Dec. 31, 1968 J. H. CURRENT 3,419,079

WELL TOOL WITH EXPANSIBLE ANCHOR

Original Filed Oct. 23, 1965

Fig. 1

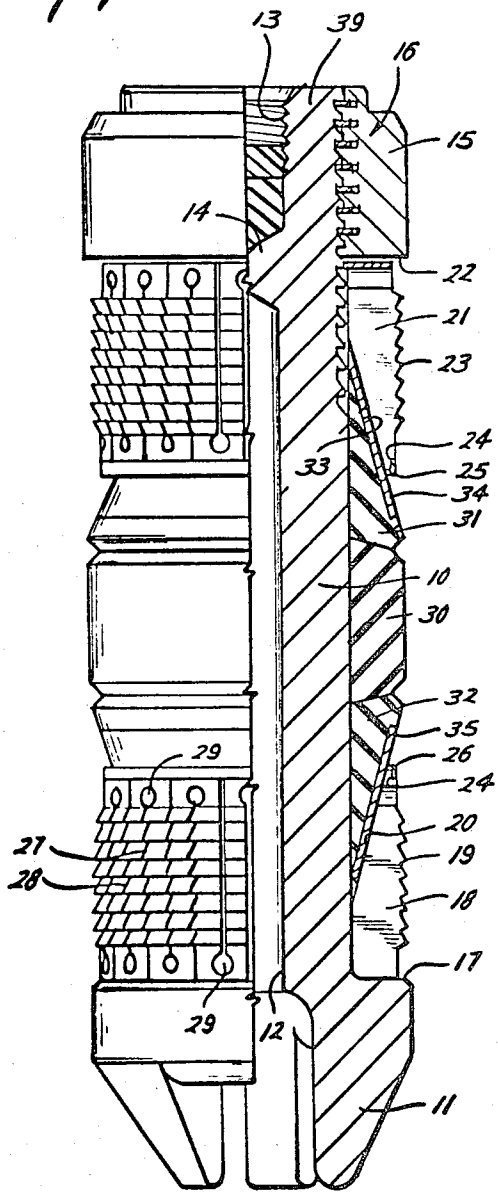


Fig. 2

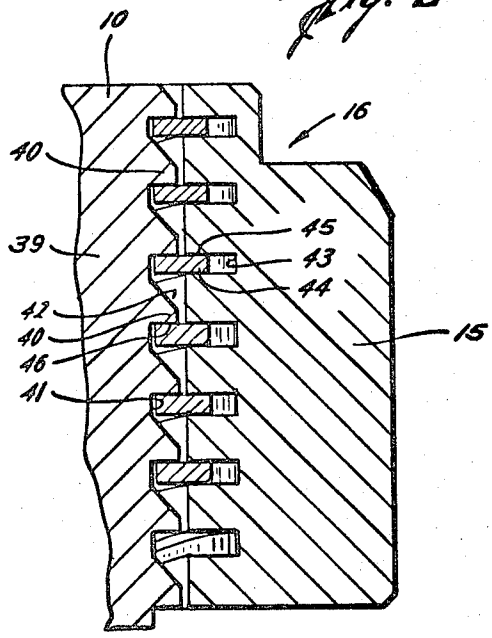
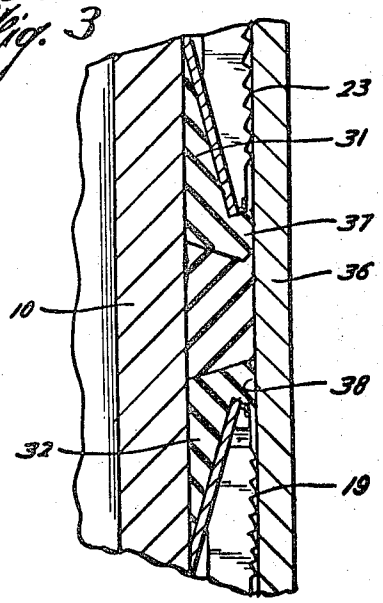


Fig. 3



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WELL TOOL WITH EXPANSIBLE ANCHOR

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Original application Oct. 23, 1965, Ser. No. 503,503, now Patent No. 3,371,716, dated Mar. 5, 1968. Divided and this application Sept. 27, 1967, Ser. No. 683,752

2 Claims. (Cl. 166—206)

ABSTRACT OF THE DISCLOSURE

Apparatus for use in locking the normally retracted parts of a well packer in expanded positions in a well bore, including an inner member having a buttress thread form on its outer periphery, an outer member having a helical groove therein, and the resilient, helically arranged lock means engaging said thread form and movably disposed in said groove.

This is a division of application Ser. No. 503,503, filed Oct. 23, 1965, now Patent No. 3,371,716.

This invention relates generally to subsurface well tools and, more particularly, to a permanently set bridge plug for blocking fluid flow in a well conduit.

A bridge plug which is permanently set in a well bore to isolate zones from one another usually has a mandrel which carries normally retracted slips and packing elements. At setting depth, the slips and packing elements are expanded into anchoring and sealing contact with the well bore wall. In order for the bridge plug to remain permanently set, it is desirable to provide a locking mechanism which functions to prevent relative movements of parts once the slips and packing elements have been expanded.

It is accordingly an object of the invention to provide a new and improved locking device for maintaining parts of the bridge plug in expanded positions in a well conduit.

Apparatus in accordance with the present invention comprises an elongated tubular body which carries normally retracted anchors and packing. The body is provided with a fixed abutment and a movable abutment. The latter abutment is movable along the body to shift the normally retracted anchors into engagement with the well conduit and to foreshorten and expand the packing. A locking device between the movable abutment and the body locks the bridge plug permanently set in a well conduit. The locking device includes a resilient element which is cooperable with a thread form on the body and is movably disposed in an helical groove on the movable abutment, permitting relative movement between the body and the movable abutment in one direction to enable expansion of the anchors and packing, but preventing relative movement in the other direction to lock the plug in expanded.

The novel features of the present invention are set forth with particularly in the appended claims. The present invention both as to its structural organization and utility together with further objects and advantages thereof may best be understood by way of illustration and example of one embodiment when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a longitudinal half-section view of a new and improved bridge plug with parts in their normally retracted positions for running-in to a well conduit;

FIG. 2 is a fragmentary enlarged view of the new and improved locking device of the present invention; and

FIG. 3 is a fragmentary view of the various part of the bridge plug when permanently set in a well conduit.

Turning now to FIG. 1, the bridge plug includes an elongated tubular body **10** having a lower guide and abutment **11** integrally formed on its lower end. Centrally of the body is a lower blind bore **12** and an upper threaded bore **13**. Between these two bores is a solid plug **14** which prevents any fluid flow through the body. The threaded bore **13** provides a means for attaching the body to a conventional setting tool (not shown) in a well-known manner.

Movably disposed on the upper portion of the body **10** is an upper abutment **15**. The upper abutment is in the form of an annular sleeve which is sized for reception on the tubular body. Between the sleeve and body is a locking device **16** for unidirectionally permitting longitudinal relative motion therebetween. The structure and function of the locking device **16** will be more fully described hereinafter.

Abutting an upper shoulder **17** on the lower abutment **11** is an integral, expansible slip member **18** having downward facing wickers or teeth **19** on the periphery thereof. An annular inclined surface **20** is formed on the interior of the slip member **18**. Another integral, expansible slip member **21** abuts a lower shoulder **22** on the movable abutment **15** and is substantially identical to the lower slip member but is oppositely disposed and has upwardly facing wickers or teeth **23** on the periphery thereof. Both slip members have peripheral grooves **24** which receive encircling expansible restraining bands **25**, **26** of differing predetermined strengths. The bands aid in initially holding the slips in inoperative positions as well as allowing various elements of the bridge plug to be selectively operated in response to setting force of predetermined magnitudes.

Each slip element is made radially expansible by providing a first series of radially cut slots **27** around the circumference thereof and providing a second series of like slots **28** alternately disposed between the first series. These slots extend from one end of each slip element to points **29** near the respective opposite ends of each slip element. Although the slip elements are integrally formed, they have sufficient resiliency to be readily expanded into engagement with the conduit wall.

An annular elastomer packing element **30** surrounds the body **10** and is disposed between an upper expander **31** and a lower expander **32**, the elements being slidably carried on body **10**. The upper expander is generally frusto-conically shaped. The outer surface **33** thereof is overlaid by a frusto-conical thin metal sheet **34** which extends from near the base of the cone to its apex. The upper expander is cooperable with the upper slip element **21** to laterally shift the slip element outwardly of the body and into gripping engagement with the conduit as the slip element is driven downwardly over the expander during setting of the bridge plug. The lower expander **32** and thin metal overlay **35** are identical in configuration to the upper expander and metal overlay but are oppositely disposed and are cooperable with lower slip element **18** to laterally shift the lower slip element outwardly of body **10**.

The expanders **31**, **32** are made of an elastomeric material such as Hycar having a significantly greater durometer hardness value than the annular elastomer packing element **30**. By way of example, packing element **30** may have a durometer hardness value in a range of 60–70, while the elastomer expanders **31**, **32** may have durometer hardness values in the range of 90–100. A characteristic of such elastomers is that they behave like incompressible fluids. External forces applied thereto will generate internal pressures within elastomers which may cause cold flow or extrusion along paths of least resistance. But, if the system is closed, the elastomers will transmit such

pressures to the enclosure, there being no substantial change in volume of the elastomers.

The expanders **31**, **32** have sufficient hardness to cause radial expansion of the integral expansible slip elements **18**, **21** as the abutments force the slips over the expanders. Metal overlays **34**, **35** reduce the frictional drag. Eventually, the wickers or teeth **19**, **23** engage the wall of the conduit. A part of the forces transmitted by the abutments to the slip elements during setting of the bridge plug acts to move expanders **31**, **32** toward each other to foreshorten and expand packing element **30**. Also, peripheral portions **37**, **38** of the expanders flow outwardly to engage the wall of conduit **36**. When the teeth have engaged the wall as shown in FIG. 3, both the elastomer expanders **31**, **32** and the elastomer packing element **30** are confined by the wall of conduit **36**, the plug body **10** and the metal overlays **34**, **35** which are backed by the wall engaged slips elements. The system is then closed. Further increased setting forces generate further pressures within the elastomers. Pressures within packing element **30** create a tight pack-off between the conduit **36** and body **10**. Pressures generated within expanders **31**, **32** act outwardly on the slip elements to dig the wickers or teeth **19**, **23** into the wall of the conduit and firmly anchor the bridge plug therein.

As previously mentioned, the radially outer portions **37**, **38** of the expanders **31**, **32** cold flow outwardly to engage the wall of conduit **36**. These annular portions, being of high hardness relative to packing element **30** serve to prevent cold flow of extrusion of the packing element under pressure. It will also be noted that the slip elements **18**, **21** themselves serve as back-ups for both the outer portions **37**, **38** of the expanders and the packing element **30** to aid in effectively packing-off the annulus between the conduit **36** and body **10**.

Turning now to the locking device **16** between the upper movable abutment **15** and body **10**, attention is directed to FIG. 2. An upper peripheral portion **39** of body **10** has a special thread form **40** formed thereon. This thread form is a modified coarse buttress variety and defines a helical thread track **41**. An upper beveled surface of the thread form **40** provides a helical cam surface **42**. Internally formed in movable abutment **15** is a helical groove **43**, the groove having the same lead as thread form **40**. Received in track **41** and partially in groove **43** is a locking device in the form of a rectangular wire coil spring **44**. The inside diameter of the spring in its unflexed condition is approximately equal to the diameter of thread track **41**. The width of the spring is slightly less than the depth of groove **43**. If a downward force is exerted on abutment **15** to move it downwardly relative to body **10**, cam surface **42** on thread form **40** acts to radially expand the coil spring **44** outwardly into groove **43** until the spring disengages from thread form **40**. When the upper face **45** of the spring passes the lower face **46** of the thread form, the inherent resiliency of the spring will cause it to snap inwardly into track **41**. Thus, it will be apparent that downward movement of the abutment **15** relative to body **10** is permitted. However, it will also be apparent that upward movement of the abutment relative to the body is not permitted. Abutment between the upper face **45** of spring **44** and the lower face **46** of thread form **40** locks the movable abutment and body together.

In operation, the elements of the bridge plug are assembled as shown in FIG. 1 and the plug is operatively connected to a setting tool which is capable of exerting an upward pull on body **10** and a downward push on abutment **15**. Such setting tools are well known and need not be fully described here. The apparatus is then shifted downwardly through the well conduit to a predetermined setting point. When desired, the setting tool is actuated and an upwardly directed setting force is applied to body **10** and a downwardly directed setting force is applied through a setting sleeve (not shown) to movable abutment **15**. Generally, upper restraining band **25** is made to have less strength than lower restraining band **26**. Therefore, as upper abutment **15** moves downwardly on the body **10**, the top slip element **21** is wedged over the expander **31** and expanded against the well conduit **36** prior to expansion of the lower slip element **18**.

When the upper slip element **21** abuts the conduit wall, downward shifting of the movable abutment **15** halted and the applied setting forces cause body **10** with integral abutment **11** to move upwardly, wedging the lower slip element **18** over the lower expander **32** and expanding the lower slip element against the conduit wall. During this movement, the lower and upper elastomer expanders **31**, **32** are moved toward each other to foreshorten and expand the annular elastomer packing element **30** outwardly into firm sealing engagement with the wall of the well conduit. The outer peripheral portions **37**, **38** of the upper and lower expanders are also deformed slightly and engage the conduit so that there is no substantial annular clearance space through which the relatively softer packing element **30** can cold flow or extrude. Further setting forces substantially increase pressure within the expanders **31**, **32** which act on slip elements **18**, **21** to cause teeth **19**, **23** to dig into the wall of conduit **36**.

As the upper abutment **15** is moving downwardly relative to the body **10**, cam surface **42** on thread form **40** causes the coil spring **44** to resiliently flex outwardly and into the helical groove **43**. The spring repeatedly flexes and returns into the helical track **41** until the abutment **15** is in its lowermost position relative to body **10**. When the elements of the plug are fully expanded, the aforementioned setting tool releases from the bridge plug automatically and since upward movement of the abutment **15** relative to the body is prevented by abutment between the upper face **45** of the helical coil spring **44** and the lower face **46** of threaded form **40**, the bridge plug is locked in set condition.

Any tendency of the bridge plug to move upwardly in the well conduit will be resisted by the upper slip element **21**, and conversely downward movement is resisted by the lower slip element **18**. Pressure differentials acting across the plug from either above or below will only serve to more firmly anchor the plug in the well conduit.

It will be observed from the foregoing that applicant has provided a new and improved bridge plug which is economical to manufacture and will function to effectively plug fluid flow in a well conduit. The slip expanders prevent cold-flow or extrusion of the annular packing element as well as performing the function of wedging and expanding the slips outwardly and supporting the slips in gripping engagement with the well conduit. No heavy steel cones are used. After full expansion of parts of the bridge plug, it is permanently locked in set condition in the well conduit.

Since certain changes may be made in the above-disclosed apparatus without departing from the scope of the inventive concept involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for use in a well conduit comprising: a body; normally retracted means on said body; an abutment movable in one direction along said body for shifting said normally retracted means into engagement with the conduit; and lock means for preventing movement of said abutment in a direction opposite to said one direction whereby said normally retracted means is maintained in engagement with the conduit, said lock means including a thread form on said body forming a helical track, an internal helical groove on said abutment, and a resilient lock member normally engaging said thread form and movably disposed in said groove.

2. In a well tool: a body; slip and expander means on said body; an abutment movably mounted on said body for coaction with said slip and expander means to shift said slips means outwardly of said body; and means

cooperable with said abutment and body for permitting unidirectional relative movement therebetween, said last-mentioned means including a buttress thread form on said body, a helical groove in said abutment, and a resilient helical lock member engaging said thread form and movably disposed in said groove.

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U.S. Cl. X.R.

166—237; 151—14; 285—318