This invention relates to new and useful improvements in hydraulically-actuated well packers and relates particularly to dual-production packers.

It is one object of this invention to provide a well packer adaptable for use in dual production wells which is hydraulically set by the application of pressure fluid and is releasable by manipulation of one of the pipe strings to which the packer is connected.

An important object is to provide a well packer having means for moving the packing element and pipe-gripping slips thereof into a set position by the application of pressure fluid, together with mechanical means for positively locking said packer in its set position, whereby the pressure fluid which set said packer may be relieved without releasing said packer from said set position.

Another object is to provide a well packer, of the character described, which includes an improved mechanical locking assembly for locking the packer in set position, said assembly comprising gripping means engageable with one of the well pipe strings having connection with said packer; the locking assembly being so arranged that during the setting operation, the hydraulically-operated packer setting means acts directly upon the gripping means of said assembly so that said gripping means is maintained in close contact with the well pipe string during the entire setting operation, thereby assuring that when the setting force is relieved, said gripping means will instantaneously act to prevent any reverse movement of the packer parts toward an unassembling position.

Another object is to provide a dual-production well packer having connection with a pair of independent well pipe strings, and having a locking assembly coating with one pipe string for locking the well packer against unsetting; the second pipe string being capable of manipulation to effect an unsetting of the packer to permit the same to be released and retrieved from the well bore.

A further object is to provide an improved well packer having a pair of passages extending therethrough with a tubular mandrel or section forming part of a tubing string extending through each of said passages; said tubular mandrels or sections being so connected and arranged that one of said mandrels cooperates with a locking assembly which is incorporated within the packer to prevent unsetting of the packer parts while the second mandrel is releasably connected and capable of limited movement with respect to the first mandrel, whereby said second mandrel may be manipulated to effect unsetting and release of said well packer.

A particular object is to provide a dual-production hydraulically-actuated packer, of the character described, which lends itself to combination with a packer which is set therebelow whereby production of well fluids from two zones may be conducted to the surface through separate tubing strings.

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 a vertical sectional view of a well packer constructed in accordance with the invention and illustrat-
first tubing string and the first tubular support 10 are manipulated as will be hereinafter explained in detail. Referring to the particular construction of the operating elements, the tubular support A may take any desired form and as illustrated includes two generally cylindrical bodies 19 spaced from each other by a spacing ring 20. The upper and lower ends of the packing bodies are confined by anti-extrusion end rings 21 and 22 which are constructed of a soft metal, such as lead, and which are deformed radially outwardly when the packer is in set position. Said packing bodies have parallel openings 19a extending therethrough which form part of the longitudinal passages 13 and 14. The upper abutment B consists of a solid metallic body 23 having a pair of parallel openings 20a extending therethrough which, like the openings 19a in the packing element, form part of the longitudinal passages 13 and 14. The first tubular support or mandrel 10 is secured to the upper abutment B between a snap ring 24 engaging a shoulder in abutment B and a collar 24a forming part of tubing string 11 so that any movement of the tubular support 10 will result in a similar movement of said upper abutment. The extreme upper end of the abutment is inclined or tapered as indicated at 25 and this taper or inclination, as shown in FIGURE 9, is for the purpose of guiding the second tubing string 12 into the passage 14. As has been explained, the second tubing string is resiliently connected in the passage 14 by means of the J-slot connection 16.

Immediately below and abutting the lower end of the packing element A is the anchoring means C which includes an expander cone 26, the upper end of which is engaged with the lower end of said element. The expander cone has a vertical opening 26a which aligns with the openings 19a in the packing element and 23a in the upper abutment to form part of passage 14. The opening 26a in the expander cone 26 is counter-bored (FIGURES 1 and 2) to form an annular shoulder 26b which can be engaged by a projection 27 formed on the exterior surface of the second tubular support or mandrel 11; during lowering of the packer into the well as shown in FIGURE 1, the shoulder 27 supports the expander cone, packing element and upper abutment. It is noted that the upper end of the second tubular support or mandrel 11 is slideable within one of the openings 23a of the upper abutment and is also slideable through the openings 19a in the packing element.

The external surface of the expander cone 26 (FIGURE 5) is formed with inclined slip-expanding surfaces 28 which coact with pipe-gripping slips 29. The lower ends of slips 28 are each formed with a T-shaped connection 30 which engages within a T-shaped slot 31 (FIGURE 7) provided in the upper end of a slip-carrying member 32. When the slip carrier 32 is moved upwardly on the tubular supports 10 and 11, the slips are moved upwardly with respect to the inclined surfaces 28 of the expander cone 26 and this results in a radially outward movement of the pipe-gripping slips 29. Thus upward movement of the slip-carrier 32 will effect an expansion of the slips 29 into pipe-gripping position.

In addition to the opening 26a in the expander cone 26, said cone is formed with second opening 26c and this opening is in alignment with the other openings 19a in the packing elements and the opening 23a in the upper abutment to form a part of the passage 13. The opening 26c is somewhat larger in diameter than the external surface of the first tubular support or mandrel so that an abutment shoulder 26d is formed therein. Slip 32b is a projection 33 which is formed on the first support or mandrel 10 and the function of this particular projection and its coaction with shoulder 26d will be hereinafter explained.

The slip carrier 32 to which the lower end of the pipe gripping slips 29 is attached has two openings 32a and 32b extending therethrough; the opening 32a receives the second tubular support or mandrel 11 while the opening 32b has the first support or mandrel 10 extending therethrough. It is noted that the opening 32b is of approximately the same diameter as the opening 26c in the expander cone and has an internal shoulder 32c at its lower end. Under certain conditions, the enlargement or projection 33 on the first support or mandrel 10 may enter the opening 32b.

The slip carrier 32 is attached by suitable screws 34 with the upper end of a cylinder 35 which forms part of the hydraulically-actuated means D. The cylinder extends downwardly to encircle the body 36 of the lower abutment E and is initially attached to the lower abutment by one or more shear pins 37. The upper portion of the lower abutment 36 forms a platen as indicated at 38, which piston is confined between the cylinder 35 and the tubular supports 10 and 11, this being a stationary piston. The piston is, of course, sealed with the walls of the cylinder and the external surfaces of the supports 10 and 11 by suitable O-rings. The tubular support 10 extends entirely through an opening 36a formed in the lower abutment 36 and is connected to said lower abutment by a relatively coarse thread 39 which is preferably left-hand so that it may be released upon right-hand rotation of the support 10. A second opening 36b is formed in the lower abutment 36 and has a tubular support or mandrel connected in its upper end by threads 40. A tubular nipple 41 having a reduced annular seat 41a is threaded into the lower end of the opening 36b and communicates with the area below the packer structure.

In order to introduce pressure fluid into the cylinder 35 and into the area above the piston 38 formed by the lower abutment, a plurality of ports 42 are formed in the lower portion of the second support or mandrel 11. These ports are located so that when the closure 17 is dropped to seat upon the seat 41a of nipple 41 in the longitudinal passage 14 of the packer structure, pressure fluid may be directed downwardly through the second tubing string T and will pass through the ports 42 into the cylinder above the stationary piston 38. Pressure will thus be applied to a sealing member 43 which is confined within the upper end of the cylinder just below the slip carrier 32 (FIGURE 8). The sealing member 43 is, of course, sealed with the wall of the cylinder and with the exterior of the tubular supports or mandrels 10 and 11.

The locking assembly L, which is located at the upper end of the cylinder 35, is actually housed within the slip carrier 32. As illustrated, the gripping elements 48 of this assembly have their engagement engageable with complementary inclined surfaces 44 which are formed within the slip carrier 32. The inner surface of each gripping element 48 has gripping teeth 18d formed thereon and these teeth are disposed in a direction which will prevent downward movement of each gripping member relative to the second support or mandrel 11. It is evident, however, that the gripping members 48 may be moved upwardly and will slide along the external surface of the tubular support or mandrel 11. This upward movement is effected when hydraulic pressure is introduced into the cylinder and below the sealing member 43 to move the cylinder 35 upwardly on the supports 10 and 11. As soon as the hydraulic pressure is relieved, then the gripping members 48 will prevent downward movement of the slip carrier 32 with respect to the support 11. It is noted that the sealing member 43 abuts the lower surface 18c (FIGURE 3) of the expander cone 26 and the hydraulic pressure force is transmitted directly through the sealing member 43 to each gripping member 48. From the gripping member 18, the force is transmitted through the inclined complementary surfaces 18a and 44 to the slip carrier 32 which, in turn, moves the slips 29 upwardly with respect to the expander cone 26. This results in a radially outward movement of the pipe gripping slips 29 to move them into engagement with the well pipe 15. Thereafter, the hydraulic pressure confined
between the sealing member 43 and the piston 38 formed by the lower abutment 36 exerts a force downwardly on the lower abutment and since this lower abutment is connected through the first tubing support or mandrel 10 with the upper member 32, a downward force is applied to the packing element A to deform said packing element into its sealing position. The position of the parts when the anchoring means C is set and the packing element is deformed into sealing position is illustrated in FIGURE 2.

For releasing the packer from its set position, the first tubing string T1 and the first support or mandrel 10 are rotated to the right and since the lower abutment 36 is being held stationary by reason of the pipe-gripping slips 29 engaging the well pipe 15, the threaded connection 39 between the support 10 and the lower abutment is released. Simultaneously therewith the safety joint connection 12 is undergoing release and during the releasing action the support 10 will move upwardly with respect to the lower abutment, the hydraulically-actuated means D, the locking assembly L and the anchoring means C. Such upward movement is permitted by the projection 33 traveling upwardly with respect to the openings 26b in the slip carrier and opening 26c in the expander cone 26.

Following the disconnection of the threads 39 between the support and the lower abutment and the disconnection of the safety joint 12, the projection 33 on the support 10 has preferably not engaged the shoulder 26d but rather is engaged the pipe packer generally above. Therefore, there may be sufficient room for movement of the projection 33 relative to shoulder 26d so that an upward jarring force may be imparted against the shoulder 26d. At this time it is noted that the upper abutment 23 has been moved upwardly away from packing element A (FIGURE 3) and said packer element 23, a downwardly applied force of the expander cone 26 against shoulder 26d lifts the expander cone from between the pipe gripping slips and engagement of the projection 33 with shoulder fully releases the packer to permit its removal from the well.

The packer system described is particularly adaptable for use in dual production. In this production of well fluids from two separate producing zones, as shown in FIGURE 9, a schematic illustration of the packer is shown within well bore W which traverses two producing formations or zones Z1 and Z2. In this illustration a hydraulic fluid or pressure is used in the packer in order to secure the well. Therefore, any desired construction, is formed with an axial bore 50. The packer of this invention is connected to the first tubing string T1 which projects upwardly from the packer and also projects downwardly therefrom. The safety joint 12 is connected in the lower projecting portion of the first tubing string T1 which extends downwardly through the lower packer P.

After the packer of this invention has been lowered into position by the first tubing string T1 with all of the parts in the position shown in FIGURE 1, the second tubing string T2 is independently engaged in the well derrick floor and is lowered into position to be connected in the second passage 14 of the packer structure by means of the J-slot connection 16. Thereafter, the usual well head equipment 51 is mounted in place and the upper packer forming this invention is ready to be set.

In operating the present packer and with the parts in the position of FIGURE 1, the expander cone 26 is dropped through the second tubing string T2 to seat upon the nipple 41 at the lower end of passage 14. During the lowering, the expander cone 26, packing element A and upper abutment 32 were supported by the shoulder 26b within the expander cone resting upon the annular projection 27 of the mandrel 10. The expander cone 33 was releasably latched in its lowered position relative to the lower abutment 36 by the shear pins 37. After the closure or ball 17 is in place, pressure fluid is conducted downwardly through the second tubing string T2 and passes through the ports 42 into the cylinder 35.

between the piston 38 formed at the upper end of abutment 36 and the annular sealing member 43; this applies an upward force to the sealing member 43 which, as explained, acts upon the lower ends 18e of the gripping members 18. When in turn, is in direct contact with the lock-down gripping members 18, the latter are maintained in close contact with the outer surface of the second tubing support or mandrel 11. As the upward movement continues, the pipe-gripping slips 29 are moved into engagement with the well pipe 15 and when the upward gripping slips 29 as well as the locking assembly L. Such downward movement will move the upper Abutment 23 downwardly with respect to the support 10 and 11 and will apply an endwise force to the packing element sufficient to deform it into its sealing position. As soon as the hydraulic pressure within cylinder 35 is relieved, the gripping members 18 of the locking assembly L, being in engagement with the external surface of the support or mandrel 11, will prevent any downward movement of the packing slips 29 as well as any upward movement of the mandrel 10 and upper abutment B and thus the locking assembly will maintain the anchoring means C and the packing element A in its set position. The ball or closure 17 may then be pumped or dropped out from the second tubing string T2 and production of fluid from both strings T1 and 35 from the separate zones Z1 and Z2 may be carried out.

It is pointed out that during the setting operation the sealing rings provided on the annular sealing member must be effective to hold the pressure so that the desired upward force may be imparted against the lock-down slips and thereby transmitted to the pipe gripping slips to effect upward movement of the latter into a set position. However, after the packer has been set, the lock-down gripping members 18, being a mechanical gripping means, will prevent any reverse or downward motion of the main gripping slips. Therefore, it is obvious that certain of the seals in the hydraulic piston, cylinder and sealing member should be rendered ineffective, subsequent to the setting operation, it is assured that the packer will be maintained in a set position. The use of a mechanical lock-down means, as distinguished from hydraulic hold-down, is of advantage because in certain instances, particularly where a packer has remained in the well for a considerable period of time, the sealing means of the hydraulic assembly may leak or become ineffective.

When it is desired to remove the packer, it is only necessary to rotate the first tubing string T1 which, in turn, rotates the first tubing support or mandrel 10 to uncouple the threads 39 between said mandrel 10 and the lower abutment 36 and at the same time breaks out the safety joint 12. By the time that this has occurred, the upper Abutment 23 has been moved away from the upper end of the packing element A to permit it to relax; the upward movement of the upper abutment 36 and the sliding connection between the second support or mandrel 11 and said upper abutment. The first support or mandrel 10 may be reciprocated relative to the cone with its projection 33 striking the shoulder 26d within the expander cone 26. Upon release of the cone from between the gripping slips, subsequent upward movement of the tubing string T1 will lift the expander cone out of the slips 29 so that the packer is released and may be removed from the well. In the actual removal, it will probably be desirable to first uncouple and remove the second tubing string T2 before the first tubing string T1 is manip-
culated in the manner described to effect a release of the packer structure.

From the foregoing, it will be seen that a dual production packer is provided which may be set by hydraulic pressure and which may be released by manipulation of one of the tubing strings. Of importance to the present invention is the locking assembly L which is actuated upon by the sealing member 43 so that the force which is moving the pipe-gripping slips upwardly is transmitted through the locking members 18. With this arrangement, the locking members are maintained in close contact with the exterior of the mandrel 11 during the setting operation. This means that immediately that the upward force on the elements 18 is relieved, the members 18 are in position and firmly grip the external surface of support 11 to prevent any reverse or downward movement of the gripping slips as well as upward movement of upper abutment B. The release is effected by manipulating the first mandrel 10 and moving the same upwardly with respect to the expander so that the projection 33 on said first mandrel may engage the shoulder 26u and actually pull the expander cone from between the slips to release the packer structure.

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

What I claim is:

1. A well packer adapted to be lowered and set within a well pipe, including, an elastic packing element, an upper abutment above said packing element, a lower abutment below said packing element, the packing element and upper and lower abutments each having a pair of parallel openings which are longitudinally aligned to form a pair of longitudinal parallel passages extending through the packer structure, a first tubular support extending through one of said passages and secured to the upper abutment, means releasably connecting the tubular support to the lower abutment, a second tubular support disposed within the other of said passages and secured to the lower abutment, said second support being slideable within the opening in the upper abutment, and pipe-anchoring means mounted on the supports below the packing element, hydraulically-actuated means mounted on the supports below the pipe-anchoring means and above the lower abutment for setting said anchoring means and thereafter deforming the packing element into sealing position, and locking means releasable between said second support for locking the anchoring means against movement in a direction which would unseat said anchoring means to thereby lock the anchoring means and packing element in its set position.

2. A well packer as set forth in claim 1 wherein the locking means comprises a gripping element confined between the lower end of the pipe-anchoring means and the hydraulically-actuated means, said gripping element having means engageable with the second support to prevent downward movement of the anchoring means and packing element relative to said second support.

3. A well packer as set forth in claim 1, wherein the releasable connection between said first support and the lower abutment is released by manipulation of the first support with respect to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and second support to thereby raise the upper abutment and permit removal of the well packer structure from the well bore.

4. A well packer as set forth in claim 1, wherein the releasable connection between said first support and the lower abutment is released by manipulation of the first support with respect to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and second support to thereby raise the upper abutment relative to the packing element to release said packing element from its set position, a first well tubing string, means for connecting the first well tubing string to said first well tubing string which projects above and below the well packer, a second well tubing string, and means in the longitudinal passage in which said second support is disposed for connecting said second well tubing string.

5. A well packer as set forth in claim 1, wherein the releasable connection between said first support and the lower abutment is released by manipulation of the first support with respect to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and second support to thereby raise the upper abutment relative to the packing element to release said packing element from its set position, a first well tubing string, means for connecting the first well tubing string to said first well tubing string which projects above and below the well packer, a second well tubing string, and means in the longitudinal passage in which said second support is disposed for connecting said second well tubing string.

6. A well packer adapted to be lowered and set within a well pipe, including, an elastic packing element, an upper abutment above said packing element, a lower abutment below said packing element, and upper and lower abutments each having a pair of parallel openings which are longitudinally aligned to form a pair of longitudinal parallel passages extending through the packer structure, a first tubular support extending through one of said passages and secured to the upper abutment, means releasably connecting the tubular support to the lower abutment, a second tubular support disposed within the other of said passages and secured to the lower abutment, said second support being slideable within the opening in the upper abutment, pipe-anchoring means mounted on the supports below the packing element and comprising an expander cone abutting the lower end of the packing element with pipe-gripping slips slideable relative to the expander cone, a slip carrier to which the slips are attached and mounted for movement relative to the supports, hydraulically-actuated means mounted on the supports between the slip carrier and the lower abutment for moving the slip carrier and gripping slips upwardly with respect to the expander to move the slips into gripping position with the well pipe and for thereafter applying an endwise force to the packing element for deforming the latter into sealing position, means establishing communication between one of the supports and the hydraulically-actuated means for conducting pressure fluid to said means to actuate the same, and locking means carried by the slip carrier and engageable with the second support for locking the slip carrier and slips against downward movement relative to the expander cone to thereby lock said slips in anchored position.

7. A well packer as set forth in claim 6, wherein the hydraulically-actuated means comprises a cylinder depending from the slip carrier and having its lower portion encircling the lower abutment so that the latter functions as a piston, said second support having means for conducting pressure fluid into the cylinder to move the same upwardly and thereby move the gripping slips upwardly on the expander cone into gripping position.

8. A well packer as set forth in claim 6, wherein the locking means comprises gripping elements mounted within the slip carrier and acted upon by the hydraulically-actuated means, said gripping elements having means engageable with the second support to prevent downward movement of the pipe-gripping slips relative to the expander cone and second support.
A well packer as set forth in claim 6, wherein the releasable connection between said first support and the lower abutment is released by manipulating the first support relative to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and second support to thereby raise the upper abutment relative to the packing element to release said packing element from its set position, and a projection on the first support engageable with a part of the anchoring means after the packing element has been released so that continued upward movement of the first support will disengage the pipe-anchoring means from anchored position and permit removal of the well packer structure from the well bore.

A well packer as set forth in claim 6, wherein the releasable connection between said first support and the lower abutment is released by manipulating the first support relative to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and second support to thereby raise the upper abutment relative to the packing element to release said packing element from its set position, a first well tubing string, means for connecting the first tubular support in said first well tubing string which projects above and below the well packer, a second well tubing string, and means releasably connecting the lower portion of a second tubing string within the upper portion of that passage in which the second tubular support is disposed.

A well packer adapted to be lowered and set within a well pipe, including an elastic packing element having an upper abutment above said packing element, a lower abutment below said packing element, the packing element and upper and lower abutments each having a pair of parallel openings which are longitudinally aligned to form a pair of longitudinal parallel passages extending through the packer structure, a first tubular support extending through one of said passages and secured in the upper abutment, means releasably connecting the tubular support to the lower abutment, a second tubular support disposed within the other of said passages, said second support having connection with one abutment and being slideable relative to the other abutment, pipe-anchoring means mounted on the supports below the packing element, hydraulically-actuated means mounted on the supports below the pipe-anchoring means and above the lower abutment, means communicating the bore of one of the supports with said hydraulically-actuated means whereby pressure fluid may be conducted to said hydraulically-actuated means to actuate the same, said hydraulically-actuated means including one part engageable with and imparting upward movement to the pipe-anchoring means and a second part imparting downward movement to the lower abutment when said hydraulically-actuated means is operated, whereby said anchoring means is set and thereafter the packing element is deformed into sealing position, and mechanical locking means movable into locking position by said hydraulically-actuated means and associated with the pipe-anchoring means for locking said anchoring means and packing element against movement in a direction which unsets said anchoring means and packing element.

A well packer as set forth in claim 1 wherein the releasable connection between said first support and the lower abutment is released by manipulation of the first support with respect to the lower abutment whereby the first support may be moved upwardly relative to the lower abutment and also with respect to the set packer and a portion of the anchoring means whereby a predetermined upward motion of said support relative to the packer relaxes said packer and a projection on said first support engaging with that portion of the anchoring means which has the support movable relative thereto upon continued upward motion of the first support, whereby said portion on the anchoring means is moved in a direction which will release the anchoring means.

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CHARLES E. O'CONNELL, Primary Examiner.
BENJAMIN BENDETT, Examiner.