

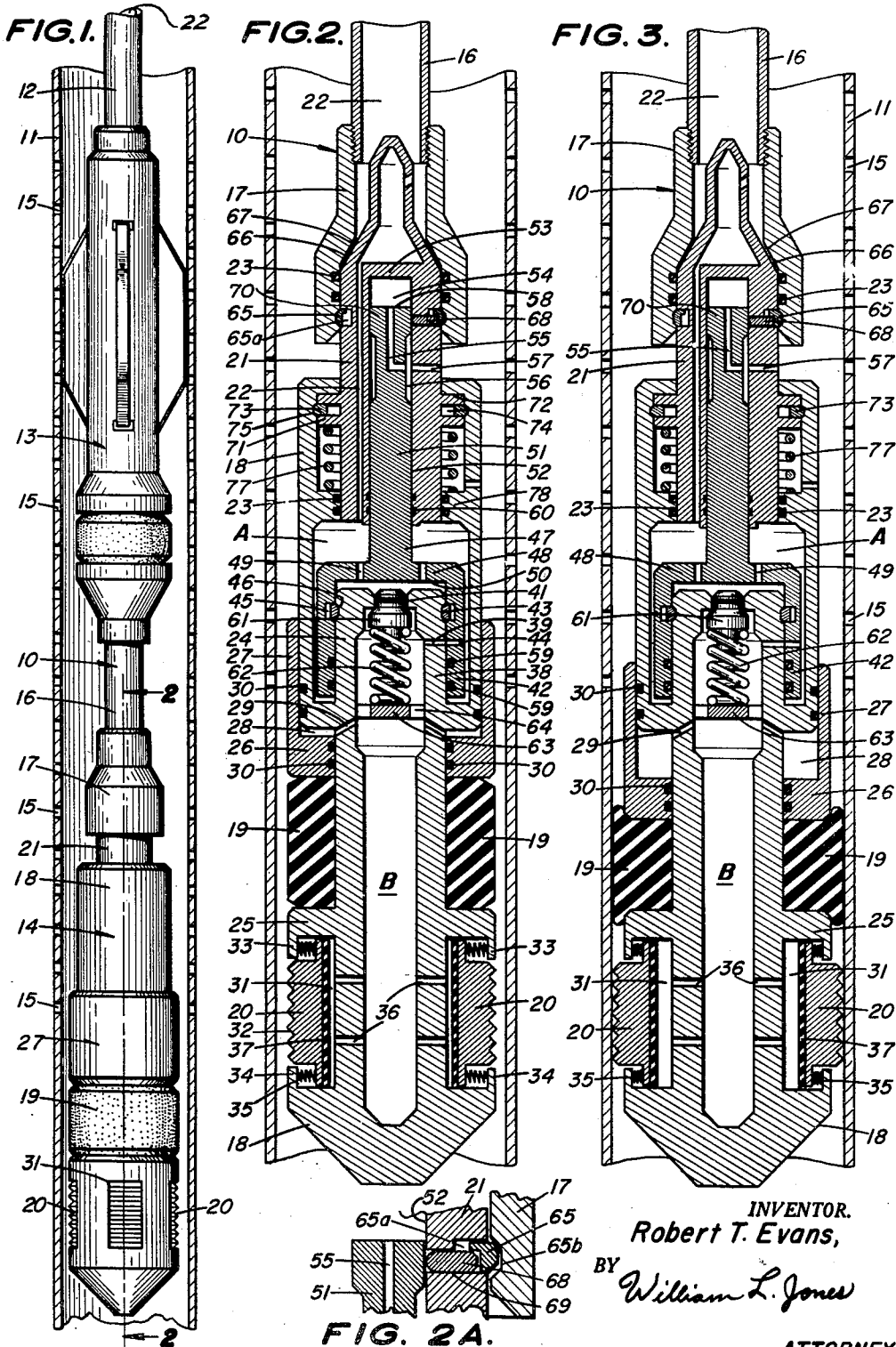
July 26, 1960

R. T. EVANS
WELL APPARATUS

2,946,388

Filed Sept. 12, 1955

3 Sheets-Sheet 1



INVENTOR.
Robert T. Evans,

BY William L. Jones

ATTORNEY.

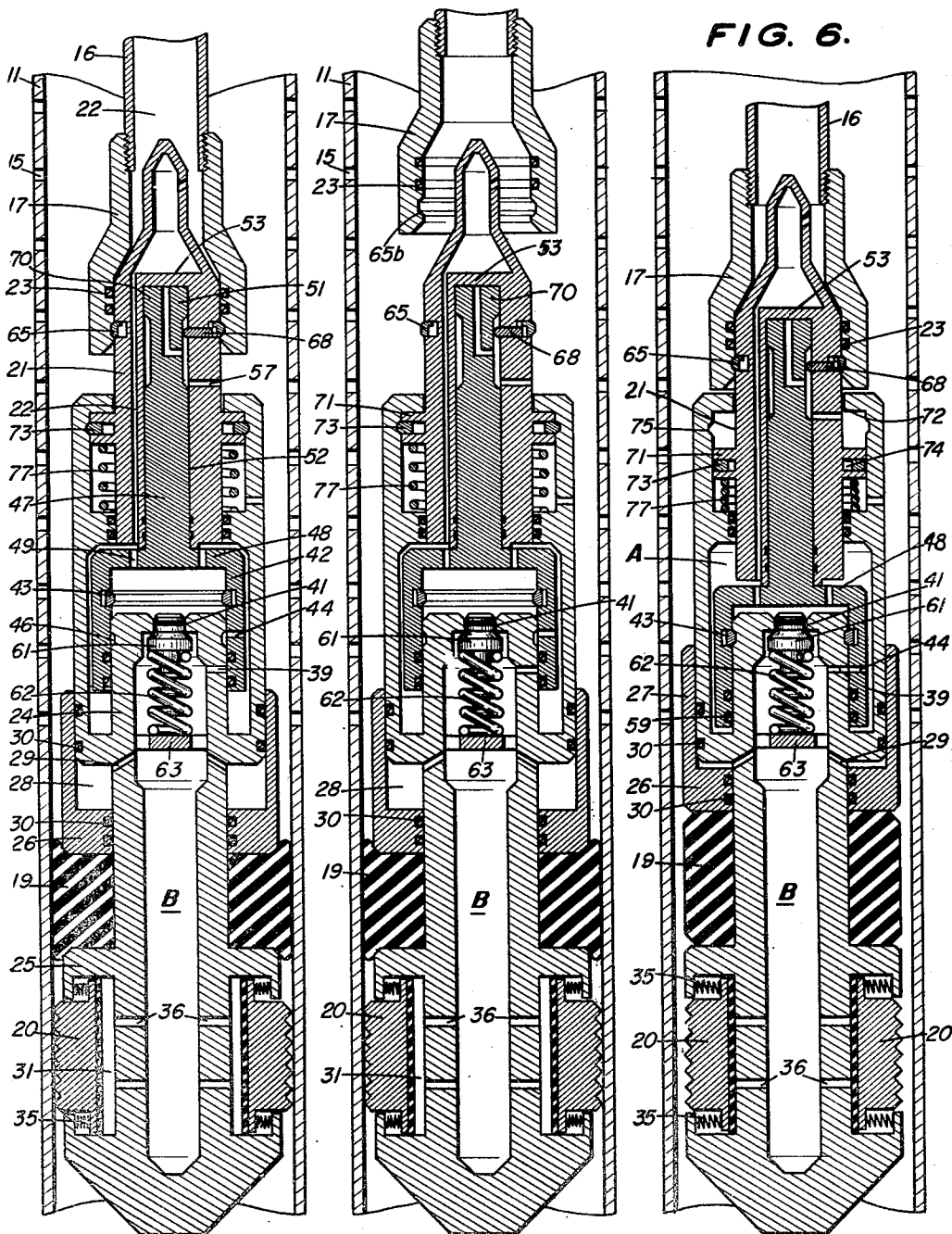
July 26, 1960

R. T. EVANS
WELL APPARATUS

2,946,388

Filed Sept. 12, 1955

3 Sheets-Sheet 2



INVENTOR.
Robert T. Evans,
BY *William L. Jones*

ATTORNEY.

July 26, 1960

R. T. EVANS
WELL APPARATUS

2,946,388

Filed Sept. 12, 1955

3 Sheets-Sheet 3

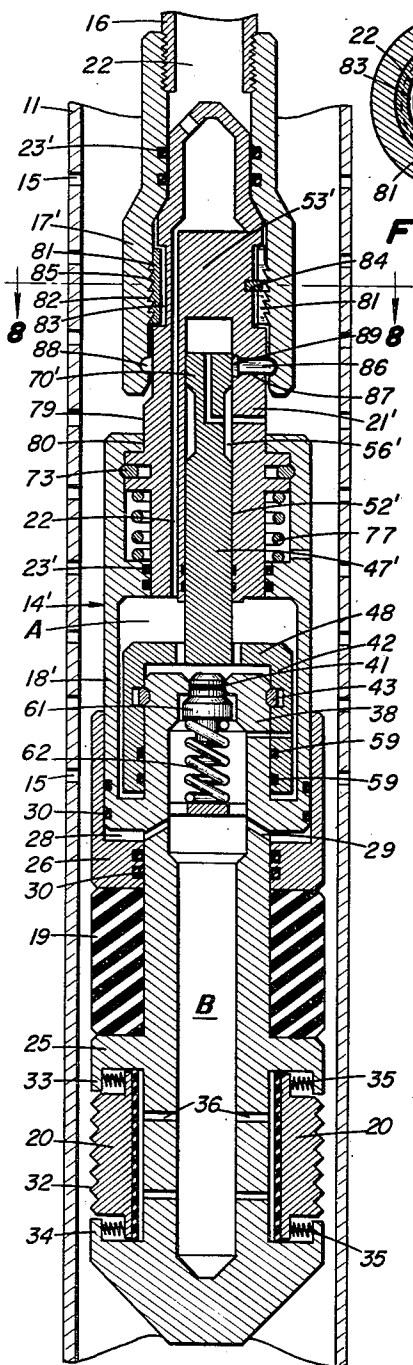


FIG. 7.

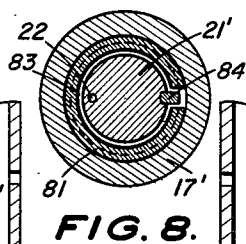


FIG. 8.

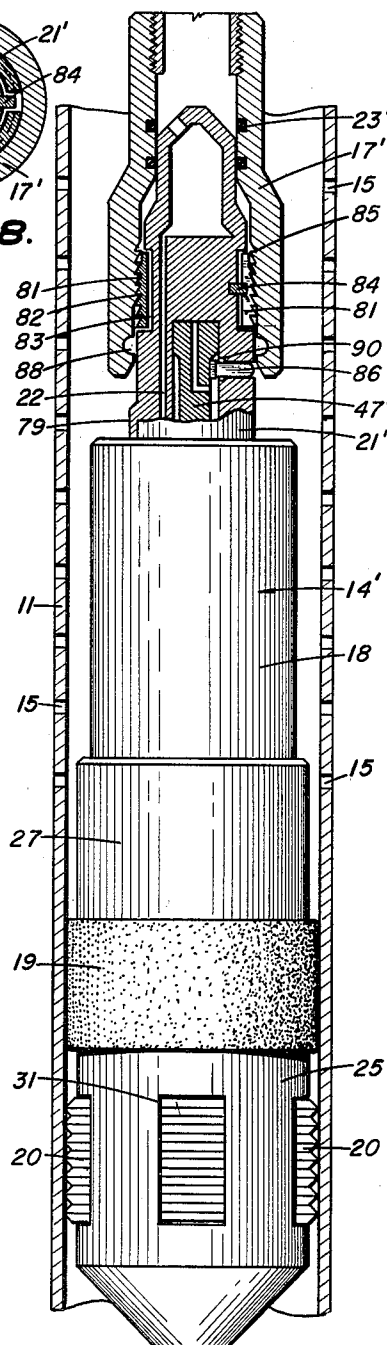


FIG. 9.

INVENTOR.
Robert T. Evans,
BY *William L. Jones*

ATTORNEY.

1

2,946,388

WELL APPARATUS

Robert T. Evans, Duncan, Okla., assignor to Halliburton Oil Well Cementing Company, Duncan, Okla.

Filed Sept. 12, 1955, Ser. No. 533,610

16 Claims. (Cl. 166—120)

This invention relates to apparatus for use in oil and gas wells or the like and, more particularly, to a well packer and a releasable connection for coupling the packer in a string of equipment of the type which is lowered into a well bore.

It is a general object of this invention to provide an improved well packer assembly useful for effecting a fluid-tight seal with the wall of a well bore into which the assembly has been lowered.

It is another object of this invention to provide an improved well packer which may be used as a retrievable bridge plug or with another packer in a "straddle" arrangement without an interconnecting pipe or tubing therebetween.

It is another object of the invention to provide an improved well packer and an improved releasable connection for coupling the packer in an equipment string of the type which is lowered into a well bore.

It is another object of the invention to provide an improved well packer assembly including a packer and a releasable connection for coupling the packer to other apparatus, the connection being adapted to be selectively broken and formed, but only after the packer has been at least partially set or expanded.

It is another object of the invention to provide an improved well packer having provision whereby upon being set or expanded in a well bore it may be held in such set or expanded position and released or disconnected from apparatus included thereabove in the equipment string lowered into the well and, if desired, also having provision whereby it may thereafter be retrieved and withdrawn from the well bore or moved to another location therein.

It is another object of the invention to provide an improved releasable connection or safety joint for releasably coupling a well packer or other apparatus in an equipment string of the type which is lowered into a well bore.

In accordance with the invention, two parts of an assembly of the type which is adapted to be lowered into a well bore are coupled together by a releasable connection for which there is provided supporting means which initially prevents the connection from being broken or separated due to relative movement between such parts. Associated with the connection supporting means is an operating member which is movable upon sufficient force being applied thereto by fluid under pressure supplied to the assembly. Upon the operating member being thus moved, the connection supporting means is removed or rendered inoperative, whereupon the releasable connection may thereafter be selectively broken and formed, as desired, by the application of forces causing relative movement between the parts interconnected thereby.

In accordance with another aspect of the invention, the assembly includes in one part thereof a well packer which is adapted to be set or expanded upon sufficient force being applied thereto by fluid under pressure supplied to the assembly. The assembly also includes ini-

2

tially open valve means which is associated with the operating member and is adapted upon movement of such member, as aforesaid, to close and thereby confine or entrap fluid in the assembly so as to hold the packer in at least a partially set or expanded position.

In one arrangement, the operating member is adapted to move, as aforesaid, upon the pressure of the fluid supplied to set or expand the packer reaching a predetermined value with respect to the pressure of fluid in the well outside the assembly. Thus, the releasable connection remains supported by the connection supporting means until after the packer has been at least partially set or expanded, whereupon the operating member moves to close the initially open valve means and at the same time remove or render the connection supporting means inoperative.

The assembly preferably also includes means whereby additional force may, if desired, be applied to further set or expand the packer after the connection supporting means has been removed or rendered inoperative. Also, the assembly preferably includes means whereby, if desired, the connection supporting means may be replaced or rendered operative again and the packer returned to its unexpanded position, thus permitting the entire assembly to be withdrawn from the well bore or moved to another location therein.

The foregoing and other objects and advantages of the invention will be more apparent from the following description when read in connection with the accompanying drawing in which similar reference characters refer to similar parts and wherein:

Figure 1 is a side elevational view of a well packer assembly having the invention incorporated therein, the assembly including upper and lower well packers shown releasably coupled together, such as during the lowering thereof into a well casing;

Figure 2 is a longitudinal sectional view taken along the line 2—2 of Figure 1, showing in greater detail the lower packer and one type of releasable connection for coupling it in the assembly;

Figure 2A is an enlarged fragmentary view of the releasable connection of Figure 2, showing in greater detail the construction of a portion thereof;

Figures 3 to 6, inclusive, are views similar to that of Figure 2, but respectively showing the parts of the packer and releasable connection in the positions occupied by them at selected later stages of operation;

Figure 7 is a longitudinal sectional view of an arrangement similar to that of Figure 2 and also in accordance with the invention, but having incorporated therein another type of releasable connection, the parts being shown in the positions occupied by them during the lowering of the assembly;

Figure 8 is a transverse sectional view taken along the line 8—8 of Figure 7; and

Figure 9 is a view similar to that of Figure 7, but partly in elevation and showing the parts in the respective positions occupied by them at a later stage of operation.

Referring to the drawing in detail, and first to Figure 1 thereof, the invention is there illustrated and is hereinafter described, by way of example, as being applied to well packer assembly 10 shown positioned within a casing 11 after having been lowered to a desired depth therein on a drill pipe 12.

The assembly 10 is shown as including generally an upper well packer 13 and a lower well packer 14 arranged for use as "straddle" packers, such as in connection with a treating, testing, fracturing or other well operation in the performance of which it is desired to effect fluid-tight seals at or near the upper and lower limits of an underground zone or formation traversed by the bore of the

well. A series of perforations 15 have been suitably provided in the casing 11 opposite the zone or formation (not shown) upon which the well operation is to be performed.

The upper packer 13 may be of conventional design and it is believed unnecessary to describe it in detail. The packer 13 is shown threadedly or otherwise connected at its upper end to the lower end portion of the drill pipe 12, which extends upwardly therefrom to the surface of the ground (not shown). A pipe or tubing 16 extends downwardly from the packer 13 and is secured at its lower end to a coupling member 17.

The lower packer 14 is adapted to be set or expanded hydraulically and includes an elongated body or case 18 upon which are mounted one or more resilient and expansible members, such as a packing sleeve 19 and a set of slips 20. Extending upwardly from the case 18 is a mandrel 21 which, as will appear more fully hereinafter, is at times movable longitudinally therein. Between the coupling member 17 and the upper end portion of the mandrel 21 there is a releasable connection which, as will appear more fully hereinafter, is initially supported so as to securely couple or lock the packers 13 and 14 together.

Referring now to Figure 2, the case 18 is hollow and is shown with its lower end closed. Within the hollow case 18 there is provided below the mandrel 21 an upper chamber A and a lower chamber B. The upper chamber A is adapted to be supplied with fluid through a passageway 22 which extends upwardly therefrom generally lengthwise of the mandrel 21, into the coupling member 17 which is hollow, and thence upwardly through the tubing 16, the upper packer 13 and the drill pipe 12 (see Figure 1) to the surface of the ground. Sealing rings 23 or the like are preferably provided between the mandrel 21 and the case 18 and between the mandrel 21 and the coupling member 17, so as to prevent the escape of the fluid to the exterior of the assembly 10.

The chambers A and B are separated by an inner partition 24 which has provided therein one or more openings through which fluid is at times permitted to pass. The arrangement is such that the operation of the packer 14 may be controlled by controlling the passage of fluid into and out of the lower chamber B through the openings in the partition 24, as will appear more fully hereinafter.

As illustrated, the packing sleeve 19 is slidably mounted on a reduced portion of the hollow case 18 and has its lower end disposed adjacent to a lower abutment or shoe 25, which is secured to the case 18 and supports the sleeve 19 against relative downward movement thereon. The upper end of the sleeve 19 is disposed adjacent to an upper or sliding shoe 26, which is movable longitudinally of the case 18 and is shown supported in its uppermost position thereon by the inherent resiliency of the sleeve 19.

The sliding shoe 26 has an upwardly extending skirt portion 27 which encircles the upper portion of the wall of the case 18, with the result that a chamber 28 is provided between the shoe 26 and the reduced portion of the case 18. A passageway 29 extending through the wall of the case 18 provides fluid communication between the chamber 28 and the lower chamber B. Sealing rings 30 or the like are preferably provided between the shoe 26 and the case 18 above and below the chamber 28, so as to prevent the escape of fluid to the exterior of the assembly 10.

As illustrated, the slips 20 are movably mounted within a series of recesses 31 angularly spaced about the wall of the case 18 below the lower abutment or shoe 25. The slips 20 may be made of metal or the like and each preferably has a plurality of teeth 32 on the exposed outer surface thereof. Each of the recesses 31 has associated therewith an upper lip or flange 33 and a lower lip or flange 34, the flanges 33 and 34 being se-

cured to the case 18 and overlapping the upper and lower ends, respectively, of each of the slips 20. A spring 35 or the like is preferably mounted between each of the flanges 33 and 34 and the corresponding end of the slip 20 overlapped thereby, so as to normally retain the slips 20 in their innermost or unexpanded positions within the recesses 31.

A plurality of passageways 36 extending through the wall of the case 18 provide fluid communication between each of the recesses 31 and the lower chamber B. A resilient and expansible pad 37 or the like is preferably closely fitted within each of the recesses 31 behind the slip 20 mounted therein, with the result that fluid entering the recesses 31 through the passageways 36 is not permitted to escape to the exterior of the assembly 10.

The arrangement is such that upon fluid under pressure being supplied to the lower chamber B through openings in the partition 24, as will appear more fully hereinafter, fluid pressure builds up within each of the recesses 31 and applies forces tending to move the pads 37 and slips 20 radially outward and to move the exposed teeth 32 on the slips 20 into biting engagement with the surrounding casing 11 (see Figure 3). At the same time, fluid pressure builds up within the chamber 28 and applies a force tending to move the sliding shoe 26 downwardly, thus compressing the sleeve 19 between the shoes 25 and 26 and expanding it outwardly into sealing engagement with the surrounding casing 11.

The flow of fluid from the upper chamber A into the lower chamber B through openings provided in the partition 24 is controlled by valve means which is responsive to forces applied thereto by the fluid supplied to the interior of the case 18 through the passageway 22.

As illustrated, the partition 24 includes an upwardly extending cylindrical portion 38 having a lateral port 39 provided therein. The partition 24 also includes an upper portion which extends radially inward from the upper end of the cylindrical portion 38 and preferably has a central opening 41 provided therein.

As will appear more fully presently, it is desirable for the flow of fluid through the lateral port 39 to be controlled by a valve which is initially open and is adapted to close upon the force applied thereto by fluid pressure in the upper chamber A becoming greater by a predetermined amount than an opposing force exerted thereagainst by a fluid pressure, such as the fluid pressure in the annular space surrounding the assembly 10, which is substantially independent of the fluid supplied to set or expand the packer 14. On the other hand, it is desirable for the flow of fluid through the central opening 41 to be controlled by a one-way check valve which is normally closed and is adapted to open upon the force applied thereto by fluid pressure in the upper chamber A becoming sufficiently greater than an opposing force exerted thereagainst by fluid pressure in the lower chamber B.

In the arrangement shown the flow of fluid through the lateral port 39 is controlled by a sliding sleeve valve including a sleeve 42 which encircles the cylindrical portion 38 of the partition 24. The sleeve 42 when in its downward position within the case 18 is normally supported by yieldable means, such as a yieldable snap ring 43, which must be overcome in order to move the sleeve 42 to its upward position within the case 18. A lateral port 44 is provided in the sleeve 42 and, when the sleeve 42 is in such downward position, as shown in Figure 2, the port 44 is aligned with the lateral port 39 in the partition 24. As a result, the sliding sleeve valve is initially held open, permitting the fluid initially supplied through the passageway 22 to the upper chamber A to pass into the lower chamber B so as to set or expand the packer 14, as hereinbefore described.

The yieldable snap ring 43 may be a split-type ring made of metal or the like and may be adapted to be overcome by radial expansion thereof resulting from rela-

5

tive longitudinal movement occurring between the sleeve 42 and the partition 24. In Figure 2 the ring 43 is shown mounted at rest in its unexpanded position within an inner annular recess 45, which is provided in the sleeve 42 and is preferably of sufficient depth to receive the entire ring 43 upon radial expansion thereof.

It will be noted that when the ring 43 is at rest, its inner portion protrudes to some extent from the recess 45. Also, it will be noted that when the sleeve 42 is in its downward position within the case 18, the protruding portion of the ring 43 registers with a groove 46 extending peripherally about the cylindrical portion 38 of the partition 14. As a result, the ring 43 resists relative upward movement of the sleeve 42 within the case 18, and thus initially holds the sliding sleeve valve in its open position.

As illustrated, the sleeve 42 is the lower portion of an operating member 47, which includes a transverse wall 48 extending radially inward from the upper end of the sleeve 42. The wall 48 has extending therethrough one or more perforations 49 which provide fluid communication between the portions of the chamber A above and below the wall 48. Accordingly, the wall 48 has its lower surface 50 exposed to the fluid pressure in the chamber A.

The operating member 47 also includes an elongated upper portion 51 which is secured at its lower end to the transverse wall 48 and is closely, but slidably fitted within a central bore 52 of the mandrel 21. The bore 52 is closed at its upper end, such as by a wall or plug 53, and includes a chamber 54 provided therein above the operating member 47. The chamber 54 communicates with the exterior of the assembly 10 through an interior passageway 55 and an annular recess 56 provided, respectively, in and on the elongated portion 51, and through a lateral passageway 57 provided in the mandrel 21. As a result, the operating member 47 has its upper end surface 58 exposed to whatever fluid pressure exists in the annular space between the assembly 10 and the surrounding casing 11.

In operation the sleeve 42 remains in its open or downward position, as aforesaid, until such time as the force applied to the operating member 47, such as to the lower surface 50 of its transverse wall 48, by the fluid pressure in the chamber A becomes sufficient to overcome any opposing force applied to the upper end surface 58 of such member 47 by the fluid pressure in the chamber 54 and also to overcome the yieldable snap ring 43.

The ring 43 is selected so that a predetermined force tending to move the operating member 47, and thus the sleeve 42, upwardly within the case 18 is required to be applied in order to expand the ring 43 radially outward to a position within the recess 45 in which the member 47 is permitted to move to its upward position, as shown in Figure 4. Similarly, a predetermined force may be required to be applied in order to overcome the ring 43 and permit the operating member 47 to be returned to its downward position within the case 18.

To facilitate such radial expansion of the ring 43 due to relative longitudinal movement between the operating member 47 and the case 18, the upper and lower surfaces of the inner portion of the ring 43 and the surfaces of the partition 24 engageable thereby may be suitably tapered, as shown, or otherwise arranged.

Sealing rings 59 or the like are preferably provided between the sleeve 42 and the partition 24 and are preferably spaced apart and arranged so that fluid-tight seals are effected above and below the lateral port 39 upon the operating member 47 being moved to its upward position within the case 18 (see Figure 4). Also, sealing rings 60 or the like are preferably provided between the elongated upper portion 51 of the operating member 47 and the bored portion of the mandrel 21, so as to iso-

6

late the chamber A of the case 18 from the chamber 54 provided in the mandrel 21.

As will appear more fully hereinafter, it is desirable for the operating member 47 to remain in its downward position within the case 18 until the packer 14 has been set or expanded sufficiently to support itself against longitudinal displacement within the casing 11. If desired, the snap ring 43 may be selected so as to retain the sleeve 42 and thus the operating member 47 in its downward position until the packer 14 has been fully set or expanded, whereupon the ring 43 will be overcome and the sleeve valve will close, thus confining or entrapping fluid in the lower chamber B and thereby holding the packer 14 in its set or expanded position.

With such an arrangement only one opening need be provided in the partition 24, but an additional, separately controlled opening is preferably provided so that, if desired, additional fluid may be supplied to further set or expand the packer 14 after the sliding sleeve valve has closed. It is primarily for this purpose that the central opening 41 is preferably provided in the partition 24.

In the arrangement shown the flow of fluid through the central opening 41 is controlled by a one-way check valve which includes an upwardly closing valve member 61 disposed within the lower chamber B and normally urged by a spring 62 or the like toward a seating surface provided therefor on the upper portion of the partition 24 around the opening 41. The spring 62 is shown with its upper end fitted to the valve member 61 and with its lower end resting on a transverse support 63, which is secured to the partition 24 and has one or more perforations 64 extending therethrough. It will be noted that the perforations 64 provide fluid communication between the portions of the chamber B above and below the support 63.

The one-way check valve is adapted to open upon the force applied downwardly against the valve member 61 by fluid pressure in the upper chamber A becoming sufficiently greater than the force exerted upwardly thereagainst by fluid pressure in the lower chamber B to overcome the spring 62. In operation the valve member 61 will ordinarily remain in its upward or closed position until after the sliding sleeve valve initially providing fluid communication between the chambers A and B has been closed and additional fluid has been thereafter supplied through the passageway 22 to increase the fluid pressure in the chamber A.

An important feature of the invention resides in the construction and arrangement whereby the lower packer 14 is coupled in the assembly 10 by a releasable connection for which there is provided supporting means which prevents the connection from being broken or separated prior to the packer 14 being at least partially set or expanded and fluid being confined or entrapped, as aforesaid, so as to hold the packer 14 in such set or expanded position.

In the arrangement shown the releasable connection is provided between the hollow coupling member 17 and the upper end portion of the mandrel 21 and is employed for coupling together the packers 13 and 14. Thus, the coupling member 17 is shown with its upper end threadedly connected to the lower end portion of the tubing 16 which extends downwardly from the upper packer 13. It is understood, however, that in certain applications, such as when the lower packer 14 is to be used as a retrievable bridge plug or the like, the assembly 10 may not include an upper packer, such as the packer 13. In such event the coupling member 17 may be threadedly or otherwise connected to or, if desired, may be made integral with other apparatus, such as the lower end of the drill pipe 12, of the type which is adapted to be lowered into a well bore.

The releasable connection includes yieldable means

which initially interconnects the coupling member 17 and the mandrel 21 and must be overcome in order to either break or form the connection. In the type of releasable connection shown best in Figures 2 and 2A the yieldable means is a yieldable snap ring 65 which upon the supporting means provided therefor being removed or rendered inoperative, as will appear more fully hereinafter, is adapted to be overcome by causing relative longitudinal movement between the coupling member 17 and mandrel 21.

As illustrated, the mandrel 21 initially has its upper end portion closely fitted within the hollow coupling member 17, which is shown in Figure 2 in its lowermost position thereon, with an upwardly facing shoulder 66 on the mandrel 21 engaging a downwardly facing shoulder 67 provided within the member 17.

The yieldable snap ring 65 may be a split-type ring made of metal or the like which is adapted to be overcome by radial compression thereof resulting from relative longitudinal movement occurring between the coupling member 17 and the mandrel 21. Thus, as shown best in Figure 2A, the ring 65 is mounted at rest in its uncompressed position within a groove 65a extending peripherally about the mandrel 21. The groove 65a is preferably of sufficient depth to receive the entire ring 65 upon radial compression thereof.

It will be noted that when the ring 65 is at rest, its outer portion protrudes to some extent from the groove 65a. Also, it will be noted that when the coupling member 17 is in its lowermost position on the mandrel 21, the protruding portion of the ring 65 registers with an inner annular recess 65b provided in the wall of the coupling member 17, thus resisting relative upward movement of the member 17 thereon.

The connection supporting means in the arrangement of Figures 1 to 6, inclusive, comprises means for initially supporting the snap ring 65 against being radially compressed to a position within the groove 65a in which the outer portion of the ring 65 no longer extends into the recess 65b. This support is shown provided in part by one or more pins 68, each of which is slidably positioned within a slot 69 extending radially inward from the groove 65a to the central bore 52 of the mandrel 21.

The pins 68 are in turn initially supported in their outermost positions within the slots 69 and when in such positions preferably engage the ring 65. The support for the pins 68 is shown provided by the operating member 47, which has its upper end portion 70 normally disposed in the bore 52 opposite the slots 69, preferably preventing the pins 68 from moving inwardly out of supporting relation to the ring 65.

Thus, the connection supporting means includes both the upper end portion 70 of the operating member 47 and the pins 68 mounted within the slots 69.

It will be noted that the annular recess 56 provided on the elongated portion 51 of the operating member 47 is initially disposed within the bore 52 a suitable distance below the slots 69 but is adapted to move into alignment therewith (see Figure 4) upon the operating member 47 being moved, as hereinbefore described, to its upward position within the case 18. Upon the recess 56 being thus moved into alignment with the slots 69, the pins 68 are no longer prevented from moving inwardly along such slots 69 and, as a result, the ring 65 is no longer supported against radial compression.

The ring 65 is preferably selected so that upon the support therefor being removed, as aforesaid, a predetermined force tending to move the coupling member 17 upwardly with respect to the mandrel 21 is required to be applied, such as by raising the drill pipe 12, in order to compress the ring 65 radially inward within the groove 65a sufficiently to permit the member 17 to be moved upwardly to a position (see Figure 5) in which the releasable connection is broken. Similarly, a predetermined force may thereafter be required to be applied in

order to overcome the ring 65 and permit the coupling member 17 to be returned to its lowermost position (see Figure 4) on the mandrel 21, thus reforming or remaking the releasable connection.

To facilitate radial compression of the ring 65 due to relative longitudinal movement between the coupling member 17 and the mandrel 18, as aforesaid, the upper and lower surfaces of the outer portion of the ring 65 and the surfaces of the member 17 engageable thereby are preferably suitably tapered or inclined, as shown best in Figure 2A.

Thus, it will be noted that the releasable connection may be selectively broken and formed, as desired, while the operating member 47 is in its upward position within the case 18, the connection supporting means being then removed or rendered inoperative. Also, it will be noted that at all times when the releasable connection is thus adapted to be selectively broken and formed, the packer 14 is in at least a partially set or expanded position and the sliding sleeve valve is closed, with the result that the lower packer 14 then supports itself against longitudinal displacement within the casing 11.

In order that the packer 14 may be returned to its relaxed or unexpanded position and the connection supporting means replaced or again rendered operative, it is desirable for means to be provided whereby the operating member 47 may be returned to its initial or downward position with respect to both the case 18 and the mandrel 21. It is primarily for this purpose that the mandrel 21 is, as hereinbefore indicated, mounted for relative longitudinal movement within the case 18.

The mandrel 21 is shown in Figure 2 in its initial or uppermost position within the case 18, with an intermediate raised portion 71 of the mandrel 21 engaging an upper abutment 72 provided within the case 18. The mandrel 21 when in its uppermost position is preferably normally supported in such position by yieldable means, such as a yieldable snap ring 73, which must be overcome in order to move the mandrel 21 downwardly within the case 18.

The yieldable snap ring 73 may be a split-type ring made of metal or the like and may be adapted to be overcome by radial compression thereof resulting from relative longitudinal movement occurring between the mandrel 21 and the case 18. The ring 73 is shown mounted at rest in its uncompressed position within a groove 74, which extends peripherally about the intermediate raised portion 71 and is preferably of sufficient depth to receive the entire ring 73 upon radial compression thereof.

It will be noted that when the ring 73 is at rest, its outer portion protrudes to some extent from the groove 74. Also, it will be noted that when the mandrel 21 is in its upward position within the case 18, the protruding portion of the ring 73 registers with an inner annular recess 75 provided in the wall of the case 18 below its upper abutment 72, thus resisting relative downward movement of the mandrel 21 within the case 18.

The ring 73 is preferably selected so that a predetermined force tending to move the mandrel 21 downwardly within the case 18 is required to be applied, such as by further lowering the drill pipe 12 when the coupling member 17 is in its lowermost position on the mandrel 21, in order to compress the ring 73 radially inward within the groove 74 sufficiently to permit the mandrel 21 to be moved to its lowermost position within the case 18, as shown in Figure 6. In order to facilitate radial compression of the ring 73 due to such relative downward movement of the mandrel 21, the lower surface of the outer portion of the ring 73 and the surfaces of the case 18 engageable thereby are preferably suitably inclined or tapered, as shown. Similarly, the upper surface of the outer portion of the ring 73 and the surfaces of the case 18 engageable thereby may be suitably inclined or tapered to facilitate thereafter returning the mandrel 21 to its uppermost position within the case 18.

It will be noted in Figure 2 that when the mandrel 21 is in its uppermost position and the operating member 47 is in its initial or downward position, the lower end of the mandrel 21 is disposed a suitable distance above the transverse wall 48, which is thus permitted to move upwardly within the chamber A as the member 47 is moved to its upward position (see Figure 4). Upon the mandrel 21 being thereafter moved downwardly within the case 18, its lower end engages the transverse wall 48 and thereby carries or returns the operating member 47 to its initial or downward position within the case 18 (see Figure 6). As a result, the sliding sleeve valve controlling the flow of fluid through the lateral port 39 in the partition 22 is opened and the fluid previously confined or entrapped in the lower chamber B is permitted to escape therefrom through the aligned ports 39 and 44, whereupon the inherent resiliency of the packing sleeve 19 causes relaxation thereof and returns the sliding shoe 26 to its uppermost position on the case 18 and the springs 35 return the slips 20 to their innermost or unexpanded positions within the recesses 31.

Upon the packer 14 being thus returned to its unexpanded position, the weight thereof may be sufficient to cause the mandrel 21 to move relatively upward within the case 18 and resume its uppermost position therein, as shown in Figure 2. In order to facilitate the return of the mandrel 21 to such position, a spring 77 or the like may, if desired, be mounted so as to normally urge the mandrel 21 upwardly. The spring 77 is shown encircling the mandrel 21 and with its upper end engaging the intermediate raised portion 71 thereof. The lower end of the spring 77 is shown supported by a lower abutment 78 provided within the case 18.

Referring now to Figures 7, 8 and 9, the arrangement there illustrated is substantially identical to that heretofore described, with the exception that another type of releasable connection is employed. In particular, the modified releasable connection is adapted to be broken or separated in response to relative rotation, rather than relative longitudinal movement, between the parts interconnected thereby.

In Figure 7 the parts of the modified arrangement are shown in the respective positions occupied by them during the lowering thereof into the well casing 11. There is shown a lower well packer 14' which includes a case 18' having a mandrel 21' extending upwardly therefrom. A spline 79 is shown secured to the mandrel 21' and extends lengthwise thereof through a groove 80 provided in the wall of the case 18' near the upper end thereof. The arrangement is such that the mandrel 21' is at time movable longitudinally within the case 18', as has been hereinbefore described with reference to the arrangement of Figures 1 to 6, inclusive, but the spline 79 prevents substantial relative rotation of the mandrel 21' therein. As a result, the mandrel 21' is supported against relative rotation within the casing 11 upon the packer 14' being set or expanded (see Figure 9).

The upper end portion of the mandrel 21' is shown in Figure 7 closely fitted within a hollow coupling member 17', which is threadedly or otherwise connected at its upper end to the tubing 16 extending downwardly from the upper packer 13 (see Figure 1). Sealing rings 23' or the like are preferably provided between the mandrel 21' and the coupling member 17' to prevent the escape of fluid from the interior of the member 17'.

The modified type of releasable connection includes a split-type collar or ring 81 which may be made of metal or the like and has provided on its outer surface a plurality of buttress or ratchet threads 82. The ring 81 is shown mounted at rest in an uncompressed position within a groove 83 which extends peripherally about the upper portion of the mandrel 21' and is preferably of sufficient depth to receive the entire ring 81 upon radial compression thereof.

As shown best in Figure 8, the ring 81 is supported, such as by a pin or bolt 84, against substantial relative

rotation with respect to the mandrel 21'. To this end the bolt 84 may be screwed into or otherwise secured to the mandrel 21' and is shown extending radially outward therefrom into the space between the split ends of the ring 81.

It will be noted in Figure 7 that when the ring 81 is at rest, its threads 82 protrude to some extent from the groove 83 so as to engage companion threads 85 which are provided within the coupling member 17'. The threads 82 and 85 are downwardly inclined or tapered or are otherwise suitably arranged so as to permit the connection to be formed by moving the coupling member 17' downwardly with respect to the ring 81 and mandrel 21'. Upon the connection being thus formed, the threads 82 and 85 resist relative upward movement of the coupling member 17' and must be overcome by rotational movement in order to break or separate the connection.

However, the modified type of releasable connection when formed initially supported against being broken or separated due to relative rotation between the parts interconnected thereby. This support is shown provided by connection supporting means which in part includes one or more pins 86, each of which is slidably positioned within a slot 87 extending radially inward from the periphery of the mandrel 21' to a central bore 52' provided therein.

The pins 86 are initially supported in their outermost position within the slots 87 by the upper end portion 70' of an operating member 47', which may be identical to the member 47 heretofore described. When in such position the pins 86 extend into an inner recess 88 provided in the wall of the coupling member 17'. The recess 88 may be annular so that the walls thereof engage each of the pins 86 and thereby limit relative longitudinal movement between the mandrel 21' and the coupling member 17'. As an alternative, a recess 88 may be provided for each pin 86 and each recess 88 may be in the form of an inwardly extending bore the walls of which engage the pin 86 therein on all sides and thereby limit both relative longitudinal movement and relative rotation between the mandrel 21' and the coupling member 17'.

In order to limit relative outward movement of the pins 86 along the slots 87, each pin 86 preferably has provided near its innermost end a flange 89 or the like which is adapted to engage an abutment 90 provided within the slotted portion of the mandrel 21'.

It will be noted that while, as hereinbefore described, the ring 81 is initially connected to the coupling member 17' by the threads 82 and 85 and is supported by the bolt 84 against substantial rotation with respect to the mandrel 21', it is initially not possible to screw the coupling members 17' off of the ring 81. This is partly because the mandrel 21' does not become supported against relative rotation within the casing 11 until the packer 14' has been at least partially set or expanded and partly because the pins 86 in cooperation with the recess 88 prevent relative upward movement of the coupling member 17' on the mandrel 21' during such time the operating member 47' is in its initial or downward position within the case 18'.

The connection supporting means in the arrangement of Figures 7 and 8 may be considered as including both the upper end portion 70' of the operating member 47' and the pins 86 mounted within the slots 87. Some additional protection against operation of the releasable connection means before the packer 14' has been at least partially set or expanded may be considered as resulting from the requirement of relative rotation to separate the interconnected parts.

As in the case of the arrangement of Figures 1 to 6, inclusive, the operating member 47' is adapted to move to its upward position within the case 18' upon sufficient force being applied thereto by the fluid supplied

11

to set or expand the packer 14'. Upon the operating member 47' being so moved, an annular recess 56' provided thereon moves into alignment with the slots 87, permitting the pins 86 to move inwardly into the bore 52' of the mandrel 21' sufficiently so that their outermost ends no longer extend into the recess 88, as shown in Figure 9, thus removing or rendering inoperative the support initially provided for the releasable connection. At the same time, fluid is confined or entrapped in the case 18' so as to hold the packer 14' in at least a partially set or expanded position, as hereinbefore described with reference to the packer 14.

Upon the support for the releasable connection being removed, as aforesaid, the connection may then be broken or separated by applying rotational force, such as by rotating the drill pipe 12, in a direction (for example, in a clockwise direction) such as to screw the coupling member 17' off of the ring 81. In Figure 9 the coupling member 17' is shown after having been screwed off of the ring 81 sufficiently to partially break or separate the connection.

After the releasable connection has been broken or separated, it may be formed again at any time by applying sufficient force, such as by lowering or setting down the drill pipe 12 so as to overcome the yieldable ring 81 by radial compression thereof and return the member 17' to its initial or lowermost position on the mandrel 21'. As in the case of the arrangement shown in Figures 1 to 6, inclusive, the packer 14' may then be returned to its relaxed or unexpanded position by applying additional force, such as by further lowering the drill pipe 12, so as to move the mandrel 21' to its lowermost position within the case 18'. Thereafter the connection supporting means becomes replaced or is rendered operative again as the mandrel 21' returns to its uppermost position within the case 18', thus returning the parts to the respective positions shown in Figures 7 and 8.

It will be appreciated by those skilled in the art that the invention as herein disclosed provides particular advantages when applied in connection with a well operation wherein it is desired to employ upper and lower well packers in a "straddle" packer arrangement. In the performance of such a well operation using, for example, the arrangement of Figures 1 to 6, inclusive, the assembly 10 is lowered on the drill pipe 12 to a position within the casing 11 in which, as shown, the lower packer 14 has its packing sleeve 19 disposed below the series of perforations 15.

During the lowering thereof, the parts of the assembly 10 are in the respective positions shown in Figures 1, 2 and 2A. That is, the packers 13 and 14 are in their relaxed or unexpanded positions and are securely coupled or locked together due to the releasable connection being then supported, as hereinbefore described.

Upon reaching the desired location in the casing 11, the packer 14 is set or expanded by supplying fluid to the lower chamber B in the case 18, such as by pumping the fluid into the upper end of the drill pipe 12 at the surface of the ground and downwardly along the passageway 22 into the upper chamber A and thence into the lower chamber B through the ports 44 and 39, which are then in alignment due to the sliding sleeve valve being initially open, as hereinbefore described.

Upon the packer 14 being at least partially set or expanded, the sliding sleeve valve closes automatically and at the same time the support for the releasable connection is removed or rendered inoperative, due to the fluid pressure in the chamber A applying sufficient force, as hereinbefore described, to move the operating member 47 to its upward position within the case 18, as shown in Figure 4.

Up to this point the procedure is substantially the same using either of the arrangements shown in the drawing. Thereafter the releasable connection is broken or sepa-

12

rated by the application of longitudinal or rotational force, depending on the type of connection used, and the upper part of the assembly 10 is moved upwardly within the casing 11 to a position in which the upper packer 13 upon being set or expanded will effect a fluid-tight seal above the series of perforations 15. Since there is then no pipe or tubing interconnecting the packers 13 and 14, it is apparent that seals may be thus effected at or near the upper and lower limits of zones or formations of any thickness, whereupon the well operation may be carried out in accordance with well known practices.

Upon completion of the well operation the releasable connection is formed again and the parts of the assembly 10 returned to their initial positions, as hereinbefore described, whereupon the entire assembly 10 may be withdrawn from the well or moved to another location therein.

It will also be appreciated by those skilled in the art that while a releasable connection or safety joint constructed in accordance with the disclosure herein provides particular advantages when used for coupling into an assembly or string a packer or other apparatus which is hydraulically operable, such a connection or joint may also be used to advantage for coupling into an assembly or string a packer or other apparatus which is not hydraulically operable, in which event fluid pressure may still be employed for removing the support initially preventing the connection from being broken or separated.

While the invention has been herein described with particular reference to its application in certain arrangements, it is understood that the invention may be applied elsewhere. It is apparent that various changes and modifications within the spirit of the invention will now present themselves to persons skilled in the art. Accordingly, the invention is best defined by the scope of the appended claims.

I claim:

1. A well packer comprising an elongated hollow case having an upper and a lower chamber therein, means within said case forming a passageway for supplying fluid under pressure to said upper chamber, an operating member mounted for relative longitudinal movement within said upper chamber, said operating member having a lower surface exposed to the fluid pressure in said upper chamber and an upper surface exposed to the space outside said case, whereby the building up of fluid pressure within said upper chamber tends to move said operating member upwardly therein, valve means including the lower portion of said operating member for controlling the passage of fluid between said chambers, said valve means being open and permitting fluid to pass in either direction between said chambers when said operating member is in its downward position and being adapted to close and thereby confine fluid in said lower chamber upon said member being moved upwardly from its downward position, at least one resilient and expansible packing member on said case adapted to be hydraulically set or expanded, means responsive to the fluid pressure in said lower chamber for expanding said packing member, and means for yieldably supporting said operating member in its downward position and thereby holding said valve means open until the fluid pressure in said chambers becomes sufficient to at least partially expand said packing member, whereupon said operating member moves upwardly and said valve means closes automatically to confine fluid in said lower chamber and hold said packing member in an expanded position.

2. A well packer as claimed in claim 1 including a mandrel mounted for limited relative longitudinal movement within said upper chamber and adapted upon being moved downwardly therein to engage said operating member, and connection means on said mandrel for securing said packer to other apparatus of the type lowered into a well bore, the arrangement being such that said operating member may be moved downwardly to open said

13

valve means and permit the escape of fluid confined in said lower chamber by moving said mandrel downwardly at a time when said packing member is held in expanded supporting engagement with the wall of a well bore into which said packer has been lowered, whereupon said packing member is permitted to return to its unexpanded position.

3. A well packer as claimed in claim 1 including an upwardly closing one-way check valve between said chambers for permitting additional fluid under pressure to be supplied to said lower chamber to further expand said packing member while said operating member is in its upward position.

4. In an assembly including upper and lower parts adapted to be releasably coupled together and lowered into an oil or gas well or the like, the combination of means within said lower part forming a chamber adapted to be supplied with fluid under pressure, a mandrel extending into said chamber and mounted for limited relative longitudinal movement therein with respect to said lower part, said mandrel having a bore extending upwardly from the lower end thereof and having a lateral slot connecting the upper portion of said bore with the space outside said mandrel, a pin mounted for movement within said slot into and out of said bore, said pin being adapted when in its outward position to prevent and when in its inward position to permit relative movement between said mandrel and said upper part in a direction such as to cause separation of said parts when coupled together, an operating member mounted for relative upward and downward movement within said bore, said operating member having a lower surface exposed to the fluid pressure in said chamber whereby the building up of fluid pressure therein tends to move said operating member to its upward position within said bore, said operating member having its upper portion disposed within said bore opposite said slot and having on said upper portion a recess alignable with said pin, said recess being adapted to move into alignment with said pin upon the fluid pressure in said chamber moving said operating member to its upward position whereby said pin is permitted to move inwardly to a position permitting separation of said parts, and said operating member having a surface engageable by said mandrel whereby said member may be returned to its downward position within said bore by moving said mandrel downwardly and then upwardly within said chamber.

5. The invention as claimed in claim 4 including means for yieldably connecting said operating member to said lower part when in its downward position within said bore and means for yieldably connecting said mandrel to said lower part when in its uppermost position within said chamber.

6. In an assembly including upper and lower parts adapted to be lowered together into a well bore or the like, the combination of releasable connection means responsive to relative movement between said parts for selectively coupling together and separating said parts, means within one of said parts forming upper and lower chambers, means within said chamber-containing part forming a passageway for supplying fluid under pressure to said upper chamber, an operating member mounted for upward and downward movement within said upper chamber, said operating member having a lower surface exposed to the fluid pressure in said upper chamber and having an upper surface exposed to fluid pressure in the well outside said assembly, whereby said operating member tends to move upwardly upon fluid under pressure being supplied to said upper chamber, connection supporting means responsive to movement of said operating member for selectively preventing and permitting operation of said releasable connection means to separate said parts when coupled together, said connection supporting means being adapted to prevent separation of said parts when said operating member is in its downward position within said upper chamber and to permit separation there-

14

of upon said operating member being moved to its upward position therein, valve means responsive to movement of said operating member for selectively permitting and preventing fluid flow between said chambers, said valve means being adapted to move from its open to its closed position as said operating member moves from its downward to its upward position, packing means including at least one resilient and expansible member mounted on said chamber-containing part, means responsive to the fluid pressure in said lower chamber for expanding said packing means into tight engagement with the wall of said well bore and yieldable means for supporting said operating member in its downward position within said upper chamber until the fluid pressure in said chambers becomes sufficient to at least partially expand said packing means.

7. The invention as claimed in claim 6 including a mandrel mounted for limited relative longitudinal movement within said upper chamber upon relative movement occurring between said parts when coupled together, said mandrel upon moving downwardly within said upper chamber being adapted to engage said operating member and return said member to its downward position therein, and yieldable means for supporting said mandrel in its uppermost position within said upper chamber whereby a predetermined force is required to move said mandrel downwardly therein.

8. A well packer comprising a body having a chamber therein and a fluid passageway adapted to conduct fluid under pressure to said chamber, initially open valve means in said body communicating said passageway with said chamber and closable for confining fluid therein, packing means on the exterior of said body, fluid pressure-actuable means actuable by the pressure of fluid in said chamber for expanding said packing means, said initially open valve means including a fluid pressure-actuable member movably mounted in said body, means for closing said valve means, releasable means initially maintaining said pressure-actuable member in open position, said member having two opposed surfaces, one of said surfaces being exposed to pressure of the fluid in said passageway being supplied to said chamber to urge said member toward valve closing position and the other of said surfaces being exposed to the pressure of fluid in the well outside said body urging said member toward open valve position, whereby said member tends to close said valve means when the pressure of fluid being supplied to said chamber exceeds the pressure of fluid in the well outside said body.

9. A well packer comprising a body having a chamber therein, means including a fluid passageway and initially open valve means forming a passageway for supplying fluid under pressure to said chamber, packing means on the exterior of said body, means actuable by the pressure of fluid in said chamber for expanding said packing means, said initially open valve means including a fluid pressure-actuable operating member mounted in said body, movable for closing said valve means to confine fluid in said chamber, releasable means initially maintaining said valve means open, said member having two opposed surfaces, one of said surfaces being exposed to the fluid pressure in said passageway and the other of said surfaces being exposed to the fluid pressure in the well outside said body, said releasable means releasing said member for movement to close said initially open valve means when the force applied to said member due to the pressure of fluid in said passageway reaches a predetermined value greater than the force applied to said member due to the pressure of fluid in the well outside said body, whereupon the fluid confined in said chamber tends to hold said packing means in an expanded position.

10. A well packer as claimed in claim 9 including additional valve means in said body adapted to communicate said passageway with said chamber and operable to permit additional fluid under pressure to be supplied to

further expand said packing means after said initially open valve means has closed.

11. A well packer comprising an elongated body having therein an upper chamber and a lower chamber and a passageway for supplying fluid under pressure to said upper chamber, initially open valve means between and communicating said chambers, at least one resilient and expansible packing member on the exterior of said body adapted to be hydraulically set or expanded, means actuatable by the fluid pressure in said lower chamber for expanding said packing member, said initially open valve means including an operating member mounted for movement in one direction in said upper chamber to close said valve means and confine fluid in said lower chamber, said operating member having two opposed surfaces, one of said surfaces being exposed to the fluid pressure in said upper chamber and the other of said surfaces being exposed to the fluid pressure in the well outside said body, said operating member being adapted to move in said one direction when the force applied thereto due to the pressure of fluid in said upper chamber reaches a predetermined value greater than the force applied to such member due to the pressure of fluid in the well outside said body, whereupon the fluid confined in said lower chamber tends to hold said packing member in an expanded position.

12. A well packer as claimed in claim 11 including normally closed, fluid pressure-actuatable one-way valve means between and communicating said upper and lower chambers for permitting additional fluid under pressure to be supplied to said lower chamber to further expand said packing member after said initially open valve means has closed.

13. A well packer as claimed in claim 11 wherein there is means movably mounted in said body actuatable to engage and move said operating member in a reverse direction within said upper chamber to return said initially open valve means to its open position after closure thereof and thereby permit the escape of fluid confined in said lower chamber, whereupon said packing member is permitted to return to its unexpanded position.

14. In an assembly including two parts adapted to be telescoped and lowered together into a well bore or the like, the combination of releasable connection means initially coupling together said parts and responsive to relative movement therebetween to effect separation of said parts, means in one of said parts forming a body having a chamber therein and a fluid passageway for conducting fluid under pressure to said chamber, an operating member mounted for movement in said body from an initial position therein, said operating member having two opposed surfaces, one of said surfaces being exposed to the pressure of fluid being supplied to said chamber and the other of said surfaces being exposed to the pressure of fluid in the well outside said body, whereby said operating member tends to move away from its initial position in said body when fluid under pressure is supplied to said chamber, connection locking means including a portion of said operating member and an element movably mounted in one of said parts and engageable by said operating member for initially preventing release of said releasable connection means, said connection locking means being in locking position when said operating member is in its initial position in said body and being adapted to unlock and thereby permit operation of said releasable connection means to separate said parts upon said operating member being moved away from its initial position in said body, and means for yieldably supporting said operating member in its initial position in said body and thereby maintaining said con-

nection locking means in its locking position until the force applied to said operating member due to the pressure of fluid being supplied to said chamber reaches a predetermined value greater than the force applied to said operating member due to the pressure of fluid in the well outside said body.

15. The invention as claimed in claim 14 wherein there is means movably mounted in said body actuatable to engage and return said operating member to its initial position in said body and thereby return said connection locking means to its locking position to prevent operation of said releasable connection means.

16. In an assembly including two parts adapted to be telescoped and lowered together into a well bore or the like, the combination of releasable connection means initially coupling together said parts and responsive to relative movement therebetween to effect separation of said parts, means within one of said parts forming a body having a chamber therein and a fluid passageway for conducting fluid under pressure to said chamber, at least one packing member on said body adapted to be hydraulically set or expanded, means responsive to the fluid pressure in said chamber for expanding said packing member, an operating member mounted for movement in said body from an initial position therein, initially open valve means including a portion of said operating member for controlling the passage of fluid from said passageway into said chamber, said valve means being open and permitting fluid to pass from said passageway into said chamber to expand said packing member when said operating member is in its initial position in said body and being adapted to close and thereby confine fluid in said chamber to hold said packing member in an expanded position upon said operating member being moved away from its initial position in said body, connection locking means also including a portion of said operating member and an element movably mounted in one of said parts and engageable by said operating member for controlling operation of said releasable connection means, said locking means being in locking position to prevent operation of said releasable connection means when said operating member is in its initial position in said body and being adapted to unlock and thereby permit operation of said releasable connection means to separate said parts upon said operating member being moved away from its initial position in said body, said operating member having two opposed surfaces, one of said surfaces being exposed to the pressure of fluid in said passageway being supplied to said chamber and the other of said surfaces being exposed to the pressure of fluid in the well outside said body, whereby said operating member tends to move away from its initial position in said body when fluid under pressure is supplied to said chamber, and means for yieldably supporting said operating member in its initial position in said body and thereby maintaining said valve means in its open position and said connection locking means in its locking position until the pressure of fluid being supplied to said chamber becomes sufficient to at least partially expand said packing member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,150,310	Baker	Mar. 14, 1939
2,187,635	Stamps	Jan. 16, 1940
2,227,730	Lynes	Jan. 7, 1941
2,227,731	Lynes	Jan. 7, 1941
2,315,921	Baker	Apr. 6, 1943
2,799,346	Baker et al.	July 16, 1957
2,806,532	Baker et al.	Sept. 17, 1957