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2,683,786

MULTISHOT CONTROLLER FOR PERFORATING GUNS

Filed Jan. 12, 1950

3 Sheets-Sheet 1

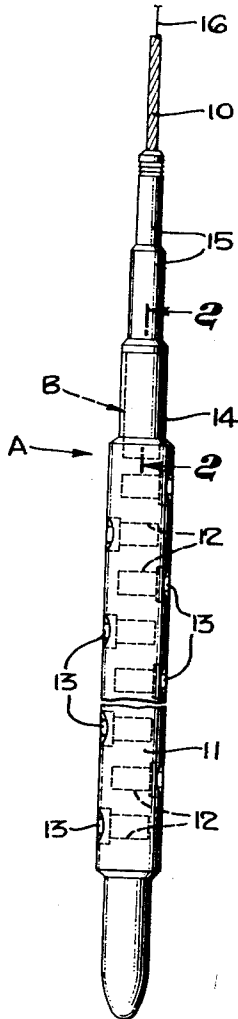


Fig. 1.

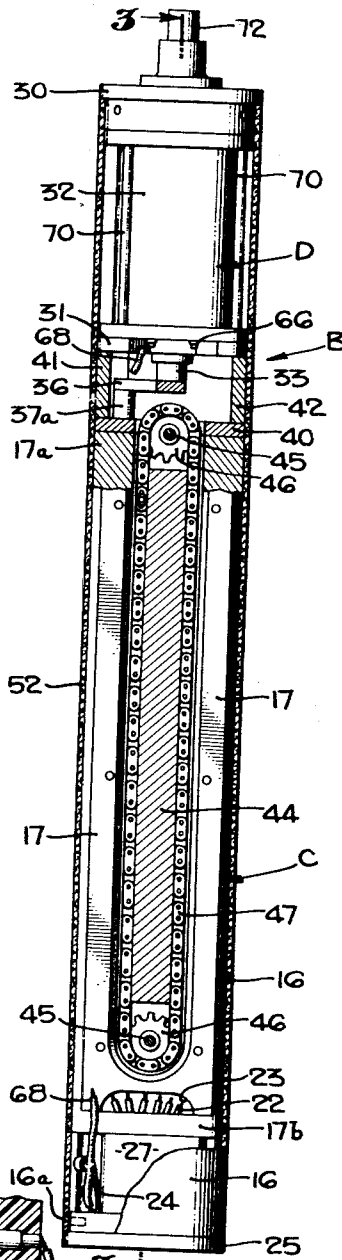


Fig. 2.

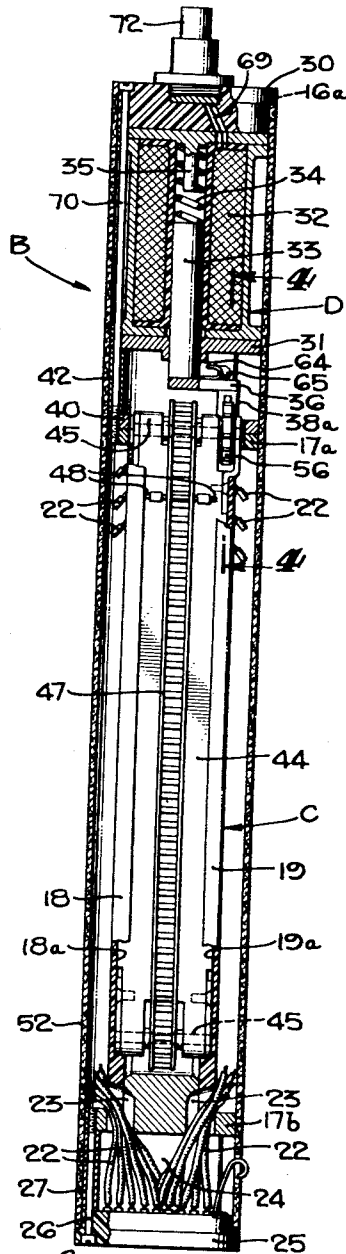


Fig. 3.

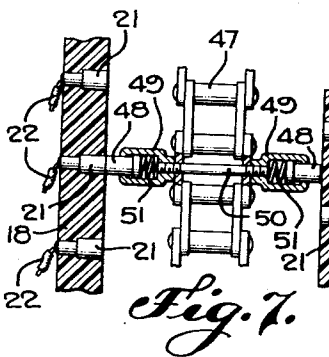


Fig. 7.

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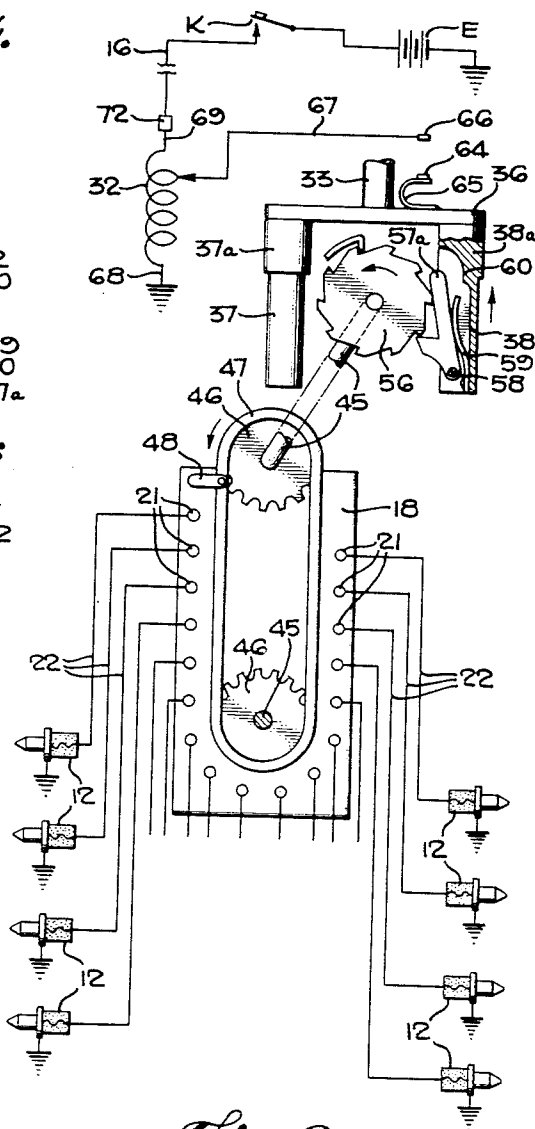
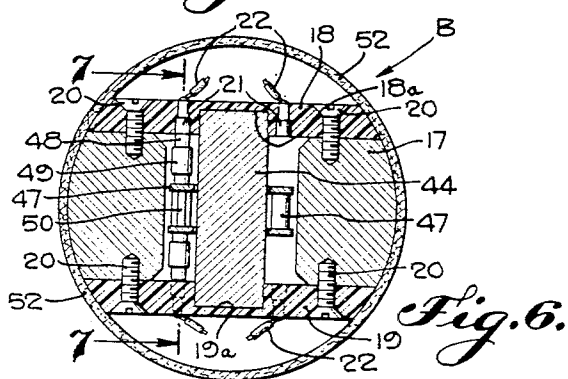
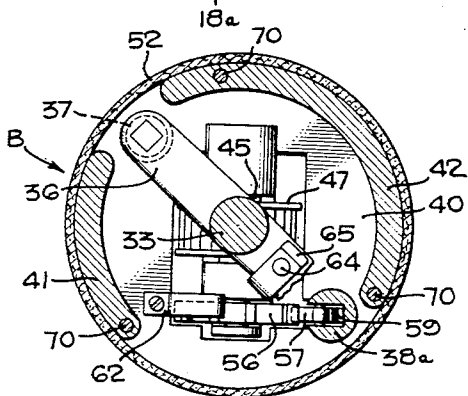
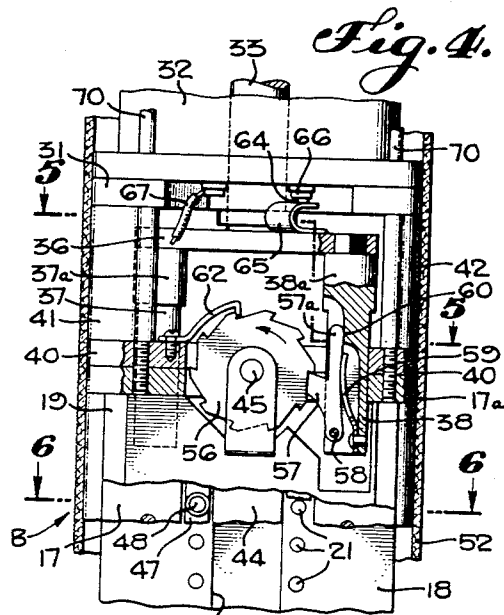
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3 Sheets-Sheet 2



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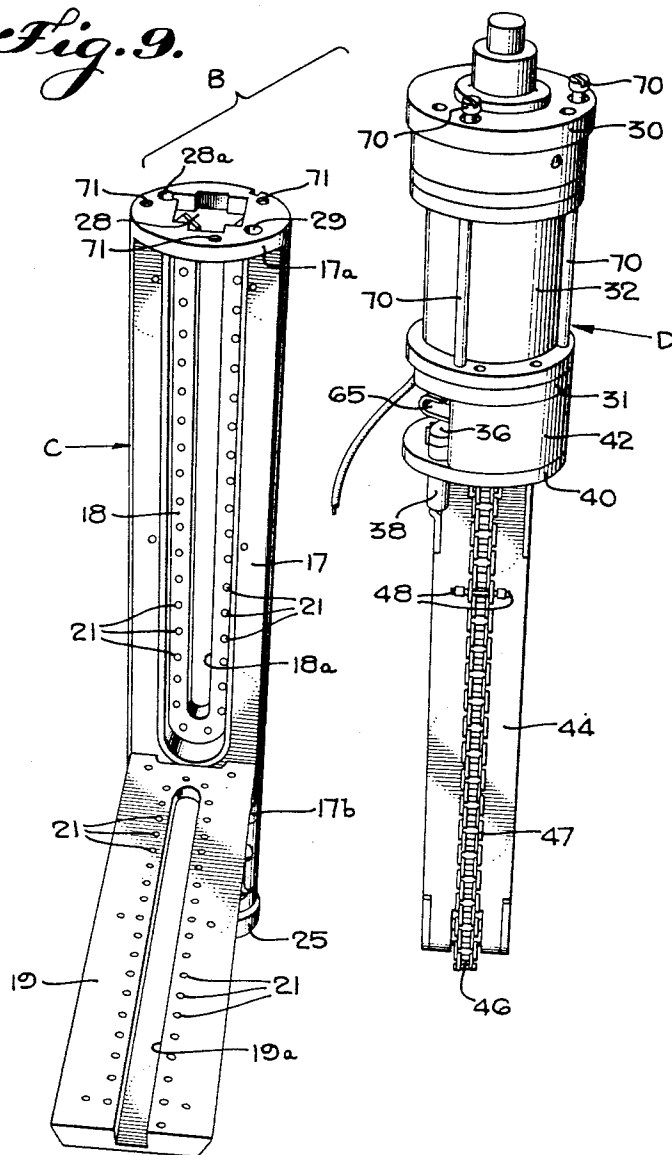
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Fig. 9.



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MULTISHOT CONTROLLER FOR
PERFORATING GUNS

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6 Claims. (Cl. 200-105)

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This invention relates to gun perforators adapted to be lowered into wells to perforate the casing or surrounding formations thereof at a plurality of points or levels. More particularly it is concerned with the selective control of the discharge of the several perforating gun units comprising the perforator apparatus.

In the use of the so-called gun perforators adapted to be lowered into oil well casings for the purpose of perforating the latter to bring in a well it is often desirable to make the perforations in a wide zone, or at several zones, in order to drain effectively the oil sands which have been penetrated by the casing. This requires a large number of shots or perforating blasts and when it is desired to make the shots one at a time from a single gun body difficulties are encountered in finding sufficient space for control mechanism due to the small diameter of the gun body, especially in very deep wells where the lowest casing may be quite small as of the order of 3 to 5 inches in diameter. By making the gun body sufficiently long, so as to hold from fifty to one hundred shots, or more, it is possible to effect the perforating of the casing in a minimum of time since a single gun body lowered only once into the well will suffice for the operation.

It is, therefore, a principal object of the invention to devise an improved form of multi-shot controller particularly adapted for deep wells and well casings of restricted bore.

Another object is to provide great flexibility in the number of shots which may be selectively controlled and fired from a single gun body.

Another object is to make the controller of small lateral dimensions so that it can be used in gun bodies for well casings of small diameter without undue restriction of the number of shots to be controlled thereby.

Another object is to provide multi-shot controllers which are simple in design but rugged and shock resistant in construction so that they can be used repeatedly, will stand up in service and operate efficiently over long periods of use with a minimum of repairs and servicing.

Other objects, advantages and features of novelty will appear from the detailed description which follows.

The invention utilizes an endless element in the form of a belt or chain which is arranged to be moved in step by step action, each step effecting the discharge of a perforating bullet or explosive blast through the casing. One or more electrical contacts carried by the belt or chain

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may engage in sequence a large number of stationary contacts adjacent the belt or chain to close electrical circuits leading to the shots in the gun body. Suitable means under control from the surface of the ground are actuated to effect the step by step movement of the belt or chain. By preference each shot is fired automatically as the belt or chain completes each step of its movement.

The controller is made in two main portions which telescope together when assembled. One portion serving as a container or insulating sheath, supports the fixed electrical contacts from which lead wires extend to the perforating charges. The other portion is the control unit supporting the actuating mechanism including the endless element and the movable contacts thereon which are mounted on an extension or blade for insertion within the sheath portion.

In order to illustrate the invention and the manner of its use, one preferred embodiment thereof is shown in the accompanying drawings in which:

Figure 1 is an elevational view of a gun body assembly partly broken away ready to be lowered into a well casing to perforate the latter at one or more levels;

Figure 2 is a vertical sectional view on an enlarged scale and partly in elevation of the shot controller, this section being taken substantially on line 2-2 of Figure 1;

Figure 3 is a similar sectional view of the controller but at right angles to Figure 2, as on line 3-3 of Figure 2, certain of the parts being shown in elevation;

Figure 4 is an enlarged fragmentary detail sectional view taken substantially on line 4-4 of Figure 3, with parts broken away but shown in firing position.

Figures 5 and 6 are cross-sectional views on the lines 5-5 and 6-6, respectively, of Figure 4, certain of the parts being broken away in Figure 5.

Figure 7 is an enlarged detail sectional view on the line 7-7 of Figure 6;

Figure 8 is a diagrammatic view to show the wiring and to indicate the relative positions of the operative parts prior to actuation of the controller; and

Figure 9 is a perspective view of the controller partly disassembled in order to show more clearly the relationship of the various parts.

Figure 1 shows a completely assembled gun perforator, A, ready to be lowered by cable 10 into a well casing. The gun perforator may consist

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of a cylindrical gun body 11 of any suitable or desired length provided with recesses or sockets 12 in which are mounted the perforating charges or gun units 13, gun body 11 being suitably connected to a controller casing 14 which is in turn attached to cable head 15. An insulated electric conductor 16 forms a part of a supporting conductor cable 10 which enters the cable head 15.

The aforesaid gun perforator may, by way of illustration, have a construction and method of operation similar to that disclosed in Lane 2,062,975.

The multi-shot controller of the present invention is mounted in a fluid tight controller casing 14 the general location thereof being indicated at B. The apparatus is shown in assembled form in Figures 2 and 3 and in partly disassembled form in Figure 9. Controller B comprises a lower switching or sheath portion C, and an upper or actuating head portion D which is the control unit. When assembled as shown in Figures 2 and 3, both upper and lower portions are surrounded by a relatively thin cylinder or tubular insulating member 52 composed of fibre board, Bakelite, plastic or other suitable insulating material held in place by screws 16a as best shown in Figures 2 and 3.

The lower sheath portion C of the controller B is made up of an elongated centrally slotted hollow metal frame 17, having an opening into the upper end of the said slot at its upper flanged end 17a and with cut-away open sides which are normally closed on opposite sides by insulating members or side plates 18 and 19, respectively, composed of Bakelite or other suitable material. The side plates 18 and 19 may be attached to frame 17 in any desired manner, as for example by screws 20 as best shown in Figure 6. Insulating plate members 18 and 19 combine with the yoke shaped metal frame 17 to close the sides at the slot therein and form thereby an elongated axial recess or passage within portion C, which passage is enlarged laterally by axially directed channels 18a and 19a formed in the side plate members 18 and 19, respectively. Both members 18 and 19 are provided adjacent the channels 18a and 19a and in the marginal portion surrounding the channels, with longitudinally extending rows of spaced contacts 21. By preference, the contacts on member 18 are staggered with reference to the opposite contacts on member 19 as best shown in Figure 7; also the longitudinal rows of contacts 21 on each member 18 and 19 are made continuous by extending them around the lower rounded end of the recesses or channels 18a and 19a as shown in Figures 8 and 9. Contacts 21 extend through from the inner faces of insulating plate members 18 and 19 as best shown in Figure 7, for attachment thereto of lead wires 22 which in turn make connection to charges 12 within the gun body as diagrammatically indicated in Figure 8. To this end, insulated wires 22 are passed through a pair of diametrically opposite openings 23 extending axially through a lower transverse annular flanged end portion 17b formed on the lower end of frame 17, and thence the wires extend into a chamber 24 closed at the lower end of the controller portion C by a disc shaped terminal receptacle 25. The terminal receptacle is spaced from and attached to the lower flanged portion 17b of frame 17 by screw bolts 26 extending through spacers 27. The head 25 may be in the form of a multi-connection socket where wires 22 terminate as indicated in Figure 3, and

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adapted to receive a mating multi-connection plug from which wires 22 pass to gun charges 12 in a manner similar to that illustrated in the beforementioned patent to Lane 2,062,975.

The upper control unit or actuating head portion D of controller B is shown by itself at the left of Figure 9 and in assembled relation with the lower or switch sheath portion C, in Figures 2 and 3. It provides between spaced head end members 30 and 40 a cylindrical chamber in which is mounted a suitable electrical actuating mechanism; in this instance, a solenoid electromagnet comprising a coil 32, and an armature 33 slidable axially within the coil and projecting through and having a sliding bearing in a central aperture in the lower head 31 of the solenoid. A coil spring 34 urges armature 33 to the limit of its outward or downward movement from coil 32 and a stop pin 35 serves both to limit its inward or upward movement and to provide a metallic magnetic circuit to the solenoid armature when the solenoid is energized. The outer end of armature 33 carries a cross bar 36 from the opposite ends of which extend a pair of parallel, axially extending guide rods 37 and 38 slidably received in suitable guide openings therefor in the lower head end member 40 which is maintained in spaced relation with the lower solenoid head 31 by suitable arcuately shaped spacers 41 and 42 as best shown in Figures 4 and 5. Rods 37 and 38 have stop shoulders 37a and 38a to engage the upper face of lower head member 40 and limit the outward or downward movement of armature 33 under the action of spring 34.

Secured to or integral with head member 40 is an extension in the form of a broad thick metal blade 44 which is adapted and intended to slide endwise into the axially extending opening in sheath portion C with the opposite edges of blade 44 received in and fitting the channels 18a and 19a in insulating side plate members 18 and 19, when controller B is assembled. Extension of blade 44 is provided at its ends with transverse shafts 45 on which are mounted pulley members or sprocket wheels 46, blade 44 and head member 40 being suitably slotted to receive sprocket wheels 46, the upper one of which is directly beneath armature 33 as clearly indicated in Figures 2-5. Mounted upon the pulley members or sprocket wheels 46 is an endless metallic belt or preferably a chain 47, the longitudinal rows of which are directly aligned with the rows of contacts 21 in the inner faces of insulating side plate members 18 and 19 when controller B is assembled with extension 44 seated in the axial channel of sheath portion C as shown in Figures 2, 6 and 7. Fixed upon and projecting laterally from opposite sides of belt or chain 47 so as to engage contacts 21 in the insulating side plate members 18 and 19 and to move with chain 47, are movable contacts 48 supported in cups 49 secured together by rod 50 extending through a link in chain 47 (Figures 3 and 7), movable contacts 48 being urged outwardly by springs 51 within cups 49. In diagrammatic Figure 8, fixed contacts 21 and movable contact 48 which engages them are shown offside or out of alignment with the belt or chain 47 for the sake of convenience of illustration only.

Step by step movement of belt or chain 47 is effected each time solenoid 32 is energized, by means of the mechanism which will now be described. Upper transverse shaft 45 journaled upon the upper end of blade member 44 carries a

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toothed ratchet wheel 56 keyed thereto in spaced relation to its sprocket wheel 46 and adjacent to guide rod 38 extending from armature 33. Rod 38 is longitudinally recessed as best shown in Figures 4 and 5, to receive a pawl 57 pivotally mounted at 58 at the lower end of rod 38. A leaf spring 59 in the recessed portion of guide rod 38 urges pawl 57 outwardly to engage the teeth on the ratchet wheel 56. Pawl 57 has an extension 57a which engages a stop 60, formed on the inner side of the rod slot, when the armature 33 has reached the end of its upward movement as shown in Figure 4, thereby momentarily locking the ratchet wheel from further movement in either direction, and at the same time another spring-pressed detent or pawl 62 carried on the head 40 at the opposite side of ratchet wheel 56, engages a tooth on the latter to prevent reverse rotation of ratchet wheel 56 and its shaft 45 when armature 33 returns to its lowermost position as shown in Figure 3, under the action of spring 34, to engage the next tooth on ratchet wheel 56. In its uppermost position as shown in Figure 4, a movable contact 64 on a supporting spring arm 65 attached to the upper side of armature cross bar 36 engages a stationary contact 66 supported on the lower end member of the solenoid, said stationary contact being connected through a conductor wire as shown diagrammatically at 67 in Figure 8, to an intermediate tap of the solenoid coil 32.

The lower end of the solenoid coil is connected to ground by way of ground wire 68 and the upper end thereof connected through conductor 69 to the terminal 72 which in turn is connected to the cable conductor 16 within the cable head.

The various parts of the upper or actuating head portion D of controller B are held in assembled relation by suitable means, such for example, as bolts or rods 70 extending longitudinally through the flanges of head members 30 and 31, spacers 41 and 42, and into head end member 40. Controller B is assembled by inserting the lower end of extension or blade 44 into the axial opening in sheath portion C until its lower head end member 40 engages the upper flanged end 17a of frame 17, at which time the projecting end of guide rod 37 on armature cross bar 36 is received in opening 29 (Figure 9) in upper frame end 17a while guide rod 38 is received in opening 28a connecting with the larger opening for blade 44. Controller B is now completely assembled and portions C and D may be secured to each other in any desired manner. In some instances the bolts or rods 70 are utilized for this purpose by screwing them into threaded holes 71 therefor in upper flanged end 17a of frame 17. Controller B now fully assembled as shown in Figures 2 and 3 is ready for insertion and use in a gun perforator such as illustrated at A in Figure 1.

The operation of the controller will be clear from the diagrammatic showing of Figure 8. With the gun perforator A in place in the well and ready for use the operator on the ground level closes switch or key K which completes the electrical circuit from source E through the conductor cable 16 in cable 10, terminal 72 and through conductor 69 to solenoid coil 32 and thence in return through the ground 68 thereby energizing the solenoid. Armature 33 is thereby raised, lifting cross bar 36 and guide rod 38 so that pawl thereon rotates ratchet wheel 56 counterclockwise one step. This turns upper shaft 45 and sprocket 46 sufficiently to move chain 47

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until movable contact 48 thereon engages the first fixed contact 21 in insulated members 48 and 19. At the instant of completion of the upward movement by armature bar 36 as shown in Figure 4, contact 64 thereon engages contact 66, thereby closing the circuit from the solenoid tap connection 67 through the ratchet mechanism, chain 47, contact 48 and said first fixed contact 21 to the fusible wire within charge 12 connected thereto, and thence return through ground to the source E, thus firing the first charge. Release of key K by the operator breaks the circuits, whereupon solenoid is deenergized and armature 33 is forced down by spring 34 to its lowermost position as shown in Figure 8. At each subsequent closing of key K, the ratchet mechanism is actuated one step thereby advancing the chain 47 sufficiently to cause movable contact 48 to engage the next successive fixed contact 21 and fire another charge 12.

From the above it will be apparent that the present invention provides a novel controller for gun perforators which is of great practical value because of its simple and rugged construction and more particularly because it occupies little space while providing for selective control and individual firing of a large number of shots so that the perforating of a well casing can be completed with a single gun perforator in a single operation. A controller for seventy-five shots is very compact, being only 16 inches overall length, due to the double row of fixed contacts on each side of the endless belt or chain which carries the movable contacts, thus there are two rows of eighteen contacts each and two rows of nineteen contacts each, plus the contacts placed around the lower rounded end of the chain. A controller for a still larger number of shots is merely somewhat longer. Due to the use of the endless belt and firing from alternate sides or insulating members the movement of the belt or chain between shots can be slight but the fixed contacts on each insulating member are adequately spaced from one another. Mounting the fixed contacts longitudinally of the controller reduces its lateral dimensions to a minimum so that the use of multi-shot controllers of the disclosed type is not hampered when casings of small diameter are to be perforated. An important feature of the invention is its manufacture and assembly in two parts—a sheath portion which includes fixed contacts and wiring to the shots or detonating charges so that this portion may be made a fixed or permanent part of the gun body—and an actuating head and switch blade portion on which is mounted all the operating mechanism. The latter portion or control unit is readily removable for repairs and can be used with several sheath portions while the gun bodies therefor are being reloaded and rechecked.

While the invention has been herein disclosed in what is now believed to be a preferred form, it is to be understood that the invention is not limited to the specific details thereof but covers all changes, uses, adaptations, and modifications within the scope of the appended claims.

What is claimed is:

1. In a multi-shot controller for electrically igniting a plurality of perforating gun charges: an elongated hollow open frame having open sides; insulating members closing the sides of said frame, said members providing a channel and having longitudinally extending rows of stationary electrical contacts adjacent said stationary channel, each of said contacts adapted to be elec-

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trically connected to separate ignition means of perforating charges in a gun body; an endless flexible element extending through and movably supported within said channel and having means attached thereto sequentially to make electrical contact with said contacts upon movement of said element in said channel to fire the charges connected thereto; and means for effecting successive movement of said element successively to engage said contacts with said means to control the firing of said perforating charges.

2. In a multi-shot controller for electrically igniting a plurality of perforating gun charges: an elongated hollow frame having open sides; insulating members closing the sides of said frame, said members providing a channel and having longitudinally extending rows of stationary electrical contacts adjacent said channel, the contacts in the rows on one of said insulating members being longitudinally staggered with respect to the contacts in the opposing rows on the other of said insulating members, each of said contacts adapted to be electrically connected to a separate ignition means of a plurality of perforating charges in the gun body on which the controller is mounted; an endless flexible element extending through and movably supported within said channel and having means attached thereto sequentially to make electrical contact with said stationary contacts upon movement of said element in said channel to fire the charges connected thereto; and means for effecting step-by-step movement of said element through said channel.

3. A multi-shot controller for electrically igniting a plurality of perforating gun charges comprising in combination: an elongated hollow frame with open sides; insulating members closing the sides of said frame, said members providing a channel and having adjacent said channel longitudinally extending rows of stationary electrical contacts, each contact adapted to be electrically connected to separate ignition means of perforating charges in the gun body on which the controller is mounted, said frame and said insulating members forming a sheath; and a control unit having an extension insertable within said channel between said insulating members of said sheath and having electrical contact means for successively engaging each one of the stationary contacts on said insulating members in sequence to fire the charges in the gun body.

4. A multi-shot controller for electrically igniting a plurality of perforating gun charges comprising in combination: an elongated sheath of insulating material providing an axial channel, and a plurality of rows of stationary electrical contacts adjacent said channel, each of said contacts adapted to be electrically connected to separate ignition means of perforating charges in the gun body on which the controller is mounted; and a control unit having an extension slidably inserted into said channel, an endless chain movably mounted on said extension and extending through said channel, and electrical contact means on said chain for successively engaging separate contacts of said rows of stationary con-

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tacts in sequence to fire the charges in the gun body.

5. A multi-shot controller for electrically igniting a plurality of perforating gun charges comprising, in combination, an elongated hollow frame with open sides; insulating members closing the sides of said frame, said members providing a channel and having longitudinally extending rows of stationary electrical contacts adjacent said channel, said contacts adapted to be electrically connected to separate ignition means of perforating charges in the gun body on which the controller is mounted, said frame and insulating members forming a sheath; and a control unit having an extension to be slidably inserted within said channel between said insulating members of said sheath, an endless flexible element movably mounted on said extension and extending through the said channel, electrical contacts on said element separately to engage each of the contacts of the rows of stationary contacts on said insulating members thereby successively to fire the charges in the gun body, and remotely controlled means for effecting movement of said endless flexible element.

6. A multi-shot controller for electrically igniting a plurality of perforating gun charges comprising: a sheath portion and a control portion in telescoping engagement with each other, said sheath portion providing an insulated channel of substantial longitudinal extent and a series of spaced contacts fixed along the sides of said channel and adapted for connection to ignition means of perforating charges in a gun body, said control portion having an extension in the form of a blade fitting said insulated channel of said sheath portion, a flexible element mounted on said extension for movement longitudinally thereof and having at least one electrical contact for separately engaging said spaced fixed contacts, and means on said control portion for effecting step-by-step movement of said flexible element.

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