June 18, 1946. R. D. ELLIOTT 2,402,153

GUN PERFORATOR

Filed March 18, 1944

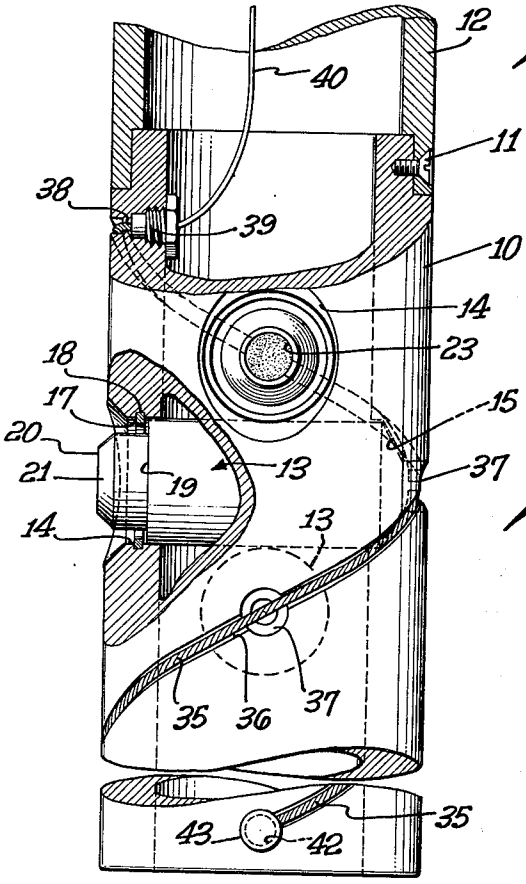


Fig. 1.

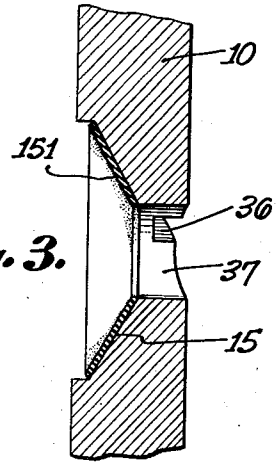


Fig. 3.

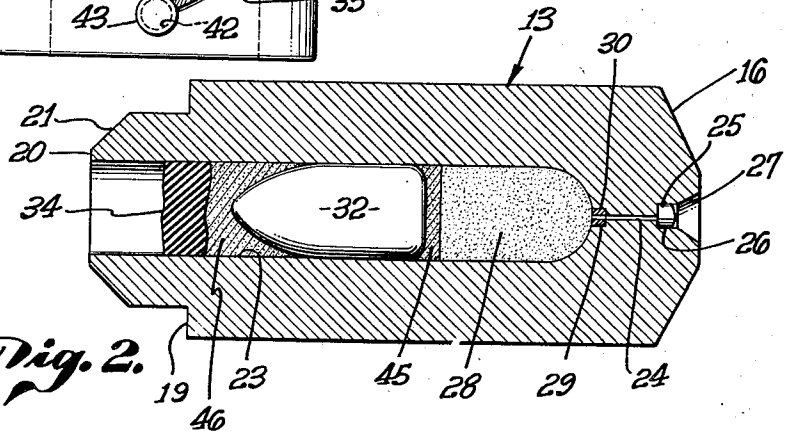


Fig. 2.

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Patented June 18, 1946 2,402,153

UNITED STATES PATENT OFFICE

2,402,153

GUN PERFORATOR

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Application March 18, 1944, Serial No. 527,110

14 Claims. (Cl. 164—0.5)

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This invention relates primarily to guns adapted to be lowered into a well casing and shoot bullets through the casing for the purpose of perforating it, and it will be described as applied to such use.

An object of the invention is to provide a gun design that permits the use of a relatively light and cheap construction without reducing the service life of the gun.

Another object is to provide a design permitting the use of relatively long barrels with resultant increase in the velocity of the bullet or a reduction in the size of the powder charge.

Another object is to provide an extremely simple and effective detonating system for a casing gun.

Still another object is to provide a detonating system that permits loose mounting of gun barrels in the body.

Other more specific objects and features of the invention will become apparent from the detailed description to follow.

Gun perforators for perforating well casings are well known and widely used. In general, a gun perforator consists of a vertically elongated body adapted to be lowered through a well casing and having a plurality of gun barrels extending radially or diametrically and adapted to fire bullets through the casing. Heretofore, to the best of my knowledge, the gun barrels have been formed integral with the body or rigidly fixed thereto so that the recoil forces were applied directly with undiminished force to the body. As a result, the body had to be made very heavy and of special steel in order to have a reasonable life.

I have discovered that if the gun barrels are loosely mounted for limited recoil movement with respect to the body and the design is such as to provide a cushion of fluid or of resilient material back of the barrel at the time of firing, the body can safely be made much lighter and of less expensive steel. Furthermore, the thickness of the body back of the barrel can be thinner, permitting the barrel to be longer and increasing the bullet velocity for the same powder charge.

Loose mounting of the gun barrels in the body would introduce difficulties in firing the guns by the conventional methods employing powder trains or electrical wires leading to each barrel, but in accordance with the present invention all such difficulties are eliminated and novel advantages are realized by employing a radically new and different firing system.

In my system each barrel is provided with a conventional percussion cap similar to the per-

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cussion caps that are employed in ordinary cartridges and are ordinarily exploded by impact thereon of a firing pin. However, I do not employ firing pins. Instead I provide a small opening in the body back of each barrel and extending from the recess in which the barrel is mounted to a helical groove in the external surface of the body, which groove contains a fuse-like explosive element having a fluid-proof covering and a core of a very fast explosive. This fuse-like element may be detonated by a conventional electric detonator located at one end of the element and energized by current supplied over a wire or wires extending up through the well in accordance with established practice.

Because of the nature of the explosive constituting the core of the fuse-like explosive element, it explodes with great violence when it is ignited and develops such pressures at the outer ends of the holes communicating the spiral groove with the rear ends of the chambers in which the barrels are mounted that the percussion caps in the barrels are detonated thereby. Since the force for detonating the percussion caps is transmitted through whatever fluid may be present, it is immaterial what exact position each gun barrel occupies with respect to the body member, and no particular exactness in manufacture is required. Therefore, aside from other considerations, this method of detonating the plurality of charges in a gun perforator has great advantages over the conventional methods employing powder trains, fuses or electrical wires in which there must be continuity between the powder train or wire and the powder charge within each gun barrel.

However, quite aside from its simplicity and effectiveness, my method of igniting the charges has additional advantages in connection with loosely mounted gun barrels. Thus, if the gun barrels are mounted for longitudinal movement (with respect to the axes of the gun barrel) in the body, the force of the explosion of the fuse-like explosive element forces the fluid in which the gun is immersed through the holes back of the chambers in which the barrels are mounted, thereby not only detonating the percussion caps in the barrels but also forcing the barrel longitudinally outwardly, and filling the space between the rear end of each barrel and the body chamber in which it is located with fluid, so that when the powder charge in the gun barrel explodes immediately thereafter, the barrel in its recoil movement has to force the fluid out of the space back of it before it can make a metal to metal

impact with the body. By virtue of the resistance of the fluid to rapid flow, the impact of the barrel against the body is greatly reduced, thereby permitting the use of a lighter body structure.

Referring now to the drawing in which a simple embodiment of the invention is illustrated;

Fig. 1 shows a portion of a gun body in accordance with the present invention with parts broken away to better show the complete construction;

Fig. 2 is a longitudinal section through one of the barrels of the gun; and

Fig. 3 is a detail sectional view showing a modified construction that may be incorporated in the body of Fig. 1.

Referring first to Fig. 1, there is disclosed a portion 10 of a vertically elongated gun body of hollow cylindrical or shell construction which may be secured, as by screws 11 at its upper end, to the lower end of a supporting frame 12, the latter being adapted to be supported in any known method for movement into and out of a well casing.

Loosely mounted in the body 10 are a plurality of horizontally directed gun barrels 13, each of which is of generally cylindrical shape and is supported at its front and rear ends by the body 10. Thus the front end of each barrel rests in an aperture 14 extending through the wall of the body 10, and the rear end rests in a recess 15 located in the inner surface of the body 10 diametrically opposite the aperture 14. The rear end of each barrel 13 is preferably beveled or chamfered as indicated at 16 in Fig. 2 and each recess 15 is beveled to correspond so that when the gun barrel is forced rearwardly with respect to the body 10, the beveled or chamfered surface 16 on the rear end of the barrel contacts the body over substantially its entire area.

The barrels 13 are inserted in the body 10 through the apertures 14 and are releasably retained in place by snap rings 17 which snap into annular grooves 18 provided therefor in the cylindrical apertures 14. The snap rings 17 can be speedily removed or inserted, and the barrels 13 are fitted loosely so that the operation of removing fired barrels and reinserting loaded barrels can be performed very quickly.

It will be observed from Fig. 1 that the snap ring 17 is spaced from the shoulder 19 of the barrel so that a certain amount of longitudinal movement of the barrel is permitted to reduce the recoil force applied by the barrel to the body 10 in a manner to be described in great detail later.

In a perforator having a body five inches in diameter and having gun barrels approximately two inches in diameter, the longitudinal play between the barrel and the body may be approximately one-eighth of an inch and the radial clearance between the barrel and the body may be of the order of one-thirty-second of an inch, although these values are not critical. The gun barrel projects beyond the shoulder 19 through the aperture 14 and the nose 20 of the barrel may project slightly beyond the outer surface of the body 10 in order to obtain as long a barrel as possible. Where the nose of the barrel extends beyond the body, the nose is desirably chamfered or beveled as indicated at 21 to prevent the barrel from hanging up on obstructions in the well casing as the device is moved therethrough.

The internal construction of each barrel 13 may be as shown in Fig. 2. Thus it is provided with a gun bore 23 extending from the nose of the barrel a substantial distance thereinto and communicating at its rear end through a small passage 24 with a percussion cap 25 which is pressed into a cylindrical recess 26 in the rear end of the barrel. The recess 26 may be chamfered or beveled at its outer end as indicated at 27. The rear and of the bore 23 is adapted to contain a powder charge 28 which is ignited through the passage 24 by the percussion cap 25 when the latter is exploded.

At the time of explosion of the powder charge 28, hot gases flow at high velocity through the hole 24 which erode the wall of the hole and eventually increase its diameter. The useful life of the barrel may be extended by providing a counterbore 29 at the forward end of the hole 24, in which counterbore there is pressed a sleeve 30 of some corrosion-resistant material such as "Inconel," the sleeve having a bore of the same or smaller diameter than the bore 24. The bore of the sleeve will not enlarge as fast as the bore 24 will and when it does eventually become too large, the sleeve can be replaced.

There is mounted in the bore 23, in front of the powder charge 28, a bullet 32. The bore in front of the bullet may be closed by a wad 34 and the spaces between the powder charge and the bullet and between the bullet and the wad 34 may be filled with a cushioning material such as rubber or plastic sealing compound to hold the bullet in place and seal the powder charge from the fluid in the well, as shown at 45 and 46.

As has been previously mentioned, the percussion caps in the barrels are exploded by a fuse-like explosive element. This element is indicated at 35 and is positioned in a helical groove 36 in the outer surface of the body 10, which groove passes directly back of each recess 15 and is connected to each recess by a firing hole 37. The upper end of the helical groove 36 communicates with a radial hole 38 through which the explosive element 35 is extended into an electrical detonator 39 of standard construction, the latter being shown as screwed into a threaded aperture provided therefor in the inner surface of the body 10 and having extending therefrom a wire 40 over which current is supplied to explode the detonator 39.

The explosive element 35 may be retained in the groove 36 by stretching it and anchoring the two ends, the upper end being anchored to the electrical detonator 39 the same as a conventional fuse is anchored, and the lower end being secured in any known manner. As shown the lower end is wedged in a hole 42 by a wooden plug 43.

The explosive element 35 may be substantially identical in general construction to a water-proof fuse, consisting of a water-proof fabric cover containing a core of explosive material. However, whereas an ordinary fuse contains a powder which burns rather quietly and develops substantially no explosive force, the core of the element 35 consists of an explosive having very fast burning characteristics so that when set off by the electrical detonator 39, the whole element explodes practically instantaneously with terrific force, driving whatever fluid is present in the holes 37 against the percussion caps 25 with such force as to detonate them and thereby explode the powder charges in the barrels.

Ordinarily gun perforators of the type referred to are used in wells containing liquid and the holes 37 and the clearance between the gun barrels and the body may be filled with the liquid. When the element 35 explodes, the force of the

explosion drives the liquid in the hole 37 into the rear end of the recess 15, forcing the gun barrel 13 forwardly against the snap ring 17, and more or less completely filling the clearance space between the rear end of the gun barrel and the walls of the recess 15 with the fluid. When the charge 28 in the gun barrel explodes immediately there following, the recoil of the barrel is resisted by the fluid back of the barrel, and by the time the recoil movement has squeezed the fluid out of the clearance, the barrel has lost a large part of its velocity so that the impact of the rear surface 16 of the barrel against the wall of the recess 15 is greatly reduced.

Although the liquid present may, in most applications of the invention, suffice to cushion the recoil of the barrel, it may be desirable in some instances to provide a layer of resilient material 151 in the bottom of the recess 15 as indicated in Fig. 3. This cushion 151 may be of rubber, plastic material, or the like and may have a thickness sufficient to fill all the space between the back of the barrel and the surface 15 or it may be dimensioned to fill only a portion of the space.

Because of the reduction in the recoil forces, it is feasible to not only make the body 10 of hollow construction as described, but it is also possible to make it out of relatively inexpensive material such as cold rolled steel, whereas in the conventional construction it is usually considered necessary to employ special alloy steels if the body is to have a reasonably long life in service.

Other numerous advantages result from the invention. Thus, the use of the explosive element 35 eliminates electrical wires in the gun and the problem of insulating such wires in the presence of water or the like. It also eliminates the necessity of employing igniting filaments in the powder charge in each gun barrel and the necessity of making electrical connections to each barrel. The fact that there is no direct connection of electrical wires, fuse or powder train to each barrel greatly facilitates the loose mounting of the barrels in the body. The use of the simple cap detonator at the rear end of the barrel reduces the length of the barrel back of the powder charge therein, enabling the bore of the barrel to be longer which reduces the size of the powder charge that is necessary.

By the use of the plastic sealing material or cushion between the powder charge and the bullet, the sealing of the powder charge from water and other fluids that may be in the well is effected in a simple manner without complicating the loading operation.

As an example of the reduction in weight that is possible as a result of the invention, a satisfactory gun can be made having a weight of only approximately ten pounds per barrel as compared with twenty to twenty-five pounds per barrel with previous constructions. In addition, my invention permits the use of cheaper material in the body.

As an example of design in a perforating gun in which the body 10 is five inches in outside diameter, the body may have an inside diameter of 3⅜ inches, leaving a wall thickness of approximately ¾ of an inch. Each barrel may have an outside diameter of approximately two inches with approximately $\frac{1}{32}$ inch radial clearance between the barrel and the body, the bore of the barrel being approximately $\frac{9}{16}$ of an inch or less. The groove 36 may be $\frac{5}{16}$ of an inch deep with a ⅛ of an inch radius in the bottom

for receiving an explosive element 35 of about $\frac{7}{32}$ of an inch in diameter. The percussion caps 25 may be standard No. 8½ primer caps. The detonator 39 may be a standard No. 6 electric blasting cap. Various commercial explosive elements can be employed as the explosive element 35, typical examples of which are sold under the trade names of "Primacord," "Mericalcord" and "Cordeau." The explosive itself may be penta erithritol tetranitrate, the speed of propagation of the wave front in which is, I believe, about 21,000 feet per second.

Although for the purpose of explaining the invention, the particular embodiment thereof has been described in substantial detail, many changes from the exact construction shown can be made without departing from the invention which is limited only to the extent set forth in the appended claims.

I claim:

1. A device of the type described, comprising: a body member and a separate gun barrel adapted to contain a projectile and a propulsive powder charge, said barrel being supported by and positioned at least partly within said body member, with means for detonating said powder charge, and a fluid recoil snubbing means between said barrel and the body member and utilizing the fluid in which the body member is immersed.

2. A device of the type described, comprising: a body member; a separate gun barrel adapted to contain a projectile and a propulsive powder charge supported by and positioned at least partly within said body member; and means for detonating said powder charge, said body member having an opening therein for slidably supporting said barrel for limited recoil movement with respect to said body member and having an opening back of said barrel for ingress and egress of fluid.

3. A device of the type described, comprising: a body member consisting of a hollow cylindrical shell, said shell having an aperture for supporting the front end of a gun barrel and having a recess diametrically opposite said aperture for supporting the rear end of the gun barrel; a gun barrel adapted to contain a projectile and a propulsive charge, said gun barrel being loosely mounted within said aperture and recess; and means for detonating the propulsive charge in said barrel.

4. A device as described in claim 3 in which said barrel is insertable and removable through said aperture; means for locking said barrel in said body member, said means permitting limited recoil movement of said barrels.

5. A device of the type described, comprising: a body member; a gun barrel loosely supported in said body member for recoil movement with respect thereto and having a bore for containing a projectile and a propulsive charge; a percussion cap supported by said barrel for igniting said charge; an explosive element supported by said body adjacent said percussion cap and adapted to explode with such violence as to detonate the percussion cap by the pressure created; and means for exploding said explosive element.

6. A device as described in claim 5 having a plurality of said gun barrels loosely mounted in said body member and in which said explosive element is in the form of a fuse extending past the percussion caps of all the barrels.

7. A device as described in claim 5 containing a plurality of said gun barrels spaced longitu-

dinally along said body, the body member having a groove in its external surface, said explosive element being in the form of a fuse positioned in said groove, the groove extending past the rear ends of all said barrels and being communicated with the percussion cap of each barrel by an opening in the body member adjacent the fuse.

8. A device of the type described, comprising: a body member; a separate gun barrel adapted to contain a projectile and a propulsive powder charge, said barrel being supported by and positioned at least partly within said body member; said body member having an opening therein substantially larger than the transverse dimension of said barrel for loosely supporting the barrel therein; and means for detonating said powder charge.

9. A device of the type described, comprising: a body member comprising a hollow shell having an aperture in the wall thereof for receiving a gun barrel; a gun barrel adapted to contain a projectile and a propulsive powder charge, said barrel being supported at least at one end thereof by the wall of said aperture; said aperture being substantially larger than the transverse dimension of said barrel whereby the barrel is loosely supported therein; and means for detonating said powder charge.

10. A device of the type described, comprising: a body member having an opening therein; a gun barrel adapted to contain a projectile and a propulsive powder charge, said barrel being supported in said opening for limited recoil movement with respect to said body member, said opening being substantially larger than the transverse dimensions of said barrel whereby the barrel is loosely mounted in the body; and means for detonating said powder charge.

11. A device of the type described, comprising: a body member having an opening therein and a stop in said opening; a gun barrel supported in said opening and adapted to contain a projectile and a propulsive powder charge; means for releasably locking said barrel in said opening; said barrel being mounted for limited recoil movement between said locking means and said stop, and said opening being substantially larger than the transverse dimension of said barrel whereby the barrel is loosely mounted in the opening; and means for detonating said powder charge.

12. A device of the class described, comprising: a body having an aperture therein; a gun barrel for said aperture adapted to contain projectile and propulsive powder charge; means for retaining said gun barrel in said aperture, said gun barrel loosely fitting said aperture for radial expansion and longitudinal recoil.

13. A gun perforator, comprising: a gun body defining a plurality of laterally directed gun barrel apertures; spaced outer and inner seats formed within each aperture; a gun barrel fitting each aperture and containing a bullet propulsive charge and detonation sensitive element. at least the major portion of each gun barrel being smaller in diameter than said outer seat to allow for removal of said gun barrel after expansion due to the force of said propulsive charge.

14. A gun perforator, comprising: a gun body having a plurality of laterally directed gun barrel apertures; a plurality of gun barrels slidably mounted therein for limited axial movement; said gun barrels containing bullets, explosive charges, and detonation sensitive devices, the latter being located at the breech ends of said gun barrels; a fuse-like detonating element extending past the breech ends of said gun barrels in proximity to said devices to detonate said devices and to drive the gun barrels forwardly in said apertures, whereby upon discharge of bullets from said gun barrels, said gun barrels are capable of recoil travel in said apertures.

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