

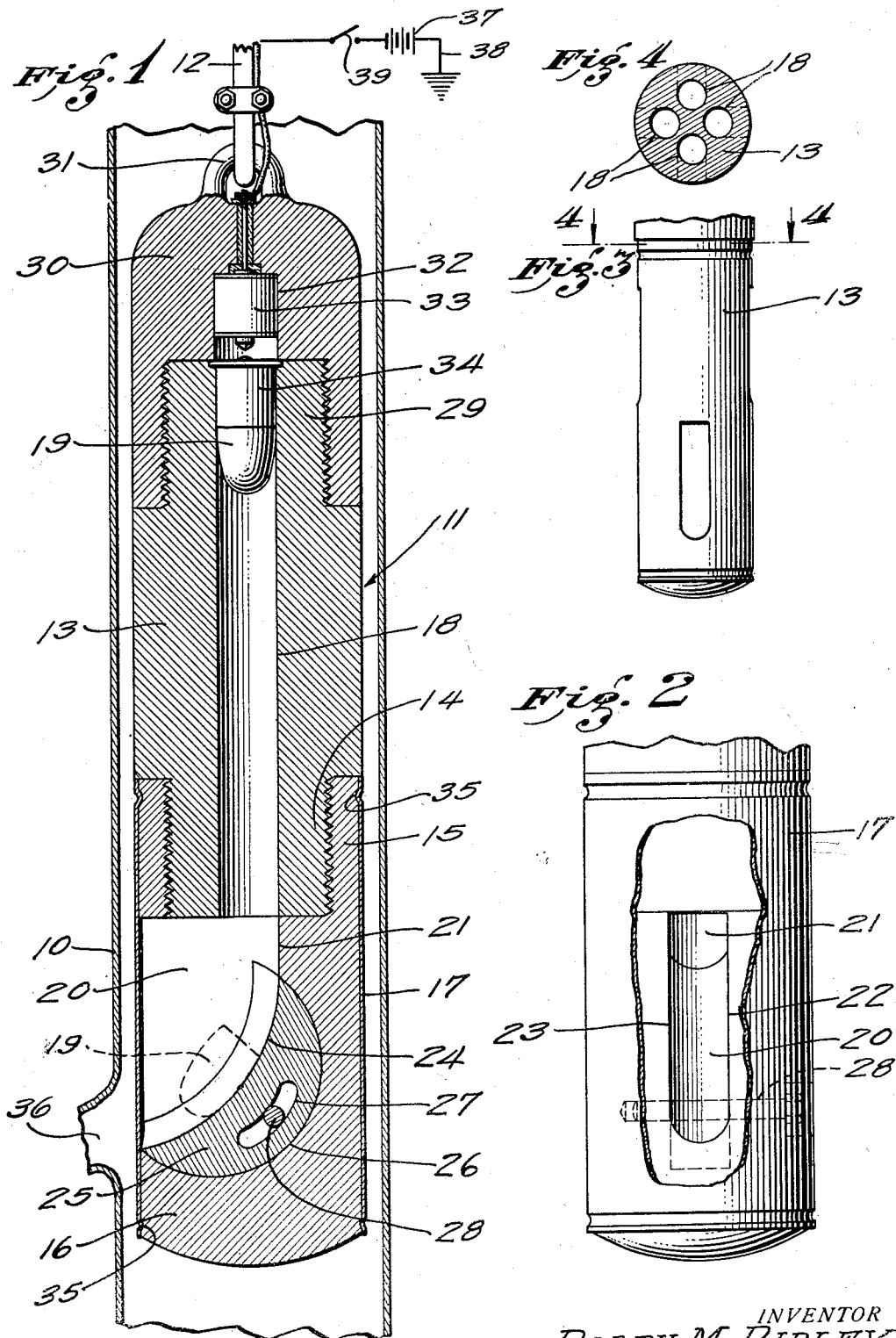
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CASING PERFORATING GUN

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## CASING PERFORATING GUN

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This invention relates to well production apparatus, and particularly pertains to a casing perforating gun. In the drilling of wells, and particularly in placing oil wells in a condition for production it is common practice to perforate the oil well casing in the productive area. This is usually done by lowering some form of mechanical perforating device into the well casing and to the zone in which the perforating operation is performed, after which the tool is manipulated from above ground to punch or cut perforations. Due to the fact that such devices must of necessity be remotely controlled there is difficulty in the successful operation of the same.

In order to efficiently effect production of a well it is desirable to open up the formation surrounding the area of the casing being perforated. This is not possible when mechanical casing perforators are used for they only penetrate the casing. It is the principal object of the present invention to provide casing perforating means which may be easily controlled from above ground and which in the nature of their operation will continue the perforating action throughout the casing and into the surrounding earth formation.

The present invention contemplates the provision of a casing perforator embodying a gun structure whereby a projectile may be fired through the wall of the casing and into the surrounding formation for a considerable distance. The invention is illustrated by way of example in the accompanying drawing in which:

Figure 1 is a view in central vertical section showing the casing perforator as suspended in a hole ready for operation.

Fig. 2 is a fragmentary view in elevation showing the discharge opening of the gun.

Fig. 3 is a view in central vertical section through another form of the casing perforator showing the manner in which a plurality of perforations may be made at one setting of the perforating gun.

Fig. 4 is a view in transverse section as seen on the line 4—4 of Fig. 3.

Referring more particularly to the drawing, 10 indicates a well casing suitably positioned within a well bore and through the wall of which casing it is desired to form perforations. Suspended within the casing is a casing perforator 11 which is secured at the lower end of a cable 12. This cable may be an electrical conductor, for a purpose to be hereinafter set forth. The casing perforator comprises a cylindrical barrel 13, the lower end of which is reduced in diameter and is threaded as indicated at 14 to receive a thread-

ed extension 15 of a deflector unit 16 which forms a continuation of the barrel 13. The outer diameter of the barrel 13 is greater than the diameter of the deflector unit 16 by a distance represented by the thickness of the wall of a sealing sleeve 17 which is placed over the deflecting unit while the device is being used in the well. The barrel 13 is formed with a central straight bore 18 through which a projectile 19 may pass. The deflector unit is formed with a throat 20 having a back wall 21 described by the same radius as that of the bore 18 through the barrel and having opposite side walls 22 and 23 tangent to the back wall 21 and parallel to each other. The back wall is also curved longitudinally as indicated at 24 of the drawing, the arc of curvature being a continuation of the back wall 21 and one side of the bore 18. The curvature of the face 24 continues to the side of the body member in the plane of the longitudinal center of the barrel so that projectile 19 may pass downwardly along the bore 18 and then be deflected laterally to be ejected from the deflector unit 16 and against the wall of the casing which it perforates. In order that the path of the projectile may be adjusted, and may be varied, and so that a suitable replaceable wear surface may be provided along the deflecting face, a deflector block 25 is inserted within the body of the deflector unit 16. This is crescent shaped in side elevation, as shown in Fig. 1 of the drawing. The back arcuate face 26 is seated within a corresponding arcuate seat. The forward arcuate face as previously indicated at 24 forms the deflecting face of the projectile 19. An arcuate slot 27 is formed through the block 25 and is held in position by a screw 28. The upper end of the barrel 13 is formed with a threaded portion 29 to receive a cap 30. The cap 30 is provided with a ball 31 to which the supporting cable 12 is connected. This cap also may be formed with a recess 32 to receive a firing mechanism or a fuse 33 by which a charge of explosive may be ignited within a cartridge shell 34.

In the operation of the device of the present character it is a matter of great difficulty to maintain the explosive charge within the capsule in a dry state and useful for providing the explosive force for the projectile. This problem is of particular concern due to the fact that usually the well casing is full of liquid at the time the perforations are made and that the hydrostatic head and pressure of this liquid is sufficiently great to force the liquid through relatively small

unobstructed passageways. In order to overcome difficulties arising from fluid pressures in the present case the sleeve 17 has been provided and is slipped over the deflecting unit 16. This sleeve fits with a tight fit so that fluid will not force its way between the sleeve and the deflecting unit and reach the passageway 20 or the bore 18. If desired annular grooves 35 may be formed around the body of the deflecting unit 16 to receive crimped portions of the sleeve 17 which sleeve is made of relatively thin sheet metal. Attention is directed to the fact that the sleeve completely seals the passageway 20 and that it is necessary for the projectile to perforate this sleeve before striking the casing.

Heretofore casing perforator guns have been designed which contemplate that the projectile would at all times be within the fluid or within an open barrel. These devices have also been designed so that the projectile would follow a relatively short straight lateral course to the casing and through the liquid therein. Such structures have not afforded an opportunity for the projectile to gain sufficient momentum to effectively perforate the casing. In the present instance it is to be noted that the bore 18 of the barrel may be of any desired length and that at all times it is empty since fluid is excluded from it. It will also be evident that the reflecting face 24 may be disposed as desired to cause the projectile 19 to strike the casing at a desired angle and form perforation 36. Attention is also directed to the fact that a curved muzzle bore is not provided but that the space 20 has a curved deflecting wall, and that it affords a space of suitable volume to receive the gases of combustion without damping the movement of the projectile. It is to be understood that various types of projectiles might be used ranging from a spherical member to one of the shape shown at 19 in the drawing in which the curved outer face of the member agrees with the curvature of the deflecting face 24 and will move around and along this face without undue disturbance in its travel.

Figs. 3 and 4 disclose a form of the invention in which the bore 18 is not disposed centrally of the barrel 13 but a plurality of bores 18 are arranged in a concentric circle and extend longitudinally of the device so that they may have separate points at which the projectiles are expelled from the perforator and produce a casing perforation.

In operation of the present invention the casing perforator is loaded and if it has the single bore barrel, as shown in Fig. 1, the cartridge 34 is placed in the firing position at the end of the bore 18, after which the cap 30 is screwed into position and will hold the cartridge in its firing position. The sleeve 17 is slipped in place over the lower end of the casing perforator, and if necessary is crimped around the body of the perforator, as indicated at 35. Previous to this the deflector block 25 has been adjusted so that the path of travel of the projectile will be established. It is preferable that the path be defined in a direction outwardly and downwardly through the casing. With the perforating apparatus assembled as here described it may then be lowered into the well casing as suspended by the cable 12, or if desired as suspended at the lower end of a string of tubing. When the casing perforator has been lowered to a desired position an electric circuit may be made through the cable 12 to a source of electric energy 37 and to a ground or

return wire 38, a switch 39 being provided for this purpose. This will cause an electric circuit to be completed to the firing mechanism or the fuse 33 within the cap 30. The projectile 19 is then expelled from the cartridge 34 and along the straight bore 18 of the barrel 13 under the impelling force of the explosive charge. When the projectile encounters the curved deflecting face 24 of the block 25 its path of travel will begin to be laterally as well as downwardly. As the projectile continues along this path it will force its way through the sleeve 17, and after puncturing the same will strike the well casing and pass through it into the formation. If the path of the projectile through the casing is downwardly and outwardly it will be observed that the perforation 36 will be formed with downwardly and outwardly inclined walls. This is desirable in oil well production since it prevents an accumulation of sand in the perforation opening, as the sand tends to settle, since with an opening having a horizontal lower wall the sand would tend to lodge on this face and accumulate to a degree which would impair the flow of fluid through the opening.

Attention is again directed to the fact that due to the relatively large volumetric area of the space defined between the side walls 22 and 23 of the outlet opening 20 there will not be an accumulation of explosive gases within the bore 18 which would tend to choke the bore and prevent satisfactory operation of the perforating gun. If it is desired to change the direction of the path of travel of the projectile from the gun the screw 28 may be loosened so that the block 25 may be appropriately shifted at which time the screw 28 may be tightened again to hold the parts in their operative positions.

If the form of the device shown in Figs. 3 and 4 is employed cartridges may be loaded into the separate bores of the barrel and may be separately and selectively fired. In this arrangement it is desirable that the deflected outlets from different barrels be at different levels and at different points in the circumferences of the casing perforator body. With this arrangement all of the cartridges may be fired at once and will simultaneously produce a plurality of perforations 36 through the casing at different points therearound and at different levels in the length of the casing.

It will thus be seen that with the casing perforator here shown the operation of the gun is not limited by the diameter of the casing, but makes it possible for casing of small diameter to be perforated since the bore of the barrel extends longitudinally within the casing perforating device and longitudinally of the casing. By this arrangement any desired distance of travel may be provided for the projectile within the casing perforator structure before reaching the point of deflection, thus making it possible to obtain any desired amount of acceleration of the speed of the projectile before it is deflected and thereby insuring that the projectile will strike the casing with a desired amount of force suitable to perforate the casing and penetrate the surrounding earth formation.

While I have shown the preferred form of my invention, as now known to me, it will be understood that various changes may be made in the combination, construction, and arrangement of parts by those skilled in the art, without departing from the spirit of the invention as claimed.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A gun having a barrel through which a straight bore extends, said bore terminating in a curved muzzle by which a projectile from the straight bore is deflected as it travels, and a member temporarily disposed across said muzzle to provide a fluid seal for the same, the terminating closed portion of the muzzle being of larger sectional area than the bore.

2. A casing perforating gun which comprises a barrel adapted to extend longitudinally within a well casing when lowered thereinto one end of said barrel being formed to receive a cartridge supported in firing position, a cap adapted to be mounted over said end of the barrel to hold the cartridge in said position, a muzzle formed at the opposite end of the barrel, the terminating portion of said muzzle being characterized by having a side face of arcuate section conforming to and being a continuation of the wall of the bore through the barrel, the opposite side of said terminating portion of the muzzle being cut away to permit a projectile and explosive gases to pass from the bore of the barrel and outwardly from the muzzle in a lateral direction with relation to the longitudinal axis of the barrel.

3. A casing perforating gun which comprises a barrel adapted to extend longitudinally within a well casing when lowered thereinto the upper end of said barrel being formed to receive a cartridge supported in firing position, a detachable cap adapted to be mounted over said end of the barrel to hold the cartridge in said position and by which the gun is supported, a muzzle section at the opposite end of the barrel, said muzzle being characterized by having a side face of arcuate section conforming to and being a continuation of the wall of the bore through the barrel, the opposite side of said muzzle being cut away to permit a projectile and explosive gases to pass from the bore of the barrel and outwardly from the muzzle in a lateral direction with relation to the longitudinal axis of the barrel, said cut away portion of the muzzle being characterized as having parallel side faces tangent to the diameter of the bore through the barrel and the curved wall of the muzzle.

4. A casing perforating gun which comprises a cylindrical barrel adapted to extend vertically within a well casing when lowered thereinto the upper end of said barrel being formed to receive a cartridge supported in downward firing position, a cap detachably mounted over said end of the barrel to hold the cartridge in said position, firing means carried thereby, a muzzle formed at the opposite end of the barrel, said muzzle being characterized by having a side face of arcuate section conforming to and being a continuation of the longitudinal wall of the bore through the barrel, the opposite side of said muzzle being cut away to permit a projectile and explosive gases to pass from the bore of the barrel and outwardly from the muzzle in a lateral direction with relation to the longitudinal axis of the barrel, and a sealing sleeve adapted to fit over the cut away portion of the muzzle whereby the projectile must of necessity puncture the sleeve in order to pass from the barrel.

5. A casing perforating gun which comprises a barrel adapted to be suspended vertically within a well casing when lowered thereinto on a supporting member the upper end of said barrel being formed to receive a cartridge supported in firing

position longitudinally of said well, a cap detachably mounted over said upper end of the barrel to hold the cartridge in said position means associated therewith to fire the same, a muzzle section formed at the opposite lower end of the barrel, said muzzle being characterized by having a side face of arcuate section conforming to and being a continuation of the longitudinal wall of the bore through the barrel, the opposite side of said muzzle being cut away to provide a trough like passageway along which a projectile may pass from the bore of the barrel and outwardly from the muzzle in a lateral direction with relation to the vertical axis of the barrel, a portion of said arcuate muzzle wall being formed by a removable insert.

6. A casing perforating gun which comprises a barrel adapted to be suspended vertically within a well casing when lowered thereinto the upper end of said barrel being formed to receive a cartridge supported in downward and vertical firing position, a cap adapted to be mounted over said upper end of the barrel to hold the cartridge in said position firing means carried thereby, a muzzle at the lower end of the barrel, said muzzle being characterized by having a side face of arcuate section conforming to and being a continuation of the wall of the bore through the barrel, the opposite side of said muzzle being relieved to permit a projectile and explosive gases to pass from the bore of the barrel and outwardly from the muzzle in a lateral direction with relation to the longitudinal axis of the barrel, a portion of said arcuate muzzle face being formed by a removable insert, and means for adjusting said insert to vary the deflecting action thereof and to change the degree of lateral path of the projectile.

7. A casing perforating gun comprising a substantially cylindrical barrel portion having a straight vertical bore therethrough, the upper end of said bore being fitted to receive and support in a vertical position an explosive cartridge carrying a projectile, a cap detachably secured over said end of the bore to hold the projectile in place, firing means for the cartridge carried by the cap and adapted to be remotely controlled, and a deflecting unit adjustably secured at the lower end of the barrel whereby the deflection of the projectile may be controlled, said deflecting unit being formed with a laterally extending muzzle portion in communication with the bore of the barrel.

8. A casing perforating gun comprising a substantially cylindrical barrel portion having a straight vertical bore therethrough, the upper end of said bore being fitted to receive an explosive cartridge carrying a projectile, a cap detachably secured over said end of the bore to hold the projectile in place, firing means for the cartridge carried by the cap and adapted to be remotely controlled, and a deflecting unit adjustably secured at the lower end of the barrel to control the angle of deflection of the projectile, said deflecting unit being formed with a laterally extending muzzle portion in communication with the bore of the barrel, said muzzle extending outwardly through the side wall of said deflecting unit.

9. A casing perforating gun comprising a substantially cylindrical barrel portion having a straight vertical bore therethrough, the upper end of said bore being fitted to receive an explosive cartridge carrying a projectile, a cap detachably secured over said end of the bore to

hold the projectile in place, firing means for the cartridge carried by the cap and adapted to be remotely controlled, and a deflecting unit detachably secured at the lower end of the barrel and being formed with a laterally extending muzzle portion in communication with the bore of the barrel, said muzzle extending outwardly through the side wall of said deflecting unit, and a sleeve adapted to slip over and embrace the deflecting unit to seal the joint between the barrel and said unit and to close the mouth of the muzzle until it is punctured by the projectile passing outwardly therethrough.

10. A casing perforating gun comprising a substantially cylindrical barrel portion having a straight vertical bore therethrough, the upper end of said bore being fitted to receive an explosive cartridge carrying a projectile, a cap detachably secured over said end of the bore to hold the projectile in place, firing means for the cartridge carried by the cap and adapted to be remotely controlled, and a deflecting unit detachably secured at the lower end of the barrel and being formed with a laterally extending muzzle portion in communication with the bore of the barrel, said muzzle extending outwardly through the side wall of said deflecting unit, and a sleeve adapted to slip over and embrace the deflecting unit to seal the joint between the barrel and said unit and to close the mouth of the muzzle until it is punctured by the projectile passing outwardly therethrough, said muzzle being formed with an enlarged gas pocket to accommodate gas incident to the combustion of said explosive.

11. A gun structure adapted to be lowered into the bore of a well, said gun being of a diameter slightly less than that of the well bore and designed to fire a projectile laterally into the well wall, a cylindrical barrel extending vertically within the well and being of a length materially longer than the diameter of the well bore, a firing head at the upper end of said barrel, means connected with the firing head for suspending the gun within a well, a muzzle section detachably

secured to the lowered open end of said barrel, said muzzle section being characterized as having an arcuate laterally extending groove formed therein and entirely open on one of its sides, the arcuate portion conforming substantially to the same circular side of the bore within the barrel, a longitudinal wall of which bore is tangent to said arcuate surface, and a metal jacket circumscribing the muzzle section to seal the same against the inflow of liquid and to create a relatively large pocket below the barrel and into which the projectile and explosive gases are discharged from the barrel.

12. A gun structure adapted to be lowered into the bore of a well, said gun being of a diameter slightly less than that of the well bore and designed to fire a projectile laterally into the well wall, a cylindrical barrel extending vertically within the well and being of a length materially longer than the diameter of the well bore, a firing head at the upper end of said barrel, means connected with the firing head for suspending the gun within a well, a muzzle section detachably secured to the lowered open end of said barrel, said muzzle section being characterized as having an arcuate laterally extending groove formed therein and entirely open on one of its sides, the arcuate portion conforming substantially to the same circular side of the bore within the barrel, a longitudinal wall of which bore is tangent to said arcuate surface, a metal jacket circumscribing the muzzle section to seal the same against the inflow of liquid and to create a relatively large pocket below the barrel and into which the projectile and explosive gases are discharged from the barrel, a shiftable wall section carried as a part of said muzzle and forming a part of the arcuate face against which a projectile is discharged from the barrel, and means for adjustably setting the shiftable wall section to vary the angle of deviation of the projectile from its longitudinal path of travel as it leaves the barrel of the gun.

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