Nov. 6, 1962 G. A. LOWREY ET AL 3,062,292

WELL PACKER

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Fig. 1B

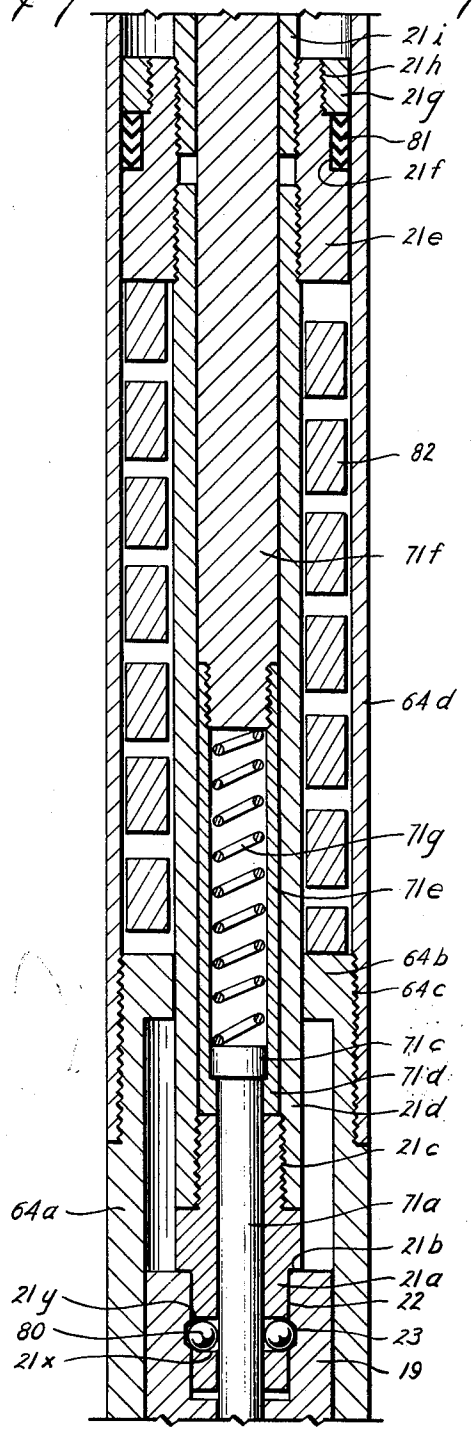
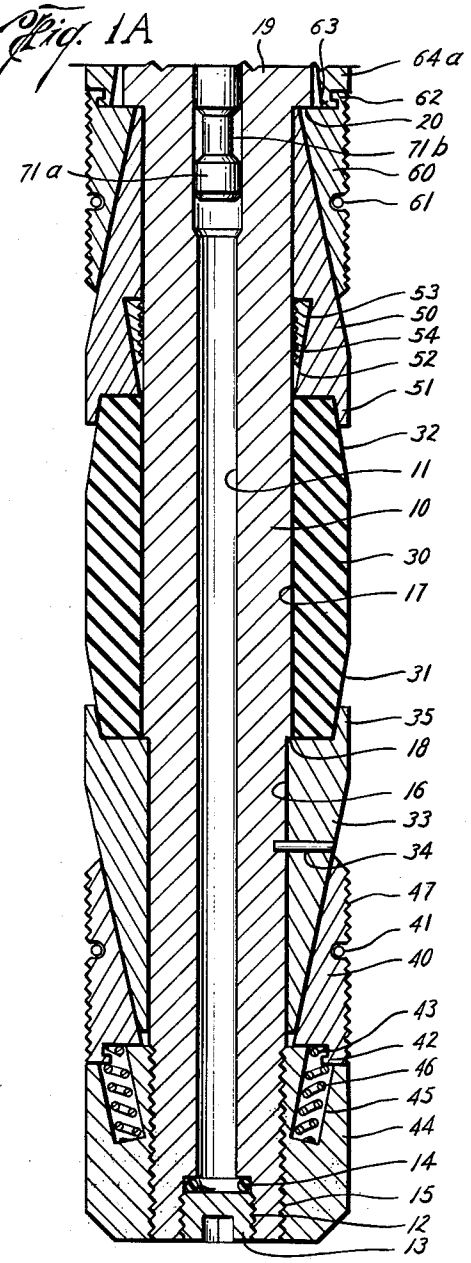


Fig. 1A



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Fig. 1D

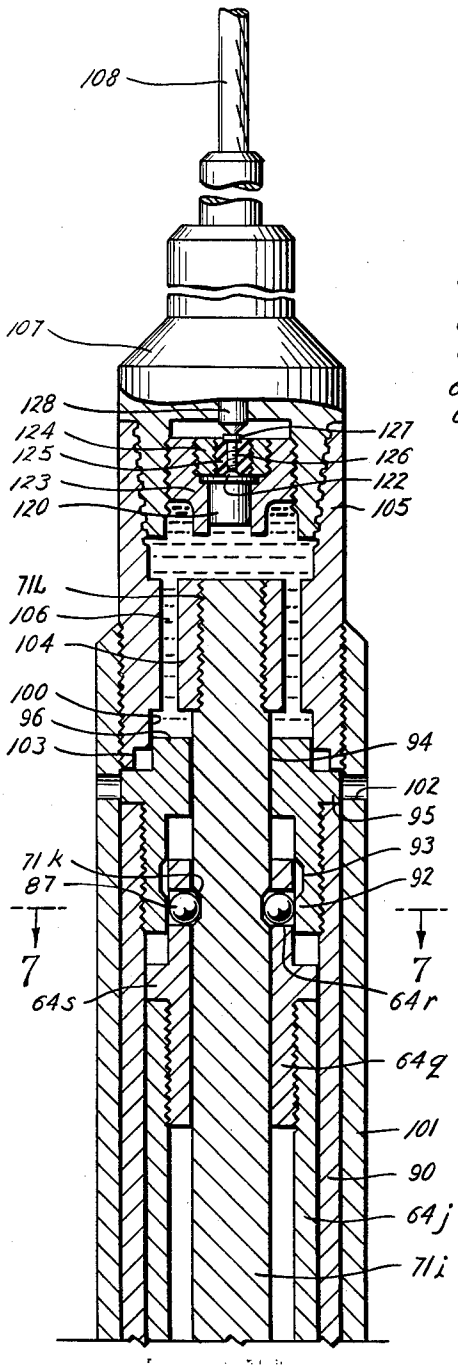
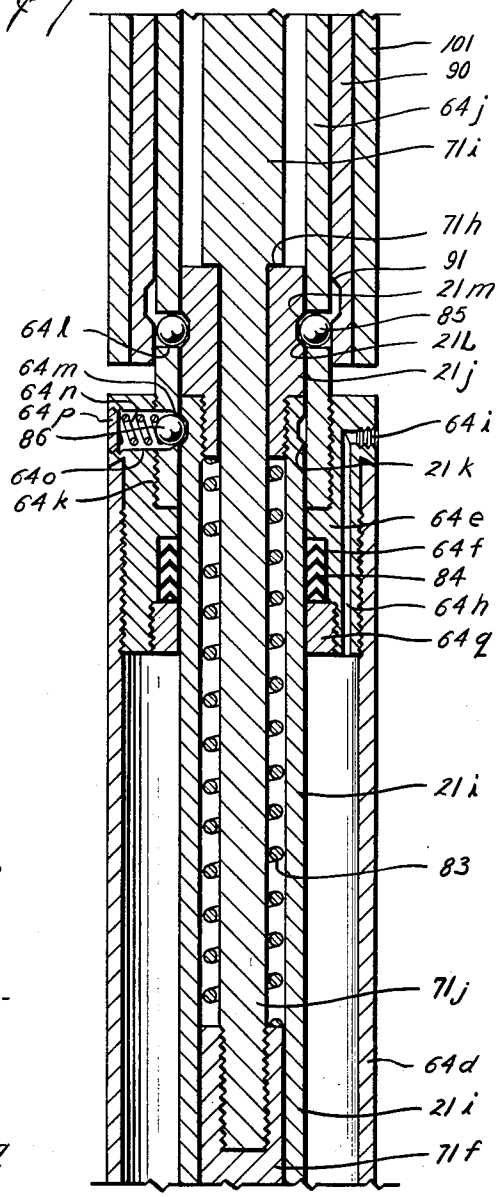


Fig. 1C



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Fig. 2

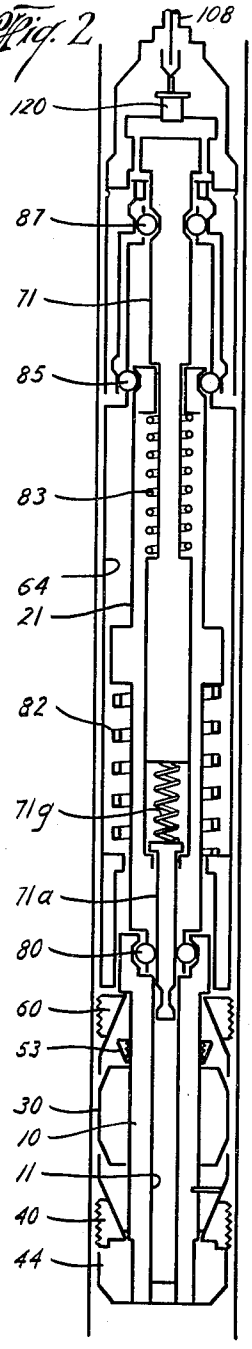


Fig. 3

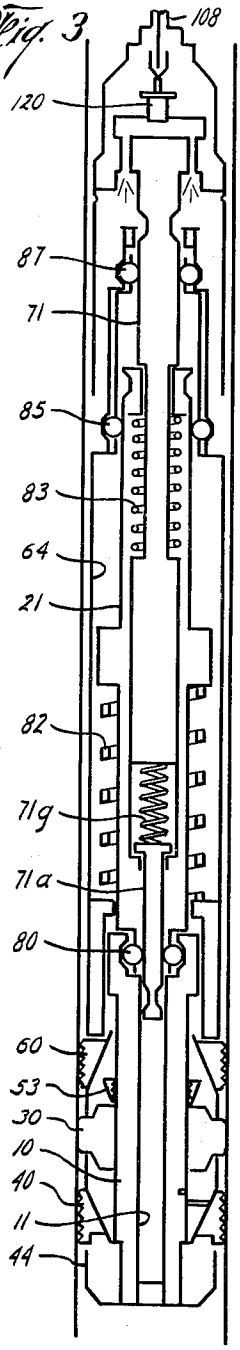
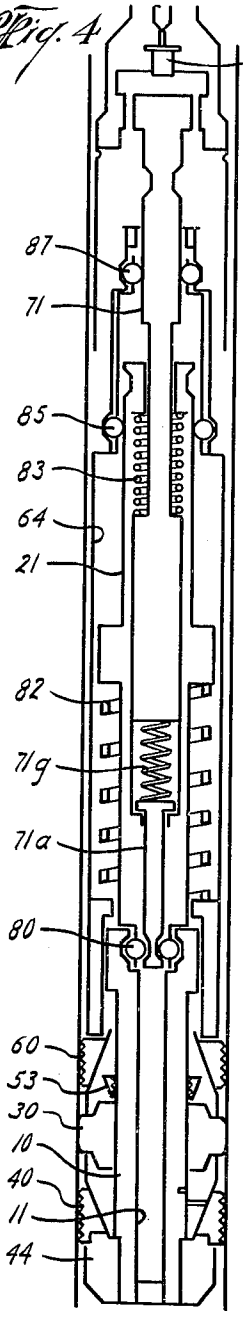


Fig. 4



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Fig. 5

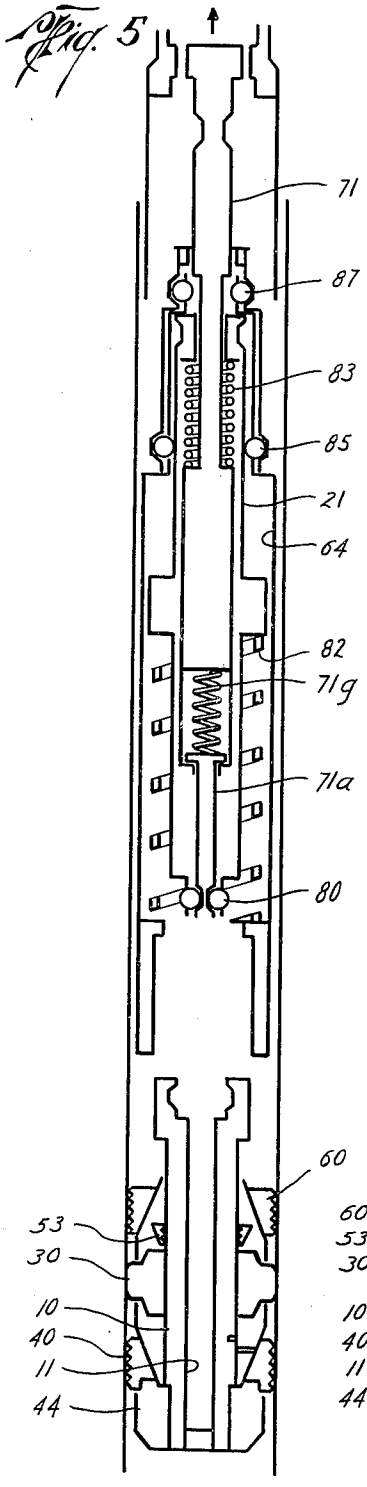


Fig. 6

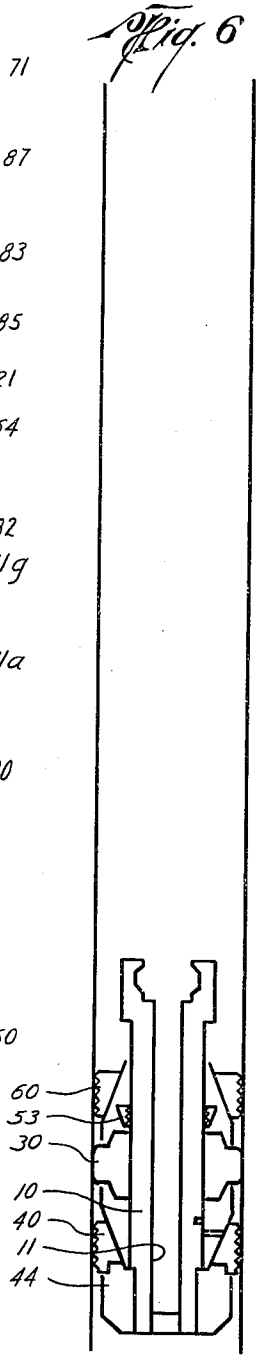
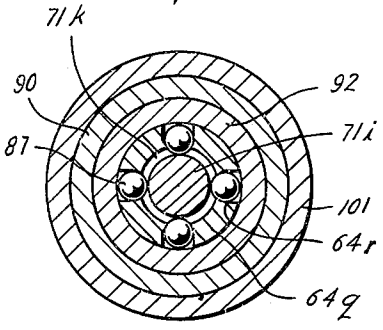


Fig. 7



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3,062,292

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3,062,292

WELL PACKER

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Filed Dec. 17, 1954, Ser. No. 476,026

11 Claims. (Cl. 166—123)

This invention pertains to well apparatus and more particularly to a drillable bridging plug to be installed in a well to provide a barrier to fluid flow in the well past the plug and to a tool for setting the plug that can be operated on the end of a wire line and removed after the bridging plug is set.

It is an object of the invention to provide such a bridging plug and setting tool that will be reliable in operation, inexpensive to manufacture, easy and economical to operate and maintain, and that will be rugged and durable.

A particular object of the invention is to provide a spring driven setting tool which can easily be cocked, i.e., the spring compressed to prepare the tool for use, this being accomplished according to the invention by hydraulic means.

Another object of the invention is to provide such an apparatus in which both the mandrel and anchor of the bridging plug are initially connected to the setting tool.

Another object of the invention is to provide a tripping device for simultaneously actuating the setting tool and preparing it for release from the plug without the need for subsequent manipulation of the wire line.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment thereof wherein

FIGURES 1A–1D together are a vertical section through an apparatus comprising a bridging plug and setting tool embodying the invention;

FIGURES 2–6 are schematic views each similar to the composite of FIGURES 1A–1D but to a smaller scale and illustrating the apparatus in different positions of operation;

FIGURE 7 is a horizontal section taken on line 7—7 of FIGURE 1D.

Referring now to FIGURE 1A, the bridging plug there shown comprises a generally cylindrical mandrel **10** having a cylindrical passage **11** through the axis thereof. The lower end of passage **11** is counterbored at **12** and the counterbore is internally threaded to receive a screw plug **13** which together with O ring seal **14** closes passage **11**.

The outer surface of the mandrel is of smallest diameter at its lower end where it is provided with a screw thread **15**. Above the threaded portion is a lower smooth portion **16** of slightly larger diameter and above that is an upper smooth portion **17** of still larger diameter with a radial shoulder **18** between the upper and lower smooth portions. The largest diameter portion **19** is at the upper end of the mandrel with a radial shoulder **20** between the uppermost portion and the upper portion **17**.

As shown in FIGURE 1B, the upper end of the mandrel is provided with means to engage the lower end **21***a* of the inner spring driven part of the setting tool, which means comprises a counterbore **22** and an annular groove **23** formed on the interior thereof.

Referring again to FIGURE 1A, a packing sleeve **30** of rubber or canvas or other sealing material that can be expanded radially by axial compression is disposed on upper portion **17** of the mandrel making a close slidable friction fit therewith. The upper and lower ends

of sleeve **30** are conically tapered at **31** and **32**. The lower end of sleeve **30** is even with shoulder **18**. A conical slip expander **33** is slidably mounted on lower smooth portion **16** of the mandrel **10** and is held up against shoulder **18** by a shear pin **34**. Expander **33** has an annular upstanding flange **35** that surrounds the lower tapered end portion **31** of sleeve **30**.

A plurality of slips **40**, for example three in number, are disposed around expander **33** and pressed radially inwardly against the expanded by means of a garter spring **41**. The lower end of each of the slips is provided with an inturned L flange **42** engaging an annular outturned L flange **43** on the upper end of a collar **44** screwed onto the lower end of the mandrel. Collar **44** is provided with a plurality of angularly disposed sockets **45** housing compression springs **46**, one for each slip, which tend to push the slips upwardly on the expander cone **33** but which are prevented from doing so as long as flanges **42** and **43** are engaged. When pin **34** is sheared and expander cone **33** pushed down into the group of slips they move radially outward until flanges **42** and **43** are no longer engaged, following which springs **46** push the slips upon the expander cone until the teeth **47** on the outside of the slips engage the well casing (not shown) to anchor the mandrel against downward motion in the well. The teeth on the slips may be downwardly directed or preferably radially directed as shown since if the expander cone is held against motion out of the slips, the mandrel will be anchored against upward as well as downward motion. The teeth could even be upwardly directed but this is not preferred.

An upper expander cone **50** is slidably mounted on upper smooth portion **17** of the mandrel between shoulder **20** and the upper end of packer sleeve **30**. It has an annular downturned flange **51** surrounding the upper tapered portion **32** of the packer sleeve. Inside expander cone **50** there is a conical recess **52** within which there are a plurality of slips **53** having teeth **54**. Preferably teeth **54** are upwardly directed, or radially directed as shown. When cone **50** is moved downwardly the slips **53** lock on the mandrel and prevent upward motion:

A plurality of slips **60** whose teeth are upwardly directed, or radially directed as shown, are disposed around cone **50** and pressed radially inward against the cone by a garter spring **61**. The upper end of each of the slips has an inturned L flange **62** engaging an annular outturned L flange **63** on the lower end **64***a* of the outer spring driven part of the setting tool. When the outer spring driven part is forced down relative to mandrel **10**, it pushes slips **60** down on cone **50** expanding garter spring **61** until the slips engage the sides of the well hole and anchor the mandrel against upward movement. As long as cone **50** keeps the slips **60** expanded they also anchor the mandrel against downward movement. When the slips **60** move out to the well wall, their flanges **62** also disengage flanges **63** of the setting tool.

The passage **11** in the mandrel receives the lower end **71***a* of the core of the setting tool. This lower end **71***a* is provided with an annular recess **71***b* adapted to receive latching balls **80** (referring now to FIGURE 1B) when raised relative to lower end **21***a* of the inner spring driven member **21** of the setting tool. When member **71***a* is so raised, balls **80** can move inwardly from annular recess **23** thereby freeing the mandrel from the inner spring driven member of the setting tool.

The outer spring driven part of the setting tool comprises lower member **64***a* having inturned flange **64***b* (referring now to FIGURE 1B) and externally threaded at **64***c* to receive tubular member **64***d*. The inner spring driven part of the setting tool comprises lower member **21***a* having a shoulder **21***b* resting on the upper end of

mandrel 10 and having a reduced threaded upper end 21c onto which a tubular member 21d is screwed. A coupling 21e is screwed into tubular member 21d and fits closely inside tubular member 64d. A Chevron packing 81 is held in place between tubular member 64d and the reduced upper end 21f of coupling of coupling 21e by an internally threaded ring 21g screwed onto threaded portion 21h. A tubular extension 21i is screwed inside coupling 21e at its upper end. Between the tubular members 21d and 64d of the inner and outer spring driven parts is a powerful helical compression spring 82 which bears at its upper end against coupling 21e and at its lower end against flange 64b.

The core of the setting tool comprises lower end member 71a, slidably extending through member 21a of the inner spring driven part of the setting tool and having an enlarged upper end 71c interlocked with an inturned annular flange 71d on the lower end of a tubular member 71e forming a telescopic lost motion connection therebetween. Tubular member 71e is screwed to the lower end of rod 71f which slides within within tubular member 21d of the inner spring driven part of the setting tool. A helical compression spring 71g presses at its upper end against the lower end of rod 71f and at its lower end against the upper end 71c of member 71a so as to press the lost motion connection to fully extended position. When the setting tool is being connected to the bridging plug the lost motion connection enables lower member 71a to be moved upwardly relative to the lower end 21a of the inner spring driven part so that recess 71b is opposite balls 80 in order that the lower end 21a of the inner spring driven part can be inserted into counterbore 22 in the upper end of the mandrel until balls 80 are opposite recess 23 in the mandrel. Then member 71a is released and it moves down locking balls 80 in recess 23, thereby connecting the mandrel and inner spring driven part.

In order that member 71a can be held retracted, as above described, during assembly of the bridging plug and setting tool, the screw plug 13 in the lower end of the mandrel is removed and the bridging plug can be centered on an upstanding pin which contacts member 71a when the setting tool is placed on top and pushes member 21a to the proper position. After the bridging plug and setting tool are connected, screw plug 13 is replaced in the mandrel before the bridging plug and setting tool are run into the well.

Referring now to FIGURE 1C, the core of the setting tool further comprises a rod 71j screwed into the upper end of rod 71f. Rod 71j is of smaller diameter than tubular extension 21i leaving an annular space therebetween in which is disposed a helical compression spring 83 bearing at its lower end against the top of rod 71f and at its upper end against a pipe 21j screwed into the top of tubular extension 21i. The upper end of pipe 21j rests against radial shoulder 71h on rod 77j at the beginning of an upper enlarged portion 71i thereof. By this means a lost motion connection is provided between the core of the setting tool and the inner spring driven part thereof. Spring 83 tends to keep this lost motion connection fully contracted and provides a shock absorber when the connection is loaded in tension as occurs when the setting tool is removed from the well after the plug has been set. On the way down into the well there is no tension on this connection as will appear hereinafter.

The outer spring driven part of the setting tool further comprises a bushing 64e screwed into the upper end of tubular member 64d. A Chevron packing 84 between a counterbore 64f in the lower end of the bushing and the outside of tubular extension 21i is compressed by a ring 64g screwed into the counterbore. Bushing 64e also serves to limit the relative motion of the inner and outer spring driven parts by engagement with coupling 21e. Longitudinal passages 64h and radial passages 64i in bushing 64e provide communication between the outside of setting tool and the annulus between tubular member 64d and tubular extension 21i to prevent hydraulic locking of these parts. Also, passage 64i is threaded to receive a check valve and pump connector so that oil can be pumped into the annulus to compress spring 82 to prepare the setting tool for use.

The outer spring driven part further comprises a pipe 64j screwed into a counterbore 64k in the upper end of bushing 64e. Pipe 64j makes a sliding fit over tubular extension 21i and pipe 21j connected thereto and constituting the upper end of the inner spring driven part of the setting tool. The extension 21i and pipe 21j are provided with annular recesses 21k and 21L. Pipe 64j is provided with upper and lower sets of apertures 64L and 64m receiving upper and lower sets of balls 85, 86. Balls 86 are urged radially inwardly by springs 64n in recesses 64o in the outer spring driven part closed by screw plugs 64p. This provides a semi-locking means connecting the upper end of the inner spring driven part to the outer spring driven part. The term "semi-locking" is used to define a device that prevents relative motion if the force is below a predetermined force but releases when the force is higher, and to distinguish from an ordinary lock which will not release at all but instead ruptures when excess force is applied.

A sleeve 90 slidably surrounding pipe 64j holds balls 85 in engagement with recess 21L except when the sleeve is lowered until annular recess 91 is opposite recess 21L. Sleeve 90 will remain in elevated position due to the friction caused by the outward pressure of balls 85 which are wedged outwardly by the upper sloping side wall 21m of recess 21L under the axial pressure of spring 82. By this means the upper end of the inner spring driven part is positively but releasably connected or latched to the outer spring driven part.

Referring now to FIGURE 1D, the outer spring driven part further comprises a bushing 64q screwed into the upper end of pipe 64j and slidably surrounding rod 71i of the core of the setting tool. As shown also in FIGURE 7, there is an annular recess 71k in rod 71i and there are a plurality of apertures 64r in busihng 64q adapted to receive locking balls 87. These balls are held in engagement with recess 71k by sleeve 92 screwed into sleeve 90, except that there is an annular recess 93 in sleeve 92 adapted to receive balls 87 and release them from recess 71k when sleeve 92 is forced down with sleeve 90. A flange 64s on bushing 64q engages the lower end of sleeve 92 to limit its downward travel. By this means the upper end of the outer spring driven part is positively releasably connected or latched to the core of the setting tool.

Sleeve 92 has a portion 94 of smaller inside diameter than the rest of the sleeve slidably surrounding rod 71i. Sleeve 92 also has an outwardly extending larger diameter portion 95 engaging the upper end of sleeve 90 to provide a large force transmitting surface for driving sleeve 90 downward. The upper end 96 of sleeve 92 forms an annular piston moving in a cylinder 100. A pipe 101 screwed onto the lower end of cylinder 100 provides a fixed housing outside of sleeve 90. Ports 102 adjacent the outwardly extending larger diameter portion 95 of sleeve 92 provide vents to the exterior of the tool from the interior of cylinder 100 when piston 96 drives sleeves 92 and 90 down and piston 96 enters enlarged portion 103 of the cylinder and portion 95 of sleeve 92 moves down and uncovers ports 102.

The upper end 71L of rod 71i of the core of the setting tool is screwed into the head 104 of cylinder 100. A tubular extension 105 above the head 104 provides a combustion chamber above the head. Ports 106 through the head, preferably filled with grease or liquid provide hydraulic means to transfer pressure from the combustion space to the interior of cylinder 100 above piston 96.

Any suitable means may be provided inside the combustion chamber of cylinder extension 105 for providing the required pressure to drive piston 96. Also any suit-

able means may be provided to connect extension 105 to means for raising and lowering the setting tool and bridging plug in the well hole. As shown, there is a rope socket 107 screwed into extension 105 for connecting it to an electric wire line 108. A cartridge 120 of exposive material has an electric detonating filament therein, one end of which is grounded to the rim 121 and the other end of which is connected to a central contact 122. Cartridge 120 is supported in rope socket 107 by a ring 123 screwed into the lower end of the rope socket and held in ring 123 by a screw ring 124. An insulating bushing 125 is screwed into ring 124 and a pin 126 is screwed into bushing 125 to engage contact 122. The head 127 of pin 126 engages conductor 128 connected to the electric wire line 108. By closing a circuit through the wire line and the filament of cartridge 120, the exposive charge in the cartridge will be ignited and the resultant pressure will be hydraulically transmitted to piston 96. Instead of detonating the cartridge electrically it could be set off by percussion by dropping a go-devil down the well, guided by the well wall or the wire line, or if the setting tool is run on tubing, an electric or percussion type go-devil could be dropped inside the tubing.

To prepare the apparatus for use the spring 82 is compressed hydraulically as previously described and sleeve 90 is lifted manually to lock balls 85 and 87 in recesses 21L and 71*k*. The hydraulic pressure is then removed from the annulus between tubular member 64*d* and tubular extension 21*i* and the force of spring 82 tends to drive balls 85 and 87 outwardly, thereby holding sleeve 90 in place. The bridging plug is then centered on a pin and the setting tool placed on top of it. Initially balls 80 in apertures 21*x* in member 21*a* protrude radially beyond 21*a* and would not enter counterbore 22 in the mandrel 10 of the bridging plug. They are prevented from falling out by peening the edges of apertures 21*x* as shown at 21*y*. However, the center pin pushes member 71*a* upwardly allowing the balls 80 to move into recess 71*b* so that the lower end 21*a* of the inner spring driven part can enter the mandrel of the bridging plug. The recess 71*b* has enough axial extent so that the balls 80 can continue to remain therein as member 21*a* of the setting tool is lowered into the mandrel 10. Then when walls 80 can move out into recess 23 in the mandrel the bridging plug can be lifted from the center pin and the member 71*a* will be pushed down by spring 71*g* and lock the balls in recess 23. Before the bridging plug is lifted off the center pin slips 60 are moved by hand against garter spring 61 and lifted to engage their flanges 62 with flanges 63 on the lower end 64*a* of the outer spring driven part. After the bridging plug is lifted off the center pin screw plug 13 is inserted in the lower end of the mandrel. The setting tool is then connected at its upper end to an electric rope socket and is ready to lower into the well hole. This is the position of the apparatus shown in FIGURES 1A through 1D.

Referring now to FIGURE 2 through 6, there is shown the operation of the apparatus in sequence. FIGURE 2 shows the parts in the same position as in FIGURE 1 with the outer spring driven part latched to the core by balls 87 and the inner spring driven part latched to the outer by balls 85 and the mandrel of the bridging plug latched to the inner spring driven part by balls 80 and the spring 82 compressed. It will be noted that because of the abutment of the upper end of pipe 21*j* of the inner spring driven part with shoulder 71*h* of the core, upward motion of the inner spring driven part relative to the outer spring driven part is prevented whether or not they are latched together by balls 85 (and 86). Balls 85, however, prevent downward motion of the inner spring driven part relative to the outer as might occur if the bridging plug became caught in the well hole. Such downward motion, however, would require further compression of spring 82. It is apparent therefore that balls 87 and the abutting shoulder 71*h* and end of pipe 21*j* and spring 82 provide a means to oppose or prevent relative motion of the inner and outer spring driven parts, just as do balls 85 and as do also balls 86 of the semi-locking device.

When the apparatus is being lowered in the well hole both expander cones 33 and 50 are positively held against upward motion by shoulders 18 and 20 so that the only way the upper anchor could be set and the packer expanded would be by the slips 60 becoming disengaged from the lower end of the setting tool which is positively prevented by flanges 62 and 63. The tool is not likely, therefore, to become accidentally stuck in the hole. The lower slips are also locked to the lower end of the mandrel by flanges 42 and 43 and cone 33 is held up by shear pin 34 so that this lower anchor is not likely to set either. However, setting of the lower anchor without setting of the rest of the bridging plug would not prevent lifting the apparatus up out of the well and would not be so serious.

When the bridging plug has been lowered to the desired position in the well, the cartridge 120 is detonated, forcing piston 96 down and driving sleeves 92 and 90 down to unlock balls 87 and 85. Spring 82 expands. Semi-locking balls 86 act as shock absorbers and release. Spring 82 expands further causing relative motion of the inner and outer spring driven parts. This causes relative upward motion of the mandrel 10 and downward motion of slips 60. The slips move outwardly on cone 50 until they engage the well wall and stop. As the mandrel 10 continues upward it causes cone 33 to move up compressing packer sleeve 30 against cone 50 which wedges into the slips 60. Then pin 34 shears and cone 33 moves down and mandrel 10 moves up until the lower end of cone 33 engages the upper end of collar 44, during which motion slips 40 expand on cone 33 until flanges 42 and 43 are disengaged. Springs 46 then propel slips 40 upwardly and outwardly still further until they engage the well wall and keep the slips in engagement with the cone 33 and the well wall as further upward motion of the mandrel 10 and collar 44 and cone 33 further axially compress packer sleeve 30 and expand it radially into engagement with the well wall. This is the position shown in FIGURE 3. It is to be noted that the axial force required to set the packer sleeve is not transmitted through slips 40 but by direct engagement of collar 44 with the lower end of cone 33. Therefore the slips 40 are relieved of a great deal of wear and tear which would otherwise occur.

By pulling upon the wire line the core of the setting tool will be lifted, causing recess 71*b* on member 71*a* to be disposed opposite balls 80. Spring 83 compresses to allow the core of the setting tool to be lifted even though the inner spring driven part is still latched to the bridging plug. This is illustrated in FIGURE 4.

When balls 80 move into recess 71*b* the entire setting tool can be lifted away from the bridging plug and spring 83 supports the inner spring driven part on the core of the setting tool and spring 82 supports the outer spring driven part on the inner spring driven part so that it is all removed together. This is illustrated in FIGURE 5.

FIGURE 6 shows the final condition of the well with only the bridging plug remaining anchored therein. Since the setting tool, and in particular all the springs thereof, are entirely removed, if it is desired to remove the bridging plug it can be easily drilled out. The bridging plug itself can be made entirely of easily drillable materials. The setting tool is undamaged and can be used repeatedly.

While a preferred embodiment of the invention has 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 cover by Letters Patent all forms of the inventtion falling within the following claims.

We claim:

1. A bridging plug including a mandrel having a packing sleeve mounted thereon, means on the mandrel below

the sleeve to support the lower end of the sleeve, anchor means slidably mounted on the mandrel above the sleeve for engaging a well casing, and means for releasably connecting said anchor means to a setting tool, said anchor means and said means for releasably connecting said anchor means to a setting tool comprising an upwardly pointing slip expander cone slidably mounted on said mandrel above said sleeve, a plurality of slips around said cone, resilient means urging said slips radially inward against said cone, an inturned flange on the upper end of each of said slips adapted to engage an outturned annular flange on the lower end of said setting tool with the radial overlap of said flanges being less than the radial movement of said slips upon axial motion thereof along said cone to cause said slips to be released from said setting tool when said slips are moved out to set the anchor means.

2. The combination of claim 1 wherein said mandrel has a downwardly facing shoulder above said expander cone, and the upper end of said expander cone is in engagement with said shoulder prior to the setting of said bridging plug to prevent said cone from moving up to expand and set said slips when the plug is being lowered into a well hole.

3. The combination of claim 2 wherein said cone has an internal tapered groove pointing down and there are a plurality of slips in said groove having teeth engaging said mandrel to prevent upward motion of said cone relative to said mandrel after said plug has been set.

4. The combination of claim 1 wherein said means to support the packing sleeve at its lower end comprises a second anchor means including a downwardly pointing expander cone slidably mounted on said mandrel below said sleeve, shearable means holding the last said cone against sliding on said mandrel, a group of slips around the last said cone, resilient means urging the slips of said group radially inward against the last cone, an inturned flange on each of the lower end of each of the slips in said group, an outturned annular flange connected to the lower end of said mandrel adapted to engage the inturned flanges of the last said slips, the radial overlap of said flanges being less than radial movement of the last said slips upon axial motion thereof along said cone to cause the last said slips to be released from said mandrel when the last said slips are moved out to set the last said anchor means.

5. The combination of claim 4 in which there is a flange connected to said mandrel below said downwardly pointing cone limiting its motion into the last said slips to less than that required to set the last said anchor means but sufficient to free the last said slips from said mandrel, and there is spring means acting on each of the last said slips to urge the last said slips farther onto said downwardly pointing cone sufficient to set said second anchor means.

6. The combination of claim 4 wherein said mandrel has a downwardly facing shoulder above said downwardly pointing expander cone and the upper end of said downwardly pointing cone engages the last said shoulder prior to the setting of the bridging plug to prevent said cone from moving up to compress said packing sleeve axially and expand it radially when the plug is being lowered into a well hole.

7. The combination of claim 4 wherein said cones have annular axially extending flanges adjacent said packing sleeve overlapping the upper and lower ends of said sleeve, said flange being internally tapered in the same direction as said cones.

8. The combination of claim 7 wherein said sleeve is tapered at its upper and lower ends to fit inside said annular flanges on said cones.

9. A setting tool comprising a first spring driven part, a second spring driven part axially slidably mounted on the first spring driven part, spring means bearing against said parts for causing relative axial motion thereof in one direction on expansion of said spring means, fluid actuated means connected to said parts for causing relative axial motion of said parts in the opposite direction to compress said spring means, releasable means for locking said parts in position corresponding to compression of said spring means, and means for releasing said locking means.

10. A well anchor comprising a mandrel, an expander cone slidably mounted thereon, a plurality of slips surrounding said cone, resilient means urging said slips radially inward, holding means on the mandrel cooperating with means on the slips for preventing axial movement thereof relative to said mandrel until the slips have moved radially outward a predetermined distance, and spring means to move said slips axially toward said expander means when said means preventing axial movement of the slips has released.

11. The combination of claim 10 in which said cone is axially slidably mounted on said mandrel for movement between an upper position adjacent a shoulder with which said mandrel is provided and a lower position against said holding means, and said cone is initially by shear means held fixed in said upper position against said shoulder.

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