United States Patent

[11] 3,542,128

[72] Inventor **Arthur L. Owen**
Houston, Texas

[21] Appl. No. **772,120**
[22] Filed **Oct. 31, 1968**
[45] Patented **Nov. 24, 1970**

[73] Assignee **Electric Wireline Specialties, Inc.**
Alice, Texas
a corporation of Texas

[54] **RETRIEVABLE BRIDGE PLUG AND PACK-OFF**
33 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **166/123,** 166/182, 166/187
[51] **Int. Cl.** **E21b 23/00,** F21b 33/12
[50] **Field of Search** 166/123, 181, 182, 187

[56] **References Cited**

UNITED STATES PATENTS

2,718,926	9/1955	Schlegel	166/182
3,100,533	8/1963	Fredd	166/181
3,107,725	10/1963	Flickinger	166/187
3,244,233	4/1966	Villalon	166/123

Primary Examiner—James A. Leppink
Attorney—Carlos A. Torres

ABSTRACT: A tool having a tubular central mandrel movable axially through an outer body which includes a cone spreader, expandable metal anchoring fingers, a locking mechanism and an elastomeric packer. Shear pins extend through the mandrel and sever in sequence when the mandrel is moved upwardly through the body by a setting mechanism to slide the cone under the fingers and compress the packer which sequentially expands the fingers and packer to anchor the tool and seal it against a surrounding well conduit. The last pin to sever releases the tool from the setting mechanism and the locking mechanism engages the mandrel to lock the tool in place. The tool is released by pulling upwardly on the locking mechanism which first releases the packer and subsequently releases the locking fingers to prevent the tool from being blown uphole by differential well pressure. The end of the mandrel may be plugged or open and, a second packer may be employed to pack off a zone in the well conduit.

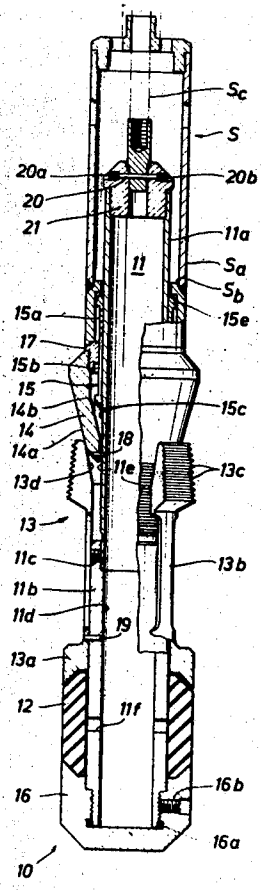


FIG. 1

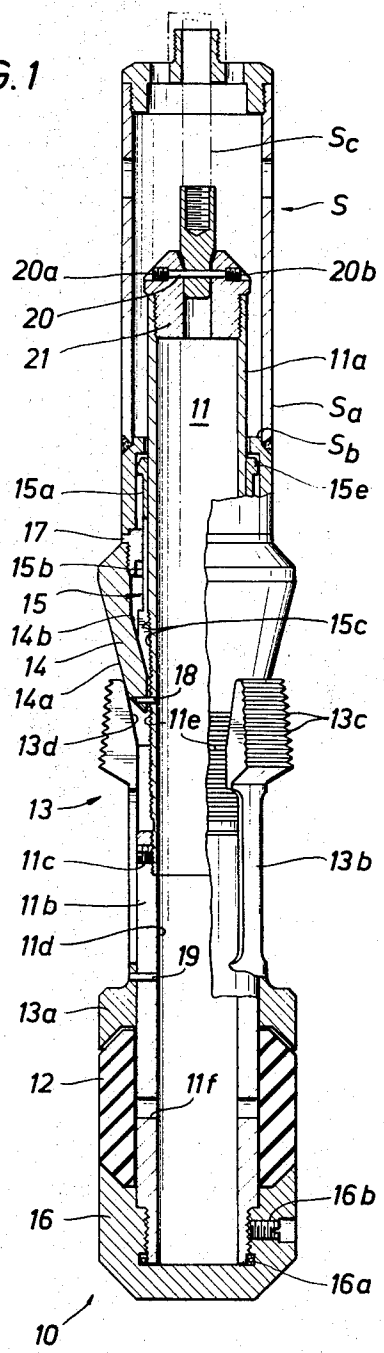
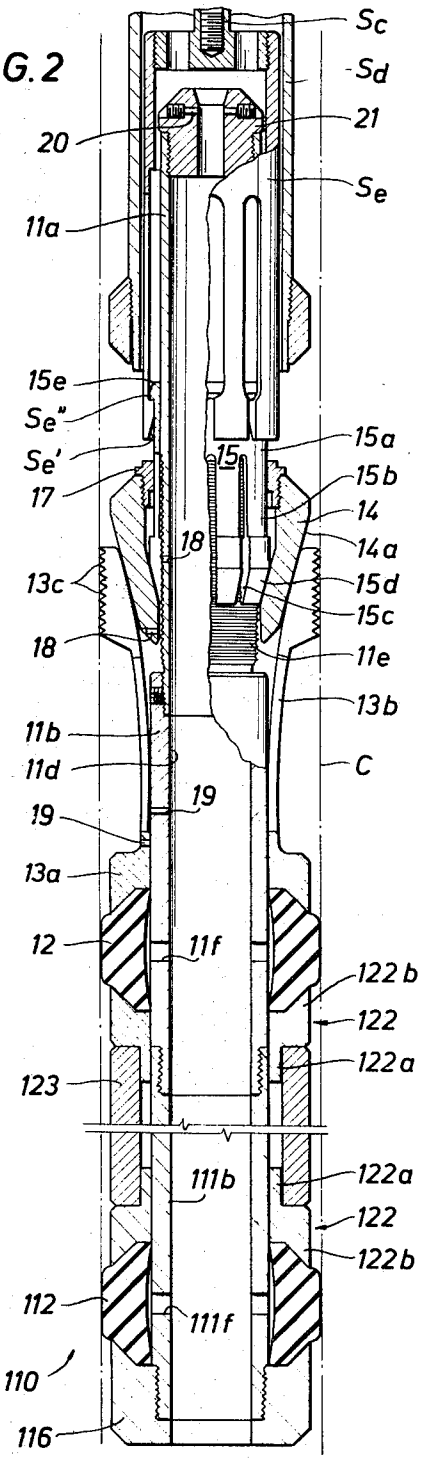


FIG. 2



Arthur L. Owen
INVENTOR

BY

Carlos A. Torres

ATTORNEY

RETRIEVABLE BRIDGE PLUG AND PACK-OFF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the field of well treatment and operation. More specifically, the present invention relates to a new and improved retrievable bridge plug and pack-off for completely sealing or for packing off a section of a well casing, liner or other well conduit at a subsurface location.

2. Description of the Prior Art

The prior art discloses a variety of tools designed to seal off or anchor to a well conduit at a subsurface location. In some instances, a complete plug of the well conduit is required while in other instances, it may be necessary to seal off a leaking, damaged, or perforated section of the conduit without disrupting fluid flow past the sealed in section. Still another need arises where it is necessary to suspend equipment in the well conduit such as testing instruments, storm chokes or bottom hole chokes.

Certain of the prior art tools employed to perform the various functions described above have relatively large external dimensions or require friction drags with the result that free movement through the well conduit is limited and the tools are subject to being unintentionally lodged in deviated or constricted sections of the conduit. If such lodging does occur, the anchoring mechanisms usually employed in such tools may be inadvertently activated during attempts to free the tools with the result that the tools are even more securely locked in the conduit. In certain of the prior art designs, the anchoring mechanism may be accidentally activated while it is being moved through the conduit even in the absence of any actual lodging of the tool. If the tool design does not permit it to be released and retrieved when improperly anchored, a costly fishing or milling job must be performed to remove the tool from the well conduit. The nonretrievable tools are also relatively expensive with respect to retrievable types in that they may be employed only once whereas the retrievable tool may be reused any number of times.

The anchoring mechanisms employed in prior art tools may also cause trouble if, after having been positioned at the desired subsurface location, they fail to properly anchor the tools to the well conduit. Thus, if the setting mechanism is set by jars or other violent forces, the tool may be forced away from the desired position before it is finally set. Displacement may also be caused by differential pressure across the tool if the elastomeric packer seals the well conduit before the anchoring means have been fully set.

In other respects, where access through the tool is required, the internal dimensions of the tool should be as large as required without undue increase of the external dimensions. If numerous, bulky components are employed in the construction of such tool, the internal dimensions are of necessity decreased and the external dimensions are increased resulting in a limited access way through the tool and a greater tendency toward sticking of the tool in the well conduit.

SUMMARY OF THE INVENTION

The tool of the present invention includes a tubular center mandrel which extends through metal anchoring means or slips and one or more elastomeric packers. The tool is anchored at a subsurface location within a well bore by a suitable setting tool which is preferably operable by wire line techniques. The external dimensions of the tool are relatively small with respect to the internal diameter of the well conduit to prevent lodging or premature setting of the tool in the well conduit and the internal dimensions of the center mandrel are relatively large to permit ready access through the tool when it has been set.

The tool is extremely versatile in that it may be easily converted to act as either an inside tubing pack-off, straddle pack-off or as a bridge plug. When employed as a pack-off, one or more packers may be employed with the central passage through the mandrel left open and conversion to a plug is effected by simply closing the mandrel passage with a suitable shoe. By properly spacing the packers, the tool may be employed as a straddle pack-off to isolate a zone within the well conduit with communication being maintained through the zone by means of the central passage in the mandrel.

The packers and slips of the tool in any of its forms may be set in the well conduit without jarring action or friction drags, and the slips engage before the packer expands to overcome any displacing force attributable to differential pressure across the packer thereby ensuring accurate placement of the tool at the desired subsurface location. After the tool has been anchored in place within the well conduit, it releases from the setting mechanism and is thereafter held in place by a locking means carried on the tool. The setting procedure is not unreversible, and the tool may be partially set and released any number of times before release from the setting mechanism. A positive setting action is required to anchor the tool in the well conduit to prevent inadvertent setting of the tool should it become lodged and a series of shear pins is also provided in the movable components of the tool to even further ensure against accidental setting.

Subsequent recovery of the set tool is effected by lowering a suitable overshot about a lip formed on the locking means and lifting upwardly with the retrieving device. Release of the locking means sequentially retracts the packer and slips to prevent the tool from being blown uphole by differential pressure.

The working components of the tool are few, which reduces the possibility of malfunction, and they are also relatively inexpensive to construct and assemble. The tool may be retrieved from its set position any number of times, refitted with shear pins and reused to further reduce its net cost.

These and other features and advantages of the tool in elevation, the present invention will be more fully described in the following specification and related drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross section, partially developed in elevation, illustrating the present invention in the form of a bridge plug; and

FIG. 2 is a partial longitudinal section, partially developed in elevation, illustrating the present invention in the form of a straddle pack-off.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Structure of the Tools

With reference to FIG. 1, the tool 10 of the present invention employs a tubular central mandrel 11 formed in two threadedly engaged sections 11*a* and 11*b* locked together by a set screw 11*c*. The mandrel 11 extends through an outer body which includes an elastomeric packer 12, metallic slips 13, a convexly tapered conical spreader 14 and a releasable locking mechanism 15. The lower end of the mandrel section 11*b* is threadedly engaged with a shoe 16 which acts as a lower bearing surface for the packer 12 and seals a central passage 11*d* extending through the mandrel 11. The shoe 16 is provided with a concave end surface which receives the convex end surface of the packer 12 to contain the packer as it is compressed. An O-ring 16*a* of rubber or other suitable material is disposed between the shoe 16 and the mandrel 11 to provide a leak-proof seal of the mandrel passage 11*d*. The shoe 16 is held in secure engagement with the mandrel section 11*b* by means of a set screw 16*b* which extends radially through the side of the shoe 16 and bears against the mandrel.

The slips 13 include an enlarged tubular base 13*a* which is provided at its lower axial end with a concave bearing surface adapted to receive and contain a convexly tapered surface at the upper end of the packer 12. A series of resilient metal fingers 13*b* extend upwardly from the base 13*a* to form the body of the slips 13. The upper end portion of each of the fingers

13*b* includes an enlarged wedge-shaped body having laterally developed teeth 13*c* formed on its external surface. The under surfaces 13*d* of the wedge-shaped bodies are outwardly tapered and extend over a conical external surface 14*a* on the cone spreader 14.

The locking mechanism 15 includes a closed tubular body portion 15*a* which closely encircles the mandrel section 11*a*. Locking fingers 15*b* extend downwardly from the body portion of the locking mechanism and terminate in wedge-shaped bodies having lateral teeth 15*c* formed on their under surfaces and outwardly tapered faces 15*d* formed on their external surfaces. The teeth 15*c* interlock between lateral teeth 11*e* formed on the external surface of the mandrel section 11*a*, and the tapered faces 15*d* bear against a concave surface 14*b* formed internally of the cone 14. The upward axial movement of the locking mechanism 15 is confined by means of a collar 17 which encircles the fingers 15*b* and is threadedly engaged with the cone 14. The upper axial end surface of the collar 17 also acts as a bearing surface for a tubular setting sleeve S_a forming a portion of a setting mechanism S. As will hereinafter be more fully explained, an internally developed constriction S_b in the setting sleeve S_a limits the upward movement of the locking mechanism 15 during the setting procedure and a radially extending tapered lip 15*e* formed on the locking body 15*a* is employed for retrieving the tool 10 after it has been set in the well conduit and released from the setting mechanism S.

With reference to both of the FIGS., the tool 10, or the modified tool 110 as the case may be, is set in a well conduit C by means of the setting mechanism S which moves the mandrel 11 upwardly with respect to the components of the outer body of the tool 10. While any suitable means may be employed for setting and retrieving the tool 10, the mechanism described in U.S. Pat. application Ser. No. 764,763 filed Oct. 3, 1968, entitled "Electric Setting Mechanism for Subsurface Well Tools" and invented by the present applicant is particularly well suited for this purpose.

Two shear pins 18 and 19 extend through the cone 14 and slips 13 and into the mandrel sections 11*a* and 11*b* respectively to prevent relative movement between the pinned components before such time as the tool 10 is to be set. A third shear pin 20 is provided for securing a movable rod S_c from the setting mechanism S to a centrally apertured connecter fitting 21 which is threadedly engaged to the top of the mandrel section 11*a*. The pin 20 is held in position by two set screws 20*a* and 20*b* which extend radially through the fitting 21.

The modified form 110 of the invention illustrated in FIG. 2 is exactly like that of FIG. 1 except that the shoe 16 has been removed and a packer 112, bearing members 122, spacer 123, mandrel section 111*b* and open ended shoe 116 have been added. The bearing members 122 are formed with a narrow tubular body 122*a* slidably disposed under the spacer 123 and an enlarged portion 122*b* which is provided with a concave end surface for containing the packers 12 and 112. Complete retraction of the expanded packers 12 and 112 is assisted by radial bores 11*f* and 111*f* in the mandrel sections 11*b* and 111*b* respectively to prevent fluid from being trapped between the packers and the mandrel. FIG. 2 also illustrates the tool as it appears when it is set in a well conduit C. The setting mechanism S illustrated in FIG. 2 has also been modified by repiacing the setting sleeve S_a with a retrieving sleeve S_d and attaching an overshot locking sleeve S_e to the movable setting rod S_c. As will hereinafter be more fully explained, the modified form of the setting mechanism is adapted to attach to the tools 10 and 110 and release them from their set condition to permit their retrieval from the well conduit C.

Setting and Release of the Tools

The setting of both forms of the invention is similar and may be described with initial reference to the bridge plug of FIG. 1. When the desired subsurface location within the well conduit C has been reached, the setting mechanism S is energized and the rod S_c and attached mandrel 11 are drawn upwardly through the stationary setting sleeve S_a. This motion positions the lower end of the sleeve S_a against the upper axial end of the collar 17 and prevents upward movement of the cone 14. Continued upward movement of the mandrel 11 severs the shear pin 18 and draws the slips 13 upwardly with respect to the stationary cone 14 causing the wedge-shaped end portions of the slip fingers 13*b* to expand radially outwardly as the internal slip surfaces 13*d* advance along the cone surface 14*a*. The engagement of the locking mechanism teeth 15*c* and mandrel teeth 11*e* draws the locking mechanism 15 upwardly during this initial movement of the mandrel until the upper end of the mechanism 15 engages the internal shoulder S_b in the setting sleeve S_a. With the mechanism 15 thus raised within the cone 14, the locking mechanism teeth 15*c* are forced outwardly by the movement of the mandrel teeth 11*e* which permits the mandrel to continue to move freely in an upward direction. With continued upward movement of the mandrel 11, the slip fingers 13*b* continue to open radially as they move along the cone surface 14*a* until they wedge tightly between the cone 14 and the internal wall of the conduit C in the manner illustrated in FIG. 2. Further upward movement of the slips 13 is thereafter prevented and the continued upward motion of the mandrel 11 severs the second shear pin 19 which permits the mandrel to continue to move upwardly through the slips 13. Once the slips become stationary, subsequent upward movement of the mandrel 11 compresses the packer 12 between the bearing surfaces of the moving shoe 16 and the stationary base 13*a* of the slips 13. As the packer 12 is thus foreshortened axially, it expands radially until it engages and bears tightly against the inner wall of the well conduit C.

When the lifting force exerted by the setting bar S_c exceeds a preestablished maximum value, the third shear pin 21 is severed and the mandrel 11 is released from the setting tool S and immediately begins to move downwardly under the restorative influence of the compressed packer 12. The locking teeth 15*c* are resiliently engaged against the mandrel teeth 11*e* and the initial downward movement of the mandrel draws the locking mechanism 15 downwardly and wedges the lower ends of the fingers 15*b* between the mandrel and the internal cone surface 14*b*. Radial opening of the fingers 15*b* is prevented in this position and, as illustrated in FIG. 2, the teeth 15*c* and teeth 11*e* securely lock to prevent further downward movement of the mandrel 11 which locks the tool in its set condition within the well conduit C.

Retrieval of the tools 10 or 110 is effected by modifying the setting mechanism S as illustrated in FIG. 2 and lowering it over the top of the anchored tool. With reference to FIG. 2, sleeve S_e is provided with a plurality of downwardly extending fingers, each of which includes a tapered surface S_e' and an internal shoulder S_e''. The setting mechanism S is lowered over the top of the tool 110 with the retrieving sleeve S_d raised axially above the fingers of the overshot sleeve S_e to permit radial expansion of the fingers. The upper surface of the connecter fitting 21 is tapered to assist in guiding the sleeve S_e past the fitting as the setting mechanism is lowered. When the tapered surface S_e' engages the taper at the upper end of the locking mechanism 15, the fingers of the sleeve S_e are forced radially outwardly and continued lowering of the mechanism S allows the fingers to snap over the lip 15*e* into the position illustrated in FIG. 2.

With the sleeve S_e thus positioned, the setting mechanism is energized to pull the rod S_e upwardly with respect to the retrieving sleeve S_d. This movement initially draws the lower end of the sleeve S_d into engagement with collar 17 and subsequently exerts a lifting force on the locking mechanism 15. The presence of the sleeve S_d about the fingers of the overshot sleeve S_e prevents the fingers from opening radially and the upward force on the locking mechanism 15 raises the mandrel 11 through the cone 14 until the locking mechanism fingers 15*b* are free to open radially which releases the mandrel 11. The axial forces exerted by the compressed packers 12 and 112 then move the mandrel downwardly through the cone 14

and slips 13 which permits the packers to return to their retracted condition. At this point, the slips 13 are still anchored against the well conduit which prevents any pressure differential existing across the tool from blowing the tool uphole. The continued upward movement of the sleeve S_e lifts the wedge bodies of the locking fingers 15*b* into engagement with the internal surface of the collar 17 which subsequently pulls the cone 14 upwardly with respect to the slips 13. The lifting of the cone 14 permits the resilient fingers 13*b* of the slips to retract radially inwardly which completely releases the tool from the well conduit C. The tool 110, or 10 as the case may be, when thus freed from the well conduit C may then be drawn upwardly with the setting mechanism S to the well surface.

It will be understood that any number of packers may be employed with the tools of the present invention and that the spacing between packers may be any desired length. Similarly, the lower ends of the mandrels may be plugged or unplugged and any desired equipment may be suspended therefrom.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A tool of the type which may be anchored in a well conduit by a setting mechanism comprising:
   a. a tool body having first and second axially spaced ends;
   b. connection means for securing said body to the setting mechanism;
   c. anchoring means included between said first and second body ends for mechanically anchoring said body to the surrounding wall of the conduit;
   d. sealing means included between said first and second body ends for forming a seal between said body and the conduit;
   e. setting means included in said body and operable by the setting mechanism for sequentially moving first said anchoring means and then said sealing means into engagement with the conduit;
   f. first releasable means included in said connection means for releasing said body from the setting mechanism after said anchoring means and said sealing means are engaged with the conduit; and
   g. locking means for retaining said anchoring means and said sealing means in engagement with the well conduit after said body is released from the setting mechanism.

2. The tool as defined in claim 1 further including retrieving means for releasing said locking means and moving said anchoring means and said sealing means out of engagement with the well conduit.

3. The tool as defined in claim 1 further including:
   a. a mandrel having first and second axially spaced ends extending internally of said anchoring means and said sealing means; and
   b. a passage included in said mandrel extending axially between said first and second mandrel ends.

4. The tool as defined in claim 2 further including:
   a. a mandrel having first and second axially spaced ends extending internally of said anchoring means and said sealing means; and
   b. a passage included in said mandrel extending axially between said first and second mandrel ends.

5. The tool as defined in claim 1 wherein said anchoring means includes:
   a. a plurality of radially movable friction members; and
   b. a spreader means having a convex external surface for moving said friction members radially into engagement with the well conduit.

6. The tool as defined in claim 1 wherein said sealing means includes at least one radially expandable elastomeric packer.

7. The tool as defined in claim 2 wherein said anchoring means includes:
   a. a plurality of radially movable friction members; and
   b. a spreader means having a convex external surface for moving said friction members radially into engagement with the well conduit.

8. The tool as defined in claim 3 wherein said anchoring means includes:
   a. a plurality of radially movable friction members; and
   b. a spreader means having a convex external surface for moving said friction members radially into engagement with the well conduit.

9. The tool as defined in claim 4 wherein said anchoring means includes:
   a. a plurality of radially movable friction members; and
   b. a spreader means having a convex external surface for moving said friction members radially into engagement with the well conduit.

10. The tool as defined in claim 9 wherein said sealing means includes at least one radially expandable elastomeric packer.

11. The tool as defined in claim 8 wherein said locking means includes:
   a. a concave internal surface formed on said spreader means;
   b. wedge members disposed between said mandrel and said concave surface; and
   c. cooperating locking means formed on said mandrel and said wedge members for preventing axial motion of said mandrel in one direction when said cooperating locking means are interlocked.

12. The tool as defined in claim 11 wherein said retrieving means include means operable by the setting mechanism for releasing said cooperating locking means to permit said mandrel to move in either axial direction.

13. The tool as defined in claim 12 including outlet means forming an escape passage for fluids and gasses trapped behind said packer to permit said packer to fully disengage the conduit wall.

14. The tool as defined in claim 9 wherein said mandrel is movable relative to said spreader means, friction members and sealing means for moving said friction members and said sealing means both into and out of engagement with the conduit.

15. The tool as defined in claim 9 wherein said setting means includes:
   a. second releasable connection means securing said spreader means and said mandrel against relative axial movement; and
   b. third releasable connection means securing said friction members and said mandrel against relative movement.

16. The tool as defined in claim 15 wherein said first, second and third releasable connection means include shear pins.

17. The tool as defined in claim 1 including a plurality of axially spaced sealing means disposed between said first and second body ends for sealing a zone within the well conduit.

18. The tool as defined in claim 16 further including means for sealing said mandrel passage.

19. The tool as defined in claim 16 further including a plurality of axially spaced sealing means disposed between said first and second body ends for sealing a zone within the well conduit.

20. The tool as defined in claim 18 further including a plurality of axially spaced sealing means disposed between said first and second body ends for sealing a zone within the well conduit.

21. A retrievable oil tool for subsurface use in a well conduit comprising:
   a. a central mandrel having first and second axially spaced ends;
   b. a first releasable connection means for securing said first mandrel end to the movable member of a setting mechanism;
   c. anchoring means carried externally of said mandrel between said first and second mandrel ends for anchoring the tool to the well conduit;

d. sealing means carried externally of said mandrel between said first and second mandrel ends for forming a seal between said mandrel and the conduit; and

e. locking means disposed about said mandrel for securing said mandrel against axial movement in one direction relative to said anchoring means and sealing means with said locking means including retrieving means selectively movable axially with respect to said mandrel for releasing said mandrel to permit mandrel movement in both axial directions relative to said anchoring means and said sealing means.

22. The tool as defined in claim 21 wherein said anchoring means includes:

a. a plurality of radially movable friction members circumferentially disposed externally about said mandrel; and

b. an axially movable spreader means encircling said mandrel and including a convex external surface for moving said friction members radially into engagement with the well conduit as said spreader means moves axially with respect to said mandrel.

23. The tool as defined in claim 22 wherein said locking means includes:

a. a concave internal surface included with said spreader means;

b. wedge members disposed between said mandrel and said concave surface; and

c. cooperating locking means formed on said mandrel and said wedge members for preventing axial motion of said mandrel in one direction when said cooperating locking means are interlocked.

24. The tool as defined in claim 23 wherein said retrieving means includes release means operable by a setting mechanism for releasing said cooperating locking means to permit said mandrel to move in either axial direction.

25. The tool as defined in claim 23 further including:

a. second releasable connection means securing said spreader means and said mandrel against relative axial movement; and

b. third releasable connection means securing said friction members and said mandrel against relative movement.

26. The tool as defined in claim 25 wherein said first, second and third releasable connection means include sequentially severable shear pins for sequentially anchoring said friction means, and sealing means and releasing said mandrel from the setting mechanism.

27. The tool as defined in claim 25 further including a plurality of axially spaced sealing means disposed between said first and second body ends for sealing a zone within the well conduit.

28. The tool as defined in claim 26 wherein said mandrel further includes a central passage extending axially along at least a portion of its length.

29. The tool as defined in claim 28 further including outlet means forming an escape passage for fluids and gases trapped behind said packer to permit said packer to fully disengage the conduit wall.

30. The tool as defined in claim 1 wherein:

a. said anchoring means further includes radially movable friction members and a spreader means disposed about a mandrel for radially moving said friction members into engagement with the well conduit; and

b. said locking means includes wedge means disposed between said spreader means and said mandrel for selectively preventing axial movement of said mandrel through said spreader means.

31. The tool as defined in claim 1 wherein:

a. said anchoring means further includes a plurality of radially movable friction members and a spreader means disposed about a mandrel for moving said friction members radially into engagement with the well conduit; and

b. said mandrel is movable axially relative to said spreader means for moving said friction members and said sealing means into engagement with the conduit.

32. The tool as defined in claim 1 further including:

a. first and second compression members axially movable relative to each other for compressing said sealing means to move said sealing means radially outwardly away from said body; and

b. connecting means connecting said anchoring means and said first compression member for preventing relative axial movement between said anchoring means and said first compression member.

33. The tool as defined in claim 22 wherein:

a. said lock means includes a tubular lock base means circumferentially disposed about said mandrel, a plurality of fingers extending axially from said lock base means, wedge means secured to said fingers, said wedge means disposed between said spreader means and said mandrel and a plurality of circumferentially extending grooves formed along the internal surface of said wedge means for selectively engaging a plurality of circumferentially extending extending grooves formed along the external surface of said mandrel;

b. said anchoring means includes a tubular anchor base means circumferentially disposed about said mandrel and secured to said plurality of radially movable friction members whereby said anchor base and said friction members are axially fixed with respect to each other; and

c. said sealing means includes at least one radially expandable elastomeric packer positioned between plural, axially spaced compressive members with one of said compressive members being axially fixed relative to said anchor base and another compressive member being secured to and axially fixed with said mandrel whereby axial movement of said two compressive members toward each other axially foreshortens and radially expands said packer.