Feb. 29, 1944. H. C. OTIS 2,343,075

LOCKING MECHANISM FOR WELL TOOLS

Filed Nov. 12, 1940 3 Sheets-Sheet 1

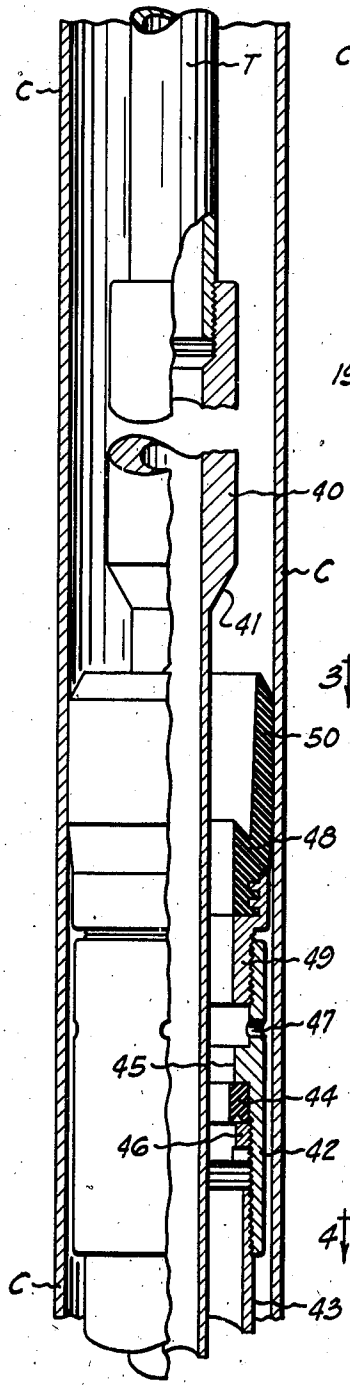


Fig. 1.

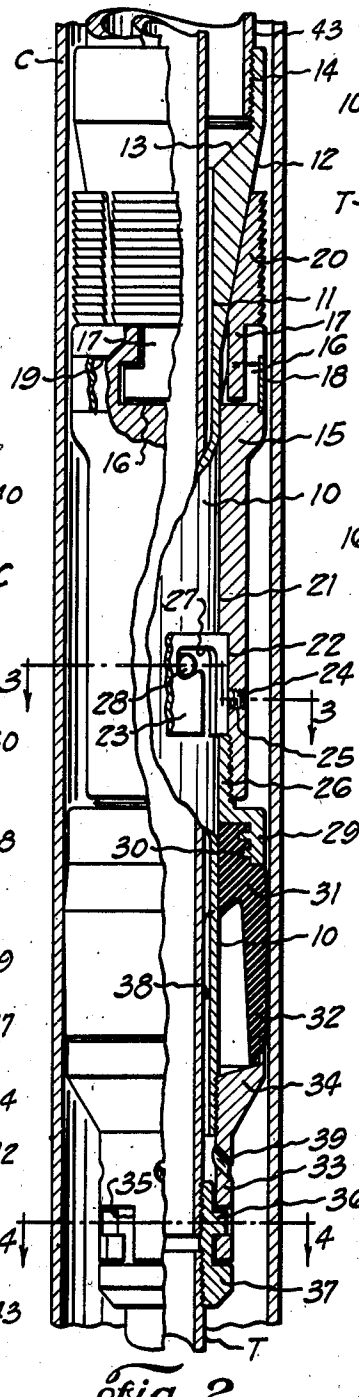


Fig. 2.

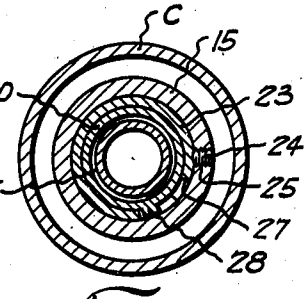


Fig. 3.

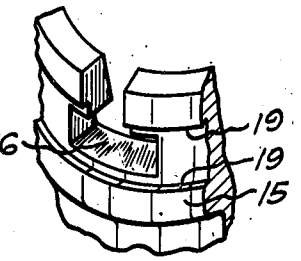


Fig. 5.

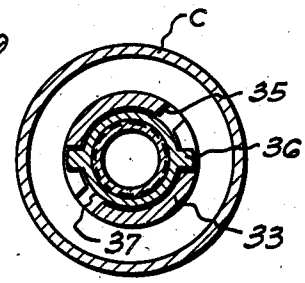


Fig. 4.

Inventor
Herbert C. Otis
Jack A. Ashley
Attorney

Feb. 29, 1944. H. C. OTIS 2,343,075

LOCKING MECHANISM FOR WELL TOOLS

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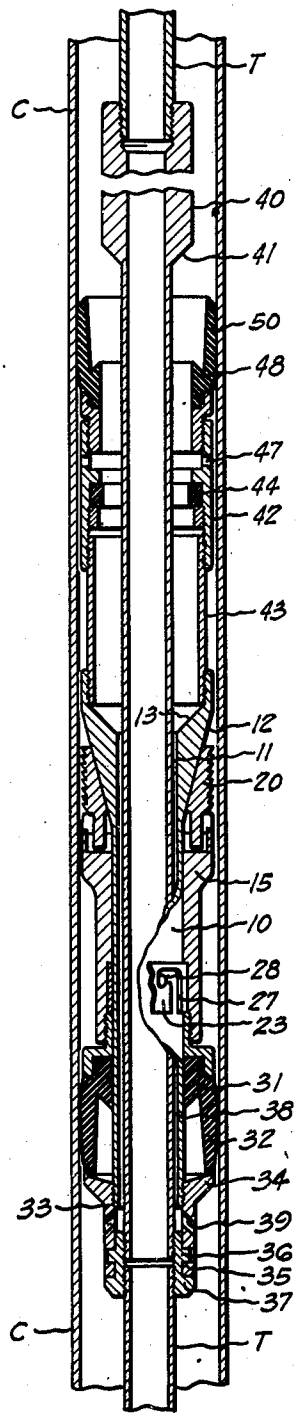


Fig. 6.

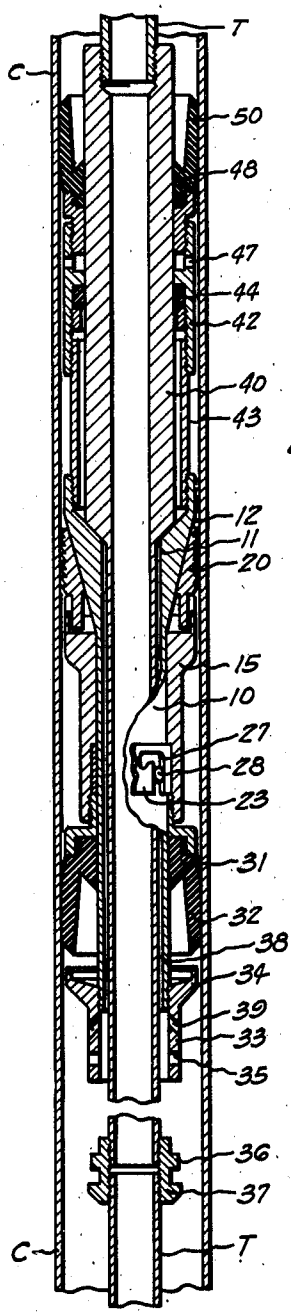


Fig. 7.

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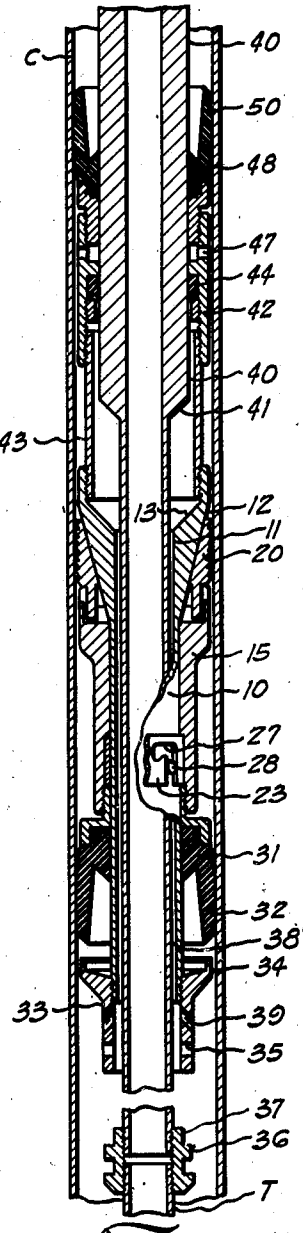


Fig. 8.

Inventor
Herbert C. Otis

Jack A. Ackley

Attorney

Feb. 29, 1944. H. C. OTIS 2,343,075

LOCKING MECHANISM FOR WELL TOOLS

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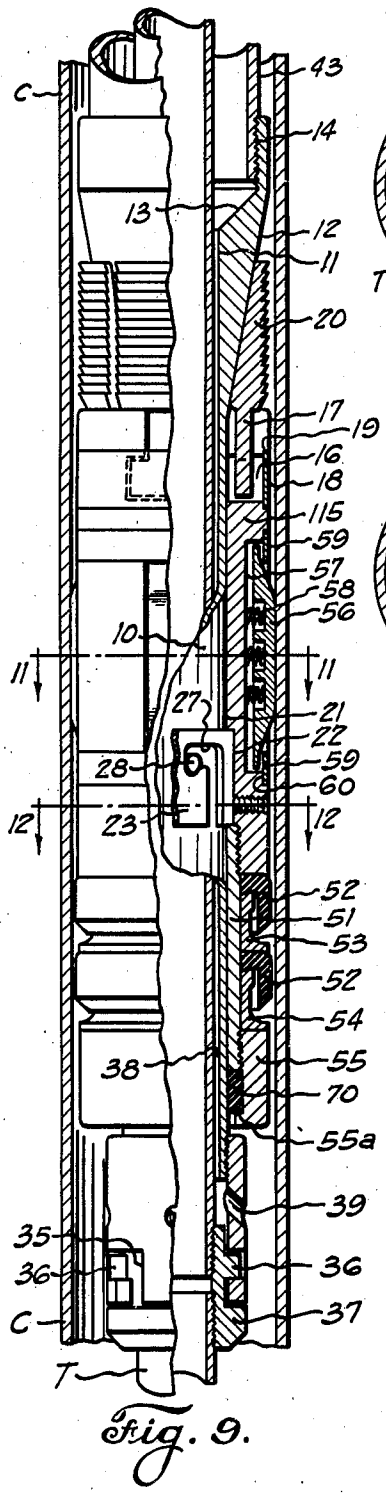


Fig. 9.

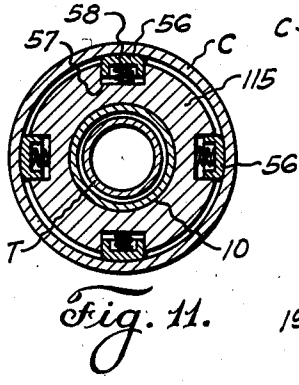


Fig. 11.

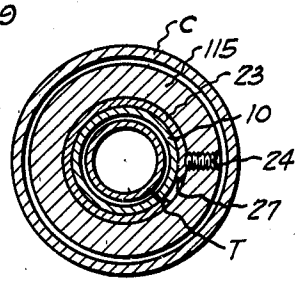


Fig. 12.

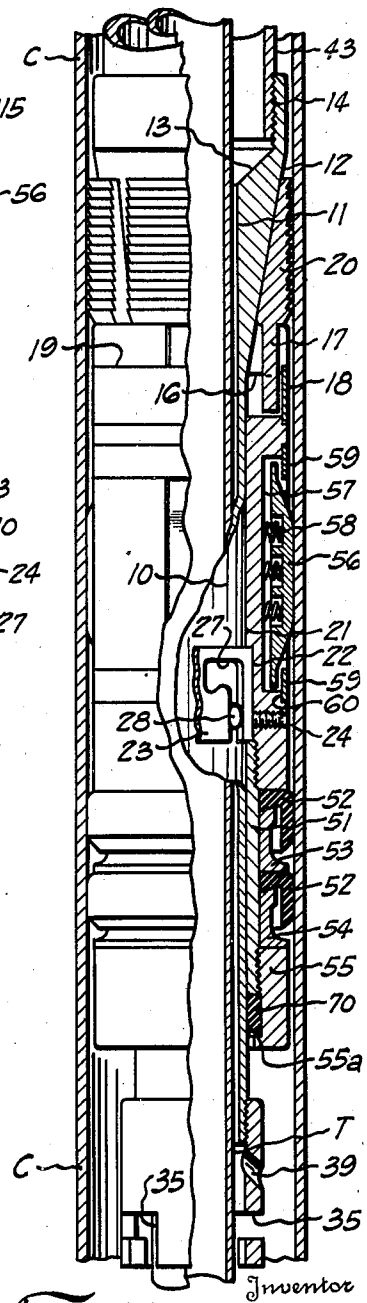


Fig. 10.

Inventor

Herbert C. Otis

By

Attorney

Patented Feb. 29, 1944 2,343,075

UNITED STATES PATENT OFFICE

2,343,075

LOCKING MECHANISM FOR WELL TOOLS

Herbert C. Otis, Dallas, Tex.

Application November 12, 1940, Serial No. 365,394

15 Claims. (Cl. 166—12)

This invention relates to new and useful improvements in locking mechanisms for well tools.

One object of the invention is to provide an improved locking mechanism which is particularly adaptable for use with well packers, although it may be employed with other well tools which are to be lowered and locked against displacement within a well bore.

An important object of the invention is to provide an improved locking mechanism for well tools which is arranged to be maintained in a locked position within a well bore independently of the well tubing or string of pipe, whereby the weight of said tubing is not depended upon to hold the mechanism in its set position, the assembly being constructed so that when set, displacement in both directions is prevented.

A particular object of the invention is to provide an improved locking mechanism which is so constructed that an applied force from either direction, either above or below, on said mechanism increases the gripping or locking action thereof to more firmly lock the mechanism in its set position; the arrangement of said mechanism making it possible to utilize the fluid pressures above and below, or only the fluid pressure below the mechanism, for constantly urging the locking mechanism to its set position and thereby prevent accidental or unintentional displacement of the device.

Another object of the invention is to provide an improved locking mechanism having a support with locking elements adapted to coact with the support and arranged to be expanded and retracted upon a relative movement of the support with respect to the elements; said elements being exposed to the fluid pressure below the assembly whereby said fluid pressure constantly exerts an upward force against the elements to urge the same toward their locking position, together with means for balancing the action of the fluid pressure from below on the support, whereby said support is not urged upwardly by such pressure but remains stationary and functions as a spacer between the locking elements to hold said elements in their locking position.

Another object of the invention is to provide an improved locking mechanism, of the character described, including a mandrel having locking elements movable radially outwardly into gripping position upon a relative downward movement of the mandrel with respect to said elements, together with means for utilizing the fluid pressure below the device for constantly urging the parts in a direction holding the elements in their locking position, whereby displacement of the device in either direction is prevented; the locking elements being readily retractible from their locking position by an upward movement of the mandrel with relation to said elements, whereby removal of the device from the well bore may be accomplished at any desired time and without the necessity of rotation of any of the parts.

A further object of the invention is to provide an improved locking mechanism, of the character described, which has the well tubing or production string extending therethrough and detachably connected thereto, whereby said tubing may be employed to lower the mechanism into the well casing to the position at which the same is to be set, and after setting of the mechanism, said tubing may be disconnected therefrom so as to hang free and be capable of independent movement through said mechanism, whereby "landing" of the tubing in its surface support, as well as running of bottom hole devices through the tubing, are facilitated; the mechanism having means which will co-act with the tubing to support said tubing to prevent the entire string of tubing from falling to the bottom of the well bore in the event the tubing parts above the mechanism and falls downwardly.

Still another object of the invention is to provide an improved mechanism, of the character described, which is particularly adaptable for use in combination with a well packer having a packing means which is held in its sealing position by fluid pressure, the device being so constructed that fluid pressures across the packing means may be equalized during running in and removal of the device from the well to facilitate these operations.

Another object of the invention is to provide an improved device, of the character described, which may be combined with a well packer and lowered into the well bore on a production string or tubing and which may have a by-pass means arranged so that a free circulation of well fluid may be had, either prior or subsequent to the setting or locking of the assembly within the well bore, said by-pass being adapted to be opened and closed by a longitudinal movement of the tubing relative to said assembly; the device being particularly adapted for use in unloading wells which have been "killed" or loaded by a mud, or other fluid, column.

A construction designed to carry out the in-

vention will be hereinafter described together with other features of the invention.

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

Figure 1 is a view, partly in elevation and partly in section, of the upper portion of a device, constructed in accordance with the invention, and illustrating the same combined with a well packer,

Figure 2 is a view similar to Figure 1, being a continuation of the parts shown in Figure 1 and ilustrating the lower portion of the device,

Figures 3 and 4 are horizontal, cross-section views, taken on the lines 3—3 and 4—4, respectively, of Figure 2,

Figure 5 is a partial isometric view of the upper portion of the slip carrier,

Figure 6 is a schematic view of the complete assembly and shows the parts in position during the lowering of the device in the well, a circulation past the packer being possible,

Figure 7 is a view similar to Figure 6, illustrating the position of the parts during the setting of the locking mechanism,

Figure 8 is a view similar to Figures 6 and 7, showing the by-pass closed and the parts in position during the production of the well fluid upwardly through the production string or tubing,

Figure 9 is a view, similar to Figure 2, of a modified form of packing arrangement,

Figure 10 is a similar view with the slips in their set position, and

Figures 11 and 12 are horizontal, cross-sectional views, taken on the lines 11—11 and 12—12, respectively, of Figure 9.

In the drawings, the numeral 10 designates an elongate tubular mandrel or tubular support which has an axial bore 11 extending entirely therethrough. The lower portion of the outer surface of the mandrel is substantially cylindrical, while the upper portion of said mandrel is flared or inclined outwardly to form a slip expanding member or portion 12, having an inclined, annular outer surface. The member 12 is provided with an internal, inclined upwardly facing surface or annular seat 13, above which internal screw-threads 14 are formed. This member 12 constitutes setting or slip expanding means or an actuating member.

A tubular slip supporting carrier or sleeve 15 is slidable longitudinally on the cylindrical portion of the mandrel 10 and the upper portion of this carrier or sleeve is formed with a plurality of radially extending, inverted T-shaped slots 16. The slots 16 are spaced equidistant around the upper end of the carrier and the lower end of gripping elements 17, which lower ends are also T-shaped, are inserted within said slots. A retaining ring 18 which fits within an annular groove 19, formed in the periphery of the carrier 15, surrounds said carrier and prevents outward displacement of the gripping elements from the slots. Manifestly, the gripping elements are supported by the carrier and are movable longitudinally and radially with relation to the mandrel 10. Each gripping element includes an arcuate slip 20 at its upper end and the inner surface of each slip engages and rides upon the inclined slip expanding surface of the member 12 of the mandrel. The outer surface of each slip is formed with suitable gripping teeth which are adapted to engage the inner wall of a well casing or pipe C to prevent displacement or movement of the assembly. When the slips are at the lower end of the inclined surface of the member 12 (Figure 2), they are retracted and out of engagement with the casing wall; however, movement of the mandrel 10 downwardly with relation to the slips causes the outward radial movement thereof to the position shown in Figures 7 and 8, whereby said slips engage the casing wall to fasten the device within said casing. The elements 15 and 20 constitute anchoring elements or anchoring means.

The bore 21 of the slip carrier or sleeve 15 has a diameter which is substantially equal to the external diameter of the cylindrical portion of the mandrel 10. The lower portion of the bore 21 is slightly enlarged as shown at 22 (Figure 2), whereby a connecting collar 23 may be inserted within the bore of the carrier, the upper end of said collar abutting the internal shoulder formed between the bore 21 and the enlarged portion 22. The collar 23 is held against rotation within the carrier by means of a set screw 24 which is threaded through a radial opening 25 provided in the carrier, the inner end of the screw frictionally engaging the collar 23. Downward displacement of the collar is prevented by a nipple 26 which is threaded into the lower end of the slip carrier or sleeve 15.

For connecting the slip carrier or sleeve 15 with the mandrel 10, the collar 23 is formed with an inverted J-slot 27, and a radially extending pin 28 is secured to the mandrel and projects into said slot. As is clearly shown in Figure 2, when the pin 28 is within the lateral or horizontal leg of the slot 27 the slip carrier 15 is in its lowermost position on the mandrel, in which position the slips 20 are retracted. When the mandrel 10 is rotated with relation to the carrier 15, the pin 28 may be alined with the vertical portion of the slot 27 and when so alined, a downward movement of the mandrel with relation to the carrier may be accomplished. Such downward movement of the mandrel with relation to the carrier and to the slips 20, will cause the slips to be moved outwardly by the slip expanding portion 12 of said mandrel, whereby the teeth of said slips engage the casing wall C to fasten the assembly within said casing.

The nipple 26, which is threaded into the lower end of the slip carrier 15, has its lower portion enlarged to provide an annular skirt 29 which skirt is formed with inwardly extending rings 30. An elongate packing element or sleeve 31 has its upper end molded or otherwise secured to the skirt 29 of the nipple. The nipple 26 and its skirt being shown as secured to the slip carrier 15 may be considered a part thereof. As is clearly shown in Figure 2, the upper portion of the packing element has its bore engaging the outer surface of the mandrel 10, while its lower portion is reduced and flared outwardly to provide an elongate sealing lip 32. The external diameter of the sealing lip is substantially the same as the internal diameter of the well casing C, whereby said lip engages the casing wall as the device is lowered therethrough. Since the packing element is attached to the lower end of the slip carrier, the frictional engagement of said element with the casing wall is sufficient to prevent rotation of said carrier within said casing. Thus, when it is desired to set the slips, it is only necessary to rotate the mandrel to move the pin

28 into alinement with the vertical portion of the slot 27 in the connecting collar, after which the mandrel may be moved downwardly with relation to the carrier and slips to expand said slips. During rotation and downward movement of the mandrel, the slip carrier and slips are held stationary by the frictional engagement of the packing element with the casing. The element 31 is so constructed that a pressure from below the packing element may enter behind the elongate sealing lip 32 to increase the sealing engagement of the external surface of said lip with the casing. The packing element may be constructed of rubber, "neoprene," or any other suitable packing material.

A coupling element 33 is threaded onto the extreme lower end of the mandrel 10 and extends downwardly therefrom. If desired, this coupling element may be formed with a retaining thimble 34 at its upper portion, which thimble may engage the lower end of the flexible sealing lip 32 of the packing element while the device is being lowered in the well casing, whereby pressure fluid cannot enter within said sealing lip so long as the thimble is engaged therewith, as shown in Figure 2. The lower portion of the coupling element 33 is formed with a pair of inverted L-shaped slots 35 which extend upwardly from the lower edge of said element and which are located diametrically opposite each other. These slots are adapted to co-act with radially extending lugs 36 which are formed integral with a coupling collar 37. The coupling collar 37 is adapted to be connected in the well tubing or production string T, which well tubing extends axially through the mandrel 10. Manifestly, when the lugs 36 are in the upper or lateral portions of the slots 35, the well tubing T is coupled to the mandrel 10. To accomplish a disconnection of the parts, it is only necessary to rotate the tubing so as to aline the lugs 36 with the vertical portions of the slots 35, after which downward movement of the tubing with relation to the coupling element 33 and to the mandrel 10, attached thereto, may be accomplished.

The tubing string T has an external diameter which is less than the diameter of the bore 11 of the mandrel 10, whereby an elongate annular fluid passage or by-pass 38 is provided between said tubing and mandrel. This fluid passage has its lower end communicating with the bore of the well casing C below the assembly through a plurality of inclined ports 39 which are provided in the coupling element 33 and obviously, when the parts are in position shown in Figures 2 and 6, fluid from below the assembly may pass upwardly through the fluid passage 38.

The well tubing T, which extends upwardly to the surface of the well, has an elongate enlarged portion or section 40 of an external diameter greater than the diameter of the remaining sections of tubing connected therein. The tubing member constitutes a flow conductor as well as a support. This enlarged section 40 is spaced some distance above the upper end of the mandrel 10 when the tubing is coupled to said mandrel by means of the coupling collar 37 and the coupling element 33. The external diameter of the section 40 is not only larger than that of the other sections of the tubing string T but is also at least equal to, or greater than, the external diameter of the cylindrical portion of the mandrel 10. This relationship between the diameters of the section 40 and the cylindrical portion of the mandrel is important, for such relationship controls the effect or action of the fluid pressure below the device on the mandrel 10, as will be hereinafter explained. The lower portion of the section 40 is inclined to provide an inclined annular shoulder 41 which is adapted to be moved downwardly and engaged with the seat 13, within the mandrel 10, when the device is being set or anchored within the casing.

The enlarged section 40 of the tubing not only limits the downward movement of the well tubing with relation to the mandrel but also co-acts with internal packing or sealing elements 44 and 48 to trap pressure fluid above the seat 13 and shut off the by-pass 38. As is clearly shown in Figure 1, the assembly includes an elongate cylindrical housing 42 which has its lower end connected to the upper end of a tubular spacer 43 which is illustrated as a section of pipe, the lower end of said pipe being screwed into the threads 14 at the upper end of the mandrel 10. As has been explained, the upper end of the mandrel is enlarged with relation to the bore 11, with the result that the bore of the spacer pipe 43, as well as the bore of the housing 42, are of a larger diameter than the tubing. A packing ring 44, of the pressure fluid sealing type, is disposed within the housing 42 and abuts the underside of an internal flange 45 formed within said housing, being retained in position by means of a suitable retaining collar or ring 46. The internal diameter of the packing ring 44 is substantially equal to the external diameter of the enlarged section 40, whereby when said enlarged section is moved downwardly into the ring (Figures 7 and 8), said ring provides a seal between the section 40 and the housing 42. Since the interior of the housing 42 communicates with the upper end of the by-pass 38, it will be obvious that the ring 44 will serve to close off said by-pass. Above the sealing ring 44, the housing 42 is provided with a plurality of radial ports 47 which act to equalize the pressures around the entire assembly and packing elements, as will be explained.

Above the sealing ring 44, a second packing element 48, which is constructed in substantially the same manner as the packing 31, is provided. This packing element is inverted, as compared to the element 31, and has its lower end molded or otherwise secured to a nipple 49 which is threaded into the upper end of the housing 42. The lower portion of the packing element is adapted to engage the external surface of the enlarged section 40 of tubing, while the upper end thereof is reduced and flared outwardly to provide an elongate sealing lip 50. The external diameter of the lip is such that its outer surface normally engages the inner wall of the well casing C.

While the element 10 constitutes the mandrel proper, the parts 12, 43, 42 and 49 being rigidly attached to the mandrel proper and movable therewith, may be said to be a part thereof; and the term "mandrel" as used herein may include the parts above enumerated. Also either the upper packer 48, the lower packer 31, the packer 52 or the packing ring 44 may be referred to as a "packing element."

In the operation of the device, the slip carrier 15 is latched in its lowered position on the mandrel 10 by engaging the radial pin 28 on the mandrel within the lateral portion of the slot 27 within the connecting collar 23, as is clearly shown in Figures 2 and 6. The well tubing T, having the enlarged section 40 and also having the coupling collar 37 connected therein, extends downwardly through the mandrel 10 and is attached to said

mandrel by engaging the lugs 36 of said coupling collar 37 within the horizontal portions of the slots 35 in the coupling element 33. In such position, the thimble 34 at the upper end of the coupling 33 is engaged over the lower end of the sealing lip 32 of the lower packing element 31 so as to prevent pressure fluid from entering within said sealing lip during the lowering operation. Also, in such position, the enlarged section 40 of tubing is located some distance above the upper end of the mandrel 10 and is disposed above the upper packing element 48 (Figures 1 and 6). Thus, the slip carrier is held in a position which maintains the slips 20 in a retracted position and the well tubing may be utilized to lower the assembly downwardly through the well casing C. During such lowering, the fluid within the casing may by-pass the entire assembly, such fluid flowing upwardly through the inclined ports 39 in the coupling element 33 and upwardly through the annular by-pass 38, and parts 43, 42, 44, 49 and 48, which parts with the by-pass provide a flow passage to the space above the assembly. As has been pointed out, the external surface of the sealing elements 31 and 49 engage the wall of the casing C and slide downwardly along said wall as the assembly is lowered.

If the device has been lowered into a well having a loading fluid therein, such fluid may be removed by merely pumping a pressure fluid downwardly through the well tubing. The pumped pressure fluid will flow downwardly through the tubing, outwardly through the flow inlet (not shown) in the lower end thereof, and then upwardly through the well casing. This fluid will then pass upwardly through the by-pass 38 and the flow passage and will thereby clean the well bore of the loading fluid above the assembly. Although it is desirable to remove the mud or other loading fluid by pumping through the tubing, it would be possible to remove this fluid by pumping downwardly through the casing and this may be accomplished by merely reversing the circulation at the surface. The unloading of the fluid column in the well bore is preferably carried out after the assembly has reached the position at which it is to be set and prior to the setting of the slips, although it may be done after the slips have been set and the mandrel locked within the casing, as will now be explained.

After the assembly has been lowered to its proper position, the tubing T is rotated to move the lugs 36 on the coupling collar 37 into alinement with the vertical portions of the slots 35 in the coupling element 33 and then to impart a rotation to the mandrel 10 through the coupling collar and the coupling element, whereby the radial pin 28 on the mandrel is moved into alinement with the vertical portion of the slot 27 in the connecting collar 23 of the slip carrier. The slip carrier is, at this time, held against rotation by the frictional engagement of the lower packing element 31, which is mounted on said carrier, with the casing wall. By the foregoing operation, the tubing member, slip carrier and mandrel are each made free and may be moved independently. Upon downward movement of the tubing the section 40 passes down through the upper packing element 48 and then through the packing ring 44, whereby upward fluid flow through the assembly is shut off and pressure fluid is trapped between the seat 13 and the ring 44 and in the by-pass 38. Continued downward movement of the tubing brings the shoulder 41 into engagement with the seat or upwardly facing surface 13, whereby the mandrel is moved downwardly of the slip carrier 15, from the position shown in Figure 6 to the position shown in Figure 7. As is obvious, this movement of the mandrel is short. When the shoulder 41 of the section 40 engages the seat 13, the weight of the tubing string may be imposed upon the mandrel and thus force the latter downwardly. This short downward movement of the mandrel causes the member 12 to ride down the slips 20 and move them into firm engagement with the casing wall. When the mandrel is moved downwardly the thimble 34 is likewise moved, thus releasing the lip 32, whereby pressure fluid from beneath may enter and increase the frictional contact of said lip 32 with the casing wall.

After the slips 20 have been set to anchor the assembly in place, the well tubing may be lifted upwardly to the position shown in Figure 8, whereby the weight of the tubing string is taken off of the mandrel and slips. However, as the enlarged section 40 remains in contact with the pressure-sealing ring 44, the well pressure fluid is trapped in the space above the seat or upwardly facing surface 13, as well as in the by-pass 38 and therebelow. It will be observed that the force of the well pressure fluid will act downwardly on the surface 13 and upwardly against the lower end of the mandrel and the packer 31. By varying the upwardly facing areas and the downwardly facing areas exposed to the trapped pressure fluid, the resultant force may be so controlled as to equalize the pressure on opposite areas or to over balance it on one area, as will be hereinafter more fully explained.

With the parts in the position shown in Figure 8, it will be obvious that the annular space between the mandrel 10 and the well casing is sealed off by the lower packing element 31, which element is urged toward an increased sealing contact with the casing wall by the fluid pressure therebelow. Since the packing element 31 is carried by the slip carrier 15, it is also obvious that the fluid pressure is thus utilized to urge the gripping slips 20 upwardly relative to the mandrel 10. The by-pass 38 remains open, but the space above the seat 13 is closed at this time by the engagement of the internal packing ring 44 with the outer surface of the enlarged section 40, and this packing ring is maintained in a tight sealing engagement by means of the fluid pressure which is present below the assembly and which has entered the by-pass 38. If there is any pressure fluid present in the well casing above the assembly, this pressure fluid acts downwardly on the upper packing assembly which is in sealing engagement with the well casing C and also with the enlarged section 40. Manifestly, with the pack-off arrangement shown, the well fluid from below the assembly must flow upwardly through the well tubing T since it cannot by-pass said assembly and, therefore, this fluid will be conducted to the surface through said well tubing.

As has been previously described, the enlarged section 40 of the tubing has an outer diameter which is at least equal to, or larger than, the outer diameter of the lower cylindrical portion of the mandrel 10 below the slip expanding portion 12. Assuming that the outer diameter of the section 40 is equal to the outer diameter of the cylindrical portion of the mandrel 10, then the fluid pressure below the assembly, which would ordinarily urge the mandrel upwardly from between the slips, is balanced across the mandrel so as to exert no upward resultant force on said

mandrel, whereby the mandrel with the member 12 remains stationary and functions merely as a spacer block to hold the slips expanded. Referring to Figure 8, it will be seen that the fluid pressure below the assembly is acting against the lower packing element 31 and is urging the slip carrier 15 and the slips 20 upwardly with respect to the mandrel 10. At the same time this pressure is acting upwardly against the cross-sectional area of the lower cylindrical end surface of the mandrel 10 which is exposed thereto. The fluid pressure below the assembly is within the passage 38 and is also within the annular space between the enlarged section 40 and the spacer pipe 43 immediately above the mandrel 10, whereby this fluid pressure is also acting upwardly against the internal packing ring 44. Since this internal ring 44 is attached to the mandrel 10 through the spacer pipe 43, it will be seen that the combined cross-sectional area of the ring 44 and the cross-sectional area of the lower cylindrical end of the mandrel 10 is acted upon by the fluid pressure tending to lift the mandrel.

However, since the fluid pressure is within the annular space immediately above the upper end of the mandrel, said fluid pressure is also acting downwardly on the upwardly facing surface of the internal seat 13 and by making the area of this upwardly facing surface substantially equal to the combined cross-sectional area of the packing ring 44 and the lower cylindrical end of the mandrel, the effect of the pressure from below the assembly on the mandrel is equalized; in other words, by exposing equal upwardly and downwardly facing areas on the mandrel and portion 12 to the same pressure, a balance is obtained, with the result that the mandrel is not urged upwardly by the fluid pressure from below the assembly. The areas which are exposed, as above referred to, are directly controlled by the relationship of the external diameters of the section 40 and the lower cylindrical portion of the mandrel. Obviously, when these diameters are substantially equal, the effective cross-sectional area of the packing ring 44 is equal to the effective cross-sectional area of the seat 13, less the thickness of the wall of the cylindrical portion of the mandrel. The cross-sectional area of the cylindrical wall thickness is, of course, balanced out since the fluid pressure acts both above and below said wall. With the above arrangement, the effect of the fluid pressure from below, which would ordinarily tend to urge the mandrel upwardly, is nullified, with the result that the mandrel remains stationary and only the slips are urged upwardly by the pressure from below. Thus, the fluid pressure below the assembly is utilized to maintain the slips in a positive gripping position.

Since the areas of the upwardly and downwardly facing surfaces on the mandrel and seat 13 which are subjected to the fluid pressure from below the device, may be varied or controlled by changing the outer diameter of the tubing section 40 with respect to the external diameter of the cylindrical portion of the mandrel, it follows that it is possible to not only produce a balanced condition, but actually, the fluid pressure below the mandrel may be utilized to urge the mandrel 10 downwardly at the same time that this fluid pressure is urging the slip carrier upwardly. To accomplish this result, it is only necessary to make the outer diameter of the tubing section 40 larger than the outer diameter of the cylindrical portion of the mandrel, whereby the cross-sectional area of the internal packing ring 44 is reduced. When this is done, the combined cross-sectional area of the ring 44 plus the cross-sectional area of the cylindrical portion of the mandrel 10, which are the areas acted upon by the fluid pressure urging the mandrel upwardly, is less than the effective cross-sectional area of the seat 13, which is the area acted upon by the fluid pressure to urge the mandrel downwardly, and therefore, the fluid pressure below the assembly is utilized to urge the mandrel in a downward direction. In this instance, with the mandrel urged downwardly and the slips urged upwardly, the locking engagement of the slips with the casing is assured, regardless of the fluid pressure which might be present below the assembly and also regardless of whether or not a fluid pressure is present in the casing above the assembly.

From the above, it is apparent that it is not necessary that a fluid pressure be present in the casing above the assembly in order to urge the mandrel downwardly and thereby maintain the slips in a gripping position. Of course, if any fluid pressure is present above the assembly, such pressure will act downwardly on the upper packing element 42 and will urge the mandrel 10 downwardly with relation to the slips, such pressure being added to any other pressure which is urging said mandrel downwardly. However, in many instances, the assembly will be employed in wells wherein there is substantially no fluid pressure above the device and in such instances, the upper packing element 42 may be entirely eliminated and the fluid pressure below the device depended upon to maintain the assembly locked within the casing, as has been explained.

With the device locked in the casing, the tubing T is hanging free through said device and may be moved longitudinally therethrough within certain limits and this facilitates landing of said tubing in the surface support. Also, since the functioning of the locking mechanism and the packing elements is not dependent upon the weight of said tubing being left upon the assembly, no cork-screwing of said tubing will occur, with the result that the running of bottom hole instruments and devices is facilitated. In the event the surface support for the tubing string should fail, or in the event the tubing should part above the device, said tubing will move downwardly until the shoulder 41 of the enlarged section 40 engages the mandrel 10, as shown in Figure 7, at which time further downward movement of the tubing will be prevented. It is particularly pointed out that a jar such as the falling tubing would produce on the mandrel 10 would not disconnect the locking mechanism, but, rather would increase the gripping engagement of the slips 20.

During the production of the well fluid through the well tubing and with the parts in the position shown in Figure 8, the fluid pressures across the packing elements 31 and 42, will, in all probability, be unbalanced. When it is desired to remove the assembly from the well, it is preferable that the fluid pressures across the packing elements be equalized and it is for this purpose that the ports 47 are provided in the tubular housing 42. In effecting the removal of the apparatus, the well tubing string T is moved upwardly until the enlarged section 40 is moved upwardly above the equalizing ports 47. When this occurs, the pressure from below the device may pass upwardly through the by-pass passage and then through the ports 47 into the space between the

packing elements 31 and 48. A continued upward movement of the tubing string will move the enlarged section 40 completely above the uppermost sealing element 48 and an equalization of fluid pressures throughout the well casing may occur. Such equalization of fluid pressures prevents the packing elements from interfering with the removal of the device from the casing.

The tubing string T is moved upwardly until the lugs 36 on the coupling collar 37 re-engage the coupling element 33 and, after such re-engagement, a continued upward movement of the tubing will transmit an upward movement to the mandrel 10. The gripping slips 20 will be held substantially stationary by means of the frictional engagement of the packing element 31 with the casing wall, with the result that the mandrel may move upwardly relative to such slips. Upward movement of the mandrel continues until the pin 28 on said mandrel strikes the upper end of the slot 27 in the connecting collar 23 of the slip carrier at which time the retaining thimble 34 has re-engaged the lip 32 of the packing element 31. Continued raising of the tubing removes the entire apparatus from the casing C. It is noted that it is not necessary that the lugs 36 on the coupling collar 37 be re-engaged with the slots 35 of the coupling element 33 in order to accomplish removal of the device. It is only necessary that these lugs impart an upward movement to the coupling element and to the mandrel 10 to which said element is connected. Of course, by re-engaging the coupling collar 37 and the coupling element 33, as well as moving the pin 28 into the lateral portion of the slot 27, it would be possible to move the entire apparatus upwardly or downwardly and then re-set the same at a different elevation within the well casing.

In Figures 1 to 8, an elongate, sleeve-type packing element has been shown as combined with the improved locking mechanism. It is pointed out that the invention is not to be limited to the use of any particular kind or shape of packing element and in Figures 9 to 12, a modified form of packing arrangement is illustrated. In this form of the invention, a slip carrier 115 is substituted for the slip carrier 15 of the first form. The carrier 115 is constructed in a manner similar to the carrier 15 and is provided with the T-shaped slots 16 which receive the lower ends of the anchoring elements 17 in its upper end. The connecting collar 23 is secured within the bore of the slip carrier 115 and is adapted to be connected with the mandrel 10 by the pin 28 and slot 27. Instead of receiving the nipple 26, as in Figures 1 to 8, the lower end of the carrier 115 receives the upper end of an elongate sleeve 51. A pair of inverted pressure seal packing cups 52 are mounted on the sleeve and are spaced from each other by a suitable spacer ring 53. A spacer ring 54 is disposed within and below the lowermost cup 52 and a retaining collar 55 is threaded onto the lower end of the sleeve, whereby the cup assembly is confined between the collar and the lower end of the slip carrier. The cups 52 are constructed of the usual composition or material and are normally in a non-sealing position spaced from the wall of the well casing. For sealing off the space between the sleeve 51 and the mandrel, a sealing ring 70 preferably of the pressure seal type, surrounds the mandrel and is confined between an inwardly directed flange 55a on the collar 55 and the lower end of the sleeve. When the assembly is anchored in the well casing, the pressure from below the assembly acts upon the cups and sealing ring to move these elements into sealing positions to seal off between the mandrel and casing.

As explained with reference to the form shown in Figures 1 to 8, the lower packing element 31 in that form is utilized to prevent rotation of the slip carrier 15 during the setting of the slips. However, in the form shown in Figures 9 to 12, the elongate packing element 31 is omitted and the cups 52 cannot be employed for frictionally engaging the casing wall to hold the slip carrier 115 stationary during setting of the device. In order to frictionally restrain the slip carrier 115 and the gripping elements 17 carried thereby against free movement within the well casing C and to permit setting of the device, the carrier 115 is provided with a plurality of friction shoes or members 56. Each friction shoe is elongated and is mounted within a longitudinal recess 57 which is formed in the exterior surface of the slip carrier 115. A plurality of coiled springs 58 are disposed behind each shoe and constantly urge said shoe outwardly into engagement with the well casing. Outward displacement of each shoe from its recess is prevented by retaining rings 59 which are mounted within grooves 60 formed in the external surface of the carrier at the upper and lower ends of the recesses 57.

It is obvious that the shoes 56 constantly engage the wall of the casing C and the frictional engagement is sufficient to hold the slip carrier 115 and its associate parts stationary while the mandrel 10 is rotated and moved downwardly with relation thereto. It is pointed out that the friction shoes 56 are particularly suitable but any other type of friction means may be employed. Manifestly, the upper packing element 48 may be omitted and a packing cup arrangement, similar to that which replaces the element 31, may be substituted therefor.

The operation of this form of the invention is substantially the same as the form shown in Figures 1 to 8 and above described. With the exception of the substitution of the cup assembly for the elongate packing elements 31 and 48, together with the addition of the friction shoes 56, the construction of the form shown in Figures 9 to 12 is identical.

It is noted that while the invention has primarily to do with the locking mechanism and has been illustrated and described as employed with packing elements to provide a well packer, the mechanism may be efficiently used for removably locking other well tools within the casing C. It is pointed out that when the slips 20 are set or engaged with the casing they are anchored and the device is fastened in the casing the same as in many packing devices, but when the force of the well pressure fluid applied against the upwardly facing surface or seat 13 is predominant the assembly is locked in position, while an equalization of pressure forces as hereinbefore described, prevents upward displacement of the mandrel 10 and the member 12 carried thereby.

The foregoing description of the invention is 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.

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

1. A well apparatus including, a tubular support adapted to be lowered in a well casing, ex-

pansible gripping means mounted on the support and movable into engagement with the casing upon a longitudinal movement of the support relative thereto for locking the support against displacement within the casing, packing means mounted on the support and expansible by fluid pressure from above said support for packing off between the casing and support and for transmitting the force of the fluid pressure to urge the support downwardly, and packing means carried by the gripping means and expansible by the fluid pressure therebelow, the last-named packing means acting ta pack off the space between the support and casing and also acting to transmit the force of the pressure applied thereto to the gripping means to urge the same upwardly.

2. A well tool apparatus including, a tubing member adapted to be connected in a well tubing string, a tubular mandrel surrounding the tubing member and adapted to move longitudinally of the tubing member, there being a connection between the tubing member and the mandrel for moving the mandrel downwardly with the tubing member when the apparatus is lowered into a well, an anchoring member adapted to move longitudinally of and surrounding the mandrel and including movable casing-gripping elements, said anchoring member being detachably connected with the mandrel to initially move longitudinally therewith and initially holding said gripping elements retracted, a fluid pressure expansible casing packer engaging the anchoring means below the gripping elements thereof and adapted to be exposed to fluid pressure therebelow, the mandrel being provided with actuating means for displacing the gripping elements of the anchoring means into gripping position upon relative longitudinal movement between the mandrel and anchoring means, the mandrel having an upwardly facing surface within the apparatus, the tubing member having means for engaging the mandrel upon longitudinal movement of the tubing member to move the mandrel longitudinally to cause the actuating means thereof to displace the gripping elements of the anchoring means into casing gripping position, means for by-passing pressure fluid from below the packer to the upwardly facing surface of the mandrel, and means for trapping the by-passed pressure fluid within the apparatus above the upwardly facing surface of the mandrel and to cause the pressure of said fluid to be exerted downwardly on said surface in opposition to the pressure exerted upwardly against said packer, whereby the anchoring means is locked against displacement free of the weight of the tubing member.

3. A well tool apparatus as set forth in claim 2 and an upper casing packer supported by the mandrel.

4. A well tool apparatus as set forth in claim 2 wherein the trapping means includes a packing carried by the mandrel and an element carried by the tubing member movable into sealing contact with said packing and movable from said packing to open the fluid by-pass to permit fluid to by-pass the apparatus while it is being lowered into the well.

5. A well tool apparatus as set forth in claim 2 with an upper packer, the trapping means including a packing carried by the mandrel and an element carried by the tubing member movable into sealing contact with said packing and movable from said packing to open the fluid by-pass to permit fluid to by-pass the apparatus while it is being lowered into the well, the mandrel having a port between the packing and the upper packer to equalize fluid pressures internally and externally of the mandrel and located to be closed when the tubing element contacts the packing and pressure fluid is trapped in the mandrel.

6. A well apparatus as set forth in claim 2 and yieldably sustained means mounted on the anchoring means for frictionally engaging a casing wall to hold the said means against rotation.

7. A well tool apparatus including, a mandrel having a bore, a flow conductor extending through the bore of the mandrel, the bore of the mandrel having a fluid passage exteriorly of said conductor open at its lower end to receive well pressure fluid, means for detachably connecting the mandrel with the conductor, whereby the conductor and mandrel may be disconnected for limited relative movement, said mandrel having opposed upper and lower areas connected by the fluid passage and exposed to the well pressure fluid, upper and lower packing elements disposed annularly of the mandrel, anchoring means intermediate the packing elements, actuating means carried by the mandrel for moving said anchoring means into anchoring position, and means carried by the conductor for operating the actuating means, said actuating means also being responsive to the fluid pressure exerted upon the upper and lower mandrel areas to anchor said mandrel against longitudinal displacement when said conductor is detached from the mandrel, whereby the packer may be freed from the weight of the flow conductor.

8. A well tool apparatus as set forth in claim 7, wherein the upper portion of the apparatus is maintained open while the apparatus is being lowered into the well to permit fluid to flow therethrough, and means carried by the flow conductor co-acting with the upper packing element for trapping pressure fluid after the apparatus is anchored.

9. A well locking apparatus including, a tubing member having an enlarged portion thereon, a tubular mandrel surrounding and movable longitudinally relative to the tubing member, the tubing member and mandrel being initially detachably secured together, said mandrel having an internal upwardly facing surface and an enlarged internal space above said surface for receiving the enlarged portion of the tubing member, anchoring means initially detachably secured to the mandrel and through which the mandrel is longitudinally movable when detached therefrom, a lower packer connected to the anchoring means, said anchoring means having elements engaging the surrounding well casing and resisting movement of the anchoring means relative to the mandrel, an upper packing carried by the mandrel and adapted when in one position relative to the tubing member to seal around said enlarged portion of the tubing member, actuating means on the mandrel engageable with the anchoring means and movable downwardly for forcing the anchoring means into anchoring position when the mandrel is moved longitudinally relative to the anchoring means, a fluid passage between the tubing member and mandrel for conducting pressure fluid from below the lower packer to the mandrel space above the upwardly facing surface, said enlarged portion of said tubing member being positioned above said mandrel when said tubing member and mandrel are initially secured together, whereby pressure fluid may be passed through the assembly before the enlarged portion is moved into sealing contact

with said upper packing and into said internal mandrel space and also whereby the force of said fluid pressure may be exerted downwardly on said upwardly facing surface when the said enlarged portion has entered said mandrel space and is in sealing contact with said upper packing, said enlarged tubing portion being adapted to engage said actuating means and move the mandrel downwardly.

10. A well apparatus of the character described including, a tubular mandrel adapted to be lowered into a well casing and having an upwardly facing surface, expansible anchoring means detachably mounted on the mandrel, means carried by the mandrel for expanding the anchoring means into engagement with the casing upon a longitudinal movement of the mandrel relative thereto, a well tubing extending through the mandrel and detachably connected thereto, whereby said tubing may be utilized to lower the mandrel within the casing and may be disconnected therefrom and moved longitudinally therethrough, a fluid pressure responsive packing element connected with the anchoring means, and means for conducting the pressure fluid from below the assembly to the upwardly facing surface of the mandrel, and means to cause said pressure fluid to exert a downward force upon the mandrel at least equal to the upward force exerted thereon by said pressure fluid from beneath the mandrel so that the resultant force upon the mandrel tends to prevent upward movement of the mandrel while said anchoring means is urged upwardly by the fluid pressure exerted upon the fluid pressure responsive packing element.

11. A well packer including, a tubing member adapted to be connected in a tubing string and having an enlarged portion, a mandrel having a bore through which the tubing member extends, means for initially detachably securing the mandrel to the tubing member, the mandrel having an upwardly facing internal seat and an enlarged internal space above the seat, an annular fluid pressure-responsive packing seated on the inner wall of the mandrel and extending into the mandrel space, anchoring means on the exterior of the mandrel, actuating means carried by the mandrel engaging and actuating the anchoring means, a fluid pressure-responsive packer engaged with the anchoring means, the bore of the mandrel providing a pressure-fluid passage from below the packer to above the seat, and means for initially detachably securing the anchoring means to the mandrel, the enlarged portion on the tubing member being movable downwardly into the mandrel space through the packing into sealing contact therewith and into engagement with the seat when detached from the mandrel to move the mandrel and operate the actuating means when said anchoring means is detached from the mandrel, said enlarged portion being movable upwardly away from said seat while in sealing contact with said packing.

12. A well tool apparatus including, a tubing member adapted to be connected in a well tubing string, a tubular mandrel surrounding the tubing member and detachably connected thereto, whereby the mandrel and tubing member are each movable longitudinally relative to the other when detached, an anchor support surrounding the mandrel and detachably connected thereto and adapted to move longitudinally of the mandrel when detached, casing gripping elements carried by the anchor support, a lower fluid pressure packer engaging the anchor support, the mandrel having means for actuating the gripping elements and a longitudinal enclosure, said mandrel also having an upwardly facing surface in said enclosure, the tubing member having an element provided with a downwardly facing surface for moving the mandrel longitudinally of the anchor support to cause the actuating means to displace the gripping elements into casing gripping position, means for packing off the enclosure of the mandrel between the tubing member and the mandrel when the tubing member is moved longitudinally to bring its downwardly facing surface within said enclosure above the upwardly facing surface of the mandrel, and means for by-passing pressure fluid from below the lower packer to the mandrel enclosure, whereby when the downwardly facing surface on the tubing member and the upwardly facing surface of the mandrel are in spaced relation within the enclosure the pressure fluid acts upwardly against the lower packer and downwardly against the upwardly facing surface of the mandrel to hold the gripping elements in gripping position against longitudinal displacement by pressures from above and below, the tubing member being movable longitudinally of the mandrel and anchor support when the mandrel and gripping elements are in gripping position.

13. A well tool apparatus including, a tubing member adapted to be connected in a well tubing string, a tubular mandrel surrounding the tubing member and detachably connected thereto, whereby the mandrel and tubing member are each movable longitudinally relative to the outer when detached, an anchor support surrounding the mandrel and detachably connected thereto and adapted to move longitudinally of the mandrel when detached, casing gripping elements carried by the anchor support, a lower fluid pressure packer engaging the anchor support, the mandrel having means for actuating the gripping elements and a longitudinal enclosure, said mandrel also having an upwardly facing surface in said enclosure, an enlarged portion carried by the tubing member adapted to enter the mandrel enclosure when the said member is detached and moved downwardly to engage the mandrel and move the same downwardly to cause the actuating means to set the gripping elements, means for by-passing pressure fluid from below the packer to the mandrel enclosure, and a packing carried by the mandrel and engaged by the tubing enlarged portion to trap the pressure fluid in the enclosure and cause the force of the fluid to be exerted downwardly on the upwardly facing surface to lock the gripping elements in casing-gripping position, the packing in the mandrel enclosure being exposed to the trapped pressure fluid, the enlarged portion of the tubing member having an external diameter at the packing substantially the same as the exterior diameter of the mandrel at the lower packer, whereby when the enlarged portion of the tubing member and the upwardly facing surface of the mandrel are in spaced relation the effective fluid pressure acting upwardly against the mandrel is substantially equal to the effective fluid pressure acting downwardly on the mandrel thus holding the gripping elements against longitudinal displacement.

14. A well tool apparatus including, a tubing member adapted to be connected in a well tubing string, a tubular mandrel surrounding the

tubing member and detachably connected thereto, whereby the mandrel and tubing member are each movable longitudinally relative to the other when detached, an anchor support surrounding the mandrel and detachably connected thereto and adapted to move longitudinally of the mandrel when detached, casing gripping elements carried by the anchor support, a lower fluid pressure packer engaging the anchor support, the mandrel having means for actuating the gripping elements and a longitudinal enclosure, said mandrel also having an upwardly facing surface in said enclosure, an enlarged portion carried by the tubing member adapted to enter the mandrel enclosure when the said member is detached and moved downwardly to engage the mandrel and move the same downwardly to cause the actuating means to set the gripping elements, means for by-passing pressure fluid from below the packer to the mandrel enclosure, and a packing carried by the mandrel and engaged by the tubing enlarged portion to trap the pressure fluid in the enclosure and when the enlarged portion of the tubing member and the upwardly facing surface on the mandrel are in spaced relation cause the force of the fluid to be exerted downwardly on the upwardly facing surface to lock the gripping elements in casing-gripping position, the packing in the mandrel enclosure being exposed to the trapped pressure fluid, the enlarged portion of the tubing member having an external diameter at the packing greater than the external diameter of the mandrel at the lower packer, whereby the effective fluid pressure acting downwardly on the mandrel is greater than the effective fluid pressure acting upwardly against the mandrel and the gripping elements are locked in casing-gripping position.

15. A well tool apparatus including, a tubing member adapted to be connected in a well tubing string, a tubular mandrel surrounding the tubing member and adapted to move longitudinally of the tubing member, there being a connection between the tubing member and the mandrel for moving the mandrel downwardly with the tubing member when the apparatus is lowered into a well, an anchoring member adapted to move longitudinally of and surrounding the mandrel and including movable casing-gripping elements, said anchoring member being detachably connected with the mandrel to initially move longitudinally therewith and initially holding said gripping elements retracted, a fluid pressure expansible casing packer engaging the anchoring means below the gripping elements thereof and adapted to be exposed to fluid pressure therebelow, the mandrel being provided with actuating means for displacing the gripping elements of the anchoring means into gripping position upon relative longitudinal movement between the mandrel and anchoring means, the the mandrel having an upwardly facing surface within the apparatus, the tubing member having means including a downwardly facing surface for engaging the mandrel upon longitudinal movement of the tubing member to move the mandrel longitudinally to cause the actuating means thereof to displace the gripping elements of the anchoring means into casing gripping position, the downwardly facing surface of said means being opposed to the upwardly facing surface of the mandrel, means for by-passing pressure fluid from below the packer to the said surfaces when said surfaces are spaced apart to exert a downward fluid pressure on the upwardly facing surface of the mandrel in opposition to the fluid pressure exerted upwardly against the packer to lock the gripping elements in gripping position, and means within the apparatus for trapping the pressure fluid by passed to said surfaces.

HERBERT C. OTIS.