Sept. 19, 1961 A. E. THOMPSON 3,000,443

BRIDGING PLUG

Original Filed May 5, 1954

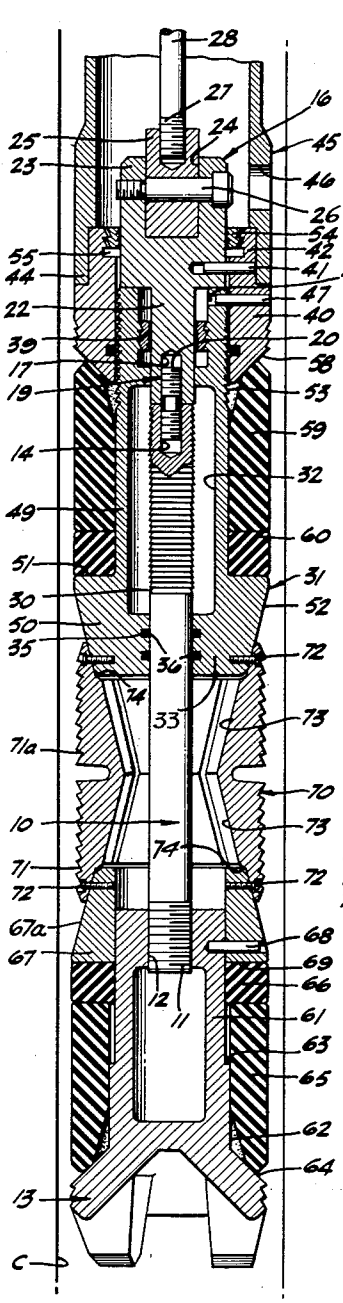

FIG. 1.

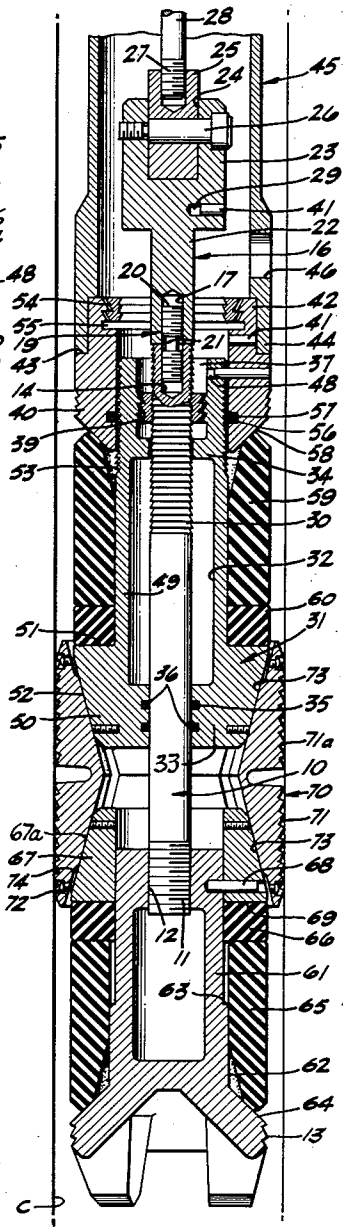

FIG. 2.

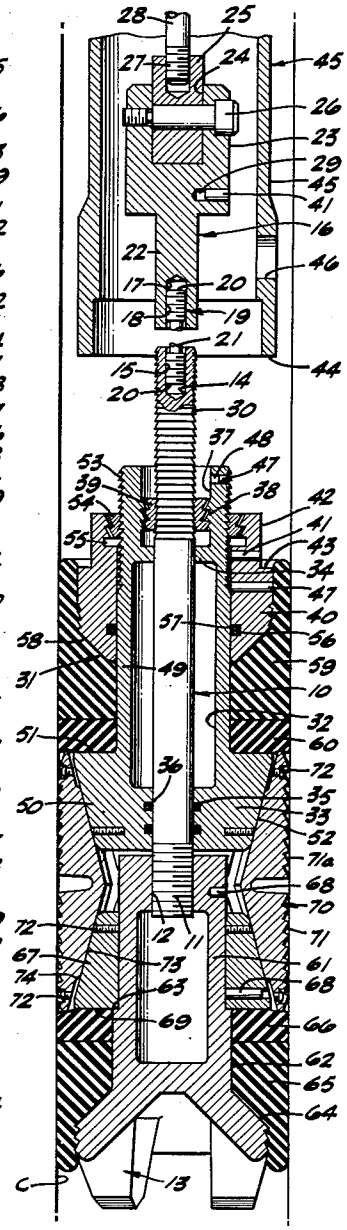

FIG. 3.

ARCHIE E. THOMPSON
INVENTOR.

BY C. Lawrence McCarthy

ATTORNEY

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BRIDGING PLUG

Archie E. Thompson, Bell Gardens, Calif., assignor, by mesne assignments, to Dresser Industries, Inc., Dallas, Tex., a corporation of Delaware

Continuation of application Ser. No. 427,819, May 5, 1954. This application Aug. 19, 1957, Ser. No. 678,808
3 Claims. (Cl. 166—135)

This invention relates to bridging plugs for well boreholes and casings and is particularly directed to anchoring and packing devices for use therein, together with the actuating and securing means for such devices. This application is a continuation of copending application Serial No. 427,819, filed May 5, 1954.

Bridging plugs of the type to which the present invention relates are primarily used to seal or pack off a well section while pumping, testing or cementing operations are carried on above the section thus sealed off. An important consideration is that the well bore or casing above the bridging plug be free and clear during such operations, and since high pressure differentials must often be resisted by the bridging plugs under such conditions, it is desirable to provide a plug capable of withstanding such pressures, which at the same time may be quickly and easily set in the well bore or casing sealing position by tools or other devices which may be readily detached from the plug and withdrawn, thus leaving the space thereabove unobstructed. It therefore follows that the plug must be capable of self-securement and retention in set position, and without likelihood of inadvertent dislodgment under high differential pressures often encountered in the well. Bridging plugs developed heretofore have been designed to satisfy these purposes, but many difficulties have been encountered in achieving such desirable results while retaining necessary simplicity compatible with economic manufacture, and of such strength and durability as required.

It is accordingly an object of the present invention to provide a bridging plug in which certain undesirable strength limitations heretofore prevalent in conventional bridging plugs have been eliminated.

More specifically, it is an object of the present invention to provide a novel bridging plug that is of improved simplicity of design, lighter in weight, and that can be set in a well or casing with substantially less setting force than heretofore required of comparable plugs.

Another object of the invention is to provide a bridging plug of improved construction that has less weight and mass and which may be readily drilled out, leaving a minimum of cast iron residue in the well after such drilling-out operation.

A further object of the invention is to provide an improved and simplified bridging plug wherein the basic parts, such as the mandrel, may be of standard size for a number of different sized plugs for use in different sized boreholes or casings.

Another object of the invention is to provide in a bridging plug of the character under consideration improved slip structure features wherein a fast slip setting action is achieved with a minimum of telescopic movement, thereby permitting the plug to have a shorter overall length.

Other objects of the invention include the provision of a unique combination and interrelation of parts whereby strength and durability are achieved with minimum material cost and operational expense in manufacture and assembly.

These and other objects and advantages and features of novelty will be evident from the following detailed description of the invention.

In the drawings which show by way of illustration a

preferred embodiment of the invention and in which like reference characters designate the same parts throughout the several views:

FIGURE 1 is a vertical sectional view of the plug of the present invention assembled in position to be lowered into a well bore or casing for subsequent setting.

FIGURE 2 is a view similar to FIGURE 1 showing the plug as it appears in partially set position within the well casing.

FIGURE 3 is a view similar to FIGURES 1 and 2 showing the plug as it appears in fully set position within a well casing.

In considering the present invention as exemplified by the present specification and accompanying drawing, it will be understood that the inventive concept hereof as outlined by the appended claims is in no way limited to the structural details herein set forth. Changes, modifications and the full use of equivalents are therefore contemplated in the practice of the invention.

Referring now to the drawing, the present structure comprises a central mandrel **10** consisting of a solid cylindrical rod of a diameter relatively small as compared to the outside diameter of the plug, and having a threaded lower end portion **11** for engagement with the internally threaded portion **12** of a bull plug **13**. The upper end of mandrel **10** is formed with an end bore **14** having internal threads **15**. A coupling member **16** has an end bore **17** at its lower end, which bore is formed with internal threads **18**. The mandrel and coupling member **16** are joined by a release stud **19** which has threaded external opposite end portions **20** for engagement with mandrel and coupling threads **15** and **18**, respectively, and has a weakened intermediate reduced diameter portion **21** which will rupture or fracture upon predetermined longitudinal tensile stress therethrough. Coupling member **16** has a cylindrical lower end portion **22** of substantially the same diameter as that of mandrel **10** and a contiguous upper head portion **23** of larger diameter. Head portion **23** is formed with an upper end bore **24** into which may be received a setting tool connector **25** which may be fastened therein by a transverse shoulder bolt **26**. Connector **25** is suitably secured as by a threaded connection **27** to the lower end of a setting tool piston rod **28**. The head portion **23** is further formed with a laterally directed pinhole **29** to receive the end of a safety shear pin **41** to be described more fully hereinafter. The upper end of mandrel **10** is formed with a plurality of downwardly facing buttress shaped threads on grooves **30**.

A sleeve member **31** is slidable on mandrel **10** and coupling member **16** and has a hollow central portion **32** forming shoulders **33** and **34**, shoulder **33** preferably having one or more internal annular grooves **35** in which are positioned seal rings **36**. Shoulder **34** is formed with a bore **37** in its upper end having inwardly and downwardly facing buttress shaped teeth **38**. A split lock ring **39** is positioned in bore **37** and has upwardly directed external teeth for engagement with teeth **38** and upwardly facing internal teeth for engaging the beforementioned downwardly facing threads or grooves **30** of mandrel **10**. A packer expander ring **40** initially surrounds the lower portion of coupling member **16** and the upper end portion of sleeve **31** and is initially secured to coupling member **16** by the beforementioned shear pin **41** which extends from packer expander ring **40** into the lateral pinhole **29** of the coupling member **16**. Expander ring **40** has an upper portion of reduced outer diameter **42** forming a shoulder **43** on which shoulder the lower end **44** of a ram adapter **45** is initially seated. Ram adapter **45** has an opening **46** in one side to permit the insertion of shoulder FIGURE 1. A shear pin **47** extends radially inward from a pinhole through the wall of expander ring **40** and

into a pinhole 48 in the upper end portion of sleeve 31. Sleeve 31 has an intermediate cylindrical packing supporting portion 49 and an enlarged lower end portion 50 forming a slip cone, there being formed therebetween an external upwardly facing annular shoulder 51. The enlarged slip cone portion 50 is tapered convergingly downward to provide a frusto-conical slip cone wedging surface 52. The upper end portion 49 of the sleeve member 31 is formed with a plurality of external, downwardly facing buttress shaped grooves 53 to be engaged by a split lock ring 54 positioned in a counterbore 55 in the upper end portion 42 of the expander ring 40, which counterbore has a plurality of downwardly facing buttress teeth, the lock ring 54 having internal and external upwardly facing teeth for engaging therewith and with the grooves 53 of sleeve member 31.

Expander ring 40 is formed with an internal groove 56 in which is positioned a sealing ring 57 for making sealing engagement with the external surface of portion 49 of sleeve member 31. The expander ring is also formed with a beveled lower portion 58 for facilitating the expanding of the packing element. A cylindrical packing element 59 made of resilient rubber-like material such as, for example, Buna-N synthetic rubber, surrounds the intermediate, cylindrical portion 49 of the sleeve member 31, and an end packing element 60, preferably a ring, also made of synthetic rubber and having a greater Shore hardness than that of packing element 59 is also carried by sleeve member 31 and is seated against shoulder 51.

Bull plug 13 has a cylindrical, packing-supporting portion consisting of an upper cylindrical portion 61 and an intermediate cylindrical portion 62 of slightly larger diameter than the upper portion 61 and forming an annular shoulder 63 at the juncture of cylindrical portions 61 and 62. The bull plug is further formed at the lower end thereof with a downwardly diverging, flared shoulder 64 to facilitate expanding a packing sleeve 65 surrounding the beforementioned cylindrical portions 61 and 62. Packing sleeve 65 is also made of a resilient rubber-like material such as, for example, Buna-N synthetic rubber. An end packing element 66 comprising a ring made of similar synthetic rubber and having a greater Shore hardness than that of packing sleeve 65 is positioned on cylindrical portion 61 above the packing sleeve 65. A slip cone 67 having an upwardly converging, frusto-conical slip wedging surface 67*a* is slidably supported on portion 61 of the bull plug 13, but is initially restrained against movement thereon by a shear pin 68 which extends radially inward from the expander ring into the bull plug. Slip cone 67 is formed with an annular, downwardly facing shoulder 69 adjacent packing element ring 66. A plurality of slips 70 having upwardly and downwardly facing wicker teeth 71 and 71*a*, respectively, adapted to make gripping engagement with a surrounding casing, are secured by and between the wedging surfaces 52 and 67*a* of slip cone portion 50 of expander sleeve member 31 and slip cone 67, and are initially held thereto by relatively weak shear screws 72 which each shear at a force of approximately 300 pounds. Slips 70 have a pair of internal surfaces 73, which surfaces are flared outwardly from the center to slide on the beforementioned wedging surfaces 52 and 67*a* and the slips are also formed with internal tapered annular shoulders 74 which form in effect a pair of sloping steps.

The assembly of the plug into the initial condition shown in FIGURE 1 is as follows: The bull plug 13 is first secured to the lower end of mandrel 10 by engagement of threads 12 with the packing element sleeve 65 and packing ring 66 positioned thereon and slip cone 67 secured thereto by placing shear pin 68 in position. Expander sleeve member 31 is then assembled with packing sleeve element 59 and ring 60 positioned thereon, and packer expander ring 40 placed thereon and secured by shear pin 47. Slips 70 are then secured to the wedging surfaces 52 and 67*a* of sleeve member 31 and slip cone 67 by the attachment of shear screws 72. Coupling member 16 is then secured to the mandrel 10 by the threaded connection using stud 19 with lock rings 39 and 54 appropriately positioned in the counterbores 37 and 45, respectively. Safety shear pin 41 is next placed as shown in FIGURE 1. The bridging plug may now be attached to the setting instrumentality having a ram adapter 45 and piston rod 28, the latter having the connector 25 at its lower end which is positioned in the bore 24 of head member 23 of coupling member 16, bolt 26 securing these parts together after being passed through aperture 46.

Prior to lowering the bridging plug into the well the slips, cones and packing elements are arranged upon the mandrel 10 and bull plug 13 in relaxed interrelation as shown in FIGURE 1. A setting tool is connected to the bridging plug by means of piston rod 28 and ram adapter 45 and the entire assembly is lowered on the setting tool to the position within the borehole or casing where it is desired to be set. Such setting tools may be of widely varying types and designs, with respect to which the present invention is not concerned. A preferred type of setting tool is well adapted for lowering and setting the present bridging plug is that disclosed in the patent to Hart No. 2,308,004 dated January 12, 1943.

In operation the setting of the plug is accomplished by the setting tool by imparting relative downward movement through the ram adapter 45 to the packer expander ring 40 and opposite relatively upward movement through the piston rod 28 to coupling member 16, release stud 19, and thence to mandrel 10 and bull plug 13. Equal and opposite movements of the rod 28 and ram adapter 45, thus effected, cause the packer expander ring 40 and bull plug member 13 to move toward each other, and this movement will shear the safety shear pin 41 and the slip shear screws 72 simultaneously, which are designed so as to shear at a predetermined total force such as, for example, 6,300 pounds, which is the sum of 5100 pounds for pin 41 and 1200 pounds for the screws 72. During this movement sleeve member 31 will be moved downwardly on mandrel 10 and the slip cone portion 50 thereof will be moved under slips 70 and, at the same time, slip cone 67 will be moved upwardly under the slips, shearing the screws 72 and causing the slips 70 to be moved outwardly into engagement with the wall C of the borehole or casing, as shown in FIGURE 2. Also, during this movement the toothed segmental lock ring 39 will be engaged with the downwardly directed threads or grooves 30 of the mandrel 10 at an intermediate position with the parts as shown in FIGURE 2, thereby locking sleeve member 31 to the mandrel at this position.

Upon further actuation of the setting tool and relative upward movement of piston rod 28 and downward movement of ram adapter 45, respectively, the bull plug 13 will be moved upward toward annular shoulder 69 of the slip cone 67 upon the shearing of shear pin 68 which can be caused to shear at a predetermined shear force such as, for example, 4,500 pounds. At the same time, the sleeve member 31 including the slip cone portion 50 may be moved downwardly an additional amount, thus increasing the setting force on slips 70. Continued actuation of the setting tool will next cause shear pin 47 to shear, permitting packer expander ring 40 to move downwardly to the position shown in FIGURE 3, thus expanding packing element 59 and at the same time, packing sleeve 65 will be expanded likewise into engagement with the well borehole wall or casing C. During this latter movement the lock ring 54 will engage the grooves 53 of sleeve member 31, thereby locking the packer expander ring 40 to the sleeve member 31 with the packing elements and slips set in firm casing gripping engagement as shown in FIGURE 3. With the bridging plug thus firmly set in position in casing engagement, continued increasing tension on piston rod 28 of the setting tool finally fractures the weakened

central section of stud **19**, thus releasing the setting tool from the bridging plug. The setting of the plug thus depends upon controlled sequential shearing of its various pins and screws for successful functioning in the well. The releases take place in the following order: (1) safety pin **41** and slip screws **72** simultaneously, 6,300 pounds; (2) slip cone shear pin **68**, 4,500 pounds; (3) expander pin **47**, 6,000 pounds; and (4) release stud **19**, 8,000 pounds.

From the foregoing it will be seen that the present invention provides a novel, simple, effective and efficient bridging plug which may be readily set to pack off a desired well zone. Among the advantages of the construction of this particular bridging plug are the self-locking features, as a consequence of which the plug may be securely set in position by the simple actuation of the setting tool. In this connection, inasmuch as the plug itself does not have any of the usual bridging plug locks, the overall size and weight of the plug can be substantially less than that of plugs as designed heretofore. The setting tool piston and ram adapter are so designed that they function as part of the plug while running in. Their subsequent removal after setting results in, or has the effect of, removing a part of the plug, and therefore the amount of cast iron that will be left in the well will be reduced by as much as thirty percent.

Another feature of particular advantage is the relatively small, slender mandrel of relatively short length which permits of thicker, stronger slips and the design of the upper packer supporting sleeve or element such that it is slidable on the mandrel which results in a relatively small frictional setting resistance. In this connection it will be noted that the upper packing element **59** does not have sliding movement on the mandrel and therefore the total force necessary for the setting of this bridging plug is substantially less than has been heretofore required of comparable plugs. The so-called pick-a-back design of the upper packing supporting element contributes highly to ease of setting. This arrangement alone eliminates the problem of dissipated setting energy due to lifting a fluid head. Costly and complicated by-pass valving is unnecessary in this two-element plug wherein packing element friction is greatly diminished.

A further additional feature of advantage is the hard back-up rings **60** and **66** which serve to reduce extrusion of the packing elements between the slips. Also, the step formation of the ends of the slips as shown at **74** permits the use of thicker slips and a fast setting action and a shorter longitudinal setting movement. The present setting plug, therefore, can be made lighter in weight, requires less setting force, and can be run in and set on a wireline more efficiently than is true of conventional plugs as developed up to this time. The mandrel **10**, being essentially a round cast iron rod, simplifies the design and manufacture of the plug, and identical mandrels can be used for several sizes of casing. The drilling of this solid mandrel is relatively simple, inasmuch as the lock ring is near the top and it becomes necessary to destroy only a short length of the mandrel to release the packer.

As hereinbefore indicated, the invention is not limited to the exact structural features herein disclosed, and the invention may be successfully practiced with numerous changes, modifications and the full use of equivalents without departing from the spirit or scope of the appended claims.

What is claimed is:

1. In well apparatus: a mandrel adapted to be lowered into a well borehole; a pair of oppositely-spaced-apart slip wedging members carried by said mandrel and mounted for longitudinal movement relative to each other, said wedging members having slip-supporting surfaces converging toward each other; a plurality of slips carried by and suspended between said slip-wedging members, each of said slips having a pair of opposite, mutually-converging cam surfaces; each of said cam surfaces being stepped at an intermediate portion thereof, and said slips being initially supported on said wedging members upon the outermost stepped portion of each of said cam surfaces, whereby said slips may be expanded rapidly during the initial movement of said slip-wedging surfaces toward each other.

2. In well apparatus: a mandrel adapted to be lowered into a well borehole; a wedging member carried by said mandrel, said wedging member having a longitudinally sloping slip supporting surface; a slip carried on said slip supporting surface, said slip having a longitudinally sloping cam surface stepped at an intermediate portion thereof, and adapted to slide longitudinally upon said slip supporting surface and thereby be moved laterally into wedging engagement with a surrounding borehole wall when said slip and said wedging member are moved toward one another, said slip being initially supported on said slip supporting surface of said wedging member upon the outermost stepped portion of said cam surface, whereby said slip may be expanded rapidly during initial movement of said slip wedging member and said slip toward one another.

3. In well apparatus: a relatively slender rod mandrel adapted to be lowered into a well borehole; a hollow cylindrical member separately attached coaxially to the lower end of said rod mandrel and having an enlargement at its lower end formed with a laterally extending flange, said cylindrical member having an outside diameter substantially greater than said rod mandrel; a slip cone slidable on said cylindrical member and having an upwardly-converging slip seat; a first annular packing element on said cylindrical member between said flange and said slip cone; a sleeve slideable longitudinally on said rod mandrel above said cylindrical member, said sleeve having an upwardly-facing annular shoulder and a downwardly-converging slip seat adjacent the lower end thereof, said sleeve being of an outside diameter substantially greater than said rod mandrel and having a lonigtudinally-extending central cavity between said sleeve and said rod mandrel, the upper end of said cylindrical member and the lower end of said sleeve member being initially spaced apart longitudinally to form an annular slip-containing space therebetween surrounding said rod mandrel; a plurality of slips carried by and supported between said slip-cone seats, having corresponding tapered seat portions, said slips being initially retracted into said annular space; a packing compression ring slideable longitudinally on said sleeve; a second annular packing element on said sleeve between said annular shoulder and said compression ring, whereby downward movement of said compression ring relative to said flange moves said sleeve and said slip cones longitudinally relative to said mandrel to thereby compress and expand said packing elements and move said slips laterally into engagement with said casing; locking means operative upon downward sliding movement of said compression ring on said sleeve to compress said second packing element to prevent retrograde movement of said compression ring relative to said sleeve; and locking means operative upon downward sliding movement of said sleeve on said mandrel to compress said first packing element to prevent retrograde movement of said sleeve relative to said mandrel thereby to maintain said first and second packing elements compressed.

References Cited in the file of this patent

UNITED STATES PATENTS

2,714,931	Bouvier	Aug. 9, 1955
2,715,441	Bouvier	Aug. 16, 1955

UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 3,000,443 September 19, 1961

Archie E. Thompson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 69, after "shoulder" insert -- bolt 26 when the plug is in the unset condition shown in --; column 4, line 5, for "45" read -- 55 --.

Signed and sealed this 10th day of April 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents