

Jan. 9, 1940.

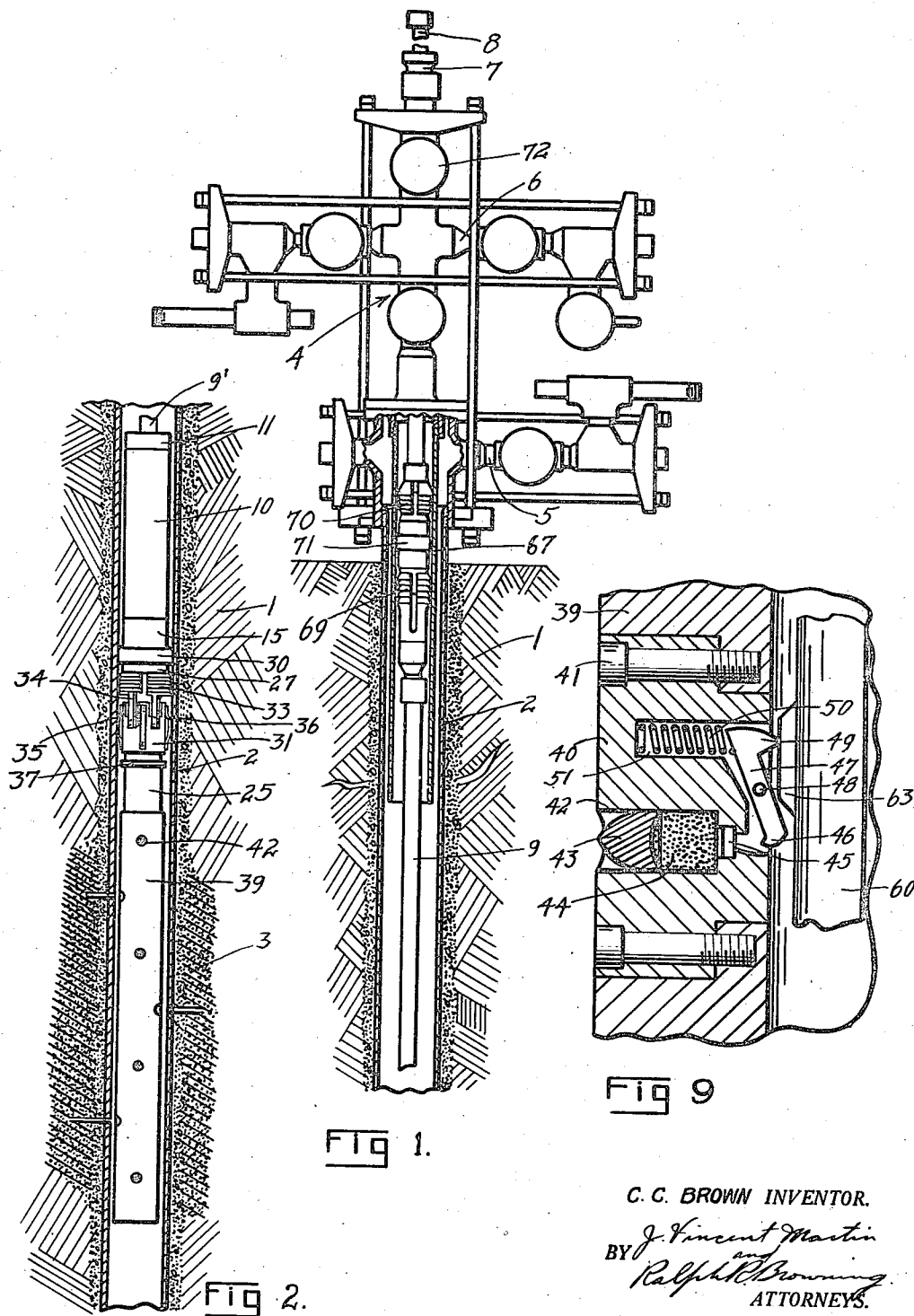
C. C. BROWN

2,186,323

CASING PERFORATOR

Filed April 5, 1937

3 Sheets-Sheet 1



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CASING PERFORATOR

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3 Sheets-Sheet 2

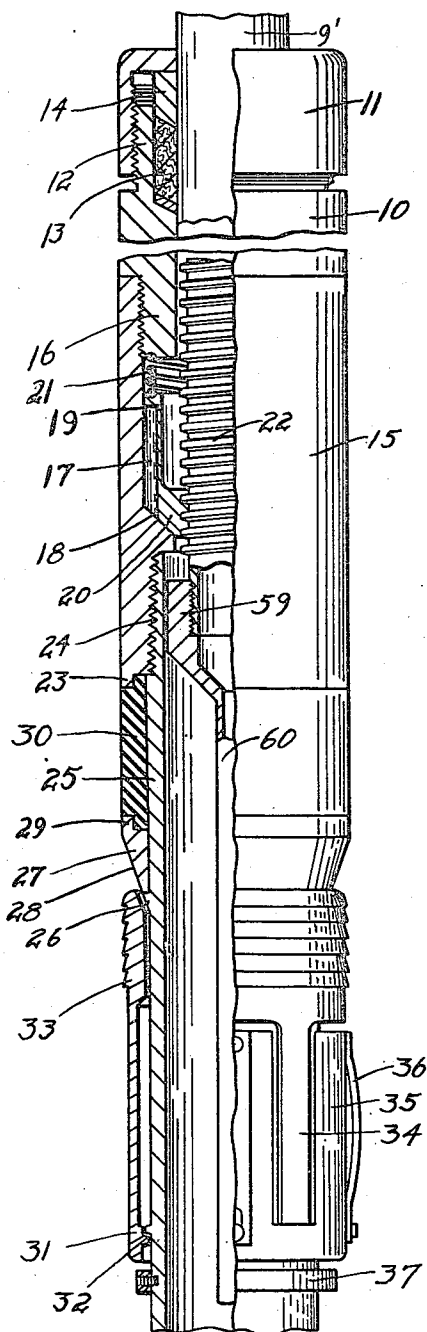


FIG. 3.

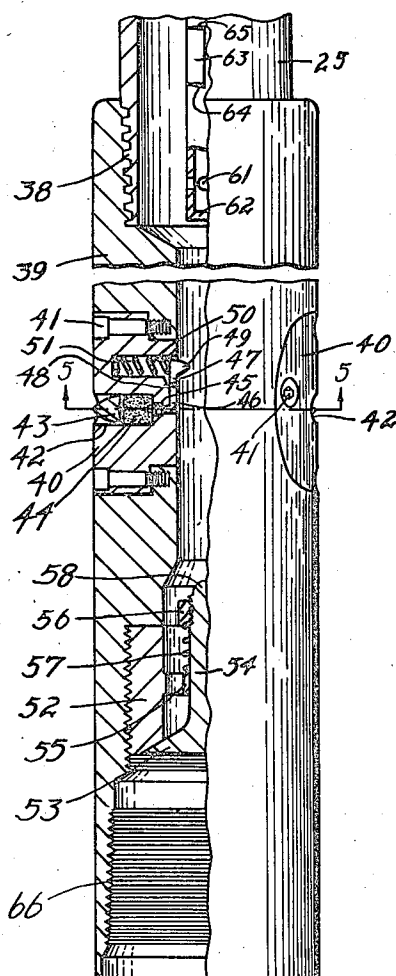


FIG. 4.

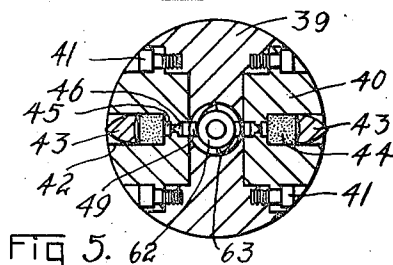


FIG. 5.

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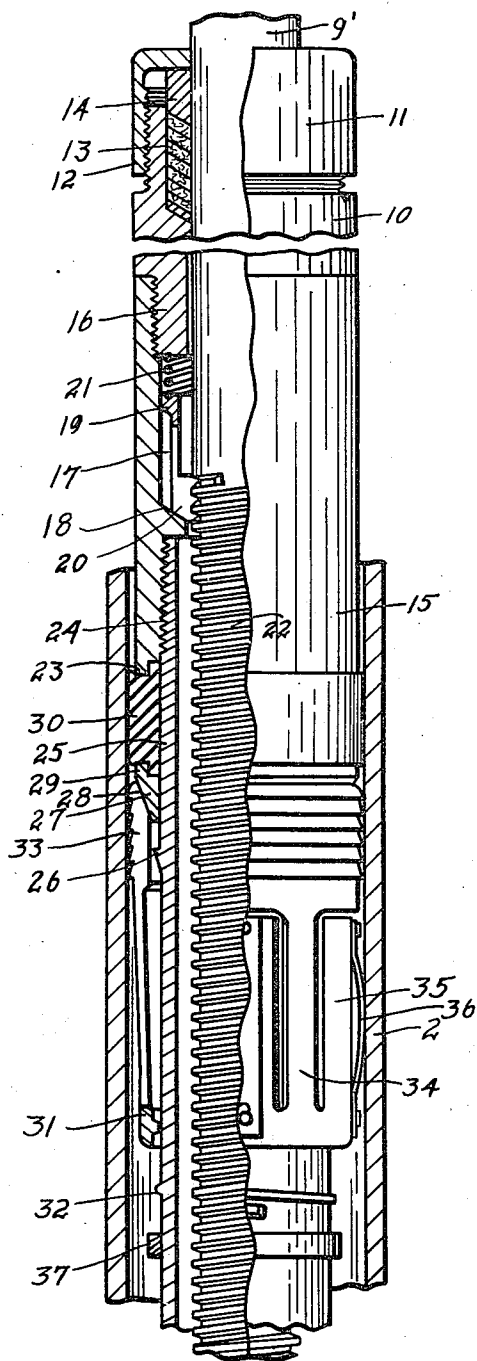


FIG 7.

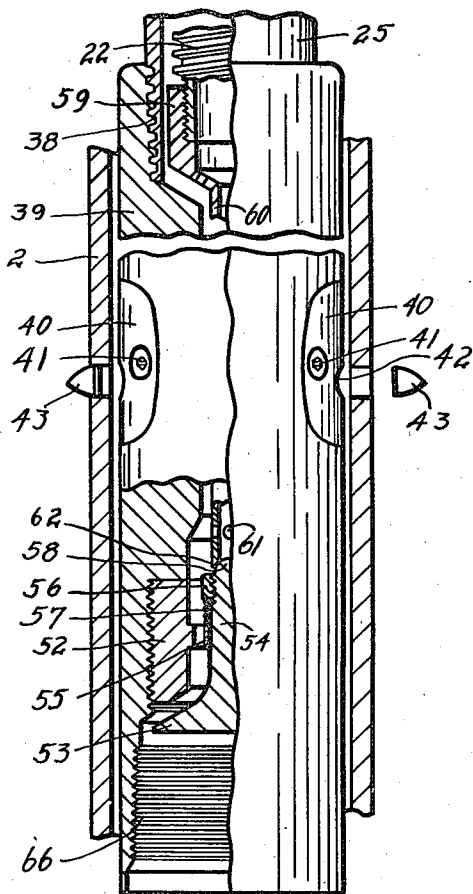


Fig 8.

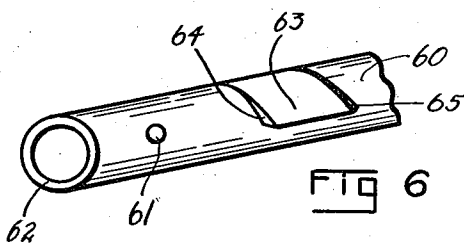


FIG 6

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UNITED STATES PATENT OFFICE

2,186,323

CASING PERFORATOR

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Application April 5, 1937, Serial No. 134,966

8 Claims. (Cl. 166—1)

This invention relates in general to means for perforating the casing of an oil well while it is in place within the oil well, and has particular reference to such a device wherein the perforation is accurately controlled from the surface of the ground.

It is customary in drilling oil wells to take samples of the formation as the drilling proceeds so that a log may be kept of the formation through which the well is drilled. When the well reaches a level at which the best producing formation is expected to be found, it is then customary to run into the well a casing to a point immediately above such formation, to cement the casing in place, and to apply to the well the necessary equipment for testing the formation at the bottom of the casing to determine whether or not it will satisfactorily produce.

It many times happens that during the course of drilling a well one or more formations will be passed which give indications that they might prove good producing formations, and in such event it may later become desirable to produce from such formations rather than or simultaneously with the production from the lower formations. Under such circumstances, it has been the practice in the past to lower into the well casing, usually upon a wire line or similar device, a body containing an explosive charge, and in most instances a pellet adapted to be propelled by the explosive charge through the side wall of the casing. One or more such charges is employed in such a body, and the body is suspended as nearly as it can be determined at the point opposite which the formation to be tested is located. The charge is then fired by means of electricity or some other suitable expedient, the body is drawn out of the well, and steps are taken to determine the nature and quantity of fluid which will enter through the perforated portions of the casing.

In perforating casing by the means and method just outlined, it is difficult first of all to determine the exact level at which the body may be located, and hence to determine whether or not the body is opposite the formation which it is desired to tap because of the stretch in the wire line from which the body is suspended. Second, when the body is perforated, the well is left wide open so that if a high pressure formation were penetrated by the perforation, a blow-out might be caused. Third, there is no readily available means for testing the production of this formation, or for producing the fluid entering through the perforation without first removing the perforating device from the well.

Furthermore, if the customary practice of having the well filled with heavy mud is followed, the weight of the mud may overbalance the pressure of the formation and immediately upon the perforation of the casing the mud will flow outwardly through the perforation and tend to plug up and prevent any subsequent flow from the formation surrounding the casing at that point.

It is an object of this invention to provide a perforating means for a casing, which perforating means may be accurately located with respect to any desired position in the well. It is a further object to positively control the firing of the charge from the surface of the ground.

Another object is to provide a means for preventing any possible blow-out and at the same time preventing the flow of any heavy mud or the like into the formation when the casing is perforated.

Another object is to provide a device for testing the production of the formation through the perforation in the casing immediately after the perforation has been made, and for relieving, insofar as possible, any back pressure which may exist within the casing tending to retard the flow from the formation.

Another object is to provide a method and means whereby the casing may be perforated and the well produced without necessity for removing the perforator from the well or for running into the well additional equipment for the purpose of producing the same.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings, it being understood that said description and drawings are by way of example and illustration only, and are not to be taken as in any way a limitation upon the spirit and scope of this invention. Such limitation is to be only by the prior art and by the terms of the appended claims.

Referring now to the drawings in which like numerals indicate corresponding parts throughout:

Fig. 1 is a view partially in section illustrating the upper end of a well equipped for production upon the perforation of the casing thereof in accordance with this invention.

Fig. 2 is a view illustrating a cross section through the lower portion of the well shown in Fig. 1, and showing the perforating and testing apparatus in elevation, this view being taken subsequent to the firing of the charges and the perforation of the casing.

Fig. 3 is an enlarged view partly in cross section

illustrating the anchoring and packing off portion of the apparatus forming a part of this invention.

Fig. 4 is a similar view illustrating the explosive charge and the body for containing the same, together with the firing mechanism and the valve arrangement for controlling and producing the well.

Fig. 5 is a horizontal cross section taken along the line 5—5 of Fig. 4.

Fig. 6 is a perspective view of the lower end portion of the tubing employed in firing the charge and sampling or producing the fluid from the formation.

Fig. 7 is a view similar to Fig. 3, but illustrating the parts in the position they occupy after the device has been anchored and packed off and the charge fired.

Fig. 8 is a view similar to Fig. 4 with the parts in the position they occupy after the charge has been fired.

Fig. 9 is an enlarged sectional view of the explosive charge and firing mechanism at the moment just before firing.

Referring now more in detail to the drawings, there is illustrated in Fig. 1 a well which has been drilled through the customary earth strata 1, and into which there has been lowered a casing 2. At the upper end of this casing there is illustrated diagrammatically a manifold or Christmas tree 4 such as is customarily employed for the purpose of controlling the flow from an oil well or the like. This Christmas tree includes a casing head and flow lines 5 for controlling flow from the casing, together with a head providing flow line 6 for controlling flow from the tubing. At its upper end, this Christmas tree is provided with a stuffing box at 7 through which a handling nipple or other tool 8 may be passed. From this element 8 is suspended a string of tubing 9 upon the lower end of which is located the device for perforating the casing and testing the production of the formation.

The device just referred to comprises a number of parts, the housing 10 being formed to receive the lower end of the lowermost section 9' of tubing 9, which section is specially formed as will be hereinafter described. At the upper end of the section 10 a cap or nut 11 is threadably engaged with the reduced threaded portion 12. This portion 12 is also formed with a countersink or stuffing box for the purpose of receiving a packing 13, which packing is compressed to the proper degree by means of the gland 14 against which the nut 11 operates. A lower special fitting 15 is threadably engaged with the reduced threaded extension 16 on the lower end of the member 10 and is provided with a hollow upper portion 17 of substantially larger diameter than the inner diameter of the member 10. This portion 17 terminates in a downwardly and inwardly extending tapered shoulder 18. A ring member 19 split from its lower end to form an expansible segmental nut 20 is located within the portion 17 and is constantly urged downwardly by means of a spring 21, this spring bearing against the lower end of the member 10 and against the upper end of the ring 19. This forces the expansible nut 20 against the inclined or tapered surface 18, and tends constantly to contract this expansible nut into engagement with the threads 22 formed on the special lower section 9' of the tubing 9. It is noted that when an excessive upward force is exerted upon the tubing, the tubing may move upwardly against the tension of

the spring 21, whereupon the nut 20 may expand and permit the threads 22 to slip past as the tubing moves upwardly. Likewise, if the downward movement of the tubing is stopped and its rotation continued, the nut 20 will be forced upwardly by the threads 22 against the tension of the spring 21 until it has moved a sufficient distance to permit it to expand and allow the threads to slip past.

At its lower end, the special fitting 15 is provided with a downwardly extending annular lip 23, and with an internally threaded portion 24 adapted to threadably receive the special nipple 25. This special nipple 25 has a slight upwardly facing shoulder 26 thereon, and a slidable tapered collar 27 having a downwardly tapering surface 8 and an upwardly facing annular lip 29 thereon is rested upon the shoulder 26. It will be understood that this collar 27 is freely movable longitudinally with respect to the nipple 25.

Interposed between the downwardly extending annular lip 23 on the fitting 15 and the upwardly extending lip 29 on the collar 27 is a packer element 30 which may be of any desirable construction capable of being distorted so that it may expand into sealing engagement with a surrounding casing when the collar 27 is forced upwardly with respect to the nipple 25 and the packing 30.

Surrounding the nipple 25 below the shoulder 26 is a ring 31 formed for a single threaded engagement with the nipple 25 to normally hold it against upward movement with respect to the nipple, and split to form segmental slips 33 at its upper end. These slips, as illustrated in the lower right hand portions of Figs. 3 and 7, are carried by upwardly extending portions 34 which act as spring supports for the slips, and segmental parts 35 of the sleeve are provided between the supports 34 for carrying the outwardly bowed friction springs 36. These springs 36 are of such formation that they are adapted to constantly engage the inner surface of the casing. A ring 37 is preferably secured about the nipple 25 below the threaded engagement 32 so as to prevent the slip ring 31 from dropping downwardly below this threaded engagement.

At its lower end, the nipple 25 is provided with external threads at 38 to receive the body member 39. This body member 39 is cut away at desired intervals to form seats for the inserts 40, these inserts being of hardened very strong material such as that from which gun barrels are made. The inserts 40 are secured in place within the body 39 by means of counter-sunk screws 41 or the like.

The inserts 40 are provided each with a normally horizontal bore 42 within which the pellet or bullet 43 and the charge 44 are to be placed. Within a reduced portion of the inner end of this bore 42 is a small chamber adapted to receive a cap or detonator 45 which is in turn to be set off by means of a firing pin 46 upon the trigger 47. This trigger 47 is pivotally mounted at 48 and provided with a lug 49, the action of which will be presently explained. Normally this trigger is held in position illustrated in Fig. 4 with the firing pin 46 in contact with the detonator 45 by means of a spring 50 located in a bore 51.

At its lower end, the body 39 is internally threaded to receive a valve seat 52 which in turn carries and seats a valve 53 having an upwardly extending stem 54. This stem 54 passes through a guiding element 55 within the valve seat member 52 and has a nut 56 threaded onto its upper

end. Between this nut 56 and the guide 55 is a compression spring 57 which normally holds the valve 53 in seated position. The valve stem 54 has a rounded upper end 58 for a purpose presently to be set forth. Threadedly connected to the lower end of the screw threaded special tubing section 9' is the enlarged end portion 59 of a reduced tubing extension 60. This reduced tubing extension 60 has lateral perforations 61 adjacent its lower end, and at its lower end is formed with a seat portion 62 adapted to seat upon the rounded upper end portion of the valve stem 54. Above the perforations 61 the tubing extension 60 is provided with a laterally extending cam-like part 63 having beveled lower and upper shoulder portions 64 and 65. The details of this cam-like part are more clearly set forth in Fig. 6 of the drawings. It will be understood that the tubing 60 may be provided either with one or two or even more of these cam-like parts as desired. Two such parts are employed in the example illustrated, as shown more clearly in Fig. 5.

The lower end of the body 39 may or may not be threaded, as desired, but is preferably threaded as shown at 66 for the purpose of receiving any structure which it might be desired to suspend therefrom.

In order that the tubing and other apparatus carried thereby might be hung at any desired point and the well produced therethrough, a relatively short string of pipe 67 is suspended from within and has its upper end sealed to the Christmas tree equipment above the casing flow lines 5, and the tubing is provided with a hanger and packer equipment adapted to anchor and pack off the upper end of the tubing within said pipe 67. The pipe 67 may be hung and packed off by means of any suitable hanger and packer arrangement which will positively anchor the same within the Christmas tree above the flow lines and form the desired seal, such apparatus being illustrated in my copending application Serial No. 84,031 filed June 8, 1936. The hanging and packing device on the tubing is similar and comprises hanging slips 69 and hold-down slips 70 having a packer 71 between them, whereby the tubing may be positively anchored and packed off within the pipe 67. This hanging arrangement and its operation are fully set forth in my aforesaid application Serial No. 84,031.

In operation, the perforating device will be assembled as illustrated in Figs. 1 to 4, inclusive, after which the Christmas tree equipment will be placed at the top of the well, and the tubing 9 suspended from the element 8 through the stuffing box 7. The hanging and packing device 69, 70 and 71 is placed upon the tubing 9 in such position that when the tubing is in its lowest contemplated position the hanger will still be within the pipe 67.

With the body 39 located at the point where it is desired to perforate the casing (and this point can be accurately determined due to the fact that the stretch in the tubing 9 can be accurately foretold), the tubing is rotated slightly to disengage the ring 31 from its threaded engagement at 32. During this time the ring 31 will be held from rotation by the springs 36 and the rotation of the tubing will cause the unscrewing of the parts so that the ring 31 and the slips 33 may move with respect to the nipple 25. After this disengagement, the tubing is lowered, the ring 31 being prevented from moving downwardly at this time by means of the springs 36, until the tapered surface 28 of the collar 27

comes in contact with the inner surface of the slips 33, thus expanding these slips into anchoring engagement with the walls of the casing. Further downward movement of the tubing will slide the nipple 25 through the collar 27 which now rests on the slips 33, and will compress the packing 30 longitudinally and cause it to expand laterally to form a seal with the walls of the casing. The perforating mechanism is now firmly anchored with respect to the casing and the space above the perforator is packed off to hold back the pressure of the mud which may exist thereabove or to prevent fluid pressure entering the casing, after it is perforated, from causing a blow-out.

The tubing is now rotated to the right to send it downwardly by virtue of the expansible nut 20 and the threads 22. As it moves downwardly, the tubing section 60 will likewise move downwardly and carry the cam-like part 63 along with it. When this cam-like part reaches the level of the projection 49 on the trigger, further rotation of the cam will cause the projection 49 to ride up on the cam compressing the spring 50. The parts are shown at this point in Fig. 9. As soon as the sharp edge of the cam passes the projection 49, however, the spring 50 will snap the trigger back to its original position and cause it to strike the detonator and fire the charge 44. This will, of course, expel the bullet 43 and cause it to penetrate and perforate the casing.

If it should occur that the pressure which has up to this time existed within the casing is greater than that existing in the formation, the flow through the perforation will be negligible inasmuch as the column of mud above the perforation will be suspended by the packer 30. Only sufficient flow will, therefore, take place to reduce the pressure within the casing to a value equal to that in the formation, and such minute flow will be without any substantial effect. If on the other hand, the pressure within the formation should be greater than that within the casing, the presence of the packer 30 will prevent this pressure from blowing out through the casing, and it will be retained within the casing below this packer. Rotation of the tubing will be continued after the firing of the charge 44 until all of the charges which the body 39 may contain have been fired and the tubing will continue to descend until its lower end at 62 contacts with the upper end 58 of the valve stem 54, thus moving the valve 53 away from its seat. The handling nipple 8 may then be rotated in the opposite or left-hand direction to set the slips 69, the packer 71 and the slips 70, and to ultimately remove the handling nipple to a point above the valve 72 of the Christmas tree, whereupon the valve 72 will be closed and the well left in condition for production. Flow may then take place inwardly through the perforations in the casing and upwardly past the valve 53 through the openings 61 and up through the tubing to the Christmas tree and out through the flow lines 6.

If, after the first shot or shots are fired, it be desired to move to a higher or lower point in the well to fire other shots, this may be accomplished by simply pulling upwardly on the tubing, causing the split nut 20 to separate and permit the screw threads 22 to move to their upper position, releasing the slips 33 from engagement with the casing and letting the packer 30 contract, and then moving to the new elevation. Such moves may be made as many times as there are shots, if found desirable.

Inasmuch as the tubing is closed against the pressure within the casing by the valve 53 until the shots have all been fired, there will be substantially no back pressure to hinder flow once the valve 53 is opened. If desired, the production may simply be sampled by this method after which the tubing may be backed off somewhat and raised to contract the packer 30 and removed from the well, the precaution of killing the well with heavy mud being taken if the operator believes the need therefor exists. If, however, it be found that it is more desirable, the production of the well may continue through the device as it stands in the well.

It will be seen from the foregoing that a method and means has been set forth which is capable of carrying out all the objects and advantages sought by this invention.

Having described my invention, I claim:

1. The method of perforating a well casing and testing the formation thereby opened to the interior of the well casing, comprising lowering an explosive charge down the well casing inside a body adapted to direct the force of the explosion against the well casing, packing off the well casing above the point at which the casing is to be perforated, firing the charge to perforate said casing, and thereafter opening a testing chamber to the space within said casing below said packing to receive a sample of the fluid entering the casing through the perforation formed.

2. The method of perforating a casing and producing at the surface of the ground the fluid entering through such perforation, comprising lowering into the casing by means of a closed conduit an explosive charge within a body adapted to direct an explosion of such charge against the casing to perforate the same, packing off the space between said conduit and the casing above the point at which the casing is to be perforated, firing the charge, and thereafter opening said conduit to place it in communication with the perforation and receive fluid entering through the perforation and produce the same at the surface of the ground.

3. In a device for perforating well casing in place within a well hole, the combination of an explosive charge, a body holding the explosive charge and having lateral openings therein for directing the force of said charge against the casing to perforate the same when said charge is exploded, a trigger adapted to cause the firing of said charge, and a rotatable member having a cam-like part thereon adapted to actuate said trigger upon rotation of said member.

4. In a device for perforating a well casing, the combination of an explosive charge, a body for holding said explosive charge and formed to direct the force of explosion thereof against the well casing to perforate the same, a trigger mounted on said body for firing said charge, means for anchoring said body within the casing prior to the firing of said charge, and means extending downwardly through said casing and operable after said body has been anchored to cause the actuation of said trigger.

5. In a device for perforating a well casing, the combination of an explosive charge, a body adapted to receive said charge and direct the force of explosion of the same against the well casing to perforate it, a trigger mounted on said body for firing said charge, means for anchor-

ing said body within the casing at a desired point and packing off the space within said casing above said body, means for actuating said trigger and means for operating said trigger actuating means and for conducting fluid entering through the perforation thus formed in the casing to the surface of the ground.

6. In a device for perforating a well casing, an explosive charge, a body adapted to receive said charge and direct the force of an explosion thereof against the well casing to perforate the same, said body being hollow and having a valve at its lower end, a trigger mounted on said body within the hollow portion thereof for firing said charge, means for anchoring said body and packing off the space within the casing above said body, a conduit extending into said body and rotatable and downwardly movable therein after said body has been anchored and packed off and having parts thereon to first actuate said trigger, and second to open said valve at the bottom of said body, whereby said casing will first be perforated, and then said valve will be opened to permit the passage of fluid from such perforation upwardly through said conduit to the surface of the ground.

7. In a device for perforating a well casing, an explosive charge, a body adapted to receive said charge and direct the force of an explosion thereof against the well casing to perforate the same, said body being hollow and having a valve at its lower end, a trigger mounted on said body within the hollow portion thereof for firing said charge, means for anchoring said body and packing off the space within the casing above said body, a conduit extending into said body and rotatable and downwardly movable therein after said body has been anchored and packed off, and means including parts on said conduit to first actuate said trigger and second to open said valve at the bottom of said body upon such rotative and downward movement of said conduit, said conduit being perforated adjacent its lower end to permit flow of fluid thereinto, whereby said casing will first be perforated and then said valve will be opened to permit the passage of fluid from such perforation upwardly through said conduit to the surface of the ground.

8. In a device for perforating a well casing, an explosive charge, a body adapted to receive said charge and direct the force of an explosion thereof against the well casing to perforate the same, said body being hollow and having a valve at its lower end, a trigger mounted on said body within the hollow portion thereof for firing said charge, means for anchoring said body and packing off the space within the casing above said body, a conduit extending into said body and rotatable and downwardly movable therein after said body has been anchored and packed off, said conduit being connected to said body by a releasable threaded connection, and having a laterally extending cam-shaped part thereon, whereby upon rotation of said conduit it will be moved downwardly so that said cam part will actuate said trigger to fire the charge and thereafter said conduit will contact said valve to open the same and permit the flow of fluid from the perforation in the casing through said conduit to the surface of the ground.

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