Oct. 16, 1945. E. F. COOKE 2,386,841

WELL COMPLETION APPARATUS

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Fig. 1

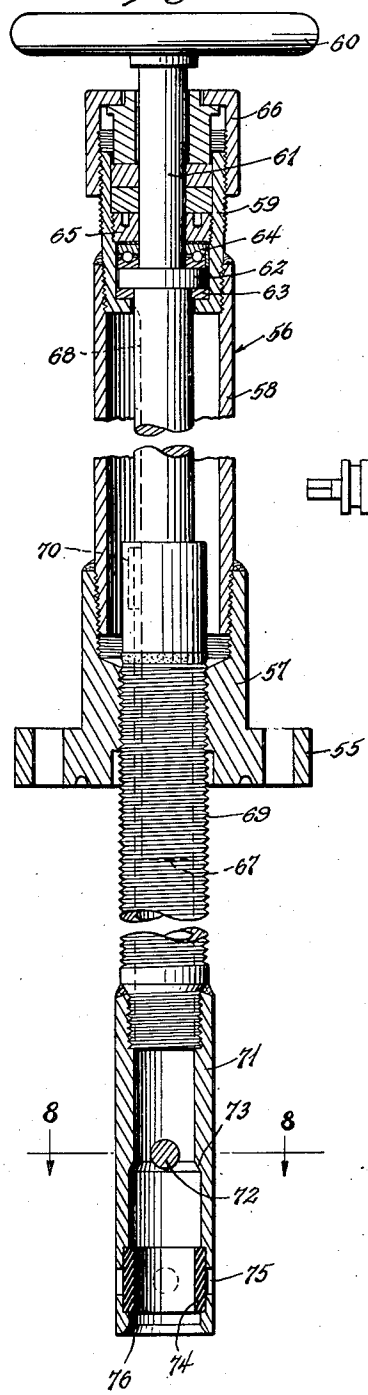


Fig. 5

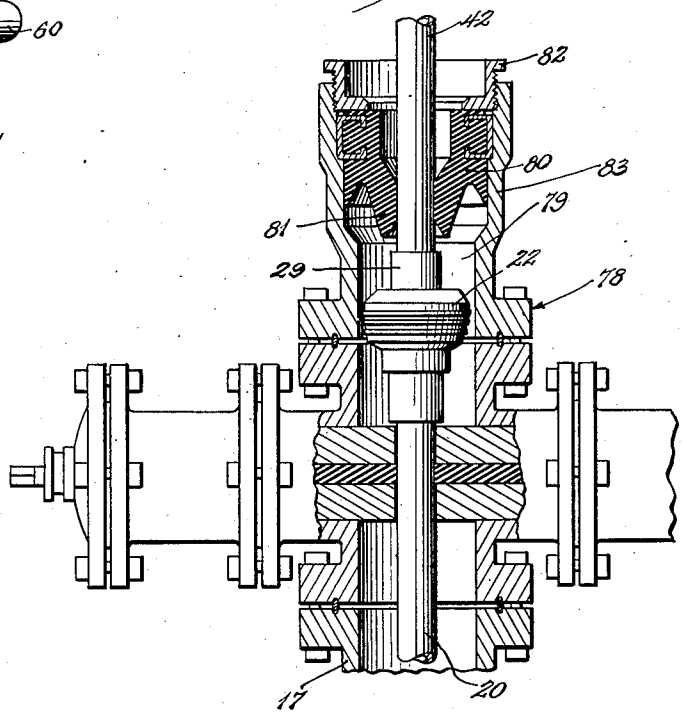


Fig. 7

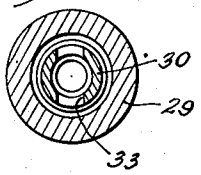
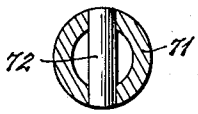


Fig. 8



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Fig.6

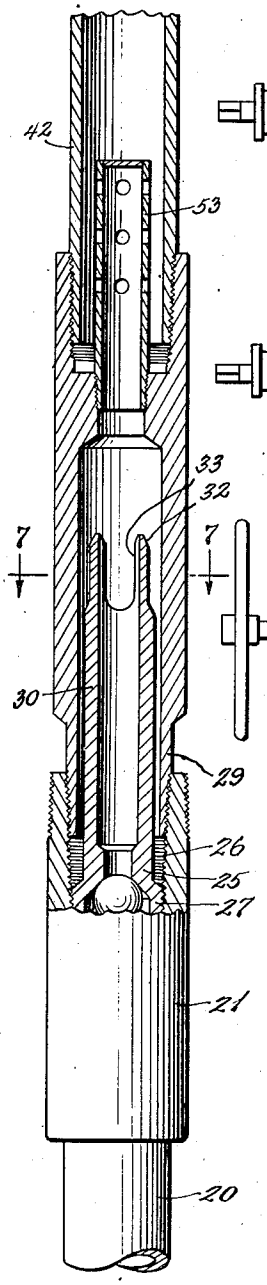
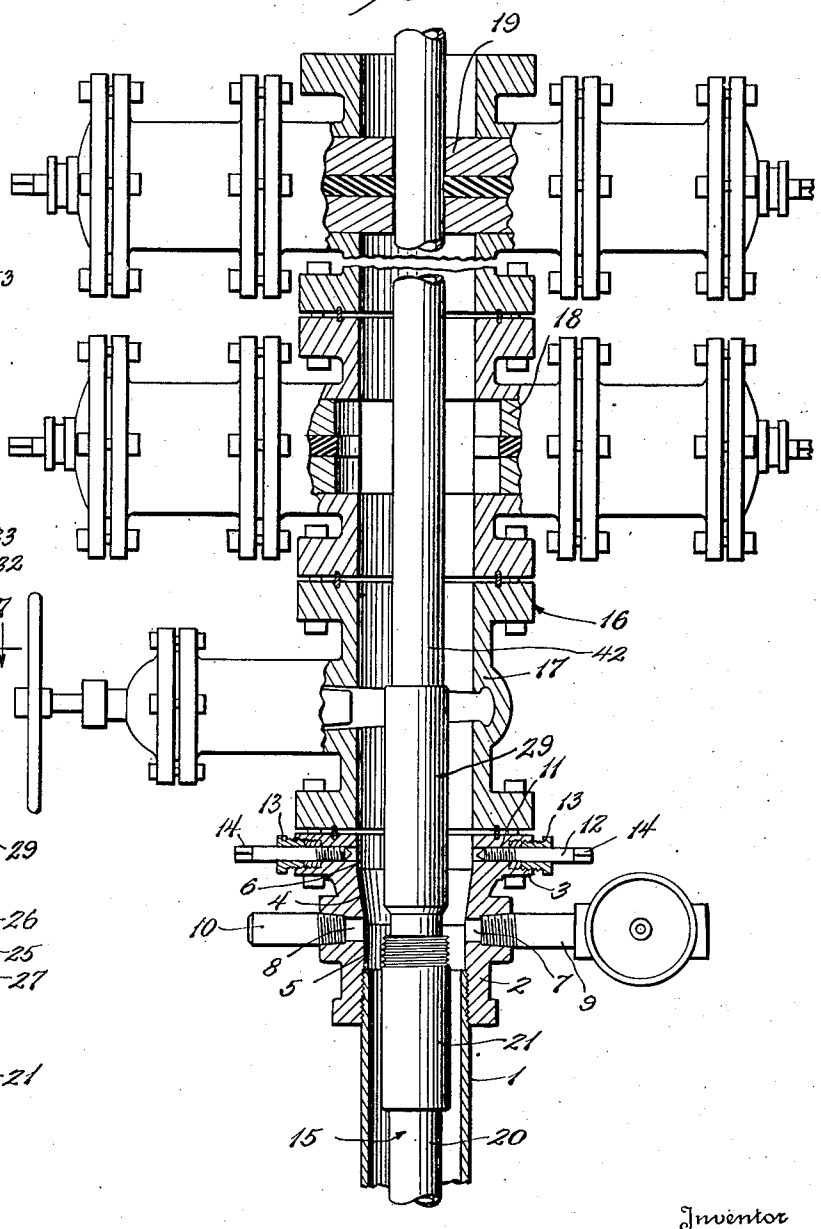


Fig.2



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WELL COMPLETION APPARATUS

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Fig. 3

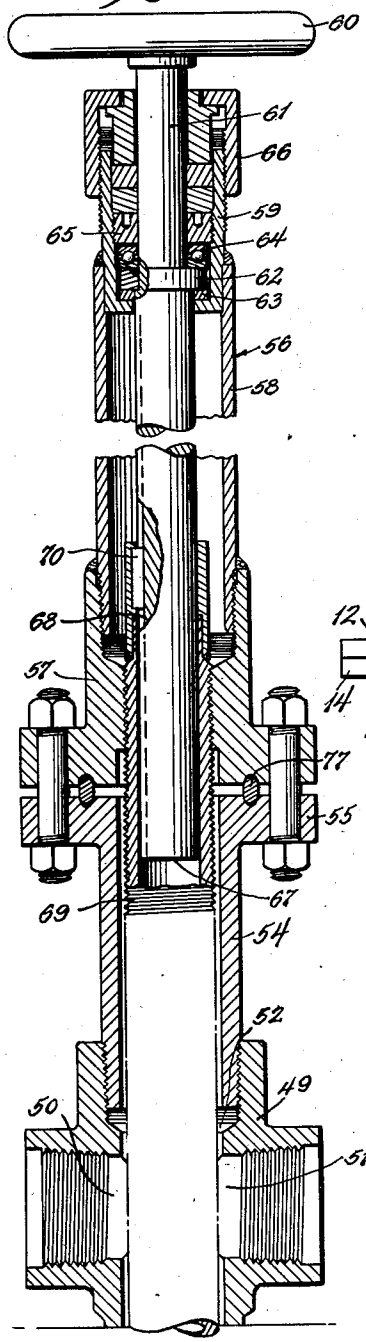
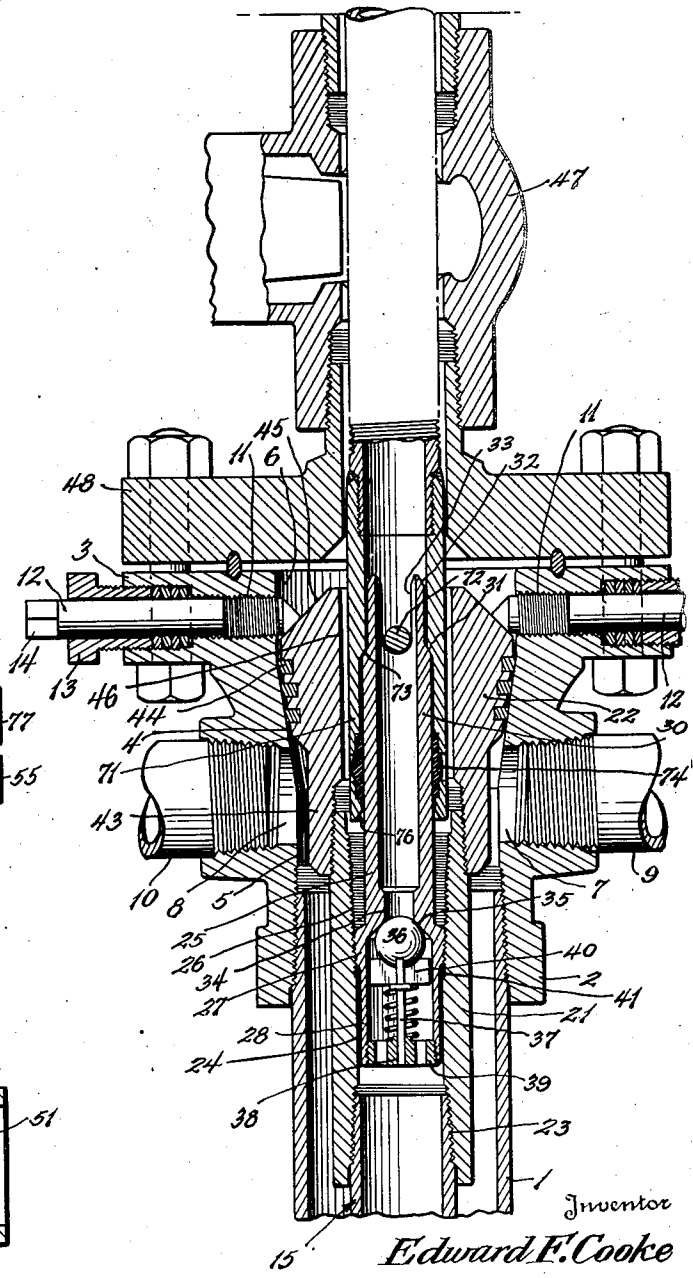


Fig. 4



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WELL COMPLETION APPARATUS

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Application October 7, 1941, Serial No. 414,013

2 Claims. (Cl. 166—15)

This invention relates to oil well completion apparatus and has for its general object the provision of means for sealing the well and withdrawing or reseating, without the escape of fluid pressure from the well, the valve cage containing the check valve which is customarily used to block the bore of the inner pipe string while the latter is being set under a mud head or blow-out preventer.

More specific objects will appear as the following description of a preferred and practical embodiment thereof proceeds.

In the drawings which accompany and form a part of the following specification, and throughout the several figures of which the same reference characters have been employed to designate identical parts:

Figure 1 is a longitudinal sectional view through the valve cage setting and removing tool embodying the principles of the invention;

Figure 2 is a longitudinal section through a casing head and accessory equipment mounted in relation thereto;

Figures 3 and 4 are complementary views in longitudinal cross-section, showing the casing head with the Christmas tree mounted thereupon and the valve cage removing tool of the subject invention in operative position for removing the valve cage, Figure 3 being a continuation of the upper part of Figure 4.

Figure 5 is a longitudinal sectional view of accessory equipment showing a modified form of blow-out preventer;

Figure 6 is a longitudinal sectional view of the handling joint and handling nipple in position with respect to the valve cage;

Figure 7 is a cross-section taken along the line 7—7 of Figure 6;

Figure 8 is a cross-section taken along the line 8—8 of Figure 1.

Referring now in detail to the several figures, and first adverting to Figure 2, this shows the upper end of a well casing 1, having the casing head 2 affixed thereto. Said casing head is of conventional construction, having a flanged upper end 3, a downwardly tapered intermediate bore 4, a lower portion 5 of relatively small diameter, and an upper portion 6 of relatively large diameter, the diameters of said upper and lower portions corresponding to the respective diameters of the tapered bore. The casing head has the customary lateral apertures 7 and 8, to one of which an outlet pipe 9 is connected, the other being connected to a pipe for admitting or withdrawing fluid from the well. Above the tapered bore the casing head is provided with the threaded apertures 11, into which the set screws 12 reciprocate, said set screws being each packed by a gland 13 and having polygonal wrench-engaging outer ends 14, permitting them to be retracted or advanced by the use of a wrench. The inner ends of said set screws are preferably tapered. As will be apparent to those skilled in the art, and as will presently appear, this casing head is designed to receive a hanger for supporting the inner pipe string 15 and for sealing the space above the apertures 7 and 8 and between the inner pipe string and the casing, against loss of fluid under pressure from the well.

It is assumed that at this stage of its completion, that is to say, before the inner string of pipe or the hanger is in place, the well is filled with heavy mud pumped in during the drilling operation and the weight of which mud dominates the fluid pressure from within the well.

For the sake of precaution, the accessory assembly 16 shown in Figure 2 above the casing head and designated as a whole by the reference character 16 may have been bolted onto the casing head as shown in Fig. 2 during the latter part of the drilling operation as a guard against the development of excessive pressure which might overcome the weight of the mud. This accessory assembly is conventional and has a number of uses in connection with the several operations involved in the completion of the well, all of which are familiar to those skilled in the art, and which need not here be reiterated. The accessory assembly comprises the gate valve 17 and above it, a pair of spaced blow-out preventers 18 and 19, which may be alternately operated so as to bring any enlargement on the outside of the inner string of pipes sequentially past the lower blow-out preventer by opening the latter while the upper blow-out preventer is closed and then bringing it above the upper blow-out preventer and out of the well by first closing the lower blow-out preventer and then opening the upper blow-out preventer.

In inserting the inner string of pipes into the well, the accessory assembly 16 will always be in place. It may be desired first to sink a screen or packer near the bottom of the well. To do this the screen or packer is attached to the bottom end of the first pipe section and then passed through the blow-out preventer, the open gate valve 17 and through the casing head and well casing, other pipe sections being added until the requisite length of inner pipe string is in the well. The hanger bushing 21 is screwed onto the upper end of the top

pipe section 20. The details of this hanger bushing can be seen in Figure 4, where it will be observed that said bushing is externally threaded at the top to receive the hanger 22, which however, at this stage of the proceedings is not put in place. The bushing 21 has a lower threaded end 23 receiving the upper end of pipe section 20, an intermediate unthreaded cylindrical bore 24 for receiving the lower end of a valve cage 25. The bushing 21 also has an upper bore 26 having a long pipe thread considerably longer than sufficient to secure the valve cage 25.

After the hanger bushing 21 has been put in place the valve cage 25 of the subject invention is placed in position. This has an intermediate externally threaded zone 27 having a pipe thread which fits the lower part of the threaded bore 26. It has a lower cylindrical portion 28 adapted to freely fit within the cylindrical bore 24 of the bushing 21. The valve cage 25 also has an elongated cylindrical portion 30 above its threaded zone and of considerably smaller diameter than the upper bore of the bushing 21 so as to leave room for a handling nipple 29 to be telescoped over the upper part of the valve cage and to screw into the upper part of the threaded bore 26 and by means of which the inner pipe string may be raised or lowered.

The upper cylindrical portion 30 of the valve cage is of reduced diameter near the top, forming a beveled shoulder 31 and the upper end of the valve cage is also beveled, as shown at 32. The upper end of the valve cage is provided with diametrically opposite longitudinal recesses 33, which form a coupling element in connection with the valve cage removing tool which will presently be described. The valve cage has a bore extending therethrough, including a restricted intermediate portion 34 forming an upwardly beveled valve seat 35 engaged by a check valve 36 having a guiding stem 37 passing through a guiding aperture 38 in an apertured disk 39 which is screwed into the lower end of the valve cage. The valve, as shown, is also provided with a guiding spider 40.

The check valve 36 closes against well pressure within the inner pipe string, so that when the valve cage is in position in the bushing 21 the lower pipe string is sealed against the escape of gas or liquid under pressure from within the inner pipe string. As the valve cage will eventually be removed it is desirable that it shall not screw so tightly within the bushing 21 as to make its removal difficult, and with this end in view an annular rubber sleeve 41 is mounted upon the lower cylindrical portion 28 of the valve cage up against the threaded portion 27, and as the latter is screwed into the bore 26 of the bushing 21 the rubber sleeve is deformed, embossing itself into the threads of the bore 26 and forming a fluid-tight seal without the necessity of the valve cage being screwed excessively tight.

Now, when the bushing 21 and the valve cage 25 have been assembled on the top end of the pipe section 20 while the latter was above the accessory assembly 16, a handling nipple 29 is slipped over the upper portion 30 of the valve cage and screwed into the bore 26 of the bushing 21, as shown in Figure 6.

As will be seen, the handling nipple 29 is screwed to the lower end of a handling joint or pipe section 42 which may be of any length desired to carry the pipe string as deeply as may be necessary into the well. In order to wash the heavy mud from the well, lighter liquid, for example, water under pressure, will be pumped down through the handling nipple and through the valve cage. The handling nipple, therefore, carries a suitable strainer 53. The water under pressure displaces the valve 36, forcing its way down through the inner pipe string, displacing the mud therein, finally issuing from the lower end of the screen, displacing the mud from the annular space between the screen and the well casing or the open hole, as the case may be, the mud being discharged through a suitable outlet, not shown, in the lower blow-out preventer 18. After this operation, the screen is lowered to bottom and released, the packer set in place and released and the fluid is again caused to flow downward through the inner pipe 20 to wash the mud from within the screen and from the annular space between the inner pipe and the screen and/or well casing.

The screen usually is equipped with a valve on the lower end which prevents the fluid in the well bore from rising in the inner pipe, but which permits fluid to flow downward and out. This valve is closed in the act of releasing the screen from the inner pipe. Where a screen is not used or is not equipped with a valve, a glass or metallic break-out disc is inserted in the lower end of the inner pipe, and broken out by dropping a bolt or go-devil through the inner pipe. When this method is used the valve cage is inserted in place in the bushing immediately after releasing the go-devil. By the above means the fluid in the well bore is prevented from flowing up and out the inner pipe before the valve cage 25 is put in place in bushing 21.

By manipulating the blow-out preventers, the handling joint may be let down with the inner pipe string to any desired depth, or elevated to any extent that may be necessary in order to accomplish the washing of the well, without the risk of the escape of any fluid under pressure at the top of the casing head or through the inner pipe string.

The washing of the well now having been completed, it is next desired to permanently hang the pipe string. The inner pipe string is hauled up by the handling joint until the bushing 21 is again above the accessory assembly 16, in which position it is temporarily supported and the handling nipple unscrewed from the bore 26. This is done to permit the intercalation of the hanger 22. Figure 4 shows that the hanger 22 has a lower cylindrical portion 43, the diameter of which is smaller than that of the casing head in the zone of the apertures 7 and 8, so that these apertures will not be occluded when the hanger is in place. The intermediate portion of the hanger has a taper corresponding to the tapered zone 4 of the casing head and adapted to seat thereupon with the intervention of the packing rings 44. The top of the hanger is inwardly and upwardly tapered, as shown at 45 in Figure 4, this portion of the hanger being in the zone of the set screws 12 when the hanger is in place and wedgingly engaged by said set screws to hold the hanger to its seat. The hanger has a through bore 46 of such size to freely pass the handling nipple and also, as will appear, to pass the tool which is employed in the removal of the valve cage. It is noted in Figure 2 that the continuous bore through the accessory assembly 16, when the blow-out preventers and gate are open, is of sufficiently large diameter to pass a hanger that will fit in the tapered bore 4 of the casing head.

After the hanger has been screwed onto the

upper end of the bushing 21, the handling nipple is lowered through said hanger and again screwed into the threaded bore 26 of the bushing 21. The lower pipe string, including the hanger, is passed successively through the blow-out preventers 19 and 18 and through the open gate valve 17 until it rests upon its seat 4 in the casing head. The set screws are then advanced wedgingly against the upper portion of the hanger, whereby the annular space between the inner pipe string and the well casing is sealed off from the escape of fluid under pressure by way of the top of the casing head, and the hanger together with the inner pipe string are secured from being forced upwardly due to excessive fluid pressure in the well. The inner pipe string is also permanently suspended at the proper distance in the well. At the same time, the check valve 36 seals the inner pipe string from the escape of fluid under pressure.

Under these circumstances, the handling joint and nipple and the accessory assembly 16, shown in Figure 2, may be removed and the permanent conventional Christmas tree installed.

Christmas tree structures, of course, differ, but by way of example the Christmas tree as shown, comprises a gate valve 47, Figure 4, having a flanged base 48 which is bolted to the flange 3 of the casing head. Above the gate valve 47 is a cross 49, having the lateral distribution outlets 50 and 51 and the axial outlet 52. In the final installation, other members or Christmas tree may be connected to the outlet 52, but in the present stage of completion of the well an adapter 54 is screwed into the outlet 52, providing a flange 55 to receive the base of the valve withdrawing tool. The latter is shown separately in Figure 1, and in operative relation to the well structure in Figures 3 and 4.

Referring to Figure 1, there is a hand wheel support generally designated by the reference character 56, consisting of a flange base 57, a tubular body 58 and a bearing receiving socket 59, screwed one to another and made integral by welding so that they form a substantially integral member. A hand wheel 60 has a shaft 61 with an intermediate integral collar 62. Said collar rests upon a wear ring 63 retained on a flange at the bottom of the bearing socket 59. An end thrust ball bearing 64 rests upon the top of the collar and is retained by a ring nut 65 screwed into the bearing socket. A packing gland 66 surrounds the shaft 61 above the ring nut. The shaft 61 terminates preferably at the point 67 a short distance below the supporting flange, and carries a keyway 68 substantially throughout its length below the collar 62. The shaft of the hand wheel is rotatable but not reciprocable within the support 56.

A relatively long externally screw-threaded sleeve 69 telescopes over that portion of the shaft 61 below the bearing socket and screws through the flanged base 57. Said sleeve at its upper end carries a key 70, which plays within the keyway 68. Thus, when the hand wheel is rotated, the sleeve 69 reciprocates upwardly or downwardly with respect to the hand wheel support.

At its lower end, the sleeve 69 carries a tubular fitting 71, known in the industry as an "overshot." This is preferably screwed to the lower end of the sleeve 69 and in addition, welded, so that it cannot become disconnected. The function of the "overshot" is to couple positively with the valve cage so that the valve cage may be screwed or unscrewed from the threaded bore 26 of the bushing 21 through the rotational movement of the sleeve 69 in either direction. For the purpose of effecting this coupling, the "overshot" is provided with a transverse pin 72 intersecting its bore and which is adapted to enter the recesses 33 in the valve cage. The bore of the "overshot" is of two diameters, the lower portion fitting over the part 30 of the valve cage, and the upper portion fitting over the upper part of the valve cage of reduced diameter. The bore of the "overshot" is formed with a tapered shoulder 73 joining the parts of relatively large and small diameters, and which shoulder fits upon the tapered shoulder 31 of the valve cage. A compressible annular sleeve 74 is secured within a suitable seat in the lower portion of the bore of the "overshot." In its normal position, as shown in Figure 1, the internal diameter of the sleeve 74 is less than the diameter of the lower part of the bore of the "overshot" and correspondingly less than the diameter of the portion 30 of the valve cage. When the "overshot" is forced down over the valve cage, the sleeve 74 is compressed so that it tightly grasps the portion of the valve cage which it surrounds. The "overshot" is provided with a plurality of apertures 75 in the zone of the sleeve 74, providing spaces into which the sleeve bulges when compressed thereby preventing the sleeve from becoming displaced. The entire valve cage removing tool, as illustrated in Figure 1, is of course, designed to be used upon various wells which many differ in length from the location of the valve cage to the top of the Christmas tree, and the externally threaded sleeve is consequently made of a length to suit the longest of these distances. Differences in the distances from valve cage to top of Christmas tree in different wells are compensated by selecting adapters 54 of different and appropriate length.

In order to remove the valve cage 25, the entire tool, as illustrated in Figure 1, is placed above and in alignment with the adapter 54, and the "overshot" and threaded sleeve 69 inserted through the Christmas tree, the gate valve 47 and into operative proximity to the valve cage 25. Assuming that the proper adapter 54 has been employed, the flanged base 57 may now be brought down upon the flange 55 of the adapter and more or less loosely bolted in place. The hand wheel is then turned in a direction to screw the externally threaded sleeve 69 downward. Presently, the bottom end of the "overshot" 71, which is internally tapered as at 76, centers over the tapered end 32 of the valve cage and the "overshot" freely moves down upon the valve cage until the compressible sleeve 74 abuts against the tapered shoulder 31 of the valve cage. One can tell when this contact takes place, by the resistance encountered by the hand wheel. The bolts between the flanged base 57 of the valve cage removing tool and the flange 55 of the adapter are then removed and the flanged base 57 screwed upwardly by hand along the threaded sleeve 69 until it is separated from the flange by a distance somewhat greater than the longitudinal distance of the lower end of the compressible sleeve 74 from the bottom of the pin 72. The flanged base 57 is then forced downwardly, the handwheel being rotated, if necessary, so as to cause pin 72 to slide within recesses 33 of valve cage 25, carrying with it the threaded sleeve 69 until it will go down no further. This indicates that the pin 72 is resting in the bottom of the recesses 33 of the valve cage, and that the compressible sleeve 74

has been forced down upon the portion 30 of the valve cage and is tightly gripping the same. The threaded base 57 of the tool is then screwed down into sealing contact with the packing ring 77 which intervenes between the two flanges. The bolts are then replaced and tightened. The hand wheel 60 is then turned in a direction to screw the threaded sleeve 69 in an upward direction. This unscrews the valve cage from the threaded bore 26 of the bushing 21, and no great effort is required to do this because the valve cage was not screwed tightly into place, in view of the rubber sleeve 41, the function of which has been explained. The threaded sleeve 69 is screwed upwardly until the valve cage is above the gate valve 47. This position can be ascertained by the ability of the operator to close the gate valve. After the gate valve has been closed the bolts which secure the valve removing tool to the adapter 54 are removed and the tool is pulled out longitudinally, bringing with it the valve cage which is gripped by the compressible sleeve 74. It is obviously not necessary to employ blow-out preventers in removing the valve cage. After the valve removing tool has been removed the adapter 54 may be taken off and the superposed members of the Christmas tree connected to the outlet opening 52. The gate valve 47 may then be opened.

In Figure 5 a modified form of blow-out preventer is shown which is part of the accessory assembly 78 and is, in fact, not a part of the subject invention, but introduced merely to show how the hanger 22 is inserted within the chamber 79 between the blow-out preventers where this type of blow-out preventer is used, the blow-out preventer comprising a flexible rubber bushing 80 having a skirt portion 81 which automatically grips the inner pipe string including the handling joint 42, and which automatically spreads to pass the couplings in the pipe string, including the bushing 21. This blow-out preventer is retained by a ring nut 82 and it is necessary to remove the blow-out preventer in order to insert the hanger 22. The procedure is as follows. The inner pipe string, including the bushing 21 and the landing joint and nipple, but without the hanger 22, is lowered through the blow-out preventer 80 until it is within the chamber 79, the lower blow-out preventer 18 being closed against the pipe section 20. The ring nut 82 is then removed and the pipe string raised. This causes the handling nipple 29 or the bushing 21 to push against the skirt 81 of the blow-out preventer, lifting the blow-out preventer out of its seat in the casing 83. The pipe string is then suitably supported, the handling joint and nipple unscrewed from the bushing 21, the hanger 22 screwed on the bushing 21, the blow-out preventer pushed up over the handling nipple and onto the handling joint 42. The handling joint and nipple are then passed through the hanger and secured in the threaded bore 26 of the bushing 21, the pipe string then lowered until the hanger is in the chamber 79, the blow-out preventer 80 replaced on its seat within the casing 83 and the ring nut 82 screwed back into place. The pipe string with the hanger may then be let down through the lower blow-out preventer and lodged upon its seat in the casing head.

It is obvious that reversal of the proceeding operations allows placing the valve cage 25 within the bore 26 of bushing 21 to restrict or stop the flow of fluid with the inner pipe to allow replacing portions of the Christmas tree or to reinstall the assembly 16 to all further work on the well bore.

While I have in the above description disclosed what I believe to be a preferred and practical embodiment of the invention, it will be understood to those skilled in the art that the specific details of construction and the arrangement of parts are by way of illustration and not to be construed as limiting the scope of the invention which is defined in the appended claims.

What I claim as my invention is:

1. Well completion apparatus comprising a rotary and reciprocatory valve cage withdrawing means comprising a base, a shaft carried by the base and rotatably mounted with respect thereto, means for manually rotating said shaft, a sleeve coaxial with said shaft and in telescopic relation thereto, screwing through said base and extending therebeyond, a longitudinal sliding connection between said shaft and sleeve whereby upon rotation of said shaft said sleeve simultaneously rotates and reciprocates by virtue of the screw connection between said sleeve and base, and a tubular overshot secured coaxially to the remote end of said sleeve, said overshot having a transverse pin in the upper part of its bore adapted to couple positively with complementary coupling means on a screw seated valve cage upon which said overshot is adapted to telescope, for unseating said valve cage, and having a compressible sleeve in the lower part of its bore adapted to be expanded by said valve cage into gripping relation thereto when said overshot is forcibly telescoped over said valve cage.

2. In well completion apparatus, a valve cage remover comprising a hand wheel unit including a base adapted to be bolted to the well head structure and form a seal for the well, a shaft journaled in the base rotated by said hand wheel, a screw shaft threaded through a socket in said base and having a spline connection with said hand wheel shaft to simultaneously rotate and reciprocate responsive to actuation of said hand wheel, said screw shaft terminating in a tubular portion having a compressible gripping ring retained in its lower end and a transverse pin above said ring.

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