July 12, 1966 C. C. BROWN 3,260,310

SCREW-SET HIGH-PRESSURE PACKER

Filed May 27, 1963 4 Sheets-Sheet 1

Fig. 1B

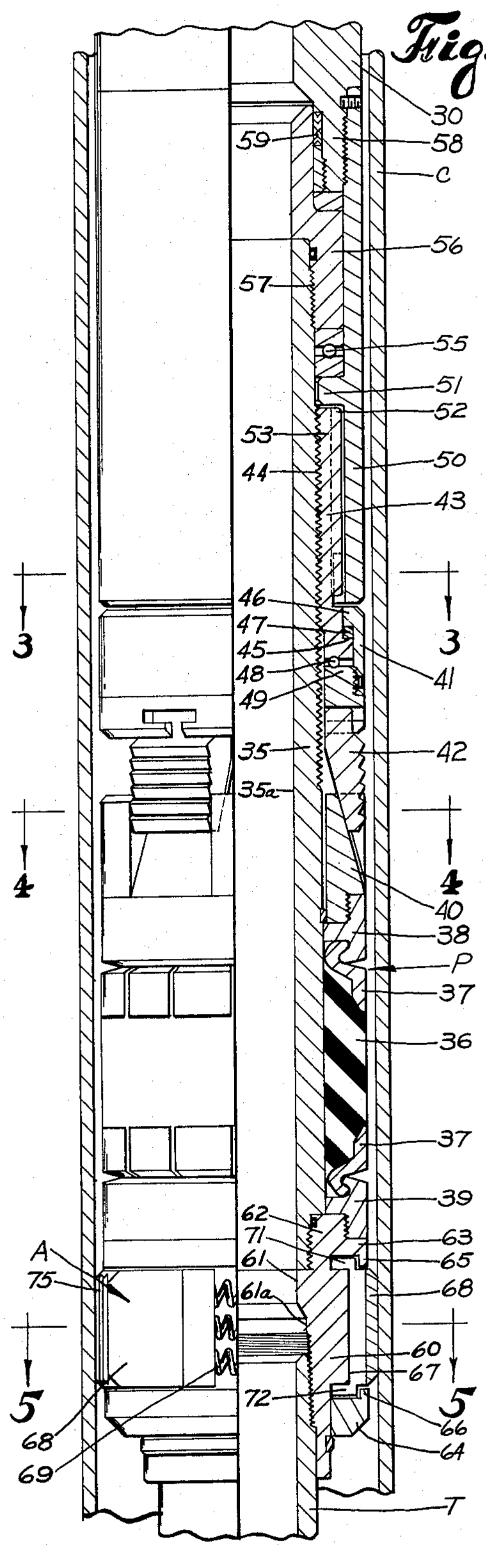
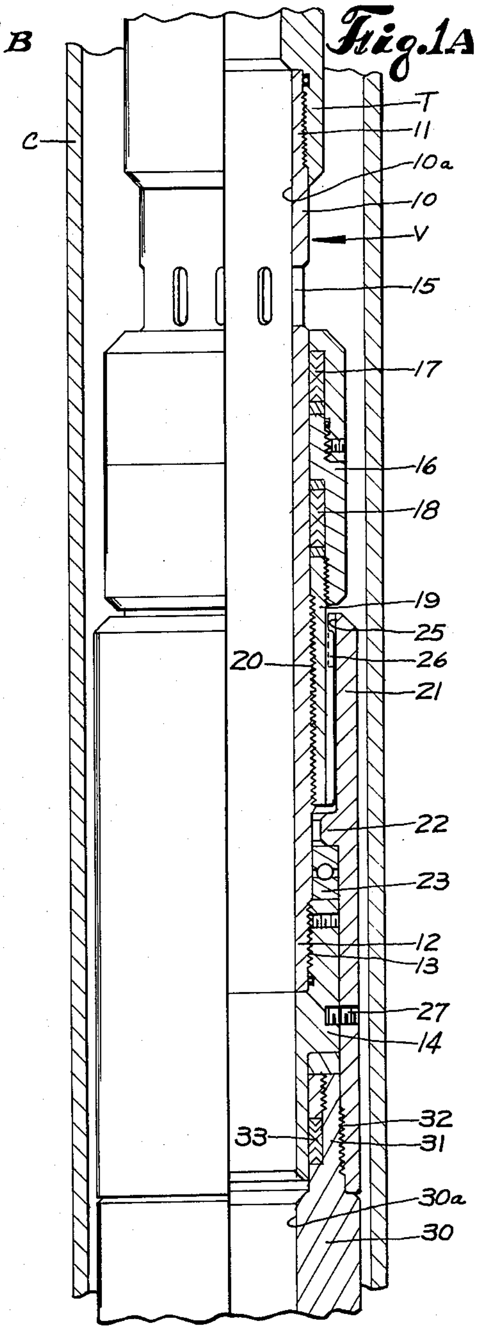


Fig. 1A



CICERO C. BROWN
INVENTOR.

BY [signature]

ATTORNEY

SCREW-SET HIGH-PRESSURE PACKER

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Fig. 2B

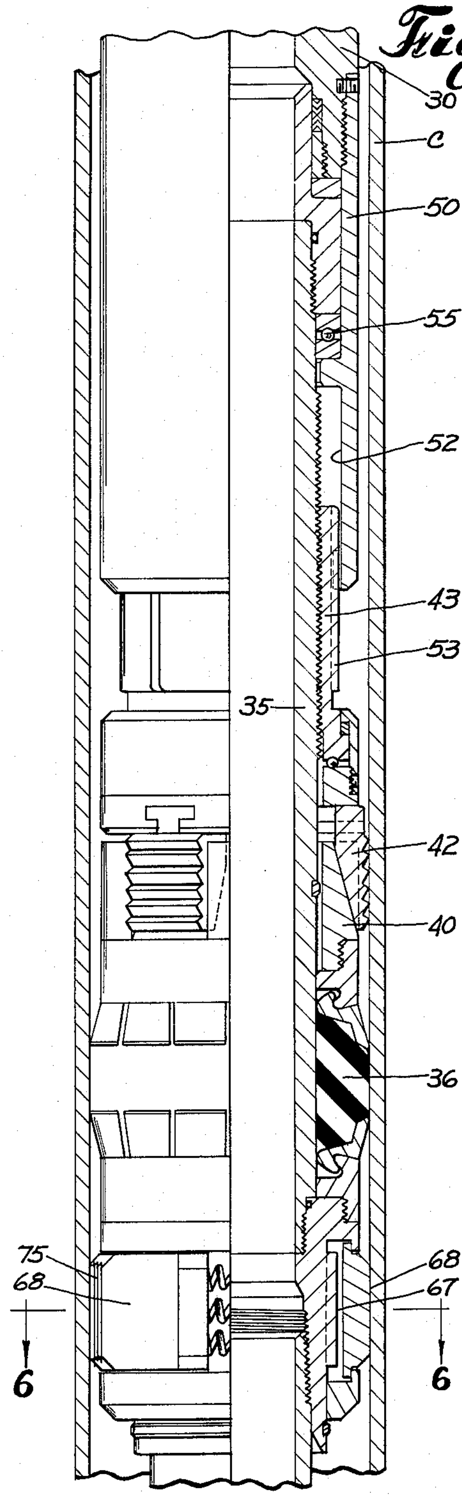
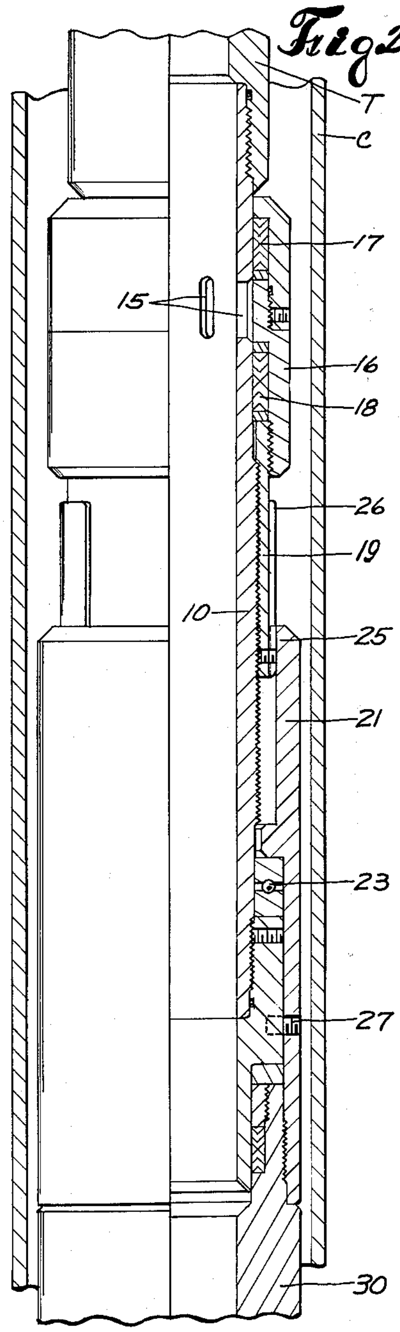


Fig. 2A



CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

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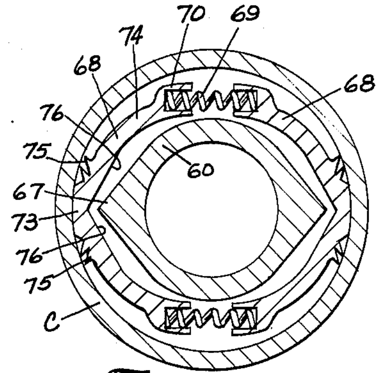

Fig. 5

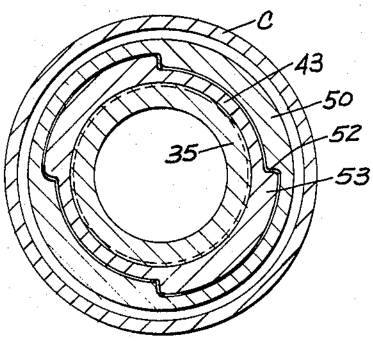

Fig. 3

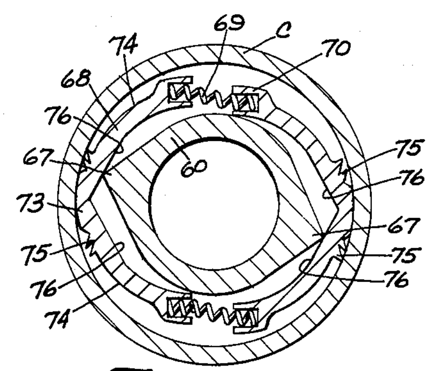

Fig. 6

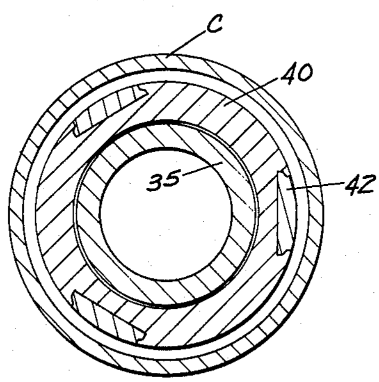

Fig. 4

CICERO C. BROWN
INVENTOR.

BY [signature]

ATTORNEY

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Fig. 7

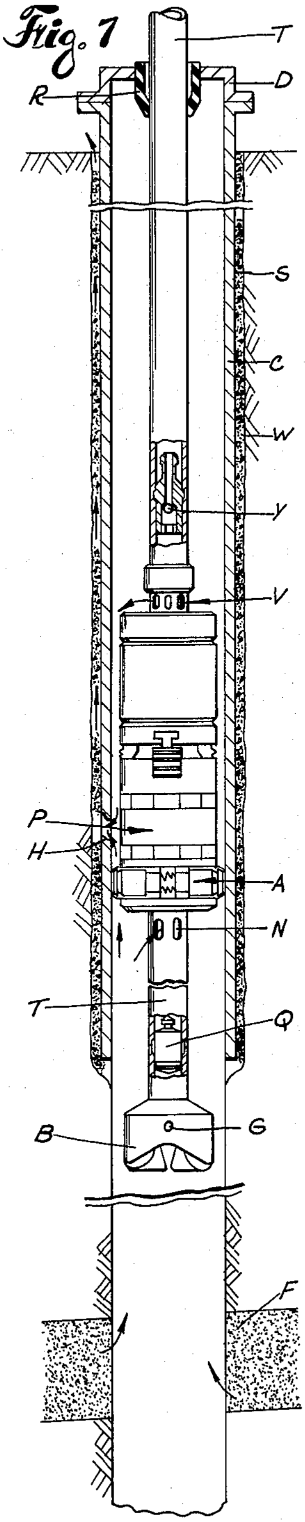


Fig. 8

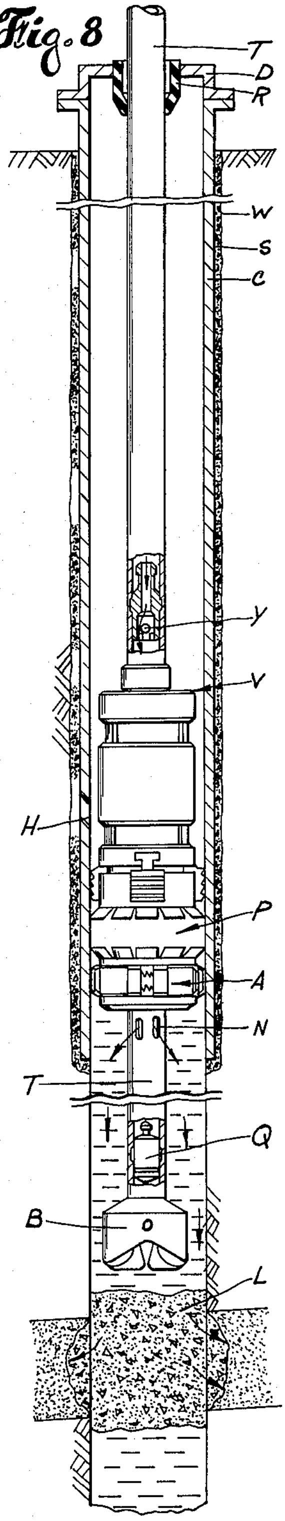
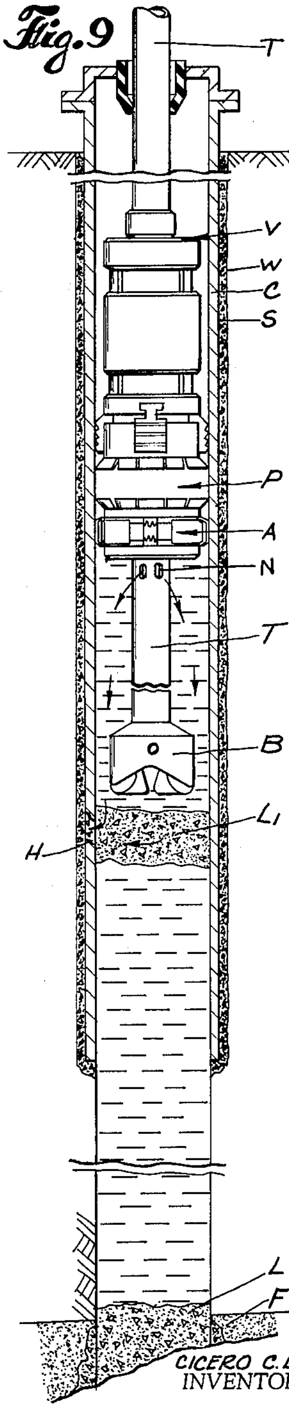


Fig. 9



CICERO C. BROWN
INVENTOR.

BY

ATTORNEY

United States Patent Office

3,260,310
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3,260,310
SCREW-SET HIGH-PRESSURE PACKER
Cicero C. Brown, % Brown Oil Tools, Inc., P.O. Box 19,236, Houston, Tex.
Filed May 27, 1963, Ser. No. 283,504
7 Claims. (Cl. 166—131)

This invention relates to well packers and particularly to well packers for use in controlling leaks in the casing of high-pressure gas wells.

In the drilling of oil and gas wells where the drill penetrates high-pressure gas zones, a leak will frequently occure in the casing above the drilling zone through which gas will escape. Where the cementing of the casing is defective, a common condition particularly near the surface, the gas will leak through the cement outside the casing and create a dangerous potential blowout condition. In these situations, particularly where the casing is bad, it is usually desirable to kill the well rather than risk an uncontrollable blowout with the serious danger of a disastrous fire.

To kill the well, a packer is lowered into the well bore on a string of pipe and set between the leak and the high-pressure zone, after which cement or heavy mud is pumped into the producing zone to kill it or control the flow of gas therefrom. Thereafter, the packer is moved above the leak in the casing and cement is squeezed through the leak to seal it off.

Packers of conventional design are generally not suitable for use under the conditions present in wells of the kind mentioned because the flow of high-pressure gas through the usually very narrow annulus between the packer and the casing wall, as the packer is lowered into the well, develops such high velocities that the seal elements of the packer will be severely eroded or otherwise damaged to a degree destroying its usefulness as a seal. Further, if the leak occurs during drilling, it is desirable to pull up only enough of the drill pipe so that when a packer is mounted thereon and run back into the well, it will be below the leak, and thereby leaving as much drill pipe as possible in the well. It is necessary, therefore, that the packer be able to carry a long heavy string of drill pipe suspended from it and still be capable of actuation when it has been lowered to the setting position.

It is a primary object of this invention, therefore, to provide packer means particularly adapted for use in controlling high-pressure wells in order to seal off casing leaks which occur during drilling or running of pipe into the well.

It is an important object of this invention to provide a form of packer in which the seal element will not be subject to the destructive or erosive effect of high-pressure gas flow past the packer.

A further object is the provision of a screw-set type packer for controlling high-pressure flows and having means for supporting long heavy strings of pipe suspended therefrom.

Still another object is to provide a screw-set packer having valved by-pass means therein for transmitting high pressure flows of gas through the packer without damage to the seal elements.

Other and more specific objects and advantages of this invention will become more readily apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

FIGS. 1A and 1B, together, constitute a longitudinal quarter-sectional view of the packer in accordance with this invention, showing the parts in the unset condition during running of the packer into a well bore;

FIGS. 2A and 2B, together, comprise a view similar to

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FIGS. 1A and 1B, showing the packer parts in the set position;

FIGS. 3, 4 and 5 are cross-sectional views taken generally along line 3—3, 4—4 and 5—5, respectively, of FIG. 1B;

FIG. 6 is a cross-sectional view taken generally along line 6—6 of FIG. 2B;

FIG. 7 is a generally diagrammatic view, showing the packer mounted on a rotary drill string in the process of being lowered into a well to seal-off a leak in the casing of the well;

FIG. 8 is a view similar to FIG. 7, showing the packer set between the leak in the casing and the high pressure formation, the latter being shown after cementing to kill the flow therefrom; and

FIG. 9 is a view similar to FIGS. 7 and 8, showing the packer moved to a position above the leak in the casing and cement placed to seal the leak.

Referring to the drawing, the packer structure is made up of several sub-assemblies comprising a by-pass valve assembly, designated generally by the letter V, secured to the upper end of a packer, designated generally by the letter P, and an anchor assembly, designated generally by the letter A, secured to the lower end of the packer assembly.

Valve assembly V comprises an elongate sleeve valve **10**, having an axial bore **10*a*** and provided with a threaded upper end **11** for threaded attachment to a section of drill pipe or tubing T, depending upon the nature of the operating pipe string upon which the packer is to be run. The lower end of valve **10** is likewise provided with a threaded connection **12** for threaded reception in the socket **13** of a bearing collar **14**. Sleeve valve **10** is provided with a plurality of radial ports **15** near its upper end and the valve is slidably enclosed by a valve housing **16** provided with longitudinally spaced packings **17** and **18** sealing with the exterior of sleeve valve **10**. As seen in FIG. 1A, valve ports **15** are elevated above the upper end of valve housing **16** and the valve is, therefore, in the open position.

In the closed position, ports **15** will be positioned between packings **17** and **18** and sealed-off thereby, as illustrated in FIG. 2A. A valve actuating sleeve **19** is secured to the lower end of housing **16** and is threadedly engaged with a section of external threads **20** provided on the exterior of valve **10** intermediate ports **15** and the lower end of the valve. Thus, by relative rotation between housing **16** and valve **10** relative longitudinal movement will be produced by which ports **15** will be moved between open and closed positions with respect to packings **17** and **18** in the housing.

An elongate drive collar **21** is mounted about the exterior of drive sleeve **19** and valve **10** below housing **16** and is provided with an internally extending annular shoulder **22** which is spaced from the upper end of bearing collar **14**. An antifriction bearing **23**, of any suitable design, is disposed between the lower face of shoulder **22** and the upper end of bearing collar **14**. A spline connection is provided between drive collar **21** and drive sleeve **19** and comprises longitudinal spline grooves **25** in the bore of drive collar **21** above shoulder **22** and cooperating longitudinal splines **26** formed on the exterior of sleeve **19**. One or more shear pins **27** extend through drive collar **21** into bearing collar **14** to intially secure these parts against relative movement, thereby initially securing valve **10** and drive sleeve **19** against relative movement. A connector collar **30**, having an axial bore **30*a***, is provided at its upper end with an ternally threaded extension **31** which is inserted between the lower end of drive collar **21** and bearing collar **14**. Extension **31** is threadedly secured at **32** to the lower end of drive collar **21** and a packing **33** is disposed between the bore wall of extension 31 and the bearing collar. Connection 30 forms the operative connection of valve assembly V to packer assembly P.

The packer assembly includes a tubular packer body or mandrel 35 having an axial bore 35*a*. About the lower end of mandrel 35 is mounted on annular seal element 36 of the usual flexible, resilient construction. The opposite ends of the latter are enclosed by segmented support collars 37—37, the segments of each of which are rockably secured to the upper and lower end rings 38 and 39, respectively. Upper end ring 38 is connected to an upwardly and inwardly tapering slip expander 40 slidably disposed about mandrel 35. A slip cage 41 is mounted about the exterior of mandrel 35 and carries a plurality of toothed wedge slips 42 pendently secured thereto for radial movement in the conventional manner, the slips being arranged to cooperate with the tapered surface of expander 40 for moving the slips in and out in response to relative longitudinal movement between the slips and the expander. A slip-actuating sleeve 43 is internally threaded to engage a section of external threads 44 provided on the exterior of mandrel 35. The lower end of sleeve 43 extends into slip cage 41 and is provided with an external shoulder 45 which projects beneath an inwardly extending lip 46 on the cage to support the cage for relatively rotational movement. An antifriction bearing 47 is provided between these shoulders and a second antifriction bearing, such as a roller bearing 48, is mounted between the lower end of sleeve 43 and an internal shoulder 49 provided in cage 41. A setting sleeve 50 is disposed about the exterior of actuating sleeve 43 and mandrel 35 above cage 41, and is provided at an intermediate point thereof with an internal shoulder 51 which projects inwardly above the upper end of slip-actuating sleeve 43. Setting sleeve 50 is provided with a spline connection to sleeve 43, as best seen in FIG. 3, and comprises longitudinal spline grooves 52 cooperating with longitudinal splines 53 on the exterior of slip-actuating sleeve 43. The upper face of shoulder 51 provides a seat for antifriction bearings 55 which, in turn, support a bearing collar 56 which extends between the upper end of mandrel 35 and setting sleeve 50 and is threadedly secured to the mandrel at 57. The upper end of bearing collar 56 is radially spaced from the upper end of setting sleeve 50 and the lower end of connection 30 is provided with an externally threaded extension 58 which is received in this space and is threadedly connected to the upper end of setting sleeve 50. A seal packing 59 is provided between the inner wall of extension 58 and bearing collar 56.

Anchor assembly A is of the general form disclosed in Joe R. Brown application Serial No. 228,971, which is operable to anchor a connected tool element against rotation relative to a surrounding pipe in response to an initial slight rotational movement of the tool element relative to the pipe. As disclosed in the aforesaid application and as illustrated herein, anchor assembly A includes a generally tubular body 60 having an axial bore 61. The upper end of body 60 is formed with upstanding annular flange 62 threaded internally and externally to be received and threadedly secured between lower end ring 39 and the lower end of packer mandrel 35 to thereby secure the anchor assembly to the packer assembly. The lower end of body 60 has an internally threaded counterbore 61*a* to receive the subadjacent section of pipe string T, thereby completing the installation of the packer structure in the pipe string. Bores 10*a*, 30*a*, 35*a* and 61 are substantially uniform in diameter which is at least as great as the internal diameter of pipe string T to thereby provide a full open passage through the packer structure.

Anchor body 60 is enclosed within a cage defined by longitudinally spaced upper and lower radially extending annular flanges 63 and 64, respectively, terminating in oppositely facing annular lips 65 and 66, respectively. As best seen in FIGS. 5 and 6, body 60 is provided on diametrically opposite sides thereof with radially outwardly projecting V-shaped cams 67—67 which may be integral with body 60. Mounted about body 60 inside the cage is a pair of generally semicircular friction shoes 68 which are normally urged apart radially by means of relatively light coil springs 69 seated in suitable sockets 70 in the opposing inner ends of shoes 68, the opposing inner ends of the shoes being spaced apart to permit limited independent movement of the shoes. The upper and lower edges of the shoes are provided with oppositely extending upper and lower flanges 71 and 72, respectively, which are adapted to engage the related lips 65 and 66 to prevent the shoes from being radially expelled from the cage.

Each of the shoes 68 is provided centrally on its external surface with a convex smooth arcuate surface portion 73 which has a circular radius adapted to provide smooth engagement with the inner wall of a surrounding well casing, such as casing C. Surface portion 73 extends for a relatively short arcuate distance about the outer periphery of the shoe. On each side of surface portion 73, the exterior of the shoe is off-set slightly radially inwardly at 74 and this radially off-set portion is provided immediately adjacent each side of surface portion 73 with a plurality of vertically extending radially projecting teeth 75 which, by reason of the off-sets 74, are normally out of contact with casing C. These teeth are adapted, upon relative rotation between the shoes and casing C, to engage the casing and prevent further relative rotation between the shoes and the casing, and thereby securely engage the shoes with the casing. To effect this relative rotation or rocking movement of the shoes, the inner periphery of the shoes on each side of the center thereof, is provided with relatively flat or noncircular cam surfaces 76 which are engageable by the opposite faces of cams 67 in response to an initial small amount of relative rotation between body 60 and the shoes. As best seen in FIG. 6, cam surfaces 76 are shown engaging with the cooperating cams 67 to rock the shoes 68 angularly relative to casing C, so as to project teeth 75 into gripping engagement with the wall of casing C. Once teeth 75 bite into the casing further relative rotation between anchor body 60 and casing C is effectively stopped.

Operation of the packer structure will now be described in connection particularly with FIGS. 7, 8 and 9. In the latter, there is shown a well bore W which intersects a high-pressure gas-containing earth formation F. The upper portion of well bore W is lined in the conventional manner with surface casing C and a cement sheath S is interposed between casing C and the well bore, as is also conventional. A hole or opening H is shown to be present in casing C at a point intermediate its ends and the arrows in FIG. 7 indicate the flow of high-pressure gas through the bore of casing C and out through hole H, and thence through the body of cement sheath S to the surface. As previously mentioned, the cementing of the surface casing is frequently defective and porous in character. The upper end of casing C is closed by a conventional casing head D fitted with symbolically illustrated blowout preventers R, which may be of any conventional and well-known form.

In this illustration, the leak, indicated by hole H, has occurred during the drilling of the well by means of a rotary drill pipe string T carrying the bit B, the latter having the usual discharge passages G for discharge of mud or other fluids conventionally circulated during drilling.

Upon the appearance of a leak, such as indicated in FIG. 7, the drill pipe will be plugged by means of a plug Q and then pulled upwardly, the joints thereof being broken out in the usual manner until just enough pipe has been pulled out of the well so that when the packer structure, in accordance with this invention, is installed thereon and the pipe string then returned to the bottom, the packer structure will be located inside casing C below the leak H, as shown in FIG. 8. It is advantageous in situations of this kind that as much of the heavy drill string as possible should be left in the well at all times, but this necessarily places a heavy load on the packer structure, which, in the case of the present invention, is provided with means specifically designed to support the load and permit rotation as may be required in the operation of the packer.

When the packer structure is initially installed on the drill pipe, a ported nipple with ports N is installed below the packer, and a retrievable back-check valve, indicated at Y, of generally conventional construction, will be run into the drill pipe string at a point just above the packer to prevent reverse flow of fluids through the drill string during the subsequent operations.

The packer structure, in accordance with this invention, will be installed with the parts in the respective positions illustrated generally in FIGS. 1A and 1B, wherein valve **10** of the valve assembly will be in the open position so that as the string of tools is run into the well bore past the hole H, gas or other high pressure fluids tending to flow upwardly from formation F will flow into ports N through the bore of the packer and out ports **15**, and thence to the hole H. Provision of this valved by-pass arrangement avoids the difficulties experienced with more conventional packer constructions which force the high pressure gas to flow through the very narrow annulus defined between the exterior of the packer structure and the well casing, which as indicated previously, may result in severe erosive damage to the seal elements of the packer. With the open valve arrangement of the present invention, the pressures will be balanced across the tool structure and the disadvantage of the more conventional structures is thus overcome.

When the packer structure has reached the desired elevation below the leak, rotation of the drill string to the right will be begun. The initial rotation will be transmitted through the several above-described connections between the drill pipe string and the several sections of the packer structure and will first be transmitted to body **60** of the anchor assembly. This initial rotational movement will engage cams **67** with shoes **68**, actuating the latter to bring teeth **75** into gripping engagement with the wall of casing C and thereby stop further rotation of packer mandrel **35** and the parts directly connected thereto which are connected to anchor body **60**.

Continued rotation of the drill string will then be transmitted through shear pin **27** between bearing collar **14** and drive collar **21**, and thence through connector **30** to setting sleeve **50**, and from the latter through the spline connection **52, 53** to actuating sleeve **43**, causing the latter, through its engagement with threads **44** on the packer mandrel, to move downwardly, forcing slips **42** over expander **40** and, in turn, forcing the latter downwardly to compress and thereby expand seal element **36**, as illustrated particularly in FIG. 2B, the slips being contemporaneously forced into gripping engagement with casing C. This serves to set the packer in sealing engagement with casing C while valve **10** remains in the open position illustrated in FIG. 1A. Once packer **36** has been set, continued rotation of the drill string will generate sufficient force finally to break shear pins **27**, which heretofore had been holding drive collar **21** against rotation relative to valve **10**. Once shear pins **27** have broken, then the continued rotation of the pipe string will produce rotation of valve **10** relative to actuating sleeve **19** and will produce upward movement of the latter relative to valve **10**, thereby elevating valve housing **16** until ports **15** are positioned between seals **17** and **18**, thereby closing the fluid by-pass through valve assembly V, as seen in FIG. 2A. It is to be noted that as the packer seal is being set, the pressure fluid by-passes through the bore of the packer to prevent any erosion of the seal element.

When the packer has thus been set and the by-pass valve closed, cement may then be pumped through the drill pipe string, out ports N and is squeezed by pressure into the gas zone to kill formation F with cement body L, as seen in FIG. 8, thereby cutting-off further flow of high pressure fluid to leak H.

When this cementing operation has been completed and the cement allowed to harden, the drill string is rotated to the left, retracting slips **40** and releasing the packer. Thereupon, the pipe carrying the packer assembly is elevated until the latter is positioned above leak H, as shown in FIG. 9. When this position has been attained, the packer is again set by right-hand rotation of the pipe string and an additional cementing operation is conducted to squeeze a second cement body L' into the bore of casing C and out through hole H in order to seal off the latter, as seen in FIG. 9. When this cementing operation has been completed and the cement hardened, the packer is again released and the drill string carrying the packer is pulled back to the surface to remove the packer structure and the back-check valve Y and plug Q are withdrawn from the drill string, after which the drill pipe is run back into the well to drill out the cement and resume the drilling operation.

It will be seen from the foregoing that setting of the packer requires relative rotation between the parts of the assembly, despite the fact that a very large weight of drill pipe may be hanging from the packer structure. To assure that the required relative rotation may be accomplished without difficulty, the present invention includes the provision of the antifriction bearings **23**, **48** and **55** between the several parts, as previously described, so that the loads may be taken on such bearings and thereby permit the necessary relative rotation between the parts of the packer structure to be accomplished with a minimum of difficulty.

It will be evident that the packer structure in accordance with this invention may be run on tubing strings or other pipe strings in any instance where it is desired to seal off a leak in a well casing, particularly when subjected to high gas pressures.

It will be understood that various modifications and alterations may be made in the details of the illustrative embodiment in accordance with this invention, within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A screw-set well packer, comprising, a tubular packer mandrel, a by-pass valve assembly connectable to an operating pipe string, means forming a rotatable connection between the valve assembly and the upper end of the packer mandrel, a radially expansible slip-and-seal assembly mounted about the mandrel for operative engagement with a surrounding well casing, slip actuating sleeve means surrounding said mandrel and having screw connection thereto constructed and arranged to actuate said slip-and-seal assembly in response to rotation relative to the mandrel, said rotatable connection including a setting sleeve extending about said slip actuating sleeve means and having a longitudinally slidable non-rotatable connection thereto whereby to transmit rotation of said by-pass valve assembly to said actuating sleeve means, and anchor means carried by the lower end of said mandrel for engaging said well casing to hold said mandrel against rotation during actuation of said slip-and-seal assembly.

2. A screw-set well packer according to claim **1** having anti-friction bearing means in said rotatable connection between said setting sleeve and said valve assembly.

3. A screw-set well packer according to claim **1**, wherein said by-pass valve assembly includes a sleeve valve communicating with the bore of said mandrel and having one end connectable to the operating pipe string, said sleeve valve having ports through the wall thereof, a valve housing slidably surrounding said sleeve valve, a screw connection means between the housing and the sleeve valve for moving the housing longitudinally relative to the sleeve valve between positions opening and closing the ports in response to rotation of the sleeve valve relative to the housing, breakable means initially securing the housing to the valve in the port-opening position and releasable in response to rotation of the valve beyond that required to actuate said slip-and-seal assembly.

4. A screw-set well packer according to claim 3, wherein said drive sleeve also has a longitudinally slidable non-rotatable connection to said screw connection between said valve housing and said sleeve valve.

5. A screw-set well packer according to claim 4, wherein said breakable means comprises breakable shear pins securing said sleeve valve to said screw connection means.

6. A screw-set well packer, comprising, a tubular packer mandrel, a by-pass valve assembly connectable to an operating pipe string, means forming a rotatable connection between the valve assembly and the upper end of the packer mandrel, a radially expansible slip-and-seal assembly mounted about the mandrel for operative engagement with a surrounding well casing, slip actuating sleeve means surrounding said mandrel and having screw thread connection thereto for actuating said slip-and-seal assembly in response to rotation relative to the mandrel, said rotatable connection including a setting sleeve extending about said slip actuating sleeve means and having a longitudinally slidable non-rotatable connection thereto whereby to transmit rotation of said by-pass valve assembly to said actuating sleeve means, and anchor means carried by the lower end of said mandrel for engaging said well casing to hold said mandrel against rotation during actuation of said slip-and-seal assembly, a fixed shoulder means on said mandrel, said slip-and-seal assembly including an annular resilient seal element having its lower end abutting said fixed shoulder means, an upwardly tapering slip expander slidable on the mandrel and engaging the upper end of said seal element, and a set of pipe-gripping wedge slips depending from said actuating sleeve and slidably disposed about the mandrel in cooperative relation to said slip expander.

7. A screw-set well packer, comprising, a tubular packer mandrel, a by-pass valve assembly connectable to an operating pipe string, means forming a rotatable connection between the valve assembly and the upper end of the packer mandrel, a radially expansible slip-and-seal assembly mounted about the mandrel for operative engagement with a surrounding well casing, slip actuating sleeve means surrounding said mandrel and having screw thread connection thereto for actuating said slip-and-seal assembly in response to rotation relative to the mandrel, said rotatable connection including a setting sleeve extending about said slip actuating sleeve means and having a longitudinally slidable nonrotatable connection thereto whereby to transmit rotation of said by-pass valve assembly to said slip actuating sleeve means, anchor means carried by the lower end of said mandrel for engaging said well casing to hold said mandrel against rotation during actuation of said slip-and-seal assembly, said valve assembly including initially open valve means communicating the bore of the mandrel with the exterior thereof above said slip-and-seal assembly, and said rotatable connection also including means operable to close said valve means in response to continued rotation of said valve assembly after said slip-and-seal assembly have been actuated.

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CHARLES E. O'CONNELL, *Primary Examiner.*

C. D. JOHNSON, J. A. LEPPINK, *Assistant Examiners.*