

May 1, 1956

C. C. BROWN

2,743,780

WELL PACKERS

Filed Feb. 20, 1950

6 Sheets-Sheet 1

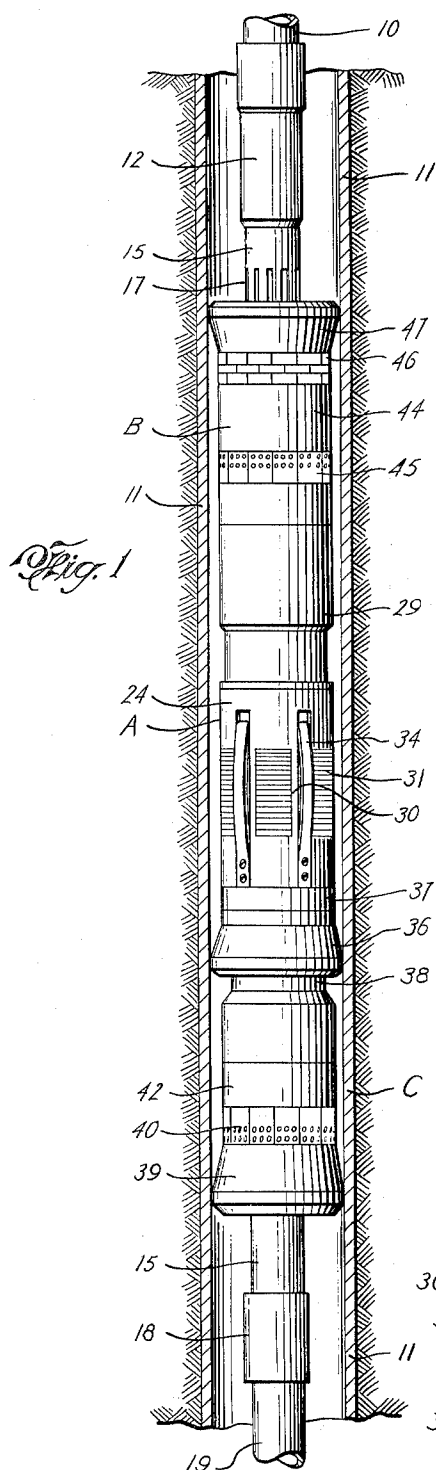
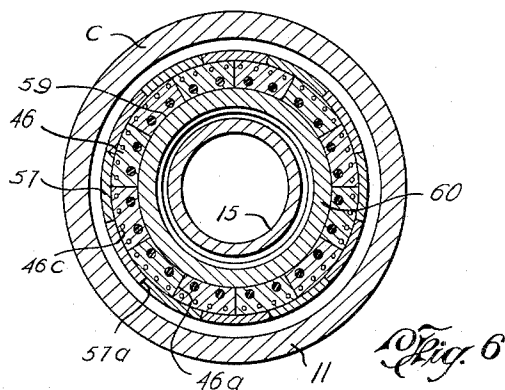
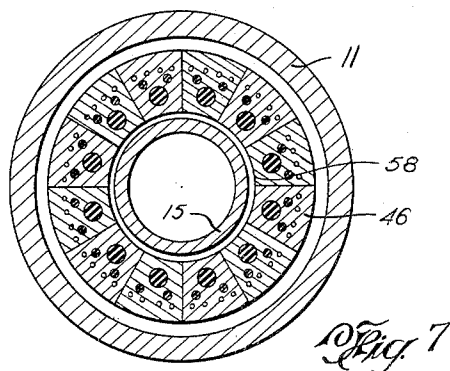
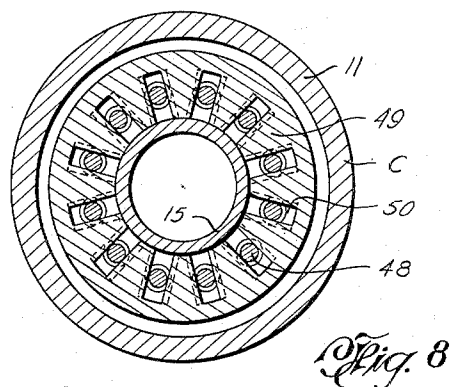
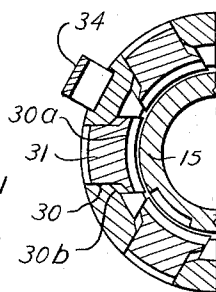


Fig. 9

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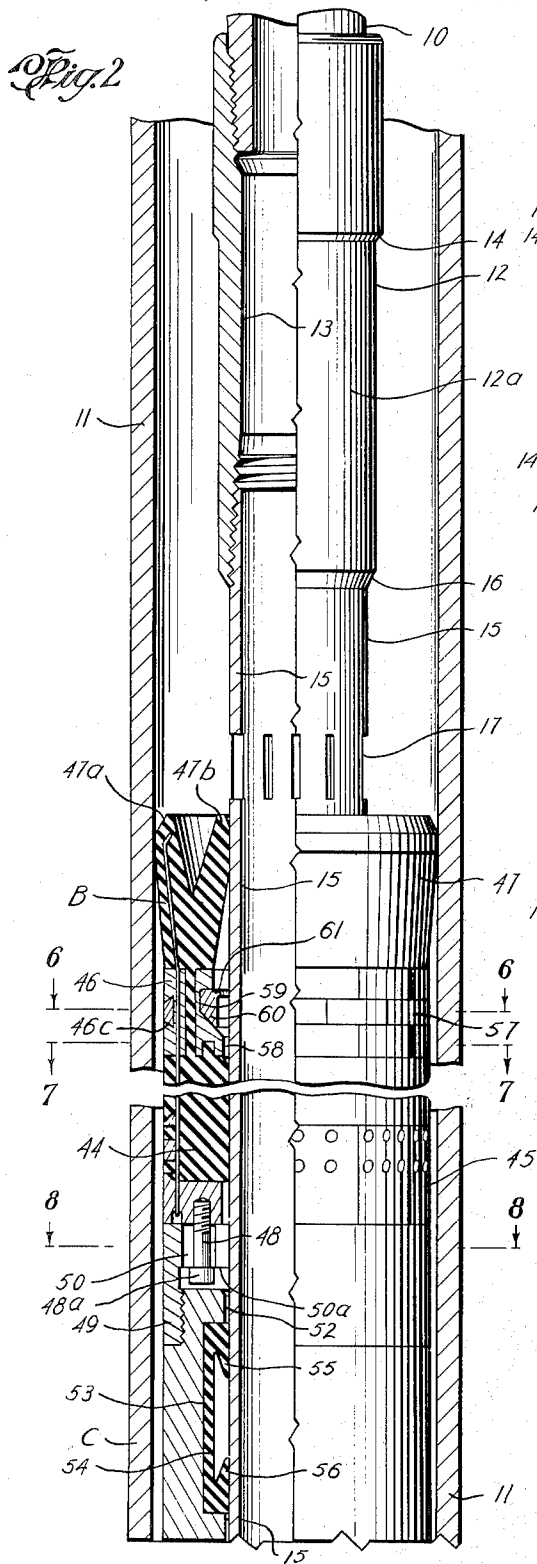
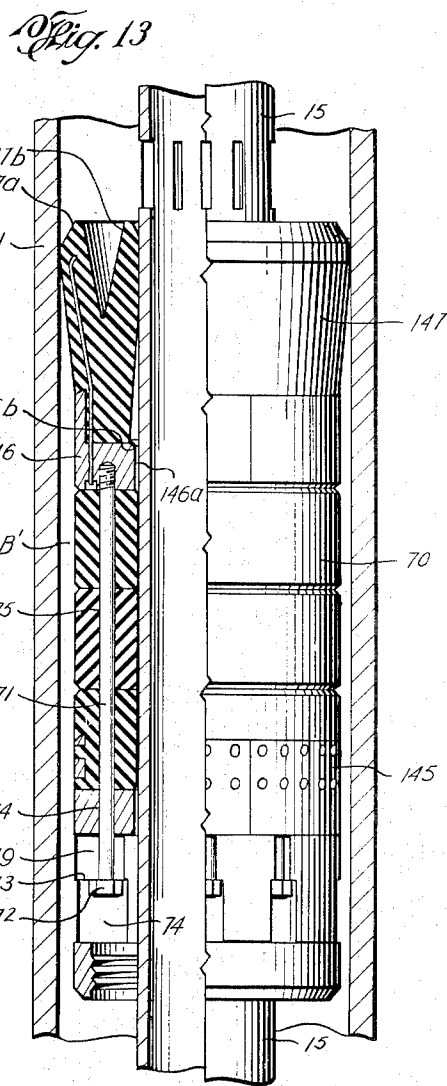
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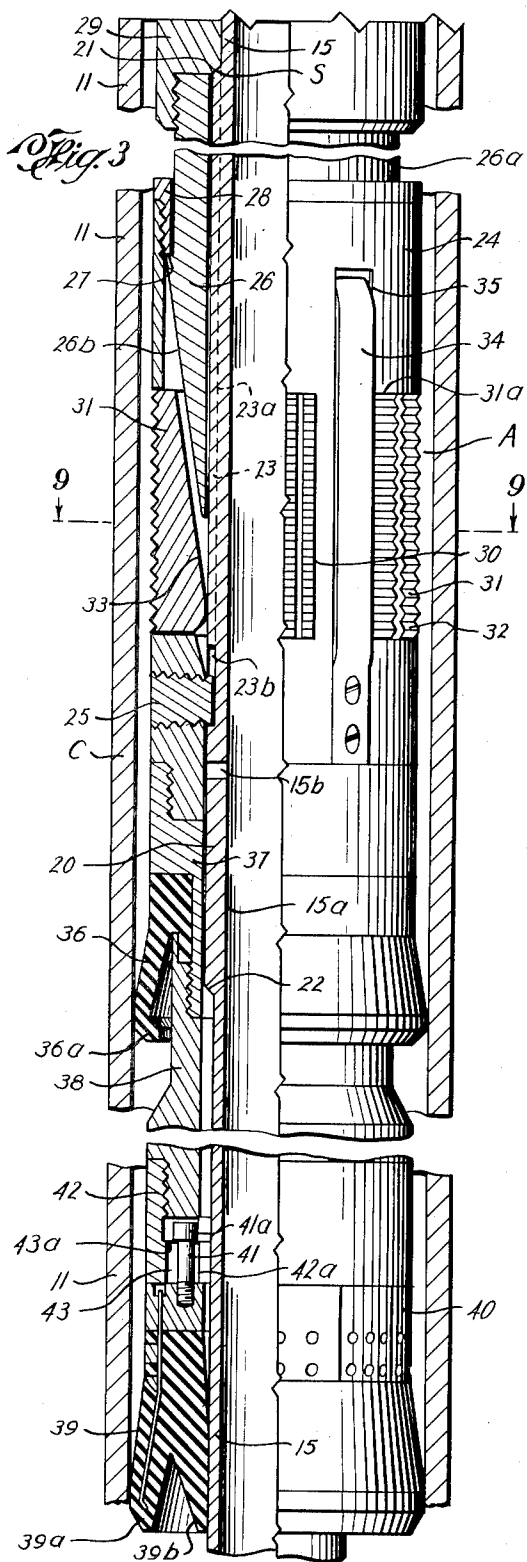
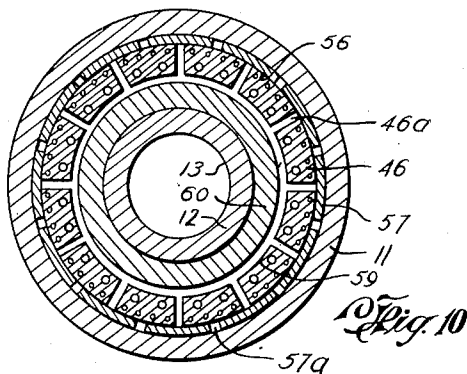
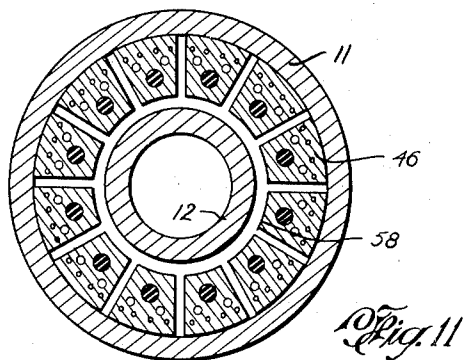
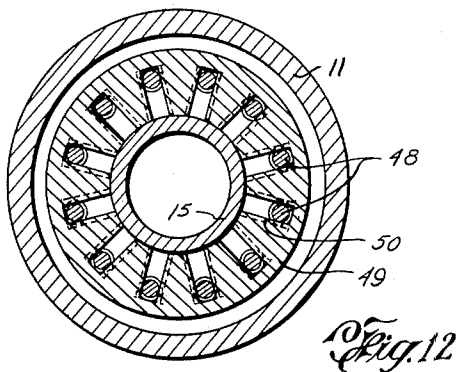
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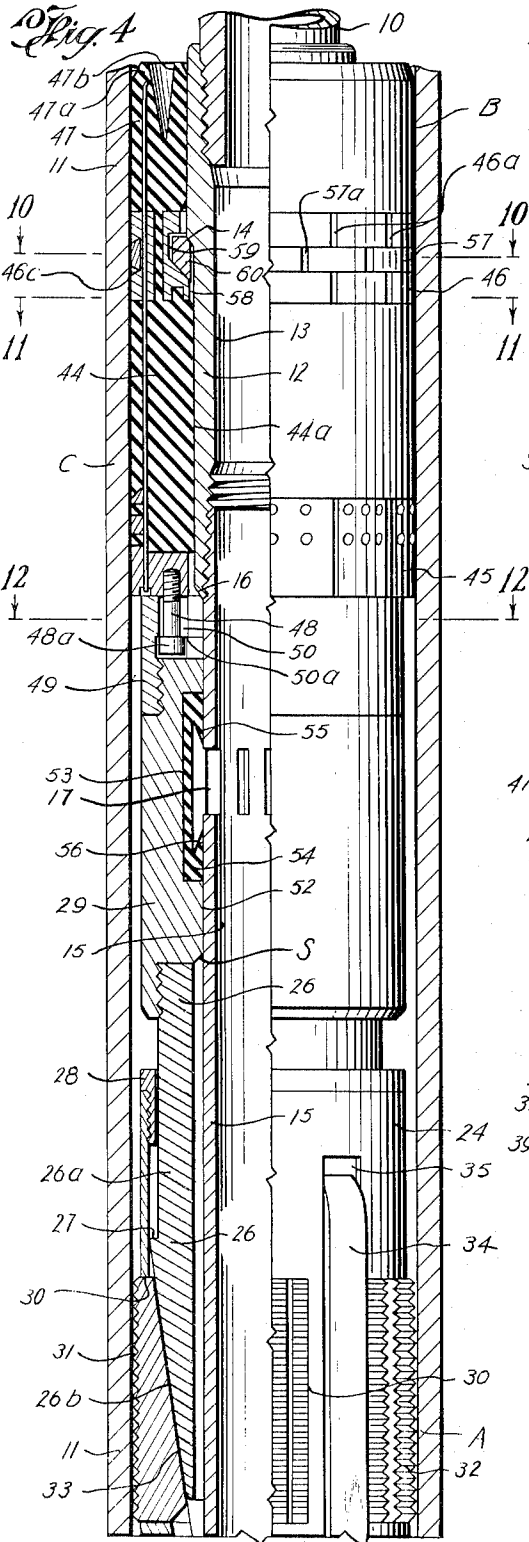
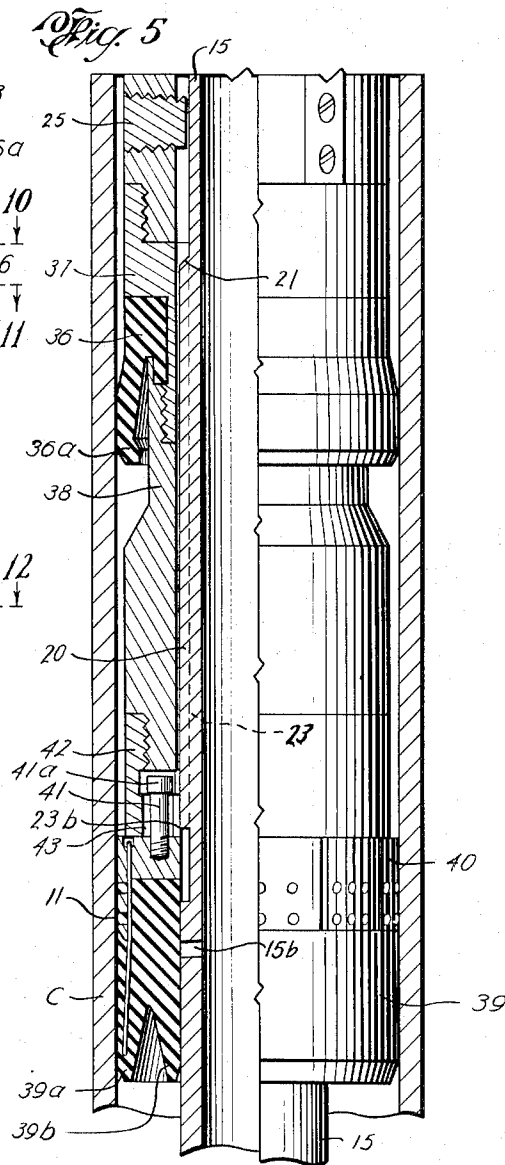
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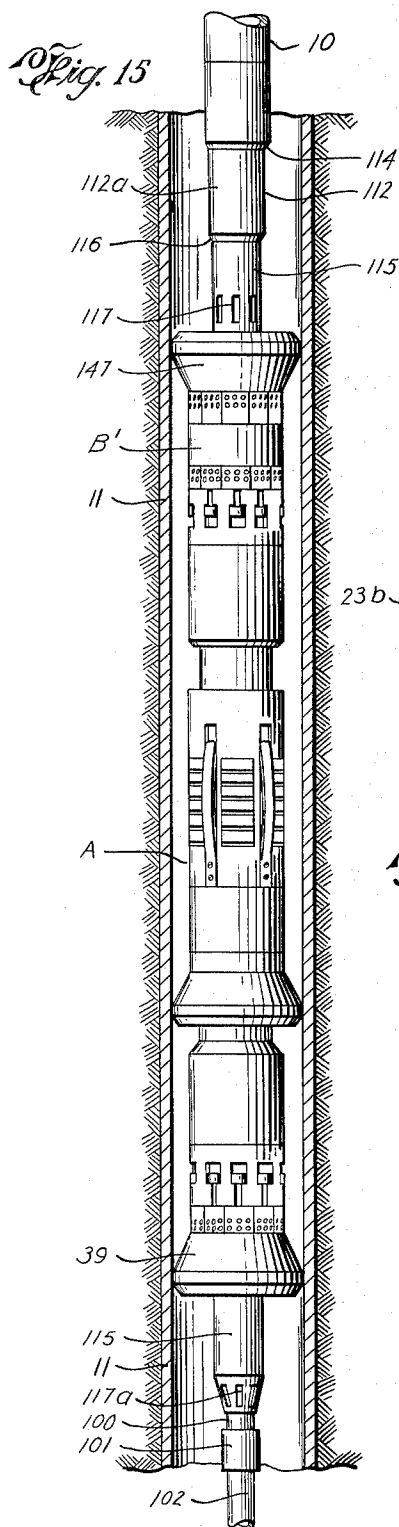
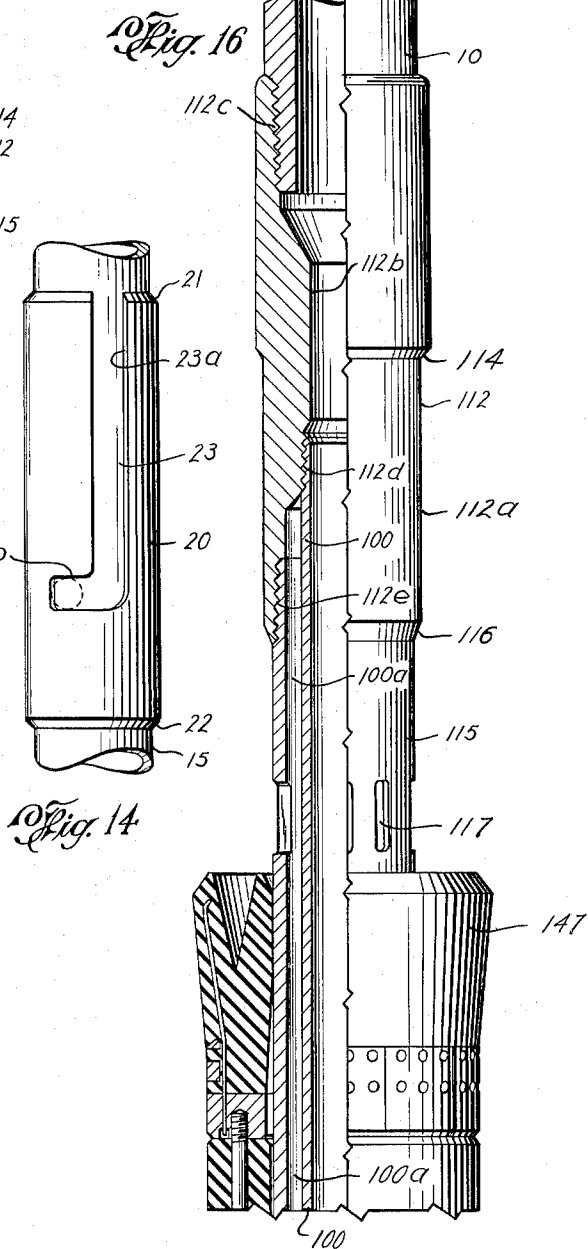
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6 Sheets-Sheet 5



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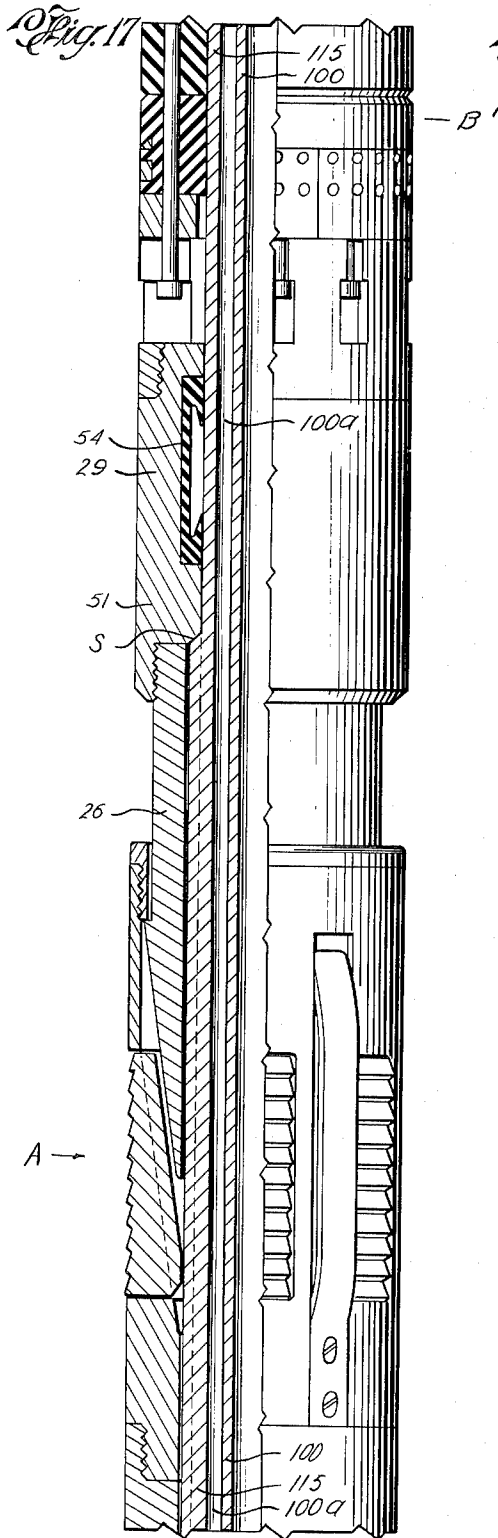
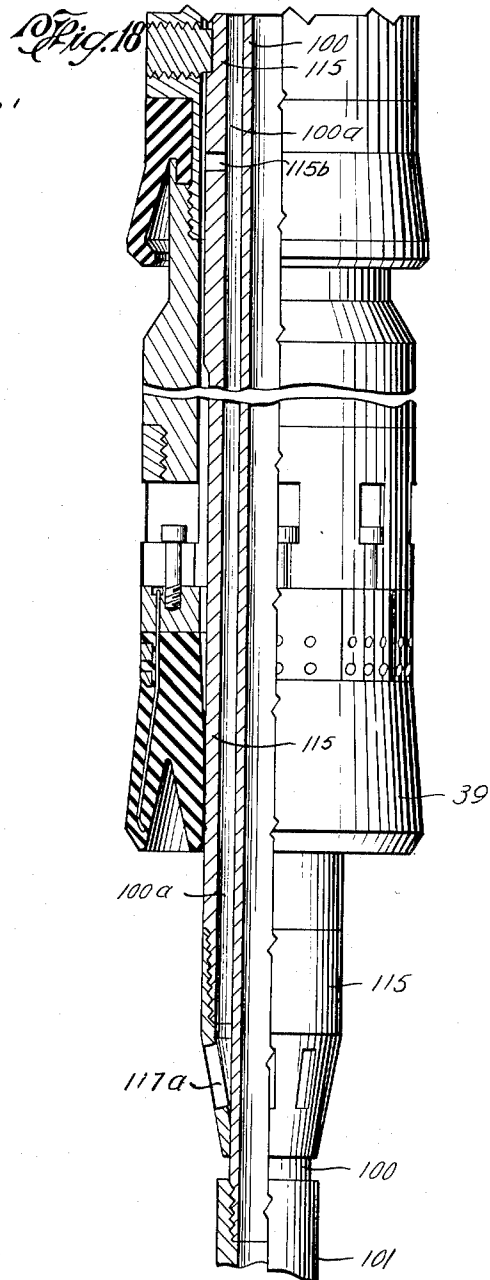
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6 Sheets-Sheet 6



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WELL PACKERS

Cicero C. Brown, Houston, Tex.

Application February 20, 1950, Serial No. 145,252

15 Claims. (Cl. 166—120)

This invention relates to new and useful improvements in well packers.

In the usual type of well packers, it has been the general practice to employ an annular flexible sealing element constructed of rubber or the like and to depend solely upon the weight of the tubing or pipe string to apply an end-wise or longitudinal compression to the sealing element to expand and maintain the sealing element in its set position. As packers are set at greater depths within the well casing control over the weight applied to the packer becomes increasingly difficult with the result that the imposition of the weight of the tubing or pipe string upon the sealing element may be excessive and in many instances may actually cause the expanded sealing element to deform or bulge the well casing outwardly; in addition, an excessive weight imposed upon the packer causes extrusion or "creeping" of the sealing element around the retaining members which normally confine the ends of the element and this extrusion either by itself or in conjunction with the bulging of the well casing is a major cause of packers becoming stuck in the well casing.

Packers are employed for various well operations as, for example, sealing off the annular space between a well casing and a well tubing for the purpose of permitting production or flow of well liquids upwardly through the well tubing. Packers are also employed in various squeeze and pipe testing operations wherein the packer is lowered to a desired elevation and is actuated to seal off between the well casing and the inner conductor or well tubing; in this type of packer, it is usual practice to provide a free by-pass around the sealing element during lowering and to close said by-pass as well as to provide an outlet below the packer after the latter has been set. Packers are also employed in well cementing operations and for other purposes.

Because each operation varies to some extent with respect to other operations, it has been difficult to provide a single packer which is capable of performing all packer operations which might be carried out in a well and the past practice has been to manufacture each packer for a specific purpose. As a result each packer is identified by the particular use for which it has been designed and packers are therefore referred to as production packers, cementing packers, squeeze packers, etc.

It is one object of this invention to provide an improved well packer which is adaptable for performing any packer operation within a well bore, whereby the device may be employed as an ordinary production packer or may be used for special operations, such as squeeze, pipe testing or cementing without any material change in the general structure of the device.

An important object of the invention is to provide an improved packer having an improved sealing element assembly, such as shown in my co-pending application, Serial No. 132,589, filed December 12, 1949, now Patent No. 2,720,267, and also having a tubular conductor or mandrel for lowering the assembly, with a fluid by-

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pass in said conductor adapted to be opened during the lowering operation and completely closed after the packer is moved to its set position, whereby lowering of the assembly is facilitated and complete sealing effected after setting to permit said packer to function as a production packer.

Another object of the invention is to provide an improved well packer wherein the sealing assembly is lowered on a tubular support having by-pass openings therein which are closed when the packer is moved to a set position, together with an inner conductor extending through the lowering conductor, whereby the inner conductor provides a communication through the packer assembly after the by-pass in the lowering conductor has been closed.

A further object is to provide a well packer wherein a lowering mandrel or support coacts with the sealing assembly to assure radial displacement and movement of said assembly into sealing position and also wherein the coaction between said mandrel and the sealing assembly controls the opening and closing of a fluid by-pass past the sealing assembly of the packer.

Still another object of the invention is to provide an improved well packer which is universally applicable for various uses or purposes in carrying out well operations and which has pressure seal means disposed above and below an annular packer member, with said pressure seal means being so arranged that pressures above and below the packer function to maintain the packer in its set position, whereby tubing weight alone is not depended upon to hold the packer in its set position.

Still another object is to provide a packer, of the character described, wherein a mechanical radial displacement of the annular elastic sealing and packing element is first effected by a coaction with the lowering mandrel or support, after which the packing and sealing members are moved to final sealing position by the pressures in the well casing; said packer also having means for utilizing a portion of the tubing weight to assist the pressure in moving and maintaining the packer in its set position.

Still another object is to provide a packer, of the character described, which is adaptable for use in carrying out any well operation and which is so constructed that excessive application of pressure to the packing member is prevented.

The construction designed to carry out the invention will be hereinafter described together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is an elevation of a well packer constructed in accordance with the invention and showing the same within a well casing,

Figure 2 is a view partly in elevation and partly in section of the upper portion of the packer,

Figure 3 is a continuation of Figure 2 showing the lower portion of the packer,

Figure 4 is a view partly in section and partly in elevation showing the sealing assembly in its set position,

Figure 5 is a continuation of Figure 4 showing the lower end of the packer,

Figure 6 is a horizontal cross-sectional view taken on the line 6—6 of Figure 2,

Figure 7 is a horizontal cross-sectional view taken on the line 7—7 of Figure 2,

Figure 8 is a horizontal cross-sectional view taken on the line 8—8 of Figure 2,

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Figure 9 is a horizontal cross-sectional view taken on the line 9—9 of Figure 3,

Figure 10 is a view similar to Figure 6, with the upper confining segments and retaining ring expanded radially,

Figure 11 is a view similar to Figure 7, with the confining segments expanded radially,

Figure 12 is a view similar to Figure 8, showing the lower confining segments expanded radially,

Figure 13 is a view partly in section and partly in elevation illustrating another type of sealing assembly,

Figure 14 is a detail view of the J-slot connection between the lowering conductor or mandrel and the sealing assembly,

Figure 15 is a view similar to Figure 1 of a modified form of the invention,

Figure 16 is a view partly in section and partly in elevation of the upper portion of the form shown in Figure 15,

Figure 17 is a continuation of Figure 16, illustrating the intermediate portion of the form shown in Figure 15, and

Figure 18 is a similar view of the lower portion of the form shown in Figure 15.

In the drawings, the numeral 10 designates a well pipe or tubing which is adapted to be lowered through a well casing 11 in the usual manner. An elongate tubular sealing sub or stem 12 is connected to the lower end of the tubing 10 and this sub has an axial bore 13 extending entirely therethrough; intermediate its ends the sub is formed with an external beveled or inclined annular shoulder 14. An elongate tubular mandrel or support 15 having a diameter substantially equal to the diameter of the tubing 10 has its upper end threaded into the lower end of the sealing sub or stem 12. The external diameter of the portion 12a of the stem 12 which is below the external shoulder 14 is of a greater diameter than the external diameter of the mandrel 15 and the extreme lower end of the portion 12a is beveled or inclined to provide an annular shoulder 16 at the point of connection between the mandrel and the sub. The tubular mandrel or support is formed with a plurality of fluid openings or slots 17 which are spaced downwardly from the shoulder 16. The lower end of the mandrel may be connected by a coupling 18 with a suitable tail pipe 19 (Figure 1).

The mandrel 15 functions as the main support for the well packer and said mandrel has an annular upset portion 20 of enlarged diameter nearer its lower end with the upper end forming an annular external shoulder 21 and its lower end forming an external shoulder 22 on the mandrel. A J-slot 23 (Figure 14) is formed in the upset portion with the vertical leg 23a of the J-slot extending downwardly from the shoulder 21 and the lateral portion 23b of the slot being disposed slightly below the horizontal center of the upset portion. Although it is preferable that the upset be formed integral with the mandrel 15, it is obvious that it could be formed separately as a sleeve member which may be welded or otherwise secured to the external surface of the mandrel.

An anchoring device or assembly A is adapted to be detachably connected with the mandrel or support and includes a slip carrying cage or sleeve 24 which encircles the mandrel (Fig. 3). The cage or sleeve has an inwardly directed lug 25 formed within the lower portion of its bore and said lug 25 is engageable within the J-slot 23 of the mandrel. When said lug is in the lateral portion 23b of the J-slot, the mandrel and cage are interconnected and the mandrel may be utilized to raise and lower the cage within the well casing. Rotation of the mandrel to align the lug 25 with the vertical portion 23a of the J-slot will permit the mandrel to be lowered relative to the cage 24.

An annular expander or cone member 26 surrounds the mandrel above the cage or sleeve 24 and the upper portion 26a thereof is cylindrical while its lower portion

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is formed with a tapered slip-expanding surface 26b. An external annular shoulder 27 is formed intermediate the ends of the expander at the intersection of the lower end of the cylindrical portion 26a and the upper end of the slip-expanding surface 26b. The upper portion of the cylindrical cage 24 encircles the expander 26 and has a flanged retainer collar 28 threaded into its upper end, which collar is of such diameter that it is slidable on the cylindrical portion 26a of the expander 26 above the shoulder 27. Downward movement of the cage or sleeve 24 relative to the expander is limited by the engagement of the lower end of said collar with the shoulder 27 and thus the cage is actually suspended from the expander but said expander may move downwardly relative thereto when the cage is held stationary. The expander or cone member 26 surrounds the mandrel 15 above the upset portion 20 and an internal shoulder S formed within the lower portion of a tubular body 29 which is connected to the upper end of said expander is adapted to engage and be supported upon the annular shoulder 21 formed by said upset portion 20, whereby the expander is suspended from the mandrel but said mandrel may be moved downwardly with respect thereto when the expander is stationary.

The cage or sleeve 24 is formed with a plurality of longitudinal slots 30, arcuate in cross section, which extend through the wall of the cage and which are spaced circumferentially therearound. Slip members 31 are movable radially within the slots and complete outward displacement of such slip is prevented by longitudinal stop ribs 30a on the slip which coact with longitudinal stop shoulders 30b formed at the inner end of the wall of each slot (Figure 9). Each slip member has external gripping teeth 32 while its inner surface is tapered complementary to the tapered surface 26b of the expander or cone member 26 and it will be evident that when the expanding surface 26b is raised with respect to the slips, said slips are in a retracted position; however, when the expanding surface 26b is moved downwardly relative to the slips, the engagement of the complementary tapered surfaces 26b and 33 of the expander and slips, respectively, causes a radially outward movement of the slips whereby the gripping teeth of said slips engage the wall of the well casing 11. To maintain the cage 24 temporarily stationary to allow downward movement of the expander or cone member 26 with respect to the slips during the setting operation the cage 24 carries curved or bowed friction springs 34. The ends of the friction springs are disposed within slots 35 formed in the external surface of the cage and the lower end of each spring is bolted or otherwise secured to the cage. The curved or bowed portion of the springs 34 has constant frictional engagement with the wall of the well casing.

In setting the slips, the parts are run into the well in the position shown in Figure 2 with the lug 25 engaged within the lateral portion 23b of the J-slot which limits the upward movement of the cage 24 with respect to the mandrel. At this time the expander or cone member 26 is suspended from the shoulder S of the body 29 and the cage 24 is suspended from the shoulder 27 of the expander whereby the slips 31 are retracted. When it is desired to set the slips the mandrel is rotated by imparting a rotation to the tubing 10 in a direction which will align the vertical portion 23a of the J-slot with the connecting lug 25, after which a lowering movement of the mandrel with respect to the slip carrying cage 24 is possible. The cage will be held stationary by the frictional engagement of the springs 34 with the wall of the well casing and as the mandrel moves downwardly the expander or cone member 26 also moves downwardly therewith since it is supported on the external shoulder 21. This causes the tapered surface 26b of the expander to move said slips radially outwardly into gripping contact with the wall of the well casing. Upon wedging of the tapered

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surface or cone 26b within the slips, further downward movement of the expander 26 is prevented.

A pressure seal cup 36 of elastic sealing material encircles the lower portion of a sleeve 37 and this sleeve surrounds the mandrel and has its upper end secured to the lower end of the slip carrying cage. A tubular retainer 38 is threaded onto the lower end of the sleeve 37 and abuts the sealing element or cup 36. The seal cup has a downwardly directed flared sealing lip 36a which is in constant engagement with the wall of the well casing 11 within which the device is lowered. The tubular retainer 38 surrounds the mandrel and has a lowermost sealing cup assembly secured thereto.

The lowermost sealing cup assembly includes an annular sealing cup 39 having a pair of flanged sealing lips 39a and 39b which lips are adapted to engage the inner wall of the well casing C and the external surface of the lowering mandrel 15 so as to seal the annular space between these elements. The upper end of the sealing cup 38 is molded to a plurality of arcuate segmental members 40 which coact with each other to form a substantially annular supporting member. The segmental members are unconnected with each other except by the material of the sealing cup and thus, said members may undergo a limited radial expansion or movement. Each segmental member is connected through a headed bolt 41 with a coupling collar 42, which collar has its upper end threaded onto the tubular retainer 38. The coupling collar is formed with a plurality of T-shaped slots 43 which extend inwardly from the bore 42a of the collar and which are adapted to receive the connecting bolts 41. The shoulder 43a formed within each slot (Figure 3) is arranged to be engaged by the enlarged head 41a of the connecting bolt and thus, the lowermost sealing cup assembly is suspended from the collar and is connected by means of said collar 42, retainer 38 and sleeve 37 to the lower end of the cage 24. It is evident that the bolt and slot connection between the segments 40 and the collar 42 permit a radial movement of the segments and therefore when an internal mechanical pressure is applied to the segments and to the lowermost sealing cup 39 a radial movement of these parts is permitted. Since the lowermost sealing cup is connected to the lower end of the slip carrying cage it will be evident that after the slips are set, as has been explained, any pressure below the assembly acting on the cup 39 will urge the cage 24 and the slips 31 mounted in said cage upwardly with respect to the cone 26, whereby the slips will be urged into a tighter gripping engagement with the wall of the well casing.

It is noted that the lowermost sealing cup seals between the casing 11 and the mandrel 15 while the upper seal cup 36 seals only with the wall of the casing. The sealing cup 36 is provided in the event that the outer seal lip 39a of the lowermost cup should fail, in which event the cup 36 will hold the pressure and transmit the force of such pressure to the cage 24.

The tubular expander or cone member 26 is adapted to support an annular sealing assembly B and this sealing assembly is clearly shown in Figures 2 and 4. The sealing assembly includes an annular elastic packing collar 44 having its lower end molded to arcuate segmental retaining members 45 with its upper portion molded to arcuate segmental retaining members 46. The material of the packing element or sleeve 44 is extended upwardly and is formed into an upper seal cup 47 having upwardly directed sealing lips 47a and 47b and this sealing cup packs off between the well casing 11 and the external surface of the mandrel 15 (Figure 2). The lower segmental retaining members 45 are unconnected with each other except by the material of which the packing element or sleeve 44 is constructed and each member is adapted to be connected by a bolt 48 with a coupling collar 49. The collar 49 has a plurality of inverted T-shaped slots 50

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therein and each slot receives one of the bolts with the bolt head 48a abutting the shoulder 50a formed within the slot. With this connection the metallic arcuate segments 45 may undergo a radial movement with respect to the collar 49 and yet upward displacement of the segments from the collar is prevented by the retention of the bolt heads within the inverted T-slots.

The tubular body 29 which has its lower end threaded onto the upper end of the expander 26 and has its upper end connected with the collar 49 has an axial bore 52 of substantially the same diameter as the external diameter of the mandrel 15. An annular recess or cavity 53 (Figure 4) is formed in the body 51 and an annular pressure seal element 54 is disposed within this cavity. The pressure seal element is provided with sealing lips 55 and 56 which engage the exterior surface of the mandrel 15 and function to seal off therewith. The purpose of the pressure seal member 54 is to coact with the by-pass slots 17 in the mandrel after the device is set within the well casing as will be hereinafter explained. It is obvious that any pressure acting on the uppermost seal cup 47 will be transmitted as a downward force onto the packing member 44 and then through the lower segmental retaining members 45, body 29 and to the expander 26, thereby urging the expander in a direction which will increase the gripping action of the gripping slips 31.

The upper confining or retaining members 46 are also segmental and are unconnected from each other except for the material of which the packing sleeve 44 is formed. The joints 46a between the members 46 may in some instances provide a space through which the material of the packing sleeve 44 may be extruded upwardly and to prevent this extrusion, the segmental retaining or confining members 46 are formed with an external groove 46c on their outer surfaces. The grooves 46c being in the same horizontal plane form a substantially continuous annular groove around the members 46 and this groove is adapted to receive arcuate segments 57 which coact with each other to form a substantially continuous retaining ring. The joints 57a between the sections of the ring 57 are offset or staggered with respect to the joints 46a between the confining members 46 and thus the sectional ring 57 functions to prevent extrusion of material upwardly between the joints 46a (Figure 6).

The bore 58 formed by the segmental confining members 46 is of slightly larger diameter than the external bore of the mandrel 15 (Figure 2) and each segment is formed with an internal groove 59 with said grooves coacting with each other to provide an annular recess for the reception of a seating ring 60. This seating ring has a beveled seat 61 which is at its upper surface and the internal diameter of the ring is substantially equal to the enlarged lower portion 12a of the connecting sub or stem 12. Thus, when the mandrel 15 is lowered with respect to the sealing assembly B the enlarged lower portion 12a thereof may enter the upper sealing cup 47 and move downwardly through the sealing ring and also through the bore 58 of the confining members 46. The shoulder 14 on the sub 12 is adapted to engage the seat 61 to limit the downward movement of the mandrel with respect to the sealing assembly. The engagement of the shoulder 14 with the seat 61 not only limits downward movement of the mandrel but also permits application of tubing weight to the tubing assembly and at the same time locates the by-pass opening 17 in the mandrel directly opposite the sealing member 54 so that said by-pass openings will be automatically closed. Prior to engagement of the shoulder 14 with the seat 61 the enlarged portion 12a of the sub moves through the upper seal cup 47, upper confining members 46 and through the annular packing sleeve 44 to apply a mechanical radial pressure to these parts to move the same radially outwardly of said mandrel; after such initial mechanical displacement pressure acting on the upper seal cup may complete the radial movement

of the sleeve into sealing position with the well casing or the imposition of tubing weight through the shoulder 14 may complete such displacement. As the mandrel 15 moves downwardly relative to the assembly the enlarged portion 20 on the mandrel in which the J-slot is disposed moves within the segmental confining members 40 of the lowermost seal cup 39 and also within said seal cup to displace these parts radially outwardly.

As the shoulder 14 engages the seat 61 and tubing weight is applied, the coaction between the beveled seat and the beveled external shoulder 14 of the sub 12 results in a further radial expansion of the upper confining members so that said members are further expanded at the same time that end-wise compression is applied to the sleeve 44. When the confining members 46 are moved into contact with the wall of the casing 11 no further application of tubing weight may be applied to the packing sleeve 44 and thus the confining members function to prevent the application of excessive tubing weight to the assembly. It is pointed out that by the time the shoulder 14 has engaged the seat 61 of the ring 60 the enlarged diameter portion of the mandrel 12 above the shoulder 14 is within the uppermost sealing cup 47 and has further distorted or displaced the sealing cup outwardly to increase the sealing action between the lips of the seal cup and the walls of the casing and mandrel.

In the operation of the device the tubular mandrel or support 15 which is coupled to the lower end of the well tubing string 10 is connected by means of the J-slot 23 and the lug 25 to the slip carrier and the parts are in the position shown in Figures 1 to 3 with the slip expander or cone member 26 supported on the shoulder S and with the slip cage 24 suspended from the shoulder 27 of the expander whereby the slips 31 are in a retracted position. At this time the packing member or sleeve 44 is in a normal undistorted position and the upper confining segments 45 as well as the lower confining segments 45 are in a normal inward position. The confining segments 40 of the lowermost seal cup are also in an inner position. The by-pass openings or slots 17 in the mandrel 15 are disposed above the upper sealing cup 47 and the sealing sub or stem 12 is of course located above said openings. The lowermost seal cup 39 has its sealing lips 39a and 39b engaging the casing and mandrel, respectively, to seal off the annular space therebetween. The upper sealing cup 47 also has its sealing lips 47a and 47b engaging the casing and the mandrel to seal off between these parts.

As the assembly is lowered downwardly through the well the seal cups 39 and 47 pack off the anchoring mechanism A and sealing assembly B from contact with the fluid which might be present within the casing so that said fluid or any debris or extraneous material present within the well bore cannot contact said slips and the packing member 44. During the lowering, fluid may pass upwardly through the tail pipe 19 and through the bore 15a of the mandrel 15 and then through the by-pass openings 17 into the area above the sealing assembly. To prevent a pressure lock in the area between the upper seal cup 47 and the lower seal cups 36 and 39, a small bleed port 15b is provided in the mandrel and this port communicates with the area between the seal cups when the mandrel is connected to the slip carrier. The port is of such small size that larger particles of extraneous matter which might be present in the fluid within the well casing and which may be carried upwardly through the mandrel cannot pass therethrough. This free by-pass of fluid through the device during lowering provides for substantially no resistance by the fluid to the lowering operation and facilitates proper positioning of the device within the well casing.

When the position at which the packer is to be set is reached the well tubing 10 is rotated to impart a rotation to the mandrel and thereby move the vertical portion 23a of the J-slot 23 into alignment with the connection lug

25 of the slip carrier cage and thereafter the mandrel and tubing may be moved downwardly with respect to the assembly. The slip carrier or cage 24 is held stationary by the frictional engagement of the curved friction springs 34 and also by the frictional engagement of the lower seal cups 36 and 39 with the wall of the well casing and as the mandrel is lowered the expander or cone member 26 moves downwardly relative to the gripping slips whereby the gripping slips 31 are expanded into firm engagement with the wall of the well casing. As soon as the gripping slips engage the casing, as shown in Figure 4, a further downward movement of the expander 26 is prevented and since the expander is directly connected through the tubular body 29, coupling collar 49 and bolts 48 with the sealing assembly B further downward movement of said assembly is halted.

Lowering of the tubing 10 is thereafter continued until the lower enlarged diameter portion 12a of the sub 12 enters the bore of the upper seal cup 47. Because the portion 12a is of a larger external diameter than the mandrel 15, an outward radial pressure is applied to the seal cup 47 whereby the sealing lips thereof are more firmly engaged with both the wall of the well casing and the exterior of the portion 12a of the mandrel to increase the sealing effectiveness. Continued lowering of the tubing causes the portion 12a of the sub to engage the bore 53 formed by the upper retaining segments 46 and to apply an outward radial force to said segments so that the outer or peripheral surfaces thereof are moved into close proximity with the wall of the well casing. Further lowering of the well tubing causes entry of the portion 12a into the bore 44a of the packing sleeve 44 to apply an outward radial force to the sleeve and to displace the exterior surface of said sleeve into close proximity or possibly into contact with the wall of the well casing. After passing through the sealing element the lower end 16 of the sub will contact the upper inner edges of the lower confining segments 45 and will function to displace these segments radially outwardly. At the same time that the portion 12a of the sub is displacing the packer sleeve 44 and its segments, the enlarged portion 20 of the mandrel has moved within the segments 40 and within the lowermost seal cup 39 to assure more efficient sealing action of said lowermost cup.

By the time that the portion 12a has displaced the confining or retaining segments and the packing sleeve 44 radially outwardly the external shoulder 14 on the sub has engaged the beveled shoulder 61 of the seating ring 60 and the by-pass openings 17 in the mandrel have moved opposite the sealing member 54 within the tubular body 29, as shown in Figure 4. When this occurs the openings 17 are in effect closed and any further by-pass of fluid through these openings is shut off. Thereafter the pressure from below the device acts in an upward direction against the lowermost seal cup 39 to urge the slip carrier and slips upwardly while any fluid pressure in the annulus above the packer acts downwardly on the upper seal cup 47 to apply an end-wise compression to the packing sleeve 44 and through the sleeve to apply a downward force on the expander 26. Therefore, in actual practice, by the time the parts have assumed the position shown in Figure 4 with the shoulder 14 engaging the shoulder 61 the differential in pressure across the packer has not only moved the gripping slips into a firm engagement with the wall of the well casing but also sufficient pressure has been applied to the packing sleeve 44 to deform the same into a tight sealing engagement with the wall of the well casing. In many instances, this pressure is sufficient to maintain the packing sleeve 44 in an efficient sealing position and so long as a differential is maintained across the packer the packing member will remain in a set position.

If the pressure in the annulus acting downwardly on the upper seal cup 47 is excessive the end-wise compressive force applied to the sleeve 44 may cause the

material of said sleeve to extrude or creep upwardly around the segments 46 which is, of course, undesirable. To prevent such extrusion and creeping and also to utilize some of the weight of the tubing string to assure tight sealing engagement of the packing sleeve 44 with the casing the tubing string may be slacked off after engagement of the shoulder 14 with the shoulder 61 within the upper confining segments. This applied weight to the upper segments and the coaction between the beveled shoulders 14 and 61 results in a further downward radial displacement of the upper segments 46 and simultaneously results in the imposition of additional end-wise compressive force to the packing sleeve 44. The segments 46 are expanded radially outwardly until their outer surfaces engage the wall of the well casing and when this position is reached (Figure 4) no further weight can be applied to the assembly through the tubing. The outward displacement of the arcuate segments 46 into contact with the well casing not only limits the application of further tubing weight to the packing member 44 but also closes the annular space between the segments and the casing and thereby functions to confine the packing member below the segments whereby any further application of end-wise pressure to the packing member by fluid pressure applied through the upper seal cup cannot extrude the material of the upper packing sleeve around the segments 46. As has been pointed out the segmental ring 57 which is mounted on the exterior surface of the members 46 spans the joints 46a between the segments and prevents extrusion of packing material through these joints.

With the packer in its set position the by-pass openings 17 in the mandrel are disposed opposite the sealing element 54 in the body 51 and any pressure flowing upwardly through the mandrel is merely trapped by the sealing element 54 so that there is no by-pass around the packer. The packer may thus be employed as the usual production packer to allow a flow upwardly through the mandrel and tubing string.

When in a set position the pressure from below is transmitted to the slip cage 24 while the pressure from above is transmitted to the expander 26 and thus these pressures are utilized to constantly increase the gripping force of the slips. When it is desired to remove the packer, it is only necessary to lift upwardly on the tubing string to withdraw the sub 12 from within the sealing assembly B. As the portion 12a of the sub 12 moves from within the packing sleeve 44 the inner radial force which was exerted by this portion is immediately removed and as soon as the slots 17 move upwardly beyond the internal sealing element 54, pressures across the packer are substantially equalized because pressure within the mandrel may flow into the area between the mandrel and the packing member 44 as well as between the packing member and the casing. As this pressure is equalized any normal elasticity left in the packing member 44 will naturally function to pull the periphery of the packing sleeve away from the wall of the well casing.

Raising of the tubing is continued until the shoulder 21 on the mandrel engages the connecting lug of the cage after which the tubing is rotated to align the vertical portion 23a of the J-slot with said lug so that the shoulder 21 may move upwardly into engagement with the shoulder S at the upper end of the expander or cone member 26. At this time, the by-pass slots 17 have moved above the upper seal cup and pressures above and below the entire assembly are equalized. In the event that the packing sleeve 44 has not retracted from the casing wall the shoulder 21 may be utilized to jar upwardly on the shoulder S and such jar is imparted to the packing member. This jar is longitudinally of the member 44 and will tend to break the adherence of the surface 44 with the wall of the well casing. After the expander 26 has been lifted with respect to the cage 24 the lug 25 is re-engaged with the lateral portion 23b of

the J-slot and thereafter the entire assembly may be removed from the well casing by means of the tubing string. It is, of course, evident that as the enlarged portion 12a of the sub moves from between the confining segments as well as from within the bore of the packing member, the packing member as well as the segments may be retracted radially inwardly to their normal unexpanded position; at the same time the enlarged portion 20 on the mandrel moves from within the lowermost cup 39 and its segments 40 to relieve the internal outward pressure on these parts.

The form of the invention shown in Figures 1 to 12 provides a so-called production packer which has a by-pass means during lowering, with said means being completely shut off when the packer is in its set position. It is not necessary that the packing element be an annular sleeve as shown and described with reference to Figures 1 to 12, and in Figure 13 a slightly modified form of sealing assembly B' is shown. In this form of the invention a plurality of superposed packing collars 70 are substituted for the single annular packing sleeve 44. The lowermost collar 70 is molded to retaining or confining segmental members 145 and said lower confining members are supported upon a coupling collar 149. The lower segmental members 145 are connected to the collar 149 by through bolts 71, each of which has its head 72 engaging the shoulder 73 formed within an inverted T-slot 74, with said T-slots being cut in the coupling collar 149. Each bolt extends upwardly through an opening 74 in one of the segments and then upwardly through openings 75 in the superposed packing collars. The upper end of each through bolt 71 is threaded into the bottom of an arcuate segmental member 146 and the members 146 are similar to the segmental members 46 of the first form and provide an upper confining unit. The upper segmental members are molded within the base of an upper seal cup 147 which has its sealing lips 147a and 147b directed upwardly and sealing between the well casing 11 and the mandrel 15. Each segment 146 has a bore 146a which is slightly larger than the enlarged portion 12a of the sub whereby the portion 12a may pass therethrough. An inclined shoulder 146b at the upper inner edge of each segment 146 is adapted to be engaged by the external shoulder 14 of the sub 12. The operation of this form is identical with the first form of the invention. When the packer is to be set the mandrel 15 is moved downwardly to move the enlarged portion 12a of the sub 12 through the upper seal cup 147 and through the superposed packing collars 70. The enlarged portion 12a of the sub thus functions to apply a mechanical pressure which displaces the confining segments and the packing collars radially outwardly. Downward movement of the mandrel 15 continues until the external shoulder 14 thereon engages the shoulder 146b formed by the upper inner edges of the segments 146 and thereafter tubing weight may be applied to further expand the segments and to apply additional end-wise compressive force to the collars 70; the application of tubing weight will be limited by the engagement of the outer surface of the segments 146 with the inner wall of the well casing. It is evident that the form of sealing arrangement shown in Figure 13 has all of the advantages of the sealing assembly illustrated in Figures 1 to 12.

In Figures 15 to 18 a slight modification of the well packer is illustrated. Where it is desired to employ the packer for squeeze operations for introducing acid, cement or other material into the well bore at some distance below the lowermost sealing cup, it is desirable to provide an inner conductor which will permit a downward flow through the packer assembly when the by-pass openings 17 are closed. In this case, a mandrel 115 is substituted for the mandrel 15 and is substantially identical in construction with the mandrel 15 except that its lower end terminates just below the lowermost seal cup 39 when the mandrel is coupled to the packer by

means of the J-slot (Figure 17). This lower end of the mandrel 115 is reduced and is provided with openings 117a. The mandrel 115 has by-pass openings 117 in its upper portion, these openings being similar to the by-pass slots 17 of the mandrel 15. The mandrel 115 is connected with a sub 112 which is similar to the sub 12 in that it has a portion 112a which is slightly larger than the mandrel 115 to provide a shoulder 116 therebetween. An external shoulder 114, similar to the shoulder 14 of the first form is provided on the mandrel 112.

Internally the mandrel 112 is modified and is provided with a bore 112b. The upper portion of this bore is enlarged and internally threaded at 112c (Figure 16) for connection with the tubing string 10. Internal screw threads 112d are formed within the bore nearer the lower portion thereof and below these threads the bore is enlarged and threaded at 112e for connection with the mandrel 115. The intermediate threads 112d have the upper end of an inner conductor 100 threaded therein and this conductor extends downwardly throughout the length of the mandrel 115 and extends from the lower end thereof. The lower reduced portion of the mandrel 115 (Fig. 18) engages the external surface of the inner conductor 100 and is sealed therewith. The inner conductor is connected by a coupling 101 with a suitable tail pipe 102.

The mandrel 115 is substituted for the mandrel 15 of the first form and provides the main supporting element for a slip assembly A and a sealing assembly which is illustrated as the sealing assembly B' shown in Figure 15. The mandrel 115 is coupled to the slip assembly through the J-slot connection as hereinbefore described and when so coupled, the parts are as shown in Figure 15. In this position the by-pass openings 117 are disposed above the upper seal cup 147 and the openings 117a are located below the lower seal cup 39. In such position it is evident that a by-pass of fluid may occur through the openings 117a and upwardly through the annular space 100a which is formed between the inner conductor 100 and the mandrel 115 and then upwardly into the area above the assembly through the openings 117 in the upper portion of said mandrel. Thus, the device may be lowered into position within the well casing. The small bleed port 115b in the mandrel 115 serves to prevent a pressure lock between the seal cups in the same manner as port 15b in mandrel 15 of Figures 1-12.

Setting of the device shown in Figures 15 to 18 is accomplished in the same manner as has been described with reference to the first form of the invention, that is, the mandrel is rotated and moved downwardly with respect to the gripping slip assembly and the sealing assembly. As the mandrel 115 moves downwardly the openings 117 in the mandrel move opposite the internal sealing element 54 which is mounted within the tubular body 29 just above the expander 26 and as has been explained, this results in a closing of the openings 117. Thus, any attempted flow upwardly through the openings 117a in the lower end of the mandrel 115 and then through the openings 117 is prevented and the by-pass through the mandrel is completely shut off.

The inner conductor 100 has its upper end in communication with the tubing and it is apparent that fluid may be conducted downwardly through the tubing and then through the conductor to the tail pipe 102. The tail pipe may be of any desired length to discharge the material at any point within the well bore below the packer. The gripping slip or anchoring assembly A as well as the sealing element B' which is shown combined with the mandrel 115 and the inner conductor 100 function in the same manner as has been described with reference to the other forms of the invention.

From the above it will be seen that a composite well packer has been provided which makes it possible to carry out substantially any well operation which requires a packer. Through the use of the sub 12 and mandrel

15 in connection with the anchoring and gripping assemblies an ordinary production type packer is had. By merely substituting the mandrel 115 and sub 112 together with the inner conductor or pipe an efficient squeeze type packer is produced. Where no appreciable pressure is present in the annulus above the upper seal cup 47 or 147, it may be possible to eliminate the upper seal cup and to rely upon the weight of the tubing as imposed through the upper segments of the sealing assembly to maintain the packing member in its set position. Also, it is evident that the intermediate lower seal cup 36 may be omitted, in which event the lower seal cup 39 would be directly connected through the tubular retainer 38 with the lower end of the slip carrying cage 24.

It is noted that the invention contemplates the initial mechanical expansion of the sealing cups and packing element by the movement of the enlarged diameter portions of the mandrel within such parts, after which the pressure acting on the seal cups further expands and maintains the same in sealing position.

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 structure.

It will be understood that certain features and sub-combinations 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.

Having described the invention, I claim:

1. A well packer including, a tubular support adapted to be lowered within a well casing, an anchoring assembly slidably mounted on said support and including a slip carrying sleeve, casing gripping slips laterally slidable in said sleeve, and a slip expanded slidable on said support and relative to said sleeve to expand said slips, connecting means releasably connecting said support to said sleeve for holding said sleeve against longitudinal movement on said support, means on said sleeve for holding it stationary in said casing, means for holding said expander against movement toward said slips during the lowering of the packer into the well casing whereby said anchoring slips are prevented from moving into gripping position with the well casing while said support and anchoring assembly are connected, release of said connecting means permitting a longitudinal movement of said support relative to said sleeve and also permitting relative movement of said slips and said expander into engagement with each other for moving said slips into gripping engagement with the well casing, an annular radially expandable seal member having connection with said slip carrying sleeve and movable longitudinally therewith, said holding means for said slip expander comprising an annular radially expandable seal member having connection with said slip expander and movable longitudinally therewith, said seal members being sealingly engageable with the support and the well casing within which the support and the assembly are lowered, and means on the support adapted to engage and coax with the bores of the seal members to impart a radially outward movement to said members when the support is moved longitudinally of the anchoring assembly and members, whereby efficient sealing engagement between the members and the well casing and support is assured.

2. A well packer including, a tubular support adapted to me lowered within a well casing, an anchoring assembly slidably mounted on said support and including a slip carrying sleeve, casing gripping slips laterally slidable in said sleeve, and a slip expander slidable on said support and relative to said sleeve to expand said slips, connecting means releasably connecting said support to said

sleeve for holding said sleeve against longitudinal movement on said support, means on said sleeve for holding it stationary in said casing, means for holding said expander against movement toward said slips during the lowering of the packer into the well casing whereby said anchoring slips are prevented from moving into gripping position with the well casing while said support and anchoring sleeve are connected, release of said connecting means permitting a longitudinal movement of said support relative to said sleeve and also permitting relative movement of said slips and said expander into engagement with each other for moving said slips into gripping engagement with the well casing, said holding means for said slip expander comprising an annular packing element surrounding the support and secured to the slip expander, an upper annular radially expansible seal member secured to the upper end of the packing element, a lower annular radially expansible seal member secured to the slip carrying sleeve, said seal members and packing element being sealingly engageable with the support and the well casing within which the support and the assembly are lowered, and means on the support adapted to engage and co-act with the bores of the seal members and packing element to impart a radially outward movement to said members and element when the support is moved longitudinally of the anchoring assembly, members and element, whereby efficient sealing engagement between the members and element and the well casing and support is assured.

3. A well packer as set forth in claim 1, wherein the seal member having connection with the slip expander is positioned above said expander and wherein the seal member having connection with the slip carrying sleeve is positioned below said slips, said seal members being exposed to the fluid pressure of the well fluid in the annular space between the support and the well casing, whereby said pressure assists in maintaining the seal members in sealing position.

4. A well packer as set forth in claim 1, wherein the seal members are exposed to pressure in the annular space above and below said members whereby these pressures urge the members into sealing position and in a direction toward each other, and the connection of the seal members to the slip carrying sleeve and the slip expander of the anchoring assembly serving to transmit the force of the pressure acting against the seal members to the anchoring assembly to thereby increase the gripping action of said assembly.

5. A well packer as set forth in claim 2 wherein the upper and lower seal members comprise annular seal cups with the upper cup being exposed to pressure in the annular space between the support and well casing thereabove and with the lower seal cup being exposed to pressure in the annular space between the support and well casing therebelow, whereby said pressures maintain the seal cups in sealing position.

6. A well packer as set forth in claim 2 wherein the upper and lower seal members comprise annular seal cups with the upper cup being exposed to pressure in the annular space between the support and well casing thereabove and with the lower seal cup being exposed to pressure in the annular space between the support and well casing therebelow, whereby said pressures maintain the seal cups in sealing position, and the connection of the seal cups to the slip carrying sleeve and slip expander of the anchoring assembly permitting the pressure acting on said seal cups to be transmitted to the anchoring assembly as an applied force which increases the gripping action of said assembly.

7. A well packer as set forth in claim 2 wherein the packing element comprises an annular elastic collar having its ends confined by arcuate confining segments which are capable of limited radial expansion whereby said segments may move radially as the packing element

is radially expanded by the coaction with the means on the support.

8. A well packer as set forth in claim 2 wherein the packing element comprises a plurality of superposed packing collars and arcuate segmental confining members at each end of the superposed collars, together with means extending through the collars for connecting the confining segments together, whereby the confining segments may undergo radial expansion with the packing element.

9. A well packer as set forth in claim 1, wherein the seal member connected to the slip expander is the upper seal member and wherein the tubular support is formed with a by-pass opening which is located above the upper seal member when the support is connected with the anchoring assembly, said by-pass opening being movable downwardly into the anchoring assembly upon detachment and longitudinal movement of the support with respect to the assembly, and sealing means within the assembly coacting with the support to close the by-pass opening.

10. A well packer as set forth in claim 1, wherein the seal member connected to the slip expander is the upper seal member and wherein the tubular support is formed with a by-pass opening which is located above the upper seal member when the support is connected with the anchoring assembly, said by-pass opening being movable downwardly into the anchoring assembly upon detachment and longitudinal movement of the support with respect to the assembly, sealing means within the assembly co-acting with the support to close the by-pass opening, an inner conductor extending axially through the tubular support, and means for sealing the annular space between the upper end of the conductor and the support, whereby when the by-pass opening in the support is closed flow through the annular space between the support and conductor is prevented.

11. A well packer including, a tubular support adapted to be lowered within a well casing, an anchoring assembly slidably mounted on said support and including a slip carrying sleeve casing gripping slips laterally slidable in said sleeve, and a slip expander slidable on said support and relative to said sleeve to expand said slips, connecting means releasably connecting said support to said sleeve for holding said sleeve against longitudinal movement on said support, means on said sleeve for holding it stationary in said casing, means for holding said expander against movement toward said slips during the lowering of the packer into the well casing whereby said anchoring slips are prevented from moving into gripping position with the well casing while said support and anchoring assembly are connected, release of said connecting means permitting a longitudinal movement of said support relative to said sleeve and also permitting relative movement of said slips and said expander into engagement with each other for moving said slips into gripping engagement with the well casing, a lower seal member secured to the slip carrying sleeve and including an annular radially expansible seal cup having downwardly flared sealing lips and having its upper portion confined by separate arcuate segments which are attached to the material of the seal member, said expander holding means including a packer element surrounding the support and secured to the slip expander of the anchoring assembly and having its ends confined by arcuate segmental members which may undergo limited radial movement, said seal member and said packer element being sealingly engageable with the support and the well casing, and means on the support adapted to engage and co-act with the bores of the packer element and the lower seal member for imparting a radially outward movement to said member and element and their confining segments when the support is moved longitudinally of said seal member and said packer element.

12. A well packer as set forth in claim 11, wherein the means on the support which co-acts with the bores

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of the seal member and the packer element comprises enlarged diameter portions formed on said support.

13. A well packer as set forth in claim 11, said expander holding means including an upper seal member disposed above and connected with the packer element and including upwardly directed sealing lips for sealing off the space between the support and the well casing within which the support is lowered.

14. A well packer as set forth in claim 11, wherein the support is provided with a by-pass opening which is located above the packer element when the support is attached to the anchoring assembly, said by-pass opening being movable into the anchoring assembly upon release of the connecting means and longitudinal movement of the support with respect to the assembly, and sealing means within the anchoring assembly for sealing off and closing the by-pass opening in said support when said by-pass opening moves opposite said sealing means.

15. A well packer as set forth in claim 11, wherein the support is provided with a by-pass opening which is located above the packer element when the support is attached to the anchoring assembly, said by-pass opening being movable into the anchoring assembly upon

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release of the connecting means and longitudinal movement of the support with respect to the assembly, sealing means within the anchoring assembly for sealing off and closing the by-pass opening in said support when said by-pass opening moves opposite said sealing means, and an inner conductor extending longitudinally through the support and having its upper end connected with said support, the connection between the inner conductor and the support closing the annular space between the exterior surface of said conductor and the bore of the support, whereby closure of the by-pass opening permits flow only through the inner conductor.

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