

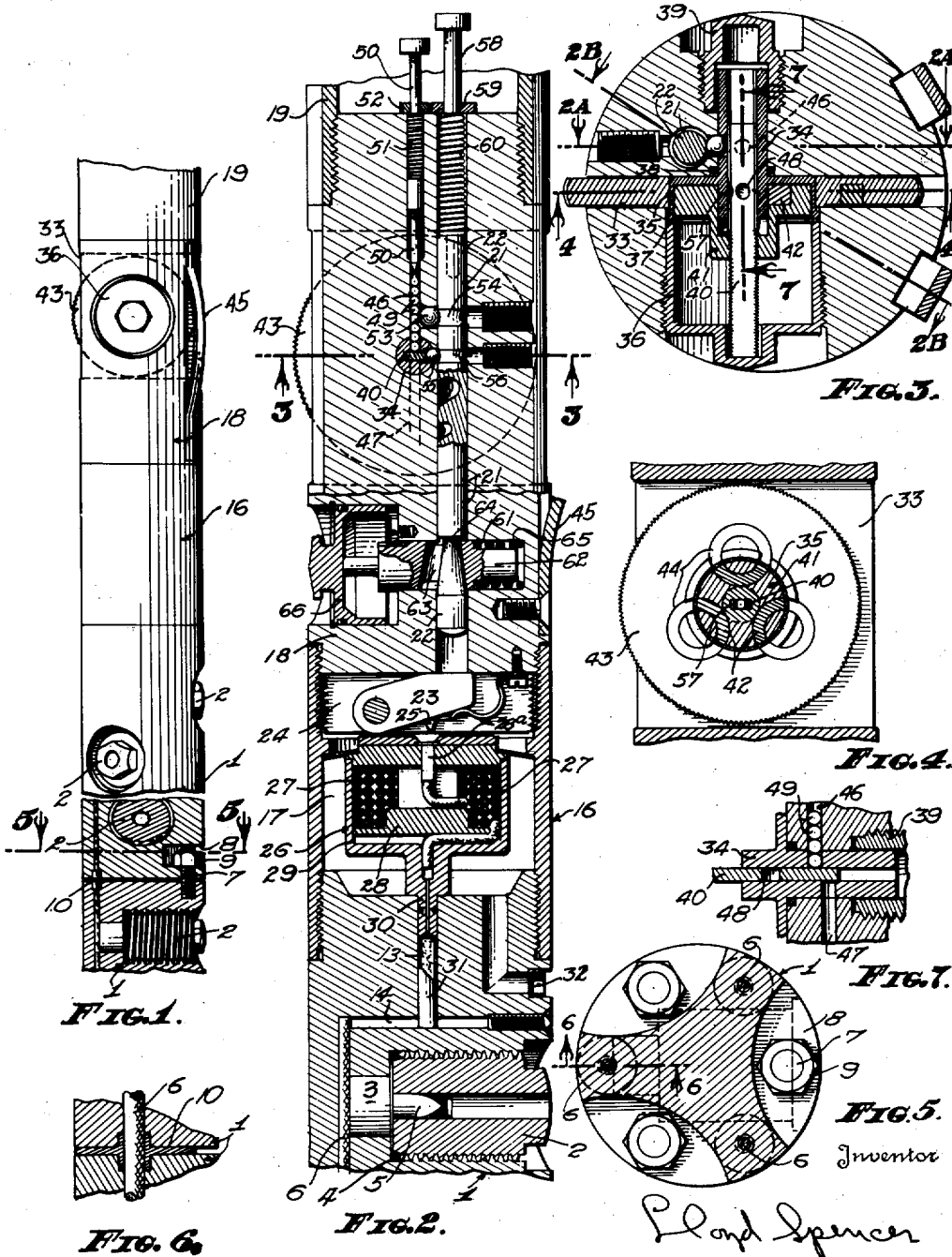
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CONTROL DEVICE FOR GUN PERFORATORS

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CONTROL DEVICE FOR GUN PERFORATORS

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My invention relates to gun perforators, more particularly to gun perforators and control devices therefor adapted for cable suspension in a well bore.

Included in the objects of my invention are:

First, to provide a gun perforator which may be suspended from a conventional "sand" line or from a single strand wire line such as are commonly available for other well operations; that is, to provide a gun perforator which obviates the need of a special conductor cable and the attendant surface equipment required by electrically operated gun perforators.

Second, to provide a gun perforator which incorporates a novel control device which may be depended upon to fire the gun perforator when and at the level desired, but which is particularly safe to handle at the surface of the well, there being series related safety elements which virtually eliminate the possibility of accidental operation.

Third, to provide a gun perforator which is divided into readily assembled sections and which incorporates a novel arrangement whereby a detonating cord or other detonating means may extend continuously through several sections.

Fourth, to provide a gun perforator which provides, without sacrificing other valuable features, the features recognized as essential in a gun perforator; namely, substantial barrel length to gun diameter ratio, high number of shots per unit of gun length.

Fifth, to provide a control device for gun perforators which incorporates a magnetic drive between a casing engaging wheel and an arming mechanism, the arming mechanism being so arranged that only by reciprocation of the gun perforator within the central portion of a predetermined length of its travel within the well bore can the arming mechanism be manipulated to fire the gun; thus, when the gun perforator is traveling continuously upward or downward in the well bore the control device is disarmed; furthermore, the control device may incorporate means whereby the gun perforator cannot fire

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in any case unless submerged beyond a predetermined depth in liquid, and still further a time delay may be provided so that, in the unlikely event that all other safety elements fail, ample warning may be given that the gun is about to fire, such time delay means normally serving to permit movement of the gun perforator to the exact spot at which perforation is desired.

With the above and other objects in view as may appear hereinafter, reference is directed to the accompanying drawings, in which:

Figure 1 is a fragmentary partial elevational, partial sectional view of my gun perforator.

Figure 2 is an enlarged fragmentary longitudinal sectional view thereof, the upper portion being taken approximately in the plane 2A-2A of Figure 3, and the lower portion being taken approximately in the plane 2B-2B of Figure 3.

Figure 3 is an enlarged transverse sectional view taken through 3-3 of Figure 2.

Figure 4 is a fragmentary sectional view through 4-4 of Figure 3 showing the magnetic drive means.

Figure 5 is a transverse sectional view through 5-5 of Figure 1 showing the manner in which the gun sections are joined.

Figure 6 is a fragmentary sectional view through 6-6 of Figure 5 showing the manner in which the detonating cord is threaded between gun sections.

Figure 7 is a fragmentary sectional view taken through 7-7 of Figure 3.

My gun perforator includes a series of gun sections 1. Each gun section is provided with laterally directed threaded gun barrel bores which receive gun barrels 2. The gun bores and barrels are preferably arranged in three sets displaced 120° from each other. At the inner end of each gun barrel bore there is formed a cartridge chamber which receives an explosive cartridge 3. Suitable sealing means 4 covering the bore of the barrel 2 is clamped between the inner end of the barrel 2 and the socket in which it is screw-threaded. The disk 4 seals off the cartridge 3. A bullet 5 is placed in each gun barrel bore. Each

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gun perforator is provided with a longitudinally extending bore for each set of cartridge chambers. Each bore receives a detonator cord 6.

The gun perforator sections are connected by stud bolts 7 set into one end of each section. These extend into bores provided in the mating sections, which bores are intersected by lateral slots 8. Nuts 9 are adapted to be inserted in these slots for threaded engagement with the bolts.

The detonator cord bores of the several gun sections are disposed in axial alinement. Between the gun sections the detonator cords pass through pressure sealing washers 10. These washers include radial disk portions which are clamped between the gun sections and axial boss portions which extend into counterbores in the extremities of the detonator cord bores. The boss portions may be press fitted in their counterbores and in addition tend to expand radially under internal pressure to prevent leakage when the detonator cord is fired. The disk portion has sufficient radial thickness to withstand the internal pressure without bursting. The disk portion also serves as a seal gasket against entrance of liquids in which the gun perforator is immersed.

The uppermost gun perforator section is provided with an axially disposed detonator socket 13 of small diameter communicating by suitable passages 14 with the detonator cord bores. The upper end of the uppermost gun perforator unit is externally threaded for connection to a tubular connector member 16. The connector member forms a chamber 17 and its upper end is internally threaded for attachment to a controller body 18. The controller body is, in turn, joined to a cable head 19, shown fragmentarily, suspended from a cable, not shown. The cable may be a conventional "sand" line or a conventional single strand line, known in the oil industry as a "Halliburton" line.

The body 18 is provided with a longitudinally extending bore 21 which is offset from the axis of the body 18 and receives a firing bar 22. Action of the firing bar is restrained by devices to be described hereinafter. The lower end of the firing bar, when released, engages a lever 23 set into a slot 24 provided in the lower extremity of the body 18. The lever 23 is provided with a firing pin 25 located in approximately the axial center of the body 18.

Mounted within the chamber 17 of the connector member 16 is a time delay unit 26 which incorporates a time delay fuse 27. The time delay unit may include a spool 28 on which is wound the fuse 27, one end of the fuse being connected to an ignitor 28a set in the upper end of the spool for engagement by the pin 25. The spool 28 may be encased in a shell 29 having a depending tubular stem 30 adapted to receive an end of the fuse 27. The stem 30 is reduced in part and provided with a seal ring to fit within the detonator chamber 13. The fuse 27 actuates a suitable detonator 31 placed within the detonator chamber 13 and operatively associated with the extremities of the detonator cords 6.

In the event that the seal between the stem 30 and the detonator chamber 13 should fail, a blowout disk 32 is provided in a relief passageway in the gun body 1 communicating with the chamber 17.

The controller body is provided with a vertical and diametrically extending slot 33 intersected by a transverse bore. The transverse bore

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is counterbored at one side of the slot 33 and reduced at the opposite side of the slot to receive a liner 34 having an enlarged hollow or cupped journal shell 35 fitted within the slot 33.

5 An externally threaded cup shaped housing 36 is fitted in the counterbore. Its inner end through an intervening gasket 37 bears against the extended edge of the shell 35 to hold the shell in place. A sealing ring 38 may surround the liner 34 adjacent the shell 35. The extremity of the bore containing the liner 34 is closed by a cap 39.

The liner 34 is provided with a slot extending therethrough which receives a slide bar 40 flattened on its upper and lower sides. A portion of the slide bar extends into the chamber formed by the shell 35 and housing 36 and the edges of the bar are provided with screw threads. A rotor 41 having an internally threaded bore fits the bar 40 to move the bar longitudinally in the liner 34 as the rotor is rotated.

The rotor is provided with inserts 42 in the form of permanent magnets the extremities of which confront the inner cylindrical surface of the shell 35. A drive wheel 43 having corresponding magnetic inserts 44 is journaled on the shell 35 within the slot 33. The axis of the shell and liner is displaced from the axis of the controller body 18 to enable one edge of the drive wheel 43 to protrude for engagement with the interior of a well casing. Springs 45 set into the opposite side of the body 18 bear against the opposite wall of the well casing to maintain the wheel 43 in contact.

35 The body 18 is provided with displaced vertical bores 46 and 47 which intersect the liner 34 and confront opposite sides of the slide bar 40. The slide bar is provided with a hole 48 which, when the slide bar is reciprocated in the central portion of its travel, may be caused to register alternately with the bores 46 and 47. The upper bore 46 receives a plurality of counter balls 49 backed by a pusher pin 50 and a spring 51. A reduced end of the pin 50 protrudes from the upper end of the body 18. A removable plate 52 holds the spring in place.

50 The body 18 is provided with a lateral bore communicating between the bore 46 and the bore 21 in which the firing bar 22 is mounted. Mounted in this lateral bore is a key ball 53 which fits a channel 54 provided in the firing bar and is held therein by the counter balls 49.

Opposite the edge of the slide bar 40, the body 18 and liner 34 form another lateral bore which receives a key ball 55 adapted to fit a channel 56 provided in the firing bar below channel 54. The corresponding edge of the slide bar 40 is provided in the region of the hole 48 with a notch 57 which permits the key ball 55 to withdraw from the channel 56.

60 The upper end of the firing bar 22 is provided with a stem 58 which protrudes from the upper end of the body 18. A removable ported plate 59 slidably receives the stem 58 and overlies the bore 21. A spring 60 surrounds the stem 58 and urges the firing bar downwardly when unrestrained by the key balls 53 and 55.

Below the slot 33, the body 18 is provided with a transverse bore 61 in a diametrical axis passing through the axis of the firing bar bore 21. The bore 61 is larger than the bore 21 and receives a plunger 62 having a hole 63 therein through which extends the firing bar 22. The firing bar is reduced to form a shoulder 64 which is adapted to engage a margin of the hole 63 to hold the

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bar 22 from descending. The plunger 62 is held in an outward, locking position by a spring 65.

The outer end of the bore 61 is counterbored to receive a cupped piston 66 having a sealing ring to isolate the interior of the piston from external fluids. The piston 66 is responsive to external pressures sufficient to overcome spring 65 to move the plunger 62 clear of the firing rod.

Operation of my gun perforator and its control mechanism is as follows:

The gun is loaded and the control device is set as shown in the drawings; that is, the firing bar is restrained by: (1) key ball 53, (2) key ball 55 and (3) plunger 62. The slide bar 40 is preset in the extreme position to which it tends to move under urge of the magnetic drive coupling between the wheel 43 and the rotor 41 as the gun perforator is moved downwardly within a well casing. A size of the controller is, of course, selected which is appropriate for the size of casing or liner in which the gun is to be fired, even though the casing may have a larger diameter section above the region to be perforated.

A "gear" ratio between the drive wheel 43 and the slide bar 40 is selected so that a substantial vertical travel of the gun perforator is required to move the slide bar its full stroke; for example, the vertical travel may be as much as thirty feet. When the gun perforator is reciprocated in the central zone of its travel for a distance of five to ten feet, the hole 48 is moved back and forth between the bores 46 and 47 causing the counter balls 49 to move one at a time from bore 46 to bore 47. The bore 47 extends to the bottom end of the body 18 and may be closed by a screw plug, not shown, so that after use the counter balls may be retrieved.

When the gun perforator is lowered to the approximate depth at which the perforations are desired the gun perforator is raised sufficiently to place the slide bar 40 in its central zone of travel and reciprocated a number of times corresponding to the number of counter balls 49 above the key ball 53. This releases key ball 53. The notch 57 is opposite the key ball 55 when the slide bar is in its central zone of travel so that both key balls are free and permit the firing bar 22 to drive downward and fire the time delay unit 26. A time delay is pre-selected which is sufficient to account for any uncertainty in the interval required to release the key ball 53 and to permit the gun perforator to be raised or lowered to the exact level at which perforation is desired.

It should be observed that in most cases gun perforating is performed below the surface of the liquid within a well bore. However, if the liquid level is below the desired perforation level, water or other liquid may be added. By reason of the plunger 62 and the submergence pressure responsive piston 66, the gun perforator cannot be operated unless submerged below a predetermined distance in liquid. Thus, even though it should be possible to manipulate the drive wheel when the gun is at the surface of the well until the key balls release the firing rod, the gun will not fire. Still further, should, in spite of the safety features provided, the time delay fuse be set off, a muffled explosion will be heard to warn that the gun is about to fire.

After the gun has been lowered to the proper depth, and manipulated to fire, and then started on its return trip from the well, the slide bar is moved to an extreme position at which the control mechanism is disarmed, that is, either

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or both key balls 53 or 55 prevent operation of the firing bar should it have failed to have previously functioned. As the gun perforator reaches the surface of the liquid the plunger 62 tends to relock the firing bar.

Having thus described a certain embodiment of my invention, I do not desire to be limited thereto, but intend to claim all novelty inherent in the appended claims.

10 I claim:

1. A gun perforator adapted to be lowered on a cable into a well casing and comprising: a series of gun units; a firing means for said gun units; a primary arming means having an initially unarmed position and caused to arm by predetermined repeated reciprocation in said casing; a second arming means associated with said primary arming means and having unarmed positions at the extreme zones of reciprocation of said primary arming means and an armed position at the central zone thereof; said arming means individually restraining said firing means when in their unarmed positions.

2. A gun perforator adapted to be lowered on a cable into a well casing and comprising: a series of gun units; a firing means for said gun units; a primary arming means having an initially unarmed position and caused to arm by predetermined repeated reciprocation in said casing; a second arming means associated with said primary arming means and having unarmed positions at the extreme zones of reciprocation of said primary arming means and an armed position at the central zone thereof; a tertiary arming means responsive to submergence pressure of a liquid in said casing to move between an unarmed and an armed position; said arming means individually restraining said firing means when in their unarmed positions, whereby said firing means is restrained until all said arming means assume armed positions.

3. A gun perforator adapted to be lowered on a cable into a well casing and comprising: a series of gun units; a firing means for said gun units; a primary arming means having an initially unarmed position and caused to arm by predetermined repeated reciprocation in said casing; a second arming means associated with said primary arming means and having unarmed positions at the extreme zones of reciprocation of said primary arming means and an armed position at the central zone thereof; a tertiary arming means responsive to submergence pressure of a liquid in said casing to move between an unarmed and an armed position; said arming means individually restraining said firing means when in their unarmed positions, whereby said firing means is restrained until all said arming means assume armed positions; and a time delay means interposed between said firing means and said gun units.

4. A gun perforator fire control, comprising: a firing member; a key restraining said member; a series of retainer elements holding said key in restraining position; a dispenser for removing said retainer elements in sequence until said key releases said firing member; and means including a member engageable with a surrounding well casing to actuate said dispenser upon reciprocation of said member along said casing.

5. A gun perforator adapted to be suspended from a cable within a well bore, comprising: a plurality of gun units; an ignitor for said gun units; a firing member for said ignitor; a series of retainer elements operable to restrain said

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firing member; a dispenser for removing said retainer elements in sequence until said firing member is released; a wheel rotatable on the interior of a surrounding casing; and a drive means between said wheel and dispenser for actuating said dispenser, said wheel being responsive to predetermined repeated reciprocation of said cable in said casing.

6. A gun perforator adapted to be suspended from a cable within a well bore, comprising: a plurality of gun units; an ignitor for said gun units; a firing member for said ignitor; a series of retainer elements operable to restrain said firing member; a dispenser for removing said retainer elements in sequence until said firing member is released; a wheel rotatable on the interior of a surrounding casing; and a magnetic drive between said wheel and dispenser for actuating said dispenser when wheel is rolled back and forth within said casing a predetermined distance, said magnetic drive adapted to permit overtravel of said wheel.

7. A control means adapted for cable suspension with a gun perforator, comprising: a firing member adapted to actuate a gun perforator; a retaining means therefor including a series of retainer elements; a reciprocable dispenser for removing said retainer elements in sequence until said firing member is released, said dispenser having a predetermined overtravel and arranged to dispense said elements in the central zone of its travel; and a drive means for said dispenser including a member engageable with a surrounding well casing and adapted when reciprocated therein to effect reciprocation of said dispenser.

8. A control means adapted for cable suspension with a gun perforator, comprising: a firing member adapted to actuate a gun perforator; a retaining means therefor including a series of retainer elements; a reciprocable dispenser for removing said retainer elements in sequence until said firing member is released, said dispenser having a predetermined overtravel and arranged to dispense said elements in the central zone of its travel; a drive means for said dispenser including a member engageable with a surrounding well casing and adapted when reciprocated therein to effect reciprocation of said dispenser; and a secondary retaining means for said firing member adapted to secure said firing member when said dispenser is in the end zones of its travel and release said firing member when said dispenser is in the central zone of its travel.

9. A control means adapted for cable suspension with a gun perforator, comprising: a firing member adapted to actuate a gun perforator; a retaining means therefor including a series of retainer elements; a reciprocable dispenser for removing said retainer elements in sequence until said firing member is released, said dispenser having a predetermined overtravel and arranged to dispense said elements in the central zone of its travel; a drive means for said dispenser; a wheel rotatable on the interior of a surrounding casing; and a magnetic connection between said drive means and wheel, said wheel adapted upon reciprocation in said casing to reciprocate said dispenser, said magnetic connection permitting overtravel of said wheel.

10. A gun perforator, comprising: a plurality of gun units adapted to be lowered in a well bore; a firing means disposed in proximity to said gun units and including an ignitor, and a firing bar engageable with said ignitor; a latch normally engaging and restraining said firing bar in

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an unarmed condition; a piston continuously exposed to submergence pressure of a surrounding liquid and operable in response to a predetermined submergence pressure to engage said latch and urge said latch free of said firing bar thereby to arm said firing bar; and means for actuating said firing bar if and when released from said latch.

11. A control means for gun perforators, comprising: a body structure having means at its lower end for attachment to a gun perforator and means at its upper end for attachment to a suspension cable; a firing means for said gun perforator contained in said body structure; an arming device for said firing means having an armed position permitting operation of said firing means and at least one disarmed position preventing operation of said firing means; and means engageable with a surrounding casing and operatively connected with said arming device to cause said arming device to move to and from said armed position on reciprocation of said body structure in said casing, whereby said arming device occupies an unarmed position in the extreme zones of said reciprocation and an armed position in the central zone thereof.

12. A control means for gun perforators, comprising: a body structure having means at its lower end for attachment to a gun perforator and means at its upper end for attachment to a suspension cable; a firing means for said gun perforator contained in said body structure; an arming device for said firing means having an armed position permitting operation of said firing means and at least one disarmed position preventing operation of said firing means; a drive wheel carried by said body structure and engageable with a surrounding casing; and a magnetic coupling operatively connecting said arming device and drive wheel to cause said drive wheel to move said arming device to and from its armed position upon reciprocation of said body structure in a well casing whereby said arming device occupies a disarmed position in the extreme zones of said reciprocation and an armed position in the central zone thereof.

13. A control means for gun perforators, comprising: a body structure having means at its lower end for attachment to a gun perforator, and means at its upper end for attachment to a suspension cable; a firing means for said gun perforator extending longitudinally in said body structure; an arming device for said firing means extending transversely of said body structure and reciprocable between an armed position permitting operation of said firing means and a disarmed position preventing operation of said firing means; and means engageable with a surrounding casing and operatively connected with said arming device to cause said arming device to move to and from said armed position on reciprocation of said body structure in said casing, whereby said arming device occupies an unarmed position in the extreme zones of said reciprocation and an armed position in the central zone thereof.

14. A control means for gun perforators, comprising: a body structure having means at its lower end for attachment to a gun perforator, and means at its upper end for attachment to a suspension cable; a firing means for said gun perforator extending longitudinally in said body structure; an arming device for said firing means extending transversely of said body structure and reciprocable between an armed position permit-

ting operation of said firing means and a disarmed position preventing operation of said firing means; a drive wheel carried by said body structure and engageable with a surrounding casing; and a magnetic coupling operatively connecting said arming device and drive wheel to cause said drive wheel to move said arming device to and from its armed position upon reciprocation of said body structure in a well casing whereby said arming device occupies a disarmed position in the extreme zones of said reciprocation and an armed position in the central zone thereof.

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