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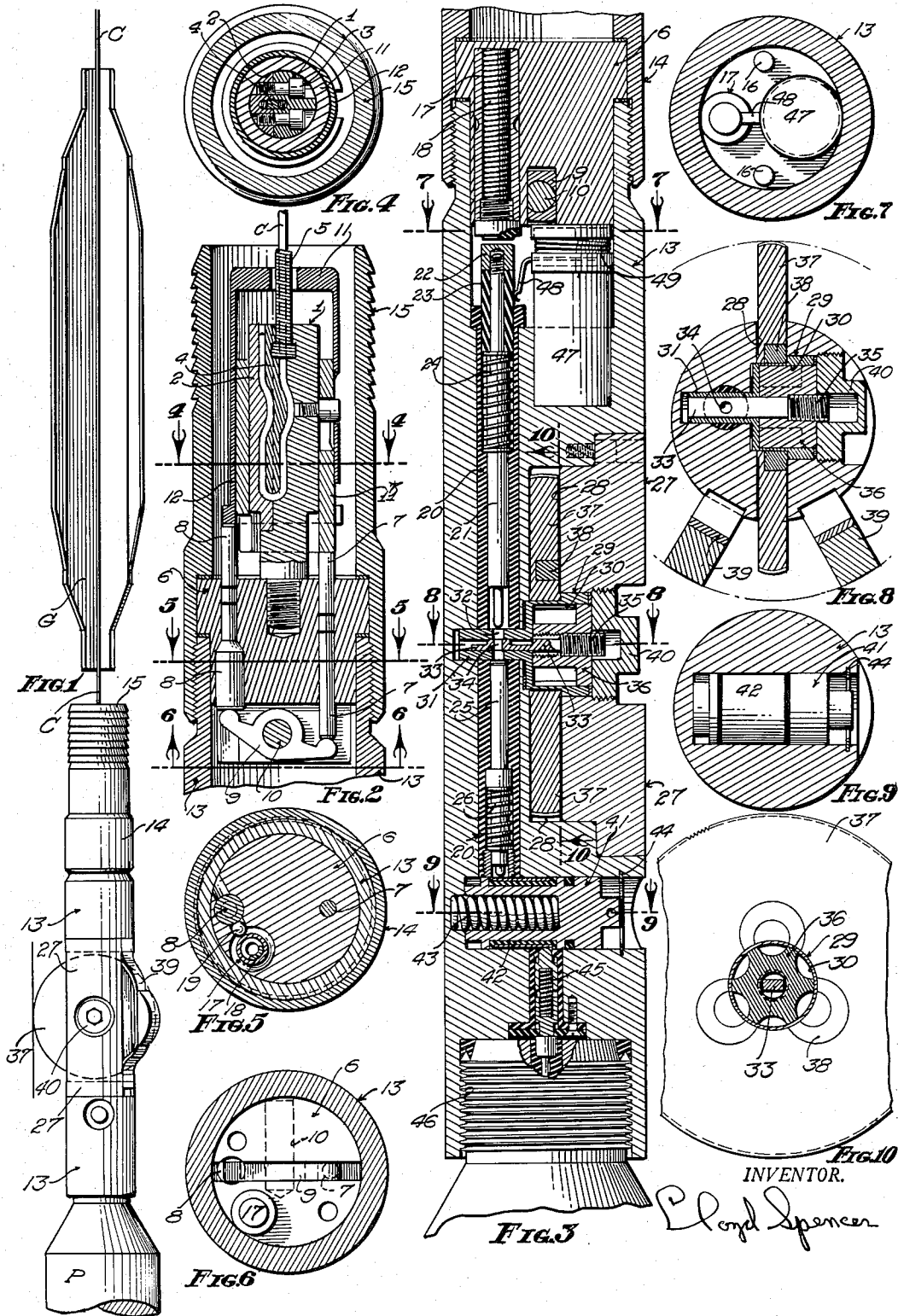
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CONTROL APPARATUS FOR CABLE SUSPENDED WELL TOOLS

Filed Nov. 9, 1951

2 Sheets-Sheet 1



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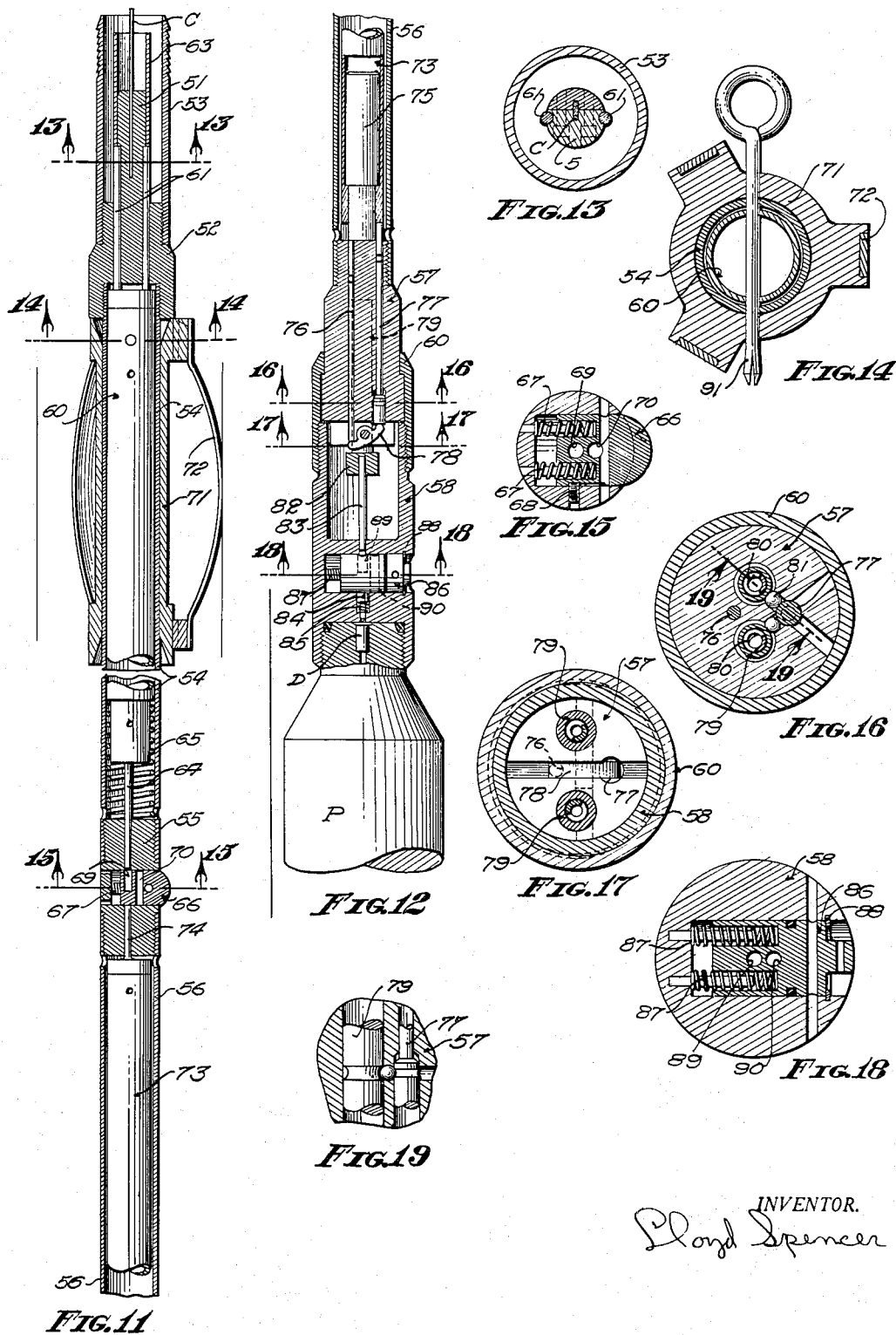
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2 Sheets-Sheet 2



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CONTROL APPARATUS FOR CABLE SUSPENDED WELL TOOLS

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Application November 9, 1951, Serial No. 255,611

12 Claims. (Cl. 89—1)

My invention relates to control apparatus for cable suspended well tools, more particularly to fire control mechanisms for cable suspended gun perforators, and included in the objects of my invention are:

First, to provide a control apparatus for cable suspended well tools which is a continuation-in-part of my copending application Serial Number 3,673, filed January 22, 1948, now Patent Number 2,655,993.

Second, to provide a control apparatus which is so arranged as to cooperate with a go-devil such as the type disclosed in my copending application Serial Number 255,612, filed Nov. 9th, 1951, said go-devil being adapted to be dropped alongside a cable from which the control apparatus and gun perforator or other well tool is suspended.

Third, to provide a control apparatus of this class which incorporates go-devil engaged means so arranged as to be uninfluenced by submergence pressures or by inertia effects due to acceleration or deceleration of the well tool as it is lowered or raised in the well bore.

Fourth, to provide a firing mechanism for cable suspended gun perforators which is disarmed during both downward and upward travel of the gun perforator in the wellbore, there being only one condition in which the gun perforator is armed, this being established by reversing the direction of travel of the gun perforator and moving the gun perforator in the new direction a predetermined distance; thus unless the gun perforator is properly positioned it cannot be fired.

Fifth, to provide a firing mechanism for gun perforators which includes arming means responsive to submergence pressures so arranged that should the housing in which the firing mechanism is encased leak, the firing mechanism is disarmed, and in any case maintains the firing mechanism disarmed unless the gun perforator is submerged below a predetermined depth.

Sixth, to provide a firing mechanism for gun perforators which, should attempt be made to fire the gun perforator when the firing mechanism is disarmed, the mechanism is locked in its disarmed position.

Seventh, to provide an operating apparatus for cable suspended well tools which may be arranged for mechanical or electrical detonating devices.

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

Figure 1 is an elevational view of one embodiment of my control apparatus shown suspended from a cable and supporting a gun perforator, and a go-devil being shown as about to engage the operating apparatus.

Figure 2 is a fragmentary longitudinal sectional view of the upper portion of my control apparatus.

Figure 3 is a fragmentary longitudinal sectional view continuing from Fig. 2.

Figures 4, 5, and 6 are transverse sectional views taken through 4—4, 5—5, and 6—6 respectively of Fig. 2.

Figures 7, 8 and 9 are fragmentary longitudinal views taken through 7—7, 8—8, and 9—9 respectively of Fig. 3.

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Figure 10 is a longitudinal sectional view taken through 10—10 of Fig. 3 with the body structure omitted.

Figure 11 is a fragmentary longitudinal sectional view of a modified form of my operating apparatus.

Figure 12 is a fragmentary longitudinal sectional view thereof continuing from the lower end of Fig. 11.

Figures 13, 14 and 15 are transverse sectional views thereof taken through 13—13, 14—14 and 15—15 respectively of Fig. 11.

Figures 16, 17, and 18 are transverse sectional views taken through 16—16, 17—17, and 18—18 respectively of Fig. 12.

Figure 19 is a fragmentary longitudinal sectional view through 19—19 of Fig. 16.

Reference is first directed to Figures 1 through 10. The construction here shown is adapted to be attached to the upper end of a gun perforator P and suspended from a cable C for engagement by a go-devil G.

The cable C is shown as a single strand line and a special cable head is shown; however, a multiple strand line and corresponding cable head may be used. The cable head shown includes a semi-cylindrical body 1 having a complementary clamp bar 2, secured by bolts 3. The confronting faces of the body and clamp are longitudinally grooved to receive the doubled end of the cable. A spacer bar 4 separates the doubled end of the cable so that the cable is secured without kinks. A coil protector sleeve 5 may guard the adjacent portion of the cable extending from the cable head.

The cable head body 1 is provided with a screw-threaded end for attachment to a cylindrical block 6. Mounted within the block are two axially extending trigger rods 7 and 8 protruding from the ends thereof. The lower end of the block 6 is provided with a transverse slot which receives a rocker lever 9 journaled on a pin 10. The rods 7 and 8 bear against opposite ends of the rocker lever so that the rods move in opposite directions. Suitable sealing means are provided for the trigger rods.

The upper extremities of the trigger rods 7 and 8 are engaged respectively by concentric sleeves 11 and 12 which fit around the cable head. The sleeve 12 projects above the cable head and has an internal flange for engagement by the go-devil. The trigger rods 7 and 8 are equal in area and the sleeves 11 and 12 are equal in mass so that pressure differentials across the block 6 and accelerations along the axis of the cable head have no effect in shifting the rods.

The lower portion of the block 6 is reduced in diameter to fit into a socket provided in the upper end of a main body structure 13 and is secured in place by a clamp collar 14 screwthreaded to the body structure. Sealing means are provided between the block 6 and body structure 13. The collar may project above the block 6 to form a guard 15 terminating slightly above the sleeve 12 to prevent its accidental operation. Aligning pins 16 extending between the block 6 and body structure 13 position these members in proper relation.

The block is provided with a downwardly directed eccentrically disposed socket which receives a firing bolt 17 having a head, preferably of insulating material. The bolt is tubular and receives a spring 18 to drive the bolt downwardly. The bolt is normally restrained by a ball key member 19 interposed in a transverse bore between the bolt and the trigger rod 8. The trigger rod is enlarged at its lower end. The bolt is grooved to receive the key ball 19. On downward movement of the trigger rod 8 the key ball may move laterally to free the bolt.

The body structure 13 is provided with an eccentric bore which alines with the firing bolt 17 and receives a liner 20, preferably of insulating material which carries

an upper and a lower firing pin assemblies. The upper firing pin assembly includes a firing pin 21 having a contact head 22 adjacent the head of said bolt 17, and an insulated sleeve 23 below the head. The firing pin is held in its upper position by a spring 24. The lower firing pin assembly is spaced from the upper assembly and includes a pin 25 spaced from the pin 21 and held in an upper position by a spring 26.

The central portion of the body structure is provided with a laterally directed recess which receives a complementary side block 27 which forms therewith a longitudinally extending slot 28, paralleling the liner 20. The block 27 is provided with a lateral opening, and the body structure is provided with a concentric socket of smaller diameter intersecting the bore containing the liner 20. The opening and socket receive a housing 29 comprising an enlarged cup or chamber 30 and reduced stem 31. In the region transversing the slot 29 walls of the chamber 30 are as thin as possible. The stem 31 is provided with an opening therethrough of rectangular cross section. The stem projects through the liner 20 and is provided with a small transverse opening 32 interposed between the firing pins 21 and 25.

Slidably mounted in the stem 31 is a gate 33 having an opening 34 adapted to register with the opening 32 when the gate is in its mid-position. The gate projects into the chamber 30 and is provided with a screw threaded end 35. An armature or drive nut 36 for the gate 33 is rotatably mounted in the chamber 30. The drive nut is formed of magnetic material, whereas the surrounding material is non-magnetic. The drive nut is provided with axial ribs or armature pole pieces confronting the thin wall portion of the housing opposite the slot 28. This portion of the housing journals a drive wheel 37. The drive wheel is formed of non-magnetic material but has imbedded therein a ring of permanent magnets 38 arranged so as to create a magnetic field tending to rotate the armature or drive nut 36.

The axis of the housing and drive wheel is offset from the center of the body structure so that the wheel protrudes farther from one side than the other. The wheel 37 engages a surrounding well casing and may be provided with a tread. Bow springs 39 secured to the opposite side of the body structure 13 and block 27 maintain the wheel in rolling contact with the casing.

The housing 29 is held in place by a screwthreaded plug 40 and suitable gaskets are provided to seal the interior of the housing.

Immediately below the lower firing pin assembly the body structure 13 is provided with a lateral socket which receives a piston 41 having suitable sealing means. The piston is provided with a contact band 42 insulated from the piston and surrounding socket walls. A spring 43 normally urges the piston outwardly against a stop 44, but the piston is urged to its inner position by submergence pressure of the surrounding well liquid.

Below the piston the body structure is provided with an insulated and centered contact terminal means 45 one end engaging the band 41 the other facing into an internally threaded socket 46 forming the lower end of the body structure. This socket is adapted to receive the upper end of a gun perforator P or other electrically operated well tool provided with a contact terminal T.

The upper end of the body structure 13 is provided with a cavity adapted to receive a battery power supply unit 47 having a contact member 48 normally bearing against the insulated sleeve 23 of the upper firing pin assembly, but adapted to contact the head 22 when the firing pin assembly is lowered. The battery power supply unit may be held in place by a spring cap means 49 bearing against the under side of the block 6.

Operation of my firing or control apparatus is as follows:

The apparatus is suspended from a cable and in turn supports a gun perforator or other device capable of oper-

ation by a momentary electrical impulse. During travel of the control apparatus in the well bore, either upwardly or downwardly, the drive wheel 37 through its armature nut 36 moves the gate 33 laterally so that its opening 34 is out of registry with the opening 32 and the upper firing pin 21 cannot engage the lower firing pin 25. The upper side of the gate may be grooved at either side of its opening 32 so that should the firing pin be released when the gate is disarmed, the gate becomes locked in its disarmed position.

Until the apparatus is submerged a sufficient depth that the submergence pressure overcomes the force of the spring 43 which backs the piston 41 the contact band 42 is out of alinement with the lower contact pin 25 and disarmed.

Under the conditions shown in the drawings, the operating apparatus is armed, both as to the gate 33 and piston 41. Thus engagement of the sleeve 12 by the go-devil G causes trigger pin 8 to be depressed releasing the key ball 19 from the bolt 17 so that its spring 18 may engage the upper firing pin 21 and move its lower end through the gate member to engage the lower contact pin 25 and in turn force this pin in to contact with the band 42 completing the circuit to the gun perforator terminal T. The force of the spring 18 overcomes the force of the springs 24 and 26. These springs, however, return the firing pins to their upper positions when the block 6 is separated from the body structure 13 in the course of resetting the mechanism and replacing the battery cell. Also these springs are sufficient to absorb acceleration and deceleration shocks imposed on their firing pins in the course of movement of the apparatus in the well bore.

Arming of the gate 33 is accomplished by lowering the apparatus to a predetermined distance below the desired level, then raising the apparatus such predetermined distance. For example, the drive wheel, armature nut and gate may be so arranged that the apparatus has a ten foot travel between extreme positions of the gate; thus, by reversing movement the apparatus for a distance of five feet, the gate is placed in its armed position shown.

It is preferred to use a battery power source which though adequate for its purpose, will have a short life if shortcircuited. Thus, in the event of malfunctioning for any reason, the energy of the battery will soon be discharged and the apparatus rendered inoperative.

After use, the apparatus is reset, by separating the block 6 and body structure 13, forcing the bolt 17 to its initial position. The key ball 19 will automatically assume its locking position. The firing pins automatically return to position. The drive wheel may be rotated to free the upper pin should the gate bind thereon. A new battery unit is, of course, inserted. To adapt the apparatus to different size casings the side block 27 and housing 29, or the plug 42 and housing 29 are removed and a new wheel of the desired diameter is substituted. The bow springs 39 are likewise changed.

It will be observed that irrespective of submergence pressures the rods 7 and 8 are in balance, and that any acceleration or deceleration forces act equally on the rods due to the equal masses of the sleeves 11 and 12.

Reference is directed to Figures 11 through 19. The construction here shown utilizes a slide cage and gate bolt in place of the drive wheel, armature and gate of the previously described structure and is disclosed as operating mechanically rather than electrically; however, either modification may be adapted to electrical or mechanical operation.

The cable C is attached to a cable head 51 comprising complementary clamp members such as shown in the first described structure. The cable head 51 is, in this case, joined integrally to an adapter 52 externally screwthreaded at its upper side to receive a guard tube 53 surrounding the cable head. The lower end of the adapter is provided with an internally threaded socket which receives an upper tube 54. This tube is connected through a coupling body

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55 to another tube 56. The tube 56 is joined to a cylindrical block 57 adapted to sealingly abut a body structure 58 and be secured thereto by a collar 59. The body, in turn, is provided with a socket at its lower end for attachment to a gun perforator G or the like.

The upper tube 54 receives a tubular firing shaft 60, closed at its ends. The upper extremity of the firing shaft 60 is provided at its upper end with a pair of slide rods 61 which extend through the adapter 52 along opposite sides of the cable head 51. The rods are engagable by a sleeve 63 fitting the cable head 51 and projecting above the cable head within the guard 53.

The lower end of the firing shaft 60 is provided with a firing pin 64 which projects into a central bore through the coupling body 55. A spring 65 supports the static weight of the firing shaft 60.

The coupling body 55 is provided with a lateral socket which receives a gate bolt 66 which normally projects laterally from the coupling body and is provided with a cam end. The gate bolt is urged outwardly by springs 67 and is limited by a stop 68. The gate plug is provided with a blind socket 69 in registry with the central bore of the coupling body 55, when the gate plug is in its outer or disarmed position, and a through opening 70 in registry therewith when the plug is in its inner or armed position.

The gate bolt is engaged by a sleeve 71 slidable on the tubes 54 and 56. The sleeve is provided with a spring cage 72 engagable with a surrounding casing to occupy an upper position when the apparatus is moving downwardly in a well and a lower position when the apparatus is moving upwardly. Only when the sleeve is in an intermediate position is the gate bolt in its inner or armed position.

The lower tube 56 receives a lower hollow firing shaft 73 having a firing pin 74 projecting upwardly in the bore of the coupling body 55 for engagement by the firing pin 64. The lower end of the hollow shaft 73 receives a counterbalance member 75 equal in mass.

The block 57 receives a pair of trigger rods 76 and 77 extending therethrough, and positioned for engagement respectively by the lower end of the firing shaft 73 and counterbalance member 75. The lower ends of the trigger rods engage an equalizer lever 78 pivotally mounted at the lower end of the block 57.

The block 57 is provided with a pair of upwardly directed sockets which receive bolts 79 backed by drive springs 80. The bolts are held in retracted position by key balls 81 fitting in grooves provided in the bolts 79. The key balls are held therein by the enlarged end of the trigger rod 77, and release the bolts when the trigger rod is moved downwardly.

The bolts 79 are joined by a cross bar 82 and from the center of the cross bar depends a firing pin 83. The firing pin 83 engages a final firing pin 84 in the lower end of the body structure which, in turn, engages a detonator D set in the upper end of a gun perforator G. The final firing pin is held in an upper, inoperative position by a spring 85.

Interposed between the firing pins 83 and 84 is a lateral socket in which fits a piston 86 having suitable sealing means and responsive to submergence pressures. The piston 86 is urged outwardly by springs 87 to a disarmed position against a stop ring 88. The piston is provided with a blind socket 89 in registry with the firing pin 83 when the piston is in its disarmed position, and is provided with a through opening 90 in registry therewith when the piston is in its armed position.

Operation of the control or firing apparatus disclosed in Figures 11 through 19 is as follows:

The gate plug 66 and piston 86 are shown in their disarmed positions, and the cage 72 is shown in its upper position assumed when the apparatus is lowered into a well bore before encountering fluid. When the desired level is reached, the piston 86 has been armed by submergence

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pressure. The apparatus is lowered a few feet below the desired level, depending on the length of the tubes 54 and 56, then raised to bring the sleeve 71 opposite the gate plug 66 to place this member in its armed position. Thereupon a go-devil such as shown in Fig. 1 may be dropped. The weight of the go-devil is relied upon in preference to impact to depress sleeve 63, rods 61, upper shaft 60, firing pin 64, lower shaft 73, and trigger pin 77 to release the bolts 79. The force of springs 80 then causes the firing pins 83 and 84 to fire the detonator D.

Any reciprocation of the upper shaft 60 due to acceleration or deceleration forces imposed on the apparatus merely causes the pin 64 to enter the blind socket 69. Such forces have no influence on the trigger rods 76 and 77 due to the counterbalanced relation of the lower shaft 73 and member 75.

The apparatus may be locked in its disarmed position by providing alinable openings in the cage sleeve 71 and upper portion of the tube 54 and shaft 60 arranged to receive a lock pin 91. Similarly, the gate plug 66 and piston 86 may be arranged to receive lock pins.

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

I claim:

1. A control apparatus for well tools, comprising: a sealed body structure; a pair of axially movable rods sealed in and extending through a wall of said body structure, their outer ends being exposed to well pressures tending to force said rods into said body structure; a lever having a pair of opposed arms connecting said rods to effect outward movement of one rod upon inward movement of the other, the relative areas of said rods and the relative lengths of said rods being such that hydrostatic pressure against the exposed end of each rod is opposed equally by the hydrostatic pressure against the other whereby said rods are in hydrostatic balance; and a firing mechanism within said body structure responsive to movement of said rods.

2. A control apparatus for well tools, comprising: a sealed structure adapted to be suspended from a cable and support a well tool; a pair of axially movable rods protruding from the upper end of said body structure, their outer ends tending to be forced into said sealed structure by the submergence pressure of liquid in which the sealed structure may be submerged; seal means for said rods; equalizer means connecting said rods to effect outward movement of one rod upon inward movement of the other rod whereby submergence pressure against either rod is counterbalanced by the submergence pressure against the other rod; a pair of axially movable exposed members of substantially equal mass disposed above said housing each engaging one of said rods whereby inertia of one of said members on acceleration and deceleration of said body structure is equalized by the other; at least one of said exposed members being arranged for mechanical engagement from above said body structure; and a firing mechanism within said body structure operatively associated with said rods.

3. A control apparatus for well tools, comprising: a sealed body structure adapted to be suspended from a cable and to support a well tool; hydrostatically balanced and inertia balanced trigger means mechanically accessible from the exterior of said body structure and extending into the interior thereof; sealing means for said trigger means; and firing means within said housing operatively associated with said trigger means.

4. A control apparatus for well tools, comprising: a sealed body structure adapted to be suspended from a cable and support a well tool; a pair of axially movable rods protruding from the upper end of said body structure their outer ends tending to be forced into said sealed structure by the submergence pressure of liquid in which the sealed structure may be submerged; seal means for said rods; equalizer means connecting said rods to effect

outward movement of one rod upon inward movement of the other rod whereby submergence pressure against either rod is counterbalanced by the submergence pressure against the other rod; a pair of axially movable exposed members of substantially equal mass disposed above said housing each engaging one of said rods whereby inertia of one of said members on acceleration and deceleration of said body structure is equalized by the other; at least one of said exposed members being arranged for mechanical engagement from above said body structure; a firing mechanism within said body structure operatively associated with said rods; and an arming mechanism including actuating means engageable with a surrounding casing, an arming means operated by said actuating means and moveable between at least one disarmed position and an armed position, said arming member being disposed in operative association with said firing mechanism.

5. A control apparatus for well tools as set forth in claim 4 wherein: said arming mechanism is located externally of said body structure above said rods and arranged to prevent operation of said rods when said arming means is in its disarmed positions and permit operation of said rods when in its armed position.

6. A control apparatus for well tools as set forth in claim 4 wherein: said actuating means is disposed externally of said body structure and said arming means is located within said structure, a magnetic coupling connects said means, and said arming means is interposed in said firing mechanism.

7. A control apparatus for well tools, comprising: a sealed body structure adapted to be suspended from a cable and to support a well tool; hydrostatically balanced and inertia balanced trigger means mechanically accessible from the exterior of said body structure and extending into the interior thereof; sealing means for said trigger means; firing means within said body structure operatively associated with said trigger means; and an arming mechanism including an actuating means engageable with a surrounding casing, an arming means moveable by said actuating means between at least one disarmed position and an armed position, said arming means disposed in operative association with said firing mechanism.

8. A control apparatus for well tools as set forth in claim 7, wherein: both said actuating means and arming means are located externally of said body structure above said trigger means to prevent engagement of said trigger means when said arming means is in its disarmed position and permit engagement when in its armed position.

9. A control apparatus for well tools as set forth in claim 7, wherein: said actuating means is located externally of said body structure, said arming means is located within said body structure, a magnetic coupling operatively connects said actuating and arming means, and

said arming means is interposed in said firing mechanism.

10. A go-devil operated control apparatus adapted to be interposed between a cable and a well tool suspended thereby, comprising: tandem related firing elements including a top element engageable by a go-devil and a bottom element moveable to operate a well tool; an arming means for said firing elements including a gate interposed between said firing elements and moveable between a disarmed position and an armed position; an actuating means for said gate engageable with a surrounding casing and moveable, during initial travel of said well tool in said casing in either direction, to arm then disarm said gate, whereby said gate occupies its disarmed position during continued monodirectional movement of said well tool in said well casing.

11. A go-devil operated control apparatus as set forth in claim 10 wherein: said gate is mounted in a tubular structure and protrudes laterally therefrom when in its disarmed position, and said actuating means is a spring cage structure having means slideable on said tubular structure between upper and lower positions clear of said gate through an intermediate position engaging and arming said gate.

12. A go-devil operated control apparatus as set forth in claim 10 wherein: said gate is moveable laterally of said firing elements between extreme disarmed positions through an intermediate armed position, said actuating means is a wheel rotatably engageable with a surrounding casing, and a yieldable means connects said actuating means and gate.

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