July 12, 1960 W. W. DOLLISON 2,944,605

MEANS FOR CARRYING OUT A REMOVABLE FLOW TUBE PROGRAM

Filed July 25, 1958 2 Sheets-Sheet 1

FIG-1

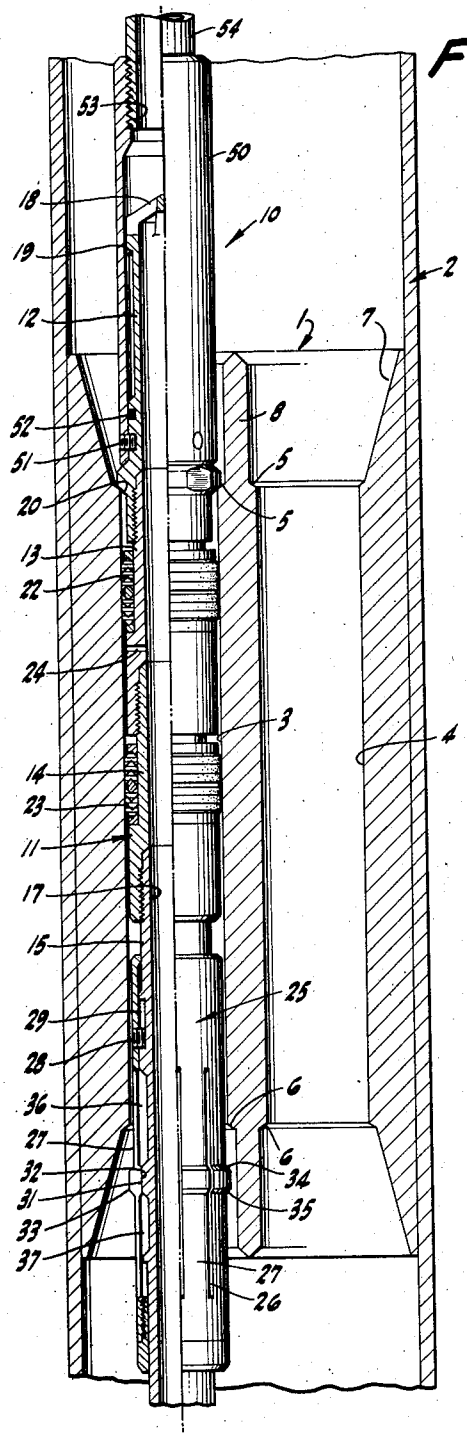
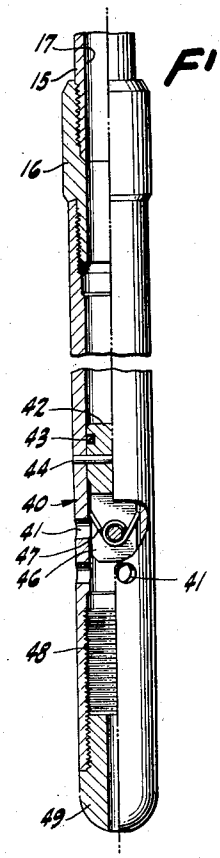


FIG-2



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Filed July 25, 1958 2 Sheets-Sheet 2

FIG-3

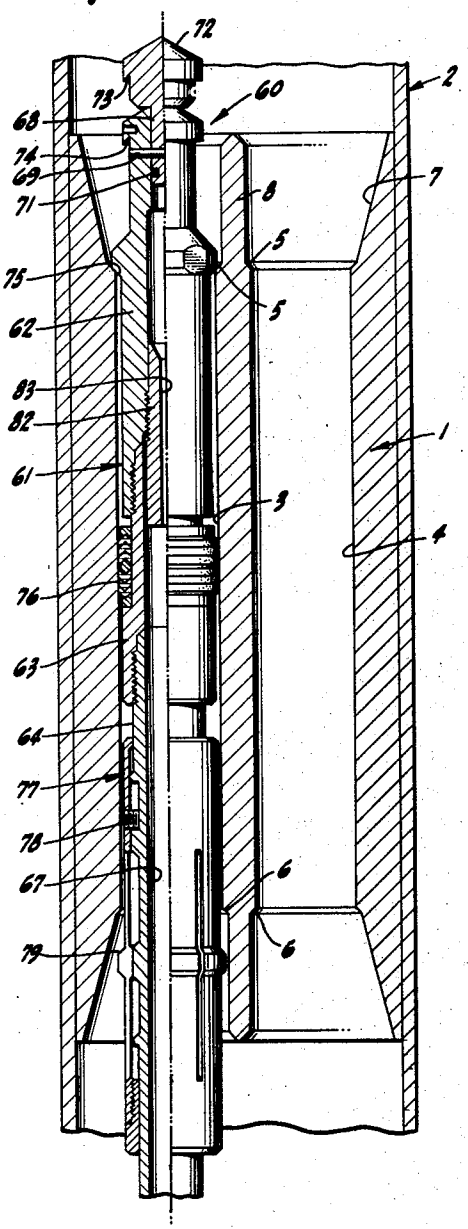
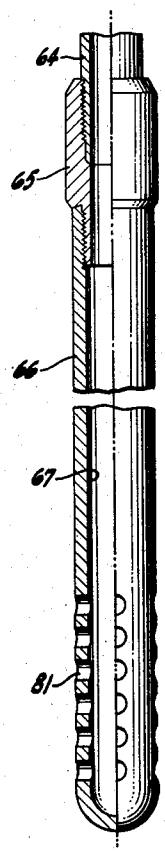


FIG-4



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MEANS FOR CARRYING OUT A REMOVABLE FLOW TUBE PROGRAM

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16 Claims. (Cl. 166—143)

This invention relates to well tools for use in the completion of a multiple zone well, and more specifically to well tools which may be landed in, locked and sealed to, and removed from well packers by means of wire line equipment. This application is a continuation-in-part of my co-pending application, Serial No. 729,682, filed April 21, 1958 and entitled, "Means for Carrying Out a Removable Flow Tube Program."

As set out in my above mentioned application, multiple zone well production can be carried out by installing a duel-bore packer in the well casing between upper and lower production zones. An upper dual-bore packer is lowered into the well by a tubing string and set in place in the casing above the upper production zone, and a second tubing string is connected to the upper packer. This completes the permanent installation of the well, with both tubing strings being open to the upper production zone. The tubing handling rig at ground surface may then be removed, and all subsequent operations may be carried out by wire line apparatus.

An example of such a subsequent installation may be that it is desired to produce the upper zone through one tubing string and to produce the lower zone through the other tubing string. To carry this out, an extension pipe is lowered by wire line through one of the tubing strings and is locked and sealed in the lower end thereof. A safety joint carried at the lower end of the extension pipe is locked and sealed in one bore of the lower packer. A plug choke is lowered by wire line through the other tubing string and is locked and sealed in the other bore of the lower packer to seal against flow therethrough. With this installation, the two production zones are fluidly separated and the lower zone produces through the first tubing string while the upper zone produces through the second tubing string.

In the event that it is desired to rework the lower zone, the plug choke is removed from the lower packer by wire line, and a second extension pipe is lowered through the second tubing string. This second extension pipe is also provided with a safety joint on its lower end which is locked and sealed to the bore of the lower packer from which the plug choke has been removed. This then establishes a flow path down through the second tubing string and second extension pipe into the lower zone, and then back up through the first extension pipe and first tubing string.

To return to the original operation, the second extension pipe is removed from its connection with the lower packer, and a plug choke is reinstalled therein.

From the brief foregoing description, it is apparent that such operations require readily removable plug chokes and safety joints which may be landed in, locked and sealed to, and removed from the lower packer by wire line operation, and it is the primary object of this invention to provide such well tools.

Other objects and advantages will become more apparent in the course of the following detailed description.

In the drawings, forming a part of this application, and

in which like parts are designated by like reference numerals throughout the same,

Figs. 1 and 2 are elevational sectional views of the upper and lower portions, respectively, of a safety joint constructed in accordance with the invention and shown as landed, locked and sealed in one bore of a dual-bore packer.

Figs. 3 and 4 are views similar to Figs. 1 and 2 and illustrate a plug choke constructed in accordance with the invention.

The safety joint

Referring now to the drawings, and particularly to Figs. 1 and 2 thereof, the lower packer **1** is secured in well casing **2**. Since the particular details whereby the packer **1** is set in place and sealed in casing **2** are conventional and form no part of the present invention, the packer **1** has been illustrated in schematic form in the drawings. If desired, a duel bore packer such as that shown on page 936 of the Composite Catalog of Oil Field Equipment and Services 1957 (22nd) edition, may be used in the present invention. The two longitudinal bores **3** and **4** of the packer are adapted for use in the present invention by machining each bore so that it has an internal landing nipple profile, as shown in Fig. 1. Each honed bore has an upwardly and outwardly inclined annular shoulder **5** at the upper end thereof, and a downwardly and outwardly inclined annular shoulder **6** at the lower end thereof. The upper inner wall **7** of the packer is tapered outwardly and upwardly so that tools lowered into the packer will be guided thereby and by the bore separating partition **8** into one of the packer bores.

The safety joint **10** comprises a vertically disposed generally cylindrical mandrel **11** formed by the joint member **12**, upper and lower packing mandrels **13** and **14**, lock mandrel **15** and end sub **16**, connected together as shown, and having a constant diameter axial bore **17** therethrough.

The joint member **12** has an upwardly and inwardly converging perforate upper end **18** to permit fluid flow therethrough and to serve as a guide to facilitate the connection of a fishing member (not shown) with the undercut fishing neck **19** formed thereon. The joint member **12** is radially enlarged to form an outwardly extending and downwardly facing seating surface **20** engageable with the upper shoulder **5** of one of the packer bores **3** or **4**.

Vertically spaced apart chevron packing members **22** and **23** are carried on the upper and lower packing mandrels **13** and **14**, respectively, and a testing passage **24** is formed through the upper packing mandrel **13** to provide fluid communication from the bore **17** to between the packing members **22** and **23**.

The locking assembly comprises a bow spring collet sleeve **25** having a plurality of longitudinal slots **26** therethrough from below the upper end thereof to above the lower end thereof to form a plurality of ribs **27**. The collet sleeve **25** encircles the lock mandrel **15** and can move between an upper position thereon wherein the upper end of the sleeve abuts the lower end of the packing mandrel **14** and a lower position thereon wherein the lower end of the sleeve abuts the upper end of the end sub **16**. However, normal downward movement of the sleeve is limited to the intermediate position shown in Fig. 1 by the shear screw **28** which extends through sleeve **25** into the longitudinal recess **29** in the lock mandrel.

When the sleeve **25** is in its illustrated intermediate position, the outwardly projecting portion **31** of the lock mandrel engages the inwardly projecting portion **32** of the ribs **27** so that the ribs are prevented from flexing inwardly. An outwardly projecting portion **33** formed

on each rib provides a downwardly and outwardly extending seating surface **34** engageable with the lower shoulder **6** of the packer bores, and an upwardly and outwardly extending cam surface **35**.

When the sleeve **25** is in either its upper or lower position, the inwardly extending rib portions **32** will be opposite one of the annular grooves **36** or **37** so that the ribs may flex thereinto.

A lead-in pipe **40**, secured to the lower end of end sub **16**, may be considered as a part of the mandrel **11**, and has a plurality of ports **41** therethrough to provide fluid communication between the interior and exterior thereof. A plug member **42**, disposed within the lead-in pipe, is sealed thereto by O-ring **43** and is locked thereto by shear pin member **44**. The lower end of the plug member **42** is slotted, at **46**, and a spring latch member **47** is carried thereby. As will be noted in the drawings, the upper ends of the spring latch are biased outwardly against the bore of the plug member. If the shear pin **44** is sheared and the plug member moves downwardly, the upper ends of the latch member will engage the internal threads **48** which will act as latch shoulders to restrain upward movement of the plug member within the lead-in pipe. Downward movement of the plug member is limited by engagement with sub **49**.

The upper end of the mandrel **11** has telescopically connected thereto a tubular member **50**, which is held thereto by shear screw elements **51** and is sealed thereto by O-ring **52**. The tubular member is internally threaded at **53** for connection to an extension pipe **54**.

The shear strength of shear screws **51** is greater than the shear strength of shear screws **28**, for a reason to be explained hereinafter.

In the installation of the safety joint **10**, the tubular member **50** is connected to the lower end of an extension pipe **54** and the latter is lowered by wire line through one of the tubing strings of a dual zone well. As the cam surface **35** of the outwardly projecting portions **33** on the bow spring collet sleeve ribs encounters obstructions in the tubing string, the sleeve will move upwardly on the lock mandrel to position the inwardly projecting rib portions **32** to flex into the lock mandrel groove **36**, so that the obstructions may be passed

The same upward movement of the sleeve **25** will occur when the safety joint enters one of the bores of packer **1**, enabling the safety joint to pass downwardly therein until the seating surface **20** engages the upper shoulders **5** of the packer to prevent further downward movement. If an upward force is exerted on the safety joint, the collet sleeve **25** will move downwardly on the lock mandrel to the position shown in Fig. 1, and the seating surface **34** on the sleeve ribs **27** will engage the lower shoulder **6** of the packer to prevent upward movement of the safety joint from the packer. The safety joint is now locked in the packer against upward or downward movement therethrough.

The effectiveness of the seal established between packing members **22** and **23** and the honed bore **3** of the packer **1** may be ascertained by applying a pressure in the extension pipe **54** and safety joint **10**. If the seal is not properly established, the pressure will leak out through the testing passage **24** and by the defective seal of either of the packing members **22** or **23**.

The pressure within the safety joint is then increased until sufficient to shear the pin **44**, thus allowing the plug member to move downwardly in the lead-in pipe **40**, where it is latched out of the way by the spring latch **47**. Fuid communication is now had through the ports **41** into the bore **17** of the safety joint and up through the extension pipe **54**.

To remove the safety joint from packer **1**, the extension pipe **54** is pulled upwardly to engage the outwardly projecting rib portions **33** with the lower packer shoulder **6**. The safety joint is now jarred upwardly to shear the shear pins **28**, allowing the sleeve **25** to move to its lower

position on the lock mandrel **15**. The ribs **27** may now flex inwardly so that the safety joint may be removed from the packer.

In the event that the stafety joint is sanded or otherwise stuck in the packer, additional upward jarring will shear the stronger shear screws **51**, enabling the extension pipe **54** to be removed from the well. A fishing tool (not shown) can then be run into the well to grapple the fishing neck **19** of the joint member **12**. Without the large mass of extension pipe between the jarring tool and the safety joint, the safety joint can then be more easily removed from the packer by upward jarring.

In normal removal, the weaker shear screws **28** will be sheared before the shear screws **51**, so that the only time when the latter screws are sheared is in the abnormal situation when the safety joint is struck in the packer.

The plug choke

The plug choke **60**, illustrated in Figs. 3 and 4, comprises an elongated mandrel **61** comprised of the top sub **62**, packing mandrel **63**, lock mandrel **64**, bottom sub **65** and lead-in pipe **66** connected together as shown, and having an axial bore **67** therethrough.

A plug member **68** slidably fits within the bore **67**, at the upper end thereof, is connected to the top sub **62** by shear pin **69**, and is sealed against flow therepast by O-ring **71**. The upper end **72** of the plug member projects upwardly from the top sub and is provided with an undercut fishing neck **73**.

The top sub **62** is also provided with an undercut fishing neck **74**, and is radially enlarged to provide a downwardly facing seating surface **75** adapted to engage the upper shoulder **5** of one of the bores of packer **1**.

A packing member **76** is carried by the packing mandrel **63** to seal against a honed bore of packer **1**. A bow spring collet sleeve **77**, carried by lock mandrel **64**, is identical to that described in connection with the safety joint **10**, and is provided with shear screws **78** and with upwardly facing seating surfaces **79** engageable with the lower shoulder **6** of packer **1**, as previously described.

The lead-in pipe **66** is relatively long, in the order of 3 or 4 feet, to permit the plug choke to be inserted easily into one of the bores of the packer **1**, and if lost atop the packer, to facilitate fishing for it. A plurality of passages **81** are formed through the lead-in pipe to provide fluid communication between bore **67** and the exterior of the device.

An equalizing sub **82**, disposed within bore **67** and connected to the top sub **62**, has a restricted axial passage **83** therethrough.

The shear pin member **69** has a lesser shear strength than the shear screw means **78**, for a purpose to be explained hereinafter.

In the installation of the plug choke **60**, a suitable running tool (not shown) is attached to the fishing neck **73**, and the plug choke is lowered by wire line into the well until the lead-in pipe enters one of the bores of packer **1**. The plug choke is installed in packer **1** in the same manner as the safety joint previously described. The running tool is then disconnected by suitable jarring operation and is removed from the well. The plug choke **60** will now seal the bore of packer **1** against flow therethrough, and will be prevented from upward or downward movement through the packer by the engagement of the seating surfaces **75** and **79** with the lower and upper shoulders **6** and **5**, respectively, of packer **1**.

Prior to the removal of the plug choke **60** from packer **1**, the pressures above and below the packer are equalized by removing the plug member **68**. This is accomplished by engaging the fishing neck **73** with a suitable pulling tool, operated by wire line, which is jarred upwardly to shear the relatively weak shear pin **69**. Well fluids may now pass through the bore **67** of the plug choke, with the rate of flow and equalization being governed by the much smaller diameter bore **83** of the

equalizing member 82. After the pressures have been equalized, a suitable wire line operated pulling tool engages the fishing neck 74 on the top sub 62. Upward jars will then shear the stronger shear screws 78 to permit the removal of the plug choke in the same manner as previously described in connection with the removal of the safety joint 10.

It is to be realized that the embodiments of the invention, herewith shown and described, are to be taken as preferred embodiments of the same, and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the attached claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A well tool comprising an elongated tubular mandrel having an axial bore therethrough, an outwardly extending and downwardly facing seating surface on the upper end of said mandrel, a collet sleeve mounted for longitudinal sliding movement on the exterior surface of the lower end of said mandrel between upper, intermediate and lower positions thereon, said collet sleeve having a plurality of longitudinally extending flexible ribs, said ribs having an outwardly extending projection and an inwardly extending projection thereon intermediate their ends, a recess formed in said mandrel adjacent said sleeve, said recess having a closed lower end, shear screw means extending through said sleeve into said recess and freely movable therein to allow normal movement of said sleeve between said upper and intermediate positions on said mandrel and engageable with the closed lower end of said recess to normally prevent movement of said sleeve from said intermediate position to said lower position on said mandrel, an outwardly extending projection formed on said mandrel engageable by said inwardly extending rib projections when said sleeve is in its intermediate position said mandrel having first and second annular grooves therein one above and one below said outwardly extending projection into which said inwardly extending rib projection may flex when said sleeve is in its upper or lower positions on said mandrel, and packing means mounted on the exterior of said mandrel between said downwardly facing seating surface and said sleeve.

2. In a well tool as set forth in claim 1 wherein said packing means comprises two vertically spaced apart packing members, and further including a testing passage formed through said mandrel from said bore thereof to between said packing members.

3. In a well tool as set forth in claim 1 further including a tubular member telescoped onto the upper end of said mandrel, a shear element releasably connecting said tubular member to said mandrel, said shear element having a greater shear strength than said shear screw means, and means on said tubular member for attaching a tubing string thereto.

4. In a well tool as set forth in claim 1 further including a pressure equalizing member disposed within said mandrel bore, said equalizing member having a restricted passage longitudinally therethrough.

5. A well tool comprising an elongated tubular mandrel having an axial bore therethrough, a fishing neck on the upper end of said mandrel, an outwardly extending and downwardly facing seating surface on the upper end of said mandrel, a collet sleeve mounted for longitudinal sliding movement on the exterior surface of the lower end of said mandrel between upper, intermediate and lower positions thereon, said collet sleeve being longitudinally slotted therethrough from below the upper end thereof to above the lower end thereof to form a plurality of longitudinally extending flexible ribs, said ribs having an outwardly extending projection and an inwardly extending projection thereon intermediate their ends, a recess formed in said mandrel adjacent said sleeve, said recess having a closed lower end, shear screw means extending through said sleeve into said recess and freely

movable therein to allow normal movement of said sleeve between said upper and intermediate positions on said mandrel and engageable with the closed lower end of said recess to normally prevent movement of said sleeve from said intermediate position to said lower position on said mandrel, an outwardly extending projection formed on said mandrel engageable by said inwardly extending rib projections when said sleeve is in its intermediate position, said mandrel having first and second annular grooves therein one above and one below said outwardly extending projections into which said inwardly extending rib projections may flex when said sleeve is in its upper or lower positions on said mandrel, packing means mounted on the exterior of said mandrel between said downwardly facing seating surface and said sleeve, a flow passage formed through the said mandrel below said packing means to communicate the exterior of said mandrel with said bore, an imperforate plug member slidably disposed within said bore and sealed thereto, and a shear member releasably securing said plug member to said mandrel in said bore above said flow passage.

6. In a well tool as set forth in claim 5 wherein said packing means comprises two vertically spaced apart packing members, and further including a testing passage formed through said mandrel from said bore thereof to between said packing members.

7. In a well tool as set form in claim 5 further including a tubular member telescoped onto the upper end of said mandrel, a shear element releasably connecting said tubular member to said mandrel, said shear element having a greater shear strength than said shear screw means, and means on said tubular member for attaching a tubing string thereto.

8. In a well tool as set forth in claim 5 further including a latch member carried by said plug member, spring means biasing said latch member outwardly into engagement with said bore, and a latch shoulder formed in said bore for engagement by said latch member when said plug member is below said flow passage to restrain upward movement of said plug member within said bore when latched thereto.

9. In a well tool as set forth in claim 5 wherein said packing means comprises two vertically spaced apart packing members, and further including a testing passage formed through said mandrel from said bore thereof to between said packing members, an inwardly and upwardly converging perforate end member formed on the upper end of said mandrel, a tubular member telescoped onto the upper end of said mandrel, a shear element releasably connecting said tubular member to said mandrel, said shear element having a greater shear strength than said shear screw means, and means on said tubular member for attaching a tubing string thereto.

10. In a well tool as set forth in claim 5 wherein said packing means comprises two vertically spaced apart packing members, and further including a testing passage formed through said mandrel from said bore thereof to between said packing members, an inwardly and upwardly converging perforate end member formed on the upper end of said mandrel, a tubular member telescoped onto the upper end of said mandrel, a shear element releasably connecting said tubular member to said mandrel, said shear element having a greater shear strength than said shear screw means, means on said tubular member for attaching a tubing string thereto, a latch member carried by said plug member, spring means biasing said latch member outwardly into engagement with said mandrel bore, and a latch shoulder formed in said bore for engagement by said latch member when said plug member is below said flow passage to restrain upward movement of said plug member within said bore when latched thereto.

11. In a well tool as set forth in claim 5 further including a pressure equalizing member disposed within said

mandrel bore, said equalizing member having a restricted passage longitudinally therethrough.

12. In a well tool as set forth in claim 5 wherein the shear strength of said shear screw means is greater than said shear member.

13. In a well tool as set forth in claim 5 wherein the shear strength of said shear screw means is greater than said shear member, wherein said plug member extends above the upper end of said mandrel, and further including a fishing neck formed on the upper end of said plug member.

14. In a well tool as set forth in claim 5 wherein said plug member extends above the upper end of said mandrel, and further including a fishing neck formed on the upper end of said plug member, and a pressure equalizing member disposed within said mandrel bore, said equalizing member having a restricted passage longitudinally therethrough.

15. In a well tool as set forth in claim 5 wherein said plug member extends above the upper end of said mandrel, and further including a fishing neck formed on the upper end of said plug member, a pressure equalizing member disposed within said mandrel bore, said equalizing member having a restricted passage longitudinally therethrough, and an elongated perforate tubular member secured to the lower end of said mandrel and extending downwardly therefrom.

16. In a well tool as set forth in claim 5 wherein the shear strength of said shear screw means is greater than said shear member, wherein said plug member extends above the upper end of said mandrel, and further including a fishing neck formed on the upper end of said plug member, a pressure equalizing member disposed within said mandrel bore, said equalizing member having a restricted passage longitudinally therethrough, and an elongated perforate tubular member secured to the lower end of said mandrel and extending downwardly therefrom.

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