Dec. 8, 1964 J. W. BONNER 3,160,209

WELL APPARATUS SETTING TOOL

Original Filed Oct. 19, 1956 4 Sheets-Sheet 1

Fig. 1

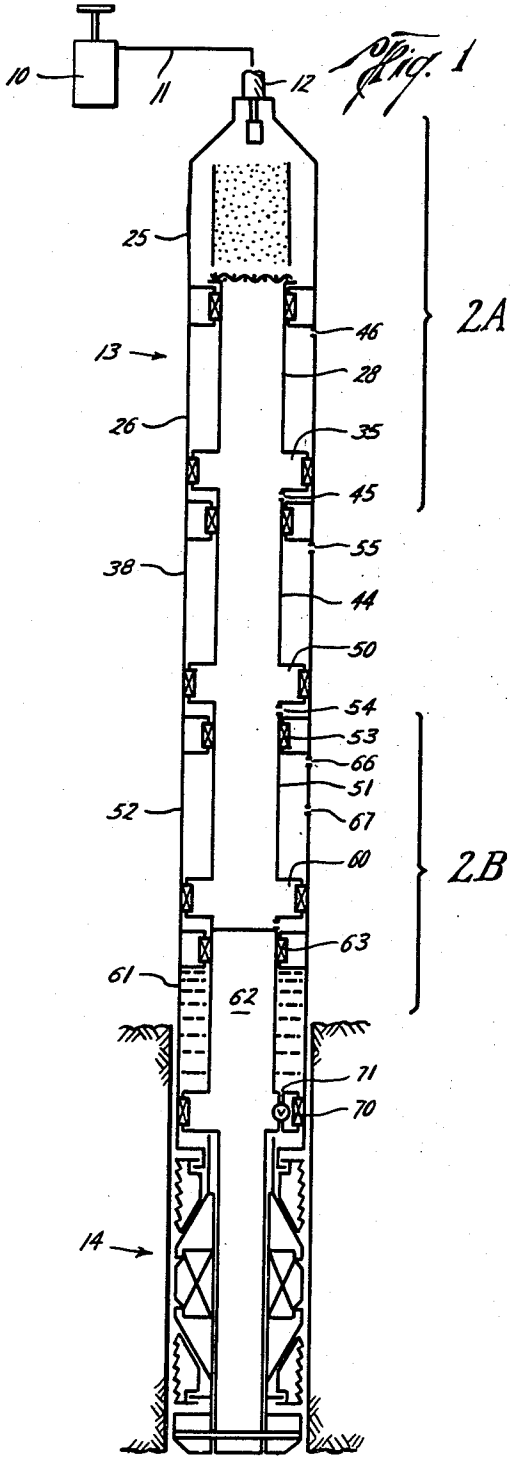
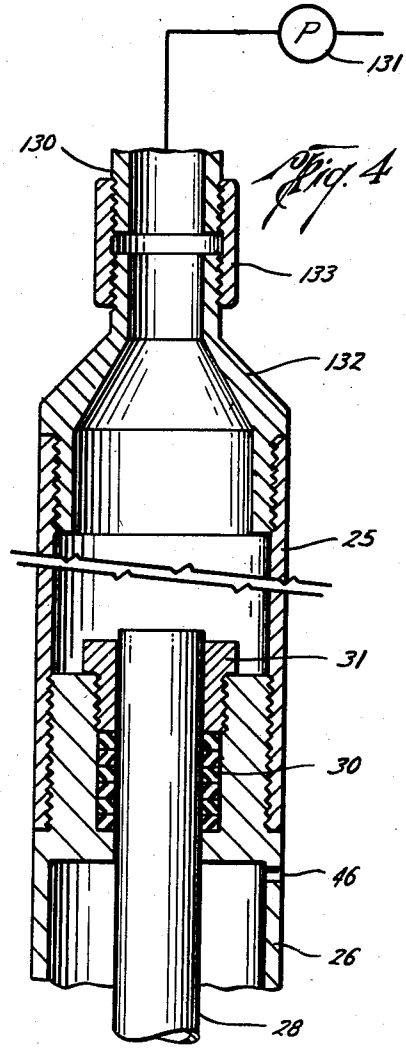



Fig. 4




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Fig. 2A

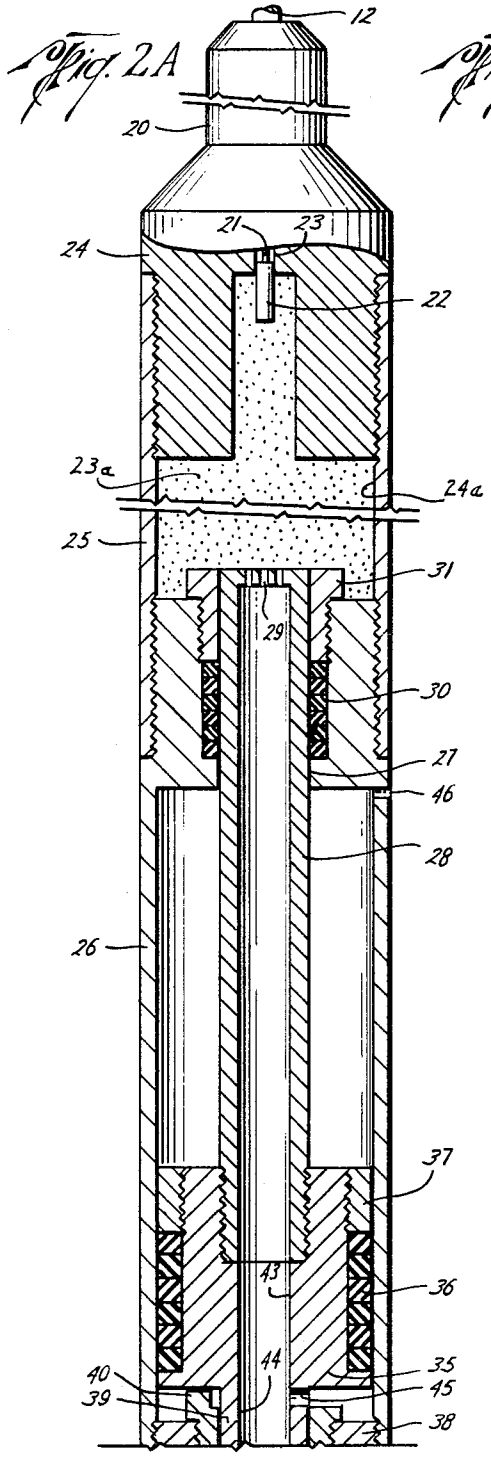
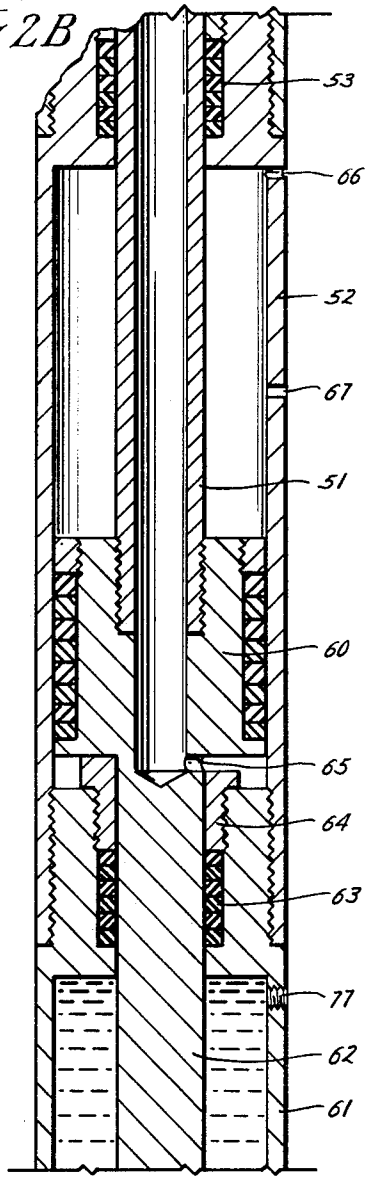



Fig. 2B




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Fig. 2C

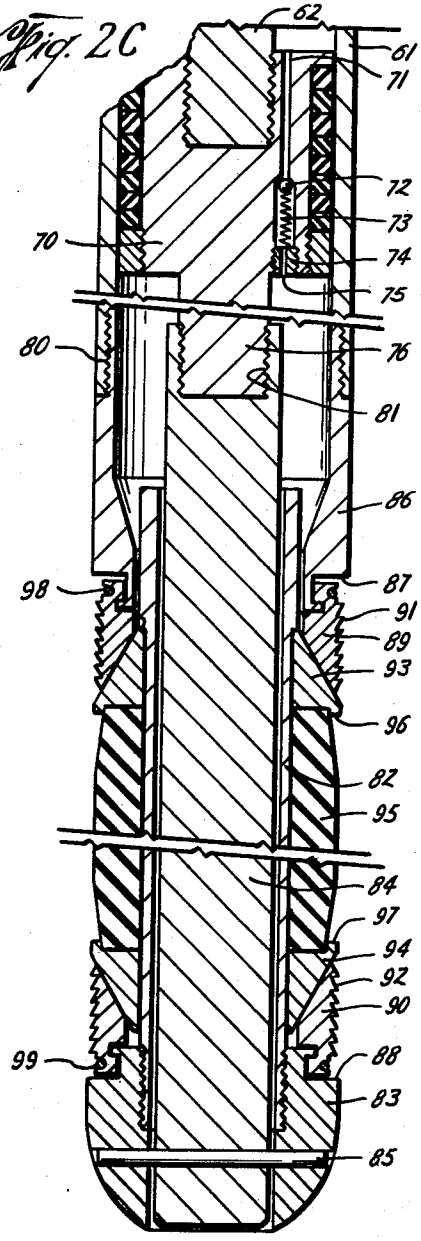
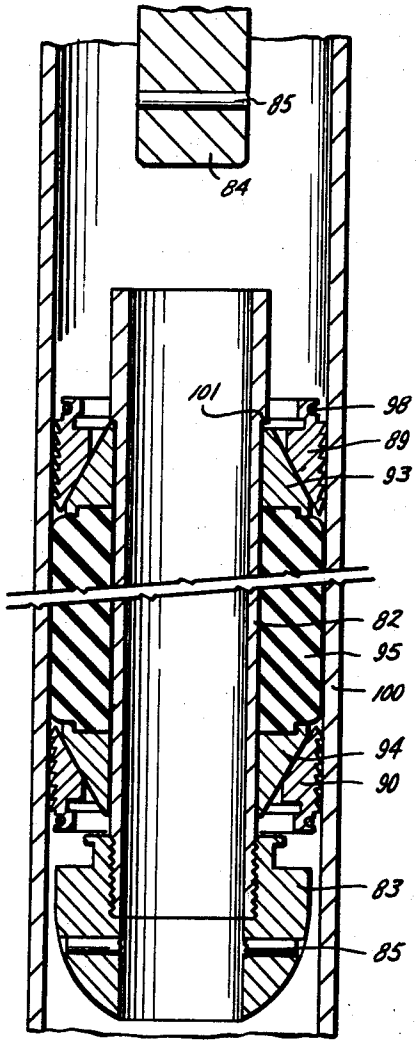



Fig. 3




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Fig. 5

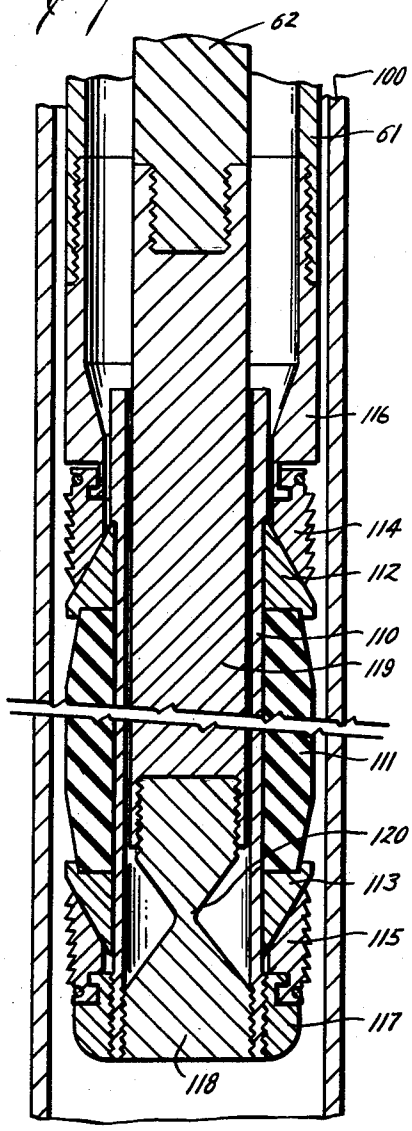
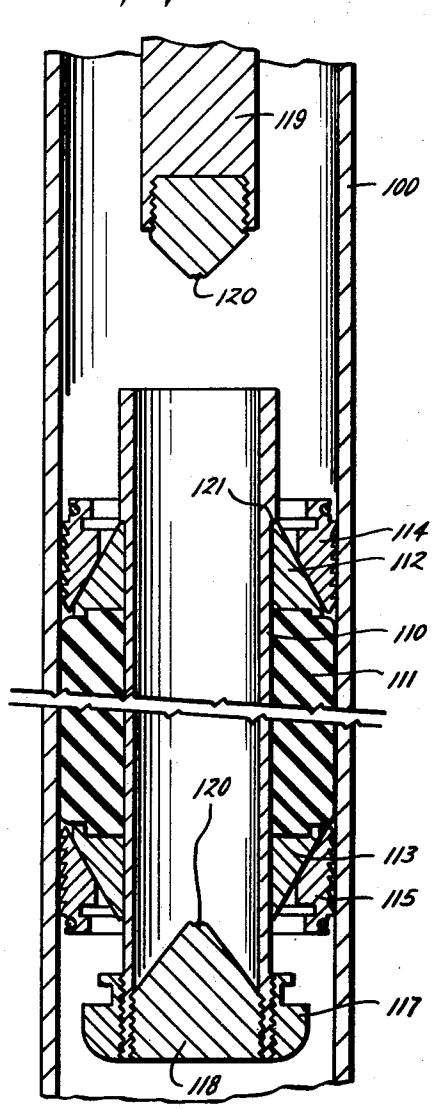



Fig. 6




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3,160,209

# WELL APPARATUS SETTING TOOL

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Continuation of abandoned application Ser. No. 617,112, Oct. 19, 1956. This application Dec. 20, 1961, Ser. No. 160,740

5 Claims. (Cl. 166—63)

This invention pertains to well apparatus including a setting tool and well sealing apparatus particularly adapted for use therewith, namely, a packer and a bridging plug.

This application is a continuation of my co-pending United States Patent application Serial No. 617,112, filed October 19, 1956, and now abandoned.

While it is a principal object of the invention to provide a setting tool that can be operated from a wire line, the apparatus of the invention can, by suitable modification as herein described, be adapted for operation from drill pipe, tubing, or the like.

An important object of the invention is to provide a setting tool that is both inexpensive to manufacture and operate and simple and reliable in operation. Simplified construction is one of the chief advantages of the tool.

A further object of the invention is to provide a well packer that is full opening and a bridging plug that is easily drillable which can be run on the aforementioned setting tool.

Other objects and advantages of the invention will appear from the following description of preferred embodiments thereof, reference being made to the accompanying drawings wherein:

FIG. 1 is a schematic vertical section through a wire line setting tool and packer embodying the invention;

FIGS. 2A, 2B, and 2C are enlarged views of different portions of the apparatus shown in FIG. 1;

FIG. 3 is a vertical section to a still larger scale showing the packer in set position;

FIG. 4 is a vertical section through the upper end of a setting tool adapted for use on drill pipe or tubing;

FIG. 5 is a vertical section through a bridging plug embodying the invention; and

FIG. 6 is a vertical section similar to FIG. 5 showing the bridging plug in set position.

Referring now to FIG. 1, there is shown well apparatus as follows: a source of electricity 10, an electric connection 11, an electric cable 12 adapted to be run in a well and to mechanically support a setting tool 13 at the lower end of which is disposed a production packer 14.

Referring now also to FIGS. 2A, 2B, and 2C, starting with FIG. 2A, the setting tool comprises a rope socket or cable connection 20 to which cable 12 is mechanically connected. One wire 21 of the cable is electrically connected to the end of electric detonating cap 22 releasably held in passage 23 in breach block 24. The other wire (not shown) of cable 12 is grounded to the rope socket and breach block and exterior contact or shell of the cap 22. When energized by the source of electricity 10, cap 22 explodes, igniting the relatively slow burning explosive 23*a* disposed in the supply chamber 24*a* formed by hollow cylinder 25. The upper end of chamber 24*a* is closed by the breach block 24 threadedly connected thereto so that the gaseous fluid resulting from the explosion leaves the lower end of the chamber. To the lower end of cylinder 25 is screwed the upper end of cylinder 26 closing off all of the lower end of the cylinder 25 except for a passage 27 within which is slidably disposed a fluid conduit 28, the upper end of which carries a solid particle filter or screen 29. Packing rings 30 held in place by compression ring 31 seal between the upper end of cylinder 26 and fluid conduit 28 so that all the gases from the explosion must leave through conduit 28.



Within cylinder 26 is slidably disposed a piston 35 screwed to the lower end of fluid conduit 28. Packing rings 36 are held in place on the outside of the piston 35 by a nut 37. The lower end of cylinder 26 is closed by the upper end of another hollow cylinder 38 screwed thereon, and by hollow piston rod 39 integral with the lower end of piston 35 and slidably extending through cylinder 38. Piston rod 39 is sealed to cylinder 38 in the same manner as fluid conduit 28 is sealed to the upper end of cylinder 26, the ring 40 compressing the packing rings therebetween.

The gases from the explosion pass through fluid conduit 28, passage 43 in piston 35, into passage 44 in the piston rod 39. Some of the gases escape through port 45 into the space in cylinder 26 below piston 35 and exert a pressure to move the piston up relative to the cylinder. The space in cylinder 26 above piston 35 is vented by port 46 so that the piston is free to move. The explosion chamber 24*a* has enough axial length to accommodate fluid conduit 28 as it rises with piston 35.

Referring now particularly to FIG. 1 hollow piston rod 44 carries a hollow piston 50 similar to piston 35 sliding within and sealed to cylinder 38. A hollow piston rod 51 is integral with the lower end of piston 50 and extends therebelow. A hollow cylinder 52 is connected to the lower end of cylinder 38. There is a seal 53 between piston rod 51 and cylinder 52 (see also FIG. 2B) similar to the seal between piston rod 44 and cylinder 38 closing off a chamber around piston 50. Explosive gas from piston rod 44 passes through hollow piston 50 into hollow piston rod 51. Some of this gas escapes through port 54 into the space below piston 50 and the resulting pressure acts to move piston 50 up relative to cylinder 38. The space in cylinder 38 above piston 50 is vented through port 55 so that piston 50 is free to move.

In like manner hollow piston 60 is connected to the lower end of hollow piston rod 51 and is slidingly disposed within and sealed to cylinder 52. Another cylinder 61 is screwed to the lower end of cylinder 52. A solid piston rod 62 is integrally connected to the lower end of piston 60. Rod 62 is sealed to cylinder 61 at 63 by packing rings held by compression ring 64 screwed into the upper end of cylinder 61, thereby closing off the lower end of cylinder 52. Explosive gases in hollow piston rod 51 enter the space beneath piston 60 through port 65 and act to move piston 60 up relative to cylinder 52. The space above piston 60 is vented at 66 so that the piston is free to move. This space is also vented at 67 so that as soon as piston 60 passes vent 67 there is a vent for the explosive gases whereby their pressure can be dissipated so that upward movement of piston 60 and the several other pistons 50 and 35 connected thereto by piston rods 51 and 44 is gradually stopped.

To the lower end of piston rod 62 is connected piston 70 sliding within and sealed to cylinder 61 the same as the other piston slide within and are sealed to their respective cylinders. The space above piston 70 is not vented through the cylinder wall however but only through passage 71 which is closed to inflow by a ball check valve 72 biased to closed position by a spring 73. The lower end of spring 73 bears against a plug 74 which has a small passage 75 therethrough so that plug 74 acts as a choke when fluid flows out of cylinder 61. The space in cylinder 61 above piston 70 is filled with hydraulic liquid such as a light oil before the tool is lowered into the well. Any tendency of the pistons of the tool to rise relative to their cylinders, e.g. due to a bump on the device carried by the draw bar 76 integral with piston 70, is resisted by the hydraulic fluid in cylinder 61 to the extent of the pressure of spring 73 on valve 72. This resisting force is sufficiently large because of the dif-

erence between the large area of piston 70 acted upon by the hydraulic fluid relative to the small area of port 71 acted on by the spring. In addition, as the tool is lowered into the well, the well fluid acts through ports 46, 55, and 66 on top of pistons 35, 50, and 60 to assist in keeping the pistons in their lowermost positions, the spaces beneath these pistons being sealed off from the pressure of the well fluid. When the charge in the upper end of the tool is set off the action of the explosive gases moving the pistons up relative to their cylinders is cushioned by the dampening action of the well liquids above the pistons 35, 50 and 60 which must escape through ports 46, 55, and 66 and by the dampening action of the hydraulic fluid above piston 70 which must, after overcoming spring 73, pass through choke 74. The size of choke 74 can be adjusted to the size of the explosive charge used.

Once the tool has been actuated and the pistons have moved up relative to their cylinders, the valve 72 closes and prevents liquid from re-entering cylinder 61. The resultant differential fluid pressure on piston 70 as soon as there is any downward pull on draw bar 76 keeps the pistons from moving down again until the tool is brought to the surface where plug 77 can be removed and cylinder 61 refilled with hydraulic fluid before the tool is again run.

To set a well sealing device, e.g. a packer or bridging plug, or any similarly operated device, it is connected to the lower end of cylinder 61, which is threaded at 80 for that purpose, and to the lower end of draw bar 76, which is threaded at 81 for that purpose. Explosion of the charge in the tool then causes relative movement of cylinder 61 and draw bar 76 to set the device connected thereto.

For example, as shown in FIG. 1 the permanent production packer 14 is connected to the setting tool. Details of the packer are shown in FIG. 2C. The packer comprises a tubular mandrel 82 having a combined guide and slip support ring 83 screwed to the lower end to which an adapter rod 84 is secured by shear rod 85. The upper end of the adapter rod 84 is screwed to the lower end of draw bar 81. A slip support ring 86 is screwed to the lower end of cylinder 61. Slip support rings 83 and 86 are provided with circumferential grooves 87, 88 interlocking with the grooved ends of upper and lower sets of slips 89, 90 having respectively upwardly and downwardly directed serrations as shown at 91, 92. Expander cones 93, 94 are slidably mounted on mandrel 82 and adapted for engagement with the sets of slips. Between the cones and slidably mounted on mandrel 82 is a packer sleeve 95, which may be made of a synthetic rubber compound. Annular flanges 96, 97 on the cones retain the tapered ends of the packer sleeve. The sets of slips are held radially inwardly against the cones by garter springs 98, 99 disposd in external grooves in the slips.

On actuation of the setting tool the sets of slips are drawn together axially by the slip supporting rings 83, 86 and, as shown in FIG. 3, the cones 93, 94 cause the slips to simultaneously move radially outward into engagement with the well casing 100 and to release from the slip supporting rings 83, 86. The cones 93, 94 are pushed together by the slips, causing the packer sleeve to be contracted axially and radially expanded into contact with the casing. An upward pull on the setting tool shears rod 85 so that adapter bar 84 is freed from slip supporting ring 83 and since slip supporting ring 86 has been released from slips 89 the tool can be removed. mandrel 82 tends to drop its travel is limited by shoulder 101 engaging the upper expander cone.

It is to be noted that since the setting tool engages the packer at its lower end, the mandrel 82 is not placed in tension during the setting operation and need have only enough wall strength to resist the radial compressive load. Therefore the mandrel can have a relatively thin wall and be full opening.



After the packer is set as shown in FIG. 3, a seal nipple run on tubing will be telescoped inside the packer mandrel and sealed therewith, the seal nipple having a shoulder that comes to rest on top of the packer mandrel, all as is known heretofore. Likewise the packer may, if desired, be provided with a flapper check valve to be opened by an extension on the lower end of the seal nipple.

Referring now to FIGS. 5 and 6, there is shown a well sealing device similar to the packer shown in FIGS. 2C and 3 but adapted for use as a bridging plug. The plug comprises a hollow mandrel 110 on which are slidably mounted packer sleeve 111 and expander cones 112, 113. Sets of slips 114, 115 engaged with the cones are interlocked with slip support rings 116, 117, all as described in detail with respect to the well packer. Ring 116 is screwed to the lower end of cylinder 61 of the setting tool. Slip support ring 117 is screwed to the lower end of the hollow mandrel 110. Parting plug 118 is screwed into the lower end of mandrel 110 and to the lower end of adapter bar 119. When the setting tool is actuated the slips 114, 115 move together and the plug is set as shown in FIG. 6. An upward pull on the tool then parts plug 118 at the reduced area 120 and the tool is free to be removed. The shoulder 121 on the upper end of the mandrel 110 hangs on upper cone 112 to prevent it from being forced out of the sleeve 111 by any pressure above the plug. Since the mandrel 110 is of thin section, like mandrel 82 of the previously described packer, if it becomes necessary to drill out the bridging plug there is very little metal to be drilled up and the removal of the plug is thus facilitated.

Referring now to FIG. 4, there is shown a modification of the upper end of the tool adapting it for operation on a string of tubing 130 connected at its upper end to a hydraulic pump 131. In place of the breach block 24 of the FIG. 1 construction an adapted nipple 132 is screwed into cylinder 25 and the upper end of the nipple is connected to the tubing by coupling 133. The tool is then actuated by applying liquid fluid pressure to supply chamber 24*a* and conduit 28 from tubing 130 instead of gaseous fluid produced by exploding a charge in cylinder 25. In other respects the tool operates the same as the FIG. 1 tool.

In both embodiments of the tool the large force required to set the well seating device is achieved by the additive effect of a plurality of coacting pistons and cylinders whereby the unit pressure of the power fluid can be kept low enough so that the wall thickness of the cylinders is within practical limits.

While preferred embodiments of the invention have been shown and described many modifications thereof can be made by one skilled in the art without departing from the spirit of the invention and it is desired to protect by Letters Patent all forms of the invention falling within the scope of the following claims.

What is claimed is:

1. A well apparatus setting tool having an upper end and a lower end and comprising a plurality of coaxial serially connected cylinders disposed with their axes vertical with respect to said tool, a plurality of pistons disposed one in each of said cylinders, each piston having a passage therethrough from its upper part to its lower part, hollow piston rods serially connecting said pistons and said passages therethrough, the uppermost of said cylinders being adapted for connection to a source of pressure fluid, means sealing between each piston rod and the adjacent cylinder, said piston rods including passages connecting the interiors of the hollow piston rods to the spaces below the pistons inside the several cylinders, there being a vent to the space above each piston inside the several cylinders whereby any fluid in the cylinder above the piston can escape so that the piston is free to move upwardly so far as such fluid is concerned, said vents being disposed just below said sealing means, there being an additional vent to the space inside the lowermost cylin-

der, the last said vent being spaced below the first mentioned vent for the last said space a distance greater than the height of the lowermost piston, the last said vent providing a passage for the escape of fluid through the last said space from the lowermost piston rod when the lowermost piston is disposed above said additional vent, and means connected to the lowermost piston and cylinder for connection to a device to be actuated by relative movement between said lowermost piston and cylinder.

2. The combination of claim 1 with an explosive chamber connected to the uppermost cylinder and a fluid conduit connected to the uppermost piston and means forming a sliding seal between said fluid conduit and chamber.

3. The combination of claim 2 including a powder charge in said explosive chamber, the upper end of said fluid conduit being provided with a solid particle filter, and a breach block closing the upper end of said chamber and having an electric detonating means mounted thereon, said breach block being connected by a rope socket to an electric wire line.

4. The combination of claim 3 including a tubular mandrel connected to the lowermost piston, a packer sleeve slidable thereon, expander cones slidable on said mandrel adjacent said sleeve pointing away from the sleeve, slips adjacent said cones, rigid slip support rings around said mandrel adjacent said slips, the uppermost one of said rings being connected to said lowermost cylinder, readily partable means connecting the other of said rings to said mandrel, and disengageable means connecting said rings to said slips preventing while engaged any relative axial motion of each ring and the slips adjacent thereto while allowing radial motion of the slips and when disengaged allowing said relative axial motion.

5. A well apparatus setting tool comprising an explosive chamber adapted to receive explosive, a plurality of serially connected power cylinders, said cylinders being disposed with their axes in a single line forming the vertical axis of the tool, means connecting the uppermost power cylinder to said explosive chamber, a plurality of pistons disposed one in each of said power cylinders, each of said pistons having a vertical passage therethrough, hollow piston rods serially connecting said pistons and said passages therethrough, means sealing between each piston rod and the adjacent power cylinder, said piston rods including passages connecting the interior of the hollow piston rods to the spaces below the pistons inside the several power cylinders, there being a vent to the space above each piston inside the several power cylinders, said vents being disposed below said sealing means, there being one additional vent to the space inside the lowermost power cylinder, said additional vent being disposed below the first mentioned vent for said space a distance greater than the height of the one of said pistons that is disposed in said lowermost cylinder, a hydraulic cylinder connected to the aforementioned power cylinders, a hydraulic piston in the hydraulic cylinder, means connecting the last said piston to the first said pistons, means connected to one of said pistons and to one of said cylinders for connecting them to a device to be actuated by relative movement between the last said piston and cylinder, means to vent the hydraulic fluid space between the hydraulic cylinder and the hydraulic piston, and check valve means to prevent entrance of fluid through said means to vent the hydraulic fluid space, whereby when explosive is placed in said explosive chamber and set off said pistons move up in said power and hydraulic cylinders due to explosive gas pressure beneath said pistons in said power cylinders until the lowermost power piston passes above said additional vent and continues to move up thereafter under residual pressure of said explosive gas as the pressure thereof is reduced due to escape through said additional vent, said hydraulic cylinder pressure locking the hydraulic piston in its uppermost position and thereby holding said pistons in said power cylinders in their uppermost positions.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,228,241 | Baker et al. | Jan. 14, 1941 |
| 2,290,142 | Burt | July 14, 1942 |
| 2,377,249 | Lawrence | May 29, 1945 |
| 2,566,323 | Forsyth et al. | Sept. 4, 1951 |
| 2,589,506 | Morrisett | Mar. 18, 1952 |
| 2,644,530 | Baker | July 7, 1953 |
| 2,651,371 | Toelke | Sept. 8, 1953 |
| 2,692,023 | Conrad | Oct. 19, 1954 |
| 2,701,614 | Ragan et al. | Feb. 8, 1955 |