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COMBINATION BRIDGING PLUG AND COMBUSTION CHAMBER

Filed July 22, 1957

3 Sheets-Sheet 1

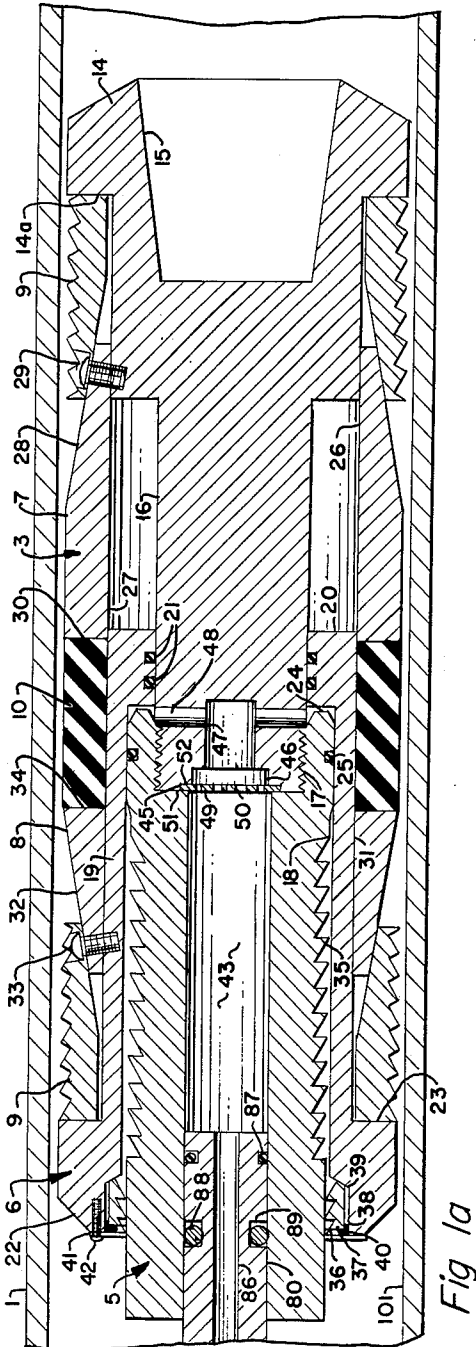
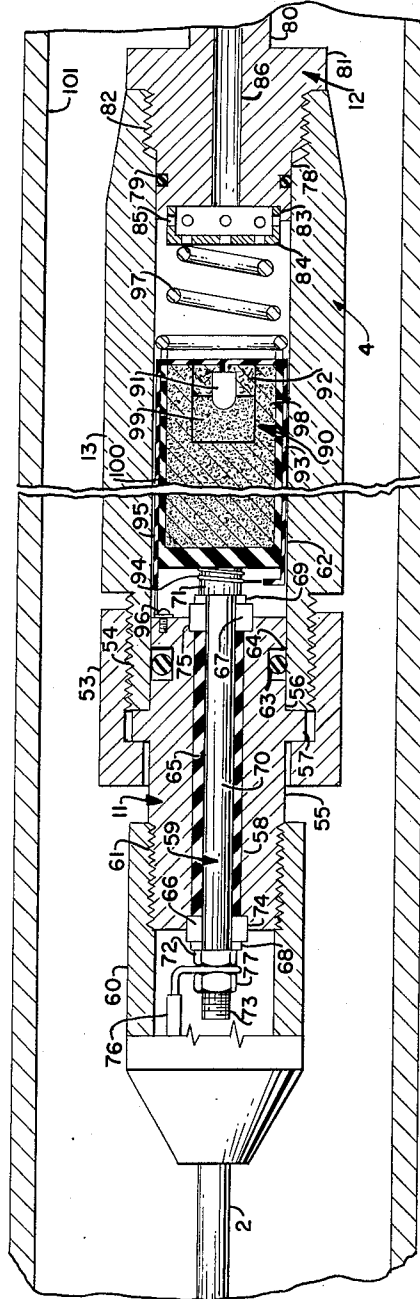


Fig 1a



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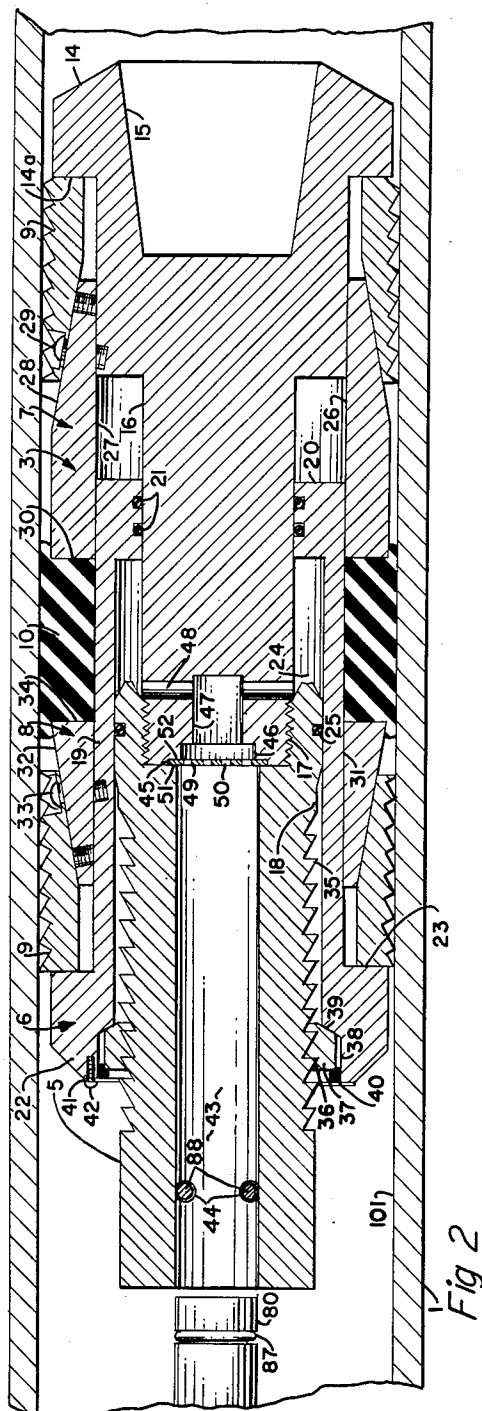
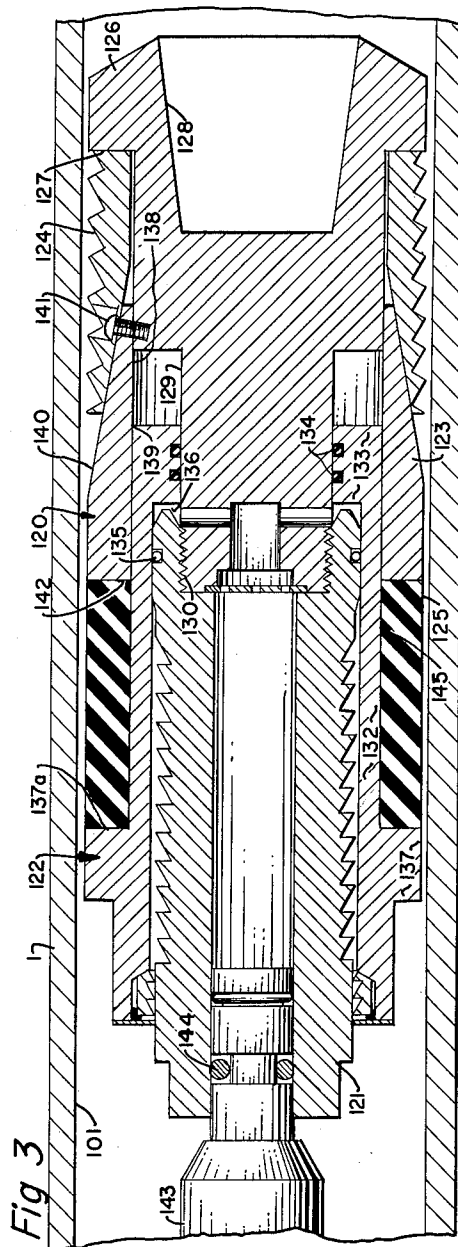
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

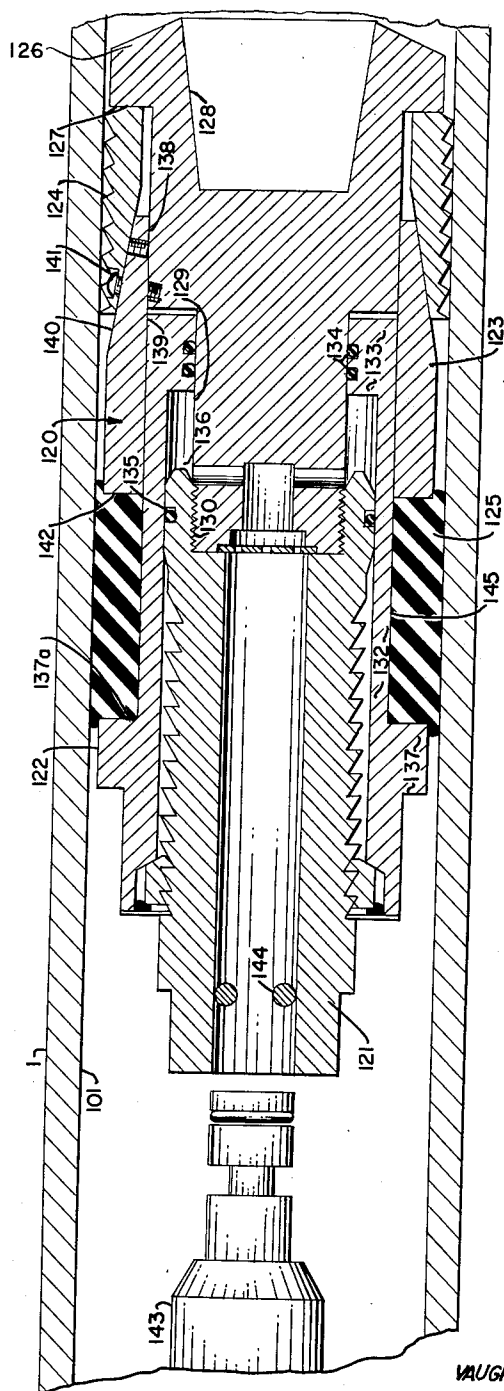


Fig 4

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1

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COMBINATION BRIDGING PLUG AND COMBUSTION CHAMBER

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This invention relates to oil well tools. More particularly, the invention relates to oil well bridging plugs of the type which are run into a well on a wire line and then expanded and locked into position by means of high pressure gas generated by the burning of propellants in a closed chamber.

The invention described herein is a modification of the invention described and illustrated in my copending patent applications filed simultaneously herewith, Serial Nos. 673,339, 673,260 and 673,298.

Bridging plugs are employed in oil wells for the purpose of forming a barrier in the well bore. The barrier may be either permanent or temporary, and may be located either in the well casing or in the uncased portion of the well bore. The barrier, thus formed, serves to separate the well bore into upper and lower sections which are isolated from each other. A pressure differential may exist across the bridging plug and may vary from a few pounds per square inch to several thousand pounds per square inch.

The bridging plug of the present invention is intended for use primarily in those cases where the pressure differential is high across the bridging plug.

Heretofore, it has been the practice, when establishing a high pressure barrier in a well, to employ bridging plugs which are relatively large and which therefore contain large amounts of metal which must be drilled up when it is desired to remove them from the well. Such bridging plugs are relatively complicated and expensive to manufacture.

It is an object of the present invention to provide a high pressure bridging plug which is relatively small, simple in construction and cheap to make.

Another object is to provide a bridging plug and propellant combustion chamber combination adapted to be attached together to form a gas pressure setting bridging plug arrangement.

In recent years the method of setting bridging plugs has undergone a radical change. Formerly, the plugs were run into the well on drill pipe or tubing, necessitating the use of a derrick and rotary drilling equipment at a cost sometimes of several thousand dollars, for the entire job. In recent years, the development of propellant-activated setting tools has made possible the running of the bridging plugs on a wire line instead of on pipe with a consequent large savings in expenses.

It is an object of the present invention to provide a bridging plug of the propellant-activated type, for wire line operation. Propellant-activated bridging plugs of the high pressure type, as heretofore constructed, required the use of separate, detachable setting tools containing the propellant-activated mechanism which adds to the cost and expense of setting the plug.

It is an object of the present invention to provide a high pressure bridging plug of the wire line type which requires a separate combustion chamber but does not require a separate setting tool and thus reduces the cost of setting the plug.

Other objects and advantages will be apparent from the following description and drawings disclosing several embodiments of the invention.

FIGURES 1a and 1b show in longitudinal section one embodiment of the invention in the running in position.

2

The left hand end of FIGURE 1b showing a wire line running to the surface, and the left hand end of FIGURE 1a being a continuation of FIGURE 1b.

FIGURE 2 shows the parts of FIGURE 1a set in an oil well casing.

FIGURE 3 shows in longitudinal section a modified form of the invention in which the lower end of the bridging plug is equipped with only one set of slips.

FIGURE 4 shows the parts of FIGURE 3 set in an oil well casing.

Referring to FIGURE 1, the numeral 1 indicates a well casing. Disposed within the well casing 1 and supported by a wire line 2, is a bridging plug 3 and a combustion chamber 4, in the running-in position.

The bridging plug 3 comprises six major parts which are movable relative to each other. These parts are: a piston 5, a cylinder 6, a floating sleeve 7, a floating body 8, upper and lower wedge slips 9, and a compressible packer sleeve 10. The piston 5 and cylinder 6 constitute a telescopic housing on the exterior of which the well wall engaging parts are mounted.

The combustion chamber 4 comprises three major parts not movable in relation to each other. These parts are upper plug 11, lower plug 12, and combustion cylinder 13.

The piston 5 is formed in two parts, the lower member being provided at its lower end with an enlarged head 14 forming annular shoulder or abutment 14a, and a recess body 15 and an upwardly extending cylindrical shank 16 of reduced diameter, to which is connected as by the threads 17, an enlarged tubular upper piston member 18 a peripheral shoulder being thus formed between shank 16 and upper piston member 18.

The cylinder 6 is slidably mounted on the shank 16 and piston member 18. To this end, the cylinder 6 is provided with a tubular lower portion 19 which slidably engages the outer surface of the piston member 18 and has an inwardly turned flange 20 at its lower end slidably engaging the exterior surface of the tubular shank 16. A suitable sealing means, such as the O rings 21, are mounted in the flange 20 in sealing relation with the exterior surface of the shank 16. The upper portion of the cylinder 6 is enlarged as indicated at 22 to provide a downwardly facing annular shoulder or abutment 23 against which the upper wedge slips 9 are supported in their retracted position, as shown in FIGURE 1. The interior of the cylinder 6, above the flange 20, which slidably engages the exterior surface of the piston 5, forms a pressure or expansion chamber 24 below the lower end of the upper member 18 of the piston. Sealing means, such as the O ring 25, is positioned in the exterior surface of the piston member 18 in sealing engagement between the walls of the cylinder 4 and the piston member 18.

The floating sleeve 7 is tubular in form with its interior surface, as indicated at 26, in slidable engagement with the exterior surface of the enlarged head 14 and its interior surface, as indicated at 27, in slidable engagement with the exterior surface of the tubular portion 19 of the cylinder 6. The lower outer portion of the floating sleeve 7 is tapered downwardly and inwardly to form a frusto conical seat 28 for the lower wedge slips 9. The lower wedge slips are normally held in their retracted position, supported by the shoulder 14a, by any suitable means, such as shear pins 29 attached to the floating sleeve 7 as indicated in FIGURE 1.

The upper end of the floating sleeve 7 terminates in an upwardly facing annular shoulder seat 30 which serves as a seat for the lower end of the cylindrical, resilient packer sleeve 10.

The floating body 8 is tubular in form with its interior surface 31 in slidable engagement with the exterior surface of the cylinder 6. The upper outer portion of the floating body 8 is tapered upwardly and inwardly to form

a frusto conical seat 32 for the upper wedge slips 9. The upper wedge slips are normally held in their retracted position, by any suitable means, such as the shear pins 33 attached to the floating body 8.

The lower end of the floating body 8 terminates in a downwardly facing annular shoulder seat 34 which serves as a seat for the upper end of the cylindrical, resilient packer sleeve 10.

In order to lock the cylinders 6 and piston 5 in the set position, the outer surfaces of piston member 18 is provided with a series of vertically spaced, downwardly facing teeth 35. The teeth 35 are adapted to engage a series of vertically spaced, upwardly facing teeth 36 formed on the inner face of the wedge locks 37 mounted in recess 38 formed in the upper end of the cylinder 6. The bearing wall 39 of the recess 38 is tapered downwardly and inwardly. A compression body of any suitable material, such as an O ring 40, is mounted in the recess 38 between the upper surface of the wedge locks 37 and the lower surface of a retainer plate 41. The retainer plate 41 is attached to the cylinder 6, by any suitable means, such as the screws 42.

The cylindrical resilient packer sleeve 10 is mounted between the shoulder seats 30 and 34 and has its interior surface in slidable engagement with the exterior surface of the cylinder 6.

The piston member 18 is provided with the axial hole 43 and at its upper end with the transverse holes 44 (FIG. 2).

The shank 16 is provided with the counterbores 45 and 46, the hole 47 and the transverse holes 48. A screen, such as the plate 49 with its holes 50 may be placed between the lower surface 51 of the member 18 and the upper surface 52 of the shank 16.

Referring to FIGURE 1, the combustion chamber 4 is provided at its upper end with a reduced diameter to which is connected the union nut 53 by the threads 54. The cylindrical upper plug 11 is provided with the upper shank 55, the lower shank 56, the flange 57 between the upper shank 55 and lower shank 56, and the axial hole 58 in which is mounted the insulated electrical connection device 59. The wire line cable head 60, of a suitable type, details not shown, is attached to the upper end of upper shank 55 by the threads 61. The lower shank 56 of the upper plug 11, is adapted to fit into the axial bore 62 provided in the combustion cylinder 13. A suitable sealing means, such as the O ring 63, is mounted on the lower shank 56 in sealing engagement with the interior surface 64, formed by the bore 62, of the combustion cylinder 13.

The upper plug 11 is attached to the combustion cylinder 13, by means of its flange 57, union nut 53 and the threads 54. The upper plug 11 can be removed from the combustion chamber 4 by unscrewing the threads 54.

The electrical connection device 59, is mounted in the axial hole 58 of the upper plug 11, and consists of the tubular insulating material 65 mounted within the axial hole 58 and supported between the insulating-sealing washers 66 and 67 and retained in place by means of support washers 68 and 69, the electrical rod 70, the lower enlarged head 71 of the rod 70, and nut 72 on threads 73 at the upper end of rod 70. The electrical rod 70 passes through the axial hole in the tubular insulating material 65, the holes in the insulating-sealing washers 66 and 67, and the holes in the support washers 68 and 69. The insulating-sealing washers 66 and 67 are mounted in countersunk bores 74 and 75 provided in the upper plug 11. The electrical connecting device 59 seals the axial hole 58 by means of the tubular insulating material 65 and the insulating-sealing end washers 66 and 67 being compressed and expanded between the support washers 68 and 69 by means of the rod 70, the enlarged head 71, the nut 72 and the thread 73.

The insulated electric cable 76 is clamped against nut 72 on the rod 70 by means of the nut 77. The electric

cable may extend to the surface by any suitable means, such as the wire line 2.

The combustion chamber 4 is provided at its lower end with the lower plug 12. The lower plug 12 has the upper shank 78 adapted to fit into the axial bore 62 and to seal said bore 62 by means of suitable sealing means, such as the O ring 79. The lower plug 12 also is provided with the downward extending shank 80 having flange 81 located between the shank 78 and 80. The lower plug is attached to the combustion cylinder 13 by means of the threads 82.

The upper surface of the shank 78 is provided with the counterbore 83 in which may be mounted a screen, as indicated by the body 84, having screen holes 85. The lower plug 12 is provided with an axial passageway 86. The extending shank 80 is adapted to fit into the axial hole 43 of the piston member 18. Sealing means such as the O ring 87 is mounted in the exterior surface of the extending shank 80 in sealing engagement between the walls of the piston member 18 and the shank 80.

The combustion chamber 4 is slidably and shearably connected to the bridge plug 3 by means of the shear pins 88 and the shoulders 89 provided in the extension shank 80 of the combustion chamber 4.

A charge of gas generating propellant grain 90 is positioned in the axial bore 62 of the combustion cylinder 13 between the upper plug 11 and the lower plug 13. An electric igniter of any suitable type such as the squib 91, is positioned in the lower end of the propellant grain 90 and retained in place by the plug 92. The insulated lead 93 of the squib 91, is connected to the enlarged head 71, of the rod 70, by any suitable means such as the wraps 94 around the head 71 and the ground lead 95 of the squib 91 is grounded to the combustion chamber 4, by any suitable means, such as the screw 96 to complete the electric circuit. A resilient means, such as the spring 97 may be used to support the propellant grain 90 above the screen body 84.

The propellant grain 90 consists of a cylindrical gas producing propellant 98 in which is mounted the squib 91. A quantity of igniter material 99, such as a mixture of black powder and magnesium may be placed between the propellant 98 and the squib 91 to assist in ignition of the propellant grain 90. The propellant grain 90 is provided with the external covering 100 to prevent burning of the propellant on any other surface than its lower end to produce an end burning grain. The combined volume of the bore 62, the counterbore 83, the passageway 86, the hole 43, the counterbore 46, the hole 47, the communicating transverse holes 48 and the pressure chamber 24 from a closed fluid chamber within the interior of the combustion chamber 4 and the bridging plug 3.

FIGURE 2 illustrates the bridging plug of FIGURE 1 in a set position in the wall casing 1. Upon application of electrical current, from any suitable source such as a wire line service unit, the electric squib 91 is fired, igniting the igniter material 99 and initiating the burning of the propellant 98.

The gas pressure generated by the burning of the propellant grain 90 within the combustion chamber 4 causes the cylinder 6 to move downwardly on the shank 16 of the piston 5, and in so doing shears the pins 33 and 29, releasing the upper and lower wedge slips 9. Continued downward movement of the cylinder 6 with respect to the piston 5 pushes the floating sleeve 7 and the floating body 8 downwardly. The compressible packer sleeve 10, being restrained between the shoulders 30 and 34 is compressed and expanded laterally until packer sleeve 10 is tightly engaged with the inner wall 101 of the casing 1 as indicated in FIGURE 2. At the same time, downward movement of the cylinder 6 in respect to the piston 5, forces the upper and lower wedge slips 9 into contact with the inner surface 101 of casing 1 due to movement on the frusto conical seats 28 and 32. Also, at the same

5

time, downward movement of the cylinder 6 in respect to the piston 5 causes the teeth 36 of the wedge lock 37 to engage the teeth 35 of the piston member 18 to lock the cylinder 6 against any subsequent upward movement, and thus maintaining the packer sleeve 10 in sealing engagement with the well casing 1.

Continued build-up of pressure will cause the shear pins 88 to shear, thereby releasing the combustion chamber 4 from the bridging plug 3 and releasing the gas pressure from the bridging plug 3 and the combustion chamber 4.

The expanded packer sleeve 10 together with the expanded upper and lower slips 9 will enable the bridging plug 3 to withstand high differential pressures in either direction.

The shearing of the pins 88 releases the combustion chamber 4 and the wire line 2 from the bridging plug. The wire line 2 and combustion chamber 4 may be removed from the well.

FIGURE 3 illustrates a variation of the bridging plug shown in FIGURES 1 and 2 which has two sets of wedge slips 9, these being so positioned as to prevent movement in either direction in the well casing 1. Sometimes, a bridging plug is used to support pressure in the downward direction only. In this case it is customary to provide the bridging plug with only one set of wedge slips to prevent downward movement of the plug in the casing.

Referring to FIGURE 3, the numeral 120 indicates a single slip bridging plug, in the running-in position, disposed within the oil well casing 1 and supported on a wire line not shown. The bridging plug 120 comprises five major parts which are movable in relation to each other. These parts are: a piston 121, a cylinder 122, a floating body 123, wedge slips 124, and a compressible packer sleeve 125.

The piston 121 is provided at its lower end with an enlarged head 126 forming an upwardly facing annular shoulder 127, a recessed body 128 having an upwardly extending shank 129 of still further reduced diameter to which is connected, as by the threads 130, the piston member 121.

The cylinder 122 is slidably mounted on the shank 129 and the piston member 121. To accomplish this, the cylinder 122 is provided with a tubular lower portion 132 which slidably engages the outer surface of the piston member 131 and has an inwardly turned flange 133 at its lower end, slidably engaging the exterior surface of the shank 129. Suitable sealing means such as the O rings 134, are mounted in the flange 133 and the O rings 135 are mounted in the piston member 131 to form an expansion chamber 136. The upper end of the cylinder 122 is provided with the enlarged head 137 forming a downwardly facing shoulder seat 137a that serves as a seat for the upper end of the resilient packer sleeve 125.

The floating body 123 is tubular in form with its interior surfaces 138 in slidable engagement with the exterior surface of the tubular body 128 and its interior surface 139 in slidable engagement with the exterior surface of the cylinder 122. The lower portion of the floating body 123 is tapered downwardly and inwardly to form a frusto conical seat 140 for the wedge slips 124. The wedge slips 124 are normally held in their retracted position, resting on the shoulder 127, by any suitable means, such as the shear pins 141, attached to the piston 121.

The upper end of the floating body 123 terminates in an upwardly facing annular shoulder 142 which serves as a seat for the lower end of the resilient packer sleeve 125. The locking arrangement is similar to that described for the bridging plug of FIGURE 1. Fluid passageways are also provided in the plug of FIGURE 3 similar to those of the plug of FIGURE 1.

A combustion chamber device 143, similar to the combustion chamber 4 of FIGURE 1, is attached by shearable means not described to the bridging plug 120 as indicated at the numeral 144.

6

FIGURE 4 illustrates the device of FIGURE 3 in set position in the well casing 1. High pressure gas supplied by the combustion chamber 143 into the expansion chamber 136 causes the cylinder 122 to move downwardly in relation to the shank 129 and in so doing shears the pins 141, releasing the wedge slips 124. Continued downward movement compresses the resilient packer sleeve 125 between the shoulders 137a and 142 and expands it into sealing engagement with the casing 1 and in sealing engagement with the exterior surface 145 of the cylinder 122. At the same time, continued gas pressure build-up in the combustion chamber 143 and bridging plug 120 sets the wedge slips 124 into the casing 1 and shears out the retaining means to release the combustion chamber 143 from the plug 120. The locking means retains the bridging plug in the set condition.

When fluid pressure is applied to the casing 1 above the set bridging plug of FIGURE 4, the fluid is prevented from flowing downward in the casing 1 due to the sealing of the packer sleeve 125 against the interior of the casing 1 and due to the holding action of the wedge slips 124 into the casing 1.

The exterior surface 145 of the cylinder 122 forms a piston rod type engagement with the interior surface of the packer sleeve 125. Application of pressure to the upper side of the casing sealing means of the bridging plug causes the packer sleeve 125 to be compressed and expanded tighter against the casing 1 interior wall due to the piston cross section area of the tubular lower portion 132 of the cylinder 122 being restrained from downward movement by its head 137 being supported by the upper surface of the packer sleeve 125. The higher the pressure the greater the load applied to the packer sleeve 125 to prevent the tubular portion 132 of the cylinder 122 from being pumped or forced through the packer sleeve 125. Therefore, the bridging plug is pressure responsive after being set and thereby automatically increases its sealing engagement with the casing.

I claim:

1. Well apparatus comprising: a piston, a cylinder slidably receiving said piston, a plurality of wedge slips surrounding said piston and said cylinder, a first means for supporting one of said wedge slips attached to said cylinder, a second means for supporting one of said wedge slips attached to said piston and extending through said cylinder, a packer sleeve surrounding said cylinder and positioned between said wedge slips, a plurality of means for expanding said wedge slips surrounding said cylinder and positioned between said wedge slips and said packer sleeve, said piston having a passageway therethrough in communication with said cylinder, means for generating a fluid positioned remote to said piston and cylinder, and a means for providing a passageway for fluid attached to said fluid generating means and said piston and in communication with the piston passageway and said fluid generating means.

2. Well apparatus as defined in claim 1 and in addition: means for locking attached to said piston and said cylinder, said locking means used to prevent movement in a direction reversed to that desired.

3. Well apparatus as defined in claim 1 and in addition: a shearable pin interconnected to said passageway means and said piston.

4. Well apparatus as defined in claim 1 wherein said fluid generating means comprises: means for forming a combustion chamber, a solid propellant arranged in said chamber forming means, means for igniting said propellant arranged in said chamber forming means.

5. Well apparatus as defined in claim 1 and in addition: a means for attaching said passageway means to said piston and connected thereto.

6. Well apparatus comprising: a piston, a cylinder slidably receiving said piston, said cylinder having an inwardly extending flange contacting said piston, an enlarged head attached to said piston and extending ex-

ternally of said cylinder past said cylinder flange, said cylinder having an outwardly extending enlarged portion thereon, wedge slips circumscribing said piston and said cylinder and abutting said enlarged head and cylinder enlarged portion, a packer sleeve circumscribing said cylinder and positioned between said wedge slips, means for expanding said wedge slips positioned between said wedge slips and said packer sleeve, said piston having a passageway therethrough in communication with said cylinder, means for generating fluid positioned remote to said piston and said cylinder, and a means for providing a passageway for fluid attached to said fluid generating means and said piston and in communication between said fluid generating means and said piston passageway.

7. Well apparatus as defined in claim 6 and in addition: means for locking attached to said piston to said cylinder, said locking means used to prevent movement and direction reversed to that desired.

8. Well apparatus as defined in claim 6 wherein said fluid generating means comprises means for forming a combustion chamber, a solid propellant arranged in said chamber forming means, and means for igniting said propellant arranged in said chamber forming means.

9. Well apparatus as defined in claim 6 and in addition: a shearable pin interconnected to said passageway means and said piston.

10. Well apparatus as defined in claim 9 in which the shearable pin is constructed of a material that will shear at a pressure greater than that required to set the slips and sleeve packer.

11. Well apparatus comprising: a piston consisting of a tubular member, an enlarged head having a cylindrical shank attached to said piston tubular member, a cylinder slidably receiving said tubular member, said cylinder having a flange extending radially inwardly in contact with said cylindrical shank, said tubular member having a port therethrough positioned adjacent the said cylindrical shank thereby having the interior of said piston tubular member in communication with said cylinder, said cylin-

der having an enlarged portion extending radially outwardly, wedge slips circumscribing said cylinder and said cylindrical shank and abutting said cylinder enlarged portion and said enlarged head, an annulus shaped packer sleeve circumscribing said cylinder and positioned between said wedge slips, a means for expanding wedge slips positioned between said sleeve packer and said wedge slip, a means for generating fluid remotely positioned in relation to said tubular member and cylinder and a means for providing a passageway attached to said fluid generating means and said tubular member and in communication with said fluid generating means and said tubular member port.

12. Well apparatus as defined in claim 11 and in addition means for locking attached to said tubular member and said cylinder to prevent movement in a direction reverse to that desired.

13. Well apparatus as defined in claim 11 wherein said fluid generating means comprises means for forming a combustion chamber, a solid propellant arranged in said chamber forming means, and a means for igniting said propellant arranged in said chamber forming means.

14. Well apparatus as defined in claim 11 and in addition a shearable pin interconnected between said passageway means and said tubular member constructed of a material which will shear at a pressure greater than that required to set the wedge slips and the sleeve packer.

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