April 18, 1961 T. W. ROYER 2,979,904

BOOSTER DEVICE FOR OPERATING WELL TOOLS

Filed April 27, 1959 2 Sheets-Sheet 1

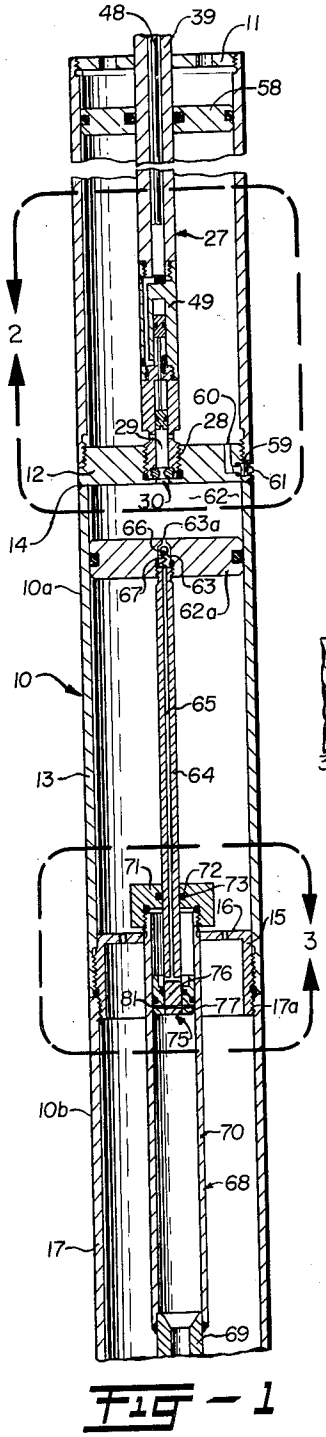


FIG - 1

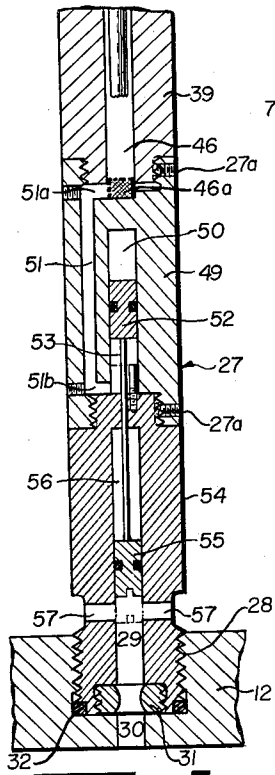


FIG - 2

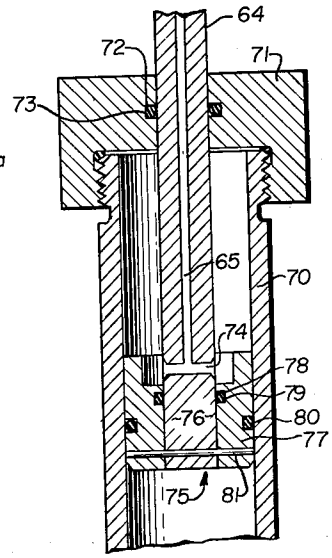


FIG - 3

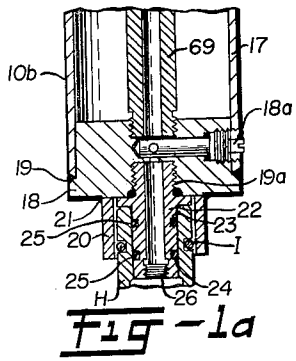


FIG - 1a

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BOOSTER DEVICE FOR OPERATING WELL TOOLS

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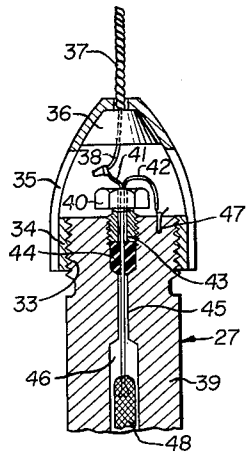


Fig-4

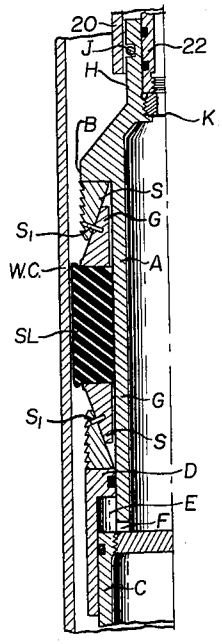


Fig-5

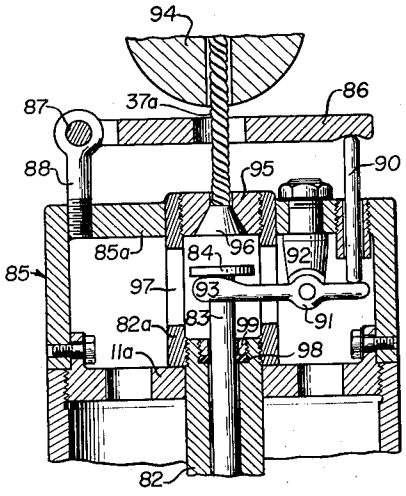


Fig-7

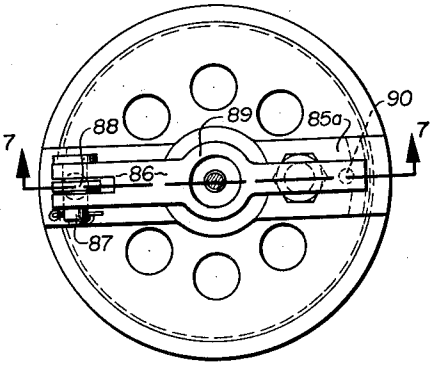


Fig-6

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2,979,904

BOOSTER DEVICE FOR OPERATING WELL TOOLS

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Filed Apr. 27, 1959, Ser. No. 809,256

16 Claims. (Cl. 60—54.5)

The present invention relates to an operating device for tools adapted to be used under hydrostatic pressure. The device of the invention will be hereinafter described with reference to the operation of an oil well tool by way of illustration but not by way of limitation of its field of use.

While there are a variety of well tools, the invention will be described with reference to the setting in position of oil well bridging plugs which are widely used in the art and are particularly adapted to operation by the device.

A bridging plug is a tool of elongated cylindrical shape provided with a thick sleeve of rubber of resilient material around its outer surface and intermediate the length thereof. The sleeve is fitted between upper and lower flanges on the tool which may be forced together to thereby axially compress and radially expand the sleeve into engagement with the well casing. Bridging plugs are also commonly fitted with either a single or double row of slips, which are serrated wedgelike elements mounted on a conical seat around the tool and forced into positive gripping engagement with the well casing. The bridging plug is therefore effective to seal the bore of the well and also to prevent movement of the plug up or down in the well due to existence of a pressure differential between the surfaces of the plug.

The force required to expand the sleeve of the bridging plug into engagement with the well casing is less than that required to engage the slip serrations in the well casing. It is therefore the general object of this invention to provide an operating device utilizing the hydrostatic pressure existing in the well at the point at which the bridging plug or other similar tool is to be set to furnish hydraulic pressures required to operate the tool.

It is another object of the invention to provide an operating device in which hydraulic pressure to operate a well tool is developed in a sequence, one pressure being sufficient to set elements of the tool requiring a lower pressure, followed by a higher pressure required to set other elements of the tool preferably followed by a still higher pressure effective to release the operating tool from the well tool.

It is a further object of the invention to provide an operating device for tools functioning under a hydrostatic pressure which is rapid and effective in action and is adapted to operate any tool of the kind operated under hydrostatic pressures by fluid pressure introduced into the tool.

With the above and further objects and features of invention in view which will appear from the following specification, the invention comprises an operating device for tools adapted to function under a hydrostatic pressure, said device having a casing providing a cylindrical chamber open at one end and containing a free piston upon which the hydrostatic pressure acts, a partition in the chamber providing a reservoir between it and the free piston for a body of fluid pressurized by the

hydrostatic pressure. A compound diameter cylinder is connected by a demand-valve controlled passage to said reservoir, said cylinder having a section of maximum diameter less than that of the free piston and having successive sections of progressively smaller diameter than said maximum diameter section. A piston acted on by the pressurized fluid is fiitted with a piston rod extending into said compound diameter cylinder and carries a composite piston, the elements of which are initially secured together by automatically releasable means and which progressively work in corresponding sections of the compound diameter cylinder. Means are provided to lead hydraulic fluid from the length of smallest diameter of said compound diameter cylinder to the tool to be operated.

In the drawings:

Fig. 1 is a central vertical section view through the operating device of the invention, the lower portion being broken through to reduce the length of the figure.

Fig. 1*a* is a section view showing the lower end of Fig. 1.

Fig. 2 is a fragmentary sectional view of the portion of the device indicated by the dotted line 2 in Fig. 1, drawn on a larger scale.

Fig. 3 is a section view drawn on a larger scale of the portion of the device indicated by the dotted line 3 in Fig. 1.

Fig. 4 is a fragmentary section view showing the manner of attaching the device to a suspending cable.

Fig. 5 is a vertical half section view of an oil tool adapted to be operated by the device of the invention, shown partly set, the slips being still retained on their seats by shear pins.

Fig. 6 is a plan view of a mechanical arrangement for operating a valve initiating operation of the device and actuated by a go-devil; and

Fig. 7 is a central vertical section view through the parts shown in Fig. 6.

Referring now to Fig. 1, the numeral **10** indicates the elongated casing of the novel operating device of the invention. The casing is preferably fitted with an apertured disc **11** at its upper end and with a fixed partition or bulkhead **12** in its upper portion **10***a*. The lower portion **10***b* of the casing comprises an upper length **13** which may be welded at its upper end, as indicated at **14**, to the bulkhead **12** and at its lower end is screwed to an interior cup-shaped member **15** having a transverse head provided with apertures for air passage around a central opening for the support of interior parts later described.

A lower length **17** of the lower portion **10***b* of the casing **10** is connected at its upper end to the interior cup-shaped member **15** as shown at **17***a* by a threaded joint.

The lower end of casing length **17** is closed by a plug **18** shown in Fig. 1*a* to which the casing end may be welded as indicated at **19**. Plug **18** is provided with an axial bore **19***a* and a downwardly extending tubular extension **20** which may be formed integral therewith, or as indicated at **21**, welded thereto.

A tubular suspending fitting **22** is screwed into the bore of the plug **18** and is provided with upper and lower peripheral grooves **23** and **24**, in which O ring seals **25** are mounted.

The lower end of the bore of the fitting **22** may be interiorly threaded as indicated at **26** to receive the nozzle of a filling hose.

Certain interior spaces in the operating device require to be charged with hydraulic fluid and the arrangements made for this purpose will latter appear.

A supporting tube generally indicated at **27** is screwed at its lower end into a threaded socket in the fixed bulkhead **12** as indicated at **28** in Fig. 1, the bore **29** of the

lower end of the support tube 27 being aligned with a central opening 30 in the fixed bulkhead.

As shown in Fig. 2 an exchangeable flow control nozzle 31 is screwed into a recess in the lower end of the support tube 27. An O ring seal 32 is compressed between the end of the support tube 27 and the bottom of the threaded socket in the bulkhead 12 in which it is mounted.

As shown in Fig. 4 the upper end of the support tube 27 is threaded at its upper end 33 and engaged in a threaded ring 34 connected by yoke arms 35 to a frusto-conical socket 36 in which the end of an electric cable 37 is secured as for instance by fraying out the end of the cable in the conical socket and setting the ends in solder poured into the socket. A conductive wire 38 wound in the cable is connected to electrical igniting means for a slow burning propellant charge positioned in the support tube 27 which will be now specifically described.

Referring now to Fig. 2 it will be noted that the support tube 27 is built up of a plurality of sections screwed together and pinned by set screws 27*a* so that it may be readily unscrewed from the bulkhead 12 to change the flow control nozzle 31 and may also be broken down into components to give access to parts contained therein.

The top section 39 is shown in Fig. 4 as being provided with a threaded socket opening into its upper surface in which is mounted the gland nut 40 having an axial passage for the lead 41 connected to conductive wire 38, and ground wire 42 which pass through an insulated bushing 43, a rubber packing 44 compressed by the gland nut 40 into sealing engagement with the wires which extend through a restricted passage 45 in the head of top section 39 into the enlarged diameter bore 46. The ground wire 42 is secured at its upper end in a short hole 47 drilled into the upper end of the top section 39.

The wires 41 and 42 are embedded in a thin rod-like grain 48 of slow burning propellant, the ends of the wires being connected by a short length (not shown) of high resistance wire by heating of which the grain may be ignited, when electric current is sent therethrough by closing a switch positioned at the surface of the well.

It is seen in Fig. 2 that the lower end of top section 39 of the support rod 27 is screwed to a section 49 which is formed to provide a cylinder 50, a passage 51 connected at its upper end by port 51*a* to the lower end of the bore 46 and its lower end by port 51*b* to the lower end of the cylinder 50. A wire mesh screen 46*a* is placed at the lower end of bore 46 to prevent debris entering the port connecting passage 51 to the lower end of bore 46.

A piston 52 is mounted in cylinder 50 and a piston rod 53 threaded thereinto passes through a hole drilled through the upper end of the lowest section 54 of the support rod 27.

The section 54 contains valve means to open a passage from the space above the bulkhead 12 into the space below it. The valve means comprise a piston-like member 55 sliding in fluid tight relation in the bore 56 of section 54 of the support tube 27 and mounted on the piston rod 53. Ports 57 in the wall of section 54 immediately above the bulkhead 12 admit fluid to the bore 29 of section 54 from which the fluid flows through the lower portion of bore 29 and central opening 30 in the bulkhead 12. In closed position valve 55 closes ports 57 as indicated in dotted lines in Fig. 2.

A free piston 58 is shown in Fig. 1 as positioned in the space above the bulkhead 12 in fluid tight sliding arrangement with the inner surface of the casing 10 and the outer surface of the support tube 27. Hydraulic fluid loaded into the space between the bulkhead 12 and piston 58 before the setting tool is lowered into the well will therefore be under the static pressure of the liquid in the well which may reach high values, but the fluid will be trapped in the space until valve 55 is operated to open the passage through ports 57 and the central aperture 30 through the bulkhead. Fluid is introduced into the space under piston 58 by the filling port 59 and passage 60 provided in the bulkhead 12. Port 59 is sealed after filling the space by a threaded plug 61. The space in the casing 13 below bulkhead 12 constitutes a working cylinder 62.

A working piston 62*a* is arranged in the working cylinder 62 in sliding but fluid tight relation to the inner wall of the casing 13. The piston 62*a* is provided with a narrow central opening 63*a* leading into a vertical chamber 63, the lower portion of which provides a threaded socket.

A piston rod 64 threaded at its upper end is screwed into the threaded socket of vertical chamber 63. The piston rod 64 is preferably though not necessarily tubular, the interior passage being indicated at 65 for reasons later discussed. A ball check valve 66 is positioned in chamber 63 and resiliently held by coil spring 67 against the edge of opening 63*a*, the lower end of the spring being supported on the upper end of the tubular piston rod 64.

A two diameter cylinder 68 is mounted in the lower portion 17 of casing 10 and comprises a thick walled length of small diameter 69, the lower end of which is exteriorly threaded and screwed into the threaded bore in plug 18 and the upper end of which extends into and secured to a cylinder of greater diameter 70. The upper end of cylinder 70 extends through the central opening in head 16 of member 15 and is securely positioned thereby. The exterior upper end of cylinder 70 is threaded and closed by a cap 71 screwed on the threaded end of cylinder 70.

Cap 71 is centrally vertically bored. Piston rod 64 extends through the bore in cap 71 and an O ring seal 72 is mounted in cap 71 in a groove 73 around the bore therethrough and provides a fluid tight seal between the cylinder cap 71 and piston rod 64.

A composite piston 75 is arranged at the lower end of the piston rod. The end 76 of the piston rod 64 is solid and acts as a high pressure piston when working in the smaller diameter cylinder 69. An annular piston element 77 mounted around the end 76 of the piston rod 64 provides with the end 64 of the piston rod 76 an intermediate pressure piston working in the cylinder 70 of greater diameter than cylinder 69. O ring seal 78 mounted in a groove 79 in annular element 77 seals against leakage between ring 77 and the surface of piston rod end 76 and O ring seal 80 in a peripheral groove in ring 77 sealing against leakage between the ring 77 and the wall of the greater diameter cylinder 70. The annular element 77 is mounted on the end 76 of the piston rod 64 by a shear pin 81.

The bore 65 of the piston rod 64 is connected to the space between the two diameter piston 75 and cap 71 by lateral ports 74.

An oil well tool of a type suitable for operation by the operating device of the invention is indicated in Fig. 5. The tool comprises a hollow mandrel member A having an upper shoulder B and a depending skirt member C of greater diameter than mandrel A. A force member member has an inturned head flange D, the space E defining a pressure chamber connected to the interior of the mandrel by ports F in the wall of the mandrel. Upper and lower separate wedge shaped slips S abut shoulder B and flange D, and are connected to conical seats G by shear screws S_1. The wide ends of the conical seats G abut the upper and lower ends of a sleeve S_1 of resilient material surrounding and slidable on the surface of the mandrel.

The mandrel is provided at its upper end with a neck H which fits closely over the tubular suspending fitting 22 of Fig. 1*a*, of the setting device and is releasably secured thereto by a U-shaped shear pin J received in a peripheral groove in the outer surface of the neck H, and in aligned holes in the tubular extension 20 of plug

18. The tool is maintained in fluid tight engagement with the surface of the suspending fitting 22 by the engagement of the O rings 25 with the neck H.

The interior cavity of the mandrel is filled with hydraulic fluid which may be retained therein by frangible disc K held against its seat by a threaded ring.

It will be appreciated that on the forcing of hydraulic fluid from the operating device of the invention into the tool the disc K will be ruptured. Pressure fluid forced into the interior of the mandrel and thence into chamber E will force flange D upwardly exerting equal and opposite downward force on shoulder B on the mandrel. Force is transmitted through the slips S and shear screws S_1 and conical seats G to the resilient sleeve SL shortening it and radially expanding it into engagement with the well casing WC after which the shear pins S_1 yield and the slips are driven further onto the conical seats until firmly engaged with the well casing. Further increase in pressure will thereafter act between the tool, which cannot move, and the setting device which is free to move upwardly, until the pressure is sufficient to shear pin J.

It is to be noted that the well tool shown in Fig. 5 forms no part of this invention and is described to make clear the type of tool capable of operation by the device of this invention. The tool shown does not represent any specific construction and illustrates only those parts operated by the pressure fluid supplied by the device of the invention which is to be considered widely as a source of power for various types of tools operated under hydrostatic pressure, for instance, on a deep sea bottom. The means for operating the valve admitting hydraulic fluid into the operating device under the static pressure of the liquid in the well or deep sea bottom has been described with reference to the use of gas pressure developed by a charge of slow burning propellant ignited by electrical means operated from the surface, but it is obvious that ignition of the charge may be effected by a cartridge fired by a go-devil by utilizing arrangements of parts within the skill of the art to provide, and any such means are held to fall within the scope of this invention.

In place of operating the valve admitting hydraulic fluid into the operating device under the static pressure of the well liquid by gaseous pressure, it may be preferred to operate the valve by the use of mechanical means operated by a go-devil. Such an arrangement is shown in Figs. 6 and 7 in which the modified support tube 82 is a unitary length of tube from its fitting with the bulkhead 12 (not shown in Fig. 7) to the upper end shown in Fig. 7. Ports are arranged communicating through the wall of the tube 82 with its bore in an area adjacent the upper surface of the bulkhead 12 as was shown in Figs. 1 and 2.

The ports are closed until the device is operated by the lower end of a rod 83 which extends through the support tube 82 and projects from the upper end thereof. Rod 83 is furnished with a head 84.

A bridge fitting 85 is mounted on the apertured disc 11*a*. A lever 86 is mounted at one end on a pivot 87 passing through the eye of a bolt 88 extending upwardly from the horizontal member 85*a*, the bridge fitting 85 and is formed with a ring portion 89 through which the cable 37*a* extends.

The free end of lever 86 rests on a thrust pin 90 resting on the tail of a lifting lever 91 pivoted on a stud 92 secured to and projecting downwardly from the horizontal member 85*a*. The opposite end of the lever is formed with a forked head 93 engaging under opposite sides of head 84. A "go-devil" 94 hitting lever 86 will cause the rod 83 to be raised and the lower end of the rod to be drawn clear of the ports at the lower end of the support tube 82.

In order to provide space for parts acting to raise the rod 83 the upper end of the support tube 82 is engaged with an internally threaded coupling member 82*a* which extends through an opening in the horizontal member 85*a* of the bridge fitting 85 and in the upper end of which a threaded disc 95 having a tapered seat is secured. A conical ferrule 96 in which the lower end of the cable is secured, fits into the conical recess in the threaded disc 95. The coupling member 82*a* is slotted as shown at 97 for passage of the head of the lever 91.

The upper end of the support tube 82 is sealed against the entry of well fluid around the rod 83 by a packing 98 placed in a central threaded recess in the upper end of the support tube 82 and compressed between the wall of the recess and the surface of the rod 83 by a threaded pressure ring 99 which is screwed down upon the packing.

Operation

In the preparation for use of the operating device of the invention after a previous use, the well tool or other tool to be operated under hydrostatic pressure is filled with hydraulic fluid.

The chamber between the bulkhead 12 and free piston 58 is also filled with hydraulic fluid as is the space in the two diameter cylinder. The operation of filling the space under the free piston 58 in the setting tool with hydraulic fluid will result in moving the free piston 58 against the underside of the apertured disc 11. Section 13 of the casing is unscrewed from the lower section 17, the cap 71 unscrewed from the upper end of cylinder 70 and the composite piston 75 withdrawn from the cylinder. This operation will empty the oil trapped between the top of the annular piston element 77, the piston rod 64 and the cap 71 and enable the shear pin 81 if fractured by the previous use of the device to be replaced in the reassembled composite piston 75, which may then be replaced in the cylinder 70 and the cap 71 replaced. The casing sections 13 and 17 may then be screwed together and the two diameter cylinder 68 filled with hydraulic fluid through the threaded lower end 26, moving the composite piston 75 to the inward end of its travel. The hydraulic fluid may be retained in the two diameter cylinder 68 by corking the lower end of the bore of the suspending fitting 22 or by providing a plug valve 18*a* in the plug 18 closing the bore therethrough.

A fresh grain of slow burning propellant 48 is placed in position by unscrewing the support tube 27, slacking back the set screw 27*a* previously holding the top section 39 against being unscrewed, removing the gland nut 40 and wires 41 and 42.

The fresh grain may then be put in place with its wires threaded through the gland nut which is then put back in place and the upper section assembled into the support tube 27 which is then screwed back into bulkhead 12 and the wires properly connected.

While the use of a composite piston having concentric elements secured together by a shear pin is specifically described it is to be understood that any other means such as spring pressed detents may be used to hold the concentric elements for movement with the small diameter piston provided by the end of the piston rod until the pressure on the detent is sufficient to release it. If the detent arrangement was used, the provision of a venting plug in the cap 71 would obviate the necessity for unscrewing the cap to empty trapped oil and replace the shear pin 81. To use the operating device after a previous use or when initially used, it is prepared as previously described by being filled with hydraulic fluid and fitted with a grain of slow burning propellant with means for igniting it and with a shear pin in place in the composite piston 75. The pressure chambers in the tool to be operated are also filled with hydraulic fluid and the tool attached by the shear pin to the device. A flow nozzle 30 suited to the needs of the job, a large orifice being employed for light "down hole pressures" and a smaller orifice for high "down hole pressures" is inserted in assembling the tool, and a shear pin yielding at the pressure estimated to be sufficient to complete

the lower pressure phase of the job is placed in position in the composite piston **75**.

Obviously if it is desired to operate a tool which can be hoisted after operation still attached to the device, any suitable means to relieve excessive pressure may be provided. If a heavy tool such as a deep sea grab for securing samples of the sea bottom is to be operated, the tool could be secured to a heavy cable and be detached from the operating device which would be suspended by a separate cable.

The operating device and attached tool are then lowered to the point of operation and the grain of slow burning propellant ignited by the use of electric current or of a go-devil to open the valve **55** resulting in the hydraulic fluid under the hydrostatic pressure, which at a depth of about 2000 feet for instance, amounts to over 1000 lbs. per sq. in., acting in the working cylinder **62** and forcing the working cylinder downward. Assuming the working piston **62***a* is three times the diameter of the composite piston and that the latter is three times the diameter of the end **76** of the piston rod, a pressure of over 9000 lbs. per sq. in. is available to operate the tool. In the case of the bridging plug illustrated the resilient sleeve SL would be squeezed tight against the well casing by the lower pressures, the shear pin **81** would then shear as resistance to movement of the telescopic parts of the tool increased. The higher pressure developed by the piston **76** in the smaller diameter cylinder **69** will be effective to fracture the shear pins S_1 and set the slips.

Although the action described would take place if a solid piston rod **64** were to be used, it is evident that the space between the cap **71** and rear of the composite piston **75** would be void of fluid so that when the shear pin **81** in the composite piston gives way, which it might do before piston rod and **76** entered small diameter cylinder **69**, the outer portion or annular element **77** thereof would then be forced toward cap **71** by hydraulic fluid under the pressure of the downwardly moving piston rod and hydraulic fluid back flow from parts which had been operated by the fluid under pressure of the composite piston **75**. The least disadvantage of the temporary cessation of delivery of effective pressure to the tool would be a break in the time of operation of the tool. The advantage of the provision of delivery of oil to the space behind the composite piston is that when the annular element **77** shears from the piston end **76**, the hydraulic fluid trapped behind it by check valve **66** holds the annular element and ensures continued delivery of hydraulic fluid but at a higher pressure to the tool.

Preferred embodiments of the invention have been described and illustrated by way of example but not as limitative of the invention since various modifications will be evident to those skilled in the art and may be made without departing from the scope of the invention as defined by the appended claims.

I claim:

1. An operating device for tools functioning under hydrostatic pressure, comprising: a cylinder open at one end to the hydrostatic pressure; a free piston working in said cylinder; a wall closing the opposite end of said cylinder, the space between said wall and free piston constituting a reservoir for fluid pressurized by said hydrostatic pressure; said wall having a passage leading fluid out of said reservoir; valve means effective to initially close said passage; means for moving said valve to open said passage; a compound diameter cylinder having a plurality of sections each of progressively less diameter than the preceding section, the compound cylinder having a maximum diameter less than that of the free piston; a piston displaced by fluid from said reservoir and having a piston rod permanently secured thereto and extending into said compound diameter cylinder; a composite piston mounted on said piston rod and working in said compound diameter cylinder, said composite piston having coaxially nested elements the outermost of which works in the section of greatest diameter, and the innermost of which works in the section of least diameter of said compound diameter cylinder; automatically releasable means initially holding said composite piston elements in alignment; and conduit means adapted to connect the tool to be operated to the cylinder of least diameter of said compound diameter cylinder.

2. An operating device as set forth in claim 1 and in addition comprising: a flow control nozzle removably mounted in the passage leading fluid out of said reservoir.

3. An operating device as set forth in claim 1 and in which said piston rod is provided with an axial bore communicating at its upper end with the fluid issuing from the reservoir and at its lower end communicating with the space between said composite piston mounted on said piston rod and the head of said composite diameter cylinder; and a check valve at the upper end of said axial bore to prevent reverse flow of fluid therethrough.

4. An operating device for tools functioning under hydrostatic pressure as set forth in claim 1 and in addition comprising: a flow control nozzle removably mounted in the passage leading hydraulic fluid from said reservoir.

5. An operating device as set forth in claim 1 and in which said automatically releasable means holding the composite piston elements in alignment comprises a shear pin fitted in a hole drilled diametrically through all elements of said composite piston.

6. An operating device for tools functioning under hydrostatic pressure, comprising: a cylindrical casing open to the entry of liquid at hydrostatic pressure at its upper end; a free piston sliding in liquid tight engagement with the wall of said casing; a transverse wall closing said casing but below said free piston, the space between said piston and wall constituting a reservoir for hydraulic fluid pressurized by said ambient hydrostatic pressure; a working cylinder positioned in said casing below said wall; said wall having a passage connecting said reservoir to said working cylinder; valve means controlling said passage; means for opening said valve to enable the pressurized hydraulic fluid to flow into said working cylinder; a compound cylinder mounted coaxially with the working cylinder in said casing and having a plurality of lengths of progressively less diameter, and a maximum diameter less than that of the working cylinder; a cylinder cap separating said first cylinder of the compound diameter cylinder from the working cylinder and provided with a central opening therein; a piston working in said working cylinder; a piston rod secured to said working piston and extending through the opening in said cap in fluid tight relation therewith into said compound cylinder; a composite piston mounted on the piston rod within said compound cylinder, said composite piston having coaxially nested piston elements, the outer of said piston elements having a diameter fitting the length of greatest diameter of said compound cylinder; automatically releasable means initially holding said composite piston elements in alignment; means connecting the device to a suspending member; and means for connecting the tool to be operated in fluid tight relation to the device to receive the hydraulic fluid at maximum pressure from the cylinder of least diameter of the compound cylinder of the device.

7. An operating device for tools functioning under hydrostatic pressure, comprising: an elongated cylindrical casing having a fixed partition provided with an axial opening therethrough extending across an upper portion of said casing; a support tube axially positioned in the upper portion of the casing with its lower end secured in said partition with the bore thereof in alignment with the axial opening therein; a free piston spaced from said fixed partition and slidably mounted on said support tube in fluid tight relation to the wall of the cylindrical casing

and the surface of said support tube, hydraulic fluid being positioned in the upper portion of the casing between said free piston and partition, the upper surface of said free piston being under the hydrostatic pressure of the liquid in the well; passages through the wall of the support tube adjacent the upper surface of said partition and leading into the bore of the support tube; flow controlling means arranged within said support tube adapted to close said passages; means operated from the ground surface for moving said flow control means to enable hydraulic fluid to flow out of said space between the free piston and partition under the pressure of the hydrostatic pressure in the well; a working piston in said cylindrical casing below said partition in fluid tight sliding relation to the wall of the casing; the space above said working piston constituting a working cylinder receiving the hydraulic fluid flowing out of the space between the free piston and fixed partition; a piston rod secured at its upper end to said working piston; a compound diameter cylinder arranged coaxially with the working cylinder and having a plurality of lengths of progressively less diameter, and a maximum diameter less than that of the working cylinder; a cylinder cap separating the first cylinder of the compound diameter cylinder from the working cylinder and provided with a central opening therein; a piston rod secured to said working piston and extending through the opening in said cap in fluid tight relation therewith into said compound cylinder; a composite piston mounted on the piston rod within said compound cylinder, said composite piston having coaxially nested piston elements, the outer of said piston elements having a diameter fitting the length of greatest diameter of said compound cylinder; automatically releasable means initially holding said composite piston elements in alignment; and means for connecting the tool to be operated in fluid tight relation to the device to receive the hydraulic fluid at maximum pressure from the cylinder of least diameter of the compound cylinder of the device.

8. An operating device for tools functioning under hydrostatic pressure as set forth in claim 7 and in which said support tube is formed with a chamber to receive a charge of slow burning propellant; and means for igniting said propellant, the gas generated by the burning of said propellant being effective to open said flow controlling means.

9. An operating device for tools functioning under hydrostatic pressure as set forth in claim 7 and in which said working piston is formed with a central opening and a chamber in communication with said opening; a check valve mounted in said chamber to prevent reverse flow of hydraulic fluid into the working cylinder; the said piston rod being provided with an axial bore communicating at its upper end with said recess, being closed at its lower end, said piston rod wall having ports therethrough positioned toward its lower end leading from said bore above the composite piston mounted on said piston rod into the space between said composite piston and the cap of said compound diameter cylinder.

10. An operating device for tools functioning under hydrostatic pressure as set forth in claim 7 and in which said support tube is formed with a chamber to receive a charge of slow burning propellant; means for igniting said propellant, an elongated chamber in said support rod between the propellant chamber and the passages through the wall of the support tube; a piston like member provided with a depending portion mounted in said elongated chamber, the depending portion closing said passages in the inoperated condition of the device; and said support tube wall having a passage means therethrough leading gases generated by the slow burning propellant to said elongated chamber below said piston like member to cause movement thereof removing the depending portion from position closing said passages through the wall of the support tube.

11. An operating device for tools functioning under hydrostatic pressure, as set forth in claim 9, comprising: means connecting said support tube to a supporting cable, said cable including an electric conductor; liquid tight lead-in means arranged in said support tube to lead electric current into said charge of slow burning propellant; and a section of high resistance wire included in the electric circuit within the slow burning propellant, and brought by the flow of electric current therethrough to a temperature sufficient to cause ignition of the propellant.

12. An operating device for tools functioning under hydrostatic pressure, comprising: an elongated cylindrical casing having a fixed partition provided with an axial opening therethrough extending across an upper portion of said casing; a support tube axially positioned in the upper portion of the casing with its lower end secured in said partition with the bore thereof in alignment with the axial opening therein; a free piston slidably mounted on said support tube in fluid tight relation to the wall of the casing and the surface of said support tube, the free piston being under the hydrostatic pressure; said support tube wall having passages therethrough positioned adjacent the upper surface of said partition leading into the bore of the support tube; a rod arranged in the bore of the support tube, the lower end of said rod closing the passages at the lower end of the support tube until the rod is raised; a head at the upper end of said rod; means connecting the upper end of the support tube to a suspending cable down which a go-devil may be dropped; lever means mounted on the upper end of said casing in position to be struck by said go-devil and effective thereupon to engage the head of the rod and raise said rod to open the passages through said support tube to hydraulic fluid; a working piston in said casing below said partition in fluid tight sliding relation to the wall of the casing; the space above said working piston constituting a working cylinder receiving the hydraulic fluid flowing out of the space between the free piston and fixed partition; a piston rod secured at its upper end to said piston; a compound diameter cylinder arranged coaxially with the working cylinder and having a plurality of lengths of progressively less diameter, and a maximum diameter less than that of the working cylinder; a cylinder cap separating said first cylinder of the compound diameter cylinder from the working cylinder and provided with a central opening therein, the piston rod secured to said working piston extending through the opening in said cap in fluid tight relation therewith into said compound cylinder; a composite piston mounted on the piston rod within said compound cylinder, said composite piston having coaxially nested piston elements, the outer of said piston elements having a diameter fitting the length of greatest diameter of said compound cylinder; automatically releasable means holding said composite piston elements in alignment; and means for connecting the tool to be operated in fluid tight relation to the device to receive the hydraulic fluid at maximum pressure from the cylinder of least diameter of the compound cylinder of the device.

13. An operating device for tools functioning under hydrostatic pressure as set forth in claim 12 and in which said piston rod is tubular, the upper end of the piston rod being secured in a threaded recess in said working piston communicating with the working cylinder, said piston rod having a solid lower end and extending through the opening in said cap in fluid tight relation therewith into said compound cylinder; and said tubular piston rod wall having a port discharging hydraulic fluid into the space between the back of the composite piston and the cap of the compound diameter cylinder.

14. An operating device as set forth in claim 13 and in addition comprising a check valve arranged in the recess in said working piston and effective to prevent reverse flow of fluid through said tubular piston rod.

15. An operating device for tools functioning under hydrostatic pressure comprising: a first cylinder adapted

to be subjected to the hydrostatic pressure; said first cylinder having a passage adapted to admit the hydrostatic pressure to said first cylinder; a piston in said first cylinder acted on by said hydrostatic pressure; valve means effective to initially close said passage; means for moving said valve means to open said passage; a second cylinder co-axial with the first cylinder and of less diameter than said first cylinder; a piston rod extending from said piston into said smaller diameter cylinder; a compound piston in said second cylinder having a plurality of nested piston elements mounted on said piston rod; pressure sealing means between the piston elements; automatically releasable means initially holding said piston elements in nested relation to operate as a single piston but released on predetermined pressure being reached in said second cylinder, the piston element of greatest diameter being first ereleased from the piston element of next smaller diameter; means preventing reverse movement in the second cylinder of the released piston element; and conduit means leading fluid under the pressure developed in said second cylinder to means to be operated by the pressure fluid.

16. An operating device for tools functioning under hydrostatic pressure comprising: a vertical chamber open at one end to the hydrostatic pressure of liquid in which the device is immersed and closed at its opposite end; hydraulic fluid positioned above said closed end of the

chamber; freely movable means in said vertical chamber separating the liquid in which the device is immersed from the hydraulic fluid in said chamber; a first cylinder adapted to be subjected to the pressure of said hydraulic fluid; said first cylinder having a passage adapted to admit the hydraulic fluid under hydrostatic pressure to said first cylinder; valve means effective to initially close said passage; means for moving said valve to open said passage; a piston in said first cylinder, acted on by said hydraulic fluid; a second cylinder co-axial with the first cylinder and of less diameter than the first cylinder; a piston rod extending from said piston into the smaller diameter cylinder; a compound piston having a plurality of nested piston elements mounted on said piston rod in said second cylinder; pressure sealing means between the piston elements; automatically releasable means initially holding said piston elements in nested relation but released on predetermined pressure being reached in the second cylinder, the piston element of greatest diameter being first released from the piston element of next smaller diameter; means preventing reverse movement of the released piston element in said second cylinder; and conduit means leading fluid under the pressure developed in said second cylinder to means to be operated by the pressure fluid.

No references cited.