June 15, 1954 H. W. HARRISON 2,681,110

WELL TOOL

Original Filed July 26, 1951 2 Sheets-Sheet 1

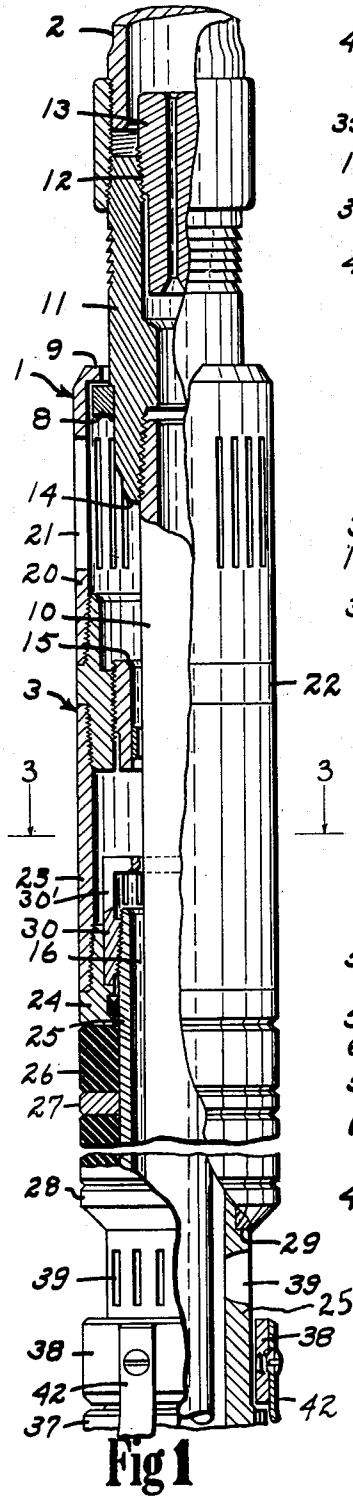


Fig 1

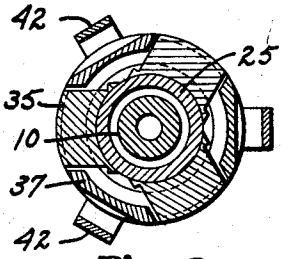


Fig 2

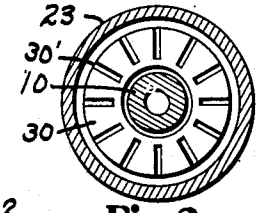


Fig 3

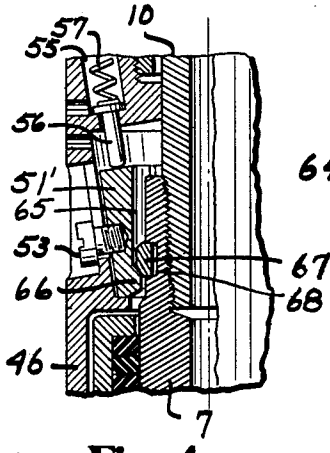


Fig 4

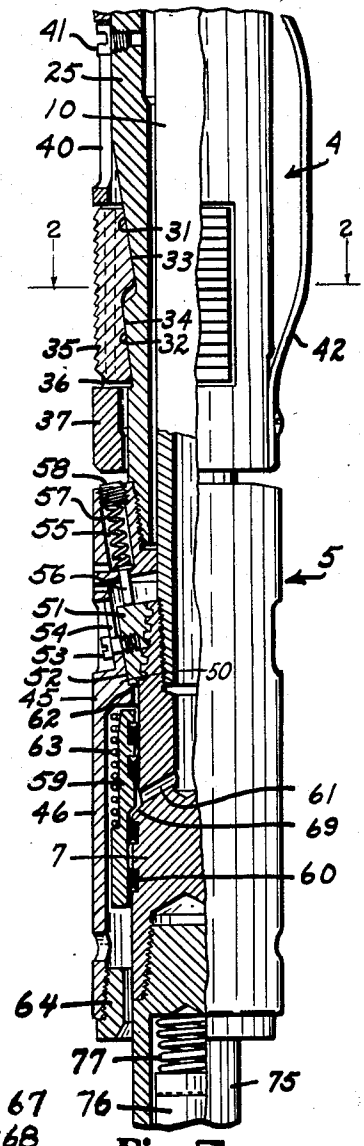


Fig 5

H.W. HARRISON
INVENTOR.

BY Jacob W. Hayden

ATTORNEY

June 15, 1954 H. W. HARRISON 2,681,110

WELL TOOL

Original Filed July 26, 1951 2 Sheets-Sheet 2

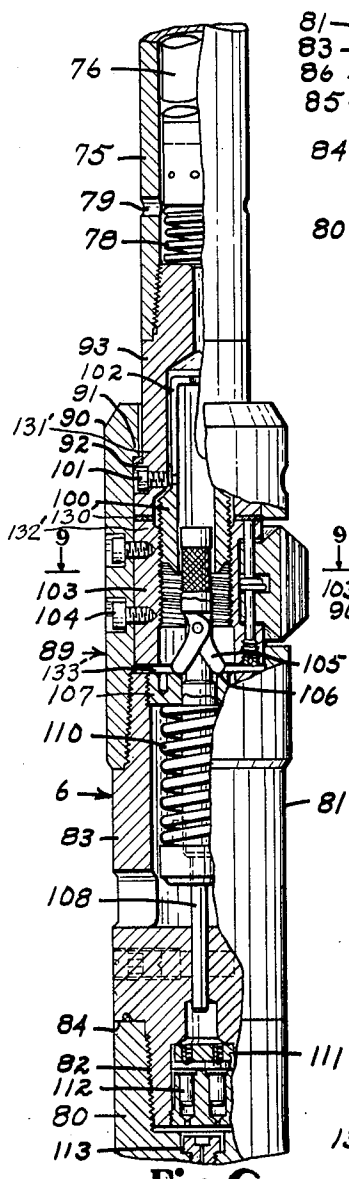


Fig 6

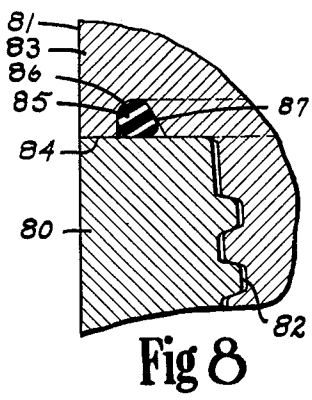


Fig 8

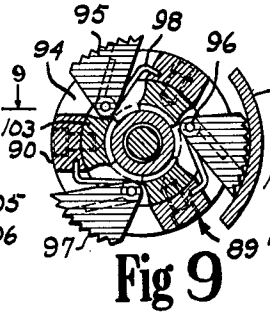


Fig 9

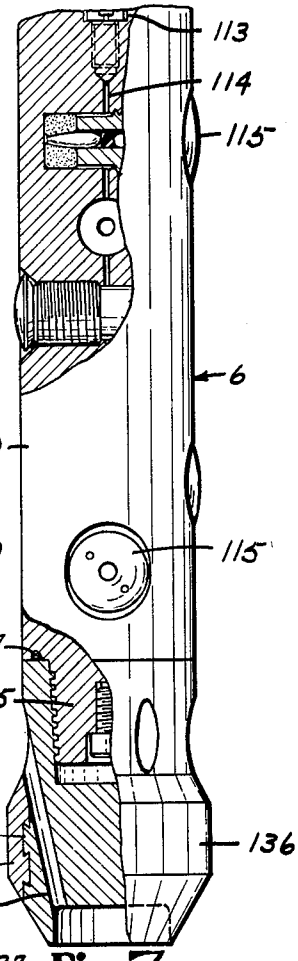


Fig 7

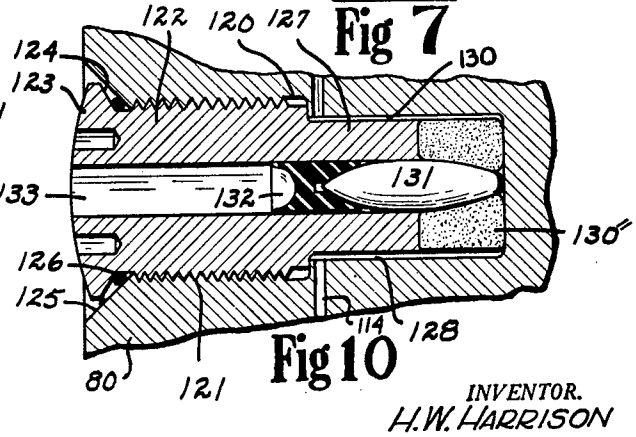


Fig 10

INVENTOR.
H.W. HARRISON

BY Jacob W. Hayden

ATTORNEY

Patented June 15, 1954 2,681,110

UNITED STATES PATENT OFFICE

2,681,110

WELL TOOL

Harry W. Harrison, Houston, Tex.

Continuation of application Serial No. 238,636, July 26, 1951, which is a continuation of application Serial No. 661,928, April 13, 1946. This application March 5, 1954, Serial No. 414,286

9 Claims. (Cl. 166—55)

1

This invention relates to a well tool, and more particularly to a tool that is capable of being lowered into a cased well bore for actuation to perforate the casing, to admit formation fluids to the interior thereof, and to effectively obtain a sample of the admitted fluids.

This application is a continuation of my prior application filed July 26, 1951, bearing Serial No. 238,636, now abandoned, for an invention in Well Tool, which is in turn a continuation of my prior application, Serial No. 661,928 for an invention in Well Tool filed April 13, 1946, now abandoned. The present application is entitled to the benefit of the filing date of April 13, 1946 for all common subject matter.

The primary object of the invention is to provide a well tool that is simple both in construction and operation and that is extremely effective in accomplishing results for which it is intended.

Another object is to provide a well tool of novel construction in which the component parts are so constructed and arranged that it is extremely compact and hence may be readily transported to and from the location where used.

A further object is to provide a well tool that includes a gun perforator, a segregating packer and a valve assembly, all operable through a tubing string to selectively effect desired operations.

The tool of the invention is so constructed that all necessary operations can be carried out by manipulation of the operating string.

Still another object is to provide a well tool having a through mandrel capable of manipulation to actuate the gun perforating mechanism, to set a packer within the well, and to open and close a fluid sampling valve.

Still another object is to provide a gun perforator which is actuated by the relative rotation and axial movement of parts thereof, the mechanism including a no-back assembly whereby the gun assembly is held stationary while the actuating mechanism is placed in operation through rotation of the operating string and the through mandrel.

Still another object is to provide a gun perforator including a gun unit of novel construction and capable of effectively performing the desired perforating operation.

The foregoing objects are the primary objects of the invention, which together with other objects and advantages will be more fully apparent from the following description considered in connection with the accompanying drawings in which:

2

Fig. 1 is an elevational view partly in section showing the upper portion of a tool embodying the invention and includes the packer and the bypass assembly therefor;

Fig. 2 is a horizontal sectional view taken on line 2—2 in Fig. 5;

Fig. 3 is a sectional view taken on line 3—3 in Fig. 1;

Fig. 4 is a detail in section showing a modified construction for providing a releasable connection within the sampling valve assembly;

Fig. 5 is an elevational view partly in section showing the slip assembly and the valve and trip mechanism for admitting a sample and comprises a continuation of Fig. 1;

Figs. 6 and 7 are elevational views partly in section showing successive portions of the gun perforator comprising the lower portion of the tool;

Fig. 8 is an enlarged sectional detail of the leak proof joint at the upper end of the perforator;

Fig. 9 is a horizontal sectional view taken on line 9—9 in Fig. 6, and showing the no-back mechanism which holds the perforator against rotation when operation thereof is effected;

Fig. 10 is an enlarged detail in section showing one of the guns comprising elements of the invention.

A tool embodying the invention is generally shown at 1 as connected to a tubing or operating string 2, such tool comprising a valve and packer section 3 at its upper end, a slip section 4, a valve and trip mechanism 5, and the gun perforator 6 suspended therebeneath.

An important feature of the invention resides in the construction which includes a composite through mandrel 10 including a valve coupling 11 threadedly interconnected through a coupling to the tubing string 2. This mandrel extends downwardly through the valve and packer section 3 and the slip assembly 4 and terminates in the valve member 7 of the valve and trip mechanism 5. The valve coupling 11 is threaded internally at 12 for attachment of the choke 13 thereto so that entrance of a sample to the operating string 2 is regulated. This choke may also serve as a bottom hole choke in event conditions warrant permitting the tool to remain in the well so that the well can be flowed therethrough.

The lower end of the valve coupling 11 has a valve surface 14 thereon. This surface is engageable with the seat 15 therebelow to close the passage 16 through the packer assembly 3 and about the mandrel 10. This assembly comprises a collar 20 which is peripherally slotted at 21

and which is connected by means of coupling 22 to the seat member 15 and to nipple 23 in turn connected to ring 24. Slidably fitting within the ring 24 is annulus 30 slotted at 30' to facilitate passage of fluids upwardly about the mandrel 10. The annulus 30 is attached to the packer sleeve 25 which is surrounded by packer rings 26 proximate its upper end. These packer rings may be separated as desired, by spacers 27, and the telescopic structure just described is such as to permit relative axial movement between the ring 24 and the sleeve 25.

A ring 28 beneath the lowermost packer ring 26 rests upon a shoulder 29 on the sleeve 25, and it thus becomes possible upon relative axial movement of the rings 24 and 28 to expand the packer rings into sealing engagement with a surrounding casing in which the tool is being used.

Attention is directed to the fact that the collar 20 has an inwardly extending flange 8 at its upper end engageable with ring 8 secured to the valve coupling 11 of the mandrel 10. This serves to positively lift the collar 20 and associated elements when the mandrel 10 is lifted.

Proximate the lower end of the packer sleeve 25 are tapered stepped peripheral areas 31 and 32 (Fig. 5) which are complementary to inner faces 33 and 34 on slips 35 which extend through openings 36 in the cage 37 slidably surrounding the lower end of the packer sleeve 25. There is a releasable connection between the cage 37 and the sleeve 25, such connection comprising an inverted J-slot 40 into which projects the head of an anchor pin 41 threadedly secured to the sleeve 25.

Drag springs 42 are secured to the cage 37 intermediate the slips 35. The upper end of each spring is attached to the ring 38 which is slidable upon the member 25 below the by-pass slots 39 therein.

The lower end of the sleeve 25 is connected to the housing 45 which extends downwardly about the mandrel 10 and terminates in a skirt portion 46 surrounding the admission valve 7. Near the upper end of the housing 45 an enlargement 50 in the bore thereof forms a bowl to receive segments 51 which, as shown in Fig. 5, are threaded for engagement with complemental threads on valve member 7 and have tapered surfaces 52 complementary to the interior of the bowl. These segments are guided for upward linear movement only along the inner walls of the bowl by means of guide screws 53 threadedly secured thereto and passing through slots 54 in the housing.

Axially extending bores 55 in the walls of the housing 45 slidably receive the heads of pins 56 which are resiliently held downwardly by compression springs 57 secured in place by caps 58 at the upper ends thereof. This arrangement normally holds the segments 51 upon the shoulder 52, but enables a functioning of the device as will be more fully described.

Within the skirt 46 of the housing 45 is an annular gland ring 59 surrounding the valve member 7, there being one or more seal rings 60 interposed between the ring and the member both above and below the ports 61 in the latter. The gland ring 59 is constantly urged downwardly by means of spring 63 to normally hold the complementary shoulders 69 into engagement, and obviously at such time the passage 61 is maintained closed.

An alternate form of the connection between the mandrel 10 and the housing 45 as just described is shown in Fig. 4 wherein the segments 51' are not threaded, but instead are provided with an interiorly cut away portion 65 whereby the segments provide an annulus 66 at their lower ends for co-action with the spring ring 67 which fits within the groove 68 in the upper end of the valve member 7.

In order to disconnect the mandrel 10 from the housing 45 and associated elements as shown in Fig. 5, the mandrel 10 may be rotated, preferably in a clockwise direction as viewed from above, so that the mandrel is unthreaded downwardly. As soon as the connection is released the mandrel is, of course, free to move downwardly relative to the remainder of the device and such downward movement will cause the gland ring 59 to move downwardly with the valve, assisted by the force exerted by the spring 63, until the stop or collar 64 at the lower end of the housing is engaged by the gland ring. Further relative movement between the parts will cause the valve member 7 to move outwardly from within the gland ring whereupon the passage 61 in the valve is uncovered, and a sample of fluid is permitted to enter the mandrel, it being intended that such sample shall be flowed to the surface or withdrawable for examination when the tool is removed from the well.

When it is desired to close the passage 61 and to entrap the fluid sample within the mandrel and the operating string thereabove, the mandrel is moved in the opposite direction. Such movement will cause the teeth upon the mandrel and the segmented nut 51 to contact whereupon the segments of the nut will rise against the tension of the springs 57 a sufficient distance that the threads will over-ride and interengage without the necessity of producing relative rotation between the mandrel and the remainder of the assembly.

The operation of the alternate construction shown in Fig. 4 is comparable to that just described. As distinguishing, however, it is to be noted that, once the slip assembly is set, a downward thrust upon the mandrel 10 will cause the spring ring 67 to contract and therefore pass within the annulus 66 whereby the connection is released. Downward movement of the mandrel 10 will effect valving operations in the manner just described. When it is desired to close the passage 61 and thereby to entrap a fluid sample within the mandrel 10, the mandrel is moved in the opposite direction whereupon the ring 67 engages the annulus 66 on the segments 51'. The segments will then rise within the bowl 50 against the tension of the springs 57 until the ring 67 enters the space 65 above the annulus 66 whereby the interconnection of the mandrel with the remainder of the device is again effected.

The composite through mandrel 10 which includes the admission valve member 7 is connected to the upper end of the gun perforator 6 by means of the stem 75 which is hollow and encloses a pressure bomb 76 supported by the springs 77 and 78, there being passages 79 in the stem to provide for the entrance of fluid whereby pressures at the level of the device will be properly indicated by the bomb 76. The springs 77 and 78 are instrumental in protecting the bomb against forces arising from impacts and which would otherwise give spurious readings of the pressure bomb.

A swivel connection 130' between the lower end of the mandrel and the upper end of the gun perforator is shown in Fig. 6. The portion 131' is rotatable relative to the portion 132'.

The gun perforator 6 comprises a body 80 that is attached to the firing head 81 by means of threads 82, the member 83 of the firing head having a shoulder 84 thereon (Fig. 8) grooved at 86 to receive an annular seal ring 85 of deformable but non-compressible material such as rubber and the like. The groove 86 has an inwardly tapering wall 87 into which the ring 85 is slightly deformed. If fluids tend to enter the gun along the juncture of the body 80 and the member 83, the pressure exerted upon the ring 85 will cause it to distort wedgingly into the tapered area whereby a firm seal between the members is effected.

A special coupling 90 comprising an element of the no-back assembly 89 is attached to the upper end of member 83 and has an inward flange 91 at its upper end to overlie a complementary flange 92 on the swivel head 93 which is in turn attached to the stem 75. This coupling has recesses 94, shown as three in number, (Fig. 9) to receive dogs 95 pivotally mounted at 96 eccentrically of the assembly. These dogs have teeth 97 on their outer surfaces and are constantly urged outwardly, by means of springs 98, into engagement with a surrounding casing 99 within which the tool is used. It seems apparent that the no-back assembly 89 is so constructed that it will permit rotation of the entire gun assembly in a counter-clockwise direction as viewed in Fig. 9, but will restrain the gun against rotation in the opposite direction.

If the string 2, and hence the mandrel 10 and the stem 75, is rotated in a clockwise direction while the gun 6 is restrained against rotation, as just explained, the thimble 100 is driven therewith by the drive pin 101 having its inner end extending into the slot 102 in the thimble. This causes the thimble to move downwardly within the threaded sleeve 103 secured to the coupling 90 by screws 104. When the lower end of the thimble engages trip fingers 105 it wedges these fingers inwardly whereby they are dislodged from the ledge 106 on the ring 107 secured in the upper end of the member 83. This releases the cocked trip assembly whereby the pin 108, to which the fingers 105 are pivotally attached, is forced downwardly under the influence of the spring 110. In turn the firing pin assembly 111 is forced into engagement with the primer or primers 112 from which there proceeds a pressure wave which travels downwardly through the choke 113 and thence through the passage 114 to and about the various gun units 115.

Continued rotation of the thimble 100 by means of the mandrel and drive pin 101 jams the thimble against surface 133' and shears pin 101. This causes a definite change in the amount of energy required to rotate the string at the top of the well bore which indicates that the firing pin has been released.

The gun body 80 is provided with a plurality of transversely extending bores 120 (Fig. 10) oriented in a desired manner about the gun body. Each of these bores is enlarged and threaded as shown at 121 to receive complementary threads on the barrel 122. The head 123 on the barrel has a tapered nether surface 124 to cooperate with the tapered surface 125 at the mouth of the bore 120 to receive a seal ring 126.

The inner and smaller portion of the bore 130 receives extension 127 of the barrel which is of such diameter as to provide an annular space 128 serving the dual function of transmitting the pressure wave between successive portions of the passage 114 and also transmitting such wave to the explosive charge 130''. Burning of the explosive charge effects discharge of the projectile 131 and the seal plug 132 from within the bore 133 of the gun barrel. The progressive firing of the gun is, of course, instrumental in producing desired perforations in a surrounding casing.

The gun body 80 is provided with a pin 135 at its lower end for the attachment of the plug 136. A seal 137 at the juncture of these elements is constructed and serves the same purpose as the structure shown in Fig. 8 and heretofore described.

Attention is directed to the fact that the plug 136 may be removed, and by virtue of the construction above described, an additional gun section or sections may be attached and in this manner a gun of any desired length may be provided.

The plug 136 is of special construction in that the lower portion thereof is configured peripherally, as by dovetails 137', to hold a cast ring 138 of a soft material, such as lead or other suitable material, thereon. This construction serves as a centering element for the lower end of the tool and the ring 138 thereon, being of a soft material, will readily score when the tool is moved within a casing and thus indicate the existence of burrs or other projections on the wall of the casing, and yet permit passage of the tool. Passages 139 in the plug serve as by-passes for liquid during movement of the tool.

The operation of the tool is believed apparent from the foregoing description. By way of summary of operational steps and the description of the tool, it will be assumed that the successive sections as shown in Figs. 1, 5, 6 and 7 are assembled with the respective parts thereof in the relative positions shown in the drawings. The tool is then connected to an operating string 2 and is lowered to the level in a well at which it is desired to use the tool.

The casing 99 (Fig. 9) is conventionally cemented within a bore hole in which the tool of the invention is to be used. However, in some instances the cement does not effectively seal about the casing and if this condition exists testing for leakage prior to perforating should be made.

To this end the preferred initial operational steps comprise rotation of the operating string in a counter-clockwise direction sufficiently to release anchor pin 41 (Fig. 5) from the horizontal portion of the J-slot 40 whereupon the entire device, except the cage 37 and the slips 35, is lowered and the slips are forced outwardly into engagement with the casing 99. Then the operating string 2 and the mandrel 10 are rotated in a clockwise direction to release the threaded connection between the segments 51 and the valve member 7. The string is then lowered whereby, sequentially, the valve surface 14 engages seat 15 to close the passage 16 and pressure is applied to expand the rings 26 and form a seal with the casing. Substantially simultaneously the gland ring 59 engages stop collar 64 whereupon the gland ring stops and the valve member 7 moves downward to uncover ports 61. If the casing 99 is not tightly sealed within the well bore, fluids will enter the ports 61 and rise in the operating string 2, thus indicating an undesirable condition requiring re-cementing. The gun 6 may be fired for squeeze cementing or other cementing operations may be utilized.

If, and when, the casing 99 is properly set within the well bore as indicated by test as above described, the operating string 2 is lifted to effect

a reconnect between segments 51 or 51' and the mandrel assembly 10. The operating string is then rotated in a right hand or clockwise direction whereby the entire through mandrel assembly is rotated relative to the packer and slip assembly. The gun 6 is restrained from rotation by the no-back assembly 89 and hence rotation of the operating string effects downward movement of the thimble 100 to actuate the firing mechanism whereby the projectiles 131 are discharged from the guns to effect the perforating operation.

The entire tool is then preferably lifted a few feet whereupon the operating string is lowered, but the slip assembly 4 remains stationary by virtue of the friction between the springs 42 and the surrounding casing.

The operating string 2 is then rotated in a clockwise or right hand direction to release the connection between the segments 51 and the valve member 7 as shown in Fig. 5 or downward pressure by the operating string will release the connection shown in Fig. 4. Continued lowering causes the valve surface 14 to engage the seat 15, and substantially simultaneous therewith, the gland ring 59 engages stop collar 64 whereby movement of the former is terminated and the valve moves from therein and ports 61 are uncovered. A fluid sample thus enters the perforations in the casing below the packer assembly and rises within the mandrel 10 and the string 2.

In order to entrap the sample the mandrel 10 is lifted and the segments 51 when engaged by the valve member 7 will rise and lift the pins 56 against the tension of the springs 57 until there is sufficient clearance for interengagement of the segments 51 or 51' and the valve member 7. Continued upward movement of the operating string will cause the ring 8 to engage flange 9 and effect lifting action upon the packer and slip assembly whereby the slips are released and the entire tool may thus be withdrawn from the well. At the same time, of course, the valve surface 14 is lifted from the seat 15 whereby there is provided a free passage about the packer assembly so that the tool can be withdrawn without the production of a swabbing action by the assembly.

Broadly, the invention comprehends a well tool which may be lowered into a cased well bore for actuation to perforate the surrounding casing and to obtain a sample of the fluids admitted thereby or to flow the well through the operating string upon which the tool is lowered.

What is claimed is:

1. A well tool comprising, an operating string, a through mandrel secured thereto, a packer and slip assembly surrounding said mandrel, a perforating gun, a swivel connection between the lower end of said mandrel and the upper end of the gun, whereby the gun is swivelly suspended on the lower end of said mandrel, gun actuating means operable by relative rotation of the mandrel and gun, and a no-back assembly on the gun operable to restrain the gun against rotation when the operating string is rotated.

2. A well tool comprising, an operating string, a through mandrel secured thereto, a packer and slip assembly surrounding said mandrel, a perforating gun swivelly suspended on the lower end of said mandrel, gun actuating means operable by relative rotation of the mandrel and gun, and a no-back assembly on the gun including at least one dog eccentrically mounted on the gun and movable outwardly to engage a surrounding casing and restrain the gun against rotation in one direction.

3. A well tool comprising, a hollow mandrel, a packer and slip assembly surrounding the mandrel and operable thereby to form a seal with the surrounding wall of a casing in which the tool is used, said mandrel including a valve member at its lower end, said valve member having a passage leading from the exterior to the interior of the mandrel, means normally closing said passage, a perforating gun suspended from the mandrel, means operable by the mandrel for actuating the gun, and means operable by the mandrel after the gun has been actuated to operate said first mentioned means and open said passage.

4. A well tool including a hollow mandrel, a packer assembly surrounding the mandrel, means for anchoring said assembly, said mandrel including a valve member at its lower end having at least one passage from the exterior to the interior of the mandrel, a housing attached to said anchor means and extending about said valve member, a releasable connection between said mandrel and housing, a gland ring slidably surrounding the valve member and forming a closure for said passage, a stop on said housing engageable by the gland ring when the mandrel and valve are lowered to arrest movement of the gland ring and open the passage.

5. A well tool including a hollow mandrel, a packer assembly surrounding the mandrel, means for anchoring said assembly, said mandrel including a valve member at its lower end having at least one passage from the exterior to the interior of the mandrel, a housing attached to said anchor means and extending about said valve member, a bowl formed within said housing, means within said bowl releasably engaging said mandrel, and means surrounding said valve member and normally forming a closure for said passage but movable to open the passage when said means within the bowl is released.

6. A well tool including a hollow mandrel, a packer assembly surrounding the mandrel, means for anchoring said assembly, said mandrel including a valve member at its lower end having at least one passage from the exterior to the interior of the mandrel, a housing attached to said anchor means and extending about said valve member, a bowl formed within said housing and having tapered side walls, there being a threaded area on said mandrel within said housing, a segmented nut within said bowl engageable with said threaded area to form a connection between the housing and mandrel, and means normally closing said passage but movable by the housing when the connection is released to open the passage and admit fluid to the interior of the mandrel.

7. In an oil well tool the combination comprising, a tubing string including a hollow mandrel at its lower end, means for forming a pack-off between the mandrel and a surrounding casing, a valve structure normally closing the lower end of the tubing string and mandrel, a gun perforator suspended from said mandrel, means operable by rotation of the string for actuating the gun, said first mentioned means being thereafter operable by the tubing string to form a pack-off, and additional means thereafter operable to admit a fluid sample through said valve to the interior of the mandrel and to entrap said sample by opening and closing the valve structure.

8. A gun perforator for lowering into a cased well bore on an operating string to perforate the casing in the well bore comprising, a gun body, a swivel connection for accommodating relative rotational movement between said body and the operating string, a no-back assembly on the gun operable to restrain the gun against rotation when the operating string is rotated in one direction, a cocked pin in said body, means to releasably retain said pin in cocked position, spring means urging said pin toward firing position, and additional means to release said pin retaining means, said last mentioned means comprising a thimble movably enagged with the operating string and threaded in said body and movable longitudinally of said body to engage and release said pin retaining means upon rotation of said string in one direction while said no-back assembly restrains said gun body against rotation.

9. A gun perforator for lowering into a cased well bore on an operating string to perforate the casing in the well bore comprising, a gun body, a swivel connection for accommodating relative rotational movement between said body and the operating string, a no-back assembly on the gun operable to restrain the gun against rotation when the operating string is rotated in one direction, a firing pin mounted longitudinally of said body, means to releasably retain said pin in cocked position, spring means to urge said pin toward firing position, and additional means to release said pin retaining means, said last mentioned means comprising a thimble movably engaged with the operating string and threaded in said body and movable longitudinally of said body to engage and release said pin retaining means upon rotation of said string in one direction while said no-back assembly restrains said gun body against rotation.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,234,943	Asbury	July 31, 1917
1,484,304	Hall	Feb. 19, 1924
2,124,172	Wildes	July 19, 1938
2,169,559	Halliburton	Aug. 15, 1939
2,186,323	Brown	Jan. 9, 1940
2,305,139	Collins	Dec. 15, 1942
2,307,360	Collins	Jan. 5, 1943
2,327,340	Couch	Aug. 24, 1943
2,388,938	Smylie	Nov. 13, 1945

FOREIGN PATENTS

Number	Country	Date
37,697	Germany	Nov. 20, 1886