

March 25, 1969

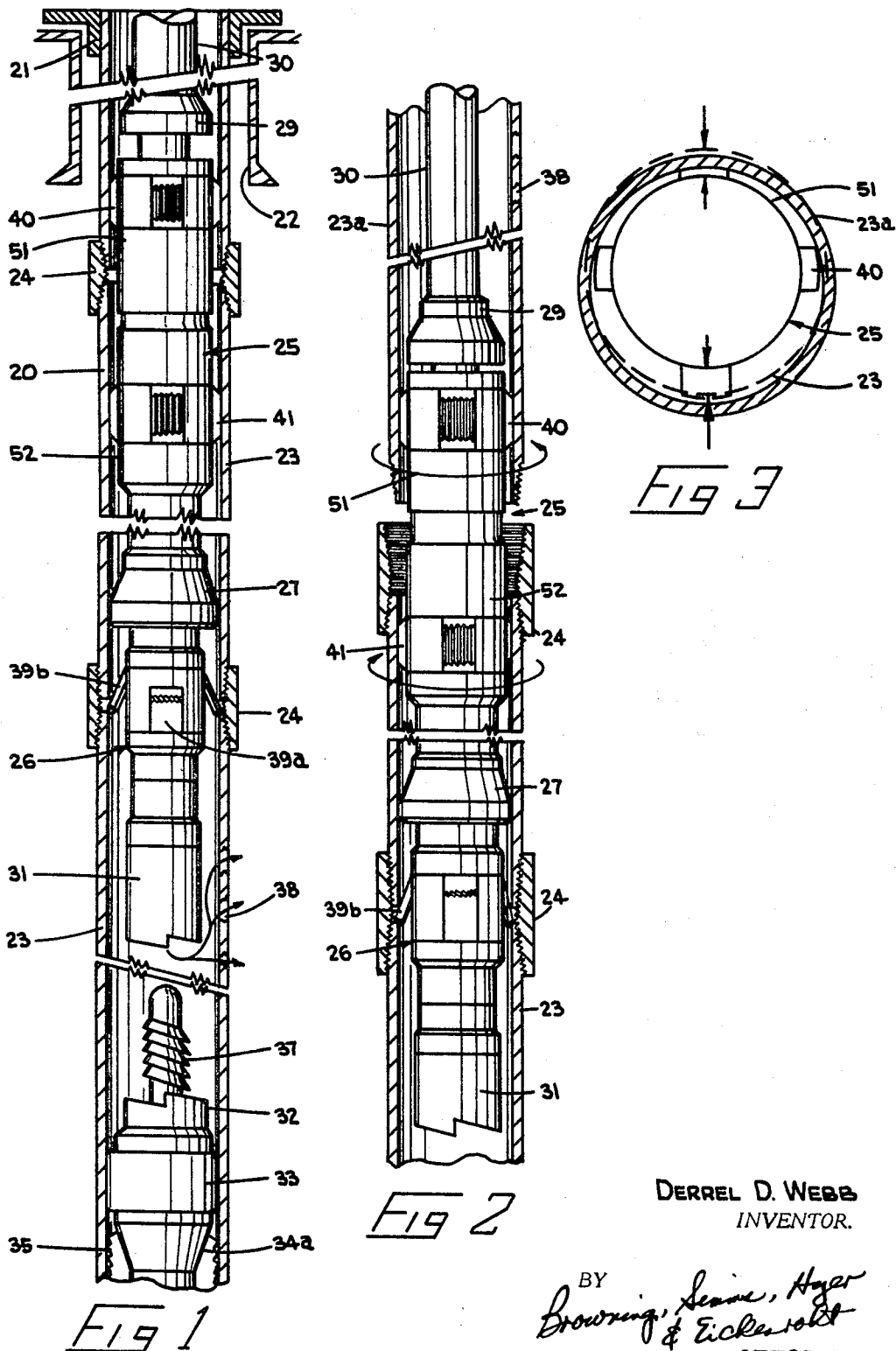
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3,434,543

METHOD AND APPARATUS FOR SEPARATING SECTIONS OF WELL PIPE

Filed March 14, 1966

Sheet 1 of 3



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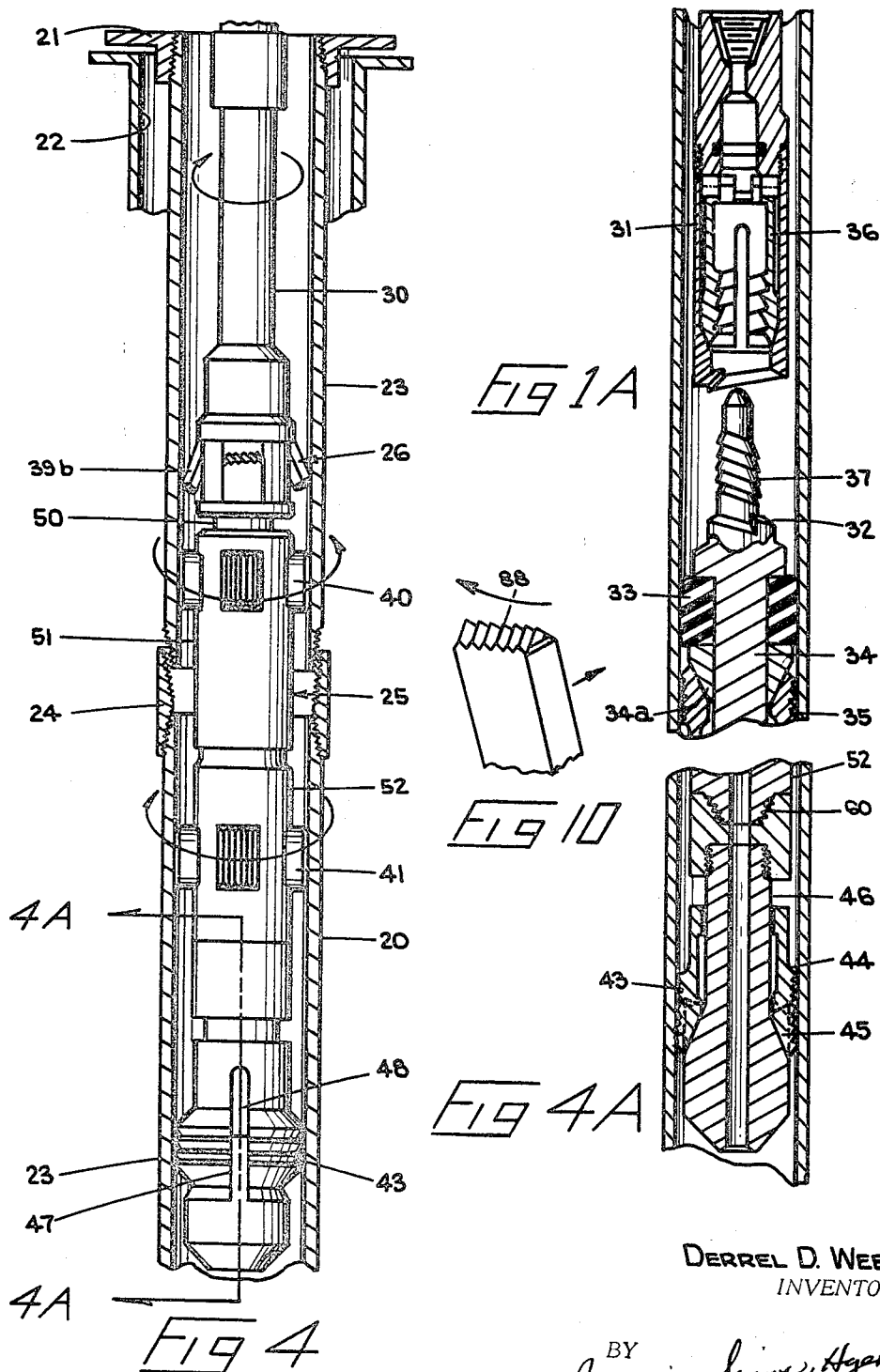
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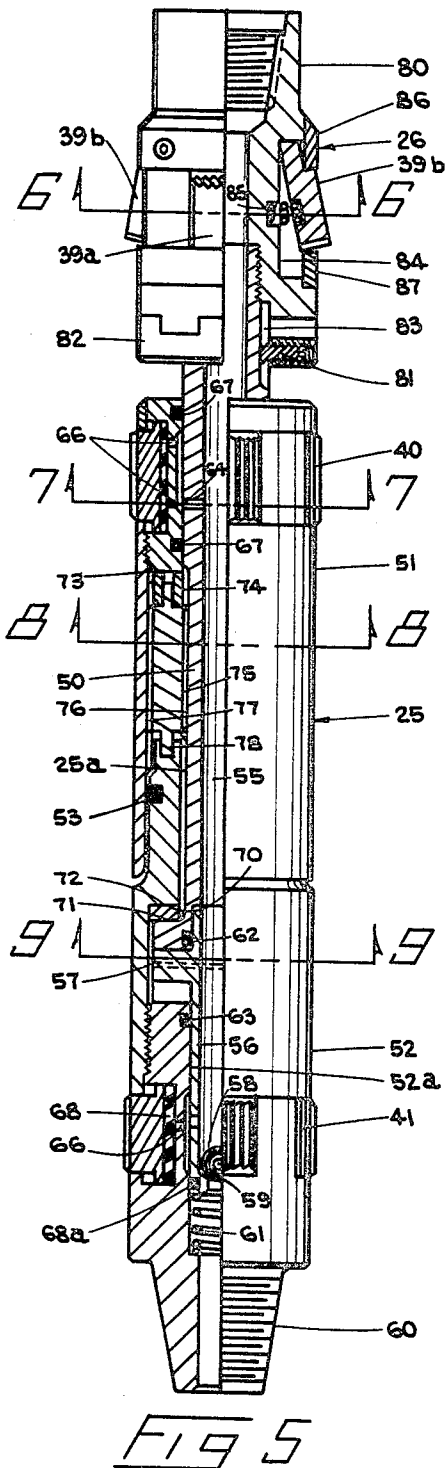
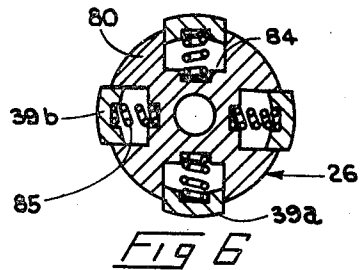
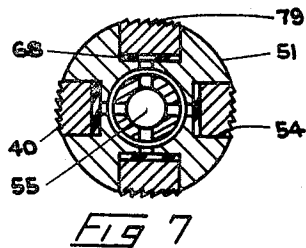
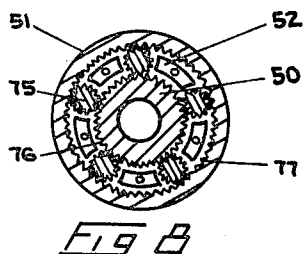
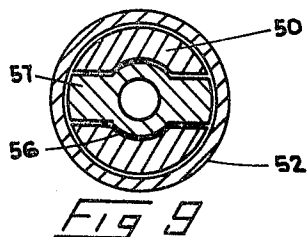
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Sheet 3 of 3



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METHOD AND APPARATUS FOR SEPARATING SECTIONS OF WELL PIPE

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Filed Mar. 14, 1966, Ser. No. 534,189

Int. Cl. E21b 23/04, 33/12, 43/00

U.S. Cl. 166—277

10 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for separating threadedly connected sections of pipe in which a tool comprising a body having upper and lower dogs carried therefrom is lowered into a well pipe on a running string so as to dispose such dogs opposite the threadedly connected sections above and below a specific threaded connection, respectively. The dogs are urged outwardly into gripping engagement with such pipe sections by means of hydraulic fluid conducted downwardly through the running string. The running string is then rotated to urge the upper and lower dogs, when so engaged, in opposite rotational directions so as to unscrew the upper pipe section from the lower pipe section. Preferably, the string is so rotated in a right-hand direction so as to urge the upper dogs in a left-hand direction and the lower dogs in a right-hand direction. The dogs are carried from the body of the tool for longitudinal movement relative to one another as the pipe sections are unscrewed.

This invention relates to a method and apparatus for separating sections of a well pipe, and, more particularly, to an improved method and apparatus for unscrewing a threaded connection between the well pipe sections. In one of its aspects, it relates to an improved method for removing and replacing an unscrewed well pipe section.

Methods and apparatus of this general type are useful, for example, in removing a perforated or otherwise defective section of a well casing. Generally, these have involved either cutters lowerable into the casing for severing it beneath the defective section or so-called back-off tools lowerable into the casing and carrying locking dogs for engaging and unscrewing the defective casing section at a threaded connection therebelow. In either case, the separated section is removed upwardly through the well and replaced with a new section.

Although the cutters permit the casing to be severed at a specific location, the subsequent replacement of the removed section has been unsatisfactory due to the inability to "patch" or seal the new section with the casing section remaining in the well, particularly in a manner to contain high pressures. While methods and apparatus for unscrewing the casing present no such problems because they leave the threads intact for connection with the new casing section, they nevertheless raise additional problems.

Thus, in accordance with one method and apparatus of this latter type, a back-off tool is lowered into successively lower joints of the casing beneath the defective section thereof until the weakest threaded connection between adjacent joints is found. This may require that the operator set and then release the locking dogs on the tool several times. Also, of course, unless the threaded connection immediately beneath the defective casing section is the weakest, this method and apparatus inherently requires the removal of sound joints of casing.

Another shortcoming of the above-described method and apparatus is that the back-off tool must be run on a special string which is capable of transmitting left-

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hand torque to the locking dogs. Thus, since the threaded connections between the joints of well casing are made up righthand, the dogs can unscrew them only by transmitting left-hand torque to the casing section above such connection.

In this prior method and apparatus for backing off a defective section of casing, the back-off tool is supported within the casing section remaining in the well bore so that the defective section and the replacement section may be stripped over the string on which the tool is run. For this purpose, it has heretofore been proposed to connect a special assembly in the string for use in lining up the threads of the replacement section with the casing section remaining in the well bore. Thus, upon unscrewing of the threaded connection, the back-off tool and line-up assembly must be moved vertically into a position in which the line-up assembly spans the connection to be made up and then reset in such position. The line-up assembly not only adds to the overall cost of the apparatus, but also necessitates this additional manipulation of the running string in resetting such apparatus.

More recently, a need has arisen for a method and apparatus for unscrewing the well casing just below a sound joint at its upper end. Thus, in the drilling and completion of some offshore wells, it is necessary to replace the upper joint with an enlarged conductor on which the wellhead is to be mounted. Obviously, the above-described methods and apparatus cannot be relied upon to unscrew the casing at this particular threaded connection. Also, prior methods and apparatus suggest no way to suspend the length of casing beneath this connection as the upper joint is removed and the enlarged conductor substituted for it.

An object of this invention is to provide a method and apparatus for separating a well pipe which overcomes the problems of prior methods and apparatus while, at the same time, retaining the advantages of each.

A more particular object of the invention is to provide a method and apparatus for unscrewing a specific threaded connection in such a well pipe.

A still more particular object is to provide such a method and apparatus in which the connection may be unscrewed with the use of a conventional right-hand torque transmitting running string.

A further object is to provide a method and apparatus of the type above-described which does not require a special assembly for lining up the replacement pipe section with the section remaining in the well bore.

Yet another object is to provide a method and apparatus which, in addition to accomplishing one or more of the foregoing objects, enables the operator to detect a perforation in the casing and thus locate the threaded connection to be unscrewed without an extra trip in and out of the well.

Another object is to provide a method and apparatus which is particularly well suited for use in the drilling and completion of offshore wells of the type above-described, not only because they enable the casing to be unscrewed immediately below the upper joint of casing, but also because they permit the remaining section of the casing to be suspended during removal of such joint and running of the enlarged conductor.

These and other objects are accomplished, in accordance with the illustrated embodiments of the invention, by apparatus which comprises a reversing section including a body connectible to a running string to permit it to be lowered into the well pipe, upper and lower dogs carried by the body for lowering with it, means for urging the dogs outwardly into gripping engagement with the pipe when so lowered, and means for urging the upper

and lower dogs in opposite rotational directions when so engaged. In the practice of the method of this invention, the body is lowered on the running string to dispose the upper and lower dogs respectively opposite sections of the well pipe above and below a specific threaded connection to be unscrewed. When the dogs are then urged outwardly to grippingly engage the pipe sections, rotation thereof in opposite directions imparts differential torque across such threaded connection to thereby unscrew the upper from the lower casing section.

Preferably, the upper dogs are urged in a left-hand direction and the lower dogs in a right-hand direction so that such apparatus is useful in unscrewing threaded connections between joints of casing or other well pipe which are made up right-hand. More particularly, the dogs are urged in these directions in response to right-hand rotation of the running string, so that such string may be composed of drill pipe or tubing which is normally made up right-hand.

A means is also provided for supporting the apparatus in the remaining casing section independently of the dogs, so that, upon unscrewing of the threading connection, the outward urging of the dogs may be relieved to permit the one section to be removed without resetting the apparatus. Then, the replacement section may be run into the well bore to dispose its lower end opposite the dogs and slightly above the connection to be made up. At this time, the dogs may be urged outwardly to engage the replacement and remaining casing sections and then rotated relative to one another to thereby force the replacement section into a substantially aligned position with respect to the remaining section, whereby the replacement sections may be lowered into threaded engagement with the remaining section.

In one illustrative embodiment of the invention, a means carried beneath the body is operable, prior to unscrewing the upper pipe section, for first setting a packer in the lower pipe section. Another packer is carried by the running string for sealing against the well pipe as the running string is moved longitudinally within the pipe. This enables the operator to isolate areas within the well pipe between the packers and thus detect a perforation in the pipe by the loss of test pressure therefrom. Upon detection of such perforation, the body may be located with the upper and lower dogs opposite sections of the pipe above and below a specific threaded connection beneath the perforation, so that the upper section may be unscrewed, as described above, without another round trip into and out of the well.

In another illustrative embodiment of the invention, a means is carried beneath the body for engaging the lower pipe section, prior to unscrewing the upper pipe section therefrom, so that when the upper section has been so separated, a strain may be taken on the running string to suspend the lower section therefrom. This enables such apparatus to be used in unscrewing the top joint of casing in the drilling and completion of off-shore wells of the type above described.

In the drawings wherein like reference characters are used to designate like parts:

FIG. 1 is an elevational view of the apparatus constructed in accordance with the first mentioned embodiment of the present invention and during use thereof in the detection of a perforation in a well casing;

FIG. 1A is a longitudinal sectional view, as seen along broken lines 1A—1A of FIG. 1, of the lower end of such apparatus and the upper end of a packer set beneath it;

FIG. 2 is another elevational view of the apparatus of FIG. 1, but viewed at 90° with respect thereto, and after the perforation has been detected, and the locking dogs have been located opposite and urged against casing sections respectively above and below a specific threaded connection beneath the perforation, and the running string has been rotated to unscrew such connection;

FIG. 3 is a cross-sectional view of the apparatus of

FIGS. 1 and 2, after unscrewing and removal of the upper perforated section of the casing and during lowering of a replacement section of casing for making up with the threads at the upper end of the remaining section of casing;

FIG. 4 is a view of the apparatus constructed in accordance with the second mentioned embodiment of the present invention and during use in suspending a lower unsupported length of casing while unscrewing the upper joint of casing;

FIG. 4A is a longitudinal sectional view of the lower end of the apparatus of FIG. 4, as seen along broken line 4A—4A of FIG. 4;

FIG. 5 is a view on an enlarged scale and partly in section of the reversing section common to both the apparatus of FIGS. 1 to 3 and the apparatus of FIG. 4;

FIGS. 6, 7, 8 and 9 are cross-sectional views of reversing section shown in FIG. 5, as seen along broken lines 6—6, 7—7, 8—8 and 9—9, respectively; and

FIG. 10 is an enlarged perspective view of the upper end of one of the fingers of the collar locator carried on the upper end of the reversing section shown in FIG. 5.

With reference now to the details of the above-described drawings, the apparatus shown in each of FIGS. 1 to 3 and FIG. 4 is disposed within a well casing 20 connected at its upper end to a wellhead 21 for extension downwardly within a well bore 22. As well known in the art, at least the lower end of the casing is anchored in the well bore by a cement column thereabout. The casing consists of joints 23 which are threadedly connected together by means of collars 24 although, in some cases, they may be connected directly to one another. In any case, the threads are tapered with the lower pin end of the upper joint fitting within the box end of either the lower joint or the collar 24 connected to the upper end of the lower joint. As illustrated in FIGS. 1 to 3, the apparatus would normally be disposed a considerable distance beneath the wellhead 21 when used to remove and replace a defective section of casing. As illustrated in FIG. 4, however, when used in the drilling and completion of an offshore well, the apparatus is disposed relatively near the wellhead 21, and particularly generally opposite the threaded connection between the upper joint and the next lower joint of the casing 20.

With reference first to FIGS. 1 to 3, the apparatus comprises a reversing section 25, which is to be described in detail in connection with FIGS. 5 to 9, means 26 connected beneath the reversing section for locating collars and supporting the apparatus in the casing, a downwardly facing cup-type packer 27 connected between the reversing section and the collar locating and supporting means, and a so-called "on-off" tool 31 carried beneath the last mentioned means 26 and thus at the lower end of the apparatus. The entire apparatus is suspended from a hollow running string 30, which may be drill pipe or tubing, by means of a collar 29 connecting the lower end of the string to the upper end of the reversing section 25.

For obvious reasons, this apparatus is hollow from one end to the other to form a continuation of the bore through the running string. In at least one position of the reversing section, the apparatus is capable of transmitting right-hand torque from the running string to the on-off tool 31. This enables a lower packer 32 to be run into the casing on the lower end of the on-off tool and set therein, as shown in FIGS. 1 and 1A, so as to close off the casing as by means of packer seal ring 33 disposed about the packer body 34.

Thus, as is conventional in equipment of this type, the packer body carries slips 35 about an expander 34a about its lower end so that when it has been lowered into the desired position, the body 32 may be manipulated downwardly to set the slips and expand the packer seal 33. This manipulation of the packer body is accomplished through the on-off tool 31 which, as in the case of the

packer 32, is of conventional construction. Thus, as shown in FIG. 1A, it includes an inner flexible member 36 having ratchet teeth for moving downwardly over opposed teeth 37 extending upwardly from the packer body 32. In a manner which will be obvious to those skilled in the art from FIG. 1A, this permits the packer to be suspended from the on-off tool as it is run into the well casing. However, after setting of the packer, the on-off tool may be disconnected from the packer by rotation thereof to the right. Thus, the ratchet teeth are left-hand so that right-hand rotation imparted to the on-off tool by means of the running string 30 will release the flexible member 36 from the ratchet teeth 37 and permit the apparatus to be raised above the packer.

As the apparatus is raised to different levels within the casing 20, as determined by engagement of means 26 in different collars 24, it is possible to detect and locate perforations 38 in the casing by conducting pressure fluid down through the running tool 30 and out the lower end of the hollow apparatus and observing the pressure of such fluid at the wellhead. Thus, when the packer 27 is raised above the perforations 38, the operator will note a decided drop in the pressure fluid due to its leakage through the perforations. He will thus know that in order to remove this defective section of casing, he will have to separate it at some point below the perforations.

Thus, the operator knows that he must raise or lower the running tool a predetermined amount in order to locate the reversing section 25 of the apparatus in the desired manner opposite a specific connection beneath the perforation 38. Normally, this will be the collar at the lower end of the joint in which the perforation 38 is detected. For this purpose, the reversing section may be spaced out a distance above the means 26 approximating the length of a joint of casing, so that the operator may merely lower the string to engage means 26 in the second collar beneath the one in which the means is engaged when perforations 38 are located. This then supports the string in the casing with upper dogs 40 of the reversing section above and the lower dogs 41 thereof below the next upper collar—i.e., the one just beneath the perforations.

Upon location of the locking dogs in this position, the operator causes them to be urged outwardly to grippingly engage the upper and lower casing sections, and rotates the running string to the right so as to urge the upper dogs to the left and the lower dogs to the right. As the result of this differential torque on the specific connection, the upper section is unscrewed from the collar on the lower section so as to separate it therefrom, as shown in FIG. 2. When the outward urging of the dogs is relieved, the defective section of casing is free to be stripped up over the supported running string 30 and replaced with a new section 23a which may be stripped down over the string.

After the replacement casing section 23a has been lowered into a position in which its lower end is about the upper dogs 40 of the supported reversing section, but above the collar to which it is to be threadedly connected, the dogs are again urged outwardly. This, of course, causes the lower dogs 41 to grippingly engage the section of the casing which has remained in the well. However, the lower end of the replacement section 23a is ordinarily out of alignment with the remaining section, and thus, with the upper end of the reversing section 25 and the dogs 40 carried thereby. Consequently, there may be gripping contact between only one of the upper dogs 40 and the section 23a. However, the upper and lower dogs may then be urged in opposite rotational directions so that, with the lower dogs 41 anchoring the lower end of the reversing section centrally in the remaining casing section, the upper dogs rotate within the lower end of the replacement casing section. As they rotate from the position shown in FIG. 3, they will gradually assume balanced positions—i.e., equally extended—

and thereby force the lower end of the replacement section into an aligned position with respect to the remaining casing. This of course permits the threads on the lower end of the replacement section 23a to be accurately lowered into the threads in the collar on the upper end of the remaining section. The same results may be obtained, however, by rotating the casing section 23a relative to the reversing section.

In its illustrated use, the embodiment of the apparatus shown in FIG. 4 includes the same reversing section 25 as the apparatus of FIGS. 1 to 3, but connected beneath rather than above the means 26. Also, in this case, the packer 27 shown in FIGS. 1 to 3 is unnecessary, and in place of the on-off tool 31 shown in FIGS. 1 to 3, a spear 43 is connected beneath the reversing section.

The apparatus thus illustrated and described is lowered into the well casing 23 so as to locate the locking dogs 40 and 41, respectively, opposite the casing sections above and below the collar 24 from which the upper section is to be unscrewed. In this case, as previously mentioned, this collar is on the lower end of the upper joint of casing. The reversing section may be properly located with respect to it by lowering the means 26 into engagement with the collar and then raising it a predetermined distance to the position of FIG. 4. Thus, in this embodiment, the means 26 does not function to support the apparatus in the casing.

In any case, with the apparatus located as shown in FIG. 4, the running tool is manipulated to set spear 43 in gripping engagement with the casing below the collar to be unscrewed to permit the long unsupported length of such casing to be suspended from the running tool. For this purpose, and as shown in FIG. 4A, the spear 43 is of conventional construction comprising a slip assembly 43 carried about an expander 45 on the spear body 46. As will be obvious from FIG. 4, and as well known in the art, an upward pull on the body 46 enables the expander 45 to urge the slips 44 outwardly in the gripping engagement with the casing. Conversely, a lowering of the body relative to the slip assembly permits the ribs 47 thereon to be moved out of the slots 48 in the slip assembly so as to lower them beneath the slip assembly, whereby right-hand rotation will dispose such ribs beneath the slip assembly and thereby permit lifting of such assembly.

In the use to which the apparatus is put in FIG. 4, the spear 43 is set prior to expansion of locking dogs 40 and 41 into gripping engagement with the casing sections. However, when the spear has been so set and the locking dogs expanded, the running string is, as described in connection with FIGS. 1 and 3, rotated to the right so as to urge the upper dogs to the left and the lower dogs to the right and thereby unscrew the upper casing section from the lower casing section.

As shown in FIG. 5, the reversing section 25 comprises a tubular body 50 having a bore 55 therethrough and threadedly connected at its upper end either to the lower end of string 30 (FIGS. 1 and 2) or the lower end of the collar locating and supporting means 26 (FIG. 4). A pair of sleeves 51 and 52 are supported concentrically about the body for rotation with respect to one another as well as with respect to the body. The upper end of sleeve 52 extends within the lower end of sleeve 51 and carries a ring 53 to form a sliding seal therewith.

The sleeve 51 carries the upper locking dogs 40 and the sleeve 52 carries the lower locking dogs 41. More particularly, and as best shown in FIG. 7, each of four equally spaced apart locking dogs 40 and 41 is carried within an annular pocket 54 formed in the outer periphery of its sleeve. Thus, each dog is free to move radially within this pocket between a collapsed position, as shown in FIG. 5, and a fully extended position, in which further outward movement is prevented by engagement of shoulders on the upper and lower ends of the dogs with

retaining flanges on the sleeves. In their collapsed positions, the dogs enable the reversing section to move freely within the casing, and, when moved toward extended positions, they are forced into gripping engagement with the casing position.

A tubular clutch member 56 is longitudinally slidable within the lower end of the bore 55 and the upper end of bore 52a through sleeve 52 so as to form a longitudinal continuation of the body bore 55. Thus, when the bore of member 56 is open, fluid in bore 55 may flow through it into the lower end of the sleeve bore 52a and thus entirely through the reversing section. In the embodiment of the invention illustrated in FIGS. 1 and 2, this, of course, permits pressure fluid to be directed downwardly into the space between packers 27 and 32.

For reasons to be described below, the clutch member 56 is vertically shiftable between the position shown in FIG. 5, in which outwardly extending clutch parts 57 thereon span the separation between the lower end of reversing section body 50 and sleeve 52 so as to connect the latter to the body for rotation therewith, and another position (not shown) in which parts 57 are moved downwardly beneath the lower end of reversing section body 50 so as to disconnect the sleeve from the body and thus permit the body to rotate relative to the sleeve 52.

As shown in FIG. 5, the tubular clutch member 56 is normally urged upwardly to its connecting position by means of a coil spring 61 acting between an upwardly facing shoulder within the bore 52a through the sleeve 52 and the lower end of the clutch member 56. Also, seal rings 62 and 63 are carried by the reversing section body and the sleeve 52 for sealing with respect to the clutch member 56 in both positions of the clutch member thereby preventing the loss of pressure fluid between them. In order to shift the clutch 56 from the position of FIG. 5 to its disconnecting position, a ball 58 is first dropped onto a seat 59 about an opening through the bore of the tubular clutch member 56 so as to close same. In this manner, the bore 55 and the continuation thereof within the clutch member 56 above the ball are closed so as to contain fluid pressure, conducted downwardly through string 30 whereby such pressure is effective to lower the member to hold it in its disconnecting position.

In this respect, it will be noted that although some of the manipulations of the illustrated apparatus require that the clutch member 56 be in the position of FIG. 5 so as to connect the sleeve and body for rotation together, such manipulations have already been performed by the time the operator drops the ball 58. Thus, for example, by means of the clutch member 56, the operator has rotated the sleeve 52 in response to rotation of the reversing section body 50 so as to impart torque to either the on-off tool 31 or the spear 43. As shown in FIG. 5, there is a pin 60 on the lower end of the sleeve 52 for connection either to the packer 27, and thus to the tool 31 beneath the packer, or to the spear 43, as shown in FIG. 4A.

The reversing section body 50 is provided with ports 64 connecting its bore 55 with the exterior thereof adjacent the upper locking dogs 40, and the tubular clutch member 56 is provided with ports 65 connecting its bore above the ball 58 with its exterior adjacent the lower locking dogs 41. More particularly, ports 66 extend through the sleeve 51 to connect its inner diameter with each of the pockets 54 therein, while ports 67 extend through sleeve 52 to connect its inner diameter with each of the pockets therein. Seal rings 67 are carried about the inner diameter of the sleeve 51 above and below the ports 66 and 64 so that pressure fluid within the bore 55 of the reversing section body is directed to the back sides of the locking dogs 40. Also, a seal ring 68a is carried about the outer diameter of tubular clutch member 56 for engagement with the bore 52a through sleeve 52 below ports 65 and 67 so that, together with seal ring 53 above such ports, pressure fluid within the bore of the

tubular clutch member is confined for flow through such ports onto the back sides of locking dogs 41.

Pads 68 of rubber or the like are mounted on the back sides of the dogs 40 and 41 so as to seal across the pockets. In this way, the dogs are responsive to such pressure fluid for expansion outwardly into gripping engagement with the casing. Conversely, upon the release of such pressure, such dogs are free to move radially inwardly out of such casing gripping engagement.

In the apparatus of FIGS. 1 and 2, the dogs are expanded outwardly to grippingly engage the casing both before and after dropping of the ball 58. In the former case, the dogs are responsive to fluid pressure conducted downwardly through the string 30 during the step of detecting and locating the perforations 38. Thus, since packer 27 is below the dogs, the pressure on the outer sides of the dogs will be substantially less than the test pressure on the inner sides thereof, so that the dogs move outwardly due to this differential. The resulting engagement of the dogs with the casing holds the apparatus down against the upward force on the string due to test pressure across the bottom of packer 27. Then, after the test has been made, the pressure may be relieved to permit the packer to be raised to another level.

The dogs of both the apparatus of FIGS. 1 and 2 and that of FIG. 4 are expanded outwardly, after dropping of the ball, in order to grippingly engage the casing preparatory to unscrewing a threaded connection therebetween. In the apparatus of FIGS. 1 and 2, the dogs are also expanded into engagement with the replacement casing, as previously described and shown in FIG. 3.

As previously described, sleeves 51 and 52 are carried from the reversing section body 50 for rotation relative to one another as well as with respect to the body. More particularly, the sleeves are carried in such a manner that they may move longitudinally with respect to one another between the position shown in FIG. 5 and a position in which the sleeve 51 is raised with respect to the sleeve 52. This permits the reversing section to compensate for the longitudinal separation of the casing sections, and thus the upper and lower locking dogs, as the threaded connection therebetween is unscrewed.

As shown in FIG. 5, a downwardly facing internal shoulder 70 on the sleeve 52 is supported on an upwardly facing outer shoulder 71 on the reversing section body 50. Preferably, there is a bearing 72 disposed between these two shoulders so as to facilitate rotation of the body 50 and sleeve 52 with respect to one another. Sleeve 51 has an internal downwardly facing shoulder 73 which rests upon a cap 74 about the upper end of a circle of pinion gears 75 mounted at their lower end on the upper end of sleeve 52. Thus, although the sleeve 51 is carried against further downward movement with respect to the sleeve 52, it is free to move upwardly relative to the sleeve 52 when, as previously mentioned, the upper casing section to which the dogs 40 are locked moves upwardly to the lower casing section to which the dogs 41 are locked.

As previously described, and as indicated by the arrows in FIGS. 2 and 4, when the locking dogs 40 and 41 are grippingly engaged with the casing sections above and below the threaded connection to be unscrewed, and the tubular clutch member 56 has been lowered so as to release the body 50 of the reversing section for rotation relative to sleeve 52 as well as sleeve 51, such dogs rotate in left-hand and right-hand directions, respectively, in response to right-hand rotation of the running string. As shown in FIGS. 5 and 8, a pin on the lower end of each of the pinion gears 75 is supported in a matching hole in the upper end of sleeve 52 for engagement between ring gear 76 about body 50 and ring gear 77 about the inner diameter of sleeve 51, and the cap 74 on the upper ends of the pinion gears permits the sleeve 51 to rotate relative to such gears, and thus with respect to the sleeve 52. Consequently, rotation of the reversing section body 50 to the right in response will urge the sleeve 51 and thus the dogs

40 carried thereby in a left-hand direction, while, at the same time urging the sleeve 52 and thus the dogs 41 in a right-hand direction. As previously described, this reverse torque on the casing sections above and below the threaded connection will thereby unscrew same.

Preferably, the outer sides of the locking dogs are provided with teeth 79 to facilitate gripping the casing. As shown in FIG. 7, these teeth extend in the same direction in which the dogs are to be urged. That is, the teeth on the upper dogs 40 extend toward the right, while those of the lower dogs 41 would extend toward the left.

As previously described, and as shown in FIG. 5, each dog has upper and lower shoulders disposed opposite flanges on each sleeve at the outer end of the pocket 54 in which each dog is carried. These ports thus retain the dogs by limiting their outward movement. Obviously, however, they are so spaced as to permit equal expansion of each dog into gripping engagement with the casing so as to normally hold the apparatus centered within such casing.

However, when the replacement casing section 23a is lowered over the upper end of reversing section 25, as illustrated in FIG. 3, it is normally out of alignment with the remaining section (indicated by broken lines) by a distance (between opposed arrows) greater than the difference between the expansion and the normal, casing engaging expansion of each dog. In this event, upon introduction of fluid pressure to the bore through the section 25, one dog may be short of the casing, even though fully expanded, and the diametrically opposite dog held in collapsed position. However, as previously described, the string 30 may then be rotated so as to cause the dogs to in turn rotate within casing section 23a, or, conversely, the casing section 23a may be rotated. As this occurs, the collapsed dog will gradually move outwardly and the fully expanded dog inwardly until all the dogs are equally expanded to force the section 23a into an aligned position with respect to the remaining casing. Then, as previously described, the aligned section may be lowered into threaded engagement with the collar 24 on the remaining section.

As shown in FIG. 5, the means 26 includes a tubular body 80 having annular recesses 84 about the outer periphery thereof, each to receive a latching finger. More particularly, there are two pairs of such fingers, a first pair 39a having their upper ends urged outwardly by springs 85 to engage a collar as the apparatus moves upwardly, and a second pair 39b having their lower ends urged outwardly by springs 85 so as to engage and be supported upon a collar as the apparatus moves downwardly within the casing. Flanges 86 and 87 extend across the upper and lower ends of the recesses to contain one end of each finger for pivoting about a horizontal axis between expanded collar engaging positions, as shown in FIGS. 1 and 2, and a retracted position, as shown in FIG. 4.

As best shown in FIG. 10, the projecting of each locator finger has teeth 88 formed diagonally thereacross so as to engage the upper or lower edge of the collar and, in response to rotation of the apparatus including body 80, to move inwardly so as to permit the fingers to be moved therepast. For example, upon lowering of the apparatus, the fingers 39b will move outwardly to engage in a collar. Then, upon right-hand rotation of the apparatus, the frictional engagement of the edge of the collar with the back sides of the teeth 88 will gradually retract the fingers 39b so as to permit lowering of the means 26 past the collar. Conversely, upon upward movement of the apparatus, the fingers 39a will engage with the upper edge of the collar's thread, and upon right-hand rotation of the apparatus, the oppositely directed diagonal teeth on the upper ends of the fingers 39a will force them inwardly so as to permit the means 26 to be moved upwardly past the collar.

As shown in FIG. 5, there is a box connection at the upper end of body 80 for threading onto the lower end

of packer 27, in the apparatus of FIG. 1, on the lower end of the running string 30, in the apparatus of FIG. 4. As also shown in FIG. 5, in the apparatus of FIG. 4, the lower end of body 80 is threadedly connected to the upper end of reversing section body 50 and locked thereto by means of lock screw 81 carried by a locking ring 82 and extendible into a longitudinal groove 83 about the upper end of body 50. In the assembly of the means 26 on the reversing section 25, screw 81 is retracted as locking ring 82 is moved downwardly over the upper end of the body 50, and the body 80 of the locator 26 is then threaded onto the upper end of the body 50. When the body 80 is fully made up with the body 50, the locking ring 82 is raised so as to engage the lugs and splines with one another and the lock pin 81 is moved into the groove 83.

In the apparatus of FIG. 1, the lower end of the means 26 is instead connected to on-off tool 31 in any suitable manner so as to transmit torque therebetween. At the upper end of such apparatus, collar 29 may have an arrangement similar to that above-described for locking its lower end to the upper end of reversing section 25.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A method of separating threadedly connected sections of a well pipe beneath a perforated area therein, comprising the steps of lowering a tool into the well pipe, setting a packer carried by the tool at a level beneath said connection, moving the tool vertically within the pipe to locate another packer carried by the tool at successively different levels within the pipe to isolate portions of the well pipe between said packers, whereby the perforated area may be detected upon the application of pressure fluid to said isolated portions, locating the tool within the pipe to dispose upper and lower dogs carried thereby opposite sections of the pipe respectively above and below a specific threaded connection beneath said perforated area, urging the dogs into gripping engagement with said sections, and urging the upper and lower dogs when so engaged in opposite rotational directions so as to unscrew the upper pipe section from the lower pipe section.

2. A method of the character defined in claim 1, including the steps of rotating the tool to set the lower packer, and then again rotating the tool to urge the dogs in opposite rotational directions.

3. A method of separating threadedly connected sections of a well pipe, comprising the steps of lowering a tool into the well pipe, expanding a spear carried by the tool into gripping engagement with a section of the pipe below a specific threaded connection so as to permit said pipe to be suspended from the tool, urging dogs carried by the tool outwardly into gripping engagement with said pipe above and below the specific connection, respectively, and urging the upper and lower dogs when so engaged in opposite rotational directions so as to unscrew the upper pipe section from the lower pipe section while said lower section remains suspended from the tool.

4. A method of the character defined in claim 3, including the steps of rotating the tool to expand the spear, and again rotating the tool to urge the dogs in opposite rotational directions.

5. Apparatus for use in separating threadedly con-

nected sections of well pipe, comprising a body having means thereon for connection to a running string to permit it to be lowered into the well pipe, upper and lower dogs carried by the body for lowering therewith into positions opposite sections of the well pipe above and below a specific threaded connection, respectively, means for urging the dogs outwardly into gripping engagement with said pipe sections, means for urging the upper and lower dogs when so engaged in opposite rotational directions to unscrew the upper pipe section from the lower pipe section and means carried by the body for engagement with the lower pipe section, prior to unscrewing of the upper pipe section from the lower pipe section so as to permit said lower pipe section to be suspended from the running string upon unscrewing of said upper pipe section therefrom.

6. Apparatus for use in separating threadedly connected sections of well pipe, comprising a body having means thereon for connection to a running string to permit it to be lowered into the well pipe, upper and lower dogs carried by the body for lowering therewith into positions opposite sections of the well pipe above and below a specific threaded connection, respectively, means for urging the dogs outwardly into gripping engagement with said pipe sections, means for urging the upper and lower dogs when so engaged in opposite rotational directions to unscrew the upper pipe section from the lower pipe section, and means carried by the body for setting a packer in the lower pipe section beneath said body prior to unscrewing of the upper section therefrom, and another packer carried by the body for sealing against the well pipe, as the body is moved longitudinally therein, so as to isolate pressure within the area of the well pipe between the packers and thereby permit detection of a leak through the pipe section above said specific connection.

7. Apparatus for use in separating threadedly connected sections of a well pipe, comprising a body having means for suspending it from a running string to permit it to be lowered into and rotated within said well pipe, a pair of sleeves carried concentrically about the body for rotation relative to one another and said body, upper dogs mounted on one of the sleeves and lower dogs mounted on the other sleeve for rotation therewith and radial movement with respect to the body so that, when retracted, they may be lowered into position for expansion into engagement with sections of the well pipe above and below a specific threaded connection, respectively, means for expanding the upper and lower dogs into gripping engagement with said well pipe sections, means on said other sleeve for connecting it in torque transmitting relation to a device beneath the body, means movable between a first position connecting said other sleeve to said body, so as to permit the connecting means to be rotated with said body prior to engagement of said dogs, and a second position disconnecting said other sleeve from said body, so as to permit the body to be rotated relative to said other sleeve upon such engagement of the dogs, and means responsive to rotation of the body relative to said other sleeve for urging the sleeves in opposite rotational directions.

8. Apparatus for use in separating threadedly connected sections of a well pipe, comprising a hollow body having means on its upper end for connecting it to a running string so that it may be lowered into and rotated within the well pipe, a pair of sleeves carried concentrically about the body for rotation relative to one another

other and said body, upper dogs mounted on one of the sleeves and lower dogs mounted on the other sleeve for rotation therewith and radial movement with respect to the body so that, when retracted, they may be lowered into positions for expansion into gripping engagement with sections of the well pipe above and below a specific threaded connection, respectively, said dogs having pressure responsive surfaces thereon connecting with the interior of the body so as to be so expandable under the influence of fluid pressure admitted from said body interior, means on said other sleeve for connecting it in torque transmitting relation to a device beneath the body, means connecting the other sleeve to the body for rotating the connection means with said body, prior to engagement of the dogs with the well pipe, and responsive to said fluid pressure to disconnect said body and other sleeve to permit said body to be rotated relative thereto upon engagement of the dogs, and means responsive to such rotation of the body for urging the upper and lower dogs in opposite rotational directions.

9. A method of removing and replacing a section of threadedly connected sections of pipe within a well bore, comprising the steps of lowering a tool into the pipe upon a running string, urging dogs carried on the tool into gripping engagement with the section of the pipe above the threaded connection, rotating the running string to urge said dogs in one direction so as to unscrew the section of pipe above said connection from the section thereof below said connection, supporting the tool within the lower pipe section, stripping the upper pipe section upwardly over the running string above the tool, stripping a replacement pipe section downwardly over the running string to a position in which the lower end of the replacement pipe is below said dogs on the tool but above said threaded connection, urging said dogs into gripping engagement with said lower end of the replacement pipe, rotating said tool and replacement pipe relative to one another to cause said dogs to assume a centered position within the replacement pipe and thereby bring it into alignment with the lower pipe section, and lowering said replacement pipe section into threaded engagement with said lower pipe section.

10. A method of the character defined in claim 9, including the steps of urging additional dogs carried on the tool beneath said first-mentioned dogs into gripping engagement with said lower pipe section, urging said lower dogs in a direction opposite to the rotation of the upper dogs in unscrewing said upper pipe section, and then urging said lower dogs into gripping engagement with the lower pipe section as the upper dogs are urged into gripping engagement with the lower end of the replacement pipe.

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U.S. Cl. X.R.

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