

April 2, 1963

G. W. NIELSON ET AL

3,083,775

FORMATION PACKER

Filed Oct. 5, 1959

3 Sheets-Sheet 1

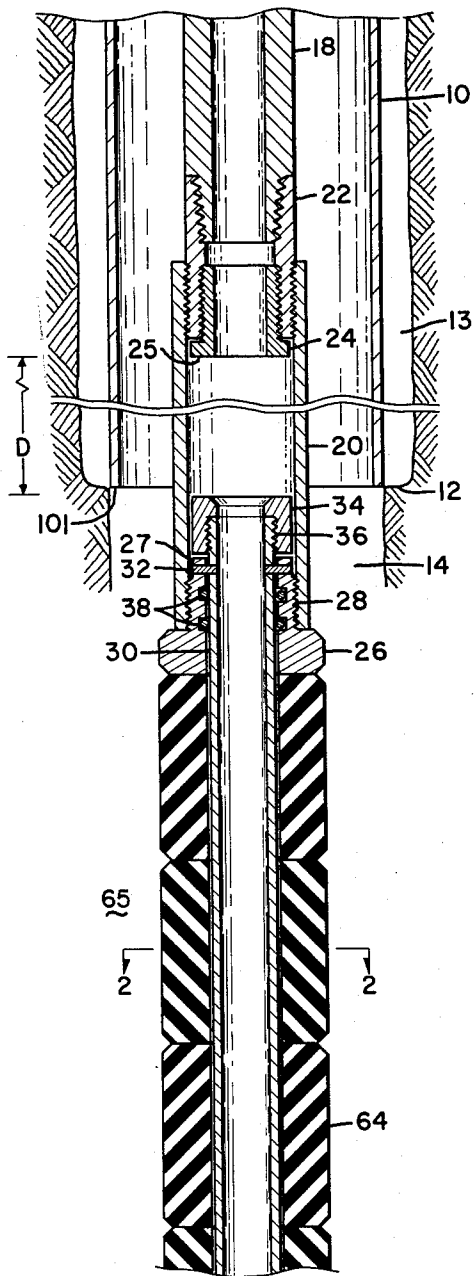


FIG. 1A

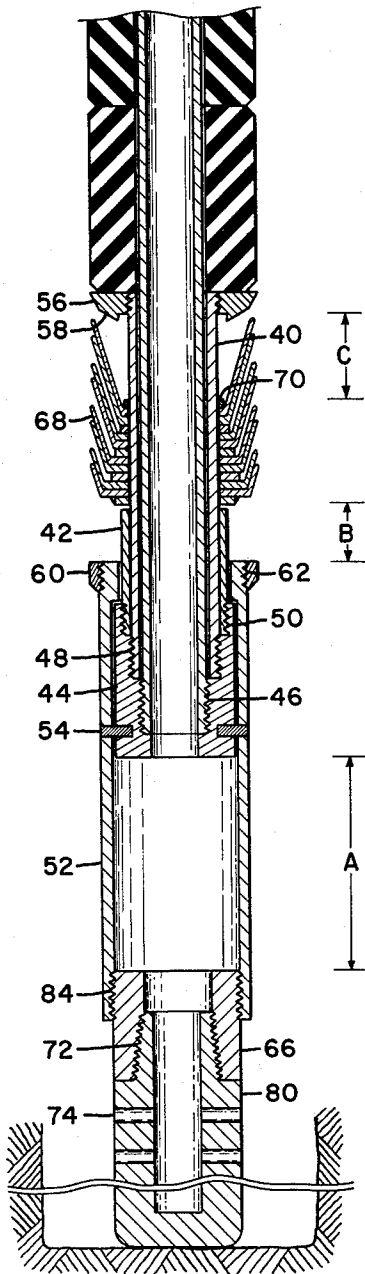


FIG. 1B

James D. Henderson
Garth W. Nielson

Inventors

By *John D. Gassett*

Attorney

April 2, 1963

G. W. NIELSON ET AL

3,083,775

FORMATION PACKER

Filed Oct. 5, 1959

3 Sheets-Sheet 2

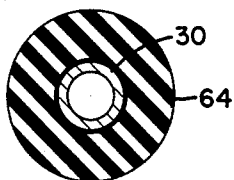


FIG. 2

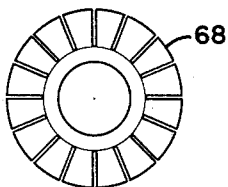


FIG. 3

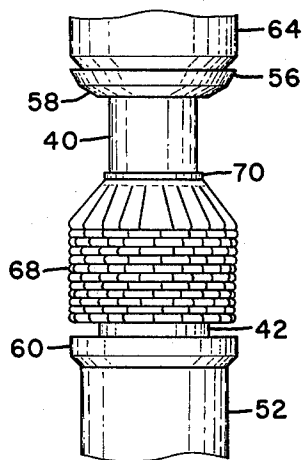


FIG. 5

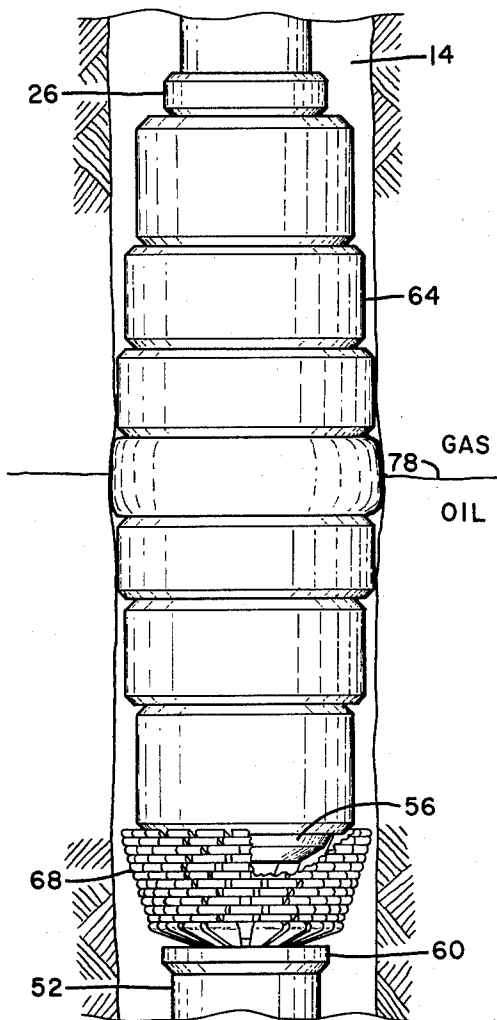


FIG. 4

James D. Henderson
Garth W. Nielson

Inventors

By *John D. Russell*

Attorney

April 2, 1963

G. W. NIELSON ETAL
FORMATION PACKER

3,083,775

Filed Oct. 5, 1959

3 Sheets-Sheet 3

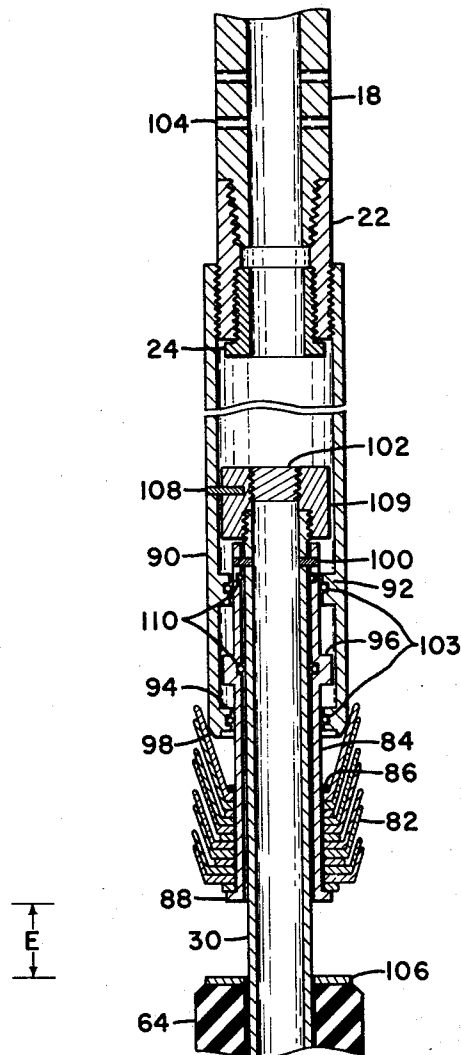


FIG. 6

James D. Henderson
Garth W. Nielson

Inventors

By *John D. Gassett*

Attorney

1

3,083,775

FORMATION PACKER

Garth W. Nielson and James D. Henderson, Devon, Alberta, Canada, assignors to Jersey Production Research Company, a corporation of Delaware

Filed Oct. 5, 1959, Ser. No. 844,542

7 Claims. (Cl. 166—201)

This invention concerns a packer for use in well bores. It especially relates to a mechanical packer for use in an open hole section below a production casing through which the packer is run.

Well bores are drilled in the surface of the earth to great depths in a search for petroleum products, as well as water and other minerals. Usually oil wells are lined with a casing which is usually steel to prevent the crumbling of the walls of the well bore and also to prevent the entry therein of undesirable fluids from the various formations traversed. In some instances, the casing is not set to the bottom of the borehole, but rather is set or cemented at a point above the bottom of the hole which is usually at the top of the formation from which it is desired to produce fluid. In such a completed well, it is sometimes desirable to set a packer in the open hole section in order to produce oil preferentially to water or to gas which may respectively be below or above the oil. There are many types of formation packers available to the industry; however, none of them are adequate to pack off in the open hole which is larger than the diameter of the casing through which the packer is run. It is thus seen that there is a need for a new type of packer which may be passed through the casing, yet expand sufficiently to pack off the open hole beneath the casing. The present invention provides such a packer.

Briefly, the invention includes: a plurality of resilient annular packing elements spaced about a tubular mandrel and a plurality of folded metal plates set on a double traveling mandrel. Means are provided for forcing the folded metal plates into a substantially horizontal position. Thus, during one travel of the mandrel, the plates are spread out so as to hold or support the resilient packing elements. Further travel of the mandrel is used to compress the packing elements against the plates so that the packing elements will expand outwardly against the walls of the borehole.

A fuller and better understanding of this invention may be had from the following description taken in conjunction with the accompanying drawing in which:

FIG. 1A is an upper portion and FIG. 1B is a lower portion of a longitudinal section showing one embodiment of the invention in the position it is in while being lowered through a string of casing;

FIG. 2 is a horizontal section on line 2—2 of FIG. 1; FIG. 3 illustrates a horizontal view of one of the plates of FIG. 1;

FIG. 4 illustrates a portion of the apparatus in an expanded position against the walls of the borehole;

FIG. 5 illustrates a fragmentary view of the apparatus, illustrating the position of plates when the apparatus of FIG. 1 is withdrawn from the well bore; and,

FIG. 6 illustrates another embodiment of the invention in which support plates are positioned above the packing elements.

Referring to the drawing, FIG. 1 in particular, there is illustrated a casing 10 which has been set with cement 13 at depth 12 in borehole 14. The packer assembly is attached to the lower end of tubing string 18 which is suspended within the casing 10.

Attached to tubing string 18 is upper travel collar 20. A head 22 is conveniently used to connect the upper travel collar 20 with tubing string 18. A travel adjustment screw 24, having head 25, is connected to head 22.

2

The extension of screw 24 into travel collar 20 is adjustable.

An annular packerhead 26 is shown at the lower end of upper travel collar 20 and connected thereto conveniently by threads 28. Packer head 26 has an upper shoulder 27 within upper travel collar 20.

A mandrel 30 is inserted through packer head 26 and is held in fixed position therewith by shear pin 32, which prevents vertical movement of the mandrel with respect to upper travel collar 20, during the lowering of the tool into a borehole and until pin 32 is sheared in a manner hereinafter described. A mandrel lock-nut 34 is connected to the upper end of mandrel 30 conveniently by threads 36. When shear pin 32 is sheared, mandrel lock-nut 34 has vertical travel within upper travel collar 20 between head 25 of travel adjustment screw 24 and the upper shoulder 27 of packer head 26. Sealing means 38 are conveniently provided in packer head 26 to provide a slidable and sealing relationship between the outer wall of mandrel 30 and the inner passage of packer head 26.

A plate retaining sleeve 40 is positioned around the lower end of mandrel 30. A plate reversing sleeve 42 is positioned about the lower end position of plate retaining sleeve 40. The lower end of mandrel 30, plate retaining sleeve 40 and plate reversing sleeve 42 are threadably connected to a mandrel nut 44 at 46, 48 and 50, respectively. Anchor nut 66 is screwed into the lower end of lower travel collar 52 at threads 84.

Mandrel nut 44 is adapted to slidably fit within a lower travel collar 52. During lowering operations, shear pins 54 retain mandrel nut 44 in a fixed position with lower travel collar 52. Shear pin 54 is of less strength than shear pin 32. The reasons for this will become apparent when the operations of the device are discussed.

A lower packer expansion head 60 surrounds the outer periphery of the upper end of lower travel collar 52 and is connected thereto by thread 62. On the exterior and at the top of plate retaining sleeve 40 is plate spreader 56. Plate spreader 56 preferably has a beveled downwardly and outwardly facing shoulder 58.

Positioned between packer head 26 and plate spreader 56 is a packer section 65 including a plurality of resilient packing elements 64. Resilient packing elements 64 are of a nature that, when compressed axially, will expand laterally and upon such compression being released, will contract substantially to their original shape. A preferred material for these packing elements is hard rubber. As will be seen, it is especially preferred that the packing elements at the top and bottom be made of a harder material than the intermediate packing elements.

A plurality of folded metal plates 68 having center apertures as more clearly seen in FIG. 3, are spaced about plate retaining sleeve 40 and are held in position thereon between plate reversing sleeve 42 and snap ring 70. Soft steel that will not break upon bending has been found to be quite satisfactory for use in these plates 68. One-sixteenth inch has also been found to be a convenient thickness for the plates. The number of plates will vary, depending upon several factors such as the amount of weight required to compress packing elements 64, as well as the differential pressure ultimately to be across the packer section 65. The plates 68 are usually just slightly smaller in diameter, in a flat state, than the diameter of the open hole. Plates 68 are also preferably staggered so that the slots of the plates are not directly underneath the slot in the plate above it.

The travel distance A of mandrel nut 44 and lower travel collar 52 should be equal to, or greater, than the distance B plus C. Distance B is the distance from the base of the lowest plate 68 to the top of lower packer head 60 when mandrel nut 44 is in its uppermost position in lower travel collar 52. Distance C is the distance be-

tween snap ring 70 and the lower base of plate spreader 56, when in a position shown in FIG. 1. The travel distance D of mandrel nut 34 in upper travel collar 20 is at least equal to and preferably greater than the expected contraction of packing elements 64.

A standpipe 80 is secured to anchor nut 66 as by threads 72. The length of standpipe 80 is selected so as to support the assembly such that the packing elements will pack off the borehole at the desired location. In the apparatus shown in FIG. 1B, standpipe 80 has perforations 74 through which fluid may be produced from that section of the formation beneath packing elements 64 after they are expanded.

Having described the structural features of the preferred embodiment of this invention showing the best mode contemplated for the practice thereof, attention is now directed toward the operation of the device. Prior to lowering the packer assembly into the well bore, standpipe 80 of the desired length is secured to anchor nut 66 of the packer assembly. The packer assembly, as illustrated in FIGS. 1A and 1B, is then lowered through casing 10 by the lowering of tubing string 18 in a conventional manner. The complete packing assembly then is lowered until standpipe 80 rests on the bottom of the borehole. At that point, downward force is applied through the tubing string and mandrel 30 so as to shear shear pins 54. It is noted that shear pin 32 is stronger than shear pin 54 and is therefore not sheared at this time. Downward force is continued to be applied through mandrel 30 forcing it downwardly. When the lower of plates 68 contracts the upper surface of lower packer head 60, continued downward force causes snap ring 70 to snap loose from engaging plate retaining sleeve 40. Plate retaining sleeve 40 and mandrel 30 are then free to move on downwardly through plates 68. During the travel B, shoulder 58 contracts the upper of plates 68 and forces plates 68 into a substantially horizontal position, as shown in FIG. 4.

At this point, shear pins 32, which are of greater strength than shear pins 54, have not yet been sheared. Therefore, additional force is applied through tubing string 18 to shear shear pins 32. As additional force is continued to be applied to the tubing string, upper travel collar 20 slides downwardly over mandrel lock-nut 34 and mandrel 30. Packing elements 64 are then compressed between packer head 26 and the support formed by the spread plates 68. Although not limited in any theory of operation, it appears that the packer segments, when compressed, form a more or less stepwise expansion with only the center segments contacting the borehole wall and sealing with it. This stepwise expansion of the packers is desirable as it aids in preventing the packer section from slipping over the retaining plates, which is one of the problems in the known systems. It is further thought that having the rubber harder in the end packer element sections, as compared to the middle sections, aids in obtaining the stepwise expansion.

The particular arrangement of the apparatus as illustrated in FIG. 4, is very useful in shutting off the gas portion of the formation. For example, FIG. 4 shows the packer assembly is set below the gas-oil contact 78. In this manner, the gas which flows into the well bore 14 is contained therein above the packer while oil is being produced below the packer through perforations 74 in standpipe 80, then up through mandrel 30 and into tubing 18. Support plates 68 are especially desired if there is any substantial pressure differential across packing elements 64.

A packer similar to that illustrated in FIGS. 1A and 1B has been built, tested in a well bore, and pulled with no difficulty. This packer was used to shut off gas zones in an oil well which had 9" open hole below 7" casing which has an internal diameter of 6½". Seventeen plates were used having an expanded diameter of 8½". The plates were ¼" thick and were made of mild steel. There

were seven packer elements, each 2.375" inside diameter, 6.0" outside diameter, and 6.5" in height. The open hole below the casing was successfully packed off using this packer. The pressure above the packer was about 1,000 p.s.i. greater than the pressure below the packer.

These packers have proved quite advantageous. For example, they are easily retrieved, as all that is necessary is to release the force expanding the packer elements 64 permitting them to return to their original shape. The tool is then pulled upwardly by the tubing string and the metal plates 68 are folded downwardly in a reverse position like that shown in FIG. 5. These packers also have sufficient strength to hold great differential pressures across rubber elements. Differential pressures of at least 1,000 p.s.i. greater, may be encountered without difficulty. It is also noted that the packers are expanded mechanically and are not dependent upon hydraulic pressures held by back check valves, etc.

In some instances it will be desired to produce from above the expanded packing elements, such as in the case of shutting off water production from oil production. In such a case, it may be desired that folded packer plates similar to plates 68 be provided above packer section 65. A suitable means for providing folding plates above the packing section is illustrated in FIG. 6. When production is from that part of the formation above the packer assembly, it is especially desirable to have a series of folded plates positioned above the packer element 64. This aids in holding the packers in place as in this example when the well is producing, the pressure is greater below the packer assembly than above.

A series of folded plates 82 are positioned about an upper plate receiving sleeve 84 which is placed about the upper end portion of mandrel 30. Plates 82 are held in place by snap ring 86 above the plates and external shoulder element 88 of sleeve 84 below the rings. Shoulder element 88 may be an integral part of sleeve 84.

Upper travel collar 90 is a modification of upper travel collar 20 illustrated in FIG. 1-A. Upper travel collar 90 has an upper internal annular shoulder 92 and a lower internal annular shoulder 94. As will be more clearly shown, shoulder member 92 and internal shoulder member 94 are spaced apart a sufficient distance to permit the horizontal expansion of folded plates 82.

Sleeve 84 has an external annular shoulder 96 which fits into upper travel collar 90 and has free vertical movement between the upper shoulder 92 and the lower internal shoulder 94. The lower end of upper travel collar 90 has a downward, preferably rounded, shoulder 98 which, as will be seen, is used for spreading plates 82.

Shear pin 100 holds sleeve 84 rigid with respect to mandrel 30. Shear pin 100 is similar to shear pin 32 and likewise is stronger than shear pin 54. Shear pin 108 connects lock-nut 109 on the upper end of mandrel 30 to travel collar 90. Shear pin 108 is preferably stronger than shear pin 32, but weaker than shear pin 100. When the lower plate means are used on the same apparatus as the upper plates, shear pin 108 insures that plates 82 will not prematurely spread.

If it is desired to use the apparatus shown in FIG. 6 to produce fluid from above the packer preferentially to fluid beneath the packer, a removable plug 102 is inserted in the upper end of mandrel 30. Perforations 104 are also provided in tubing 18. The lower portion of the packer assembly, as illustrated in FIG. 1-B, may also be used with the apparatus illustrated in FIG. 6 as the upper portion thereof.

The operation of a packer assembly which has upper folded plate means 82 is similar to that described above for the apparatus in FIGS. 1-A and 1-B. When going into the hole, sleeve 84 is supported from upper travel collar 90 through shear pin 100, mandrel 30 and shear pin 108. When standpipe 80 rests on the bottom of the borehole, as illustrated in FIG. 1-B, downward force on the tubing string 18 through upper travel collar 90, and

5

mandrel 30 shears lower shear pin 54. After shear pin 54 has been sheared, continued downward movement of mandrel 30 expands lower plates 68 as described above in connection with FIGS. 1-A and 1-B.

Additional downward force on tubing 18 will shear shear pin 108. Continued downward movement of tubing 18 causes shoulder 98 to spread or expand folded plates 82 which are prevented from downward movement by shoulder 88 of sleeve 84.

At this stage of the operation, both upper plates 82 and lower plates 68 have been spread. Further downward movement of tubing 18 will shear shear pin 100. Further downward movement of tubing 18 then compresses packing elements 64.

It is to be noted that packer ring 106 on top of the top of packing elements 64 is spaced downwardly from shoulder 88 when sleeve 84 is in its upper position, as illustrated in FIG. 6. This spaced distance E is sufficient to allow plates 82 to be folded downwardly upon contact with the lower shoulder 101 of casing 10 when the device is pulled out of the hole.

It may be desirable to use upper plate 82 when it is desired to produce from below packer section 65. In such case, perforations 104 are not formed, or if formed, then plugged. Plug 102 is also removed and sealing means 103, such as O-ring, are provided between shoulders 92 and 94 and sleeve 84; seals 110, such as O-rings, are also used between mandrel 30 and sleeve 84.

While there are above disclosed but a limited number of embodiments of the system of the invention herein presented, it is possible to produce still other embodiments without departing from the inventors' concept as herein disclosed. It is therefore desired that only such limitations be imposed on the impending claims as are stated therein.

What is claimed is:

1. A well packer for use in an open hole beneath the cased portion of a well bore which comprises: a mandrel means; a plurality of annular packing elements positioned about said mandrel means and longitudinally adjacent to each other; folded packer support plates, support means supporting said plates at the lower end of said mandrel means below said packing elements; a plate spreader above said plates; means supporting said plate spreader adjacent said annular packing elements a plate reversing sleeve positioned about said mandrel means below said plates; a lower travel collar; a mandrel nut attachable to the lower end of said mandrel means and longitudinally slidable within said lower travel collar; means to retain said lower mandrel nut in said travel collar; a shear pin holding said mandrel means to said lower travel collar; and means to longitudinally compress said packing elements against said plates whereby said packers are expanded laterally against the walls of said well bore.

2. An apparatus as defined in claim 1 in which the interior of said lower travel collar is in communication with the well bore beneath said packer elements.

3. A well packer for use in an open hole beneath a cased portion of a well bore in which a string of tubing is suspended which comprises: a mandrel; a plurality of annular packing elements positioned about said mandrel and longitudinally adjacent to each other; an upper travel collar adapted to be attached to the lower end of a string of tubing; a lower internal annular shoulder on the lower end of said upper travel collar; an intermediate internal annular shoulder on the interior of said upper travel collar and spaced above said lower shoulder; a lock nut on the upper end of said mandrel within said travel collar above said intermediate internal shoulder; means for retaining said lock nut within said upper travel collar above said intermediate shoulder with said nut having free vertical travel therein; a sleeve surrounding said mandrel and fitted slidably and sealingly within said upper travel collar, said sleeve having an external shoulder member slidably positioned between the upper internal shoulder

6

and the lower internal shoulder of said upper travel collar; a plurality of longitudinally spaced folded support plates positioned about said sleeve below said upper travel collar; a first shear pin holding said sleeve rigid with respect to said mandrel; a second shear pin holding said lock nut rigid with respect to said upper travel collar, said second shear pin being weaker than said first shear pin; and means to longitudinally compress said packing elements against said plates whereby said packing elements are expanded laterally against the walls of said well bore.

4. An apparatus as defined in claim 3 in which the interior of said upper travel collar is in communication with the well bore above said packer elements.

5. A well packer for use in an open hole beneath the cased portion of the well bore in which a string of tubing is suspended which comprises: a mandrel; a plurality of annular packing elements positioned about said mandrel and longitudinally adjacent to each other; an upper travel collar adapted to be attached to the lower end of a string of tubing; a sleeve slidably and sealingly mounted about the upper end of said mandrel, said sleeve being sealingly and slidably mounted in said collar; first frangible means adapted to hold said sleeve rigidly to said mandrel; means to limit the vertical longitudinal movement of said sleeve with respect to said collar; second means to limit the vertical longitudinal movement of said mandrel with respect to said collar; second frangible means to hold said mandrel rigid with respect to said travel collar; a plurality of longitudinally spaced folded support plates positioned about said sleeve below said upper travel collar; and means to longitudinally compress said packing elements against said plates whereby said packers are expanded laterally against the walls of said well bore.

6. A well packer for use in an open hole beneath the cased portion of the well which comprises: a mandrel; a plurality of annular packing elements positioned about said mandrel; folded packer support plates; means supporting said support plates at the lower end of said mandrel below said packing elements; a plate spreader; means supporting said plate spreader about said mandrel beneath said annular packing elements and above said plates; a lower travel collar; means to limit the longitudinal vertical movement of said mandrel within said lower travel collar; first frangible means holding said mandrel with respect to said lower travel collar; an upper travel collar adapted to slidably receive said mandrel, said upper travel collar having a packer head means at its lower end; means to limit the longitudinal movement of said mandrel within said upper travel collar; second frangible means holding said mandrel to said upper travel collar, said second frangible means being stronger than said first frangible means.

7. A packer for use in an open well bore beneath a cased portion of said well bore which comprises: an upper travel collar adapted to be attached to the lower end of a string of tubing, a tubular mandrel, a lock-nut on the upper end of said mandrel, means for retaining said lock-nut within said collar with said nut having free vertical travel within said collar, a packer head attached to the lower end of said travel collar, sealing means for sealing said mandrel with said packer head in a sliding and sealing relationship, a retaining sleeve mounted about said mandrel, a plurality of longitudinally spaced folded support plates positioned about said retaining sleeve, a plate spreader on said retaining sleeve above said plates, a plurality of sectional annular packing elements spaced about said mandrel between said plate spreader and said packer head with adjacent elements being contiguous, a plate snap ring spaced about said retaining sleeve below said plate spreader and above the upper of said plurality of plates, a lower travel collar, a mandrel nut attachable to lower end of said mandrel and said retaining sleeve and longitudinally slidable within said lower travel collar, means to retain said mandrel nut in said lower travel col-

lar, first shear pin holding said mandrel to said upper travel collar, second shear pin holding said mandrel to said lower travel collar, said first shear pin being of greater strength than said second shear pin.

References Cited in the file of this patent

UNITED STATES PATENTS

1,771,556 Cox ----- July 29, 1930

5

1,956,694
2,171,049
2,605,846
2,612,953
2,738,016
2,808,889
2,862,563
2,874,782

Parrish ----- May 1, 1934
Simmons ----- Aug. 29, 1939
Van Brunt et al. ----- Aug. 5, 1952
Morgan et al. ----- Oct. 7, 1952
Lynes ----- Mar. 13, 1956
Morrisett ----- Oct. 8, 1957
Thompson ----- Dec. 3, 1958
Johnson et al. ----- Feb. 24, 1959