing.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claim.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

In a well, a well casing, a well tubing extending into said casing, said tubing carrying casing gripping means exteriorly thereof which are expansible into gripping re-

lationship with said casing, an expansible packing surrounding said tubing and connected to said casing gripping means for expansion of the packing into sealing relationship with the casing upon expansion of the gripping means, means for expanding said gripping means including a part disposed within said tubing and movable relative thereto, a linkage between said part and said gripping means and transmitting force generated by movement of said part to said gripping means to thereby expand the same, a fluid passageway through the wall of said tubing communicating between the interior and exterior of the tubing and spaced proximate to said packing, a valve member internally of said tubing and movable relative thereto to open and close said fluid passageway, and a wire line tool movable through said tub-

ing and selectively engageable with said part and valve member to transmit force thereto to respectively expand said gripping means and to move the valve member between both its fluid passageway opening and closing positions.

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