Aug. 15, 1939. R. D. WALKER 2,169,671

CASING PERFORATOR

Original Filed June 22, 1936 2 Sheets-Sheet 1

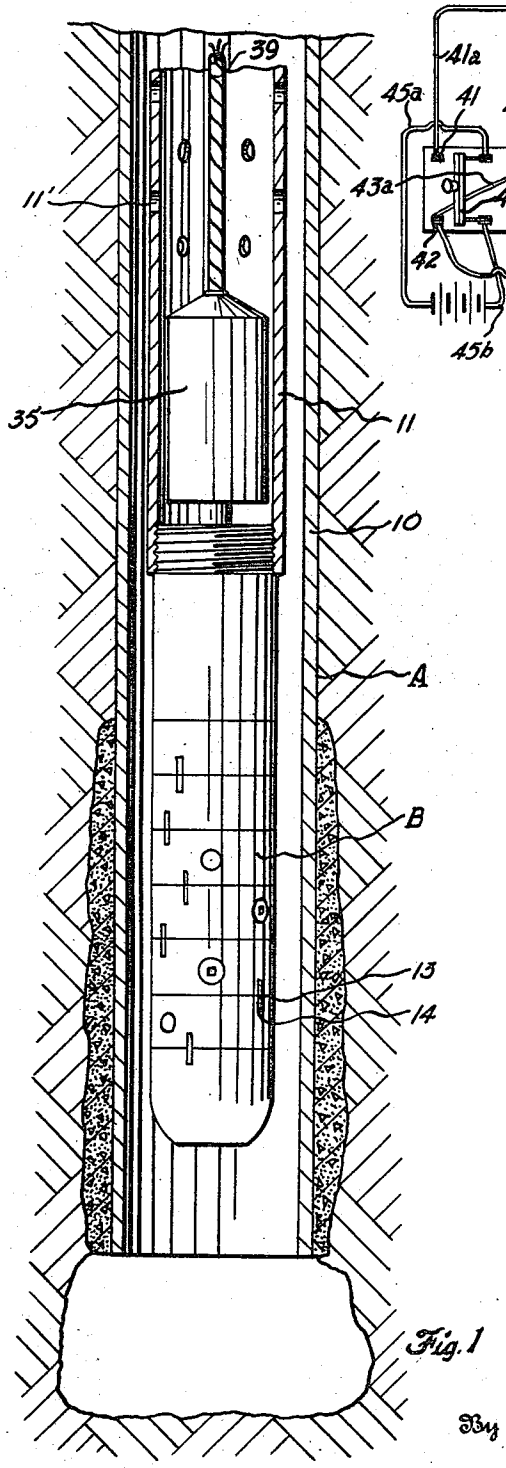

Fig. 1

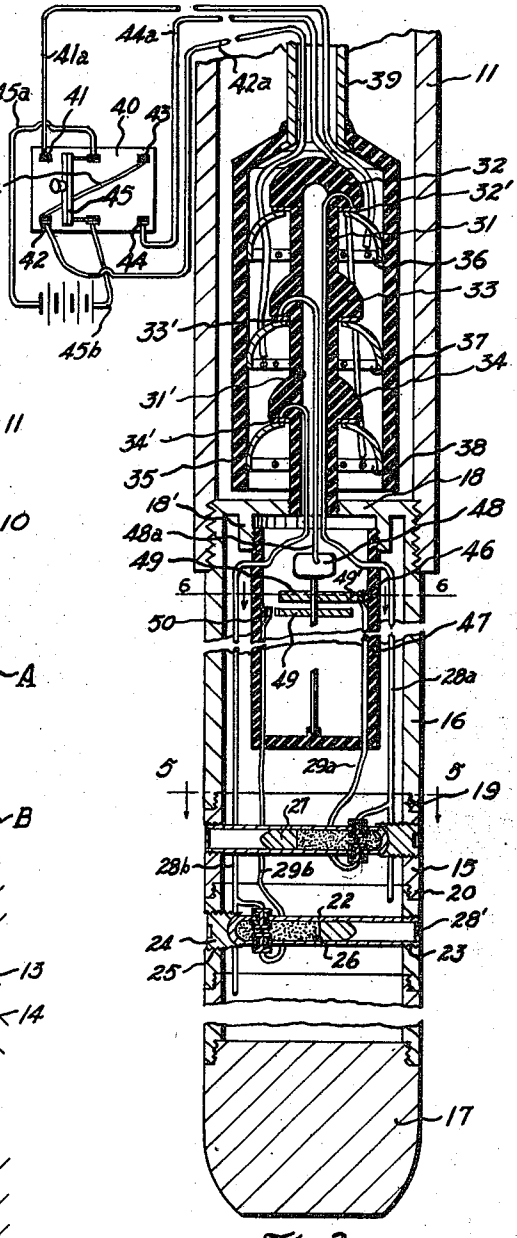

Fig. 2

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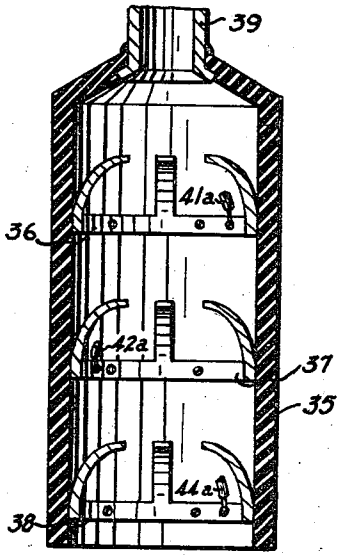

Fig. 3

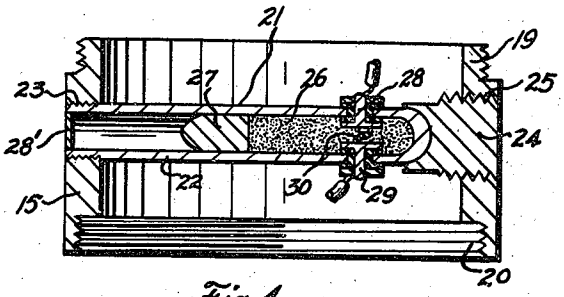

Fig. 4

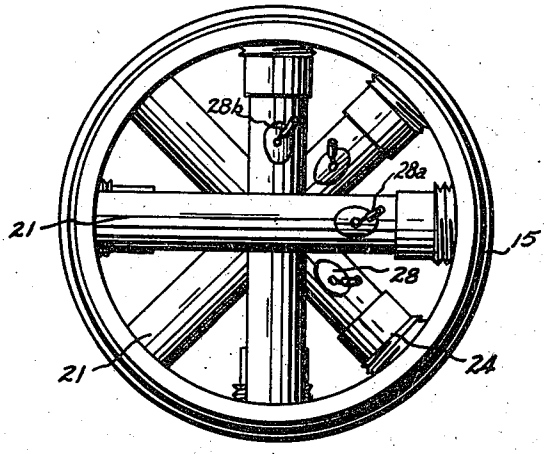

Fig. 5

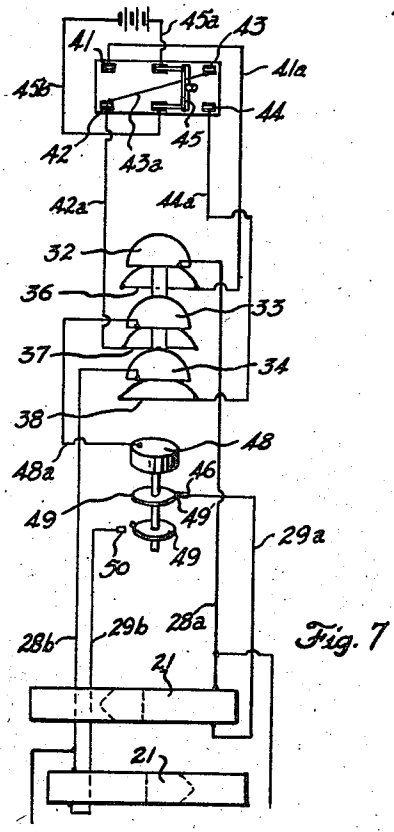

Fig. 7

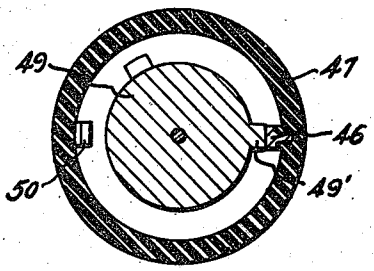

Fig. 6

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Patented Aug. 15, 1939 2,169,671

UNITED STATES PATENT OFFICE

2,169,671

CASING PERFORATOR

Robert D. Walker, Dallas, Tex., assignor of one-half to Vera E. Yarbrough, Harris County, Tex.

Application June 22, 1936, Serial No. 86,618
Renewed July 27, 1938

15 Claims. (Cl. 164—0.5)

This invention relates to new and useful improvements in casing perforators.

One object of the invention is to provide an improved device for perforating a well casing at any desired point after said casing has been set in the well.

An important object of the invention is to provide an improved well casing perforator adapted to be permanently connected to the lower end of the tubing string, whereby the device may be lowered into the well as the tubing is run therein, which eliminates running the perforator into said casing on a cable, or by other means, and also permits the well to flow immediately after the casing is perforated, without the necessity of removing the perforator from the well casing.

Another object of the invention is to provide an improved device for perforating well casing which is arranged to be located in the well casing permanently, said device having means for perforating any desired portion of the casing so that any desired amount of producing sand may be exposed, whereby the proper oil and gas ratio of the production may be established.

Another obect of the invention is to provide an improved device for perforating a well casing which includes a plurality of cartridges arranged to be fired independently of each other, whereby each cartridge may be fired at any desired time.

A further object of the invention is to provide an improved casing perforator which is permanently located in the well casing, and including a plurality of cartridges with means for adjusting the firing means for the cartridges, whereby after the device is lowered into the casing the cartridges may be fired in any desired predetermined order, which permits casing off the entire producing sand strata, which eliminates the guesswork in setting the casing a proper distance above the rathole.

Still another object of the invention is to provide an improved casing perforator which properly perforates the casing without removing the device from the casing and which in the majority of cases also eliminates swabbing of the tubing.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, and showing a casing perforator, constructed in accordance with the invention, within a well casing,

Figure 2 is an enlarged vertical, sectional view of the perforator,

Figure 3 is an enlarged vertical, sectional view of the contact housing,

Figure 4 is an enlarged, vertical, sectional view of one of the cartridge housings,

Figure 5 is a horizontal, cross-sectional view, taken on the line 5—5 of Figure 2,

Figure 6 is a horizontal, cross-sectional view, taken on the line 6—6 of Figure 2, and

Figure 7 is a wiring diagram of the firing means for the cartridges.

In the drawings, the numeral 10 designates the usual casing of an oil well, which casing is cemented in the bottom of the hole A. The tubing 11 extends downwardly through the length of casing in the usual manner. It has been the usual practice to set the lower end of the well casing a proper distance above the rathole of the well so as to expose the proper portion of the producing sand. It is the portion of producing strata which is exposed which controls the gas and oil ratio of the production, and therefore, if the casing is set too high, a high gas to oil ratio is had whereby the total oil possible is not produced; if the casing is set too low, then the lifting power of the gas is not completely utilized, thereby necessitating the earlier use of pumps. The proper setting of the casing to obtain the proper gas and oil ratio is more or less guesswork on the part of the operator, and in the majority of cases, said casing is improperly set.

In perforating the casing after the same has been set, it is possible to case the entire producing sand or area by setting the casing on bottom. Then by perforating said casing at desired points along said producing area the proper oil-gas ratio of the production may be had.

In carrying out the invention, an elongate housing B is threaded onto the lower end of the tubing 11, whereby it may be lowered into the casing with the tubing. The housing comprises a plurality of superimposed cartridge collars 15 (Figure 4) which are connected to each other by suitable screw threads. The uppermost collar has the lower end of a sleeve 16 connected thereto and the upper end of this sleeve is threaded into the lower end of the tubing 11. The lower end of the housing B, formed by the collars and sleeve, is closed by a plug 17 which is threaded into the lowermost collar, while the upper end of the housing is closed by a transverse plate

18 extending across the upper end of the sleeve 16 and preferably made integral therewith.

The upper end of each collar 15 is provided with an externally threaded nipple 19, and the lower end is formed with an internally threaded socket 20. With this arrangement, it will be seen that a flush joint is provided when the collars are connected together. If desired, the collars may be provided with registering key slots 13 in their outer surface which slots receive keys 14 to lock the collars in their connected position.

Each collar contains a cartridge 21 which extends diametrically across the same, and each cartridge includes a cylindrical shell 22 which has one end threaded into an opening 23 in the wall of the collar. The opposite end of the shell is rounded, as shown in Figure 4, and terminates short of the opposite wall of the collar. This rounded end of the shell is held in position by a plug 24 which is screwed into an opening 25 in the wall of the collar. The inner end of the plug is recessed to snugly engage the rounded end of the shell and firmly hold the same in its horizontal position within the collar.

The shell of each cartridge has gun powder, or other explosive material 26 packed in its inner end and a slug 27 is located within the shell forwardly of the powder. It is noted that the slug is mounted approximately midway within the shell, whereby the empty portion of said shell forwardly of the slug forms a barrel for directing the slug when the powder is fired. The outer or open end of the shell is closed by a disk 28', which is preferably made of a thin metal, or other light material. The purpose of the disk is to close the shell and prevent the well fluids from entering the same before the cartridge is fired. The light material of which the disk is constructed does not, however, interfere with the exit of the slug when the powder is exploded.

For exploding the powder to eject the slug 27, a pair of electrical contacts 28 and 29 are mounted diametrically opposite each other in the wall of the shell. The contacts are suitably insulated from the shell and are located in that portion of said shell which contains the powder 26, whereby the inner end of the contacts are in said powder. The contacts have their inner ends connected by a fusible wire 30, and electrical wires 28*a* and 29*a* connected to a source of suitable electrical supply lead from the contacts.

When electrical current is directed through the wires 28*a* and 29*a*, it will be seen that the current flows through the wire 30, fusing the same and causing a spark. This spark ignites the powder 26 which explodes, directing its force against the slug 27. This force ejects the slug from the end of the shell, or barrel, and due to the disposition of the cartridge, the slug is directed through the well casing 10, thereby perforating the same. It is noted that the cartridge of each collar is located out of radial alignment with the next adjacent cartridge, whereby each cartridge directs its slug into the well casing at a different radial point than the others (Figure 5).

Any desired number of cartridge collars 15 may be employed, and by firing said cartridges in a desired order, it will be seen that any portion of the casing may be perforated and therefore, any section of the producing area, exposed, whereby the proper oil-gas ratio of the production may be had. The cartridges are connected to and carried by the lower end of the tubing and are lowered into the casing therewith. After the desired number of cartridges have been fired, the production immediately starts, as the well fluids enter the casing and then the tubing through openings 11' in said tubing. The unfired cartridges remain in the well and may be fired at a later time.

With this arrangement, it is not necessary to lower the perforating device on a cable, or other lowering tool, fire the cartridges, then remove the tool and then insert the well tubing. The device is lowered once and remains until the tubing is removed. If one or two cartridges are fired and the proper gas-oil ratio is not obtained, it is only necessary to fire additional cartridges until it is obtained. This results in a great saving of time and labor.

Any suitable means may be employed for conducting the electrical current to the cartridges and for firing said cartridges in any desired order. However, it is preferable to employ a means such as is shown in the drawings. This means includes an elongate vertical shank 31 which extends upwardly from the plate 18 which closes the upper end of the housing B, being preferably threaded thereinto. The shank is made of hard rubber, or other electrical insulating material and is formed with an axial bore 31' which terminates near its upper end. A trio of annular heads 32, 33 and 34 are spaced vertically on the shank being integral therewith. Each head has a rounded top while its underside is flat forming an annular shoulder, and flat electrical contact rings 32', 33' and 34' are secured to these annular shoulders.

For conducting electrical current to the annular rings, an annular body 35, made of a suitable insulating material and having its lower end open is adapted to be lowered over the heads, is shown in Figure 2. The head is provided with a trio of electrical contact rings 36, 37 and 38 located within the body. Each ring has inwardly curved flexible spring fingers extending therefrom and when the body is positioned over the heads, the fingers of each ring engage one of the contact rings of the heads, whereby electrical connection is made between the rings 32', 33' and 34' and the rings 36, 37 and 38 respectively. The body 35 may be lowered over the heads by a cable 39, or other means, and due to the rounded heads, it is obvious that the curved fingers will readily pass thereover and engage the rings on said heads. The body is ordinarily lowered within the tubing after the housing B has been positioned within the casing, although it could be positioned before said housing is lowered. The body may be removed at any time by merely pulling the same upwardly, and the inherent resiliency of the fingers permit them to be bent so as to disengage the heads.

For controlling the current to the rings of the body 35, a double throw knife switch 40 is provided. This switch is located at the top of the well and includes four contacts 41, 42, 43 and 44, the former two completing one electrical circuit while the latter two close another circuit. One side of the blade 45 of the knife switch is electrically connected by a wire 45*a* with one side of the electrical supply, while the other side of said blade is connected by a wire 45*b* with the other side of said supply, whereby the current flows through the blade.

Assuming the blade 45 to be in engagement with the contacts 41 and 42, the electrical current flows from the contact 41, through a wire 41*a* which has its other end connected to the ring 36. From the ring the current flows to the

ring 32', and then through the wire 28a which leads to the contact 28 of the cartridge 21. From the contact 28 the current passes to the contact 29, then through the wire 29a to a contact 46 which is located within an insulated case 47 (Figure 2). The case is mounted within the upper end of the housing B and depends axially from the plate 18, being threaded into a collar 18' formed on the underside of said plate. An electric motor 48 is mounted within the case and the motor shaft extends axially therethrough. The shaft has a plurality of metallic disks 49 mounted thereon and one of these disks is provided for each cartridge. That is, the uppermost disk controls the uppermost cartridge, and so on. The uppermost disk has a contact 49' adapted to engage the contact 46 which is connected with the uppermost cartridge by the wire 29a.

When the contacts 49' and 46 are engaged the current flows through the disk and to one side of the motor 48, from which it passes through a wire 48a to the contact ring 33' of the intermediate head 33. From the ring 33', the current flows to the ring 37 and then finally, through a wire 42a which leads to the contact 42 of the switch 40, whereby the electrical circuit is completed. Thus, it is obvious that when the contact 49' of the uppermost disk is engaging the contact 46 on the inner wall of the case 47, and the switch blade 45 is thrown to engage the contacts 41 and 42, the uppermost cartridge is fired.

At the same time that the wire 30 is fused to fire the cartridge, the electric motor is energized momentarily which causes the motor shaft to rotate a predetermined number of degrees. The actual number of degrees which the motor shaft rotates is controlled by the particular construction of the motor. A motor having contact disks mounted on its shaft and adapted to be energized momentarily to move the disks a number of degrees, such as is herein described, is manufactured by the Sangamo Electric Company of Springfield, Ill., and may be purchased on the open market.

As the motor shaft is rotated, the contact 49' is moved off of the contact 46 and the contact of the disk next therebelow moves into engagement with a contact 50 mounted on the inner wall of the case 47. The contact 50 is connected by a wire 29b with the contact 29 of the next cartridge. The other contact 28 of this cartridge is connected by a wire 28b with the contact ring 34' of the lowermost head 34. The ring 34 is, of course, electrically connected with the ring 38, which is, in turn directly connected by a wire 44a to the switch contact 44. The other switch contact 43 of this circuit is connected by a wire 43a with the contact 42.

After the first cartridge has been fired, the contact 49' of the uppermost disk 49 disengages the contact 46, and the contact of the next disk moves into engagement with the contact 50 leading to the next cartridge. The blade 45 of the switch 40 is then swung to engage the contacts 43 and 44. When this occurs, the current flows from the contact 44, through the wire 44a, rings 38, and 34', wire 28b, cartridge contacts 28 and 29, wire 29b, contacts 50, disk 49 and to the motor 48. Then from the motor through wire 48a, rings 33' and 37, wire 42a, contact 42 and finally through the wire 43a to the switch contact 43, whereby the circuit is complete. This fires the second cartridge and at the same time energizes the motor to disengage the contacts 50 with the contact of its control disk. The rotation of the motor shaft, upon disengaging the contact 50, moves the next disk into engagement with a contact (not shown) which connects to the next cartridge to be fired. This next cartridge would have one side connected to the wire 28a, while its other side is connected to its contact within the case, and therefore, as the blade 45 of the switch 40 is again swung back to engage the contacts 41 and 42, this next cartridge would be fired.

Similarly, the fourth cartridge to be fired would have a contact within the case connected thereto, while its other side is connected to the wire 28b, whereby it is fired as the switch blade 45 engages the contacts 43 and 44. Therefore, the cartridges, in the order of their firing, are connected alternately to the wires 28a and 28b. As one cartridge is fired, the next cartridge is made ready because its control disk moves into engagement with the contact, located in the case 47, which is connected therewith. Then as the switch is thrown from one set of switch contacts 41 and 42 to the other set of contacts 43 and 44, the cartridges are fired.

The uppermost cartridge need not be fired first for it is obvious that by adjusting the disks 49 with relation to the contacts within the case, the cartridges may be fired in any desired order. It may be possible to fire two of the cartridges and obtain the proper gas-oil ratio of production. In such cases, the remaining cartridges remain unfired. It may occur that after some time, it is desirable to perforate more of the casing, and then it is only necessary to swing the switch blade of the switch 40 and fire one or more additional shots. Once the device has been lowered into the well on the lower end of the tubing 11, it remains therein and need never be removed. It does not, in any way, interfere with the well flow. Although only two cartridges have been shown and described in detail, any desired number may be employed. It is noted that any suitable switch means may be employed in place of the disks, and also the particular means of conducting the current to the cartridge may be varied. It would be possible to connect each cartridge individually to the current supply and provide a switch for controlling the firing of the same.

It is noted that the threads of the cartridge collars are screwed up tight so as to prevent well fluid entering the housing. Also, the heads 32, 33 and 34 on the shank 31, as well as the casing 35 may be submerged in heavy grease, or other similar substance, whereby salt water cannot enter the housing to contact the electrical connections.

What I claim and desire to secure by Letters Patent is:

1. A device for perforating well casing including, a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, a plurality of explosive charges mounted within the housing, means adapted to be lowered through the tubing and arranged to be detachably connected with the housing for firing each charge individually, the detachability of said means permitting its removal through the tubing after said charge is fired, whereby said means will not interfere with the flow through the tubing, and means for directing the force of

each charge against the well casing to perforate the same.

2. A device for perforating well casing including, a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, a plurality of explosive charges mounted within the housing, means adapted to be lowered through the tubing and arranged to be detachably connected with the housing for firing each charge individually, the detachability of said means permitting its removal through the tubing after said charge is fired, whereby said means will not interfere with the flow through the tubing, means for directing the force of each charge against the well casing to perforate the same, and means for selectively firing the charges in any desired predetermined order.

3. A device for perforating well casing including, a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, an explosive charge mounted transversely within the housing and adapted to be fired electrically, means within the housing for conducting electrical current to the charge and terminating in an electrical contact at the upper end of the housing, means adapted to be lowered through the tubing and arranged to be detachably attached to the housing and engaging the contact for conducting electrical current thereto whereby the charge may be fired, and means for directing the force of the charge against the casing to perforate the same.

4. A device for perforating well casing including, a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, a plurality of explosive charges mounted within the housing and adapted to be fired electrically, a plurality of contacts on the housing, each contact having electrical connection with one of the charges, means adapted to be lowered through the tubing and arranged to be detachably connected to the housing and having electrical connection with said contacts for firing said charges, and means for directing the force of said charges against the casing to perforate the same.

5. A device for perforating well casing including, a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, a plurality of explosive charges mounted within the housing and adapted to be fired electrically, a plurality of contacts on the housing, each contact having electrical connection with one of the charges, means adapted to be lowered through the tubing and arranged to be detachably connected to the housing and having electrical connection with said contacts for firing said charges, means for directing the force of said charges against the casing to perforate the same, and means for selectively firing the charges in any desired predetermined order.

6. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having means in its lower portion for establishing communication between the interior of the well tubing and the casing, a housing secured to the tubing below said means, whereby said housing does not interfere with the flow upwardly through the tubing, an explosive charge mounted within the housing and arranged to be fired by electrical current, said charge being positioned to perforate the casing when fired, and means adapted to be lowered through the tubing into contact with the housing for conducting current to the firing means, said means being located substantially out of the path of the flow through the tubing when in engagement with the housing.

7. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having means in its lower portion for establishing communication between the interior of the well tubing and the casing, a housing secured to the tubing below said means, whereby said housing does not interfere with the flow upwardly through the tubing, an explosive charge mounted within the housing and arranged to be fired by electrical current, said charge being positioned to perforate the casing when fired, electrical conducting means carried by the housing and connected to said charge, and means adapted to be lowered through the well tubing into contact with the conducting means for carrying current to the charge to fire the same and perforate the casing.

8. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having means in its lower portion for establishing communication between the interior of the well tubing and the casing, a housing secured to the tubing below said means, whereby said housing does not interfere with the flow upwardly through the tubing, an explosive charge mounted within the housing and arranged to be fired by electrical current, said charge being positioned to perforate the casing when fired, electrical conducting means carried by the housing and connected to said charge, and means adapted to be lowered through the well tubing into contact with the conducting means for carrying current to the charge to fire the same and perforate the casing, said last named means being readily removable from the tubing so that after the charge has been fired, it may be removed from the tubing to permit an unrestricted flow through the tubing.

9. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having a well fluid inlet in its lower portion for establishing communication between the casing and tubing, a housing secured to the lower end of the tubing below said inlet, a plurality of explosive charges mounted within the housing and positioned so as to exert their force against the well casing to perforate the same when said charges are fired, electrically operated means within the housing for firing said charges in a predetermined order, and means adapted to be lowered through the well tubing into contact with the housing for conducting electrical current to the electrically operated means, and means at the surface of the well for controlling said electrically operated means to fire the charges and perforate the well casing.

10. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having a well fluid inlet in its lower portion for establishing communication between the casing and tubing, a housing secured to the lower end of the tubing below said inlet, a plurality of explosive charges mounted within the housing and positioned so as to exert their force against the well casing to perforate the same when said charges are fired, electrically operated means within the housing for firing said charges in a predetermined order, and a contact

head adapted to be lowered through the tubing and arranged to be electrically connected to the electrically operated means to conduct electrical current thereto, whereby the charges may be fired to perforate the casing, said head being removable from the tubing so that after the charges have been fired the head may be removed to permit an unrestricted flow through the tubing.

11. A device for perforating a well casing including, a tubing string adapted to be lowered into the well casing and having perforations in its lower portion for establishing communication between the interior of the casing and tubing, a housing adapted to be connected to the tubing below said perforations, an explosive charge mounted within said housing and arranged to be fired by electrical current to perforate the well casing, and means adapted to be lowered through the tubing for conducting electrical current to the housing to fire the charge and removable after the charge has been fired, whereby fluid may flow from the casing into the tubing and to the surface without removing the housing from the tubing and without pulling the tubing.

12. A device for perforating well casing including, a housing adapted to be connected in a well tubing and lowered therewith into the casing, said tubing having an inlet above the housing to establish communication between the casing and tubing, a cartridge mounted laterally within the housing and directed toward the casing whereby when fired it perforates the casing, said cartridge being arranged to be fired electrically, means adapted to belowered through the well tubing on a cable into contact with the housing for conducting electrical current to the cartridge within the housing, whereby said cartridge may be fired, the last named means being removable from the tubing after the cartridge has been fired, whereby an unrestricted flow upwardly through the tubing is permitted.

13. A device for perforating a well casing including, a tubing having a fluid inlet, a housing secured to the tubing below the inlet, the housing comprising a plurality of collars connected together, an explosive charge mounted in each collar and directed toward the well casing so as to perforate said casing when fired, electrically operated means within the housing for firing said charges, and means adapted to be lowered through the well tubing into contact with the housing for conducting electrical current to the firing means.

14. A device for perforating a well casing including, a tubing having a fluid inlet, a housing secured to the tubing below the inlet, the housing comprising a plurality of collars connected together, an explosive charge mounted in each collar and directed toward the well casing so as to perforate said casing when fired, electrically operated means within the housing for firing said charges, means adapted to be lowered through the well tubing into contact with the housing for conducting electrical current to the firing means, and means for selectively firing the charges in any predetermined order.

15. A device for perforating well casing including a housing adapted to be connected to a well tubing and lowered therewith into said casing, said tubing having a fluid inlet above the housing, an explosive charge mounted within the housing, means adapted to be passed through the tubing and arranged to be detachably connected with the housing for firing said charge, the detachability of said means permitting its removal through the tubing after said charge is fired, whereby said means will not interfere with the flow through the tubing, and means for directing the force of said charge against the well casing to perforate the same.

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