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BRIDGE PLUG

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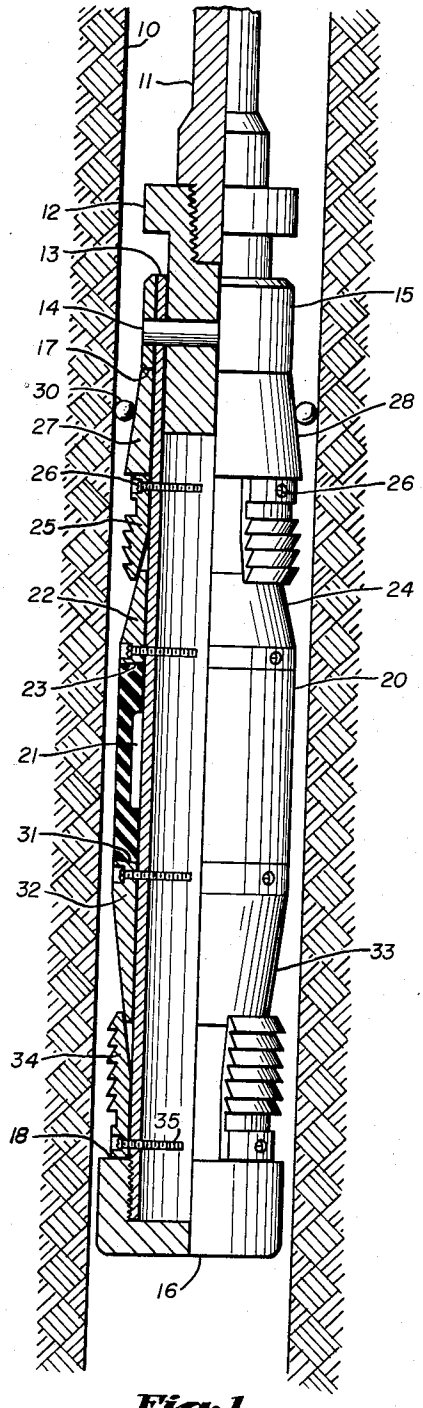


Fig. 1.

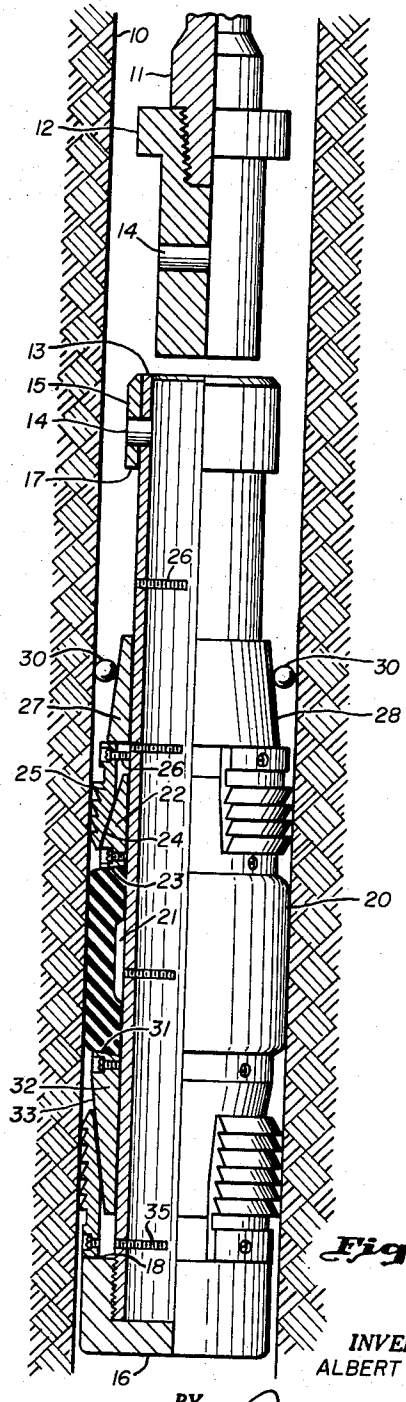


Fig. 2.

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BRIDGE PLUG

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The present invention relates to means for actuating a bridge plug into operative position within the casing of an oil well. More specifically, the invention relates to setting a deformable packer of a bridge plug into operative position by fixing one end of the deformable packer with respect to the casing wall and moving the other end toward the fixed end to deform the packer radially outward from the plug.

Bridge plugs are fundamentally simple obstructions placed at desirable positions within a casing so working fluids will be confined to particular zones along the casing. The body of a bridge plug is positioned vertically within a casing to a desired point. Some means is then provided to move packer structure on the plug body radially outward from the plug body, engaging the casing wall to form the desired obstruction in the casing at the plug position. The plug is vertically positioned on a wire line. There are many arrangements for setting the packer radially outward from the plug body.

In general, it is customary to provide slips to mechanically engage the casing walls on one end of the packer which is mounted about the plug body. The slips are essentially wedge members with teeth arranged to engage and bite into the casing wall. The slips are moved radially outward by wedge surfaces which are themselves moved parallel to the casing wall. Once the slips at one end of the packer are wedged into position, they can form an abutment, or fix the vertical position of an abutment member, against which the packer can be deformed. A second set of slips, at the opposite end of the packer, then engages the casing wall and forms an abutment to maintain the packer set, deformed into sealing engagement with the casing wall.

A problem in this combination of plug body, packer, wedges and slips is to provide a simple, positive and effective mechanism actuated from a wire line to move the slips of the plug combination radially outward into engagement with the casing wall. Once this function is accomplished, the plug can be further worked from the wire line to jar set the plug packer. The present invention provides a simple, yet surprisingly effective, means for starting a chain of actions which results in setting the packer.

The main objective of the present invention is to move a set of bridge plug slips radially outward and into engagement with the wall of the casing in which the plug packet is set.

Another object is to wedge-fix one set of slips of a bridge plug to a casing wall, so the slips will act as an abutment against which a deformable packer on the plug body will be deformed radially outward from the plug body and into sealing engagement with the casing wall.

Another object is to provide a structure between the plug body and casing wall which will enable the packer of the body to be jar set from a wire line.

The invention contemplates a bridge plug, including a deformable packer member mounted circumferentially of the body of the plug, so as to be deformed outwardly until the sides of the well bore are engaged. Slip cones about the plug body are caused to move toward each other and deform the packer member between them. A first set of slips is caused to move onto the surface of a first slip cone so the first set of slips will be positioned outwardly into engagement with the walls of the bore. The second slip cone about the plug body has the second set of slips moved onto its surface by a set cone. The set cone is limited in upward movement by structure dropped into position from the top of the well bore to wedge between the walls of the well bore and a surface of the set cone. The plug body is then positioned on a wire line to move wedges, setting cones, and slips together to deform the packer into sealing relation to the walls of the well bore.

Other objects, and advantages, of the present invention will become readily apparent from the foregoing detailed description of the invention with specific reference to the accompanying drawings in which;

FIG. 1 is a longitudinal quarter-section of a bridge plug, embodying the present invention, disposed within a well bore, with its parts in their initial positions; and

FIG. 2 is a longitudinal quarter-section of the bridge plug of FIG. 1 wherein the parts are shown as moved into operative position to form an effective obstruction within the well bore.

In the drawings, a section of casing in an oil well is indicated at **10**. The depth of this section of casing **10** is not important to the disclosure of the invention. Also, the diameter of the casing **10** is incidental. The present invention is embodied in the structure of the bridge plug illustrated within the casing **10**, lowered to any desired depth, and sized to accomplish its purpose of obstructing the casing **10**.

The bridge plug in casing **10** is illustrated as suspended from a wire line. Specifically, setting jars are mounted on the end of the wire line which is not shown. However, the inside jar **11** is shown, extending downward as an extension of the wire line. Threaded to the end of inside jar **11** is a setting sub **12**, the specific structure to which the bridge plug, as an assembly, is pinned. FIG. 1 shows this setting sub **12** pinned to the bridge plug as the plug is run in the casing. FIG. 2 shows the setting sub **12** being removed from the casing, its pin sheared after the bridge plug has been jar set.

The bridge plug assembly is built up from a basic body. This body is illustrated as a simple cylinder **13**. The lower, cylindrical portion of setting sub **12** fits down into the bore of cylinder **13**, and pin **14** is extended through both members. Pin **14** is sized and formed of material which will enable pin **14** to shear with a predetermined force exerted upward from the wire line, through the setting jars.

A shoulder, facing downward, is provided by the lower end of a collar **15**, in the form of a cylinder, slipped over the upper end of body cylinder **13** and welded thereto. A shoulder, facing upward, is provided by the upper end of a closure cap **16**, which is threaded to the lower end of body cylinder **13**. Between upper shoulder-face **17** and lower shoulder-face **18**, on and about the outer surface of body cylinder **13**, the structure embodying the essential elements of the present invention is mounted. This structure is actuated from its FIG. 1 location on body cylinder **13**, between shoulder-face **17** and **18**, to its FIG. 2 position by shoulder-face **18** moving upward toward an obstruction dropped from the top of the casing and wedging between the structure and the casing wall.

Packer

The structure mounted on body cylinder **13** is arranged and shaped to deform packer **20** outwardly from the cylinder **13**, until the body of packer **20** engages the wall of casing **10** in a sealing relationship. Force is exerted from each end of packer **20** to deform the body of the packer, shortening its length vertically and extending it radially outward from the cylinder.

Packer **20** is generally cylindrical in shape and made of deformable material such as rubber, or a material which functions in a similar manner. A section of the bore through the cylindrical body is removed as shown

at 21. This hollow section will tend to cause the middle portion of the cylindrical packer 20 to bulge radially outward, as desired, when forces are exerted from each end of the packer. Deformed into the position disclosed in FIG. 2, from the position disclosed in FIG. 1, the packer 20 functions as the sealing element of the combination between the cylinder 13 and the wall of casing 10. To carry out this ultimate result, the present invention is embodied in structure which deforms the packer 20 in a very simple manner and with very few moving parts. The simplicity of structure required to embody this invention is so unexpected that the invention is manifestly patentable on this basis alone.

As cylinder body 13 and packer 20 are disclosed in their vertical orientation, their upper and lower ends will be referred to without numerical designations. This convention, to disclose the orientation and function of the various structures on body cylinder 13, should not be confusing.

Upper Abutment Structure

The present invention basically provides an abutment, fixed relative to the wall of casing 10, for applying a force downward against the upper end of packer 20. The specific structure of this abutment, which bears directly against the upper end of packer 20, is slip cone 22. Slip cone 22 is a ring which is slipped over body 13 and slides freely on the outer surface of body 13. This upper ring 22 has a face 23 on its lower end to bear against packer 20, and the upper portion is formed with a tapered surface 24, which characterizes the upper portion of ring 22 as a conical frustum.

A number of slips 25 are spaced about the wall of cylinder 13 and fixed in their initial positions disclosed in FIG. 1 by shear screws 26 through the body of the slips and the wall of body cylinder 13. If the slip cone 22 is moved upward, relative to the slips which rest on tapered surface 24, the slips will be forced outwardly, or radially, from the center of the plug structure. The shear screws 26 will fail and the teeth of the slips will be forced into the casing wall. Once the teeth of slips 25 bite into casing wall 10, and slip cone 22 is wedged between the slips and the outside of cylinder 13, the upper abutment for packer 20 begins to take form.

The upward moving conical surface 24 of slip cone 22 will not, alone, move the slips 25 radially outward. The slips must be prevented from upward movement as the wedge surface 24 moves upward, under the slips. The lower end of set cone 27 functions to prevent upward movement of the slips, relative to the casing 13.

Set cone 27 is a vital element of the structure embodying the invention. Set cone 27 is the specific element of the upper abutment structure which is fixed in relation to casing wall 10. Once fixed, this element of the combination provides the lower surface with which the slips 25 are prevented from upward movement as slip cone 22 forces its surface 24 up and beneath the slips.

Set cone 27 provides a tapered surface 28, inclined in the same direction as surface 24 of slip cone 22. Referred to the vertical, surface 28 is tapered, or inclined, from the vertical at an angle which will effectively wedge bodies of material between surface 28 and the wall of casing 10.

The material wedged between surface 28 and the casing wall is dropped from the top of the well. The material may be irregularly shaped rocks or metal bodies—anything sized to pass between setting sub 12, collar 15, and casing wall 10 and yet wedge firmly between the surface 28 and the casing wall 10. Preferably, this wedging body is provided by spherical bodies of brass. These balls 30 are shown in position in FIG. 1 as dropped to this position from the top of casing 10. When setting sub 12 is pulled upward on the wire line, set cone 27 will not move relative to the wall of casing 10. The result is shown in FIG. 2.

The angle of surface 28 from the vertical must be small enough to efficiently wedge balls 30 between surface 28 and the casing wall 10. It has been found that an angle of substantially 7° will function efficiently. An angle greater than 7° will cause the balls 30 to roll between the surface 28 and casing wall 10 without wedging.

Steel balls have been dropped from the top of the well without success. The reason is probably that magnetic force within the formations of the earth has suspended the steel balls between the top of the casing and the plug. Whatever the reason for the malfunction of steel balls, balls made of brass, or other non-magnetic material, function satisfactorily. Properly sized to fall onto surface 28, brass balls 30 wedge efficiently in the FIG. 1 position and complete the upper abutment combination, which functions to position the packer 20 into sealing position as the plug body is pulled upward on its wire line.

This abutment structure is at the heart of the embodiment of the invention. It has, basically, the stark simplicity of set cone 27 and balls 30 to deform packer 20 into sealing relation with casing wall 30. No springs, fluid operated structures, or explosive actuated structures are involved. All prior art structures using arrangements and forces of such nature are complex and subject to many types of failure. The present invention is embodied in a simple cone structure, mounted on the plug body, having a wedge surface which engages a body of material dropped from the top of the casing. The result is that the plug can be worked from the wire line in the simple manner of pulling upward until packer 20 is set. The slips are forced into the casing wall to reinforce the union of the upper abutment structure and the casing wall. Subsequently, the setting sub 12 can be jarred to shear pin 14. The wire line may be removed, the plug will remain in position and the working of the well bore above the plug may proceed as desired.

Lower Abutment Structure

The upper abutment structure is at the center of the inventive concept. However, the plug must provide an abutment on the lower side of packer 20. This lower abutment must perform two functions.

First, the lower abutment must move upward with the plug body cylinder 13, against the lower end of packer 20. Surface 31 is provided, facing surface 23 and also abutting packer 20. Moved together surfaces 23 and 31 deform the packer 20 between them.

Packer 20 is urged to deform radially outward, at its middle section, to engage casing wall 10 in a sealing relationship. The removal of a section of packer 20, at 21, promotes this radial extension from the wall of body 13. The end portions, upper and lower, deform into this void at the middle section of packer 20, causing the material of the middle section to buckle radially outward. Sealing between the plug body and casing wall results.

Second, the lower abutment must be set, or locked, to the casing 10 wall after packer 20 has been deformed into position. Slips similar to slips 25 are used, carried into engagement with casing wall 10.

More specifically, abutting surface 31 is formed on the upper end of slip cone 32. Slip cone 32 is substantially a "mirror image" of slip cone 22. A tapered surface 33 is provided upon which slips 34 are moved upward and radially outward into engagement with casing wall 10.

Slips 34 are initially fixed in the FIG. 1 position by shear screws 35. When slips 34 are carried upward by shoulder 18 of cap 16, screws 35 fail as the slips are carried radially outward by cone surface 33. The teeth of the slips 34 bite into the wall of the casing and are shaped to bite the more deeply as a force is applied downwardly upon the slips. The slip teeth have a ratchet action in that they can be moved upward over the casing surface, but bite into the casing more deeply as they are urged downwardly. The upper slips 25 have their teeth shaped to provide this same ratchet action. How-

ever, their biting is the more deep under a force applied upwardly.

The force on both slips is, of course, that stored in the resilient, deformable, material of packer **20**. Once set, packer **20** exerts forces upon slip cones **22** and **32**, and their slips **25** and **34**, to force the teeth of the slips into the casing and to maintain the packer set into its sealing position.

Operation

The operation of each set of structure has been explained as the description has proceeded, so the FIG. 2 position of the parts will be practically evident from a study of the drawing alone. Body casing **13** has been pulled upward on the wire line. Abutment shoulder **18** has moved all the slips, cones, and packer against the lower end of set cone **27**.

Cone **27** has been fixed in position by the wedging of balls **30** against its surface **28** and casing wall **10**. The slips have failed their screws and been carried by the surface of their respective slip cones until their teeth bite into casing wall **10**.

At the same time, the slip cones have moved closer together, extending packer **20** into sealing position. It might appear that body casing **13** would slide through the resulting assembly. However, the body of deformed packer **20** will bear upon its surface, sealing it to casing wall **10**.

The setting jars, through which the plug is carried on the wire line, are then used to shear pin **14**. FIG. 2 shows the position of the parts after the pin has been sheared. The wire line is going up the casing for removal. The plug is now set in position within the casing because of the function of the structural embodiment of the invention.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The present invention having been described, what is claimed is:

1. A bridge plug for the casing of an oil well including,
- a body of drillable material and in cylindrical form,
- a packer of deformable material and in cylindrical form mounted about the body at a position intermediate the ends,
- a first abutment structure mounted on the lower end of the body to engage the lower end of the packer,
- a second abutment structure about the upper end of the body and slidable on the body to engage the upper end of the packer in sliding toward the first abutment structure to deform the packer outwardly from the body until sealed against the internal casing wall,
- a wedge surface formed on the slidable second abutment structure,
- a body of material and shape which will lodge between the wedge surface and the casing wall when dropped to the wedge surface from the top of the oil well hole,
- and means for pulling the body upward while the body of lodged material prevents the second abutment structure from moving relative to the casing wall, whereby the first abutment structure and body of the plug are moved upward to deform the packer outwardly from the body until the packer is sealed against the internal casing wall.

2. The bridge plug of claim 1 in which the wedge surface formed on the second abutment structure is slanted away and upwardly from the casing wall at substantially an angle of 7°.

3. A bridge plug for the casing of an oil well including,
- a cylindrical body of drillable material,
- a packer of deformable material and in cylindrical form mounted about the body at a position intermediate the ends,
- a first abutment structure mounted on the lower end of the body to engage the lower end of the packer,
- a second abutment structure about the upper end of the body and slidable on the body to engage the upper end of the packer in sliding toward the first abutment structure to deform the packer outwardly from the body until sealed against the internal casing wall,
- a wedge surface formed on the slidable second abutment structure and facing toward the casing wall and slanted away and upwardly from the casing wall,
- a body of spherical shape which will lodge between the wedge surface and the casing wall when dropped to the wedge surface from the top of the casing,
- and a wire line attached to the body with which the body is pulled upward to bring the first abutment structure against the lower end of the packer and the upper end of the packer against the second abutment structure and the wedge surface against the lodged body of spherical shape to prevent movement of the second abutment structure relative to the casing wall,
- whereby the continued movement of the first abutment structure and body of the plug upward will result in deformation of the packer outwardly from the body until the packer is sealed against the casing wall.

4. A bridge plug for the casing of an oil well including,
- a cylindrical body of drillable material held in a vertical position within the casing by a wire line,
- a sealing cap mounted on the lower end of the body and extending a face horizontally outward from the outer wall of the body,
- a first slip cone mounted about the body and above the cap abutment face and slidable on the body and providing a wedge surface inclined downwardly and from the casing wall,
- a first set of toothed slips spaced about the body wall and against the cap face and wedge surface of the first slip cone,
- a packer of deformable material and in cylindrical form mounted about the body above the first slip cone so as to be moved by the upper abutting end of the slip cone as the slip cone is moved upward with the body,
- a second slip cone mounted about the body and above the packer and slidable on the body with a wedge surface inclined upwardly and away from the casing wall,
- a second set of toothed slips spaced about the body wall and against the wedge surface of the second slip cone,
- a set cone mounted about the body and having on the second set of toothed slips while slidable on the body with a wedge surface inclined upwardly and from the casing wall,
- a spherical object which has been dropped from the top of the casing and lodged between the wedge surface on the set cone and the casing wall,
- and means for pulling the body upward by the wire

line to move the first set of slips with the cap face upward and outward on the wedge surface of the first slip cone and the first slip cone against the packer and the packer against the second slip cone and the second set of slips upward and outward by the wedge surface of the second slip cone and the set cone into wedge-fixed position against the spherical object,

whereby the slip sets are caused to bite into the casing wall and the packer is deformed radially outward into engagement with the casing wall.

5. A bridge plug adapted to be run on a wire line and in the casing of an oil well including;

a body of drillable material and in cylindrical form;

a packer of deformable material and in cylindrical form mounted about the body at a position intermediate the ends;

a first abutment structure mounted on the lower end of the body to engage the lower end of the packer;

a second abutment structure about the upper end of the body and slidable on the body to engage the upper end of the packer as the second abutment slides toward the first abutment structure to deform the packer between the abutment structures outwardly from the body until the packer is sealed against the internal casing wall, including,

a first ring about the body of the plug abutting the upper end of the packer and slidable on the body to deform the packer outwardly from the body

until the packer is sealed against the internal casing wall,

a first wedge surface on the first ring,

toothed slips spaced about the ring to engage the casing wall when moved outwardly by the wedge surface on the ring,

a second ring about the body of the plug and abutting the toothed slips and slidable relative to the first ring wedge surface to move the toothed slips outwardly into engagement with the casing wall,

and a second wedge surface on the second ring;

and means dropped from the top of the hole to lodge between the second wedge surface and the casing to fix the position of the second ring relative to the casing, whereby the slips are engaged with the casing wall and the position of the first ring is fixed relative to the casing when the body of the plug is drawn upward by a wire line to deform the packer outwardly from the body of the plug until the body of the packer is sealed against the internal casing wall.

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