Dec. 29, 1953 G. F. ABENDROTH 2,664,157

SMALL GUN PERFORATOR FOR OIL WELLS

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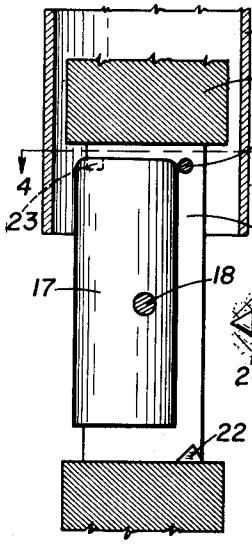


FIG. 1.

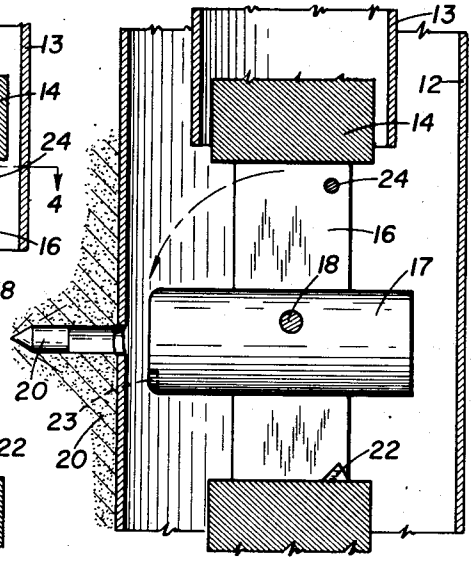


FIG. 2.

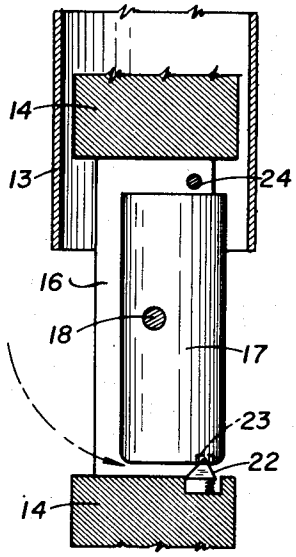


FIG. 3

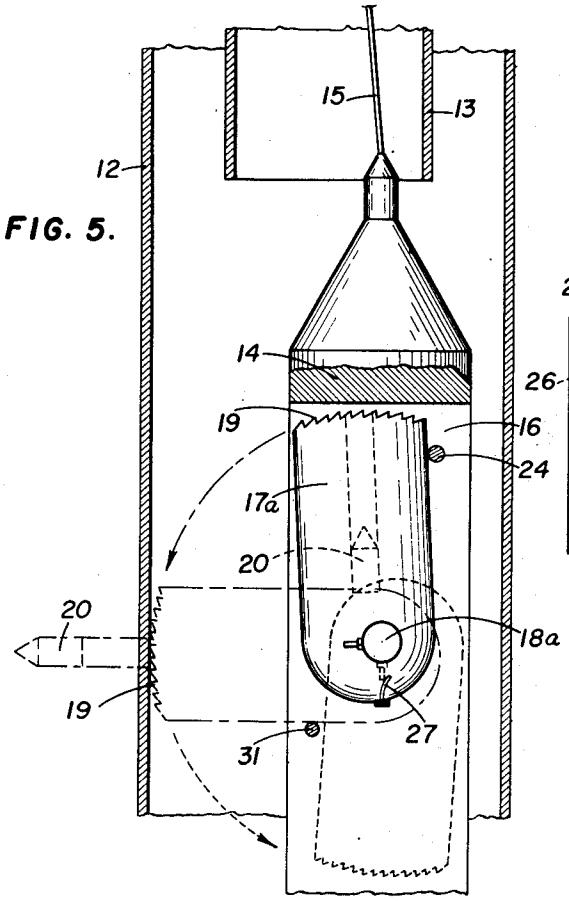
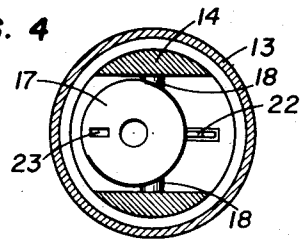


FIG. 5.

FIG. 4



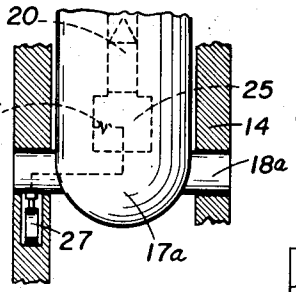


FIG. 6.

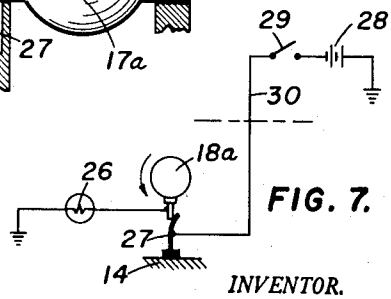


FIG. 7.

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SMALL GUN PERFORATOR FOR OIL WELLS

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Application September 11, 1950, Serial No. 184,165

3 Claims. (Cl. 164—0.5)

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This invention relates to guns for perforating pipe in oil wells or the like and more particularly to guns which are small enough to run through tubing in a well for perforating casing beneath the tubing.

Guns and explosives have long been used for perforating casing in oil wells and the art is well developed. As commonly constructed the barrels of guns used for such purposes are fixed horizontally in a carriage and these barrels approach in length, as far as is practical, the diameter of the casing so as to obtain the maximum fire power. Even under the best conditions, effective perforation of oil well casing and the cement which usually surrounds it, is difficult to accomplish, and since the size of the gun or explosive is important, casing perforators as conventionally used have not been run into the well through tubing or other pipe smaller in diameter than the casing.

It has recently been proposed to perform certain operations including the perforating of casing in an oil well while tubing is in it. See for example application of Theodore A. Huber, Serial No. 133,025, filed December 15, 1949, for "Method of Completing and Repairing Oil Wells" where the use of a casing perforating gun capable of being run through tubing is required. Large savings in time and cost can be effected in this way if effective perforation can be accomplished.

In accordance with application Ser. No. 184,161, filed September 11, 1950, by Theodore A. Huber, now Patent No. 2,639,770, it is proposed to solve the problem of providing effective firing power to perforate casing with an assembly which is run into and out of the well through tubing by arranging the guns in their carriage on trunnions and by providing means for rotating them from the vertical positions which they occupy while being lowered into the well, into horizontal firing positions. Inasmuch as the guns may be fired by electricity, Huber proposed to employ an electric motor to rotate them exactly the right amount. In accordance with the present invention, it is proposed to provide a structure for accomplishing the swinging of the barrels in a carriage to accomplish the purposes proposed by Huber in a very simple manner. The trunnions for the barrels are offset so that gravity is used to swing them into horizontal position as they come out of the tubing and so that when the guns fire, the reactive force causes them to swing into a vertical position. In addition, means may be provided for causing the ends of the barrels to grip the casing to assist in swinging them into horizontal and vertical positions when desired.

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The objects of the invention will be apparent from the following description, taken in connection with the accompanying drawings in which:

Fig. 1 is a vertical cross-sectional view of tubing in an oil well with a fragmentary portion of a gun constructed in accordance with the present invention located therein in the "running-in" position, it being understood that as many barrels as desired may be employed, all being like the one illustrated.

Fig. 2 is a vertical cross-sectional view of tubing and casing in an oil well with the gun of Fig. 1 sufficiently far beneath the tubing to permit rotation of the barrel into horizontal position as it is fired.

Fig. 3 is a vertical cross-sectional view of the tubing and gun of Fig. 1 but showing the position of the barrel after it has been fired and is in its retrieving position.

Fig. 4 is a transverse cross-sectional view of the tubing and gun of Fig. 1, the view being taken on the line 4—4 of Fig. 1.

Fig. 5 is a vertical cross-sectional view of tubing and casing in an oil well with a gun illustrating a different embodiment of the invention located therein, it being understood that as many barrels as desired may be employed, all being like the one illustrated.

Fig. 6 is a side view of a fragmentary portion of the gun of Fig. 5.

Fig. 7 is an electrical circuit diagram of the gun of Fig. 5.

Referring to the drawing in detail, and first to the embodiment of the invention shown in Figs. 1, 2, 3 and 4, it will be seen that an oil well casing is there shown at 12. A tubing 13 is positioned in the well with its lower end above the portion of the casing which is to be perforated, as shown in Fig. 2.

Within the well is a gun body or carriage 14 which is lowered into the well on a cable (not shown). This carriage may be made of steel and it is of cylindrical shape with a number of slots 16 provided transversely to accommodate gun barrels 17 which are mounted for rotation in the slots 16 by trunnions 18.

The gun barrels 17 are of a length greater than the diameter of the tubing 13 and only slightly less than the diameter of the casing 12. In order for them to be lowered into the well through the tubing, it is necessary that they be held substantially in a vertical position as shown in Fig. 1. After the carriage has passed out of the bottom of the tubing, the barrels 17 may be rotated to the horizontal position as shown in Fig. 2. The carriage 14 can then be raised and

lowered by the cable and the guns fired individually at different depths, or all of the guns may be fired at the same time, or nearly so, in accordance with well known perforating technique.

If the guns are of the type which shoot bullets, each barrel 17 may be loaded at both ends with the explosive charge in the center, as taught in the patent to Mims No. 1,532,184, with the result that bullets 20 are fired into the casing 12 and surrounding earth formation 21 in both directions. With such an arrangement, there is little strain on the trunnions 18 for the reactive firing forces balance out. However, it is within the purview of the invention to load each barrel 17 with only one bullet so as to increase the effective gun barrel length and secure greater penetration and that is the type of arrangement illustrated in Fig. 2.

After the bullets have been fired, the barrels 17 may be rotated back into the vertical position as shown in Fig. 3, so that they can be pulled back up through the tubing 13 to remove them from the well.

The sequence of steps of rotation are illustrated in Figs. 1, 2 and 3 and they are carried out automatically due to the construction of the device. When being lowered down through the tubing 13, as shown in Fig. 1, the barrels are held substantially in vertical position by the tubing itself. The trunnions 18 are offset or eccentric with respect to the center-line of the barrels 17 so that gravity tends to rotate the barrels into a horizontal position but so long as the barrels are within the tubing they cannot be rotated, being of a length greater than the diameter of the tubing.

As soon as the body 14 is brought to a point beneath the lower end of the tubing, gravity acts so that the barrels 17 swing 90 degrees, or approximately so, into the position shown in Fig. 2. This is the firing position of the guns.

Upon firing, the reaction force tends to rotate the barrels an additional 90 degrees from the natural hanging position of Fig. 2 to the retrieving position shown in Fig. 3. If the barrels 17 are each loaded with only one bullet 20, as illustrated, the reaction force will all be to the right, as viewed in Fig. 2, and since the trunnions 18 are above the center line of the barrel bore (see Fig. 4) the barrels will rotate the additional 90 degrees into the retrieving position shown in Fig. 3. If each of the barrels 17 is loaded with two bullets which are discharged in opposite directions, as mentioned above, the reactive forces may be controlled nevertheless so as to cause the barrels to rotate, as by so loading the barrel as to impart a greater driving force to the left hand bullet than the right hand bullet, when the barrel is hung as viewed in Fig. 2.

Whether the barrels are loaded with one or two bullets, one advantage of the arrangement illustrated over certain of those proposed by Huber is that the trunnions 18 do not have to withstand the entire reaction shock. Due to the offset position of the trunnions, each barrel is a pendulum and to some extent the reaction forces created by the explosion are expending in overcoming the inertia of the barrels and imparting motion to them. In fact, since each barrel 17 has some mass above as well as some below its trunnions 18, the pendulum thus constructed has a very short length compared to its mass and by proper design, the reaction force may be imparted to it at its center of percussion so as to impart no jar at all to the trunnions 18 when the explosion takes place, neglecting the mud or other fluid through which the pendulum must swing and neglecting the forces set up when the barrels are brought to rest.

It would be within the spirit of the invention to cause the barrel 17 to rotate nearly 270 degrees from the position shown in Fig. 2 before coming to rest in the body 14. The barrel would then be back in a vertical position so that it could be withdrawn from the well bore through the tubing 13. However, rotation of only about 90 degrees from the position shown in Fig. 2 is illustrated.

To hold the barrels 17 in their retrieving position, some sort of latch means must be provided. In Figs. 1 to 4, this is provided by spring pressed detents 22 mounted in the lower parts of the slots 16 in the body 14. These detents 22 engage sockets 23 in the barrels 17 when the barrels reach the position shown in Fig. 3.

The trunnions 18 are mounted closer to the breech than to the muzzle of the barrel shown in Fig. 2. This is necessary to enable the barrel to hang horizontally under the action of gravity, since the breech end is solid while the muzzle end is not when a single bullet is employed. This arrangement permits the use of a stop 24 in the manner illustrated.

In Fig. 1, the stop 24 prevents the muzzle of the barrel 17 from moving to the right. This prevents mud flow or inclination of the tubing from moving the breech end of the barrel out into contact with the tubing, where it might hang, when the gun is being lowered into the well.

In Fig. 3, it will be seen that the stop 24 limits counter-clockwise rotation of the barrel 17, it being so located that the portion of the breech of the barrel most remote from the trunnions 18 will strike it.

A disadvantage in the embodiment of the invention shown in Figs. 1 to 4 is that if a barrel 17 misfires it may be difficult or impossible to remove the body 14 from the well without pulling the tubing 13, since the barrel which misfires will remain in the horizontal position of Fig. 2. Of course, the breech ends of the barrels may be rounded and the body 14 may be shaped in such a way as to cause the tubing to rotate the barrels approximately into the position shown in Fig. 3 when the body 14 is pulled up into the tubing, but care must be exercised with such designs to avoid shortening the barrel and losing the advantages gained in having barrels mounted for rotation.

In the embodiment of the invention shown in Figs. 5 and 6, an arrangement is illustrated in which gravity is employed to move the barrels from their vertical running-in position to their horizontal firing position without incurring the danger of the barrels acting to latch the gun beneath the tubing.

In Figs. 5 and 6, the casing is again shown at 12 and the tubing at 13. The gun barrels 17a are mounted in the body 14 on trunnions 18a, the body being lowered through the tubing on an electric cable 15. Like the embodiment in Figs. 1 to 4, the trunnions 18a are offset from the center line of the barrels but they are near the breech end of the barrels so that in no position does the breech of any barrel extend out from its slot 16 beyond the side of the body. The muzzle of each barrel is curved at the end and provided with teeth 19 like those on slips commonly used in oil well drilling equipment, the purpose of which will be explained presently.

As illustrated, each barrel of the embodiment

of Figs. 5 and 6 is loaded with only one bullet 20, shown in dotted lines. The explosive is shown in dotted lines at 25 in Fig. 6 and the fuse at 26. The circuit connections for the fuse may be through one of the trunnions as illustrated and it is preferable that a switch be provided, as shown at 27, which closes only when the barrel 17a is in the horizontal or firing position. The circuit may be as illustrated in Fig. 7, where a battery is shown at 28 with one terminal grounded and the other connected through a surface switch 29 to the conductor 30 of the cable 15 to make connection through the switch 27 to the fuse 26 when both switches are closed, one side of the fuse 26 being grounded on the body 14 which is in mud or other fluid in the borehole or in contact with the casing 12.

There are two stops, designated 24 and 31, shown in the slot 16 in Fig. 5. The stop 24 functions to prevent the barrel 17a rotating to the right beyond running-in position (shown in full lines in Fig. 5). The tubing 13 prevents the barrel from swinging very far to the left, so long as the gun body is in the tubing.

When the gun body 14 passes out the bottom of the tubing 13, under the action of gravity, the barrel 17a tends to fall into its horizontal position and come to rest on the stop 31. However, since the barrel should be nearly as long as the diameter of the casing, to provide adequate fire power, the barrel 17a will normally strike the casing before reaching its fully horizontal position. When this occurs, if the body 14 is raised slightly, the teeth 19 will engage the casing and cause the barrel 17a to act as a jack or crank to move the body 14 to the right, as viewed in Fig. 5, so as to make room for the barrel to rotate on into its horizontal or firing position (shown in dashed lines in Fig. 5). If the switch 29 at the surface of the ground is held closed during this vertical movement of the body 14, the barrel will fire automatically upon reaching its horizontal position and there need be no concern that the stop 31 may be sheared by the manipulation of the body 14.

If the stop 31 is not sheared by the jacking action, it will be sheared by the firing of the barrel. The trunnions 18a being above the center-line of the bore of the barrel, the forces will be as described above in connection with Figs. 1 to 4.

If the barrel misfires, the stop 31 may still be intact, but it will be sheared when the body 14 is pulled back up into the tubing 13 for the

tubing will strike the projecting end of the barrel and cause it to rotate.

In any event the barrel will be rotated to its retrieving position (shown in dotted lines, Fig. 5) before it is removed from the well.

While only two embodiments of the invention have been shown and described, it is obvious that various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. A device for perforating casing in oil wells below tubing suspended within said casing comprising an elongated body, a gun barrel mounted on trunnions for rotation in said body, said trunnions being offset from the center-line of the barrel to cause said barrel to rotate, under the influence of gravity, when not restrained from so doing from a vertical position longitudinal of the body into a position transverse thereof and to cause said barrel to again rotate an additional amount into a substantially vertical position longitudinal of the body when fired, due to the reaction forces created by firing.

2. A device for perforating casing in oil wells below tubing suspended from said casing comprising an elongated body, a gun barrel mounted on trunnions for rotation in said body, said barrel having teeth on its muzzle end, said trunnions being positioned near the breech end thereof, whereby, under the action of gravity, the barrel may be rotated after passing out of the lower end of the tubing from its vertical running-in position into a position in which the teeth engage the casing and then into a horizontal position upon movement of the body away from the muzzle.

3. The combination claimed in claim 2 in which the trunnions are also offset from the center-line of the barrel whereby, when the barel is fired, the reaction force created by firing is expanded to some extent in causing rotation of the barrel on the trunnions.

GUSS F. ABENDROTH.

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