

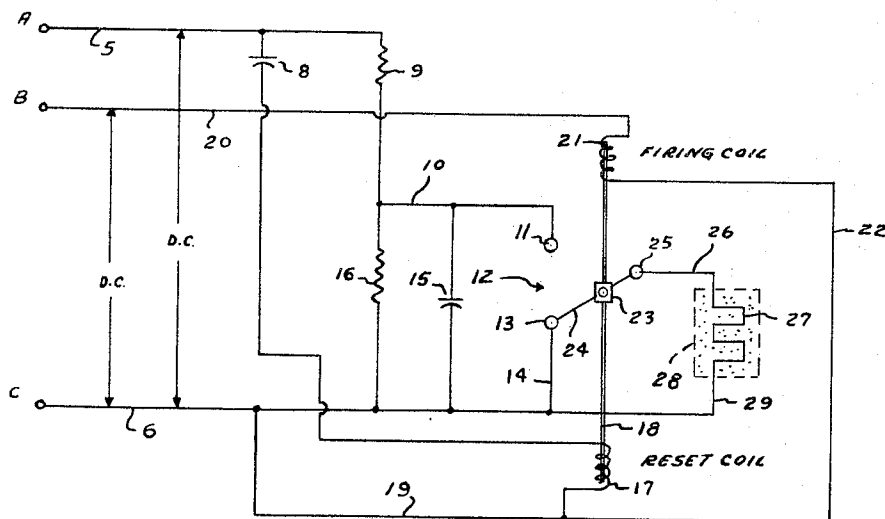
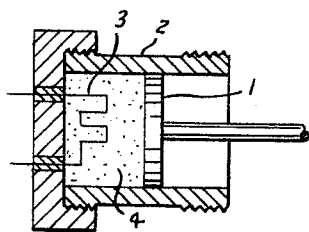
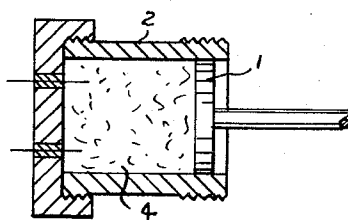
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ARMING AND FIRING CIRCUIT

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ARMING AND FIRING CIRCUIT

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ABSTRACT OF THE DISCLOSURE

The invention relates to a system for first arming and later firing an explosive squib by means of a pair of circuits including a rotary switch and which are separately energized. The switch is moved to the arming or "reset" position by the application of voltage to one of the circuits to charge a condenser and thereby to energize the "reset" coil of the switch. At the same time, a second or "firing" condenser is also charged which is later used to fire the squib. Furthermore, a short circuit is connected at this time across the squib to prevent premature firing.

The switch is rotated to the firing position by the application of voltage to the other said circuits which serves to connect the previously charged condenser to the squib and simultaneously to remove the short circuit.

Reapplication of the voltage to the first-mentioned circuit rotates the switch to the original "reset" position to recharge the "firing" condenser and short circuit the squib.

The present invention relates to a system and procedure for firing mild explosive fuzes, primacord, or other linear explosive trains.

Fuzes or squibs are employed in industry for many purposes. They serve as a miniature explosion initiator, the force of which can cause the detonation of a much larger explosive charge, as in missiles and space exploration. They can also be used to provide the initiation of movement in remotely controlled mechanisms, such as the release of bombs from their racks in airplanes, also, in propellant-actuated escape mechanisms and the release of superfluous appendages from a space capsule about to re-enter the earth's atmosphere.

The most important requirement of an explosive squib and its electrical circuit is to be able to respond instantly and without fail to a firing signal. It must also be completely foolproof as to when it is to be fired. A fuze or squib essentially is a dangerous device but highly useful in that it can provide remote control through its explosive function of a second explosion which may be many times greater than the initial discharge. The danger lies mainly in the accidental discharge of the squib or failure to provide the proper amount of electrical stimulus when the fire signal is given. This could bring about disastrous results.

The primary object of the invention is to provide an improved circuit and structure for initiating the discharge of an explosive fuze or squib which performs a detonation or work function. This improvement is featured by a low current drain, maximum safety and high reliability of initiation.

Another object is to prevent the accidental explosion of a squib by requiring two separate and independent operations, both of which must be performed in a particular sequence.

Still another object is to provide an arming and firing sequence of squibs in which these functions are initiated by separate circuits, in one of which a condenser is charged, and the other serves to discharge the condenser through the squib.

A further object is to provide an improved circuit and structure for exploding a fuze or squib and in which the

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arming circuit is separated from the firing circuit in such a way that the fuze is prevented from exploding, in the event the firing circuit is accidentally applied prior to the arming circuit.

Another object is to provide an improved circuit arrangement for achieving a high reliability initiator of an explosion, operated by arming and firing signals, the system as a whole requiring the minimum current drain.

Still a further object is to provide an arming circuit for a squib and in which the charge on the condenser which provides the firing stimulus is allowed to drain off, when and if, the squib is not fired almost immediately after the condenser has been charged so as not to leave the system inadvertently armed. But by regulating the "drain-off" circuit, it is still possible to cause the condenser to retain its charge for reasonable periods of time so as to place the squib in a "ready" condition.

The final object is to provide a squib firing circuit which is completely insensitive to radio frequency or other extraneous signals.

The above objects are attained in brief by dividing the activation of the squib into two separate and distinct manipulations, the first, to prepare an arming circuit for the squib and second, to cause the squib to be fired by a charge produced in the arming circuit. The two circuits by which these separate operations are accomplished are interrelated, but so arranged that they must be separately energized in a precise order, but not necessarily immediately following one another.

The invention will be better understood when reference is made to the following description and the accompanying drawings in which:

FIG. 1 represents a diagrammatic view of the improved system and associated structure including a typical showing of a squib;

FIG. 2 illustrates in section, but partly in elevation, a broad and exemplary use of a squib; in this case, to move a work piston; and

FIG. 2a indicates a manner in which a piston is moved to perform work when the squib is fired.

Charge initiation elements, commonly called squibs, find many uses in industry for initiating or remotely controlling mechanical movements, all of which rely upon the tremendous pressure built-up in a confined space when the squib is fired. The latter contains powder of various mixes and grades depending upon the character of the explosion desired, and the powder is ignited electrically by a so-called "bridge wire" which constitutes a heated resistance.

Another form of squib is the detonating type in which the explosion is practically instantaneous and the products of the explosion are caused to detonate charges of dynamite as used in mines, demolition work, excavations, etc.

FIGS. 2 and 2a show the use of the "slower" type of explosion within a squib in which a piston 1 is caused to move from left to right within the cylinder 2 when the heater 3 of the squib, surrounded by the powder 4, is fired. The cylinder is screw-capped at one end and the other end is threaded for attachment to a support. The movement of the piston rod has multifarious uses, such as causing the actuation of a pilot ejection seat, the release of bombs from racks, a ground release for parachutes carrying cargo, and the release of superfluous parts from the exterior of a capsule about to re-enter the atmosphere.

As stated hereinbefore, my invention contemplates electrically separate circuits, one of which is conditioned ready for firing, and the other for actually firing the squib.

Arming circuit

Referring to FIG. 1, the circuit employs a line conduc-

tor 5 leading from a terminal A, the other side of the circuit being represented by a return wire 6 leading to a terminal C. A condenser 8 is connected across the conductor 5 and the wire 6. A resistor 9 is connected between the line 5 and a conductor 10. While this resistor is only of about 100 ohms, it is nevertheless high enough relative to the resistance of the squib to limit the firing current through the squib, as explained hereinafter, to a safe value. The end of the conductor 10, remote from the resistor 9, connects with the upper contact 11 of a switch, generally indicated at 12. The lower contact 13 of the switch 12 is connected to the wire 6 by a short conductor 14. A condenser 15 is connected between the conductor 10 and the return wire 6. There is a relatively high resistance 16 leading from the conductor 10 to the return wire 6, so that the resistors 9 and 16 are effectively in series. A coil 17, designated a "reset coil," and forming part of the operating structure of the switch 12, is taken at one end from a condenser 8 which is connected to the conductor 5. The lower end of the coil 17 is connected through the conductor 19 to the return wire 6. An armature or movable core 18 passes through the coil.

It is apparent that when a voltage, for example, 28 volts D.C. is applied between the terminals A, C, the condenser 15 charges through the resistor 9, while the condenser 8 is charged direct from the line 5. The capacitor 8 passes transient of current through coil 17 to reset switch 12 as will appear hereinafter. The condenser 15 maintains its charge for sufficient time to permit normal operation of the firing circuit but not so long as to have the circuit inadvertently armed. This time would be determined by the leakage characteristic of the resistance 16, after the voltage has been removed from the terminals A and C. Thus the reset coil 17 is energized and the switch 12 moved to its lower position (FIG. 1) whenever a voltage is applied to the terminals A, C, and will remain in this condition even though the voltage is removed, as long as a sufficient charge remains in the condenser 8.

Firing circuit

The firing circuit which actually causes the squib to explode starts out with the terminals B, C. A line conductor 20 is taken from the terminal B to the upper end of a coil 21, termed a "firing coil." The lower end of the coil is connected through conductors 22, 19 to the return wire 6 back to terminal C. Thus, when a voltage, for example 28 volts DC, is applied to terminals B, C the upper coil 21 is energized which causes the armature 18 to move upwardly. The armature carries a movable swivel member 23 to which is connected a metal blade or strip 24 adapted to swing about an anchor swivel 25. The latter is connected by conductor 26 to one end of a bridge wire 27 which is embedded in an explosive powder to form the squib, generally indicated at 28. The other end of the bridge wire is connected by conductor 29 to the return wire 6. Thus, when the coil 21 is energized and the armature 18 caused to move upwardly, the blade carried by the armature will leave the contact 13 and make connection with the contact 11. This will cause the charged condenser 15 to discharge directly into the bridge wire 27 to heat the same and cause the squib to explode. As pointed out hereinbefore, this explosion can be used for many purposes, both for detonation (fast response) or a slower controlled form of explosion, i.e., gas expansion as used in mechanical movements.

It will be noted that when the squib has been fired by energizing circuit B, C, any further energization of this circuit can not fire a second squib until the condenser 15 will have again become charged. This can occur only by having energized circuit A, C return the blade to its lower position, which, in effect, short circuits the squib and serves to remove the bridge wire from the condenser 15. Thus, there is established a safety sequence between the arming and firing operations, i.e., the squib can not be fired until after the condenser 15 has been charged.

Any accidental energization of the circuit B, C can do no harm as long as the circuit A, C has not been previously energized.

It will be further noted that the high resistance 16 controls the leakage from the condenser 15 and the value of the resistance can be predetermined to allow fast or slow leakage as may be desired. Under normal operation, the leakage is set as to cause the discharge of the condenser shortly after having reached full charge in order not to leave the system inadvertently armed.

It is also apparent that if the firing coil were independently activated by applying voltage to the circuit B, C, so as to place the blade 24 on the contact 11, no harm would be done because the condenser 15 will not have been charged. Moreover, the latter could not be charged until the arming circuit A, C had been first energized. Thus, the system is rendered foolproof.

The squib is rendered practically immune from extraneous radio frequency signals because of the fact that during any period of waiting before the squib is to be fired, the latter is effectively short-circuited at the lower position of the blade 24 and this condition tends electrically to isolate the squib from extraneous disturbances. Moreover, any currents induced by extraneous electrical effects in the coil 17 would merely continue to hold the blade 24 in its lower "safe" position. Any currents induced in coil 21 would merely move the blade upwardly which again could cause no harm because the condenser 15 will not have been charged in the absence of having first energized the circuit A, C.

The connections (not shown) by which the proper voltage can be selectively applied to the terminals A, C and B, C may constitute a double-throw manually operated switch connected to a 28-volt battery or, if desired, any suitable form of double circuit time delay switch could be employed.

These terminals may also form part of a plug-in device (not shown), the sockets of which connect with remotely positioned sources of energy and suitable switching devices.

From the foregoing, it is evident I have disclosed a safety system for exploding squibs or detonators in which no explosion will take place until both the arming and firing circuits will have been energized, and furthermore, the energization of the arming circuit must precede that of the firing circuit. No other sequence is possible so that the circuit as a whole, provides a maximum safety factor in dealing with a dangerous but highly useful explosive squib.

While a certain specific embodiment has been described, it is obvious that numerous changes may be made without departing from the general principle and scope of the invention.

I claim:

1. An electrical system for causing the discharge of a squib, said system including a pair of circuits requiring separately applied energization, a switch having a pair of coils which are connected respectively in said circuits, said switch having a metal blade swingable about a stationary pivot member and movable between two contacts depending upon which coil is being activated, a condenser, connected in one of said circuits and adapted to be charged when said one circuit is energized, one of said contacts being connected to one side of the condenser, the other contact being connected to the other side of the condenser and to one side of the squib, the blade member being connected to the other side of the squib, said coils being sequentially energized within their respective circuits whereby when the blade is caused to make connection with said other contact the squib is short-circuited, but when the blade is caused to make connection with the contact that is connected to the said one side of the condenser, the charge of the condenser will flow through the squib to explode the latter.

2. An electrical system causing the discharge of a squib,

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means including an arming circuit within the system, and means including a separably energizable circuit in the system for firing the squib, the first-mentioned means comprising a condenser which is charged when the arming circuit is energized, the second-mentioned means comprising a switch and an actuating coil which is adapted to move the switch from the arming circuit to the firing circuit in order to connect the charged condenser to the squib, and a second coil adapted to move the connections of the discharged condenser back to the arming circuit in order to acquire another charge and explode the squib when the switch is moved to the firing position.

3. An electrical system for causing the discharge of a squib including an arming circuit, and a firing circuit for the squib, said arming circuit including a condenser, a switching device including a plurality of actuating coils, one of said coils being connected in the arming circuit for moving the switch to a position as will short circuit the squib and permit the condenser to be charged within the arming circuit, the other of said coils being connected in the firing circuit for moving the switch to a position as will connect the charged condenser to the squib and cause an explosion of the latter.

4. An electrical system for causing the discharge of a squib, said system including a circuit *a* and a circuit *b* having a return wire in common and requiring separately applied energization, a switching device including a pair of oppositely disposed coils for moving said device between two contacts, one of said coils being connected to circuit *b* and to said return wire, the other of said coils being connected to circuit *a* and to the return wire, a conductor connecting one of the contacts to circuit *a*, the other contact being connected to said return wire and to one side of the squib, a condenser connected across said contacts, and means including said switching device and responsive to the energization of the coil connected to circuit *b* for connecting the last-mentioned condenser to the other side of the squib whereby the charge of the condenser is caused to pass through the squib to explode the same.

5. An electrical system for causing the discharge of a squib, said system including a circuit *a* and a circuit *b* having a return wire in common and requiring separately applied energization, a switching device including a pair of oppositely disposed coils for moving said device be-

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tween two contacts, one of said coils being connected to circuit *b* and to said return wire, the other of said coils being connected to circuit *a* through a condenser and to the return wire, a conductor connecting one of the contacts to circuit *a* through a resistance, the other contact being connected to said return wire and to one side of the squib, a condenser connected across said contacts, and means including said switching device and responsive to the energization of the coil connected to circuit *b* for connecting the last-mentioned condenser to the other side of the squib whereby the charge of the condenser is caused to pass through the squib to explode the same.

6. An electrical system for causing the discharge of a squib, including an arming circuit and firing circuit for the squib, said arming circuit comprising a line conductor and a return conductor, a switching device having a blade which contacts one of two terminals, a pair of coils within the respective arming and firing circuits for moving the blade from one terminal to the other when the said circuits are selectively energized, a pair of interconnected resistances connected from said line conductor to said return conductor, a conductor taken from a point between said resistances to one of said contacts, the other of said contacts being connected to said return wire and to one side of the squib, a connection including a condenser between said last-mentioned conductor and the return conductor, the end of the blade remote from said terminals being connected to the other side of the squib, whereby when the blade connects with the contact connected to the return wire, the squib is effectively short-circuited but when the blade connects with the contact to which said conductor is taken from said pair of interconnected resistances, the squib is placed in circuit with the said condenser to cause a discharge through the squib.

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