

March 9, 1943.

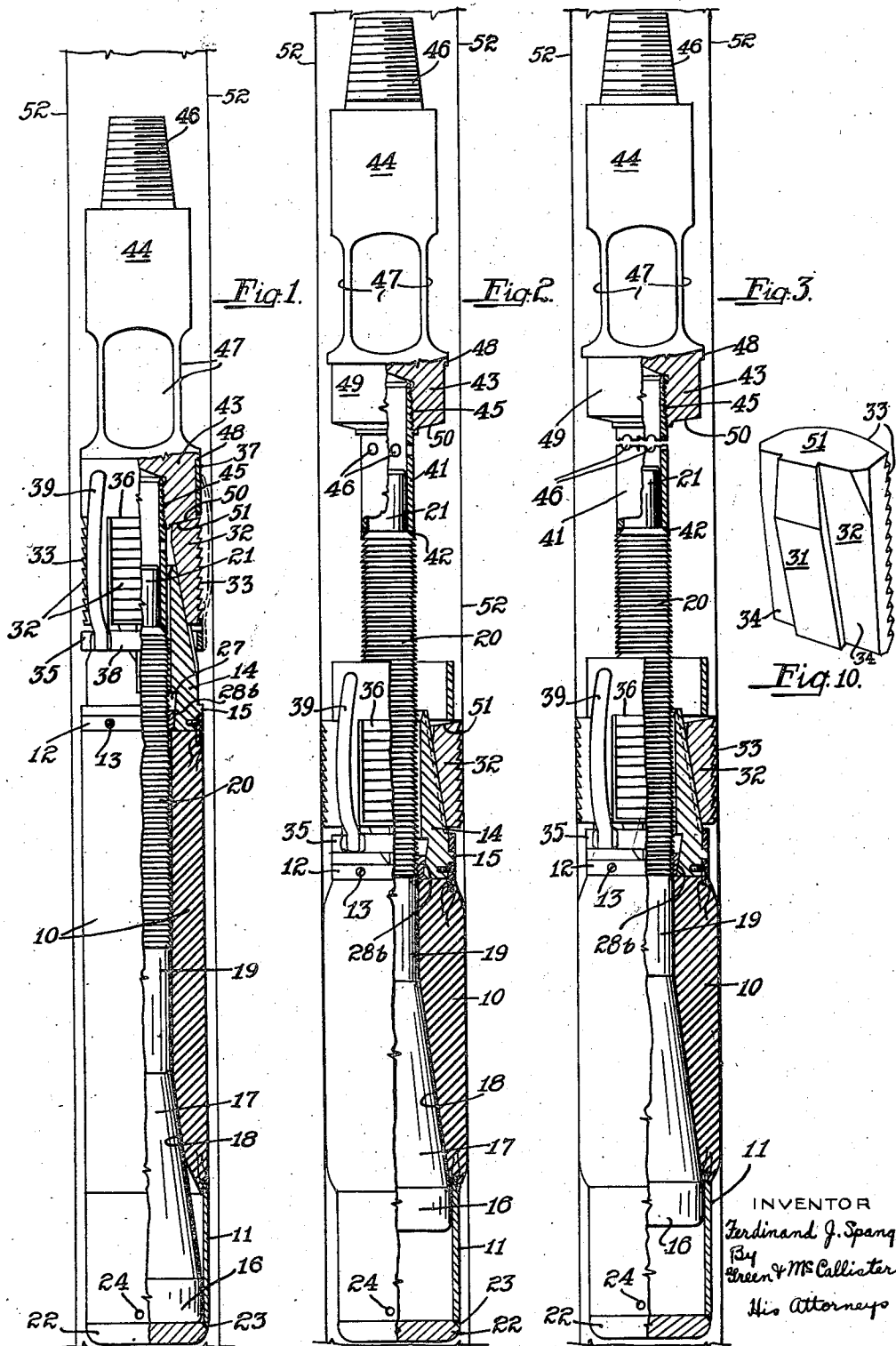
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Filed July 27, 1940

2 Sheets-Sheet 1



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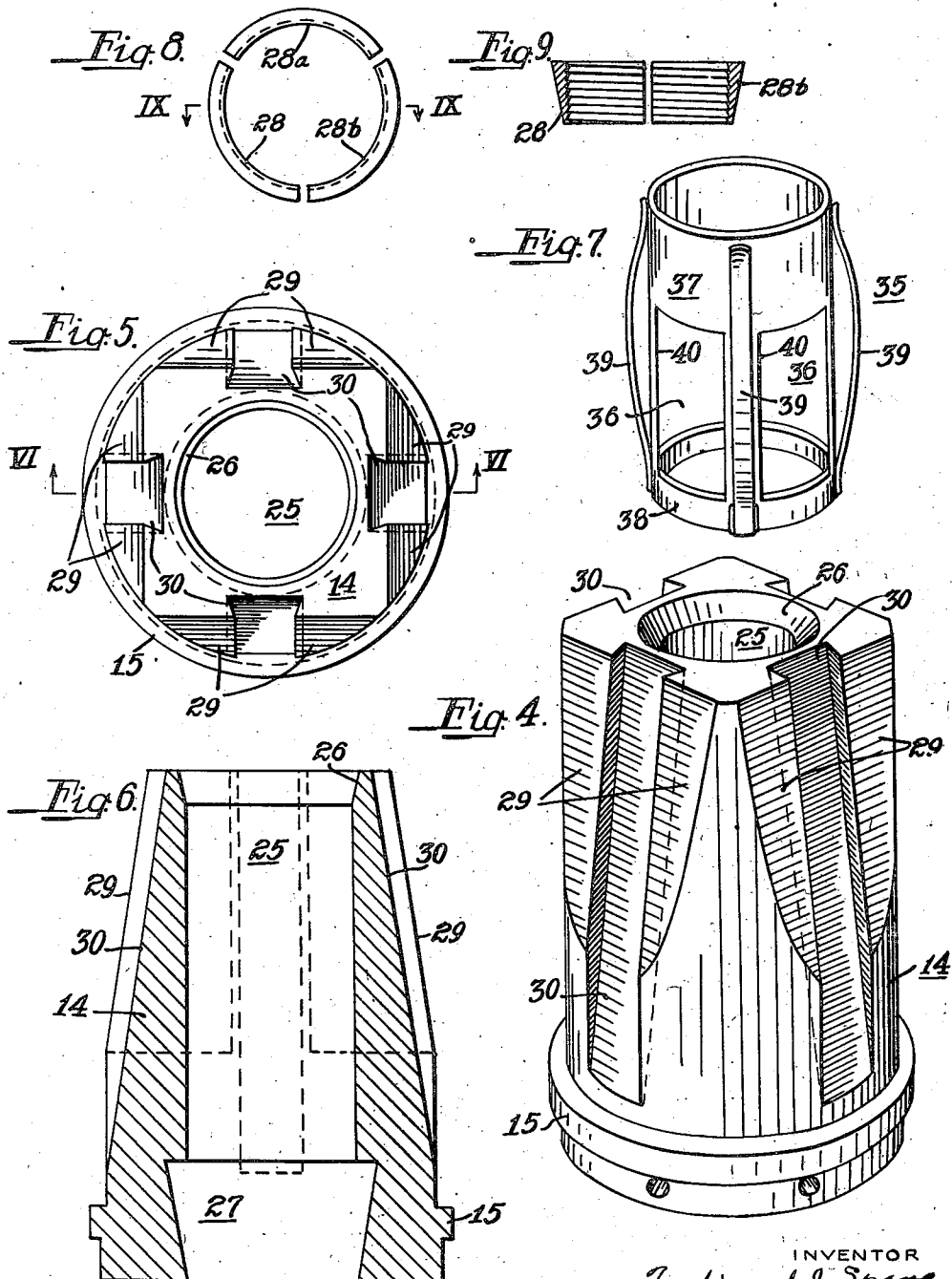
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UNITED STATES PATENT OFFICE

2,313,178

PLUG FOR OIL AND GAS WELLS

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Application July 27, 1940, Serial No. 347,975

9 Claims. (Cl. 166—13)

This invention relates to plugs for use in oil and gas wells and one object of this invention is to produce a plug which, after being lowered by means of cable tools to the desired position in the bore hole of a well, may be set or securely anchored at such position by an upward stress exerted thereon by such tools.

Another object is to produce such a plug which embodies a frangible connector element by means of which the plug proper, after being anchored in the well bore hole, may be disconnected from the cable tools used in placing the same in position.

A further object is to produce such a plug which, in its make-up, includes improved anchoring means operated by fluid pressure therebeneath for preventing the plug from rising within the bore hole.

A still further object is to produce such a plug which in its make-up, includes means for utilizing the fluid pressure therebeneath for tightening it in the well bore hole and increasing its resistance to movement therein.

These as well as other objects which will be apparent to those skilled in this particular art, I attain by means of the plug described in the specification and illustrated in the drawings accompanying and forming part of this application.

In a general way, the plug of this invention comprises a resilient deformable packing element, a packing element expander, a lock for the packing element expander, a set of anchoring slips, a slip carrier, a slip actuator provided with wiper springs for yieldingly resisting movement of the actuator to different positions within the well bore hole, a sub for connecting the plug to the lowermost member of a string of cable setting tools, and a frangible connector element by means of which the sub is connected to the packing element expander.

In the drawings, throughout which similar elements are denoted by like characters, and which illustrate a preferred embodiment of this invention:

Figure 1 is a view partially in elevation and partially in section of a plug embodying this invention. This view illustrates the plug in contracted position ready to be run or lowered to position within the bore hole of a well.

Fig. 2 is a view similar to that of Fig. 1 but illustrates the plug after it has been lowered to position in the well bore hole and then expanded; the frangible connector element above referred to, still being intact.

Fig. 3 is a view similar to that of Fig. 2 after

the plug is anchored in the well bore hole and the frangible connector element has been broken.

Figs. 4, 5 and 6 are enlarged views of the slip carrier; Fig. 4 being a perspective view, Fig. 5 a top plan and Fig. 6 a sectional view taken on the line VI—VI of Fig. 5.

Fig. 7 is a perspective view of the slip expander with its wiper springs.

Fig. 8 is a top plan view of the segmental snubbing ring which locks the plug in expanded position;

Fig. 9 is a sectional view of said ring taken on line IX—IX of Fig. 8; and

Fig. 10 is a perspective view of one of the slips.

The resilient deformable packing element 10 made from natural or synthetic rubber, when not deformed, as shown in Fig. 1, has the form of a hollow cylinder with parallel inner and outer wall surfaces throughout the major part of its length. The lower edge portion of the packing element is secured to a tubular metal member 11 while its upper end portion is secured to a metal ring or band-like member 12. The packing element is preferably secured to tubular members 11 and 12 in the manner disclosed in Patents Nos. 2,106,859 and 2,136,597 issued to me on Feb. 1, 1938, and Nov. 15, 1938, respectively.

Band-like member 12, by means of suitable screws 13, is secured to slip carrier 14 below flange 15 of said carrier.

Packing element 10, tubular member 11 and slip carrier 14 when secured together constitute a unit which is mounted on the packing element expander, which not only functions as an expander for the packing element, but as a support for said unit.

The expander comprises a cylindrical bottom portion 16 which, having a snug sliding fit with the inner cylindrical surface of tubular member 11, serves as a piston or plunger head; a conical portion 17 which makes a snug fit with the tapered lower portion 18 of packing element 10; a stem-like part having a smooth cylindrical portion 19 which makes a tight fit with the inner cylindrical wall of packing element 10; a portion 20 which is provided throughout its length with buttress threads, as disclosed in Figs. 1, 2 and 3, and an upper cylindrical end portion 21 of somewhat reduced diameter.

The lower end of tubular member 11 is closed by a closure disk 22, which is welded to the lower end of said member by a metal weld 23. A relatively small hole 24 is drilled through tubular member 11 adjacent its bottom for a purpose to be later referred to.

Slip carrier 14 is provided with a central bore 25 having a diameter such that it clears the threads of the threaded portion of the expander stem. The upper end of this bore is chamfered as shown at 26 and the bore at its lower end connects with a circular pocket-like cavity 27 having its wall inclined inwardly from its top to its bottom. This cavity serves as a housing for the segmented snubbing ring, made up of identical parts 28, 28a and 28b, and because of its inclined wall, tends to releasably hold said ring in contact with the threaded portion of the stem of the expander. As shown in Figs. 8 and 9, the outer peripheral surface of the ring is inclined to conform to the incline of the wall of pocket 27, while its inner peripheral surface is provided with threads for cooperating with the buttress threads of the threaded portion of the stem.

While the slip carrier 14 is generally cylindrical, it is provided with a series (preferably four) of longitudinally extending cut away portions as shown in Figs. 4 and 5 to provide flat slip bearing surfaces 29 which incline inwardly toward the top of the carrier.

Each inclined surface 29 is provided with an undercut slot 39 for receiving the tongue 31 of one of the slips 32. Beside the tongue, which dovetails with one of the slots 30, each slip has a curved outer toothed face 33 and side portions 34-34 which bear against inclined bearing surfaces 29.

The slip actuator which as an entirety is numbered 35 is of tubular form, as shown in Fig. 7 and is provided with a series of four rectangular windows or openings 36 one for each slip, and through which the slips project as shown in Figs. 1, 2 and 3. Openings 36 are so placed that the actuator has a broad band 37 at its top and a narrower band 38 at its bottom.

A series of four wiper springs 39, secured at their lower ends to band 38 have their upper or free ends bearing against the outer surface of band 37. These wiper springs overlie portions 40 which separate openings 36 and connect bands 37 and 38.

The inner diameter of lower band 38 is such as to permit it to slide readily on the cylindrical surface portions of slip carrier 14.

The frangible connector element before referred to and which is numbered 41, is of tubular form, and has the same outside diameter as portion 19 of the expander stem. This connector element snugly fits the reduced upper end portion 21 of the expander stem and is secured to the expander stem by a weld joint 42. The upper end of the connector element is threaded into a threaded bore in the lower cylindrical end 43 of sub 44 as shown at 45, and approximately midway between the top of the expander stem and the bottom of the sub the connector element is provided with a series of drilled through holes 46 which weaken the element and predetermine the force required to fracture the same, after the plug is secured in position within the well bore hole.

Sub 44 is provided with a threaded end 46 for the purpose of connecting the same to the mating end of a set of cable tool jars (not illustrated) forming part of a string of cable setting tools which are run on a wire or manila cable extending through the well bore to the surface. Sub 44 is also provided with wrench squares 47 and a shoulder 48 which extends outwardly and overlies the outer cylindrical surface 49 of cylindrical portion 43 at the lower end of the sub. Lower face 50 of this cylindrical portion is beveled as

shown in Figs. 1, 2 and 3 to correspond with the upper beveled surfaces 51 of slips 32 (see Fig. 1).

Before sub 44 is screwed home on the upper end of frangible connector element 41 the lower ends of tongues 31 of the slips 32 are entered within the upper ends of slots 30 of the slip carrier 14. With the slips in this position, the distance between curved faces 33 of oppositely positioned slips is less than the inner diameter of band portions 37 and 38 of the slip actuator, thus permitting the slip actuator to be slid into place over the slip carrier. The slips are held in this contracted position until openings 36 of the slip actuator register with the slips, and as soon as this registration occurs, the slips are permitted to move out or to expanded position, as the actuator is moved into contact with flange 15 of the slip carrier.

When the slip actuator has been slid into this position sub 44 may be screwed home on the upper threaded end of the frangible connector element 41. When sub 44 is screwed home on the upper end of the frangible connector element, its flange 48 forms a stop for limiting the upward movement of the slip actuator as shown in Fig. 1.

The parts are so proportioned that when band 37 contacts with flange 48, the slips will occupy a position, with relation to slip carrier 14, such that they project into windows 36, whereby, as the slip actuator is moved into contact with flange 15 of the slip carrier, the slips are moved to their fully expanded position as shown in Figs. 2 and 3. When the actuator is moved up, the slips will be retracted; the amount of retraction being limited by flange 48 of sub 44. When fully retracted (contracted) the slips occupy the position shown in Fig. 1, at which position their outer toothed faces are substantially in line with the outer surfaces of band portions 37 and 38 of the actuator.

The bevel given to the upper surfaces 51 of the slips serves to relieve the slips and facilitate their movement outward while in contact with the lower edge of band 37.

It will be apparent that the slips, together with the slip carrier and the actuator, which holds the slips against vertical movement during movement of the slip carrier, thereby causing said slips to expand or contract, constitutes a slip assembly which is secured to the upper end of the packing element. It will also be apparent that the assembly made up of the expander, its stem, the frangible connector and the sub serves as a support for the packing element, the stem of which is axially aligned with and freely passes through the slip carrier.

Lines 52 represent the wall of a well bore hole.

Operation

The plug, when in the condition illustrated in Fig. 1 that is, with packing element 10 fully elongated and the slip actuator in contact with flange 48 of sub 44, whereby the slips are in their fully contracted position, is attached to a string of cable tools and lowered within the well bore hole to the desired position. As the plug is being lowered wiper springs 39 frictionally engage the wall of the well bore hole, and hold slip actuator 35 in contact with flange 48 of the sub, insuring fully contracted slips.

When the plug has reached the desired position within the bore hole an upward stress is exerted thereon by the cable tools, and, since the wiper springs, which are carried by the slip actuator or cage, frictionally engage the wall of the well bore hole, the actuator is held stationary.

Because of this, and because sub 44 is rigidly

connected to the expander stem, this upward stress foreshortens and expands or increases the diameter of packing element 10 and causes the slip carrier to move up within the slips, which, being held against movement by band 37 of the slip actuator, are expanded to a point where they firmly grip the wall of the well bore hole.

As the sub and the expander with its stem attached thereto by means of the frangible connector element are drawn upward, the expander foreshortens packing element 10 and increases its diameter until it completely seals the space between the conical portion of the expander and portion 19 of the stem on the one hand and the wall of the well bore on the other. An upward jarring action is then applied to the cable tools with the result that the conical portion of the expander and portion 19 of its stem are tightly forced into the packing element. As the expander and its stem are elevated or travel upward with relation to the slip carrier, the buttress-like threads of the stem pass through the segmented snubbing ring which reengages said threads after each such upward movement, with the result that any tendency to downward movement of the expander and its stem causes the snubbing ring to immediately grip the stem and thus lock the expander and its stem against such downward movement.

Continuation of the upward jarring action of the cable tools causes the frangible connector element to yield and subsequently fracture at the part weakened by drilled holes 45. Complete fracture of the frangible element separates the cable tools and sub 44 from the plug so that said tools and sub may be withdrawn from the well bore hole, leaving the plug securely anchored in place.

After the expander has been moved to the position shown in Figs. 2 and 3 in which the well bore hole is effectively sealed against flow in an upward direction of oil, gas, water or other fluid trapped below the plug, such fluid may enter the space formed by tubular member 11, plunger head 16 and closure disk 22 through hole 24 drilled in the wall of said tubular member. The pressure of this fluid beneath plunger head 16 tends to force the expander and its stem further upward with relation to the packing element and assists in maintaining the seal in permanent sealing condition; upward movement of the plug being at all times prevented by engagement of the slips with the wall of the well bore hole.

From the foregoing, it will be apparent that the plug of this invention may be easily run to any desired position in a well bore and set and expanded by upward stress exerted thereon by the tools on which it is run. It will also be apparent that no anchoring or support means is needed beneath the plug, and that upward jarring will not only effectively tighten the plug, but that such jarring when continued after sealing is accomplished will fracture the frangible connector element and permit the withdrawal of the tools from the well bore hole, leaving the plug securely anchored in place and in sealing condition therein.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a plug for a well bore hole, a tubular resilient packing element; a packing element expander having an upwardly tapered part located within the lower end of the packing element, a part located below said tapered part and

forming a plunger head, and a stem which extends through the packing element and is provided with buttress threads; a connecting sub and a frangible element connecting said sub to the expander stem; a slip carrier loosely surrounding said stem and connected to the upper end of the packing element; a tubular member connected to the lower end of the packing element, having its lower end closed and having a bleeder opening extending through its side wall; a segmented snubbing ring carried within the slip carrier for cooperating with the buttress threads of said stem; slips carried by said slip carrier, and a cage for said slips, carrying a series of wiper springs and functioning as an actuator for said slips.

2. In a plug for a well bore hole, a resilient tubular packing element, a packing element expander having a generally conical portion and a stem extending upwardly therefrom through said packing element, frangible tubular means for connecting said expander stem to running in tools, a slip assembly surrounding said stem and which includes a slip carrier, slips mounted for sliding movement on said carrier, a slip actuator surrounding said carrier, mounted for movement longitudinally thereof and provided with window-like openings for accommodating radial movement of said slips, and wiper springs carried by said actuator and extending outwardly therefrom.

3. In a plug for a well bore hole, a resilient packing element, means for expanding said element into contact with the wall of the bore hole, a tubular frangible element for connecting said means to running in tools, a slip assembly on said plug including a slip carrier, slips mounted on said carrier, a tubular slip actuator surrounding said carrier and provided with openings through which said slips can move, and outwardly bowed springs carried by said actuator and adapted to frictionally engage the bore hole wall; the construction and arrangement being such that when an upward stress is exerted on the slip carrier said springs prevent relative movement between the carrier and the slip actuator thereby causing the slips to move into gripping engagement with the bore hole wall.

4. In a plug for a well bore hole, a resilient packing element, a packing element expander having a stem extending upwardly through said packing element, snubbing means for preventing downward movement of said stem with relation to said packing element, and a slip assembly on said plug and coaxial with said stem for locking the plug against upward movement in the bore hole and comprising a slip carrier, slips mounted within upwardly and inwardly extending grooves of said carrier, a slip actuator engaging the tops and bottoms of said slips, and wiper springs carried by said actuator, projecting outwardly therefrom, and adapted to retard relative movement between said carrier and said actuator when upward stress is exerted on said carrier whereby the slips are caused to move radially outward into gripping engagement with the bore hole wall.

5. In a plug for plugging a well bore hole, slips, a slip expander, a resilient tubular packing element located below said expander, a packing element expander having a generally conical portion and a stem which extends upwardly therefrom through said packing element and the slip expander and is provided with buttress threads, means including a frangible element for connect-

ing said stem to running-in tools and which is strong enough to transmit sufficient upward stress to lock the plug within the bore hole and expand the tubular packing element to completely close the opening between the packing element expander and the well bore hole wall, and means co-operating with said buttress threads for locking the packing element expander against downward movement.

6. In a plug for plugging a well bore hole, slips, a slip expander, a resilient tubular packing element located below and secured to said expander, a packing element expander having a generally conical portion and a stem which extends upwardly therefrom through said packing element and the slip expander and is provided with buttress threads, means including a frangible element for connecting said stem to running-in tools and which is strong enough to transmit sufficient upward stress to lock the plug within the bore hole and expand the tubular packing element to completely close the opening between the packing element expander and the well bore hole, a cage for said slips carrying wiper springs and functioning as an actuator for said slips, and means carried by the slip expander and co-operating with said buttress threads for locking said stem against downward movement.

7. In a plug for plugging a well bore hole, slips, a slip expander, a resilient tubular packing element located below and secured to said expander, a packing element expander having a generally conical portion and a stem which extends upwardly therefrom through said packing element and the slip expander and is provided with buttress threads, means including a frangible element for connecting said stem to running-in tools and which is strong enough to transmit sufficient upward stress to lock the plug within the bore hole and expand the tubular packing element to completely close the opening between the packing element expander and the well bore hole wall, a tubular member connected to the lower end of said tubular packing element, having a closed

bottom and a bleeder opening in its side wall, and means carried by the slip expander and co-operating with said buttress threads for locking the packing element expander against downward movement.

8. In a plug for plugging a well bore hole, a slip assembly which includes slips and a slip expander, a slip actuator extending above and below said slips, provided with openings through which said slips are movable and carrying wiper springs, a resilient tubular packing element located below and attached to the slip expander, an imperforate packing element expander having a generally conical lower end and a stem which extends upwardly through said packing element and said slip expander and is provided with buttress threads, a sub, a frangible tubular element connecting said stem to said sub and which is strong enough to transmit sufficient upward stress to lock the slip assembly within the well bore hole and expand the tubular packing element to completely close the annular opening between the packing element expander and the wall of the well bore hole, and means co-operating with said buttress threads for locking the packing element expander against downward movement.

9. In a plug for plugging a well bore hole, a slip assembly, a resilient tubular packing element located below said assembly, a packing element expander having a frusto-conical portion and a stem which extends upwardly from its top through said packing element and said slip assembly and is provided with buttress threads, means including a frangible element for connecting said stem to running-in tools and which is strong enough to transmit sufficient upward stress to lock the slip assembly within the bore hole and expand the tubular packing element to completely close the annular opening between the packing element expander and the well bore hole wall, and means co-operating with said buttress threads for locking the packing element expander against downward movement.

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