

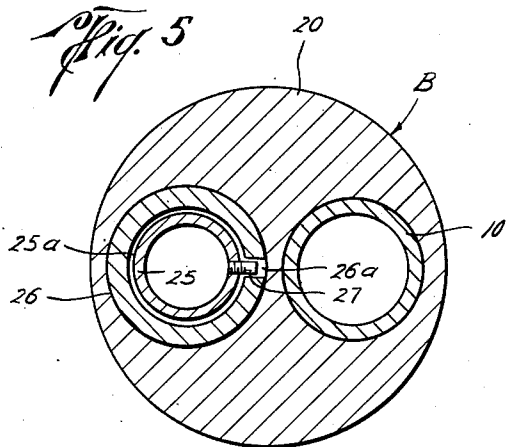
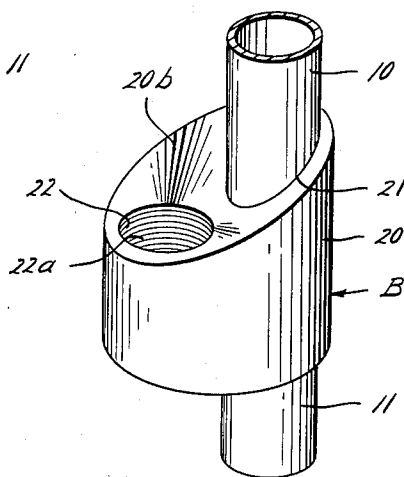
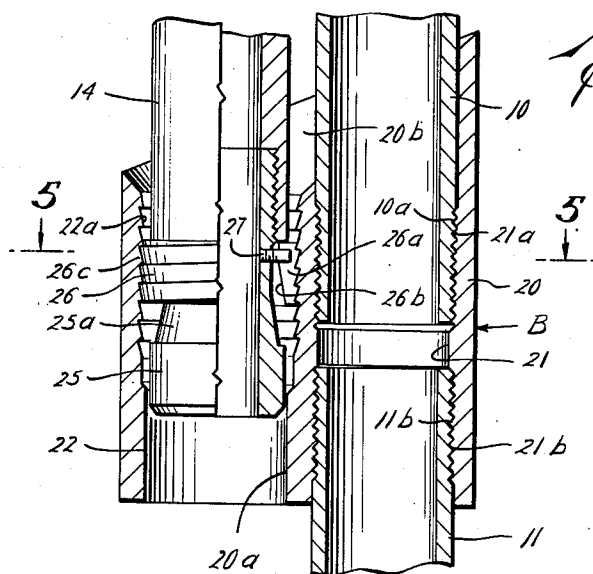
Aug. 13, 1963

C. C. BROWN
WELL APPARATUS AND METHODS OF RUNNING A
PLURALITY OF TUBING STRINGS IN A
WELL BORE OR PIPE

3,100,531

Filed June 29, 1955

4 Sheets-Sheet 2



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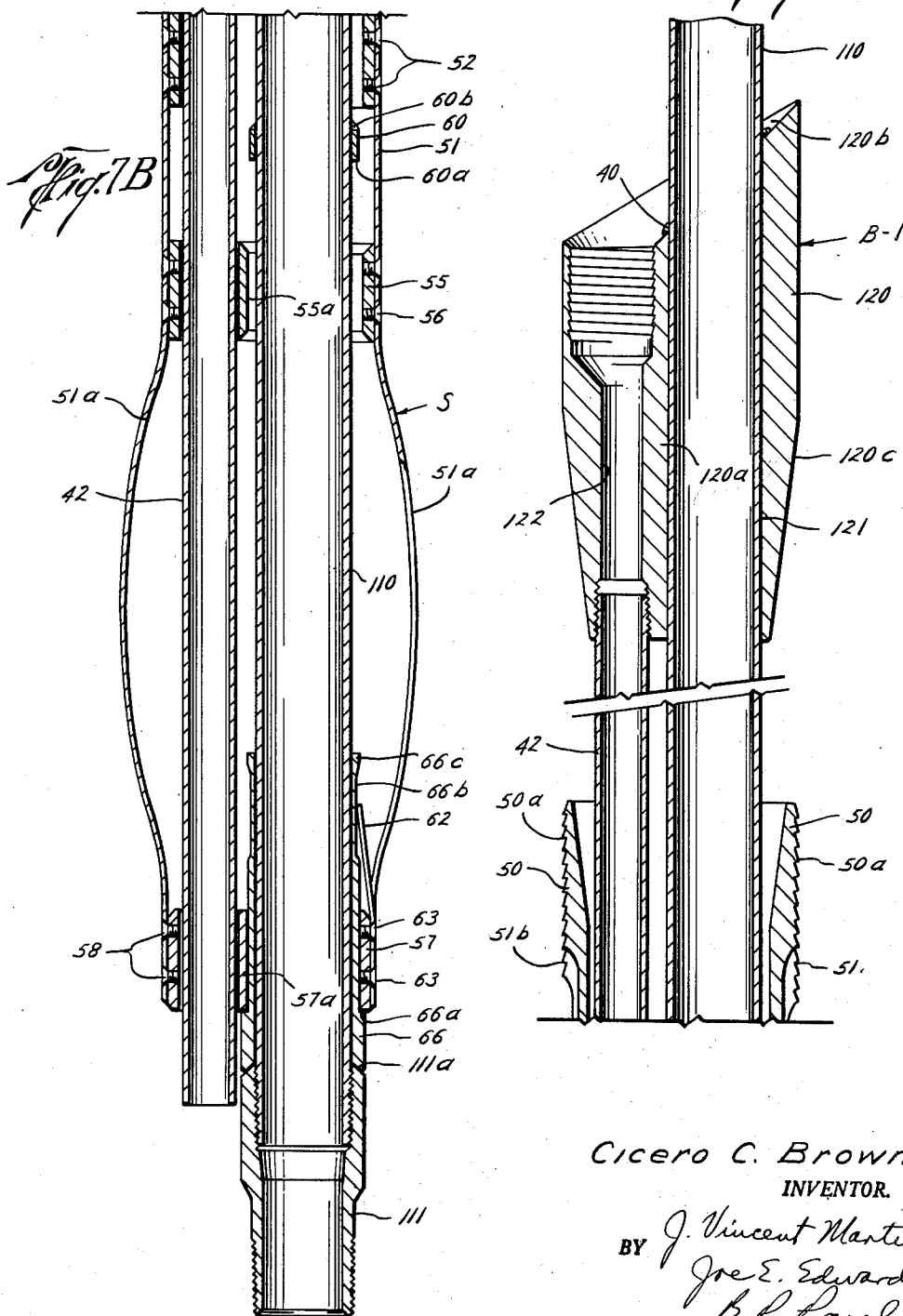
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Fig. 7A



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4 Sheets-Sheet 4

Fig. 8A

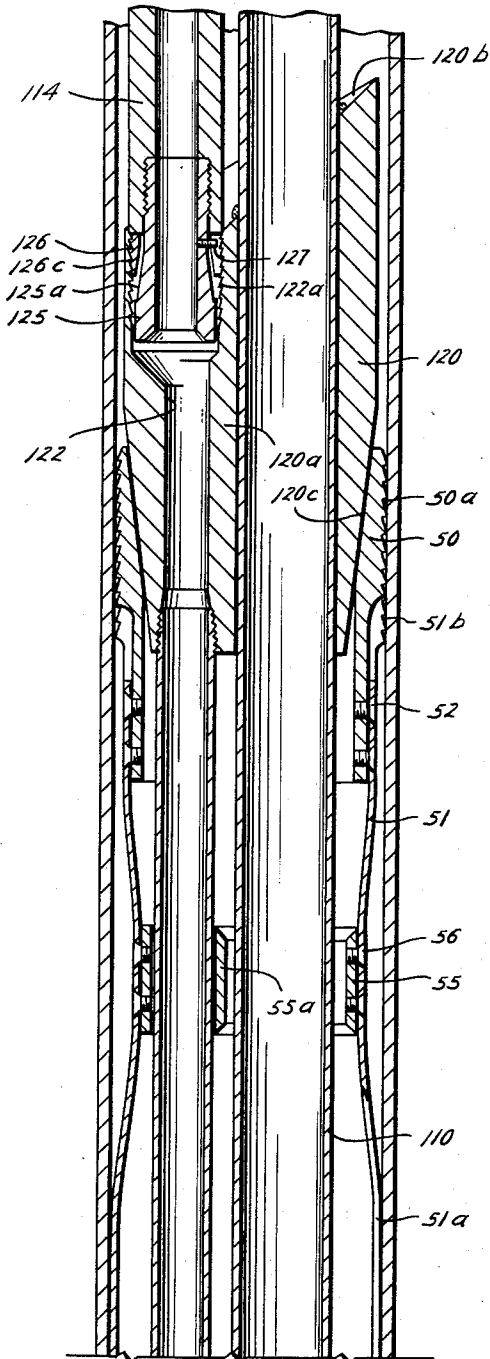
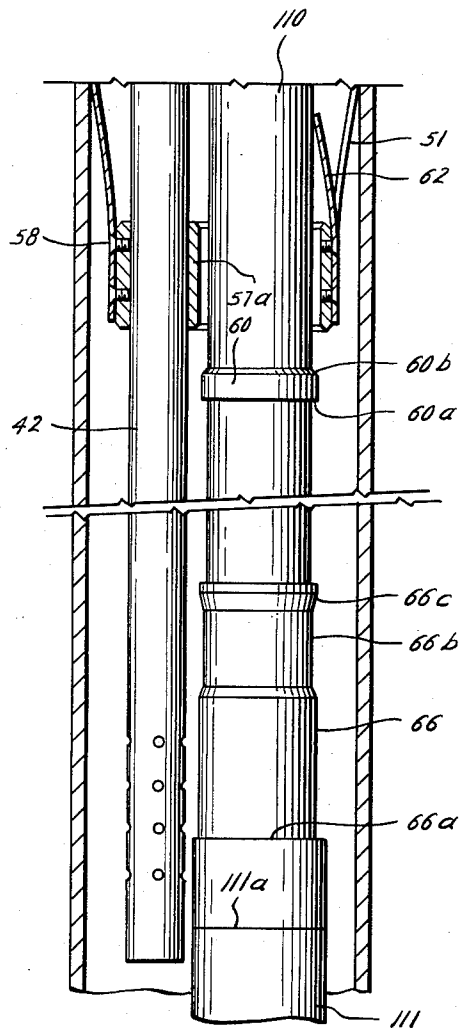


Fig. 8B



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1

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WELL APPARATUS AND METHODS OF RUNNING A PLURALITY OF TUBING STRINGS IN A WELL BORE OR PIPE

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3 Claims. (Cl. 166-114)

This invention relates to new and useful improvements in well apparatus and methods of running a plurality of tubing strings in a well bore or pipe.

The invention provides a producing string of pipe whereby production from a well may be carried on from two or more producing strata simultaneously. The invention relates to a dual string arrangement in which there is only one packer used between the two producing formations. As is well known, it has been the general practice to set two packers, one between the producing formations and one above the upper formation. In the invention disclosed herein, only the lower packer is provided and through this packer is positioned a first tubing string. This tubing string supports a second tubing support assembly, said assembly taking the second tubing, either with the lower packer or with a slip arrangement in the well casing.

In my copending U.S. patent application, Serial No. 504,512, filed April 28, 1955, as a continuation of my prior application Serial No. 473,303, filed December 6, 1954, I have disclosed a well apparatus and method wherein a first well packer is initially positioned in a well casing or bore and thereafter a second well packer is positioned in such casing or bore with a plurality of tubing strings connected thereto and with one of said tubing strings being detachable from said second well packer, whereby said second well packer is adapted to be lowered into and removed from the well casing or bore on only one of the tubing strings.

An object of this invention is to provide a well apparatus and method which are improvements on the apparatus and method of the aforesaid application, and specifically wherein the second well packer of said application is eliminated while still providing means for supporting a plurality of tubing strings in a well casing or bore, with at least one of the strings being detachable for separate removal from the well casing or bore.

A further object of this invention is to provide a new and improved method of running a plurality of tubing strings in a well pipe wherein a well packer is first set in the well pipe for receiving therethrough the lower end of a first tubing string having a support member thereon, and thereafter mounting a second tubing string with said support and above said packer.

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 diagrammatic view illustrating one form of the apparatus of this invention as it is being positioned in a well casing.

FIGURE 2 is a view similar to FIGURE 1, but illustrating the form of the apparatus of FIGURE 1 in its set position for conducting well operations.

FIGURE 3 is a diagrammatic view of another form of the apparatus of this invention, illustrating same as it is being lowered or run into the well casing.

FIGURE 4 is a view, partly in elevation and partly in

2

section, illustrating the support assembly of this invention which is utilized in connection with the first form illustrated in FIGURES 1 and 2.

FIGURE 5 is a horizontal sectional view taken on line 5-5 of FIGURE 4.

FIGURE 6 is an isometric view of the support assembly of FIGURE 4, illustrating same with one of the tubing strings detached therefrom.

FIGURES 7A and 7B are views, partly in elevation and partly in section, which together illustrate the details of the second form of the invention shown diagrammatically in FIGURE 3, such views illustrating the apparatus of the second form in its intermediate operating stage and prior to the setting of the slips thereof in engagement with the well casing.

FIGURES 8A and 8B are views, partly in elevation and partly in section, which together illustrate the second form of the invention, with said apparatus being in its set position for conducting well operations through the two tubing strings thereof.

In the drawings, the letter A designates a well packer of known construction which is adapted to be set in the well casing or pipe C by lowering same into such casing or pipe C on a wire line. The packer A is set above a lower well formation F and below an upper well formation F'. The usual perforations P and P' are provided in the well casing C to establish communication between the interior of the casing C and the formations. With the packer A set in the well pipe or casing C, a first tubing string 10 having a lower tubing extension 11 is lowered into the casing C and is positioned with its lower end extending through the opening 12 in the packer A so as to establish fluid communication between the first tubing string and the lower well formation F. The first tubing string 10 has a tubing string support assembly B therewith which is lowered into the well with the tubing string 10 and the extension 11 therebelow. The lower tubing extension 11 has a stop member 11a connected thereto by welding or other connecting means so as to limit the downward movement of the first tubing string 10 and so as to support the tubing support assembly B and the tubing string 10 in the well bore or well casing C. After the first tubing string has thus been located in the well bore or casing C, a second tubing string 14 is lowered into the bore or casing C and is connected to the support assembly B as will be more fully described hereinafter. The second tubing string 14 is in fluid communication with the upper well formation F' above the packer A. Thus, the two tubing strings 10 and 14 are positioned in the casing C for separately communicating with the well formations F and F', and the construction of the apparatus of this invention is such that only the one well packer A is necessary.

The details of the tubing string support assembly B and the connection therewith of the tubing string 10, tubing string extension 11 and the other tubing string 14 are illustrated in FIGURES 4-6. As shown therein, the assembly B includes a tubular body 20 which has longitudinally extending bores or passages 21 and 22 therethrough. Such passages 21 and 22 are ordinarily spaced from each other so as to leave an intermediate wall portion 20a between the passages 21 and 22. The lower end of the first tubing string 10 is threaded or otherwise connected in the longitudinal passage 21 by the interengagement of threads 10a and threads 21a. The upper end of the lower tubing extension 11 is similarly connected in the passage 21 by the interengagement of threads 11b on the tubing extension 11 with threads 21b in the bore 21, or any other suitable securing means. Thus, the tubing string 10 and the tubing section or extension 11 are connected for flow from one to the other.

The second tubing string 14 is provided with a bottom adapter 25 which is threaded or otherwise connected to the lower end of the tubing string 14 and which has a tapered or inclined annular surface 25a formed on the exterior thereof. Surrounding such inclined surface 25a is an annular nut 26 which is in the form of a split ring having the longitudinal slot or space 26a formed between the ends of the nut ring 26 (FIGURE 5). A pin 27 is threaded or otherwise connected to the adapter 25 and extends into the space or slot 26a to prevent a rotation of the nut 26 relative to the adapter 25 while permitting relative longitudinal movement between the nut 26 and the adapter 25. The internal surface of the nut 26 is tapered at 26b at substantially the same inclination as the tapered or inclined surface 25a of the adapter 25, and the external surface 26c of the nut 26 is formed with teeth or threads, which are preferably left-hand threads. Such teeth or threads 26c are adapted to engage with corresponding teeth or threads 22a formed in the bore or passage 22. With such construction at the lower end of the tubing string 14, the string 14 is adapted to be connected to the body 20 of the support assembly B upon a nonrotative longitudinal lowering of the tubing string 14. Such lowering causes the nut 26 to ride upwardly to its upper position (FIGURE 4) upon an engagement of the threads 26c with the threads 22a. As the tubing string 14 is continued in its lowering, the nut 26 contracts sufficiently by reason of the slot or space 26a to permit the nut 26 to move downwardly relative to the threads 22a in the bore 22. Thereafter the nut 26 cannot be removed from the bore 22, and therefore the tubing string 14 cannot be removed from the bore 22 by a nonrotative upward longitudinal movement of the tubing string 14. However, upon a rotation of the tubing string 14 to the right, assuming the threads 26c and 22a are left-hand threads, the right-hand rotation is imparted to the nut 26 through the pin 27 and therefore the nut 26 is threaded out of the threads 22a to release the string 14. It should also be noted that the upper end 20b of the body 20 of the assembly B (FIGURES 4 and 6) is sloped or inclined and is also cup shaped so that the lower end of the adapter 25 on the bottom of the tubing string 14 is automatically guided into the bore 22 of the body 20 upon a lowering of the string 14 downwardly in the casing or pipe C.

In the operation or use of the form of the invention shown in the FIGURES 1, 2 and 4-6, the well packer A is initially set in the well pipe or casing C between the well formations F and F'. As previously explained, such packer A is of a known construction wherein it is adapted to be set in the casing C while leaving the open bore 12 therethrough. After the packer A is thus set, the support assembly B is lowered into the pipe or casing C on the tubing string 10. The tubing section or extension 11 is connected to the support assembly B therebelow and the lowering of the support assembly B, with the tubing string 10 and the tubing section 11, is continued until the stop member 11a contacts the packer A. At such time, the lower portion of the tubing extension 11 has established communication with the area below the packer A since the lower portion of the tubing section 11 extends through the bore 12 of the packer A when the stop 11a is seated on the packer A. Thereafter, the second tubing string 14 is lowered in the casing C and it is guided automatically into the bore or passage 22 by reason of the inclination and cupped shape of the upper end or surface 20b of the body 20 (FIGURE 6). The nut 26 on the lower end of the string 14 is connected with the threads 22a in the bore 22 by the nonrotative lowering of the string 14. The string 14 is thus in fluid communication with the area above the packer A. The usual casing head 30 is provided at the upper end of the casing C and packing 31 of the usual type is also provided to prevent fluid flow around the upper ends of the strings 10 and

14. A valve (not shown) is ordinarily provided on the outlet pipe 32 connected to the casing head 30.

In any event, the fluid from the upper formation F' is directed through the second tubing string 14, either by the pressure of the fluid formation F' or by means of a pump located in the tubing string 14. Generally, the pressure of the fluid in the formation F' is sufficient to cause the fluid therefrom to rise in the casing C above the packer A to a point above the lower end of the string 14 so that a head of pressure is constantly exerted to force the fluid upwardly through the tubing 14 from the formation F'.

When it is desired to remove the apparatus of FIGURES 1, 2 and 4-6 from the well casing C, the tubing string 14 is ordinarily removed independently and separately from the first tubing string 10 and the support assembly B. Such removal is accomplished by rotating the tubing string 14 with suitable equipment at the surface of the well, and such rotation imparts a similar rotation to the nut 26. If the threads 26c and 22a are left-hand threads, the pipe or tubing string 14 is rotated to the right (as viewed from the top of FIGURE 2) so as to cause the nut 26 to travel upwardly relatively to the bore 22 and therefore to be released from the threads 22a, whereupon the tubing string 14 can be raised upwardly and out of the casing C. Thereafter, the tubing string 10 with the support assembly B and the lower tubing section 11 are removed from the packer A and the well casing C. The packer A can subsequently be removed in the known manner, if desired.

In FIGURES 3, 7A, 7B, 8A and 8B, another form of the apparatus of this invention is illustrated. Therein it can be seen that a first tubing string 110, which corresponds with the first tubing string 10 of FIGURE 1, is connected to the body 120 of the tubing string support assembly B-1. The string 110 extends through the bore or passage 121 of the body 120 and is connected to the body 120 by an annular weld 40 or any other suitable connection means. The portion of the tubing string 110 which extends below the support assembly B-1 has connection with a lower tubing section or extension 111, which corresponds with the tubing section or extension 11 of FIGURE 1 and which is also adapted to extend through the open central bore 12 of a packer A which is ordinarily of the same construction as the packer A previously described in connection with the first form of this invention.

The body 120 of the assembly B-1 also has a downwardly extending pipe section 42 connected in the lower portion of the bore or longitudinal passage 122 of the body 120. The pipe 42 thus establishes communication with the bore 122 and is of such length that it terminates above the packer A and ordinarily in the vicinity of the upper well formation F'. The openings or bores 121 and 122 are ordinarily substantially parallel to each other and are spaced from each other by a central portion 120a of the body 120. The upper end 120b of the body 120 is inclined and cup shaped in the same manner as previously described in connection with the surface 20b of FIGURE 6. Such guide surface 120b serves to guide the lower end of the tubing string 114 (dotted lines, FIGURE 3) downwardly into the upper end of the bore 122 automatically for releasably connecting same, as will be more fully explained. The lower external portion of the body 120 is inclined or tapered at 120c to form an expander cone.

Below the support assembly B-1 and the slip expander 120c, a slip assembly S is provided for supporting the tubing strings in the casing C during the use thereof, as will be explained. Such slip assembly S includes a plurality of arcuate slip segments or slips 50, each of which has gripping teeth 50a on the external surface thereof which are preferably extending downwardly and outwardly. Such slips or slip segments 50 are carried by a plurality of flexible metal bands 51 which are bolted

or riveted to the slip segments 50 with rivets or bolts 52, or any other suitable means. The bands 51 are all connected to an upper annular ring 55 by rivets 56 or any other suitable securing means. The portion 51a of each of the bands 51 below the ring 55 is bowed or curved outwardly so as to constantly engage the inner surface of the casing or pipe C to thereby serve as the usual friction springs or shoes. The lower ends of the bands 51 are connected to a lower ring 57 by rivets or screws 58, or any other suitable securing means. Preferably, the upper ring 55 is provided with an intermediate portion 55a which is positioned between the lower tubing section 42 and the tubing section 110. Also a similar spacer portion 57a is provided on the ring 57.

For maintaining the slip assembly S below the slip expander 120c of the support assembly B-1 during the lowering of the apparatus into the well casing C, a latch ring 60 is welded or otherwise secured to the tubing string 110 (FIGURES 3 and 7B). Such latch ring 60 is formed with a lower laterally extending surface 60a and an upper inclined surface 60b. During the running in of the apparatus of this invention, a plurality of resilient fingers 62 (FIGURE 3) which are secured to the ring 57 by screws 63, or the like, are in engagement with the lower laterally extending surface 60a of the latch ring 60 so that as the tubing 110 is lowered, the slip assembly S is carried downwardly also with the slip segments 50 spaced below the expander surface 120c. Thus, during the running in of the apparatus of this invention, the slips 50 are prevented from being set into gripping engagement with the well casing C. It should be noted in this connection that the resiliency of the bands 51 normally hold or urge the slip segments 50 inwardly to their retracted position (FIGURE 7A). It should also be noted that the upper ends of the bands 51 are provided with teeth 51b which supplement the teeth of the slip segments 50, although such additional teeth 51b may be omitted if desired.

In order to set the slips 50 in gripping engagement with the well pipe or casing C, the fingers 62 are released from the latched position below the latch ring 60. This is accomplished by means of a latch-releasing sleeve 66 which is positioned below the ring 57 during the running in of the apparatus. Such release sleeve 66 rests upon the annular shoulder or edge 111a of the collar connecting the tubing string 110 with the lower tubing section 111. The release sleeve 66 is provided with a lateral shoulder 66a near its lower end for receiving the ring 57, as will be explained. The sleeve 66 is also provided with an intermediate portion 66b of reduced thickness to provide a recess for receiving the finger 62 during the releasing operation, as will be explained. Above the intermediate recess portion 66b, the sleeve 66 is provided with an upper section 66c of substantially the same thickness as the thickness of the latch ring 60, the purpose of which will be more evident hereinafter.

As previously pointed out, the support assembly B-1 and the slip assembly S are lowered together into the well casing C on the single tubing string 110 in the usual case. Thereafter, the second tubing string 114 is lowered into the well casing, whereby only one tubing string is handled during the positioning of the apparatus of this invention in the casing. For connecting the tubing string 114 to the support assembly B-1, the tubing string 114 has an automatic bottom connection of the same type described above in connection with the tubing string 14 in the first form of this invention. Thus, the tubing string 114 has an adapter 125 (FIGURE 8A) which is threaded or otherwise connected to the lower end of the string 114 and which has a tapered or inclined surface 125a which is surrounded by the annular nut 126 having threads 126c formed on its external surface. The nut 126 is formed in the shape of a split ring with a screw or pin 127 in the slot or space of the split ring to prevent relative rotation of the nut 126 and the adapter 125 while permitting rela-

tive longitudinal movement therebetween. The threads 126 are engageable with the threads 122a of the bore 122 and preferably such threads are left-hand threads so that a rotation of the string 114 to the right (as viewed from the top of FIGURE 8A) effects a release of the nut 126c from the threads 122a.

In the operation or use of the second form of the apparatus of this invention illustrated in FIGURES 3, 7A, 7B, 8A and 8B, the well packer A, of known construction, is initially set in the well casing C so as to leave the open bore 12 thereof. Thereafter the apparatus of this invention is lowered into the well casing C on the tubing string 110. The slip assembly S is maintained in a retracted position during the lowering of the apparatus into the well bore or casing C. When the apparatus has reached the depth at which it is desired to set the slip assembly, the downward movement of the apparatus is halted by stopping the downward movement of the tubing string 110. Then the tubing string 110 is raised upwardly. Due to the frictional engagement of the bowed portions 51a of the bands 51 with the interior of the casing C, the slip assembly S does not move upwardly when the tubing string 110 is moved upwardly. Thus, the upward movement of the string 110 carries the release sleeve 66 upwardly to the position shown in FIGURE 7B, at which time the fingers 62 are positioned with their upper ends in the notch or annular recess 66b of the sleeve 66. The resiliency of the fingers 62 hold the sleeve 66 in contact therewith so that thereafter as the tubing string 110 is lowered, the sleeve 66 does not fall with the string 110 but remains stationary in the casing C with the fingers 62. Such fingers 62 are, of course, held against downward movement because of their connection with the ring 57 which in turn is connected to the friction springs 51a. As the lowering of the tubing string 110 is continued, the latch ring 60 contacts the upper end of the sleeve 66 and then forces the sleeve 66 downwardly relative to the fingers 62. However, since the thickness of the latch ring 60 and the upper section 66c of the sleeve 66 are substantially the same, the downward movement of the sleeve 66 and the latch ring 60 causes the ends of the fingers 62 to slide upwardly and over the external surface of the latch ring 60 whereby the latch ring 60 is permitted to pass below the fingers 62.

When the latch ring 60 has thus passed below the resilient fingers 62, then the support assembly B-1 is movable downwardly relative to the slip assembly S so as to move the slip expander surface 120c downwardly relative to the slip segments 50. When such downward relative movement occurs, the slip expander surface or cone 120c moves within the inner surfaces of the slip segments 50 and wedges or urges the slip segments 50 outwardly so as to move the teeth 50a thereof into gripping engagement with the interior of the casing or pipe C. The weight of the tubing thus rests upon the slips 50 and is supported in the casing C by such slips 50.

When the slips 50 are thus set, the fluid communication is established between the lower well formation below the packer A and the tubing string 110. Thereafter the tubing string 114 is lowered into the well casing C and is automatically guided by the guide surface 120b into the opening 122. As the string 114 enters the bore 122, the teeth 126 engage the teeth 122a and such engagement causes the nut 126 to ride upwardly above the tapered portion 125a of the adapter 125, whereby the nuts 126 can be contracted sufficiently to move downwardly relative to the threads 122 without requiring any rotation of the string 114 or the nut 126. Thus, the connection of the tubing string 114 with the body 120 is effected without requiring rotation of the string 114.

In order to remove the apparatus of this invention, as shown in FIGURES 3, 7A, 7B, 8A and 8B, from the well bore or casing C, the tubing string 114 is ordinarily removed first by rotating the string 114 to the right, assuming the threads 126c and 122a are left-hand threads, which

rotation threads the nut 126 upwardly with the inner surface of the nut 126 in contact with the inclined surface 125, and with the pin 127 effecting the rotation of the nut 126 as the tubing 114 is rotated. Thereafter, the tubing string 110 is raised upwardly to move the slip expander or cone 120c upwardly above the slip segments 50 whereupon the resiliency of the straps or bands 51 supporting the slips 50 urges the slips 50 to a retracted position out of engagement with the casing C. Continued raising of the tubing string 110 ultimately moves the sleeve 66 into contact with the ring 57 (FIGURE 7B) so that the entire apparatus is removed from the well casing C. Thereafter, the well packer A can also be removed in the known manner, if desired.

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 is claimed is:

1. In combination with a well packer disposed within a well bore in a set position to separate two producing zones wherein said packer has a passage extending therethrough, a tubing string support assembly including, a body having a pair of passages extending therethrough, a first tubing string extending entirely through one of the passages and connected to the body, the lower portion of said first tubing string projecting downwardly from the body and having its lower end extending through the passage in the well packer to communicate with the producing zone below said packer, a gripping slip assembly including gripping slips slidably mounted on the downwardly projecting portion of the tubing string whereby when the assembly moves upwardly relative to the body the slips encircle said body, expander means on the body to co-act with said slips for expanding the slips into gripping position when the slip assembly and the body are moved relative to each other, said slips supporting said body when the slips are in expanded position, co-acting latching means on the downwardly extending portion of said first tubing string and on said gripping slip assembly for latch-

ing said assembly against relative movement with respect to the body, means on said first tubing string engageable with a portion of the latching means for releasing said latching means upon reciprocating movement of the first tubing string relative to the assembly, whereby after release of said latching means the body secured to said first tubing string and having the expander means thereon may be moved in a direction relative to the assembly to expand the gripping slips, and a second tubing string having its lower portion landed in the second passage in the body and having its lower end terminating above the well packer to communicate with the zone above said packer.

2. The combination set forth in claim 1, together with means for detachably connecting said second tubing string in landed position whereby said second tubing string may be run in and removed from the bore independently of said first tubing string.

3. The combination set forth in claim 1 wherein the second tubing string has its lower portion terminating within the body, and a tubular extension projecting downwardly from the passage in which the second tubing string is landed, said extension projecting through the gripping slip assembly and having its lower end terminating above the well packer to communicate with the zone above said packer.

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