Fuzes, Igniters, and similar devices

2,768,604 Land mine fuse
3,397,635 Release device for land mines
3,698,315 Non-metallic mine pressure fuse
3,717,094 Mine fuze
3,759,181 Anti-disturbance fuze
3,768,407 Anti-disturbance delay fuze
3,844,215 Mine fuze
4,653,401 Self destructing fuse for sub-munitions to be expelled from a rocket
3,872,790 Fuze
3,613,593 Mechanical counting fuze
3,602,144 Spin attenuator structure for mechanical time fuses
5,355,801 Small caliber fuze with arming delay, second impact and graze sensitivity
4,230,042 Point detonating impact fuze
3,715,989 Impact fuze for projectiles
2,678,604 Land mine fuse
3,608,494 Time delay fuse
1,999,747 Projectile
1,665,666 Percussion fuze
3,782,288 Removable firing pin assembly munition
2,965,028 Fuze for depth charge
3,884,151 Detonator for land mines
1,548,693 firing mechanism for pyrotechnics and the like
3,988,989 High pressure, electrically initiated explosive igniter
3,754,511 Fuel and fuel igniter for ram-jet and rocket
3,054,351 Igniter
5,088,412 Electrically initiated time-delay gas generator cartridge for missiles
3,078,799 Delay system
2,682,221 Priming device for liquid oxygen explosive cartridges
3,272,127 Igniter squib
3,257,947 Shock focusing explosive initiator
3,181,463 Explosive device containing charge of elongated crystals and an exploding bridgewire
3,160,097 Molybdenum trioxide-aluminum explosive and exploding bridgewire detonator therefor
3,906,858 Miniature igniter
3,899,974 Electric propulsive charge igniter
3,828,677 Electric ignition element with secondary ignition capability
3,710,719 Detonator for an explosively operated connector
3,295,446 Electric primer
3,125,025 Pyrotechnic igniter
2,696,191 Electrically operated primer
3,351,015 Explosive activator

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LAND MINE FUSE

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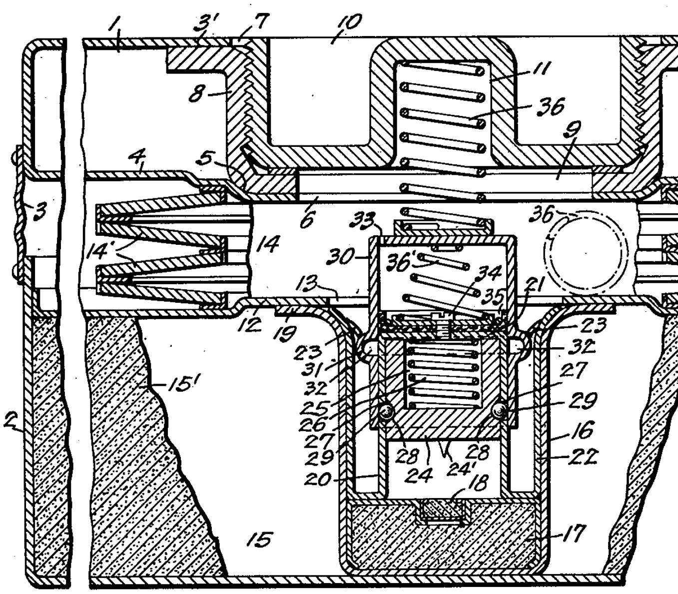

Fig. 1

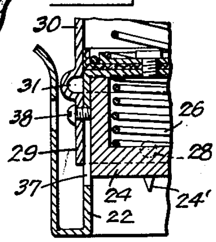

Fig. 2.

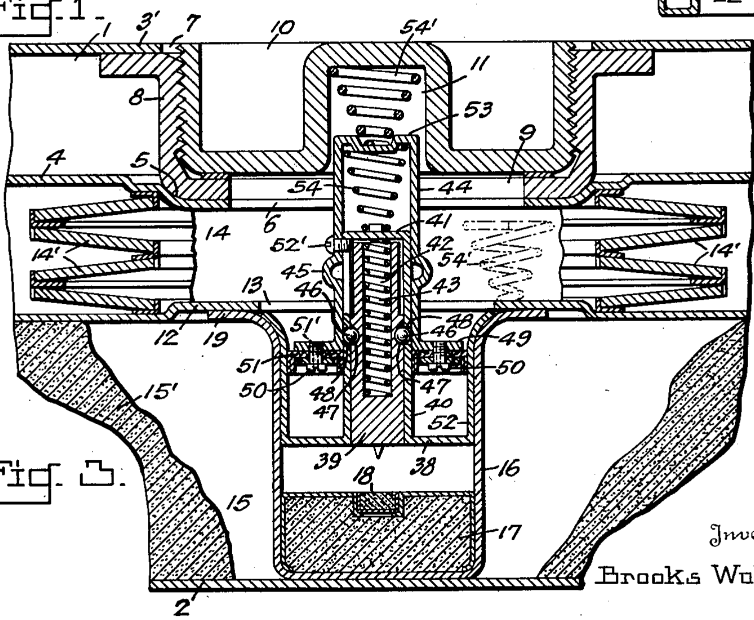

Fig. 3.

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LAND MINE FUSE

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Fig. 4.

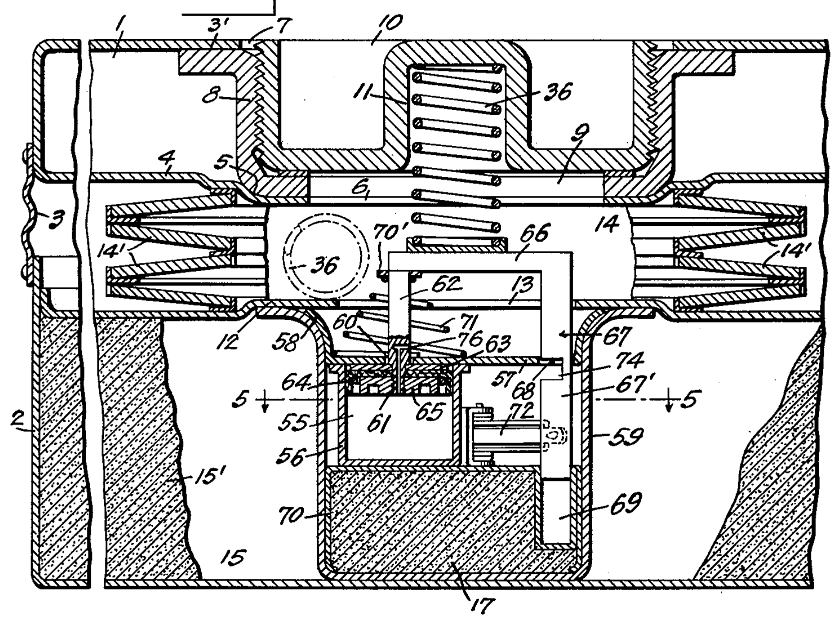


Fig. 5.

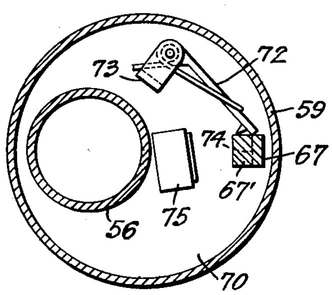
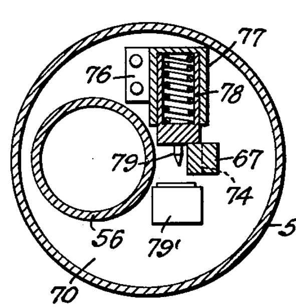


Fig. 6.



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[redacted]

groove 32 into which the balls are crowded at the time of the explosion of the mine, and at no other time, for reasons that will appear later on. The top of the dashpot cylinder is closed with exception of a breather hole 33, and secured to the top of the housing 20 by a screw 34 is a cup-leather dashpot piston 35, between which and the top of the cylinder 30 is a conical return or elevating spring 36' normally maintaining the cylinder in raised position and adapted to return it to such position from any position it might reach in telescoping over the striker housing short of that in which the mine is operated, or short of that position wherein the balls are cammed out of the pockets in the striker and into the groove 32 in the rib 31, the pockets in the striker being inclined upwardly and outwardly as shown, to effect the camming action at the time the striker spring 26 is released.

Within one end in the dome 11 and abutting the under side of the top thereof, is the arming spring 36 whose lower end rests in a shallow cup on the top of the dashpot cylinder. This spring is the intermediary between the top and bottom sections of the mine casing and without this spring the fuse will not operate. The extent of movement of the dashpot cylinder by the arming spring, for a given force acting for a given time is governed by the size of the breather ports or apertures in the dashpot. Provided for the convenient removal and replacement of the springs is the readily detachable flexible band 3 which connects the top and bottom sections of the mine casing.

Referring to Figure 2, which is a fragmentary section of a slight modification of the dashpot cylinder and closely associated parts, the striker housing is provided with a slot 37 entered by the shank of a screw 38 carried by the dashpot cylinder to limit the upward movement of said cylinder under the influence of the return spring. These screws perform the same function as the detents 23 of Figure 1, and for better balance of movement between the parts there will preferably be a slot and screw on each side of the assembly.

In the modification shown in Figure 3, the dashpot cylinder is formed as a part of the striker housing. Its bottom is closed as indicated at 38 and its outer side walls fit snugly against the inner wall of the casing 16. In this form the striker 39 is elongated and housed in the cylindrical housing 40, the latter being open at its lower end and closed at its upper end, as indicated at 41. Like the striker in Figure 1, this striker has a bore 42 terminating short of its bottom and forming a seat for a prestressed spring 43, which bears at its upper end against the closed end of the striker housing. Telescoping over the striker housing is an operating cylinder 44, like, in many respects, the operating dashpot cylinder 30 of Figure 1. The cylinder is provided with an annular rib 45 having an annular groove therein to receive balls 46 resting normally partially in pockets 47 and partially in holes 48 in the striker housing, the arrangement, so far as these elements are concerned being substantially like their corresponding parts in Figure 1. The operating cylinder 44 has a laterally extending flange 49 at its lower end to the under side of which is secured by screws 50, a cup-leather piston 51 reciprocable in the dashpot cylinder 52. The dashpot will have appropriately sized breather holes, and in the construction illustrated in this figure these are made through one or more of the screws that attach the piston to the flange 49, as indicated at 51'. To limit the upward movement of the operating cylinder 44 relative to the striker housing, the housing is provided with a vertical groove entered by a screw 52' carried by the cylinder. This cylinder is closed at its top as at 53, and between the under side of said top and the top of the striker housing is interposed the return spring 54 functioning precisely like the spring 36' in Figure 1. Between the top of the operating cylinder and the under side of the dome 11 is the arming spring 54' serving the same purpose as the spring 36 in Figure 1.

It will doubtless have been observed that forms of Figures 1 and 3 differ mainly in the dimensions of the various parts and in the locations of the dashpots, the dashpot in Figure 1 being wholly above the striker, and that in Figure 3 being laterally disposed with respect to the lower portion of the striker, the operation in both instances being substantially the same.

The forms of the fuse shown in Figures 4, 5 and 6 differ somewhat from the other forms. In this case the dashpot is arranged eccentrically of the axis of the mine casing. It is indicated by the numeral 55 and comprises the cylinder 56, whose upper end is secured to the under side of a plate 57 whose curved peripheral flange 58 is secured to the similarly shaped flange of the outer casing 59 secured to the under side of the stationary plate 12 in the lower section of the casing. There is an aperture 60 that is eccentrically positioned in plate 57 for the passage of the threaded shank 61 of the piston rod 62, which shank passes through a disc 63 and through a flanged leather dashpot piston 64 into a member 65 between which and the disks the piston is clamped. The rod 62 extends upwardly through the central opening 13 in the plate 12 into engagement with the horizontal arm 66 of a control bar 67 whose vertical arm 67' extends downwardly through an opening 68 in the plate 57 and into a well 69 formed in the booster casing 70, in which opening and well the control rod is guided in its vertical movements.

The arming spring 36 is interposed between the arm 66, and the under side of the dome 11. A flange 70' is provided at the upper end of the rod 62 and between this flange and the plate 57 is interposed a cone-shaped spiral return spring 71.

The firing means of the fuse just above described, is of the grenade type and comprises a spring urged horizontally swingable striker 72 pivoted in a bracket 73 secured to the top of the booster charge casing. In cocked position the firing pin end of the striker engages the vertical portion 67' of the control bar, thus holding the striker cocked. Cooperating with the striker 72 is a notch 74 in the control bar, which, when said bar is depressed sufficiently, allows the striker arm to pass through it and reach the primer 75 attached to the top of the booster casing to detonate the booster charge.

In Figure 6, there is shown a modification of a firing mechanism. In this case there is a bracket 76 mounted on the booster casing and formed with an open cylinder 77 for reception of a plunger 78 carrying firing pin 79, there being a spring in the plunger urging the plunger out of the cylinder and against the control arm 67 adjacent the notch 74, and ready to be forced through the notch by the spring when the control arm has been sufficiently depressed to allow such movement. On the opposite side of the control arm from the plunger, is a primer 79' appropriately positioned relative to the booster charge to ignite the charge at the proper time.

All of the dashpots have breather holes and these are of a size to permit egress of air at a rate corresponding to the pressure exerted by the arming spring when a weight or pressure depresses the upper section of the mine casing by contact with the pressure plate 3'. In Figure 4, a hole 76 is shown drilled through the dashpot piston rod 62 and communicating at one end with the dashpot and at the other with the space above the plate 57, or with the space above the piston as the piston descends, as the case may be. It will be understood that breather holes may be located in any suitable part of the dashpot cylinders or their pistons, the idea being to permit the escape of air from the dashpot and to replace it, according to the movement of the pistons shown in the several views.

To arm the fuse and the mine, the arming spring 36 in the forms of Figures 1 and 4, and 54' in Fig. 3, must be in place between the depressible top section of the mine casing and the dashpot assemblies.

It is believed that a description of the operation of the mechanism shown in Figure 1 will suffice for the other forms, since in all of them are obvious equivalents that function in the same manner. Pressure upon the top plate 3' of the upper mine casing section will be communicated to the arming spring 36, and in a degree to the heavy spring 14'. This pressure will be communicated through the arming spring to the dashpot operating cylinder, which will be depressed against the conical return spring 36' in the dashpot, forcing the cylinder to telescope over the striker housing against the resistance of the return spring and the column of air in the dashpot. Weight applied for a shorter time duration than that for which the mine is adapted by size of its aperture, depresses the operating cylinder to a certain extent through the instrumentality of the arming spring and when such pressure is relieved the return spring 36 will return the operating cylinder to normal position, but when the weight is sufficient and applied for a sufficient time duration, the arming spring will be depressed sufficiently to exhaust all, or enough of the air from the dashpot to allow the operating cylinder to be moved down to a point where the balls in the pockets in the striker and in the holes in the striker housing come opposite the annular groove 32 in the dashpot cylinder when the striker will be released and driven by spring 26 into contact with the primer to explode the mine.

As stated, all of the dashpots have breathing ports or apertures. These will be of a size to permit egress of the air from the dashpots at a rate proportionate to the pressure exerted by the arming spring 36. The rate at which the air is let out under the pressure of the arming spring is such that the striker will not be released if the pressure plate 3' and arming spring are depressed only momentarily, as is the case while, for instance, the mine is subjected to the blast effect of an explosion. However, a long duration of pressure, such for instance as created by the passage of heavy wheels or tracks will expel enough air from the dashpot to release the firing mechanism. Any part of movement of the dashpot piston which may be caused by blast effect or other

transient force will be compensated for by the return spring.

It will be noted, therefore, that the essence of my invention resides in a means for releasing the firing mechanism of the mine in response to depression of the contact or pressure plate, which means includes a spring and a dash-pot in series. Thus, pressures of relatively short duration act only to stress the spring without substantial movement of the dash-pot elements and without releasing the striker. On the other hand, the same pressures, when acting for longer periods stress the spring and cause the dash-pot to move into position releasing the firing mechanism.

In handling the mine or in shipment, safety is assured so long as the arming springs are absent from their appropriate places, at which time the springs may be conveniently stored in the spaces between the plates 4 and 12, where they are shown in dotted lines in Figures 1, 3 and 4.

I claim:

1. In an explosive mine comprising a casing proper for the reception of the main charge and a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure contact operated element, a fuse in said casing in pressure receptive relation with said element including firing means, a dash pot comprising a cylindrical member closed at one end with the open end slidably embracing a firing means housing and interposed between said pressure plate and said firing means housing, having resilient operative connections with said pressure plate and with said firing means, means for normally locking the firing means, said locking means being responsive to dashpot movement to release the locking means only upon the application of a substantial pressure applied for a substantially predetermined delay period to the contact pressure element, and means for returning the dashpot to normal operative position from any position short of that in which the locking means is released.

2. The invention of claim 1 characterized in that there is a means for limiting the dashpot return movement from the point short of that in which the firing means is released.

3. In an explosive mine comprising a casing proper for the reception of the main explosive charge including a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a fuse in the casing proper in pressure receptive relation with said element and comprising a booster and a primer for detonating it, a dashpot comprising a cylindrical member closed at one end with the open end slidably embracing a firing means housing and interposed between said pressure plate and said firing means housing, firing means controlled by said dashpot in response to the pressure applied to said dashpot, resilient means having operative connection with the contact pressure element and the dashpot through which pressure applied to the pressure element is communicated to the dashpot, means for locking the firing means in normal position away from the primer, and means responsive only to dashpot operation beyond a predetermined distance to release the firing means, and automatic means for returning the operative dashpot element to normal position from any position short of said predetermined distance.

4. In an explosive mine comprising a casing proper for the reception of the main explosive

charge and a pressure plate yieldingly supported with respect to said casing and forming a part thereof, said pressure plate constituting a pressure contact operated element, a fuse in said casing in pressure receptive relation with said element and comprising a booster charge and a primer for detonating it, a striker housing in said casing, a striker slidable in said housing, a closed top operating cylinder telescoping over said housing and forming with said housing a dashpot, releasable means interposed between the striker and the housing to normally prevent movement of the striker toward the primer, resilient means interposed between the pressure operated contact element and operating cylinder whereby pressure applied to said element is communicated to said cylinder to move the cylinder, said cylinder acting to release said locking means only when said cylinder has been moved by said yielding means a substantially predetermined distance against the column of air in the dashpot, and automatic means for returning the operating cylinder to normal position from any position short of that position in which the striker locking means is operated.

5. In an explosive mine comprising a casing proper for the reception of the main explosive charge and a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a fuse in the casing proper in pressure receptive relation with said element and comprising a booster charge and primer therefor, a closed top striker housing in the casing, a striker slidable therein, a pre-stressed firing spring between the top of the housing and the striker, a cylinder telescoping over the striker housing and forming with the top of said striker housing a dashpot, a spring interposed between said cylinder and the pressure operated element whereby when pressure is applied to said element it is communicated to said cylinder, striker locking means carried partly by the striker, partly by said housing and normally locking the striker away from the primer, means carried by the dashpot cylinder cooperating with the striker locking means to release said locking means only when the dashpot cylinder has been moved by said spring a substantially predetermined distance against the column of air in the dashpot, and means in the dashpot for returning the cylinder to normal position from any position short of that position in which the striker means is operated.

6. In an explosive mine comprising a casing proper for the reception of the main explosive charge, a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a booster charge in the casing and a primer therefor, a cylindrical fuse casing in the casing proper, a dashpot cylinder within the fuse casing and

formed with an open bottom centrally positioned cylinder constituting a striker housing, a striker in said housing, a pre-stressed firing spring interposed between the striker and said housing, means carried partly by the housing and partly by the striker for locking the striker in normal position away from the primer, an operating cylinder telescoping over said housing and carrying a dashpot piston on its lower end within said dashpot cylinder, a spring between the pressure operated contact element and said operating cylinder whereby when pressure is applied to said element it will be communicated to said cylinder, means carried by the operating cylinder cooperating with the striker locking means to release said locking means only when the dashpot piston is moved a substantially predetermined distance by a pressure applied to the contact pressure element for a substantially predetermined delay period, and means for returning the operating cylinder and striker piston to normal position from any position short of that in which the striker means is operated.

7. In a land mine, a casing, a primer in said casing, a striker housing fixed within said casing and having a cylindrical portion, a striker guided for movement in and along said portion, a pin on said striker and adapted to contact said primer to detonate the same when said striker is moved from a first to a second position in said cylindrical portion, a dash-pot cylinder fitting over said portion, a piston fitting said dash-pot cylinder and secured to said housing, first spring means urging said striker into said second position, releasable means normally locking said striker in said first position, said locking means being released in response to movement of said dash-pot cylinder from a first to a second position, yielding means urging said dash-pot cylinder into its said first position, a pressure plate on said casing, resilient means urging said plate outwardly of said casing, and a spring interposed between said pressure plate and dash-pot cylinder, whereby said cylinder is moved to its said second and striker-releasing position only in response to a predetermined minimum force acting upon said plate for a definite appreciable time.

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Aug. 20, 1968 P. MADLENER ETAL 3,397,635

RELEASE DEVICE FOR LAND MINES

Filed March 18, 1966 2 Sheets-Sheet 1

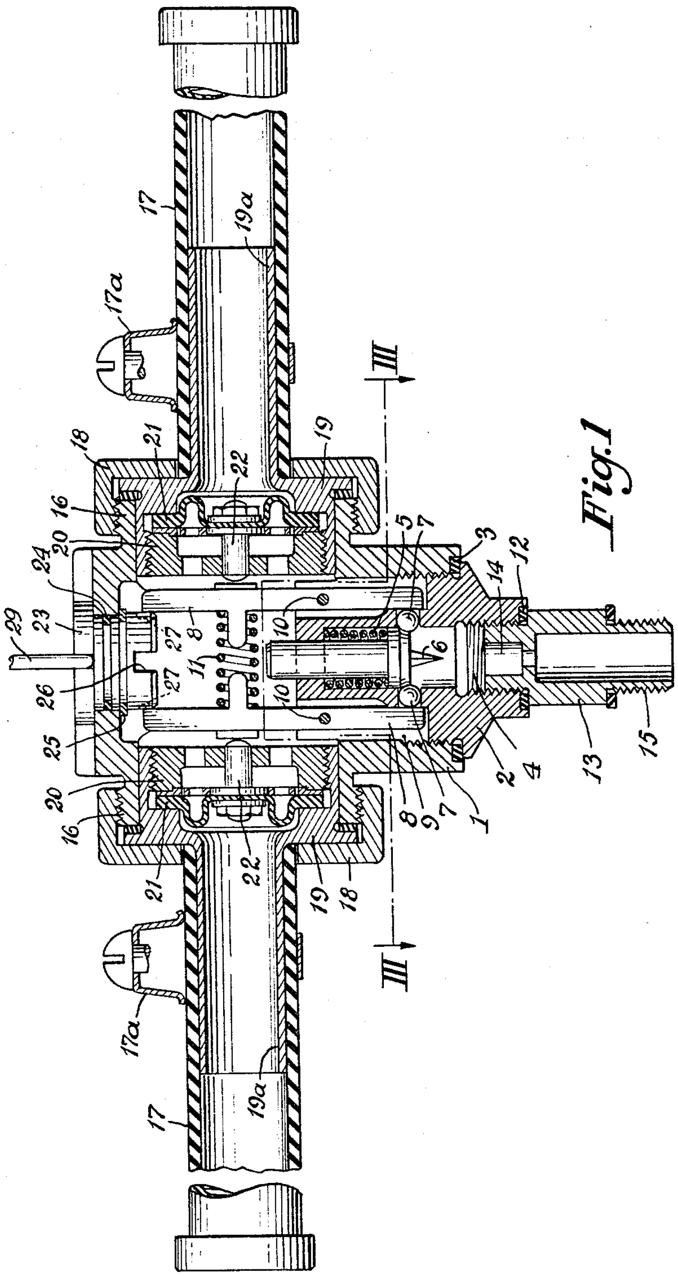

Fig. 1

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RELEASE DEVICE FOR LAND MINES

Filed March 18, 1966 2 Sheets-Sheet 2

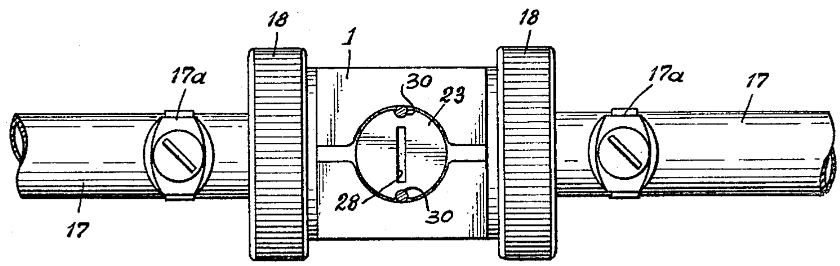

Fig.2

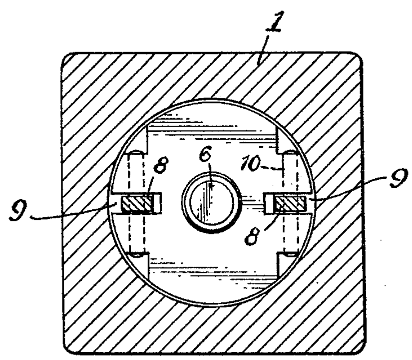

Fig. 3

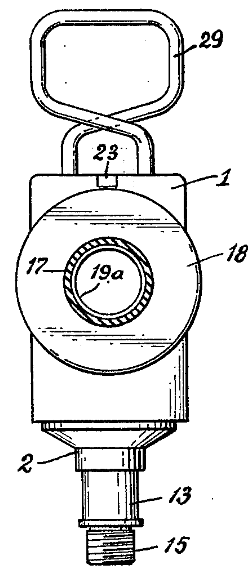

Fig.4

United States Patent Office

3,397,635

Patented Aug. 20, 1968

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3,397,635

RELEASE DEVICE FOR LAND MINES

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Filed Mar. 18, 1966, Ser. No. 538,466
Claims priority, application Germany, Mar. 27, 1965, J 27,791
5 Claims. (Cl. 102—8)

ABSTRACT OF THE DISCLOSURE

A release device for land mines in which two elastic and liquid-filled hoses extend outwardly from diametrically opposed points of a housing containing a spring actuated firing pin and two independent lever systems, both of which normally hold the firing pin in an inoperative position. Only when both lever systems are operated simultaneously by the pressure developed in both said liquid-filled hoses when a vehicle with both its tracks passes over the release device the firing pin is released.

A rotatably mounted safety member is attached to the housing above the two-lever systems and in one position prevents an operation of the lever systems which would release the firing pin and in another position permits an operation of said lever systems to release the firing pin.

The invention relates to a release device, particularly for land mines, for instance, antitank mines, in which preferably V-shaped disposed elastic and waterproof release hoses filled with a medium and entering the detonator of the mine are simultaneously put under a load for causing a change in the form of the elastic hoses which in turn actuates a system of levers by means of elastic bellows which causes an ignition of the mine.

It is an object of the invention to provide a release device which causes a detonation of the mine when the vehicle to be destroyed is directly over the mine and not on one side of the same, so that no longer an explosion of a mine without the desired result will take place. In accordance with the invention, the release device is provided with a housing containing a firing pin and two outwardly extending flexible hoses which are filled with a cold resisting fluid and closed at both ends, at one end, however, by a flexible diaphragm engaging pressure pins which in turn engage two double-armed levers pivotally mounted between their ends. These levers are urged by a common pressure spring with their shorter arms against locking balls which normally retain a spring-actuated firing pin in a tensioned position. Only when both flexible hoses are simultaneously subjected to a load, such as the two endless traction chains of an armored tank or other vehicle, both locking balls are simultaneously released by the two levers actuated by the fluid pressure actuated diaphragms and the bolts connected therewith. These bolts move the levers against their common pressure spring, so that the levers release the locking balls, so that the firing pin is propelled against a fuse thereby effecting a detonation of the mine connected with the fuse.

The invention provides that a detonation of a mine, such as an antitank mine, takes place only in the event that two release-causing flexible hoses are subjected at the same time to a pressure which should be great enough tö cause an increase of the pressure of the fluid in the hoses. If only one hose is subjected to such a pressure, a detonation of the mine connected with the release device of the invention does not take place. The vehicle or tank must be positioned directly over the mine to cause an explosion of the latter. If the vehicle is moving only over

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one flexible hose, namely laterally to one side of the mine, the latter does not explode. Ordinary walking persons, animals or flying rocks will not cause the mines to explode. In fact, a mine field, whose mines are equipped with release devices of the invention, may without danger be entered and traversed by individual persons or even by troops marching in a line.

The invention will now be described in greater detail with reference to the accompanying drawings which illustrate by way of example one embodiment:

In the drawings:

FIG. 1 illustrates a sectional view of the release device including the detonator;

FIG. 2 illustrates a top elevation view of the same;

FIG. 3 is a cross-sectional view along the line III—III of FIG. 1; and

FIG. 4 is a view of the release device in a reduced scale.

Referring to the drawings, the detonator housing **1** has screwed into its lower portion a support sleeve **2** with a sealing ring **3**. The bore **4** of the sleeve **2** contains a firing pin **6** biased by a helical spring **5** and resting upon two locking balls **7**. These balls **7** are engaged by the lower ends of two vertically arranged double-armed levers **8** which project into recesses **9** of the support sleeve **2**, and in the latter are pivotally supported between their enrs by horizontally disposed pivot pins **10**.

The upper longer ends of the levers **8** have transversely extending projections for receiving the ends of a horizontally disposed helical pressure spring **11** which tends to move the upper ends of the levers **8** apart, so that the lower ends of the levers **8** are urged against the balls **7** and retain the same in their locked position. A tubular ignition cap **13** containing a fuse **14** is screwed into the lower end of the support sleeve **2** with a sealing ring **12** arranged between these parts. The lower end of the cap **13** has an exterior thread **15** for connection with a mine.

The detonator housing **1** is provided with two oppositely disposed connecting nipples **16** on which flexible pressure hoses **17** are attached by means of screw collar rings **18**.

The outer end of the two flexible pressure hoses **17** are closed and sealed in any suitable manner. The inner end of each hose facing the housing **1** is provided with an insert **19** into which is sealingly inserted by means of a pressure member **20** a diaphragm **21**. These diaphragms **21** carry in their center a pressure bolt **22** which is guided in a bore of the pressure member **20**. The hoses **17** are additionally secured to tubular extensions **19***a* of the inserts **19** by conventional hose clamps **17***a*.

In the head or upper portion of the detonator housing **1** is rotatably mounted a safety button **23** which by a sealing ring **24** is sealed against the housing **1** and by means of a spring ring **25** is held in place. The inner end of the button **23** is provided with a transverse slot **26** which is somewhat wider than each one of the levers **8**. Perpendicularly to this transverse slot **26**, the outer circumference of the button **23** is provided with two shallow grooves **27** which also are wider than the levers **8**.

The upper face of the safety button **23** is provided with a transverse groove **28** having a width substantially of that of a coin.

The operation of this device is as follows: When a vehicle, such as a tank, having endless traction belts or traction wheels moves over the device in such a manner that both flexible hoses **17** are depressed simultaneously by the same load which is sufficient to depress the hoses, then the fluid which is in these hoses causes a flexing of the diaphragms **21** and the latter move the bolts **21** against the levers **8** which are then moved against the pressure spring **11** and are pivoted about the pivot pins **10**. This has the result that the lower ends of the levers **8** release the locking balls **7** which are displaced laterally and release the firing pin **6** which by means of the tensioned spring **5** is propelled against the fuse **14** and initiates the detonation of the mine. In the event, however, that only one of the two flexible hoses is subjected to the load or pressure of a vehicle, which is the case when the mine lies adjacent to one side of the vehicle, then only one diaphragm **21** and bolt **22** and only one lever **8** is actuated. According only one of the two locking balls **7** is released, while the other one retains the firing pin **6** in locked position and no release of the firing pin **6** takes place. If the pressure upon one of the flexible hoses **17** abates the respective diaphragm **21** returns to its initial position, the previously actuated lever **8** under the action of the spring **11** also returns to its initial position in which the locking ball **7** is again held in its firing pin locking position.

A safety locking of the device against accidental release is accomplished by rotatably adjusting the safety button **23** with a coin which with its edge is inserted into the transverse slot **28**. The button **23** is rotated until the slot **26** is disposed transversely to the levers **8**. Thereupon the two lower ends of a safety hoop **29** may be inserted into the marginal recesses **30** of the button **23**. If now the flexible hoses **17** are subjected accidentally to a load, the upper ends of the levers **8** which, as shown in FIG. 1, abut the outer circumference of the button **23** and are unable to pivot about their pivot pins **10**. In fact, the upper ends of the levers **8** which enter into the shallow gooves **27** in the button **23**, so that the latter cannot be rotated, if an attempt is made under these conditions.

If, however, the button **23** is in its "Fire Position" the transverse groove **26** is in alinement with the upper end of the levers **8**. When now both hoses are subjeted to a sufficient load, the levers **8** can center the groove **26** and the mine is detonated.

For practice purposes with blank mines, the release device of the invention may be used again and again, namely any desired number of times. A released or "fired" device may be tensioned again by pressing the upper ends of both levers **8** together, after previously having removed the flexible hoses **17** and the ignition cap **13**, and then moving the firing pin **6** upwardly, whereupon the two levers **8** are released, so that they move the balls **7** toward the firing pin **6** thereby holding the latter again in a locked position.

What we claim is:

1. A release device, particularly for the ignition of land mines, including a housing, two flexible waterproof hoses filled with a cold resisting fluid medium extending from opposite sides of said housing outwardly and closed at both of their ends, means operable by the closed inner ends of said hoses to cause the release of a spring-actuated firing pin when both hoses are simultaneously deformed by a pressure acting upon the same, said means including a diaphragm at each inner end of said hoses, two independent lever systems within said housing one for each of said diaphragms and adapted to be operated by the latter, two locking members arranged between said firing pin and said two lever systems, a common pressure spring for normally holding said lever systems in a position in which said firing pin is locked by said two locking members in an inoperative position, said firing pin being released when said two diaphragms are sufficiently flexed at the same time to operate said two lever systems and move the same against the action of said common pressure spring.

2. A release device according to claim **1**, in which each one of said lever systems comprises a double-armed lever pivotally mounted between its ends to form a long arm and a short arm, said long arm being engaged by one end of said common pressure spring, while said short arm engages a ball-shaped locking member engaging said firing pin.

3. A release device according to claim **1**, including a rotatably mounted safety member attached to said housing above said two-lever systems therein, said safety member having a transverse slot which in one position permits an operation of said lever systems so as to cause a release of said firing pin and in another position of said safety member, the same prevents an operation of said lever systems and thereby retains said firing pin in its locked position.

4. A release device according to claim **1**, including a tubular insert in each inner end of said hoses, means for removably attaching said inserts in a horizontal position to diametrically opposed portions of said housing, means for mounting said diaphragms in said inserts, and a centrally arranged pressure member on said diaphragms for operatively engaging said lever systems.

5. A release device, particularly for the ignition of land mines, including a housing, two flexible waterproof hoses filled with a cold resisting fluid medium extending from opposite sides of said housing outwardly and closed at both of their ends, means operable by the closed inner ends of said hoses to cause the release of a spring-actuated firing pin when both hoses are simultaneously deformed by a pressure acting upon the same, said means including a diaphragm at each inner end of said hoses, two lever systems within said housing adapted to be operated by both said diaphragms, said firing pin being arranged between said two lever systems, a common pressure spring for normally holding said lever systems in a position in which said firing pin is locked in an inoperative position, said firing pin being released when said two diaphragms are sufficiently flexed at the same time to operate said two-lever systems and move the same against the action of said common pressure spring, each one of said lever systems comprises a double-armed lever pivotally mounted between its ends to form two arms, one of said arms being engaged by one end of said common pressure spring, while the other arm engages a ball engaging said firing pin.

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SAMUEL W. ENGLE, *Primary Examiner.*

United States Patent

Becker

[15] **3,698,315**

[45] **Oct. 17, 1972**

[54] **NON-METALLIC MINE PRESSURE FUSE**

[72] Inventor: **Franz Becker**, Bonn, Germany

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[22] Filed: **June 13, 1969**

[21] Appl. No.: **833,025**

[30] **Foreign Application Priority Data**

Aug. 1, 1968 Germany..........P 17 71 935.6

[52] **U.S. Cl.**..**102/8**, 102/16

[51] **Int. Cl.**..**F42b 23/28**

[58] **Field of Search**.............102/8, 16, 17, 70, 79, 73

[56] **References Cited**

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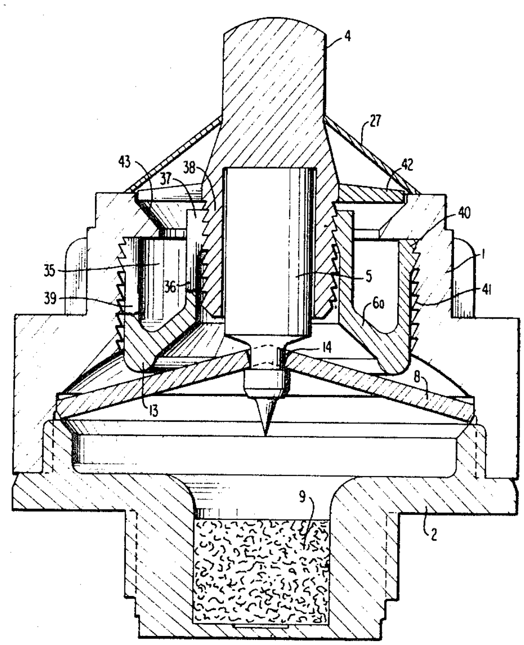
Primary Examiner—Samuel W. Engle
Attorney—Craig, Antonelli & Hill

[57] **ABSTRACT**

A non-metallic mine pressure fuse, having a housing comprising upper and lower portions secured together, a leaf spring with its peripheral surface retained between the upper and lower housing portions and its central portion projecting upwardly in the unbiased state, a percussion pin supported for axial displacement relative to the housing and retained at a central aperture provided therefor in the leaf spring so as to penetrate a percussion explosive charge in the lower housing upon flexing of the leaf spring to a downwardly projecting position, a trip member projecting from the upper surface of the housing and arranged for axial displacement relative thereto, and a pressure translating member interposed between the trip member and the leaf spring to cause a downward flexing of the spring upon an external pressure in excess of a predetermined value applied to the trip member, wherein detent means are provided to prevent restoration of the pressure translating member to its initial position prior to the exertion of a pressure of lesser magnitude than the predetermined value.

9 Claims, 1 Drawing Figure



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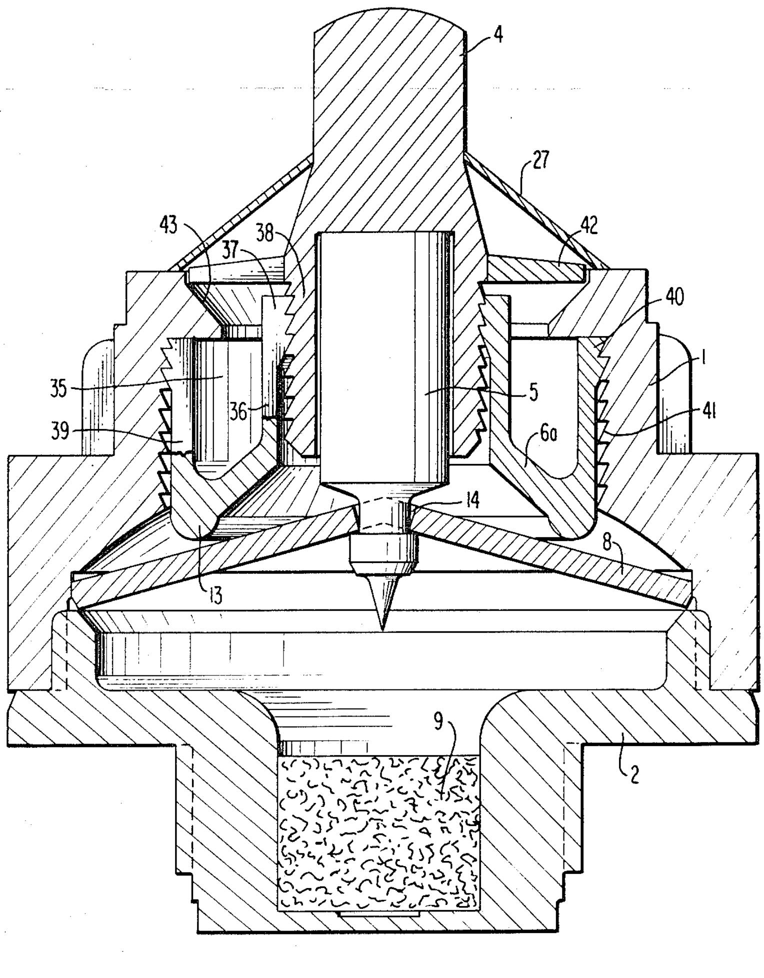

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NON-METALLIC MINE PRESSURE FUSE

BACKGROUND OF THE INVENTION

The present invention relates to a non-metallic mine pressure fuse or detonator, having a housing including upper and lower portions secured together, a percussion pin disposed, in an axially-displaceable manner, in the upper portion of the housing with its tip extending, through a leaf spring, with which it is secured for conjoint axial displacement, and a trip member projecting out of the upper portion of the housing and operatively connected with the leaf spring to cause a downward flexing of the spring, and a corresponding depression of the percussion pin into a percussion explosive charge, upon application of an external pressure, in excess of a predetermined value, upon the trip member.

In conventional non-metallic mine pressure fuses or detonators of the type described above, the percussion pin can be actuated by means of an intermediate pressure translating member causing a downward flexing of the leaf spring. This pressure or force translating member is positioned within the upper portion of the housing and adapted for axial displacement therein. At its lowermost portion, the member is adapted to engage the leaf spring by means of beads or other projections disposed so as to cooperate with the leaf spring between the peripheral rim and the center thereof. The beads or other projections are generally provided in an annular manner or in another arrangement wherein the points of contact between the pressure translating member and the leaf spring are spaced equidistant from the center of the spring.

It has been known heretofore to interpose a pressure translating member between a leaf spring and a trip or trigger member, which is guided in the upper portion of the housing by means of a conical shell or casing provided about the periphery of the trip member, which is designed to break upon application of a load or pressure in excess of a predetermined value. The trip member is preferably secured to the upper portion of the housing in a tightly sealed manner, for example, by welding or the like, along the rim of the conical casing. The shank of the percussion pin is guided within a central bore provided in the trip member.

Generally, the pressure translating member incorporates a toroidal or annular bead which engages the leaf spring during the triggering process until the tip of the percussion pin approximately impinges upon the percussion explosive charge of the detonator cap, the contact between the member and the leaf spring being precisely symmetrical about the central axis thereof. In accordance with this conventional arrangement, a precisely symmetrical bending of the spring is achieved; thus, when the spring flexes, in a snap-like manner, all portions of the spring move simultaneously, with the result that the percussion pin is depressed into the percussion explosive charge in a precisely vertical direction.

The conventional fuses described immediately above have been found to be generally satisfactory when used in conjunction with tank mines having a normal pressure lid. However, for various reasons, such as to prevent accidental detonation of a mine in the presence of extreme pressure waves, as from a nuclear explosion, alternative constructions of tank mines are often employed, wherein a rocker lid is provided in place of the

normal pressure lid. In mines of this type, the tilting or rocker lid system incorporates inherent forces of restoration which causes the lid to execute a rocking motion when passed over by a tracked vehicle, under the influence of each wheel rolling thereof. This rocking motion is translated by the central detonator system of the mine into vertical motions in accordance with a predetermined translation ratio.

When employing mines having a rocker lid, the path traversed by the peripheral or rim portion of the rocker lid, in the vertical direction, may be sufficiently large, depending upon the translation ratio, to detonate the mine when the first wheel of a tracked vehicle traverses the lid. However, if the displacement of the rim portion of the rocker lid is of a lesser magnitude than the critical value, the mine may not be detonated, even though the specific pressure forces of a vehicle passing over the lid might normally be sufficient to trigger the mine. In such cases, detonation failures may be traceable to unsuitable surface conditions, to an improperly implanted mine (in a hole without sufficiently beveled edges), or merely to a light-weight construction of tracked vehicles.

Accordingly, it is an object of the present invention to provide a non-metallic mine pressure fuse of the type described above which insures detonation even when incorporated in a tank mine utilizing a tilting or rocker lid.

Further, it is an object of the present invention to provide a fuse of the type described above which is responsive to a series of deflections each of which is of lesser magnitude than a predetermined critical value.

Finally, it is an object of the present invention to provide a fuse of the type described hereinabove which can readily be incorporated within conventional mines and detonating equipment therefore.

SUMMARY OF THE INVENTION

The foregoing objects are accomplished, in accordance with the present invention, by providing means within the fuse mechanism to accumulate the effects of a plurality of applied impulses, each of which, alone, would otherwise be insufficient for causing detonation, which means produce detonation when the total of the individual impulses exceeds the critical value. Since normal tracked vehicles include several wheels, each of which exerts a particular impulse upon a mine fuse, the present invention contemplates accumulating the total effects of the relatively small individual impulses to define an effective deflection path representing a total of the individual impulses, eventually causing detonation when the effective path exceeds the predetermined critical value.

This accumulation is accomplished, in accordance with the present invention, by providing a detent arrangement between the trip member and the pressure translating member and a second detent member between the pressure translating member and the upper portion of the housing. This double detent arrangement effectively provides for a locking of the pressure translating member in the position to which it has been depressed by an individual impulse, while permitting the trip member to resume its original position relative to the upper portion of the housing after transferring the effects of a non-critical impulse.

Thus, as the next wheel traverses the mine, the pressure pin is again depressed, the deflection being added to the deflection produced by the first wheel and fully transmitted to the leaf spring. Thereafter, the trip member is again returned to its initial position to transmit still another impulse. In this manner, depending upon the sensitivity of the locking detents provided, a desired number of incremental deflections can be totaled to achieve a final critical deflection path resulting in detonation of the mine.

It should be noted, however, that the novel arrangement contemplated by the present invention does not preclude detonation of the mine in response to the first wheel of the tracked vehicle. Thus, if a mine provided with a fuse as contemplated by the present invention is traversed by a tracked vehicle causing a sufficient deflection to traverse the required number of detents, the deflection can be fully effective to cause detonation upon the impulse of the first wheel.

Preferably, the pressure translating member is provided with an annular recess between inner and outer circumferential walls on which the locking detents are disposed, so that the annular walls can yield elastically in a corresponding manner when the trip member is displaced.

In order to enhance the restoring force of the spring, the trip member can be further supported, at the upper portion of the housing, by means of additional spring arms. Toward this end, the bearing surface for the spring arms provided on the upper portion of the housing, can be of a conical configuration.

DETAILED DESCRIPTION OF THE DRAWING

The foregoing objects, features and advantages of the present invention will become more readily apparent from a consideration of the detailed description hereinbelow, when considered in conjunction with the accompanying drawing, which is a schematic sectional view of a non-metallic mine pressure fuse constructed in accordance with one embodiment of the present invention.

The non-metallic mine pressure fuse or detonator constructed in accordance with the present invention includes an upper housing portion **1** and a lower housing portion **2**, which are threadedly engaged and sealingly cemented together. Between the upper housing portion **1** and the lower housing portion **2**, the peripheral surface of a leaf spring **8**, oriented in the direction of the upper housing portion **1**, is retained. A percussion pin **5** is retained, by its neck-like constriction **14**, by centrally-provided aperture in leaf spring **8**. A detonator cap or percussion explosive charge **9** is disposed within a recess of lower housing portion **2**. A trip member **4** is attached, by means of conical jacket **27**, to which it is glued, to upper housing portion **1**. Percussion pin **5** is disposed within a central bore provided in trip member **4**.

Between trip member **4** and upper housing portion **1**, a pressure or force translating member **6*a*** is disposed. Member **6*a*** is provided, at its lowermost surface, with a toroidal projection **13**, which can engage, in a symmetric manner, with the upper surface of leaf spring **8**. Pressure translating member **6a** is constructed as a stop member and is provided with an annular recess **35**. The annular wall **36** includes detent teeth **37** on the circumferential surface thereof facing the corresponding surface of trip member **4**. Detent teeth **37** serve to block movement of trip member **4** in the direction of percussion explosive charge **9**. Trip member **4** is provided, on its outer circumferential surface, with teeth **38** having a configuration corresponding to and adapted to engage with detent teeth **37**.

The outer annular wall **39** of pressure translating member **6*a*** is provided with ring-shaped teeth **40** on the upper circumferential surface, which teeth serve to prevent displacement of member **6*a*** in a direction opposite to the direction of detonator cap **9**. The ring-shaped teeth **40** cooperate with correspondingly-shaped teeth **41** provided on the opposing circumferential surface of upper housing portion **1**.

Additionally, trip member **4** is provided with arms, or a disk-like member **42**, which guides the trip member **4** with respect to upper housing portion **1**. The arms **42** engage within a conically-shaped recess **43** of upper housing portion **1**.

In the "ready" position of the mine pressure fuse illustrated, the pressure translating member **6a** is in its uppermost position and abuts against an annular projection of the upper housing portion, whereas the trip member **4** is in its lowermost position with respect to the engagement of its annular teeth **38** with detent teeth **37**. As individual impulses of a relatively small magnitude are applied to trip member **4**, the pressure translating member **6*a*** is, in each instance, displaced downwardly along the locking detents **41** in increments of one or more teeth, depending upon the magnitude of the impulse. Of course, member **6*a*** is effectively blocked from a return upward displacement by the cooperating teeth **40** and **41**.

The restoring force of the leaf spring, until the flexing position of the spring has been reached, operates to return trip member **4** upwardly in increments of one or more teeth so that trip member **4** is always returned to its uppermost initial position. Eventually, the addition effect of the individual impulses applied, afforded by the fuse contemplated by the present invention, results in a position being attained wherein a relatively small incremental impulse applied to trip member **4** will serve to cause leaf spring **8** to be flexed downwardly, thus permitting percussion pin **5** to penetrate into detonator cap **9**.

It should be noted that the external dimensions of a conventional fuse need not be altered by the particular construction of the pressure translating member **6a** contemplated by the present invention. Thus, the mine pressure fuse contemplated by the present invention can be incorporated, as desired, within mines provided with either a conventional pressure lid or rocker lid.

While the present invention has been disclosed with reference to but a single specific embodiment, it is to be clearly understood that the scope of the invention is in no way limited to the specific details thereof, but is susceptible of numerous changes and modifications as would be apparent to one with normal skill in the pertinent technology.

What is claimed is:

1. A non-metallic mine pressure fuse, comprising:
housing means,
leaf spring means retained, at the peripheral surface thereof, by said housing means, the central portion

of said leaf spring means projecting upwardly in the initial unbiased position thereof and defining a centrally-disposed aperture therein,

percussion pin means supported for axial displacement relative to said housing means, including means for operatively connecting said pin means with said leaf spring means for axial displacement together therewith,

detonating cap means disposed within said housing means so as to receive the tip of said pin means upon downward flexing of said leaf spring means,

trip means projecting from the upper surface of said housing means and supported for axial displacement relative thereto a distance corresponding to an applied force,

pressure translating means interposed, within said housing means, between said trip means and said leaf spring means, said pressure translating means being displaceable in the axial direction to translate a downward axial displacement of said trip means into a downward axial displacement of unretained portions of said leaf spring means corresponding to the magnitude of the force applied, and

detent on said housing and on said pressure translating means permitting the downward axial displacement of said pressure translating means relative to said housing means and precluding upwardly directed axial displacement of said pressure translating means upon removal of said force so that said leaf spring can be fixed in positions intermediate its initial unbiased condition and the position wherein said detonating cap receives said pin means whereby said fuse can be activated by the cumulation of successive forces each individually insufficient.

2. A mine pressure fuse according to claim 1, wherein said detent means includes cooperating sets of teeth provided on mating surfaces of said housing means and said pressure translating means, permitting downwardly directed axial displacement of said pressure translating means relative to said housing means, but effectively blocking corresponding displacement in an upward direction.

3. A non-metallic mine pressure fuse, comprising:

housing means,

leaf spring means retained, at the peripheral surface thereof, by said housing means, the central portion of said leaf spring means projecting upwardly in the initial unbiased position thereof and defining a centrally-disposed aperture therein,

percussion pin means supported for axial displacement relative to said housing means, including means for operatively connecting said pin means with said leaf spring means for axial displacement together therewith,

detonating cap means disposed within said housing means so as to receive the tip of said pin means upon downward flexing of said leaf spring means,

trip means projecting from the upper surface of said housing means and supported for axial displacement relative thereto a distance corresponding to an applied force,

pressure translating means interposed, within said housing means, between said trip means and said leaf spring means, said pressure translating means being displaceable in the axial direction to translate a downward axial displacement of said trip means into a downward axial displacement of unretained portions of said leaf spring means corresponding to the magnitude of the force applied, and

detent means permitting the downward axial displacement of said pressure translating means relative to said housing means and precluding upwardly directed axial displacement of said pressure translating means upon removal of said force so that said leaf spring can be fixed in positions intermediate its initial unbiased condition and the position wherein said detonating cap receives said pin means whereby said fuse can be activated by the cumulation of successive forces each individually insufficient, said detent means including cooperating sets of teeth provided on mating surfaces of said housing means and said pressure translating means and further including cooperating sets of teeth provided on mating surfaces of said trip means and said pressure translating means permitting upwardly directed axial displacement of said trip means relative to said pressure translating means but effectively blocking corresponding relative displacement in a downward direction.

4. A mine pressure fuse according to claim 3, wherein said housing means includes an upper housing portion and a lower housing portion threadedly and sealing engaged therewith, said peripheral surface of said leaf spring means being retained between said upper housing portion and said lower housing portion.

5. A mine pressure fuse according to claim 4, wherein said means operatively connecting said pin means with said leaf spring means includes a constricted portion of said pin means disposed within said aperture of said leaf spring means.

6. A mine pressure fuse according to claim 3, wherein said pressure translating means includes two annularly extending wall members defining an annular recess therebetween.

7. A mine pressure fuse according to claim 3, wherein said trip means is connected with said housing means by a conical jacket means, said trip means being glued to said conical jacket means.

8. A mine pressure fuse according to claim 7, further comprising disk-shaped bearing means of conical configuration, guiding said trip means for axial displacement relative to said housing means.

9. A mine pressure fuse according to claim 7, further comprising radially-oriented bearing arm means guiding said trip means for axial displacement relative to said housing means.

* * * * *

United States Patent [19]

Morrow

[11] **3,717,094**

[45] **Feb. 20, 1973**

[54] **MINE FUZE**

[75] Inventor: **Warren P. Morrow**, Wheaton, Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**

[22] Filed: **Dec. 3, 1962**

[21] Appl. No.: **243,193**

[52] **U.S. Cl.** ....**102/19.2,** 102/70.2 R, 102/8

[51] **Int. Cl.** **F42b 23/26,** F42b 21/34

[58] **Field of Search** .102/19.2, 70.2, 8, 7, 18, 70.2 G, 102/70.2 GA, 16

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Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—James M. Hanley
Attorney—S. J. Rotondi, A. T. Dupont and J. D. Edgerton

EXEMPLARY CLAIM

1. A pressure activated mine fuze comprising:

a. a mine casing and a pressure plate attached to said mine casing, said pressure plate free to move relative to said mine casing when a force is applied to said pressure plate,

b. an electrical signal generator attached to said pressure plate, said electrical signal generator having a lever extending therefrom, said electrical signal generator generating an electrical signal when said lever is moved relative to said electrical signal generator, said lever being caused to move by the relative movement of said pressure plate relative to said mine casing,

c. means to adjust the distance traveled by said pressure plate relative to said mine casing to cause movement of said lever, said means to adjust operable from outside said mine casing,

d. an inertia switch connected between said electrical signal generator and said detonator means, said inertial switch allowing said electrical signal to reach said detonator when the acceleration of said pressure plate is below a predetermined amount, and said inertia switch means preventing said electrical signal from reaching said detonator when the acceleration of said pressure plate exceeds said predetermined amount.

2 Claims, 3 Drawing Figures

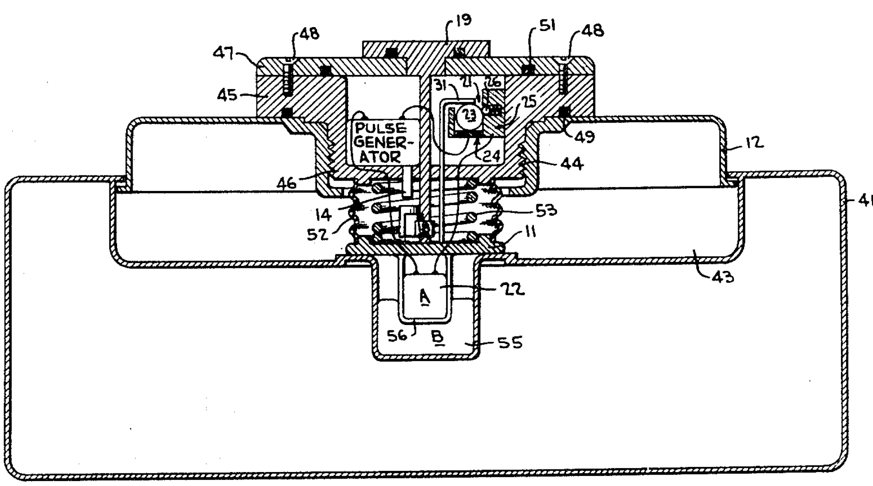


FIG. 1

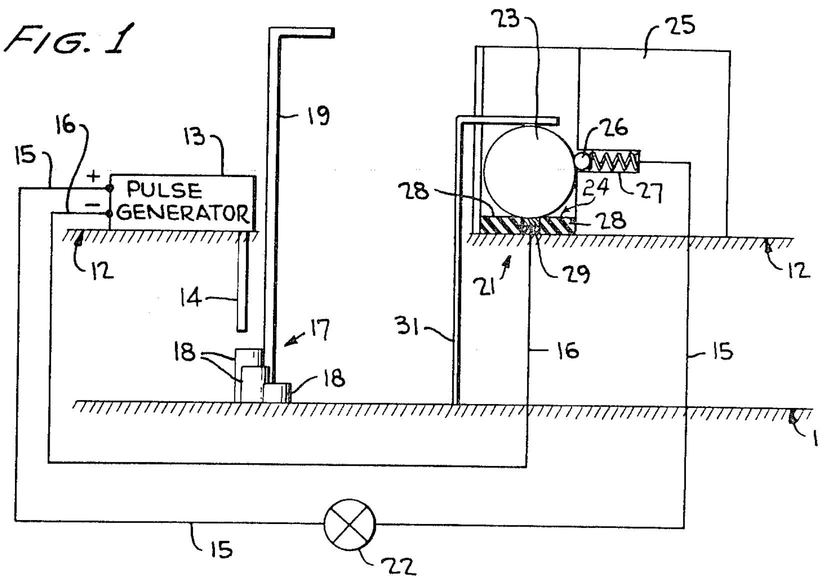
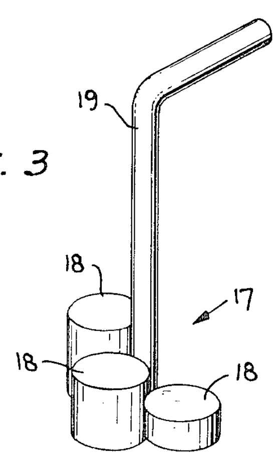


FIG. 3



INVENTOR,
WARREN P. MORROW

BY S. J. Rotondi, A. J. Dupont + J. D. Edgerton

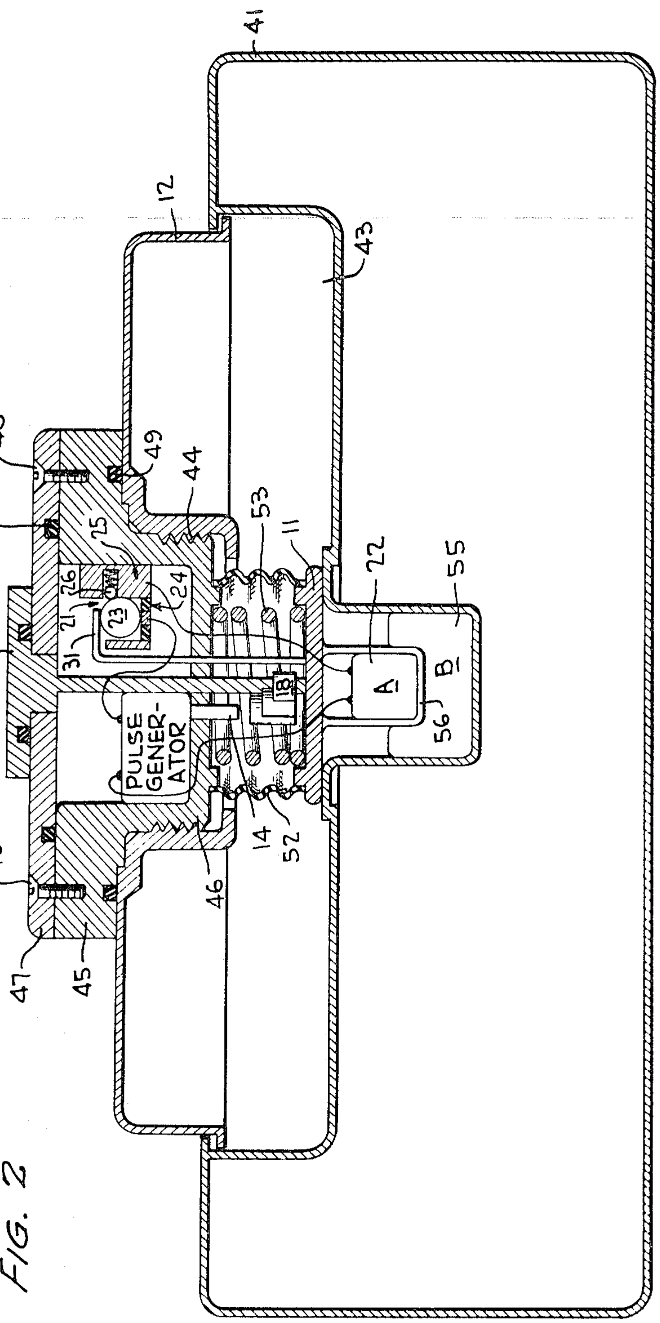

PULSE GENER-ATOR
A
B
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FIG. 2

MINE FUZE

The invention described herein may be manufactured and used by or for The Government of the United States of America for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to mine fuzes, and more particularly to a pressure actuated mine fuze.

One object of the present invention is to provide a novel pressure actuated mine fuze that will respond only to a predetermined weight or pressure built up on a mine over a considerable, and substantially predetermined, time. That is, a heavy pressure applied in short time will not explode the mine, whereas the same pressure built up over a sufficiently long time will cause detonation. With such a fuze the mine will not be exploded by the shock wave of enemy shells or bombs or by shock waves resulting from the explosion of mine clearing expedients wherein the explosive force of the expedient is used to explode the mine.

Another object of the present invention is to provide a novel pressure actuated mine fuze wherein the amount of pressure needed to actuate the fuze is easily adjustable so that personnel planting the mine field can readily adjust for the soil conditions encountered.

A still further object of the present invention is to provide a novel pressure actuated mine fuze that is relatively immune to blast pressures, and yet compact enough to be used with the World War II U. S. Army M 15 and M 6A2 land mines.

The specific nature of the invention, as well as other objects and advantages thereof, will clearly appear from the following description and from the accompanying drawings, in which:

FIG. 1 is a schematic representation showing the principle components of the fuze of this invention.

FIG. 2 is a vertical partial section showing a specific embodiment of the fuze with an M 15 mine.

FIG. 3 is a detail of an embodiment of a pressure adjusting lever.

The operation of the novel fuze of this invention centers around a combination of an inertia switch with an electrical pulse generator. Detonation, as in prior art pressure activated mines, still requires movement of a mine pressure plate. This movement is used to generate an electrical pulse which is applied to a detonator. In accordance with the teaching of this invention, an inertia switch is provided that will react to a high acceleration of a pressure plate, opening the circuit between the pulse generator and a detonator under shock conditions. Under normal stimulation, with a gradual increase in pressure and resultant slow acceleration of the pressure plate, the inertia switch remains closed, allowing firing of the detonator by the pulse generator.

In FIG. 1 there is shown the components of the novel fuze of this invention in a spread apart relation, in order to facilitate explanation. Reference numeral **11** refers to a relatively fixed base, and reference numeral **12** indicates a pressure plate which moves relative to the base **11**. Attached to the pressure plate **12** is a pulse generator **13**. The pulse generator **13** may be of the magneto type such as is shown in my application Ser. No., 862,725, now U.S. Pat. No. 3,062,071. Pulse generator **13** has a plunger or armature lever **14** and a small movement of the lever **14** causes a coil to pass rapidly through a magnetic field generating a relatively high voltage pulse on output leads **15** and **16**. The lever **14** is spring loaded, and will return to a normal rest position in the absence of an applied force.

Directly beneath the arm **14** is an adjustable striker **17**. Adjustable striker **17** is pivotally attached to the base **11**. As is more clearly shown in FIG. 3, adjustable striker **17** may be comprised of a series of steps **18**, and an arm **19** which can be accessible at the outside of the mine case. The arm **19** is pivoted on the base **11** so that turning the arm **19** rotates the steps **18**. In this manner the distance the pressure plate must move in order for the lever **14** to be actuated may be adjusted.

The output circuit of the pulse generator **13** has an inertia switch **21**, and a detonator **22** connected in series. An output pulse from the pulse generator **13** will fire the detonator **22** only when the inertia switch **21** is closed.

Inertia switch **21** is comprised of a sphere **23**, resting upon but not attached to a platform **24**. The platform **24** is attached to the movable pressure plate **12**. On one side of the sphere **23** is a wall **25** which is connected to the pressure plate **12**. A small sphere, or ball bearing, **26** is contained within a cylindrical recess in wall **25**, and makes contact with spherical mass **23**. The small sphere **26** is forced in an outward direction toward the sphere **23** by a conducting spring **27**. Lead **15** makes electrical contact with the conducting sphere **23** through small sphere **26** and conducting spring **27**. For reasons that will become more apparent later, the center line of the small sphere **26** is slightly above the center line of the large sphere **23** when the fuze is in the rest, ready-to-fire state shown.

The platform **24** upon which the sphere **23** sits is comprised of a piece of insulation **28** with an electrical contact **29** upon which the sphere **23** rests. The lead **16** is connected to contact **29** and thereby makes contact with the sphere **23**.

Inertia switch **21** is also provided with a restoring bar **31** which is attached to base **11** to restore the inertia switch **21** to a closed condition in the event it has been opened by an explosion or other sharp blast.

The operation of the fuze shown in FIG. 1 will now be explained. As is common with many types of pressure operative mines, (such as the M 15 mine), the distance pressure plate **12** moves relative to the mine base **11** is dependent upon the pressure applied to the plate **12**. Under normal conditions the pressure plate **12** will be buried beneath the surface of the earth, and in this case the pressure applied to the pressure plate **12** is dependent not only upon the weight, such as a tank track on top of the mine, but also upon the soil conditions. As will be explained shortly, the pressure required to fire detonator **22** is a function of the distance between the lever **14** and the steps **18**. The higher the step **18** which is rotated beneath the arm **14**, the less pressure required to detonate the mine.

Intended targets for the mine, such as tanks, apply a gradually increasing force to pressure plate **12** causing it to move toward the fixed plate **11**. As the pressure plate **12** moves downward the arm **14** comes in contact with one of the steps **18**, causing an upward movement of the arm **14**. This upward movement of the arm **14** is used to trigger the pulse generator **13** and thus to generate a detonating signal.

With a relatively slow acceleration of the pressure plate **12** the inertia switch **21** will be closed when the detonator pulse is produced by generator **13**. This happens because for relatively slow acceleration of the pressure plate **12**, and a resulting slow acceleration of the plate **24**, the sphere **23** will fall; be accelerated by the gravitational force — at the same rate remaining in contact with the contact **29**. Electrical continuity is maintained through lead **16**, contact **29**, sphere **23**, spring loaded sphere **26**, and the lead **15**.

A steep fronted pressure wave, such as that from an explosion, will cause a rapid acceleration of the pressure plate **12** toward the base **11**. In this situation, the base **24** and the wall **25** attached to the pressure plate **12** will move downward rapidly toward base **11**. Due to the inertia of the sphere **23** it will instantaneously remain stationary, and contact between sphere **23** and contact **29** will be broken. The contact between the sphere **23** and the contact **29** will be broken before the arm **14** has traveled the distance necessary to strike a step **18**. Therefore, when a pulse is generated by pulse generator **13** the inertia switch **21** will have been opened preventing firing of the detonator **22**. The spring loaded sphere **26** prevents the large sphere **23** from remaking contact with contact **29** after the sphere **23** and contact **29** have initially separated. This happens because when the wall **25** and the spring loaded sphere **26** move downward toward the base **11** the center line of the sphere **26** moves below the center line of the sphere **23**. The sphere **23** is then held away from the contact **29** by the force of spring-loaded small sphere **26** applied below the center line of sphere **23**. As the plate **21** gradually returns to its no load position, reset lever **31** holds sphere **23** in place as the plate **21** carries wall **25** and small sphere **26** upward past the center line of the sphere **23**. In this position the sphere **23** again makes contact with contact **29** and the fuze is reset.

Referring to FIG. **2**, there is shown a fuze of this invention in place in a U. S. Army M 15 mine. Like reference numerals have been used to designate the parts which correspond to those shown and described in connection with FIG. **1**. The mine body of the M 15 mine is a relatively large circular shaped can **41** which contains a high explosive. A pressure plate **12** fits snugly, but is free to slide, in a recess **43** formed in the mine casing **41**. Pressure plate **12** is provided with a threaded sleeve portion **44** which is adapted to receive a mine fuze.

The fuze shown and described in connection with FIG. **1** is assembled in a housing **45** having a threaded portion **46** adapted to be screwed into the sleeve **44** in the pressure plate **12**. The housing **45** is closed by a cover plate **47** held in place by a plurality of screws **48**. To make the fuze weather tight, gaskets **49** and **51** are provided. Extending through the plate **47** is the pressure adjusting arm **19**.

The housing **45** is attached to one end of a flexible bellows **52**, and the other end of the bellows **52** is attached to a base plate **11**. When the fuze housing **45** is in place in the pressure plate **12** the base plate **11** rests firmly on the casing **41**, and forms the relatively fixed base. Between the base **11** and the housing **45** there is a heavy spring **53** which tends to force the housing away from the plate **11**. Forces applied to the pressure plate **12** compress the spring **53**.

A well portion **55** is provided to receive the fuze detonator **22**. Detonator **22** marked A is assembled as part of the fuze and is enclosed in a housing **56** depending from the base **11**. If desired, a fuze detonator booster may also be placed in the space marked B in the well **55**.

The components and operation of the fuze shown in place in the M 15 mine of FIG. **2**. are identical to those shown and described in connection with FIG. **1**, with like reference numbers to identify major components. A force applied to the pressure plate **12** forces the pressure plate **12** and the housing **45** downward against the force of the spring **53** until lever **14** of pulse generator **13** strikes one of the steps **18** which are pivotally attached to the base **11**. If the acceleration of the plate **12** has not exceeded a predetermined amount the inertia switch **21** will remain closed and the mine will explode. If the acceleration of the plate exceeds the predetermined amount the inertia switch will open preventing the firing of the mine. Since the operation is the same as that of FIG. **1**, additional explanation would be repetitious and unnecessary.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim as my invention:

1. A pressure activated mine fuze comprising:

a. a mine casing and a pressure plate attached to said mine casing, said pressure plate free to move relative to said mine casing when a force is applied to said pressure plate,

b. an electrical signal generator attached to said pressure plate, said electrical signal generator having a lever extending therefrom, said electrical signal generator generating an electrical signal when said lever is moved relative to said electrical signal generator, said lever being caused to move by the relative movement of said pressure plate relative to said mine casing,

c. means to adjust the distance traveled by said pressure plate relative to said mine casing to cause movement of said lever, said means to adjust operable from outside said mine casing,

d. an inertia switch connected between said electrical signal generator and said detonator means, said inertial switch allowing said electrical signal to reach said detonator when the acceleration of said pressure plate is below a predetermined amount, and said inertia switch means preventing said electrical signal from reaching said detonator when the acceleration of said pressure plate exceeds said predetermined amount.

2. A pressure activated mine fuze comprising:

a. a mine casing, and

b. a pressure plate attached to said mine casing, said pressure plate free to move relative to said mine casing when a force is applied to said pressure plate,

c. an electrical signal generator, said electrical signal generator generating an electrical signal when said pressure plate has moved a predetermined distance relative to said mine casing,

d. detonator means connected to said electrical signal generator, said detonator means responsive to said electrical signal to explode said mine upon receipt of said electrical signal,

e. an inertia switch, said inertia switch including a sphere resting upon a first electrical contact, a second resilient electrical contact making contact above the center line of said sphere, said first and second electrical contacts being attached to said pressure plate, said sphere being constrained to move only perpendicular to said first contact,

f. said inertia switch being connected in series between said electrical generator means and said detonator means, so that electrical continuity is made from said electrical generator to said detonator when said sphere is in contact with said first and second contacts and so that electrical continuity is broken from said electrical generator to said detonator when said sphere is not in contact with said first electrical contact.

* * * * *

United States Patent [19]
Mellen
[11] 3,759,181
[45] Sept. 18, 1973

[54] **ANTI-DISTURBANCE FUZE**

[75] Inventor: **George P. Mellen**, Wayzata, Minn.
[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **Jan. 21, 1972**
[21] Appl. No.: **219,620**

[52] **U.S. Cl.** .... **102/8**, 102/70 R, 102/81
[51] **Int. Cl.** **F42b 23/26**
[58] **Field of Search** 102/8, 82, 70, 83, 102/16, 81

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Primary Examiner—Samuel W. Engle
Attorney—Harry M. Saragovitz et al.

[57] **ABSTRACT**

This invention relates to an anti-disturbance fuze capable of aerial dispersion for detecting the presence of intruders having a housing means, an arming delay means operatively positioned in the housing means for holding the fuze in a safe mode during dispersal, a pendulous inertial mass held in cantilever fashion as a disturbance sensing means proximate to the arming delay for detecting impulses to the fuze, and a firing means operatively connected to the sensing means for firing of an integral detonator. The fuze is immersed in a fluoro-carbon liquid during the dispersal stage and is held in a safe mode by the arming delay means. Upon evaporation of the fluorocarbon liquid the arming delay, after a short interval, of time actuates the disturbance sensing means, the latter is then sensitive to subsequent impulses or movements of the device and operates a biased firing mechanism to cause a detonation.

5 Claims, 8 Drawing Figures

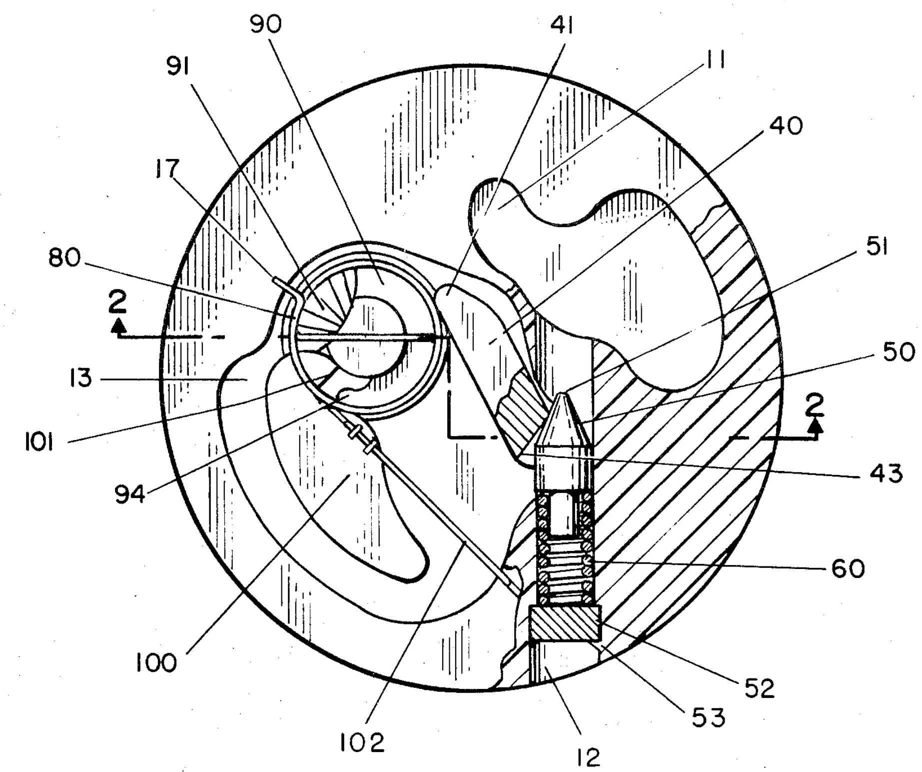


FIG. 1

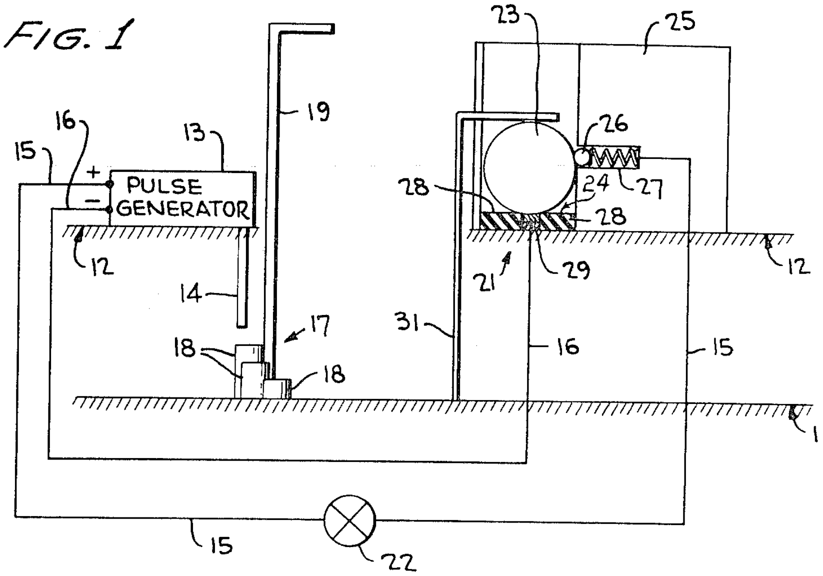
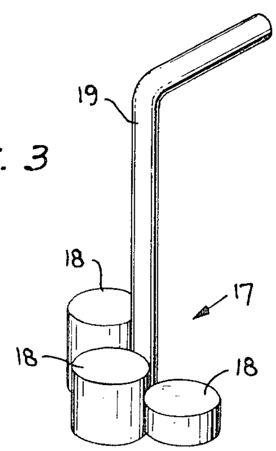


FIG. 3



INVENTOR,
WARREN P. MORROW

BY S. J. Rotondi, A. J. Dupont + J. D. Edgerton

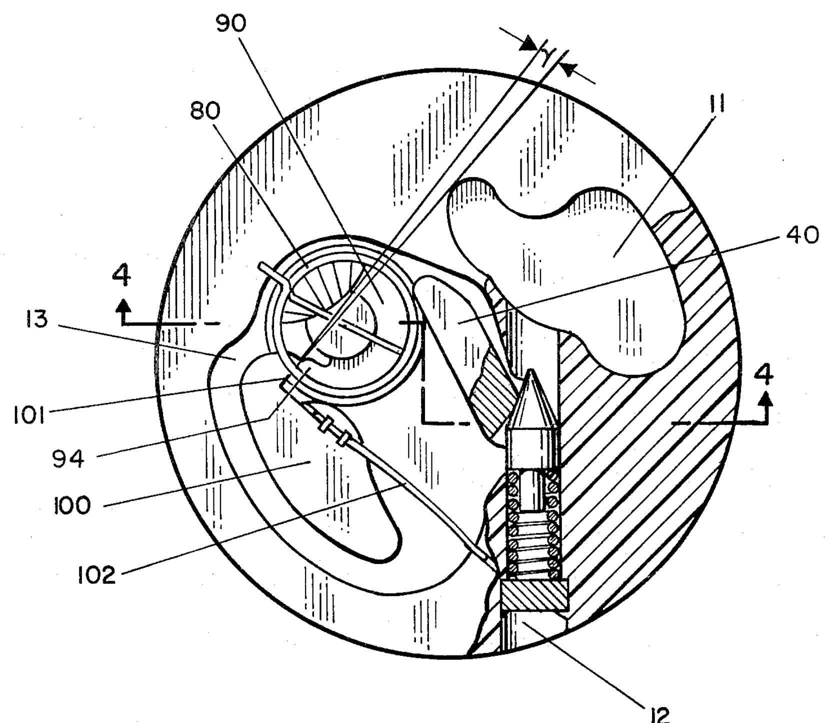


FIG. 3

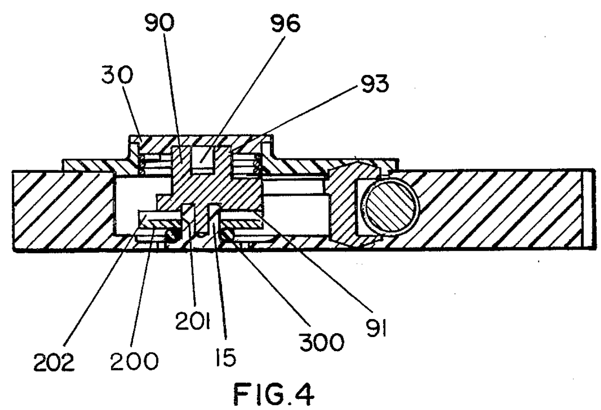


FIG.4

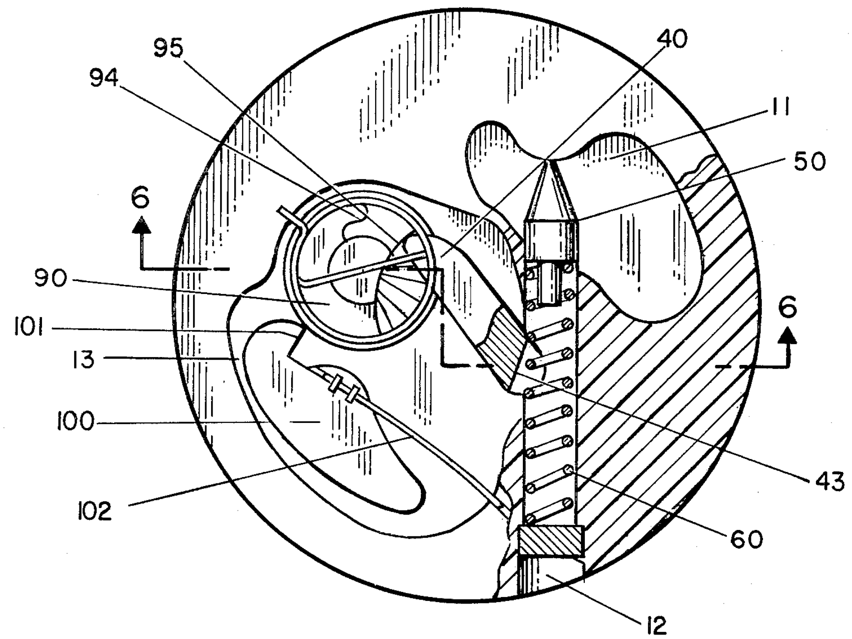


FIG.5

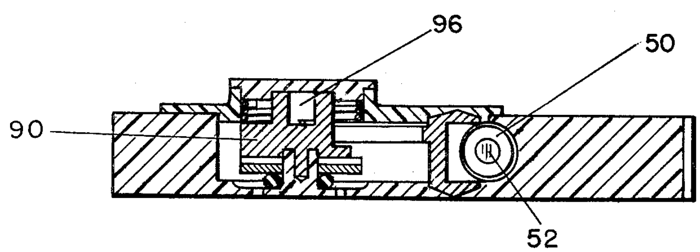


FIG.6

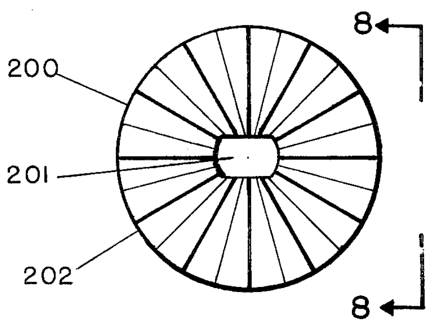


FIG.7

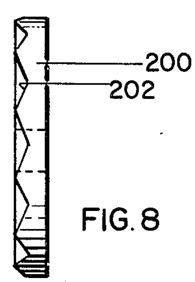


FIG.8

ANTI-DISTURBANCE FUZE

BACKGROUND OF THE INVENTION

Various mechanical, chemical and electrical means have been used in anti-disturbance devices to actuate a mechanism which will sound a warning and/or cause a detonation whenever the mechanism is moved by an intruder. Some of the prior art devices utilize either the linear acceleration and/or the angular acceleration of the carrier to change the anti-disturbance device from a safe mode or position to an armed position, and a vibratory or flexing characteristic of a spring and mass combination to effect an electrical switch closure in order to change the anti-disturbance device to the fire mode or position. Other prior art devices use an electronic and/or mechanical delay in safe and arm mode and then use the free rolling motion of a ball to contact a post to affect the closure of an electrical circuit in the firing mode. The aforementioned types of anti-disturbance devices prevent premature activation during delivery to the intended target area, however, they generally require the use of an expensive mechanical delay arming means in combination with complex electric or electronic timers. Normally in aerial mining it is desirable to have an anti-disturbance device which is both safe to handle and functionally inoperative during the dispersal stage and subsequently after dispersal to become reliably operative when subjected to movement by an unwanted intruder. It is also important that an anti-disturbance device should be insensitive to normal battlefield conditions such as rain, wind and sonic booms. Another desirable feature of an anti-disturbance device is that it be relatively small so that it can be easily camouflaged, and relatively cheap to manufacture because of the large numbers needed to cover a battle area. The aforementioned mechanical-electrical anti-disturbance devices are sometimes not reliable and are subject to premature firing and malfunction because of exposure to spurious electric or nuclear radiating fields.

The prior art mechanical-electrical anti-disturbance devices and completely electrical devices are generally less reliable over long time periods because of the dependency upon a relatively short-lived battery. Prior art anti-disturbance devices which are operative solely by mechanical means of the frictional release type using balanced lever members are generally unreliable because they will respond either to environmental changes or to a specific act of an intruder.

The present device provides an all mechanical anti-disturbance device which is safe to handle during the dispersal stages, self-arming after dispersal and insensitive to normal battlefield disturbance such as sonic boom, heat, rain and high electrical and nuclear radiations. The present device is also operatively reliable over long periods of time because of its independence from an electrical energy source of power.

SUMMARY OF THE INVENTION

The present device consists of a FREON actuated arming delay, a disturbance sensing means and a firing pin triggering means which can be actuated by the sensing means when a sudden impact is imparted to the device when it is in an armed position. The present invention is an all mechanical device. During the safe mode a FREON expanded "O" ring is used to hold a slidable, non-rotatable, clutch member against a rotatable spring biased cam rotor so that the latter will restrain a counterweight triggering means from unlocking a spring-loaded firing pin when the device is either roughly handled or subjected to sudden impact. The arming delay mode utilizes the principle that silicone rubber will increase in volume when immersed in a fluorocarbon liquid, such as FREON, and then will return to its natural size and shape in a short interval of time, such as twenty minutes, upon removal from or evaporation of the fluorocarbon liquid. After the aforementioned delay, the device is placed in an armed position by the shrinking of the "O" ring thereby permitting the slidable clutch to move away from the biased cam rotor and freeing the latter to rotate to a second armed position which carefully balances the counterweight triggering means so that it will be sensitive to any significant battlefield disturbance. The cam rotor in the armed position also holds the biased firing pin means so that it is restrained from impacting upon an adjacent integral detonator. Any significant movement of the device after it is placed in the armed mode will cause the counterweight triggering means to release the biased cam rotor so that it can further rotate and thereby release the spring loaded firing pin.

One of the objects of this invention is to provide an all mechanical anti-disturbance device.

Another object of this invention is to provide an anti-disturbance device which is not dependent upon electric circuitry for operation.

Another object of this invention is to insure reliable operation of an anti-disturbance fuze after long periods of shelf life.

Another object of this invention is to provide an anti-disturbance device which does not require a battery for a power source.

Another object of this invention is to provide an anti-disturbance fuze having an arming delay which is dependent upon the volumetric changes occurring to silicone rubber in the presence of a fluro-carbon liquid.

Another object of this invention is to provide an anti-disturbance fuze which because of simplicity of design and few component parts is small in size, light in weight, economical to manufacture and reliable in operation.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan and partial cross-sectional view of the antidisturbance device showing the device in its safe position.

FIG. 2 is a cross-sectional view of FIG. 1 taken along line 2—2.

FIG. 3 is a plan and partial cross-sectional view of the antidisturbance device showing the device in its armed position.

FIG. 4 is a cross-sectional view of FIG. 3 taken along line 4—4.

FIG. 5 is a plan and partial cross-sectional view of the antidisturbance device showing the device in its fixed position.

FIG. 6 is a cross-sectional view of FIG. 5 taken along line 6—6.

FIG. 7 is a cross-sectional view of device shown in FIG. 2 taken along line 7—7.

FIG. 8 is a side view of the FIG. 7 taken along line 8—8.

Throughout the following description like reference numerals are used to denote like parts in the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2 when the present device is immersed in a FREON environment such that the base 10 has its base cavity 13 filled with this fluorocarbon liquid, the "O" ring 300 expands against the clutch 200 forcing it to slidably move on the base clutch holding boss 15, through clutch hole 201, so that the clutch 200 is firmly pressed against rotor 90. In so doing, the clutch teeth 202, on the upper surface of the clutch 200, mesh with the rotor teeth 91 located on the bottom surface of rotor 90. Since the clutch 200 is mounted on a squared shaft, herein called the base clutch holding boss 15, neither the clutch 200 nor the rotor 90 can rotate. In this position the fuze can neither arm nor fire, this position is therefore called the "safe" position. In the safe position a firing pin lock 40 has a pivot shaft 42 rotatably held on one side in the base pin lock pivot point bore 14 and on the other side by the base cover pin lock pivot point bore 22. The cantilever firing pin lock arm 41 is forcibly held against rotor 92 by the firing pin 50 and the compressed firing pin spring 60. The firing pin point 51 is held in this spring loaded position by the firing pin lock "D" surface 43. A firing pin plug 52 is held in the base firing pin bore 12 by the firing pin plug stake 53, the plug 52 holds the firing pin spring 60 firmly against the firing pin 50.

In the safe mode the pendulous inertial mass counterweight 100 is held by the counterweight spring 102 so that the counterweight hook cam contact surface 101 does not engage the rotor arming cam projection 94. The counterweight spring 102 is of such diameter and length that regardless of the way the fuze may land after dispersal, the counterweight spring assembly will always return to the safe position shown on FIG. 1. A detonator base cavity 11 is filled with a detonating material (not shown) and is isolated from the base cavity 13 by the base 10, but communicates with the base firing pin bore 12. A base rotor pivot bore 16 is located central to the base clutch holding boss 15, holding the rotor base pivot shaft 92 on one side. The other side of rotor 90 has a rotor cover plug pivot shaft 93 rotatably engaging a base cover 20 in a base cover plug bore 21. A biased helical rotor spring 80 has one end 81 fixed in base 10 at point 17 and its other end interfittably engaging the rotor spring slot 96 and wound in such a manner as to give rotor 90 a clockwise turning movement.

Referring now to FIGS. 3 and 4 upon removal of the fuze from the FREON atmosphere, the FREON evaporates from the "O" ring 300 and after about 20 minutes the "O" ring 300 returns to its original size. In so doing, the clutch 200 is left unsupported and disengages from the rotor 90. The partially freed rotor 90 rotates clockwise until it engages the counterweight hook cam contact surface 101. In the event that the clutch 200 does not disengage from the rotor 90 merely by the force of gravity, because it is being restrained by the frictional force between the surfaces of the clutch hole 201 and the base clutch holding boss 15, separation of the rotor and clutch teeth 91 and 202 respectively is effected by having a triangular tooth configuration on each so designed that the rotor spring 80 will over ride the friction restraining force between the squared shaft 15 and clutch 200. Once the rotor 90 is free to rotate, it rotates clockwise until the rotor arming cam projection 94 engages the counter weight cam contact surface 101. In this position the rotor spring 80 establishes a balancing force and resultant moment about the counterweight spring 102 causing the latter to deflect a predetermined distance. The sensitivity of the counterweight 100 being deflected by a given impulse is a function of the counterweight hook angle $\approx$. The coefficients of friction between the aluminum rotor cam projection 94 and the brass counterweight hook cam surface 101, the flexibility of the counterweight spring 102, the torsional force of the helical rotor spring 80 and the coefficient friction between the rotor base pivot shaft 92 and the base 10, and between the rotor cover plug pivot shaft 93 and the cover plug 30.

Referring now to FIGS. 5 and 6, upon receiving an impulse, or a series of impulses, or if the device is given a predescribed angle of inclination, the counterweight 100 sets up a horizontal force component which is transmitted to the counterweight spring 102 resulting in sufficient deflection to release the rotor cam projection 94 from the counterweight hook cam contact surface 101. Once the rotor 90 is released, after being armed, it will rotate clockwise past the firing pin lock 40. At this point in the sequence of operation the firing pin lock 40 rotates in a counter clockwise direction, thus releasing the firing pin 50, which until this time had been retained by the "D" shaft 43 portion of the firing pin lock 40. The firing pin 50 is thus driven by the firing pin spring 60 into the detonator base cavity 11 into a detonator or explosive mix (not shown), thus producing the desired end results.

FIGS. 7 and 8 show the circular, radial toothed configuration of the clutch 90, the triangular shape of the clutch teeth 202, the squared base boss 15 and axially aligned rotor base shaft 92.

From the above description it will be evident that the invention provides a mechanical anti-disturbance device which may be safely dispersed, will automatically arm itself in 20 or 30 minutes after evaporation of FREON liquid, which because of simplicity of design has only a limited number of component parts, is reliable at a predetermined sensitivity level, is small of size, approximately 0.2 of a cubic inch, light in weight and independent of any battery for a power source.

I wish it to be understood that I do not desire to be limited to the exact detail of construction shown and described for obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. An anti-disturbance fuze for detecting the presence of intruders comprising:
   - a housing which includes;
     - a base having a main base cavity, a detonator cavity partially isolated from said main cavity, and a firing pin bore communicating with said detonator cavity and said main base cavity;
     - a base cover for operatively positioning said arming delay means interfitably engaging said base;
   - an arming delay means operatively positioned in said housing for holding said fuze in a safe mode which includes;
     - a clutch slidably positioned on said base in said main cavity;

an "O" ring intermediate to said clutch and said housing for operatively positioning said clutch and of a material which expands when immersed in a fluid and contracts when said fluid is not present;

a vaporizable fluid immersing said "O" ring;

a rotor held adjacent to said clutch when said "O" is expanded and releasable by said clutch when unexpanded, having a first arming cam projection surface and a second firing pin lock release cam surface;

a biased rotor spring for providing a rotational force to said rotor;

a disturbance sensing means proximate to said arming delay means for detecting impulses to said fuze; and

a firing means operatively connected to said sensing means for firing of a detonator.

2. A device as recited in claim **1** wherein said "O" ring material is SILICONE rubber and said vaporizable fluid is FREON.

3. A device as recited in claim **2** wherein said disturbance sensing means comprises:

a pendulous mass, positioned adjacent to said rotor, contacting said first arming cam projection surface, and holding said device in an armed mode.

4. A device as recited in claim **3** further including a counterweight spring cantilever, connected on one end to said counterweight.

5. A device as recited in claim **4** wherein said firing means comprises:

a firing pin slidably positioned in said firing pin bore;

a firing pin plug fixed in said firing pin bore;

a biased firing pin spring intermediate to said firing pin and said firing pin plug for providing an accelerating force to said firing pin; and

a firing pin lock rotatably mounted in said housing for releasing said firing pin when said device is subject to an impulse causing said counterweight to move away from said first arming cam projection surface thereby permitting said biased rotor to rotate, and permitting said firing pin lock to pass said second firing pin lock release cam surface so that said firing pin lock no longer restrains said firing pin, permitting said biased firing pin to travel toward said detonator and impacting thereon.

* * * * *

United States Patent [19]
Savarese, Jr.

[11] 3,768,407
[45] Oct. 30, 1973

[54] ANTI-DISTURBANCE DELAY FUZE

[75] Inventor: **Antonio Savarese, Jr.**, Morris Plains, N.J.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **June 14, 1972**

[21] Appl. No.: **263,719**

[52] **U.S. Cl.** **102/8**, 102/81, 102/83
[51] **Int. Cl.** **F42b 23/26**
[58] **Field of Search** 102/70, 76, 79, 7.2, 102/8, 75, 81, 83

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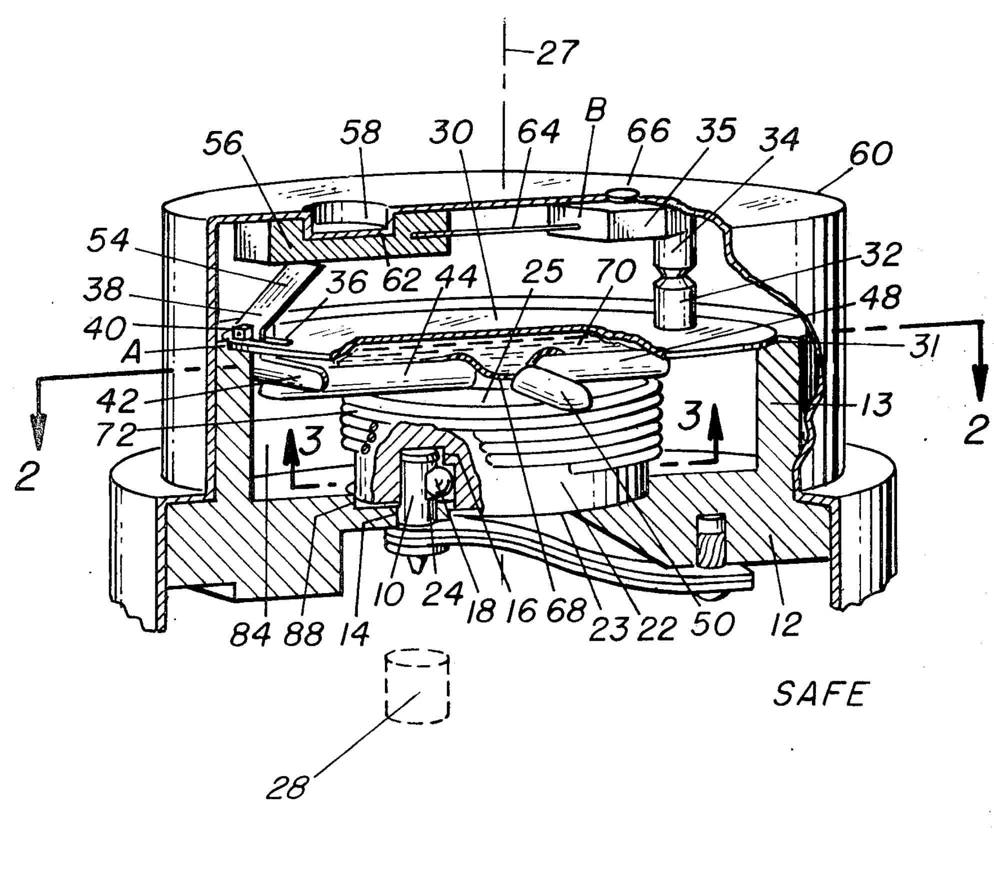
Primary Examiner—Samuel W. Engle
Attorney—Harry M. Saragovitz et al.

[57] ABSTRACT

The invention relates to an anti-disturbance delay fuze for safing, arming and initiating a munition. The present invention permits a munition to be safely handled when launched, to remain inoperative during a first interval of time equivalent to the period that this munition is being dispersed to the target area, to be responsive immediately to subsequent disturbance, and to cause initiation after a second interval of time after dispersal when there has been no disturbance.

The present invention comprises a housing having a central bore, a delay disc counter bore in an open end and an axial counter bore in a partially closed end, a biased triggering means rotatably positioned in the axial counter bore for arming the munition after a first period of time and firing the munition after a second period of time, a firing pin means operatively affixed to the housing and releasably held in the triggering means, a fuze cover circumambient to the housing having an integrally formed disturbance weight position lock and pivot depending for the inside surface of the cover, and a delay means operatively positioned intermediate to the disturbance means and the triggering means for keeping the disturbance means inoperative during the first time period and initiating the munition upon movement after the first time period, and for initiation of the munition after a second time period where there has been no movement of the munition during the interval of time between the first and second periods.

6 Claims, 6 Drawing Figures



SAFE

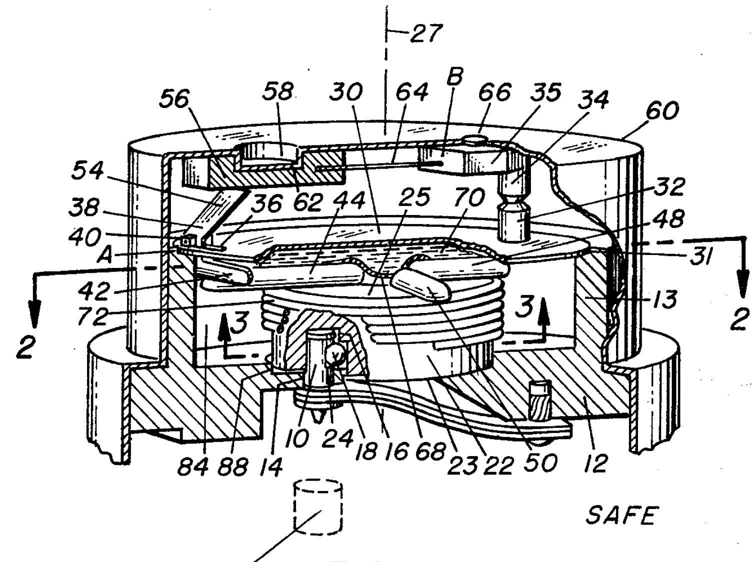

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FIG. 1

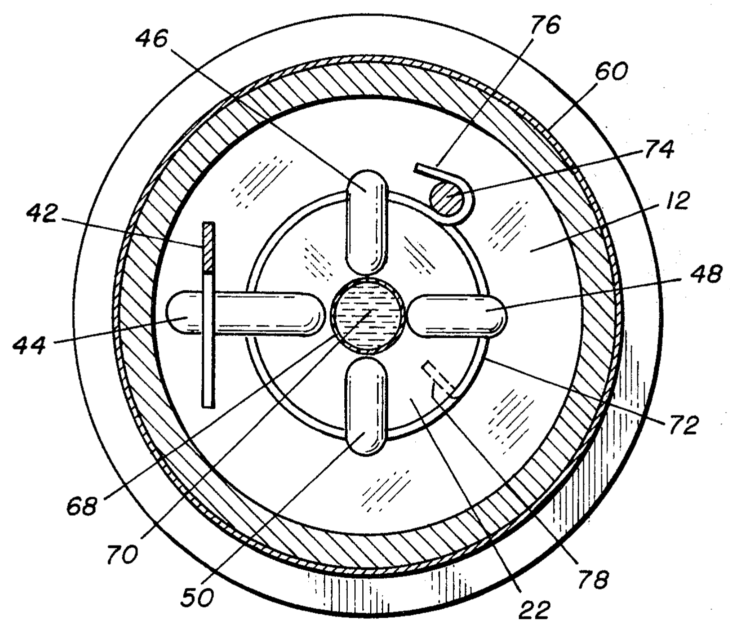
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FIG. 2

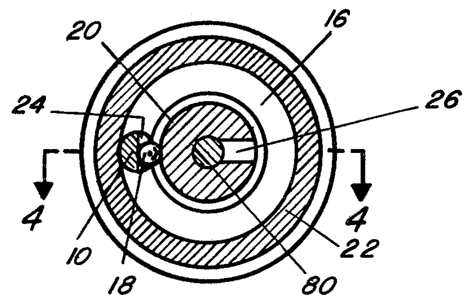

FIG.3

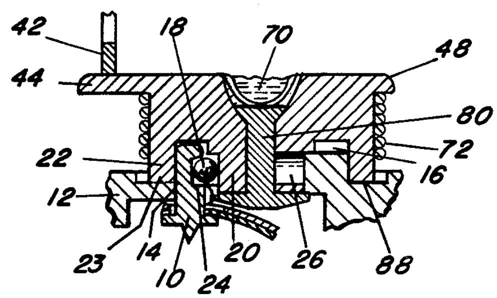

FIG.4

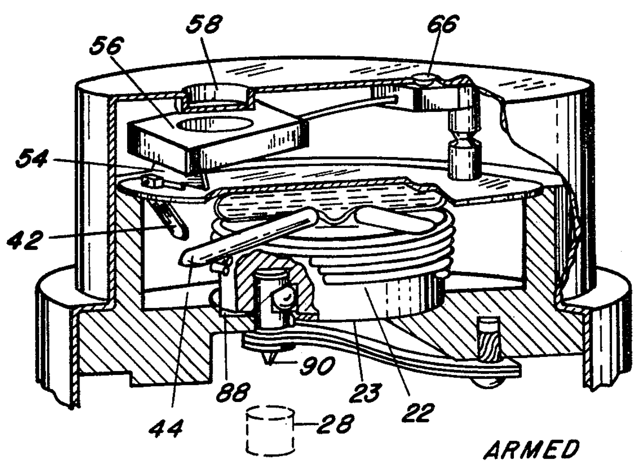

FIG.5

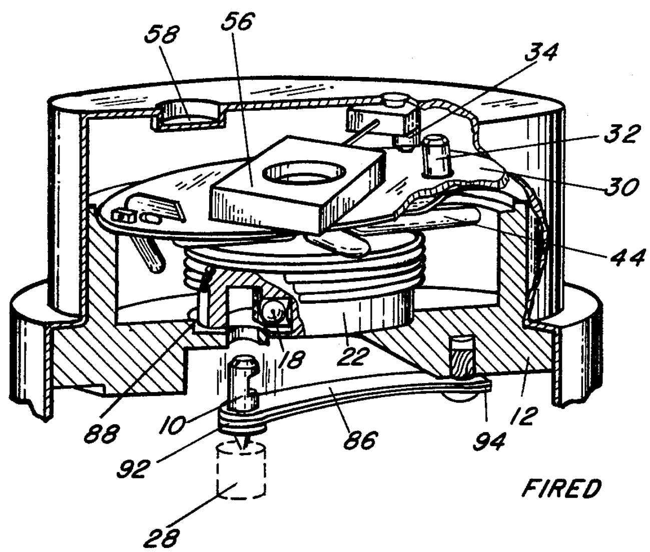

FIG. 6

ANTI-DISTURBANCE DELAY FUZE

GOVERNMENTAL INTEREST

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

Various means have been used by prior art delay fuzed mines to permit the mine to be aerially dispersed without endangering the personnel dispensing the munition nor exploding other near-by falling munition while in the air. Prior art fuzes have used the dashpot concept to provide random delays which will keep the fuze in a "safe" position varying from minutes to days. Some of the prior art devices have combined this delay function with an anti-disturbance mechanism which permits the device to explode if disturbed after the delay period has elapsed. One of the problems with such prior art has been that the disturbance feature of the switch is functioning as a contact of a terminal of an electrical switch which is connected to and associated with electrical circuitry. In some of these prior art devices, the disturbance feature utilizes the vibrating or flexing characteristic of a cantilever or double end supported member to close the switch.

Other devices utilize the free rolling motion of a ball to contact a post and a housing, or to simultaneously contact a pair of terminal posts to effect the closure of the electrical switch. In all of these prior art devices the use of an electrical circuit to initiate an explosion requires the use of an electrical source of power such as a battery which has a limited shelf life, or some other electrical energy source such as a piezo-electric crystal and condenser combination which is relatively expensive to use and requires for operation of the crystal, a significant force to generate the voltage required.

Those prior art delay type fuzes which do not utilize an anti-disturbance device in combination with the delay mechanism, do not restrict the movement of enemy troops in the target area where the delay mechanism hasn't completed the arming cycle. Under such conditions when the enemy troops choose to remain active, they could kick, step on, or otherwise disturb the grenade without causing it to explode.

The present invention overcomes the aforementioned problems by the addition of a simple, inexpensive and reliable mechanically operative disturbance feature to the delay mechanism thereby permitting the munition to function immediately after a first relatively short period of delay, and in the event that the munition has not been disturbed after the first period initiation is caused after a second subsequent period.

SUMMARY OF THE INVENTION

The present invention relates to an improved mechanical anti-disturbance device in combination with a delay fuze. In the "safe" position, a lever locking means is operatively positioned intermediate to a pivoted pendulous mass. The latter is designed to lock a detented spring-biased firing pin in a non-operative position. One end of the pendulous disturbance device has a support column mounted thereon and the other end has an integral locking detent which aligns itself with a projection in the fuze cover. A delay disc is operatively positioned underneath the pendulous mass and has a

matching support column thereon which, in the "safe" position, completely inhibits the disturbance device from operating. In the "armed" position, the two support columns are in line in a frictionally balanced position and subject to being upset by movement of fuze by either enemy troops or by a delay rotor vane after a finite period of time. Intermediate to the delay disc and a rotationally biased delay rotor is a fluid containing sac holding therein a silicone gum. After launch and during the time that the munition is being delivered to the target area, a centrifugally responsive mechanism (not shown) releases the delay rotor so that it can start to rotate. After elapse of a first period of time running from the time of release of the rotor to the release of the disturbance weight from its lock position, the device may be activated by movement of the fuze. Vanes attached to the delay rotor prevent rapid rotation of the rotor because the viscous fluid is constrictively made to flow between a narrow gap existing between the vanes and the underneath side of the delay disc. A spring loaded firing pin is positioned over a detonator by a ball detent means. The detent ball is operatively positioned in the rotor housing so that it rides the delay rotor shaft and a recess in the firing pin during the time that the fuze is in the "safe" or "armed" state. After the fuze has been armed, by release of the locking lever and by the rotation of the delay rotor, the continued rotation of the delay rotor causes a recess in the delay rotor to present itself the detent ball, freeing the ball from the firing pin recess, and thereby permitting it to forcibly strike a detonator positioned thereunder after the lapse of a second period of time.

One of the objects of this invention is to provide a mechanical antidisturbance feature to a delay fuze.

Another object of this invention is to provide a mechanical anti-disturbance device and delay means wherein the former may be activated after a first delay period.

Another object of this invention is to provide an anti-disturbance delay type fuze which will initiate a spring loaded firing pin due to the rotational movement of a pivotal pendulous mass.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric, partial cut-away, cross-sectional view of the anti-disturbance delay portion of the fuze showing the position of the major elements while the fuze is in the "safe" position.

FIG. 2 is a top view of the fuze taken along line 2—2 of the drawing illustrated in FIG. 1.

FIG. 3 is a cross-sectional view taken along line 3—3 of the drawing illustrated in FIG. 1 in order to show the constructional details of the delay rotor, firing pin, ball detent and rotor shaft ball recess.

FIG. 4 is a radial cross-sectional view thru the longitudinal axis taken along line 4—4 of the drawing illustrated in FIG. 3 in order to show the functional relationship of the ball detent locking means with the delay rotor.

FIG. 5 is an isometric, partial cut-away, cross-sectional view of the fuze showing the operative position of its major elements after munition has come to rest and the rotor vane has released the disturbance locking lever so that the fuze is placed in an "armed" position.

FIG. **6** is an isometric, partial, cut-away, cross-sectional view of the fuze in the "fired" position.

Throughout the following description like reference numerals are used to denote like parts of the drawing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to a fuzing device which will permit a munition to be safely handled when launched, to remain inoperative during a first interval of time equivalent to dispersal to the target area, to be responsive immediately to subsequent disturbance after dispersion, and to initiate the munition causing it to self-destruct after a second period of time in the event there is no disturbance of the munition after the first interval of time. In its broader aspects, the device is intended to provide an anti-disturbance and self-destruct feature to a delay fuze.

Referring now to FIGS. **1–4** showing the device in the "safe" position, a spring loaded firing pin shaft **10** is held within a delay rotor housing **12** in firing pin housing bore **14** and an internal annular rotor groove **16** of a delay rotor **22** on its bottom end **23** by the ball lock **18.** The ball **18** is located in the delay rotor **22** intermediate to a restraining rotor shaft **20**, and a D-shaped firing pin recess **24** which prevents the release of ball **18** and the actuation of the firing pin **10.** A delay rotor shaft radial recess **26** is oppositely disposed, as shown in FIGS. **3** and **4** from the firing pin **10.** When the rotor shaft recess **26** is rotated about the fuze longitudinal axis **27** so that it presents itself to the ball lock **18,** the latter is pushed into the shaft recess by a horizontal component of force exerted by the spring loaded firing pin **10** thereby freeing the firing pin **10** and driving it forcibly in a downward direction, into a detonator **28.** A delay sac disc **30** is supported by housing disc counterbore **31** and is pivotably restrained at point A by the housing wall **13.** When the device is in the "safe" position an upwardly protruding disc switch contact column **32,** attached to the upper side of the sac disc **30,** is aligned with a similarly shaped downwardly protruding disturbance member switch contact column **34** located on one end of the pivotal member **35** which can rotate in a plane perpendicular to the longitudinal axis **27.** In the aforementioned "safe" position the two aligned contacts form a solid column which together with the pivotable restraint at point A holds the delay sac disc in place against the delay rotor vanes **44, 48; 50.** Proximate to the point A the disc **30** has an elongated disturbance weight release lever clearance hole **36** therein, through which a U-shaped disturbance weight release lever **38** is pivotally held by pivot **40** so that it passes through the elongated hole **36.** The lower release lever leg **42,** in the "safe" position, is held up by one long vane **44** of the delay rotor **22.** The vane is horizontally positioned on the rotor top end **25.** The other three radially positioned vanes **46** (not shown), **48** and **50** respectively are shortened in order to clear the release lever **42.** When the disturbance weight U-shaped release lever **38** is being held up by the delay rotor long vane **44,** the upper release lever leg **54** holds a spring biased cantilever supported disturbance weight **56,** located on the other end of the pivotal disturbance member **35,** so that it engages a disturbance weight position lock circular protrusion **58.** The position lock **58** is formed out of fuze cover **60** and protrudes in a downward direction toward the rotor **22** and is aligned with and slidably fits into a disturbance weight counter bore **62.** The disturbance weight release lever **38** holds the weight **56** in a locked position in opposition to a downward force exerted by a biased disturbance weight flexible moment arm **64.** The flexible moment arm **64** is a flat spring which holds the disturbance weight **56** off the position lock **58** when unrestricted by the disturbance weight release lever **38.** The biased spring **64** has sufficient spring tension therein to keep the disturbance weight **56** free of the lock **58** regardless of the orientation of the fuze after dispersal. The flexible moment arm **64,** of the disturbance lever means, is attached to the disturbance lever switch contact column **34** at point B and is preset at an angle so that when the fuze is in an "armed" position, as shown in FIG. **5,** the disturbance weight **56** is free to pivot about disturbance switch pivot **66.** A pliable sealed delay sac **68** is operatively positioned intermediate to the underside of delay sac disc **30** and the top of the delay rotor vanes **44, 46, 48** and **50,** so that the sac **68** clears the lower release lever leg **42.** A viscous fluid **70,** such as silicone gum, is contained within the sac **68.** A biased helical wound spring **72** having one end **76** anchored by pin **74** which is in turn affixed to delay rotor housing **12,** and the other end **78** fixed to rotor **22** provides the necessary torsional force to rotate the rotor **22** through the "armed" or "fired" positions shown in FIGS. **5** and **6** respectively. A delay rotor shaft pin **80** in combination with the rotor housing counter bore **88** keeps the delay rotor **22** so that it may concentrically rotate about the fuze longitudinal axis **27** and freely within the delay rotor central housing bore **84.**

Referring now to FIG. **5,** showing the fuze in the "armed" position, the delay rotor **22** has rotated in a counter-clockwise direction, when looking at the rotor **22** from a top view, so that the long vane **44** no longer supports the lower release lever leg **42** thereby permitting the upper release lever leg **54** to release the disturbance weight **56** and to disengage itself from position lock **58.** Any motion of the fuze by enemy troops not absolutely parallel to the longitudinal axis **27** will cause the disturbance weight **56** to pivot about the switch pivot **66.**

FIG. **6** shows the fuze in a "fired" position caused by a time delay of sufficient duration to rotate the delay rotor **22** approximately 180° so that slot **26** presents itself to ball lock **18.** When the delay rotor shaft recess **26** aligns itself with the ball lock **18** the firing pin biased spring **86,** which is fixed to firing pin shaft **10** on one end **92** and to housing **12** on the other end **94,** will drive the firing pin point into the detonator **28** thereby initiating the munition.

In operation, the munition is armed by the centrifugal force of spin. This force causes the detonator **28** to move in a position directly under the firing pin **10.** A mechanism (not shown) releases the delay rotor **22** permitting it to begin to slowly rotate. After rotating the distance necessary for the long vane **44** to clear the lower release lever **42,** the disturbance weight **56** becomes disengaged from the disturbance weight position lock **58.** The delay between arming the munition by movement of detonator **28** into position as shown in FIGS. **1, 5, & 6** and release of the disturbance weight **56** permits the munition to come to rest after being delivered to the target area. In the event that the fuze is disturbed, before the delay rotor **22** rotates and causes radial recess **26** to present itself to ball lock **18**, the disturbance weight **56** will move relative to the rest of the fuze, since it is mounted on a flexible moment arm **64** and has a measurable amount of inertia. Since the flexible moment arm **64** is a flat spring, the motion of the disturbance weight **56** will be directed towards movement in a plane parallel to the delay sac disc **30**. The motion will result in the disturbance weight **56** rotating about the disturbance switch pivot **66** causing the disturbance lever switch contact column **34** to move off the disc switch contact column **32**. The aligned columns holding the delay sac disc **30** in position will therefore be broken. The delay rotor **22** will now force the sac disc **30** out of position and allow the delay rotor to swing around rapidly, unrestricted by the fluid filled delay sac **68** releasing the ball lock **18** into the shaft recess **26** causing the firing pin **10** to forcibly hit the detonator **28** thereby firing the munition.

I wish it to be understood that I do not desire to be limited to the exact detail of construction shown and described for obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. An anti-disturbance delay fuze for safing, arming and initiating a munition which comprises:

a cylindrical cup shaped housing having a delay disc counterbore located in an open end and a central bore, and an axial counterbore of smaller diameter than said central bore in a partially closed end;

biased triggering means rotatable positioned in said axial counterbore for arming said munition after a first time period and firing said munition after a second time period;

firing pin means operatively affixed to said housing and releaseably held in said triggering means;

a fuze cover circumambient said housing having an integrally formed disturbance weight position lock and a disturbance switch pivot depending from the inside top surface of said cover;

a disturbance means, held by said switch pivot operatively adjacent to said cover, and rotationally responsive to said munition movement after said first time period; and

a delay means operatively positioned intermediate said disturbance means and said triggering means for keeping said disturbance means inoperative during said first time period, initiating said munitions upon movement of said fuze after expiration of said first time period, and for the initiation of said munition after said second time period.

2. An anti-disturbance delay fuze as recited in claim **1** wherein the triggering means comprises:

a cylindrically shaped rotor having a bottom end with an axially positioned annular groove therein, an axial rotor shaft concentric with said annular groove further including a radially positioned shaft recess for releasably holding said firing pin means therein, a top end having a plurality of bar-shaped vanes radially mounted thereon and extending in a direction normal to said central bore, wherein one of said bar vanes is longer in length; and

a biased helical spring wound around said rotor intermediate said vanes and said bottom end having a first end anchored to said housing and a second end fixed to said rotor.

3. An anti-disturbance delay fuze as recited in claim **2** wherein the firing pin means comprises:

a cylindrical shaft having a flat end and a pointed end, a radial recess transverse to its longitudinal axis and intermediate to said flat and pointed end; and

a ball lock operatively positioned intermediate said firing pin shaft recess and said rotor shaft for holding said firing pin in a "safe" position during said first time period, and for releasing said firing pin when said rotor radially positioned recess aligns itself with said ball lock.

4. An anti-disturbance delay fuze as recited in claim **3** wherein the disturbance means comprises:

a pivotal member rotatably held by said switch pivot;

a switch contact column depending from one end of said member;

a bent flexible cantilevered moment arm fixedly attached to the other end of said member; and

a pendulous mass, fixedly attached to said moment arm, so that a counterbore in said mass operatively engages said position lock when said fuze is in a safe position and is free to rotate about said switch pivot when said fuze is in an "armed" position.

5. An anti-disturbance delay fuze as recited in claim **4** wherein the delay means comprises;

a disc pivotally held in said disc counterbore, having a disc switch column fixedly attached to its upper side and axially aligned with said member switch column, a U-shaped release lever, including upper and lower legs, said release lever pivotally attached to said disc and operatively positioned so that said upper leg supports said pendulous mass when said triggering means during said first period supports said lower leg; and

a pliable sac having a viscous fluid therein sealed to said disc underneath side intermediate to said disc and said plurality of vanes.

6. An anti-disturbance delay fuze as recited in claim **5** wherein the viscous fluid is a silicone gum.

* * * * *

United States Patent [19]
Rogers, Jr. et al.

[11] **3,844,215**

[45] **Oct. 29, 1974**

[54] **MINE FUZE**

[75] Inventors: **Joseph P. Rogers, Jr.; Richard G. Thresher,** both of Ledgewood, N.J.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

[22] Filed: **Apr. 13, 1960**

[21] Appl. No.: **22,066**

[52] **U.S. Cl.** .... **102/8,** 102/70.2 R
[51] **Int. Cl.** **F42b 23/00**
[58] **Field of Search** .... 102/70.2, 70 G, 70 GI, 102/70 P, 8, 16, 18; 89/28, 28.1, 33, 135; 42/84

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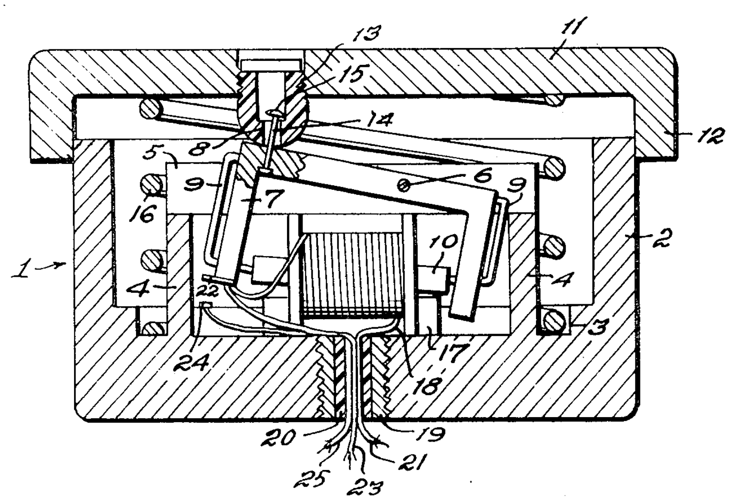
Primary Examiner—Samuel W. Engle
Attorney, Agent, or Firm—Edward J. Kelly; Herbert T. Berl

EXEMPLARY CLAIM

3. A land mine including an electrical detonator, first and second fuzes adapted to be buried in the ground; each fuze comprising a housing, a pressure plate carried by and forming a closure for said housing, an induction coil fixed in said housing, a permanent magnet extending through said coil, said permanent magnet being connected to said pressure plate so as to move in said coil in response to operation of the pressure plate, and a switch having a pair of contacts, one contact being carried by said housing and the other contact being carried by said permanent magnet whereby said switch is closed in response to depression of said pressure plate, said induction coil and said switch being electrically connected in series; opposite sides of said induction coil of said first fuze being connected, respectively, to one side of said detonator and to said switch of said second fuze and opposite sides of said induction coil of said second fuze being connected, respectively to the other side of said detonator and said switch of said first fuze.

3 Claims, 2 Drawing Figures



PATENTED OCT 29 1974 3,844,215

Fig. 1.

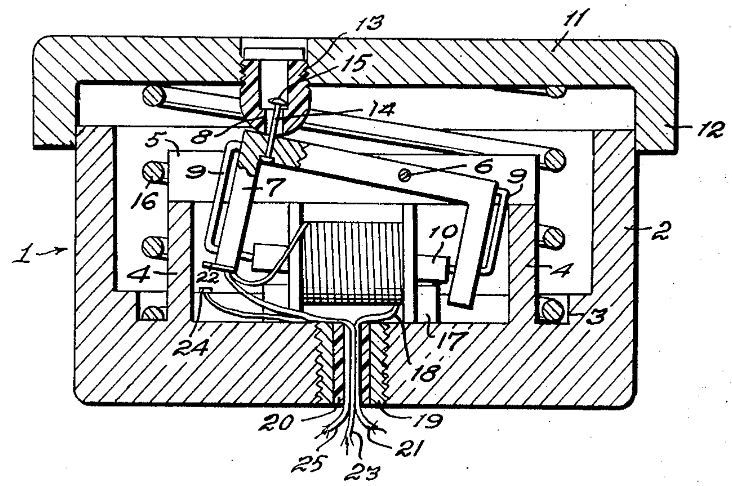
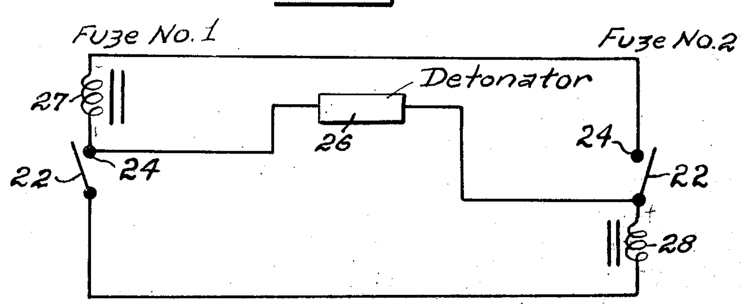


Fig. 2.



INVENTORS,
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S. J. Rotondi & A. T. Dupont

MINE FUZE

This invention relates to land mines and more particularly to antitank land mines which will be detonated only after a substantial portion of the tank has passed thereover.

In the use of land mines as an anti-tank weapon the most destructive effect on a tank cannot be obtained if the mine is detonated when first contacted by the tank. Detonation to be most effective should occur directly under the tank which is its most vulnerable point. Time delays between fuze actuation and detonation have not proven entirely satisfactory.

Briefly, our invention comprises a land mine having a pair of spaced fuzes which must both be operated before detonation will occur. Further, the second fuze must be operated while the operating means, i.e. tank, is still in contact with the first fuze. Thus, it will be sen that by properly spacing the fuzes and correctly positioning the mine with respect thereto the mine can be made to explode directly beneath a tank at its most vulnerable point. Further, since the tank must be in contact with both fuzes at the same time the mine cannot be detonated by the sequential operation of the fuzes by personnel or the like.

An object of the invention is to provide a land mine which will explode directly underneath a tank.

Another object of the invention is to provide a land mine with spaced fuzes, both of which must be operated before the mine will be detonated.

A further object of the invention is to provide a land mine having spaced fuzes which must be contacted at the same time in order to detonate the mine.

Another object is to provide a land mine having an electrical detonator and in which actuating current is induced upon operation of the fuze by a tank.

Yet another object of the invention is to provide a mine having an electrical detonator and a pair of fuzes each having an induction power source and switch in circuit with the detonator.

A further object is to provide a mine fuze having an induction power source and switch which are simultaneously operated by contact with a tank or the like.

These and other objects will become more apparent when reference is had to the following detailed description and accompanying drawing in which:

FIG. 1 is a sectional view of one of the fuzes of my invention showing the induced current power source and switch, and

FIG. 2 is a schematic diagram showing the two fuzes and the manner in which they are connected to the mine detonator.

The land mine of the present invention utilizes two fuzes, one of which is shown in detail in FIG. 1. Each fuze constitutes an electrical power source for the mine detonator and includes an induction power source and switch.

As shown in FIG. 1, the fuze is indicated in its entirety by reference character 1 and includes the housing 2 which is adapted to be buried in the ground. The housing is cup shaped as shown and is provided in its bottom wall with annular channel 3 and the two upstanding webs 4. Supported by and connected across the tops of the webs 4 is the magnet support bar 5 which carries the pivot pin 6. Pivotally mounted on the pin 6 is the yoke 7 which carries the pin 14 and magnet support wires 9. Connected between the magnet support wires 9 is the permanent magnet 10.

Slidably mounted on the housing 2 is the pressure plate 11 which has the annular flange 12 to slidably engage the housing. The pressure plate carries the pivot 13 which is provided with the opening 14 to loosely receive the pin 14. The head 15 on the pin 14 prevents withdrawal of the pin from the pivot 13. The resetting spring 16 is received in the groove 3 and acts to urge the pressure plate 11 upward.

Mounted within the housing 2 by means of the mounting pads 17 is the coil 18 which surrounds the magnet 10. The bottom wall of the housing is provided with an aperture which threadedly receives the adaptor 19 and insulating gasket 20. One lead wire 21 from the coil is led directly through the gasket 20. The pivoted yoke 7 carries one contact 22 of a switch, and the second coil lead 23 is led from the coil to the switch contact 22 and then out through the gasket 20. The second switch contact 24 is fixed to the web 4 and has lead wire 25 connected thereto. The lead 25 is conducted from the switch contact out of the housing through gasket 20.

The operation of each individual fuze should now be apparent. When pressure is applied to the pressure plate 11, the plate is depressed against the action of the spring 16. This pivots the yoke 7 and the permanent magnet 10 carried thereby. The lines of flux of the magnet then cut the turns of the coil 18 and induce a current therein and hence in leads 21 and 23. At the same time, the switch contacts 22 and 24 are closed connecting the leads 23 and 25.

The schematic diagram of FIG. 2 illustrates the manner in which a pair of fuzes similar to the one shown in FIG. 1, may be used with a single mine so that both fuzes must be operated to cause detonation. The electrically operated detonator of the mine is indicated at 26. The fuze units are indicated as fuze No. 1 and fuze No. 2. One side of induction power source 27 of fuze No. 1 is connected to the detonator 26 and one side of induction power source 28 of fuze No. 2 is also connected to the detonator 26. The opposite side of induction power source 27 is connected to switch contact 24 of fuze No. 2 while the opposite side of induction power source 28 is connected to switch contact 22 of fuze No. 1. In the operation of a mine with two fuzes, let it be assumed that a tank first operates fuze No. 1, causing power to be generated by power source 27 and closing switch contacts 22 and 24. Switch contacts 22 and 24 of fuze No. 2 are still open, however, and the detonator 26 is thus not in circuit, and the mine does not explode. The electrical pulse generated by source 27 is not stored and dissipates. If now the tank proceeds and operates fuze No. 2 while still being in contact with fuze No. 1 so that switch contacts 22 and 24 on fuze No. 1 remain closed, power is induced in power source 28 and switch contacts 22 and 24 of fuze No. 2 are closed. Inasmuch as switch contacts 22 and 24 of fuze No. 1 are also closed and no further current is being generated by source 27, the detonator is in circuit and the mine is exploded. It will be noted, however, that if the pressure of the tank is removed from fuze No. 1 allowing switch contacts 22 and 24 of fuze No. 1 to open before fuze No. 2 is actuated, the mine will not detonate upon actuation of fuze No. 2. Obviously the mine would also be detonated by a reverse operation, i.e., actuation of fuze No. **2** and then actuation of fuze No. **1** while the switch of fuze No. **2** is still closed.

It will thus be seen that a mine having two fuzes connected as shown in FIG. **2** will be effective to explode only after a substantial part of the tank has passed thereover depending on the spacing of the fuzes. The application and release of a load to one fuze before the application of a load to the second fuze will not detonate the mine.

While we have shown in FIG. **2** the use of two fuzes with a mine, it will be apparent that one fuze could be assembled to a mine with the induction power source and switch in series with the detonator to provide a contact mine fuze. Depending on the strength of the return spring, the mine could then be used for anti-tank, anti-personnel or general purposes.

It will be apparent that the embodiment shown is only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined by the appended claims.

We claim:

1. In a land mine, an electrical detonator, first and second fuzes adapted to be buried in the ground and operated by external pressure, each fuze comprising an electrical power source and a switch connected in series, one side of the power source of the first fuze being connected to said detonator and the other side of said power source being connected to the switch of said second fuze, one side of the power source of said second fuze being connected to said detonator and the other side of said last named power source being connected to the switch of said first fuze whereby said detonator will not operate unless both said switches are closed.

2. In a fuze for a land mine adapted to be buried in the ground as defined in claim **1**, each said electrical power source being of the induction type and generating power in response to operation of said fuzes whereby both of said switches must be closed one at a time to cause detonation.

3. A land mine including an electrical detonator, first and second fuzes adapted to be buried in the ground; each fuze comprising a housing, a pressure plate carried by and forming a closure for said housing, an induction coil fixed in said housing, a permanent magnet extending through said coil, said permanent magnet being connected to said pressure plate so as to move in said coil in response to operation of the pressure plate, and a switch having a pair of contacts, one contact being carried by said housing and the other contact being carried by said permanent magnet whereby said switch is closed in response to depression of said pressure plate, said induction coil and said switch being electrically connected in series; opposite sides of said induction coil of said first fuze being connected, respectively, to one side of said detonator and to said switch of said second fuze and opposite sides of said induction coil of said second fuze being connected, respectively to the other side of said detonator and said switch of said first fuze.

* * * * *

United States Patent [19]

Gatti

[11] **Patent Number: 4,653,401**

[45] **Date of Patent: Mar. 31, 1987**

[54] **SELF DESTRUCTING FUSE FOR SUB-MUNITIONS TO BE EXPELLED FROM A ROCKET**

[75] Inventor: **Antonio Gatti**, Milan, Italy

[73] Assignee: **Fratelli Borletti S.p.A.**, Italy

[21] Appl. No.: **867,937**

[22] Filed: **May 29, 1986**

[30] **Foreign Application Priority Data**

Jun. 28, 1985 [IT] Italy 67594 A/85

[51] **Int. Cl.**^{4} **F42C 15/04**

[52] **U.S. Cl.** **102/226**; 102/257; 102/489

[58] **Field of Search** 102/226, 227, 223, 225, 102/228, 229, 230, 260, 489, 393, 388, 257

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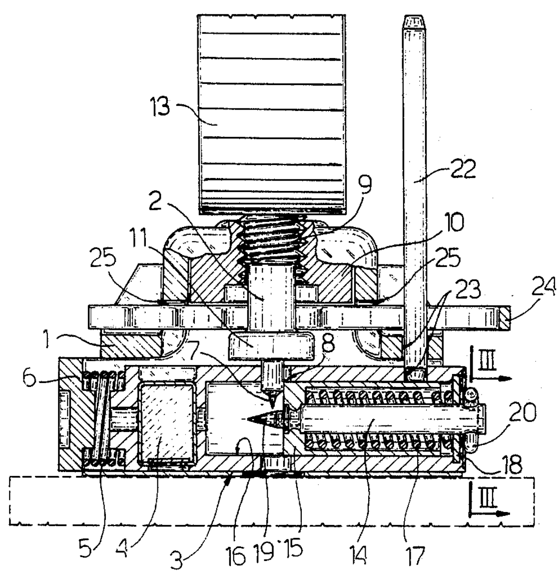
Primary Examiner—David H. Brown

Attorney, Agent, or Firm—Jeffers, Irish & Hoffman

[57] **ABSTRACT**

The fuse comprises a first striker member which is movable within the body of the fuse and is able to come into contact with a detonator to cause it to explode, and a slide which is movable in a direction substantially orthogonal to that in which the striker member is movable and which carries the detonator; within the said slide there is disposed a second striker member which is movable from a first position, in which it elastically deforms a spring and is held at a predetermined distance from the detonator, to a second position in which it comes into contact with the detonator to cause it to explode, the movement of the second striker member being delayed by delay means operable to allow the movement of the striker member itself from the first-defined first to the second position only after a predetermined time.

5 Claims, 3 Drawing Figures



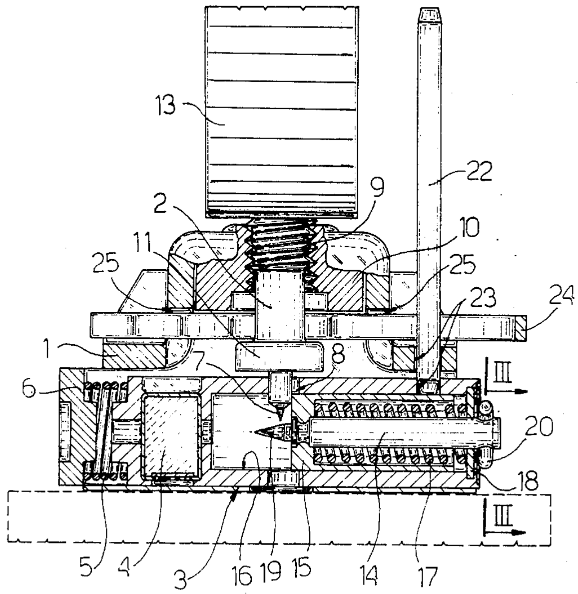
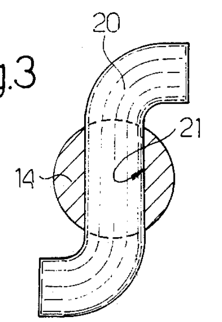


Fig.1

Fig.3



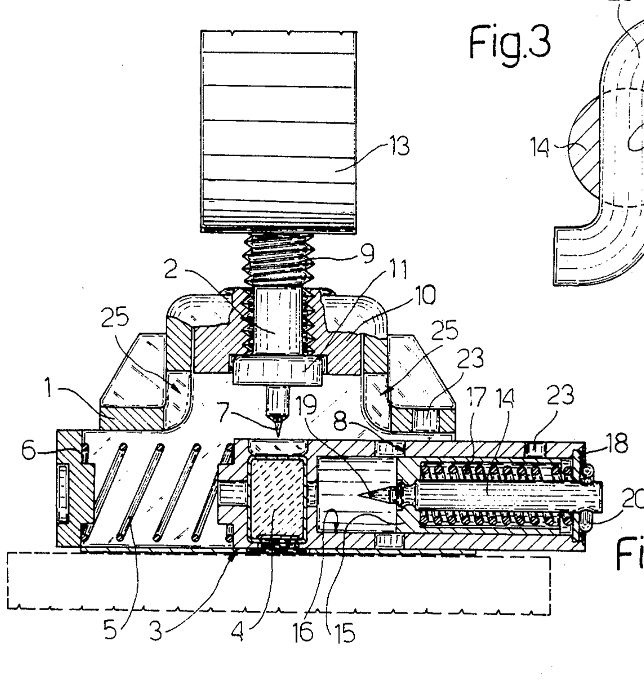


Fig.2

to allow the movement of the said second striker member from the said first to the said second position after a predetermined time from the instant in which the said slide has reached the said second position.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention there will now be given, by way of example, a more detailed description of it with reference to the attached drawings, in which:

FIG. 1 is a section of a fuse of the invention in a first operative configuration;

FIG. 2 is a section through the preceding Figure, in which the fuse has been shown in a second operative position;

FIG. 3 is a section, on an enlarged scale, of the fuse of FIG. 1 taken on the line 3—3.

DETAILED DESCRIPTION OF THE INVENTION

The fuse of the invention substantially comprises a body **1**, a striker member **2** movable in the direction of its longitudinal axis within the body itself, and a slide **3** also movable with respect to the body in a direction substantially orthogonal to the preceding direction.

The slide **3** is provided with a housing in which is disposed a detonator **4** and which is positioned at one end of the slide itself; this slide is movable in a guide, formed in the body **1**, under the action of a coil spring **5** interposed between an end surface of this and a suitable shoulder **6** formed on the body **1**. This slide can be carried, by the action of this spring, from a first position represented in FIG. **1**, in which the detonator **4** is located out of the path of the striker member **2** and to one side of this, to a second position, represented in FIG. **2**, in which the detonator itself is in the path of the striker member and immediately beneath it.

The striker member **2** which is substantially in the form of a cylindrical rod, includes a, substantially conical tip **7** at the end thereof, which can exert a force on the detonator **4** to cause it to explode; this tip can be inserted into a corresponding hole **8** of the slide **3** when this is in the first-defined first position, for the purpose of locking it in this position, as is clearly seen in FIG. **1**. The striker member **2** is provided with a threaded section **9** which, when the striker member is located in the above-defined first position, is screwed into a corresponding threaded hole of a small sleeve **10** which can move axially within the body **1** in the direction of the longitudinal axis of the striker member, but which is prevented from rotating with respect to it. At the upper end of the striker member **2** there is fixed a deformable element in the form of a strip **13** formed substantially in a loop, operable to cause rotation of the striker member **2** with respect to the body **1** of the fuse by aerodynamic action in a manner such as to cause, as will be described in more detail below, unscrewing of the threaded section **9** of the member itself from the corresponding threaded hole of the sleeve **10** to extract the tip **7** from the hole **8** in the slide **3**. In the lower part of the striker member **2** there is formed an annular projection **11** which cooperates with a corresponding shoulder formed on the sleeve **10**.

Within the slide **3** there is disposed a second striker member **14** which is movable axially with respect to the slide in a direction substantially orthogonal to that of the movement of the striker member **2**; conveniently, this striker member is rigidly connected to a sleeve **15** movable within a corresponding hole **16** of the slide **3**. The striker member **14** is thrust against the detonator **4** by the action of a coil spring **17** which is housed within the sleeve **15** between a shoulder of this and a suitable stop ring **18** fixed to the slide itself. The second striker member **14** is movable from a first position, shown in FIG. **1** and **2**, in which it is held substantially at a predetermined distance from the detonator **4**, to a second position in which a tip **19** of the striker itself comes into contact with the detonator **4** to cause it to explode.

As is clearly seen in FIG. **1**, when the slide **3** is located in the first-defined first position, the tip **7** of the first striker member **2** also constitutes a stop against movement of the second striker member **14** since it engages the end surface of the sleeve **15**.

The second striker member **14** is provided with delay means, operable to allow its movement from the first to the second position first defined after a predetermined time from the instant at which the tip **7** of the first striker member **2** has been withdrawn from the hole **8** to allow the slide **3** to reach the second position illustrated in FIG. **2**.

This delay means conveniently comprises a stop member of the striker member **4**, operable to lock it with respect to the slide for a predetermined time, after which this stop member frees the striker member to allow its movement under the action of the spring **17**. Conveniently this stop member is constituted by a section **20** of a wire of material which has a high viscus flow such as for example lead, inserted into a corresponding hole **21** formed in the end part of the second striker member **14**. This section of wire, as is clearly seen in the drawings, normally rests against the stop ring **18** in such a way as to prevent, for a predetermined time, any displacement of the sleeve **15** under the action of the spring **17**.

Conveniently, the fuse of the invention includes a pin **22** which can be inserted in corresponding holes **23** formed in the body **1** and the slide **3** for the purpose of constituting a safety pin against displacement of the slide itself. Moreover, a cotter **24** can be inserted transversely into corresponding slots formed in the body **1** to prevent any axial displacement of the sleeve **10** and therefore to constitute a further safety stop.

The operation of the fuse described is as follows.

After the sub-munition has been separated, in a known way, from the projectile which carries it, the aerodynamic forces acting on it are able to put the fuse into its armed configuration; in fact, if the sub-munition, whilst it moves along its trajectory, is given a rotary movement about its longitudinal axis, the action of the aerodynamic resistance of the deformable element **13** causes unscrewing of the threaded section **9** of the first striker member **2** from the corresponding threaded hole in the sleeve **10**, until the member itself is put in the configuration of FIG. **2** in which the annular projection **11** comes into contact with the corresponding stop surface of the sleeve.

In this configuration, as is clearly seen in FIG. **2**, the tip **7** of the striker member **2** is withdrawn from the hole **8** in the slide and therefore this, under the action of the coil spring **5**, is displaced from the first configuration shown in FIG. **1** into the second configuration shown in FIG. **2**, in which the detonator **4** is located beneath the tip **7** of the first striker member **2** in the armed position.

When the sub-munition strikes the ground the inertia action which acts on the assembly constituted by the sleeve **10** and the striker member **2** creates a force to thrust the tip 7 against the detonator 4 to cause it to explode.

If these inertia forces are not sufficiently high to cause the explosion, as can happen if the sub-munition falls onto soft ground, for example snow covered ground, or the terminal part of its trajectory is not substantially orthogonal to the ground, the sub-munition is destroyed on the ground anyway by the action of the fuse of the invention.

In fact, starting from the instant in which the tip 7 of the first striker member has been withdrawn from the hole 8 of the slide 3, the sleeve 15 to which the second striker member 14 is rigidly connected is retained in the previously-defined first position (and corresponding to that of the Figure) solely by the action of the delay means with which the fuse is provided and which comprises the wire section 20. This, under the action of the force exerted by the spring 17, and because of the nature of the material of which it is made, is platically deformed in a continuous manner; this plastic deformation proceeds for a time which depends substantially on the section of the wire element 20 and the force exerted by the spring 17, and can therefore be suitably chosen. At the end of the said plastic deformation the wire element 20 is completely cut through, therefore freeing the sleeve 15 which can be moved to the end-of-stroke position, towards the left of FIG. 2 (a position which has not been shown) carrying the tip 19 against the detonator 4 to cause it to explode.

It is evident that the delay means which have been described, and which in the illustrated embodiment are constituted by the wire element 20, can be made in a different way and comprise a partly worked element of any other form which cooperates with the second striker member 14 in such a way as to constitute a stop for it and can be deformed substantially by viscus flow until the member itself is freed and allows the spring to move it to strike against the detonator 4.

Other modifications and variations, both as to form and to disposition of the various parts, can be introduced without departing from the scope of the invention.

I claim:

1. A fuse for sub-munitions which can be ejected from a projectile, comprising a first striker member movable within the body of the fuse in the direction of its longitudinal axis to come into contact with a detonator to cause it to explode, a slide which is movable within the said body in a direction substantially orthogonally of that of the said axis and which carries the said detonator, the said slide being movable from a first position in which the said detonator is located out of the path of the said first striker member and to one side thereof, to a second position in which the said detonator is located in the said path, the said striker member being movable from a first position, in which the lower end thereof is inserted in a corresponding seating of the said slide to prevent its movement, to a second position in which the said end is withdrawn from the said seating, in such a way as to allow movement of the said slide, characterised by the fact that it includes a second striker member movable within the said slide from a first position, in which it resiliently deforms a spring and is held at a predetermined distance from the said detonator, to a second position in which it comes into contact, by the action of the said spring, with the said detonator to cause it to explode, the said second striker member being held in the said first position by the action of the said first striker member when the said slide is located in the said first position and the movement of the said second striker member being delayed by delay means operable to allow the movement of the said second striker member from the said first to the said second position after a predetermined time from the instant in which the said slide has reached the said second position.

2. A fuse according to claim 1, characterised by the fact that the said delay means comprise a stop member for the said second striker member, operable to block the movement of the member itself with respect to the slide and under the action of the said spring, the said stop member being able to free the said second striker member to allow the movement thereof after the said predetermined time.

3. A fuse according to claim 1, characterised by the fact that the said second striker member is rigidly connected to a sleeve which is movable within a first hole of the said slide, having an axis coincident with the direction of movement of the slide itself, the said seat of the said slide in which the said end of the said first striker member is inserted being constituted by a second hole which is orthogonal to the said first hole and which is positioned in such a way as to be located on one side of the said sleeve when the said second striker member is in the said first position.

4. A fuse according to claim 2, characterised by the fact that the said stop member comprises a wire of material having a high viscus flow, which is inserted in a radial hole of the said second striker member and which abuts against a shoulder of the said slide, the said wire being able to be cut after the said predetermined time.

5. A fuse according to claim 4, characterised by the fact that the said wire is made of lead.

* * * * *

United States Patent [19]

McIvor

[11] **3,872,790**

[45] **Mar. 25, 1975**

[54] **FUZE**

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[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

[22] Filed: **Feb. 24, 1958**

[21] Appl. No.: **717,273**

[52] **U.S. Cl.** .... **102/70 R,** 102/8

[51] **Int. Cl.** **F42c 7/02,** F42b 23/04

[58] **Field of Search** 102/8, 70, 82

[56] **References Cited**

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EXEMPLARY CLAIM

1. In a fuze detonating an anti-tank mine, a body, a base secured to said body, a spring-biased pressure plate slidably mounted in said body and said base, a pressure responsive countingmechanism for delaying detonation of said fuze housed in said pressure plate comprising, a shaft journaled for rotation transversely in said pressure plate, a first retaining clutch integral with said pressure plate, a second driven clutch mounted for free rotation on said shaft, a third clutch mounted on said shaft for rotation therewith and disposed between said first clutch and said second clutch, means fixed with said base adapted to rotate said second clutch upon reciprocal movement of said pressure plate, a firing mechanism housed in said base and a pressure bar integral with said third clutch for actuating said firing means and rotating in response to reciprocal movement of said pressure plate to actuate said firing means.

2 Claims, 4 Drawing Figures

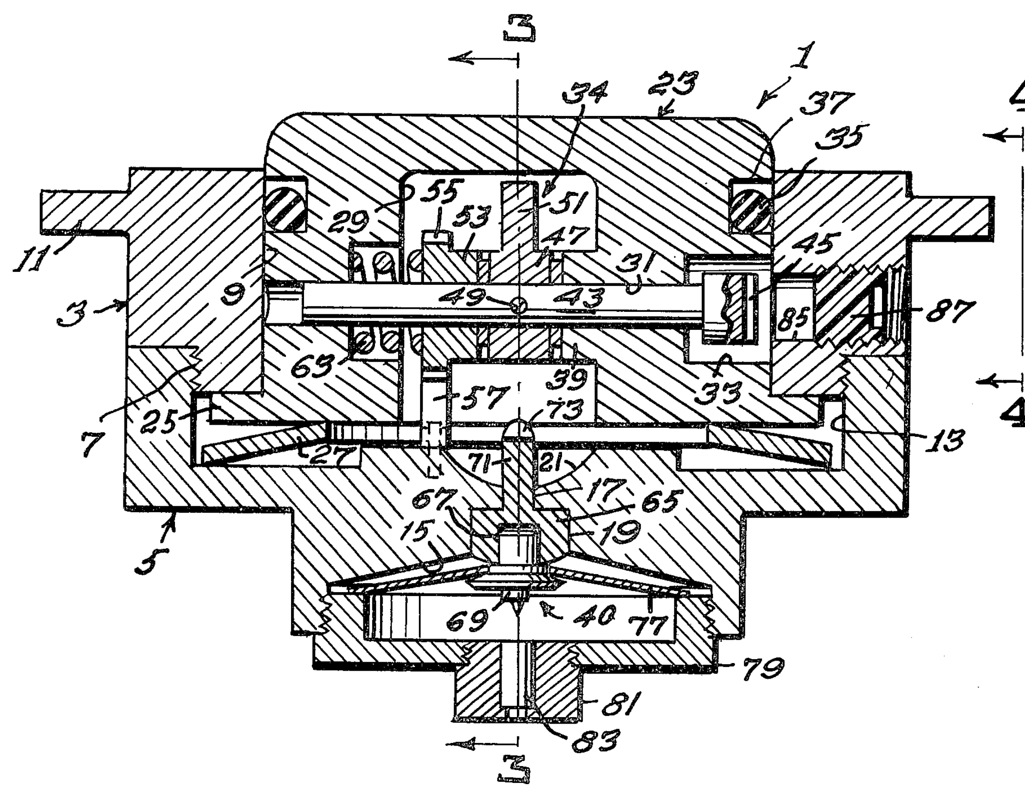


Fig. 1.

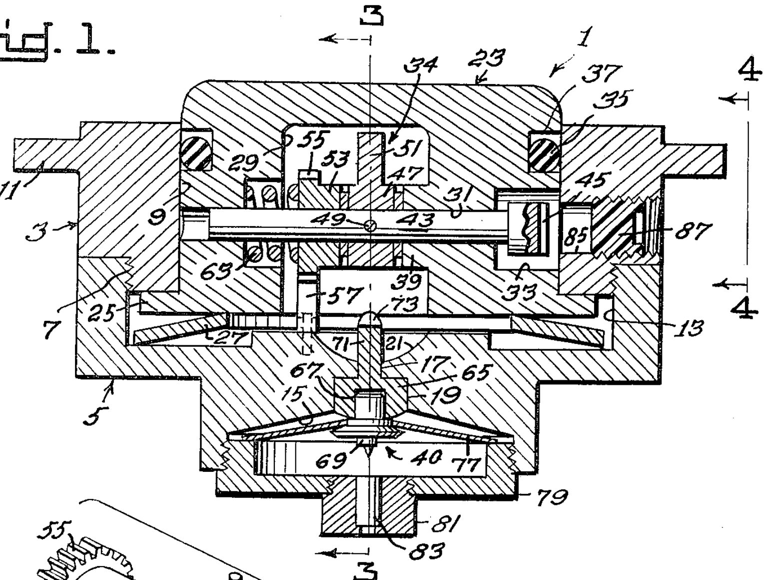


Fig. 2.

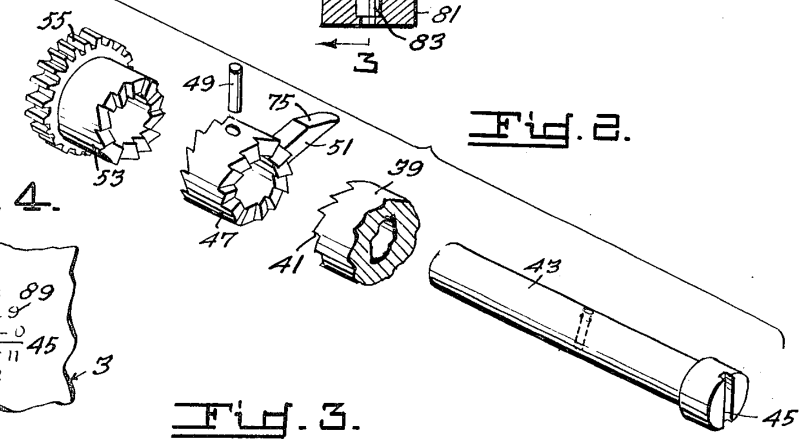


Fig. 4.

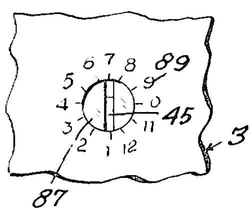
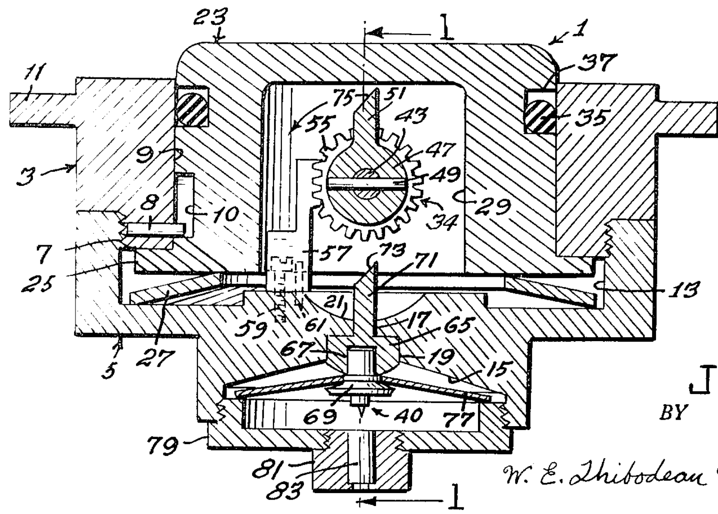


Fig. 3.



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FUZE

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to a fuze for anti-tank mines and more particularly to a fuze for use with an anti-tank mine that will function after a specific number of impulses or pressures of a certain magnitude have been applied. Present standard anti-tank mine fuzes of this type are usually attached to the mine and the complete assembly is buried and camouflaged by earth to prevent visual delection, and the mine is exploded as soon as the first tank tread passes over the fuze, resulting in damage usually to the front of the tank only.

Tests have proven that if the detonation of the mine occurs directly under the middle of the tank, greater damage could be done thereto than if the explosion occuring under the front of the tank.

Data on the pressure signatures of tanks indicate that the tank tread creates ground pressures which form peaks under the road treads and return to a null between the treads, forming a somewhat uniform cyclic pattern of known frequencies and amplitude. These signatures vary and are dependent on the physical characteristics (elasticity and compression) of various types of soil. In other words, each tread develops a very similar individual pressure signature as it passes over a point. Based on this data, the fuze of the invention was designed to function under the most vulnerable part of the tank, i.e., the middle.

The present invention provides a fuze for overcoming this functioning deficiency inherent in present standard anti-tank mine fuze designs, and provides a fuze operating on the principle of a simple rack and pawl arrangement that functions as a mechanical counter to detonate the mine at a predetermined point under the treads of a tank. The fuze is further provided with an adjustment whereby the fuze may be made to detonate at the desired number of pressures, dependent upon the size of the tank to be destroyed.

While the fuze of the invention is designed for incorporation in an anti-tank mine, it is possible to design it for anti-personnel or other automotive type mines, if required.

It is therefore a principal object of this invention to provide an anti-tank mine fuze adapted to function after a specific number of impulses or pressures of a certain magnitude are applied.

It is another object to provide a fuze acting as a mechanical counter to function at a predetermined point under the treads of a tank.

It is a further object of this invention to provide a fuze for an anti-tank mine that is adjustable to function after a number of pressures thereon.

It is a still further object to provide an anti-tank mine fuze that is highly efficient, reliable and of simple construction.

Other objects and advantages will be apparant from the following description, reference being had to the accompanying drawing forming a part of this application and in which like numerals designate like parts in all the views.

In the drawings:

FIG. 1 is a vertical section of a fuze, constructed in accordance with the invention, taken along line 1—1 of FIG. 3,

FIG. 2 is an exploded perspective view of the counting mechanism,

FIG. 3 is a vertical section taken along lines 3—3 of FIG. 1 and,

FIG. 4 is a fragmentary plan view taken in the plane 4—4 of FIG. 1 illustrating the setting indicia.

Referring to the drawing, **1** indicates generally the fuze of the invention which comprises a fuze body indicated generally by **3** and a base, indicated generally by **5** which is threadably united to body **3** by threads **7.** Body **3** is axially bored as at **9** for housing operating mechanisms, and defines at its upper portion an annular flange **11** for attachment of the fuze to a mine (not shown). Base **5** is axially bored to provide an annular chamber **13** to contain operating mechanisms, and is internally threaded at its lower portion thereof and is further provided with an upper conical wall. Bores **13** and **15** are connected by a small axial bore **17** and a counter bore **19.** The bottom of chamber **15** is milled axially to define a semi-circular well **21.** A cylindrical pressure plate, indicated generally by **23,** defines an upper portion slidable in bore **9** and a lower annular flanged portion **25** slidable in chamber **13,** and is prevented from rotational movement by pin **8** fixed in body **3** and extending into a slot **10** milled in the side wall of pressure plate **23.** Which is biased upwardly in bore **9** and chamber **13** by a Belleville spring **27** in chamber **13,** the upper portion thereof normally projecting above the upper surface of body **3** to be engaged by a tank tread or like impact. Pressure plate **23** is further bored to provide a mechanism housing **29** and is bored transversely as at **31** and counterbored as at **33** for a purpose to be later described. An O-ring **35** is received in an annular groove **37** in pressure plate **23** providing seal between the pressure plate **23** and body **3.** The inner wall of chamber **29** is provided with an annular inwardly extending annular boss which is provided with ratchet teeth **41** on the inner face thereof to form a retaining clutch **39.** A shaft **43** having a notched head **45** is received in bore **31** and counter bore **33** respectively. A pressure counting mechanism indicated generally by **34** is mounted on shaft **43** in bore **29** and comprises a clutch member **47,** having ratchet teeth on either side thereof and arranged in a unidirectional direction, is mounted to rotate with shaft **43** by a pin **49,** and is provided with a radially extending integral pressure bar **51.** A driven clutch member **53** is mounted for free rotation on shaft **43** adjacent clutch **47** and is provided with ratchet teeth on its inner face that normally mesh with teeth on one side of clutch **47** and is further provided with gear teeth **55** about its outer peripheral surface that mesh with gear teeth on a stationary upstanding rack **57** rigidly mounted on the bottom surface of chamber **13** and is secured thereon by a screw **59** and dowel pin **61.**

In their assembled relation on shaft **43,** clutch **47** is mounted between driven clutch **53** and retaining clutch **39** so that the teeth on **53, 47** and **39** are in mesh. These elements are biased into their meshed relation by a clutch spring **63** mounted about shaft **43** in a counter bore of bore **31** in pressure plate **23.**

Firing mechanism, indicated generally by **40,** for fuze **1** is mounted in the base **5** and comprises a bearing cap **65** bored centrally at its lower end to receive a firing pin **69** in press fitted relation and defines an upwardly extending shaft **71** slidably mounted in bore **17** and is further provided with a beveled end surface **73.** Shaft

71 is normally in vertical alignment with pressure bar 51 when it has been rotated whereby surfaces 73 and 75 mate. A snap-through Belleville spring 77 is mounted in chamber 15 and is held in position by a spring retainer 79 which is threadably engaged to base 5 and serves to hold the firing pin 69 in its retracted position. A detonator holder 81 is threadably engaged to spring retainer 79 and serves to hold a detonating element 83 in axial alignment below firing pin 69.

Setting means for regulating the counting mechanism are provided and comprise the notched head 45 of shaft 43 which is visable through a transverse bore 85 disposed coaxially with bore 31 and is closed at its outer end by a transparent threaded plastic plug 87 which is threadable in bore 85. Suitable setting indicia 89 is inscribed on the outer surface of body 3.

In operation, the fuze is placed in a mine well and the fuze 11 and is secured therein by suitable means (not shown). If it is desired to set the fuze for delayed detonation, i.e., after a certain number of tank treads have passed over the pressure plate 23, the plug 87 is removed and a screw driven is inserted through bore 85 to engage notched head 45 and the shaft 43 is turned to bring the pressure bar 51 into the correct position to actuate the firing mechanism 40. After the setting has been completed, the fuze is ready for use.

As each pressure is applied to the pressure plate 23, the plate 23 will be pressed downward against the Belleville spring 27 carring with it, the counting mechanism 34. Driven clutch 53 will be rotated clockwise by rack 57 which is fixed on the base 5 and the ratchet teeth on clutch 53 will slip past the adjacent ratchet teeth on clutch 47 due to the clutch spring 63, and clutch 47 will not rotate. Upon release of each pressure on plate 23, plate 23 will be moved upward by Belleville spring 27 and the rotation of driven clutch 53 is reversed and pressure bar 51 is rotated in a counterclockwise direction, the ratchet teeth on the side of clutch 47 adjacent the retaining clutch 39 slipping over the teeth 41 thereon. As each successive pressure is applied to the pressure plate 23, this procedure is repeated until the pressure bar 51 is in position whereby the beveled surface 75 on pressure bar 51 is in contact with the beveled surface 73 of shaft 71, then, when the next pressure is applied to plate 23, shaft 71 is pushed down in bore 17 carrying with it firing pin 69, Bellevile spring 77 will then "snap through" to cause firing pin 69 to detonate the detonating element 83 and fire the anti-tank mine. (not shown) The fuze may also be set for instantaneous detonation of a mine upon a single downward movement of pressure plate 23, if desired, by moving the pressure bar 51 to a position whereby it engages shaft 71. This will allow the firing pin to fire the detonator upon a single tank tread or like impression upon the pressure plate 23.

It is apparent from the foregoing description that a highly efficient fuze has been devised to delay the mine detonation until the vehicle to be destroyed has reached the position over the mine to effect the most damage thereto. The fuze of the invention is simple of construction and is easily assembled.

It is to be understood that the form of the invention herein shown and described, is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangements of parts may be resorted to without departing from the spirit of the invention, or scope of the subjoined claims.

What is claimed is:

1. In a fuze for detonating an anti-tank mine, a body, a base secured to said body, a spring-biased pressure plate slidably mounted in said body and said base, a pressure responsive counting-mechanism for delaying detonation of said fuze housed in said pressure plate comprising, a shaft journaled for rotation transversely in said pressure plate, a first retaining clutch integral with said pressure plate, a second driven clutch mounted for free rotation on said shaft, a third clutch mounted on said shaft for rotation therewith and disposed between said first clutch and said second clutch, means fixed with said base adapted to rotate said second clutch upon reciprocal movement of said pressure plate, a firing mechanism housed in said base and a pressure bar integral with said third clutch for actuating said firing means and rotating in response to reciprocal movement of said pressure plate to actuate said firing means.

2. In a fuze for detonating an anti-tank mine, a body, a base secured to said body, a spring-biased pressure plate slidably mounted in said body and said base, a detonator in said base, a pressure actuated counting mechanism for delaying detonation of said detonator comprising a shaft journaled for rotation transversely in said pressure plate, a first retaining clutch including a set of circumferentially arranged ratchet teeth integral with said pressure plate and surrounding said shaft, a second clutch mounted for free rotation about said shaft, said second clutch being provided with a set of ratchet teeth on its inner side and gear teeth about its peripheral surface, a third clutch having a set of ratchet teeth on either side thereof in unidirectional arrangement mounted on said shaft for rotation therewith, a clutch spring housed in said pressure plate and surrounding said shaft normally biasing said second clutch and said third clutch toward said first clutch, a spring held firing pin defining an upwardly extending shaft having a beveled upper end slidably mounted in said base, a pressure bar integral to said third clutch having a beveled end thereon, a toothed rack fixed with said base having its teeth meshing with said gear teeth on said second clutch, said pressure bar and said third clutch adapted to rotate in a counter clockwise direction only upon reciprocal movement of said pressure plate whereby said rack will rotate said second clutch to rotate said third clutch in a counter clockwise direction only, whereby said beveled end on said bar will contact said beveled end of said shaft on said firing pin to snap said pin downward to fire said detonator, and adjusting means for regulating detonating delay comprising a notched head on said counting mechanism shaft for receiving an adjusting tool.

* * * * *

United States Patent

[11] 3,613,593

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[21] Appl. No. 444,520
[22] Filed Mar. 30, 1965
[45] Patented Oct. 19, 1971

[54] **MECHANICAL COUNTING FUZE**
6 Claims, 7 Drawing Figs.

[52] U.S. Cl. .... 102/76 R, 102/8, 102/16
[51] Int. Cl. F42c 7/02, F42c 15/14, F42c 15/24
[50] Field of Search 102/8, 16, 18, 19.2, 70, 83, 76

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Assistant Examiner—Thomas H. Webb
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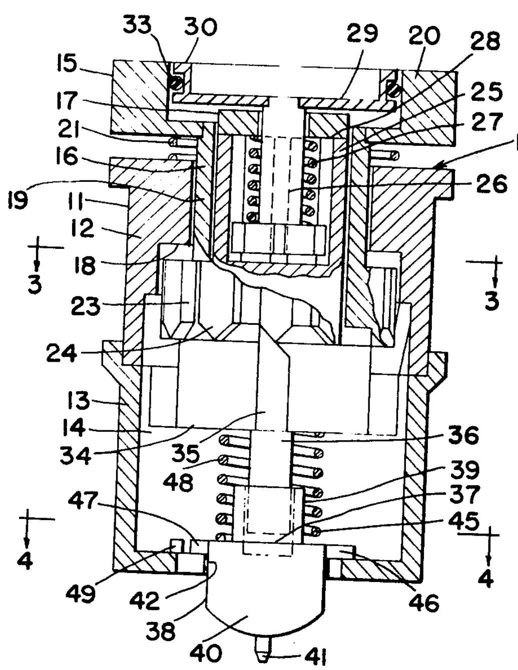
CLAIM: A fuze comprising a body with an upper and a lower end having a main axial bore therethrough, said body lower end having an axial bore smaller than said main bore and having radial groove means in the wall defining said smaller bore, a hollow outer plunger member slidably mounted in said main bore, an inner plunger member movably mounted in said outer plunger member and coaxial therethrough, a firing pin releasably secured to the lower end of said inner plunger member, cam means fixed on the end of said outer plunger member, cam follower means carried by said inner plunger member so constructed and arranged that upon relative downwardly directed axial movement of said outer plunger member with respect to said body the cam means will act on said follower means to impart a limited rotational movement to said inner plunger member, means preventing rotational movement of the outer plunger member with respect to said body, a resilient means operative between said firing pin and said inner plunger member, said resilient means arranged to oppose relative downwardly directed axial movement of said inner plunger member with respect to said body, tab means radially fixed on said firing pin and so arranged and constructed as to align with said groove means when said inner plunger member is rotationally advanced with respect to said outer plunger member by a predetermined number of axial reciprocations of said outer plunger member whereby said firing pin is freed to move downwardly under the force of said resilient means.



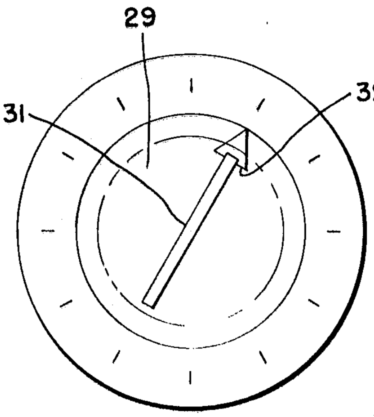


FIG. 2.

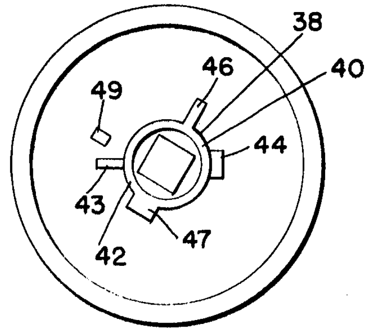


FIG. 4.

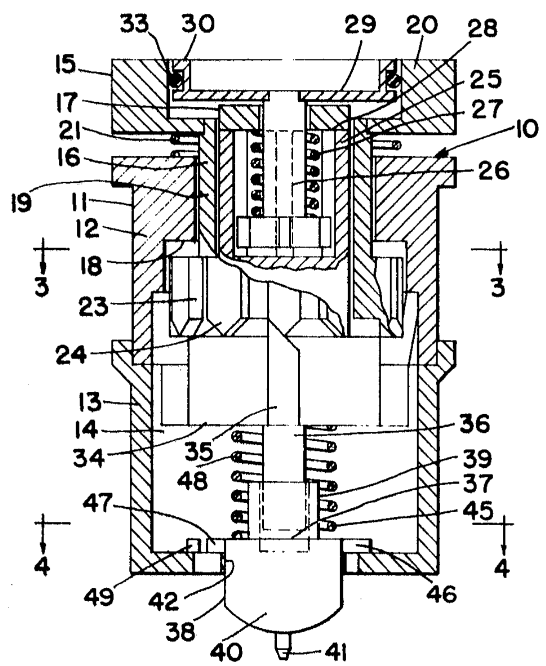


FIG. 1.

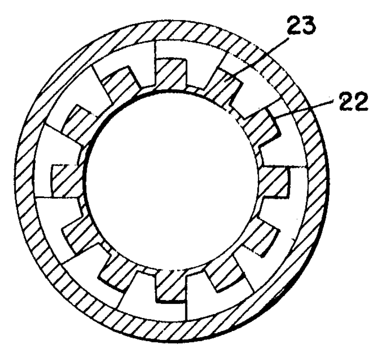


FIG. 3.

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MECHANICAL COUNTING FUZE

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

This invention relates to a fuze for an explosive, and particularly to a mechanical counting fuze for use with an antitank or an antipersonnel mine whereby the mine may be activated by the first or by such subsequent contact as may be desired.

The mechanical counting fuze of this invention is commonly known in the fuze art as a "skip" fuze. It may be used in combination with an antitank or an antipersonnel mine, and can be set to activate by the first or by such subsequent contact as may be desired. Mines using a "skip" type fuze as that of the present invention may be laid out in an infinite variety of patterns to impede, harass, or confuse the enemy in accordance with tactical requirements. A mine field could be laid out in a pattern wherein the mines would be set to be activated after different numbers of pressure pulses or contacts are applied to the fuze. The mines located at the beginning portion of the field could have their fuzes set for activation after a predetermined plurality of contacts. As the mines are positioned farther into the field the number of contacts necessary for their activation may progressively decrease. The mines at the most remote portion of the field may activate on one contact. In an enemy advance the first tanks or troops entering the field would contact the mines at the beginning portion of the field without activating them. The advance would continue into the field with subsequent contacts of mines being made without activation. Additional enemy advances would repeat contacts of the mines without their activation. However, each contact with a mine would bring it closer to activation. A condition will ultimately be reached where a certain number of enemy are on the mine field, and contact with any mine will result in its activation. The enemy will be trapped on the field since movement in any direction will cause a mine to activate.

Heretofore, the "skip"-type mechanical counting mine fuzes known in the art had many inherent disadvantages limiting their application. The most serious defect was their complexity in structure and operation. Especially complex were the structures comprising the pressure pulse or contact-counting portion of the fuze. Counting portion structures ranged from pawl and gear counters to elaborate cam and follower counters. Extensive machining with attendant high cost was required to provide the elements for the prior art counting structures.

Since the prior art mechanical counting fuzes were so complex in structure and economically impracticable for mass quantity use resort was had to electronic counting fuzes. Electronic type fuzes naturally require a power source for their operation. The necessity of a power source is attended by serious disadvantages, one of which is the inability of the electronic fuze to meet the 20-year shelf life required of mine fuzes. Current state-of-the-art in small power sources does not permit 20-year storage. Power source leakage resulting from insulation breakdown further renders the electronic fuze incapable of meeting a requirement of fuzes for maintaining active life after burial in the ground for one year.

Both the prior art mechanical and electronic "skip"-type fuzes were further limited in their use in that no provisions were made for a simple means of setting the activation count of the fuze. The only way of setting the activation count was to disassemble the fuze and make the setting. This method was extremely time consuming. Furthermore, no way, outside of markings, existed for readily and positively ascertaining the fuze activation count setting. Therefore, when a prior art "-skip"-type fuze was assembled to a mine it could not be determined whether the activation count of the fuze was prematurely changed, and if a change were required in the activation count the fuze would have to be disassembled from the mine and the involved procedure of resetting followed. As a result of the above disadvantages the prior art "skip"-type mine fuzes were marginal in fulfilling military needs and, at best, afforded an undesirable expedient to the long-existing need for an effective mechanical counting fuze.

It is, therefore, an object of the present invention to provide a mechanical counting fuze for an antitank or an antipersonnel mine which may be activated by the first or by such subsequent contact as may be desired, and which uses parts of simplified and low-cost construction.

It is a further object of this invention to provide a mechanical counting fuze for an antitank or an antipersonnel mine which may be activated by a first or by such subsequent contact as may be desired and which activation contact may be readily and easily set without disassembling the fuze.

It is also an object of this invention to provide a mechanical counting fuze for an antitank or an antipersonnel mine which may be activated by a first or by such subsequent contact as may be desired and which activation contact may be readily and easily set while the fuze is within or without the mine.

It is still another object of this invention to provide a mechanical counting fuze for an antitank or an antipersonnel mine which may be activated by a first or by such subsequent contact as may be desired and the activation contact setting of which may be positively ascertained by visual observation.

The invention will, however, be further understood and other objects and advantages thereof will become apparent from the following description, when considered in connection with the accompanying drawings, the scope of the present invention being pointed out in the appended claims.

In the drawings:

FIG. 1 is an elevation view partly in cross section of the inventive fuze;

FIG. 2 is a top view of the invention;

FIG. 3 is a sectional view of the invention through 3—3 of FIG. 1;

FIG. 4 is a view taken in the direction of the arrows on line 4—4 of FIG. 1;

FIG. 5 is a development of an operative element of the present invention showing details of construction;

FIG. 6 is a top view of FIG. 5:

FIG. 7 is an illustration of the interaction of operative elements of the present invention showing, in sequence, one operation.

Referring to the drawings, in which like reference characters refer to like parts throughout the various figures, **10** designates the mechanical counting fuze as a whole, having a cylindrical body **11** comprising an upper housing **12** and a lower housing **13**. The lower housing **13** is adapted at its upper end to receive the lower end of the upper housing **12** in abutting relationship, a continuous main axial bore **14** being formed thereby in which is carried a plunger assembly **15**.

The plunger assembly **15** comprises an outer plunger member **16** concentric with an inner plunger member **17**. At a substantially central point of the upper housing **12** the main bore **14** has a shoulder **18** defining a reduced diameter portion of the main bore upward of such shoulder, which reduced diameter portion receives the central portion of the outer plunger member **16** in slidable relationship therewith. The latter extends upwardly beyond the end of upper housing **12** and terminates in an integrally connected flangelike head **20**. Surrounding the central portion **19** of the outer plunger member **16** and arranged between the lower surface of the head **20** and the upper surface of the upper housing **12** is a helical coil spring **21**. The spring **21** is of sufficient strength to aid in returning the outer plunger member **16** to its upper position after a pressure pulse applied to the head **20**, causing a downwardly directed depression of the plunger assembly **15**, is released.

Below the shoulder **18** is disposed an enlarged chamber which is defined by a spline fitting **22** as shown in FIG. **3**. The lower end portion of the outer plunger **16** defines a spline shaft **23** and is received in slidable relationship in the spline fitting **22**. The function of the spline arrangement is to restrict outer plunger member **16** to vertical downward movement when a downward force is applied to head **20**.

The lower ends of the teeth **24** of the spline shaft **23** are formed into V-shapes, each surface of the V having a 45° inclination angle with reference to the longitudinal axis of the fuze **10**. As shown in FIG. **5** the teeth **22***a* of the spline fitting **22** have their lower ends formed into a wedgelike surface having a 45° inclination angle with reference to the longitudinal axis of the fuze **10**. The function of the lower end shapes of the teeth **22***a* and **24** will be shown further on in the course of this description.

The lower end of the central portion **19** of the outer plunger member **16** extends into the spline shaft **23** to a point substantially at the top of the V of the teeth **24**.

The inner plunger member **17** is concentrically disposed in rotatable and slidable relationship with the outer plunger member **16**. The upper end of the inner plunger member **17** is hollow cylinder **25** have spline fitting at its inside bottom. A shaft **26** having a splined lower end of larger diameter than its main body portion is force mated with the spline fitting of the cylinder. The upper end of the shaft **26** extends above the cylinder **25** and into the head **20** of the outer plunger member **16**. A helical coil spring **27** in compression is placed around the shaft **26** with its lower end in abutment with the spline portion of the shaft **26**. A retaining collar **28** having an axial opening is force fitted to the shaft **26** and is placed in abutment with the cylinder **25** and the upper end of the spring **27**. The retaining collar **28** fits into an axial opening in the lower end portion of the head **20** of the outer plunger member **16**. The shaft **26** adapted at its upper end to receive in fixed relationship therewith an indexing plate **29** which fits into an axial counterbore in the upper portion of the head **20**. The urging of the compression spring **27** against the lower surface of the retaining collar **28** assists in holding the indexing plate **29**, shaft **26**, and cylinder **25** in fixed relationship with each other.

A clearance between the outer lower surface of the indexing plate **29** and the counterbore of the head **20** allows a downward displacement of the inner plunger member **17** with relation to the other plunger member **16**.

The indexing plate **29** is formed with an upwardly extending flange **30**. An indicator **31** passes diametrically across the surface of the indexing plate **29** and is fixed thereto. The indicator **31** is raised a sufficient amount above the surface of the indexing plate **29** so that it can be firmly gripped by an operator to enable him to rotate the inner plunger member **17** when setting the activation count of the fuze **10**. When an activation count is set, the indicator **31** will align with one of the reference marks scribed on the upper surface of the head **20** of the outer plunger member **16** as shown in FIG. **2**. The operation of setting the activation count will be further detailed later on in the description.

The outer periphery of the flange **30** of the indexing plate **29** is adapted to receive an O-ring seal **33** which engages the wall of the counterbore of the upper portion of the head **20**. This seal functions to prevent entrance of any foreign matter into the space between the outer plunger member **16** and inner plunger member **17**.

The cylinder **25** extends to a point substantially at the lower end of the spline shaft **23** of the outer plunger member **16**. Disposed below the cylinder **25** and integrally a part thereof is a hub **34** having an outside diameter substantially the same as that of the central portion **19** of the outer plunger member **16**. The hub defines a spline shaft having three splines **35** spaced 120° apart. The splines **35** extend radially outwardly from the hub **34** to a diameter substantially equal to that of the teeth **24** of the spline shaft **23**. The circumferential width of the splines **35** is substantially the same as that of the teeth **24** of the shaft **23** and the spaces or grooves therebetween. The upper end portions of the splines **35** are formed into inclined surfaces having an angle of 45° with reference to the longitudinal axis of the fuze **10** and equal to the angle of inclination of either side of the V portion of the teeth **24** of shaft **23**. The inclined surfaces of the teeth **22***a* of the spline fitting **22**.

The splines **35** engage three teeth **24** of the spline shaft **23**, each spline **35** engaging a corresponding tooth **24** as shown in FIG. **1**. When the fuze **10** is in the inactive condition as illustrated in FIG. **1** an upper portion of each of the splines **35** fits into a portion of the same spline fitting **23** groove into which its corresponding tooth **24** fits. When a pressure pulse or contact is applied to the plunger assembly **15**, both the outer plunger member **16** and inner plunger member **17** will move longitudinally downwards, the teeth **24** and splines **35** sliding along their respective grooves in the spline fitting **23**. When the uppermost portion of the splines **35** is moved downwardly just beyond the lowermost portion of the spline fitting **23** the teeth **24** will act on the splines **35** to rotate the inner plunger member **17**. This operation will be shown in more detail further on in the description.

Axially disposed below the hub **34** and integrally connected therewith is a key shaft **36** having a square cross section. The key shaft **36** is slidably fitted into the bore **37** of a firing pin assembly **38**. There is sufficient clearance between the lower end of the key shaft **36** and the inside bottom of the bore **37** to allow longitudinal movement of the key shaft **36** in the bore **37** when a pressure pulse is applied to the plunger assembly **15**. The firing pin assembly **38** will not move longitudinally but will rotate about the fuze **10** axis when the plunger assembly **15** is actuated by a pressure pulse.

The firing pin assembly **38** is generally cylindrical in shape having an upper cylindrical portion **39** and an integrally connected enlarged lower portion **40** having an impinging or firing pin **41** arranged on the lower end thereof adapted to strike a primer as the firing pin assembly **38** is released. The lower portion **40** of the firing pin assembly **38** extends through the lower end of the lower housing **13**. A reduced diameter opening **42** at the lower end of the main bore **14** permits the lower end portion **40** to extend through the lower end of the lower housing **13**. The diameter of the opening **42** is slightly larger than the outside diameter of the lower portion **40** of the firing pin assembly **38**, allowing sufficient clearance for rotation of the firing pin assembly **38** therein. As shown in FIG. **4** the opening **42** is provided with two diametrically opposite slots **43** and **44** of unequal shape.

The lower portion **40** of the firing pin assembly **38** defines a shoulder **43** on its upper end having diametrically opposite tabs **46** and **47** thereon of unequal shapes corresponding to the shapes of the slots **43** and **44** respectively. The tabs **46** and **47** extend beyond the opening **42** impeding the downward movement of the firing pin assembly **38** until such time when the tabs **46** and **47** are vertically aligned with the slots **43** and **44** respectively.

Surrounding the key shaft **36** and upper portion **29** of the firing pin assembly **38** is a helical coil spring **48** in compression. The upper end of the spring **48** is adapted to contact a lower end portion of the hub **34** while the lower end of the spring **48** is adapted to seat upon the shoulder **45** of the firing pin assembly **36**. The spring **48** is of sufficient strength to cause the plunger assembly **15** to move longitudinally upwards when a pressure pulse thereon is released, and to cause the downward movement of the firing pin assembly **38** when the tabs **46** and **47** and the slots **43** and **44** are respectively vertically aligned.

An upwardly extending stop **49** is provided on the inside surface of the lower end of the lower housing **13**. The stop **49** is positioned so that the tab **46** will strike it when the activation count is set at the maximum number of counts permissible. The stop **49** precludes vertical alignment of the tabs **46** and **47** and slots **43** and **44** when setting the activation count. The stop **49** is situated in a position whereby it will not interfere with the tab **47** when the firing pin assembly **38** is being rotated during operation of the fuze **10**.

In operation of the fuze **10** with an antitank or antipersonnel mine the first function is to set number of activation counts desired in accordance with a tactical mission. To set the activation count the plunger assembly **15** is depressed by hand to its lowermost position and held there. The plunger assembly **15** is held depressed by applying the hand pressure to the indexing plate **29** of the inner plunger member **17** to insure that both inner and outer plunger members are in their lowermost depressed position. At the lowermost position the splines 35 are no longer within the grooves of the splined fitting 22. The inner plunger member 17 will be free to rotate. By grasping the indicator 31 of the inner plunger member 17, while maintaining sufficient pressure to hold the plunger assembly 15 in a lowermost position, the inner plunger member 17 may be rotated in a counterclockwise direction, as viewed from the top, to the number of counts desired before activation of the fuze. The count number desired is established when the inner plunger member 17 is rotated until the arrowhead of the indicator 31 aligns with the reference mark on the upper surface of the head 29 corresponding to the desired count number.

As shown in FIG. 1 the relationship of the teeth 24 of the spline shaft 23 to the splines 35, particularly their coacting inclined surfaces, provide a unidirectional ratchet-type rotational movement between inner plunger member 17 and the stationary outer plunger member 16. In this embodiment of the invention the rotation of the inner plunger member 17 with respect to the outer plunger member 16 when setting the activation count is in a counterclockwise direction as viewed from the top and as shown in FIG. 2.

The firing pin assembly 38 will rotate with the inner plunger member 17. The tabs 46 and 47, being diametrically opposite to each other, also have their radial axis (that is, with reference to the longitudinal axis of the fuze 10) in a coplanar parallel relationship with the radial axis (same reference) of the indicator 31. Therefore, the orientation of the indicator 31 with reference to the slots 43 and 44 of the opening 42 in the lower end of the lower housing 13 determines the orientation of the tabs 46 and 47 with respect to the same slots 43 and 44.

After the desired count number is set the plunger assembly 15 can be returned to its upper position by slowly releasing the pressure on the inner plunger member 17 while holding the indicator 31 with sufficient force to prevent the inner plunger member 17 from rotating clockwise. The interaction of the elements of the plunger assembly 15 will cause the clockwise rotation of the inner plunger member 17 as will be shown in the description which follows of the count operation of the fuze. The activation count setting may be made before or after the fuze is assembled to a mine.

The count operation results in a prescribed incremental rotational movement of the inner plunger member 17 and the firing pin assembly 38. This incremental movement is caused by the application and release of a pressure pulse or contact on the plunger assembly 15. The operation following can be best understood by reference to FIG. 7.

When contact is made by a vehicle or foot soldier, the weight on the top of the mine depresses the plunger assembly 15. The movement of the inner plunger assembly 16, and outer plunger assembly 17 at this point is longitudinally downward. The firing pin assembly 38 remains fixed while the key shaft 36 moves longitudinally within the bore 36. The outer plunger member 16 is limited to longitudinal movements by the coaction of the spline shaft 23 and the spline fitting 22 of the upper housing 12. The inner plunger member 16 is limited to longitudinal movement until the uppermost points of the splines 35 reach the lowermost point of the spline fitting 21 (FIG. 7*c*). Until this position is reached the splines 35 ride in the groove portions of the spline fitting 22 along with their corresponding teeth 24 of the spline shaft 23, and rotational movement is thereby precluded. The continued depression of the plunger assembly 15 by the external contact pressure will maintain the initial orientation of the inner plunger member 17 with regard to the outer plunger member 16. When the pressure contact is removed from the plunger assembly 15 the compressive force of the spring 48 acting on the inclined surfaces of the splines 35 and the teeth 24 they are in contacting relationship which causes the splines 35 to slide over the surfaces of the teeth 24 into the next spaces between the teeth 24 (FIG. 7*d*). The result of this relative movement between the splines 35 and teeth 24 is a clockwise rotation of the inner plunger member 17 while it and the outer plunger member 16 are both moving longitudinally upwards. Further rotational movement of the inner plunger member 17 will be restrained by the action on the longitudinal surface of the splines 35 of the next clockwise-oriented teeth 24 of the spline shaft 23. At this point the inner plunger member 17 is restrained from further upward movement by the teeth 22*a* acting on the splines 35. The spring 21 now acts to urge the outer plunger member 16 upwardly. When the upper points on the V of the teeth 24 reach the uppermost points of the splines 35 the compressive force of the spring 48 will cause the splines 35 to slide along the teeth 22*a* of the spline fitting 22 (FIG. 7*e*), resulting in another incremental rotation of the inner plunger member 17. As shown in FIG. 7*f* the sliding of the spline 35 along the teeth 22*a* continues until the inclined surfaces of the splines 35 contact the complementary inclined surfaces on the V of the teeth 24. At this point the plunger assembly 15 is in its upper position ready for the next count.

The magnitude of the rotational increments are determined by the number of teeth in the spline shaft 23 and spline fitting 22. In this embodiment there are 12 teeth on each. The total incremental movement, therefore, will be 30°, each increment of rotation being 15°.

The count operation described above is repeated each time a pressure pulse is applied to and released from the plunger assembly 15. The firing pin assembly 38 rotates on each count until the tabs 46 and 47 are respectively vertically aligned with the slots 43 and 44 at which time the compressive force of the spring 48 will act on the firing pin assembly 38 to drive it downwardly to impinge against a primer resulting in detonation.

We claim:

1. A fuze comprising
- a body with an upper and a lower end having a main axial bore therethrough,
- said body lower end having an axial bore smaller than said main bore and having radial groove means in the wall defining said smaller bore,
- a hollow outer plunger member slidably mounted in said main bore,
- an inner plunger member movably mounted in said outer plunger member and coaxial therethrough,
- a firing pin releasably secured to the lower end of said inner plunger member,
- cam means fixed on the end of said outer plunger member,
- cam follower means carried by said inner plunger member so constructed and arranged that upon relative downwardly directed axial movement of said outer plunger member with respect to said body the cam means will act on said follower means to impart a limited rotational movement to said inner plunger member,
- means preventing rotational movement of the outer plunger member with respect to said body,
- a resilient means operative between said firing pin and said inner plunger member,
- said resilient means arranged to oppose relative downwardly directed axial movement of said inner plunger member with respect to said body,
- tab means radially fixed on said firing pin and so arranged and constructed as to align with said groove means when said inner plunger member is rotationally advanced with respect to said outer plunger member by predetermined number of axial reciprocations of said outer plunger member whereby said firing pin is freed to move downwardly under the force of said resilient means.

2. A fuze comprising
- a body with an upper and a lower end having a main axial bore therethrough,
- said body lower end having an axial bore smaller than said main bore and having radial groove means in the wall defining said smaller bore,
- a hollow outer plunger member slidably mounted in said main bore,
- an inner plunger member movably mounted in said outer plunger member and coaxial therewith,

a firing pin releasably secured to the lower end of said inner plunger member,

cam means fixed on the end of said outer plunger member,

cam follower means carried by said inner plunger member so constructed and arranged that upon relative downwardly directed axial movement of said outer plunger member with respect to said body the cam means will act on said follower means to impart a limited rotational movement to said inner plunger member,

means preventing rotational movement of the outer plunger member with respect to said body,

a resilient means operative between said firing pin and said inner plunger member,

said resilient means arranged to oppose relative downwardly directed axial movement of said inner plunger member with respect to said body,

tab means radially fixed on said firing pin and so arranged and constructed as to align with said groove means when said inner plunger member is rotationally advanced with respect to said outer plunger member whereby said firing pin is freed to move downwardly under the force of said resilient means,

means on said inner plunger member for adjusting the rotational relationship between said cam means and said cam follower means whereby the number of reciprocations of said outer plunger member necessary to align said tab means with said groove means may be varied.

3. A fuze as defined in claim 2 provided with means for indicating the setting of said number of reciprocations.

4. A fuze comprising

a cylindrical body with an upper and a lower end having a main axial bore therethrough, said body defining an intermediate spline fitting having a plurality of equally spaced splines with inclined lower ends,

said body lower end having an axial bore smaller than said main bore having radial groove means in the wall defining said smaller bore,

a hollow outer plunger member slidably mounted in said main bore,

a flange member coaxially fixed with said outer plunger member above the upper end of said body and in spaced relationship therewith,

said flange member being provided with an axial bore,

a first helical coil spring surrounding a portion of said outer plunger member arranged between the lower surface of said flange member and the surface of said body upper end,

an inner plunger member slidably and rotatably mounted in said outer plunger member and coaxial therewith,

a shaft having rectangular cross section coaxially fixed to the lower end of said inner plunger member,

a firing pin slidably mounted to the lower end of said shaft,

a spline shaft coaxially fixed to the lower end of said outer plunger member defining a plurality of equally spaced splines having V-shaped lower ends,

said spline shaft mating in slidable relationship with said spline fitting whereby only axial movement of said outer plunger with respect to said body is permitted,

a plurality of teeth having inclined upper ends longitudinally fixed to the periphery of the lower end portion of said inner plunger member and equally spaced with respect to each other,

said teeth inclined upper ends contacting one side of the lower end V-shaped portions of said spline shaft splines whereby upon relative downwardly directed axial movement of said outer plunger member with respect to said body ...

said second helical coil spring arranged to oppose relative downwardly directed axial movement of said inner plunger member with respect to said body whereby upon upwardly directed axial movement of said inner plunger member said second helical coil spring will impart a force to said teeth which will coact with said spline-fitting splines to advance said inner plunger member another limited rotation increment,

a tab radially fixed on said firing pin so arranged and constructed as to align with said groove means when said inner plunger member is rotationally advanced with respect to said outer plunger member by a predetermined number of axial reciprocations of said outer plunger member whereby said firing pin is freed to move downwardly under the force of said second helical coil spring.

5. A fuze comprising

a cylindrical body with an upper and a lower end having a main axial bore therethrough, said body defining an intermediate spline fitting having a plurality of equally spaced splines with inclined lower ends,

said body lower end having an axial bore smaller than said main bore and having radial groove means in the wall defining said smaller bore,

a hollow outer plunger member slidably mounted in said main bore,

a flange member coaxially fixed with said outer plunger member above the upper end of said body and in spaced relationship therewith,

said flange member being provided with an axial bore,

said flange member having number characters scribed on the upper surface thereof spaced equally in relationship to and increasing in order in correspondence with the number of said spline-fitting splines,

a first helical coil spring surrounding a portion of said outer plunger member arranged between the lower surface of said flange member and the surface of said body upper end,

an inner plunger member slidably and rotatably mounted in said outer plunger member and coaxial therewith,

a plate member coaxially fixed to the upper end of said inner plunger member and fitted into said flange member axial bore,

a rod member having a pointer fixed on one end thereof diametrically fixed to the upper surface of said plate member,

a shaft having a rectangular cross section coaxially fixed to the lower end of said inner plunger member,

a firing pin slidably mounted to the lower end of said shaft,

a spline shaft coaxially fixed to the lower end of said outer plunger member defining a plurality of equally spaced splines having V-shaped lower ends and corresponding in number to said spline-fitting splines,

said spline shaft mating in slidable relationship with said spline fitting whereby only axial movement of said outer plunger with respect to said body is permitted,

a plurality of teeth having inclined upper ends longitudinally fixed to the periphery of the lower end portion of said inner plunger member and equally spaced with respect to each other,

said teeth inclined upper ends contacting one side of the lower end V-shaped portions of said spline shaft splines whereby upon relative downwardly directed axial movement of said outer plunger member with respect to said body said spline shaft will coact with said teeth to impart a downwardly directed axial ...

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[73] Assignee The United States of America as represented by the Secretary of the Army

[54] SPIN ATTENUATOR STRUCTURE FOR MECHANICAL TIME FUZES

6 Claims, 2 Drawing Figs.

[52] U.S. Cl. 102/84, 102/78
[51] Int. Cl. F47c 9/04, F47c 19/02
[50] Field of Search 102/82, 83, 84, 78, 79

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ABSTRACT: A cylindrical fuze housing is rotatably mounted in a shell case on the spin axis and supported by an inner or central rear ball thrust bearing on said axis and by an outer ring or annular ball bearing within the shell case. The outer ring bearing is supported by a deformable thrust ring and the rear thrust ball is likewise mounted in a housing which, in turn, is supported by a second deformable thrust ring connected with the casing. The deformable rings take up the setback shock, and the bearings provide rotational movement between the shell case and the timing mechanism of the fuze, thereby protecting it from error due to shock and rotation.

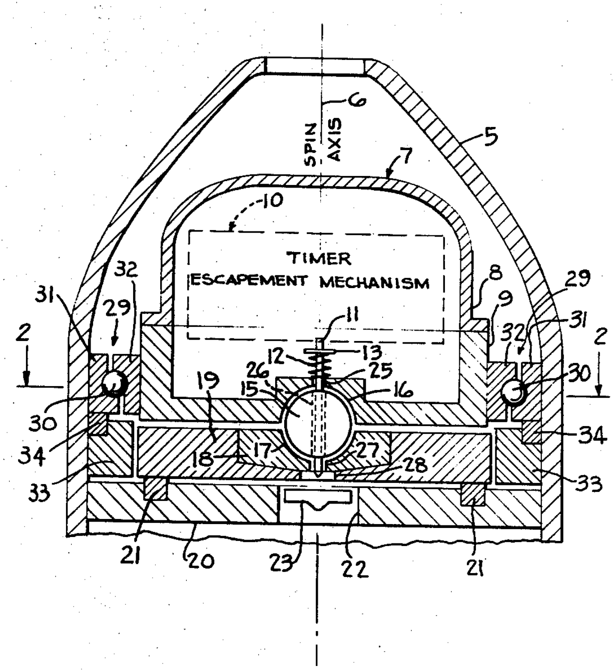
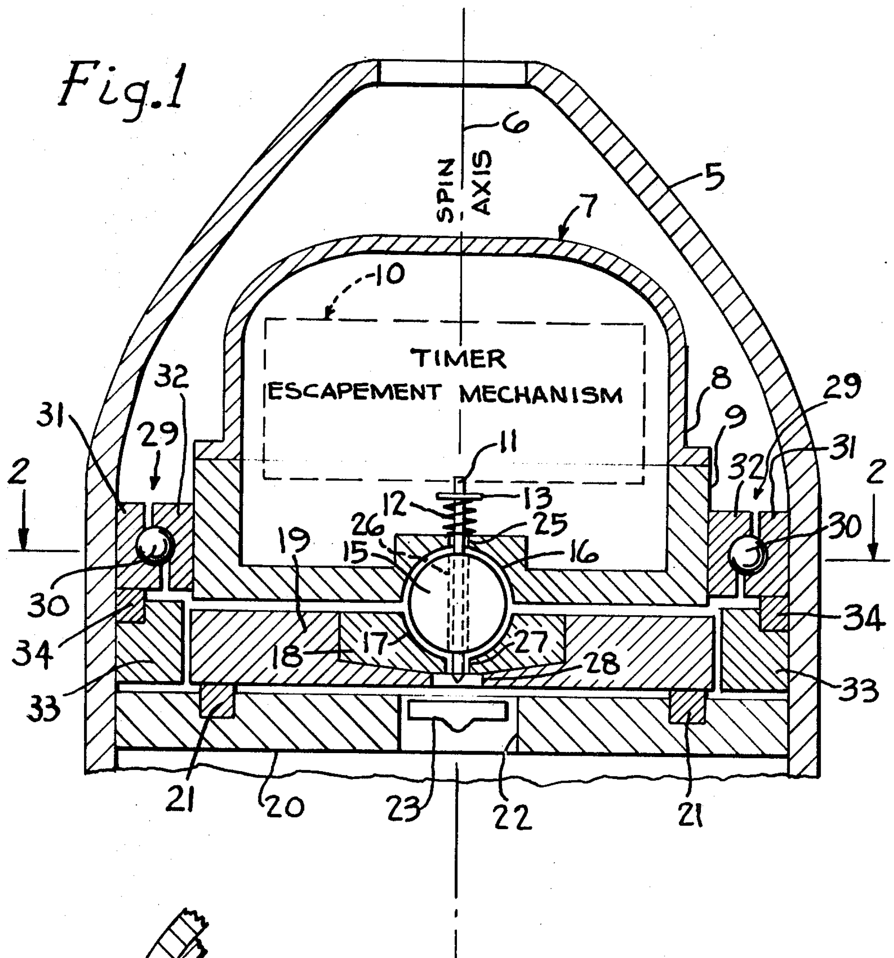


Fig. 1



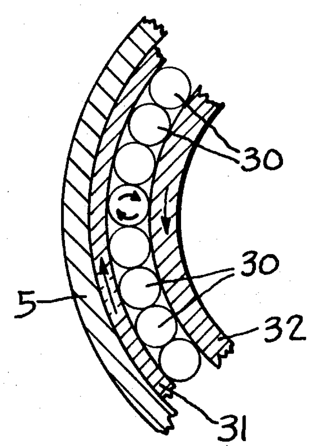


Fig. 2

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SPIN ATTENUATOR STRUCTURE FOR MECHANICAL TIME FUZES

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The present invention relates to a spin attenuator structure for mechanical time fuzes and the like, which embodies a timer escapement mechanism, and has for its primary object the provision of improved means for protecting such mechanical time fuzes and the escapement mechanism thereof in projectiles against spin effects and high acceleration forces on firing. Such timer mechanisms are of the type having an escapement wheel or the like and an oscillatory escapement lever or pallet means.

In the past, mechanical time fuzes of the type referred to, when subjected to an environment which imposed a high spin thereon and resulting from being launched from a gun, suffered a degradation in timing accuracy due to a change in the frequency rate of the escapement mechanism. The cause has been traced to the deformation of the escapement spring under this environment. A number of means have been devised in the past for eliminating this defect. These include the placing of the escapement means on the axis of spin, reducing the length of the escapement spring, and the use of axially mounted coil-type escapement springs and the like.

It is therefore an important and further object of this invention to provide an improved spin attenuator system for mechanical time fuzes of the type embodying an escapement mechanism, which prevents any degradation of its timing accuracy as above referred to and which may be constructed and serviced at low cost.

In accordance with one form of the invention, a fuze housing is rotatably mounted in a shell case on the spin axis and supported by a rear thrust ball on the axis and multiball thrust type outer bearing. The latter comprises an outer annular ball race press-fitted into the shell case and abutting rearwardly against a deformable thrust ring of powdered metal, or the like, capable of absorbing heavy setback thrust or force through deformation of the ring. The outer bearing further comprises an inner annular ball race pressure-mounted on the fuze housing and a single annular row of ball bearings therein to transmit radial and axial thrust loads to the outer race or ring.

When the carrier shell case is fired, the central ball and deformable rings, one of which is under the central ball race, take up the setback shock and the ball bearings provide rotational movement relative to the shell and the fuze housing at high spin rates without imparting more than a slow rotational movement to the fuze housing. It is thus protected against setback and spin effects.

The invention will further be understood from the following description when considered with reference to the accompanying drawings, and its scope is pointed out in the appended claims.

In the drawing,

FIG. 1 is a cross-sectional view, in elevation, of a spin attenuator structure for a mechanical time fuze embodying the invention, and

FIG. 2 is a fragmentary top view of a section of the structure of FIG. 1, taken on the section line 2—2 thereof, showing further details of the invention.

Referring to the drawings, wherein like reference characters are applied to like parts in both figures, 5 is the outer housing of a projectile or like carrier which may be subjected to high spin rates and high setback acceleration forces, and which must be provided with a timing device in a mechanical time fuze. Thus this may be a cylindrical artillery shell case or similar projectile, and in the present example only the ogival or forward portion thereof is shown. On firing, the shell case rotates on its central axis or spin axis indicated at 6. On this axis and within the shell case is mounted a cylindrical fuze or fuze housing 7 comprising a top or cover portion 8 and cup-shaped bottom or base portion 9 providing a hollow interior within which is mounted the timer escapement mechanism therefor as indicated in dash outline at 10 and the firing mechanism which is triggered thereby and includes a firing pin 11. The latter is held, in the retracted position shown, by a coiled compression or retracting spring 12 surrounding the firing pin and operating against a washer 13 carried by the firing pin. The safing and arming means for the firing pin are not shown to simplify the drawing since such means does not concern the invention.

The cylindrical fuze housing 7 is rotatably mounted in the shell case 5 on the longitudinal or spin axis 6 mainly on a single lower or rear thrust-ball bearing 15 provided with a fixed ball bearing race 16 centrally in the bottom or rear inner end of the fuze housing base 9. An opposite and lower single ball bearing race therefor is also provided as shown at 17, being formed in a shallow circular bearing rest or block 18 in turn seated in and affixed to a circular flat carrier plate 19 of considerable mass and strength. The latter is supported near its outer periphery from a fixed transverse supporting wall 20 extending across the shell casing 5 and provided with a first deformable thrust or spacing ring 21 positioned to receive the rearward firing thrust of the fuze and timer escapement mechanism through the thrust bearing 15.

The wall 20 is provided with a central timer pocket 22 in which is located a primer or detonator 23 for the projectile. This is aligned with the firing pin 11 which extends downwardly or rearwardly through a series of clearance openings. These include a clearance opening 25 in the base 9 of the fuze casing, a central hole or opening 26 in the ball bearing 15 and a central opening 27 in the bottom or rear end of the ball-race block 18. Through these openings, the firing pin extends to a position in alignment with and spaced from the primer or detonator 23, as shown in FIG. 1. An enlarged opening 28 is provided in the supporting plate 19 to clear the firing pin over the primer or detonator 23. In the present structure, the timer mechanism 10 of the mechanical time fuze 7 operates to move the firing pin 11 and fire the detonator 23 following a predetermined time delay after the projectile is fired.

The fuze housing 7 is further supported for rotation by an outer ring or annular ball bearing of the multiple-ball type as indicated at 29. This bearing is of the combined thrust and radial type comprising a continuous ring of small ball bearing elements 30 carried between a ring-type or annular outer ball race 31 and a complementary inner ring-type or annular ball race 32. The inner ball race 32 surrounds and is tightly fixed to the outer periphery of the base 9 of fuze housing 7, and the outer ball race 31 is within the shell casing and supported against rearward thrust by a relatively heavy metal annular outer bearing supporting ring 33 tightly secured to the shell casing and radially aligned with the carrier or supporting plate 19 for the central bearing 15. In a similar manner as the supporting plate 19, the outer race 31 is supported by a deformable thrust or spacing ring of suitable material as indicated at 34. This is mounted on and secured to the rigid annular supporting ring 33 which is connected with the casing or shell case 5.

Thus the mechanical time fuze 7 with its included timer escapement mechanism 10 is freely rotatably mounted within the shell case 5 on the spin axis 6 through two separate bearings, one of which is the central thrust bearing or ball 15, and the second of which is the outer annular ring of ball elements 30 and the ball races 31 and 32 therefor. There may be called, respectively, the central rear thrust-bearing and the forward outer ring bearing. The outer race 31 is mounted in contact with the inner surface of the casing 5 and is in abutting relation to and supported rearwardly against the collapsible ring 34. This, with the ring 21, may be composed of any suitable material such as a powder metal compound capable of absorbing a considerable amount of the setback force through deformation, as will be seen from a consideration of the operation hereinafter. The inner race 32 is pressure mounted on the fuze housing as noted.

The single-ball thrust bearing **15** is of relatively large diameter and provided with the central opening or hole **26** therethrough centrally located directly over the primer or pressure point **23** and aligned with the firing pin **11** so that firing operation for the fuze **7**, through the timing mechanism **10**, is transmitted through the thrust bearing and into the primer or detonator along the axis of the fuze and of the shell, that is, the spin axis.

From the foregoing it will be seen that, in accordance with the invention, the cylindrical fuze housing **7** is rotatably mounted in the shell case **5** on the spin axis **6** and is supported by a single-rear thrust ball, also on the axis, and a combined thrust and radial type outer bearing **29** coaxial with the central rear thrust bearing. Both bearings are separately supported in connection with the casing through first and second deformable or crushable spacing ring elements **21** and **34**, respectively, so that when the carrier casing or shell **5** is fired, the deformable rings, the first of which is under central ball race, take up the setback shock while the ball bearings provide rotational relative movement of the shell and the fuze housing.

Thus the system operates as follows: upon firing a shell from a launching element such as a rifle or a gun, the shell is rotated at high speed through the rifling and attains a high rate of spin. Simultaneously setback forces are transmitted as a result of the forward acceleration developed by high explosive pressures applied to the base of the shell and to all of the rear regions thereof. The spin and setback forces are transmitted to the outer race **31** which applies a turning movement to the balls or annular-ring ball elements **30** and exerts a rearward thrust on the spacing ring **34** which can deform to absorb the shock. The ball elements **30** apply a rotational motion to the inner race **32** and thus to the fuze housing **7** which then tends to maintain a relatively low spin rate with reference to the mechanical time fuze or timer escapement mechanism housed within it. In FIG. **2** the arrows indicate the relative motion of the two elements of the bearing **29** which permits the fuze housing to remain relatively stationary with respect to its initial reference position, due to the opposite thrust given to it by the balls **30**.

The same action occurs with reference to the centrally located rear single thrust-bearing **15**. The function of this central large ball is to pick up excess setback in unusually high acceleration loading conditions, such as in the firing of long range projectiles. The setback forces on the bearing **15** are transmitted to the spacing ring **21** which likewise can deform to absorb the shock. The ball also provides a pivot means for the fuze. The opening **26** in the center is to provide a means to transmit the energy of the firing pin or like firing element for effective fuze in the projectile.

Thus by this simple structure there is provided means for protecting the mechanical timer or timer escapement mechanism **10** in the fuze **7** for the projectile **5** against spin effects and the high acceleration or G forces acting upon the timing mechanism and fuze during the firing of the projectile. Such timers being of the type having an escapement wheel or the like and oscillatory escapement levers or pallet means as is known, thus are protected and operate without damaging effect on the timing rate. Thus with this system there is no appreciable change in the frequency rate of the escapement mechanism upon firing, since there is no deformation of any escapement spring under this environment, since none is used. It will thus be seen that this invention is of value in the field of timed projectiles which are launched or fired from rifled guns at high speeds for long range operation.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

I claim:

1. The combination with a projectile casing having a central longitudinal spin axis, of
   - a fuze therein including a timer escapement mechanism sensitive to spin and acceleration forces acting along said axis,
   - a cylindrical housing for said fuze,
   - an annular-ring ball bearing surrounding said fuze housing within the projectile casing,
   - said ball bearing comprising a radially inner ball race connected with the fuze housing, a radially outer ball race connected with the projectile casing, and a continuous annular ring of ball elements therebetween,
   - a first deformable thrust ring supporting the outer ball race in connection with said projectile casing,
   - means providing a central thrust bearing for said fuze housing and including a single large thrust ball having a central opening therethrough extending along the spin axis,
   - a firing pin extending through said opening in said thrust ball and along said spin axis,
   - a detonator element aligned with said firing pin within said projectile casing, and
   - a second deformable thrust ring supporting said thrust bearing in connection with the projectile casing.

2. The combination with a cylindrical shell casing having a central longitudinal spin axis, of
   - a fuze therein including a timer escapement mechanism sensitive to spin and acceleration forces along said axis,
   - a rotatable cylindrical housing for said fuze, mounted in coaxial relation to said spin axis within the forward end of said casing,
   - an annular-ring ball bearing surrounding said fuze housing within the said casing,
   - said ball bearing comprising a radially inner ball race connected with the fuze housing, a radially outer ball race connected with the shell casing, and a continuous annular ring of ball elements therebetween,
   - a first deformable metallic thrust ring supporting the outer ball race in connection with said shell casing,
   - means providing a central thrust bearing for said fuze housing and including a single larger thrust ball having a central opening therethrough extending along the spin axis,
   - a spring retracted firing pin extending through said opening in said thrust ball and along said axis,
   - a detonator element aligned with said firing pin within said shell casing,
   - a circular carrier plate in a plane normal to the spin axis and centered thereon for holding said central thrust bearing, and
   - a second deformable metallic-thrust ring supporting said thrust bearing through said carrier plate in connection with the shell casing.

3. The combination with a shell case having a central longitudinal spin axis, of
   - a fuze therein including a timer escapement mechanism sensitive to spin and acceleration forces acting on the shell case along said axis on firing,
   - a rotatable cylindrical housing for said fuze within and coaxial with said shell case,
   - an annular thrust and radial ball bearing surround said fuze between said housing and the shell case for free rotational movement of said housing on said axis,
   - said bearing comprising a radially inner ball race connected with the fuze housing, a radially outer ball race connected with the shell case, and a continuous annular ring of ball elements therebetween,
   - a fixed annular supporting ring connected with the inner wall of the shell case in rear of said outer ball race,
   - a first deformable metallic thrust ring directly engaging said outer ball race and seated on said thrust ring to provide a yielding supporting connection for said bearing and fuze housing within said shell case,
   - means providing a central thrust bearing for said fuze housing and including a relatively large diameter single-thrust ball having a central opening therethrough extending along the spin axis,
   - a firing pin operably connected with said escapement mechanism extending through said opening in said thrust ball along said spin axis,
   - a detonator element aligned with said firing pin within said shell case,

means providing a transversely divided central ball race for said central thrust bearing on said spin axis and connected with said shell case, and

a second deformable metallic thrust ring supporting said central thrust bearing within the shell case.

4. The combination as defined in claim 2, wherein the central thrust bearing is provided with a single-ball race for the thrust ball partially in the fuze housing and partially in a circular carrier plate seated on the second thrust ring, and wherein said second thrust ring is provided with a transverse supporting wall extending across the interior of the shell case and having a central pocket for the detonator.

5. A spin attenuator structure for a mechanical time fuze, comprising in combination,

a cylindrical outer carrier casing subject to high spin rates on its longitudinal axis and to high setback forces of acceleration along said axis,

a fuze having a cylindrical housing rotatably mounted on said axis in said casing and having a hollow interior,

a timer escapement mechanism sensitive to said spin rates and setback forces mounted on said axis in said fuze housing,

an elongated firing pin connected to be actuated by said escapement mechanism and extending rearwardly therefrom along said axis in a retracted position,

an outer annular ring ball bearing interposed between the fuze housing and the interior wall of said carrier casing for free rotational movement of said fuze housing on said axis within the carrier casing,

said ball bearing having radially inner and outer annular ball races,

an annular supporting ring for the outer ball race of said annular ball bearing attached to the inner wall of the carrier casing,

a first deformable thrust and spacing ring interposed between and separating the outer ball bearing race and the supporting ring for receiving and absorbing setback forces on said annular ring bearing from said fuze housing,

an inner single-ball thrust bearing for said fuze housing mounted centrally and rearwardly thereof on said axis and including a single-ball element with the firing pin extending centrally therethrough,

a fixed supporting wall for said single-ball thrust bearing extending transversely across and attached to said carrier casing,

a circular carrier plate for said thrust bearing supported by said wall,

a second deformable thrust and spacing ring interposed between and separating said wall and carrier plate for receiving and absorbing setback forces on said thrust bearing from said fuze housing,

means providing a central pocket in said transverse supporting wall, and

a detonator element in said pocket aligned with and spaced from the striker end of said firing pin in said retracted position.

6. A spin attenuator structure as defined in claim 5, wherein the single ball element of the central thrust bearing is of relatively large diameter having a fixed upper ball race in the lower end of the fuze casing and a cooperating fixed lower ball race in a bearing block in the upper face of the circular carrier plate each with a central clearance opening therein for the firing pin, and wherein the outer annular ring bearing includes a continuous annular ring of relatively small ball elements and the inner and outer ball races are of the combined radial and thrust type.

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Donahue et al.

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[45] **Date of Patent: Oct. 18, 1994**

[54] **SMALL CALIBER FUZE WITH ARMING DELAY, SECOND IMPACT AND GRAZE SENSITIVITY**

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[21] Appl. No.: **43,302**

[22] Filed: **Jun. 21, 1993**

[51] **Int. Cl.**[5] **F42C 15/22**; F42C 15/26

[52] **U.S. Cl.** **102/233**; 102/255; 102/267

[58] **Field of Search** 102/265, 266, 267, 231, 102/232, 233, 244, 254, 255

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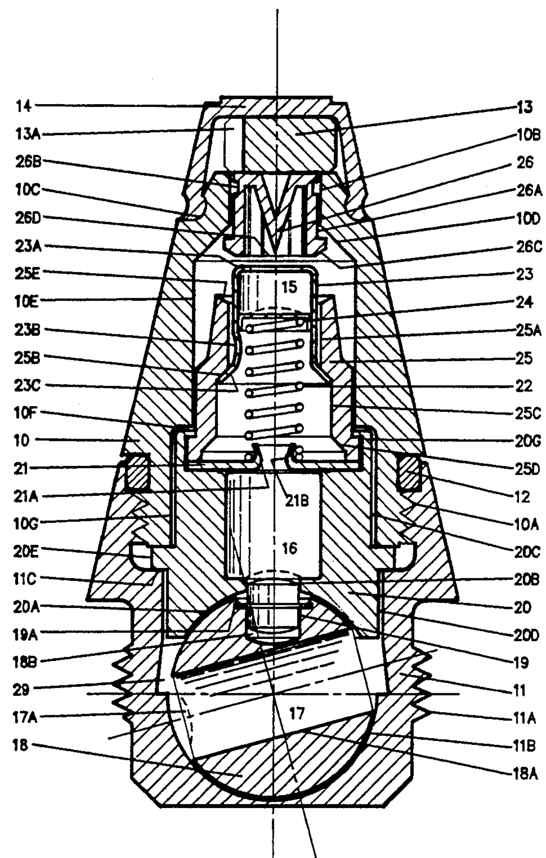
Primary Examiner—David Brown

[57] **ABSTRACT**

The objectives of these inventions are to provide simple, reliable, and low-cost mechanical means to obtain (1) second impact detonation and (2) substantial safe arming separation from the gun for point detonating fuzes for small caliber spin stabilized shell. The first objective is attained by use of a heavy shield over the firing pin which is removable between the first and second impacts by spin forces; the second objective is attained by a centrifugally driven rotor, containing the out-of-line explosive element, which deforms a ductile material to effect the arming delay.

11 Claims, 6 Drawing Sheets



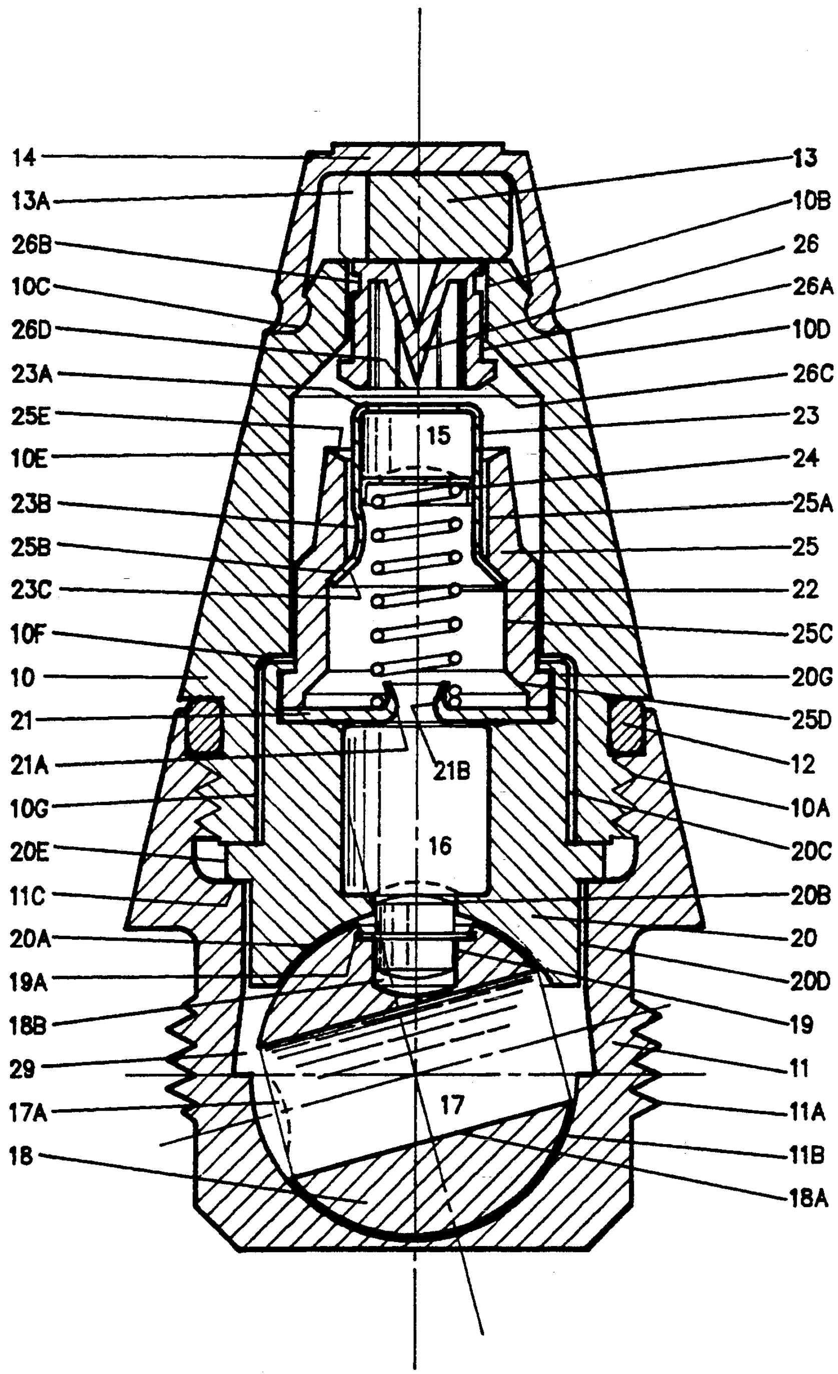

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FIG. 1

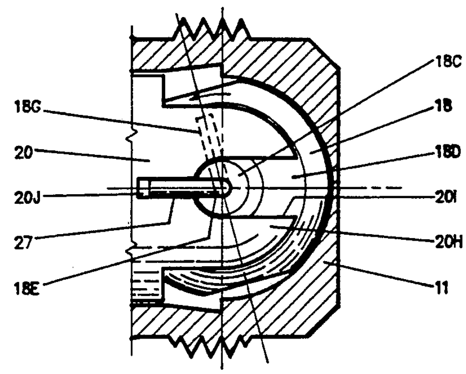

FIG. 2

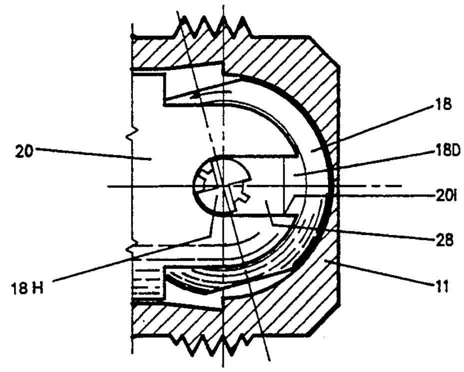

FIG. 3

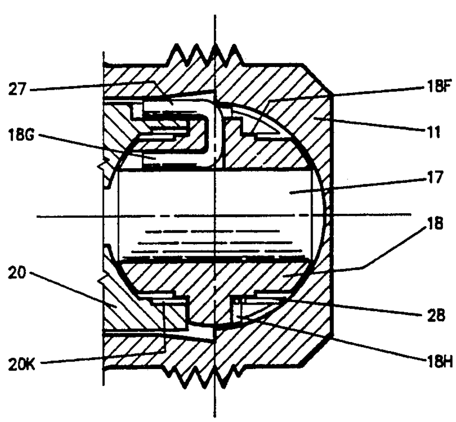

FIG. 4

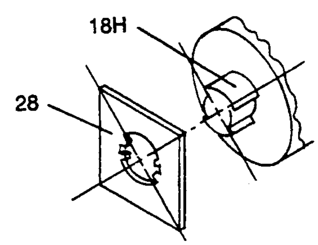

FIG. 5

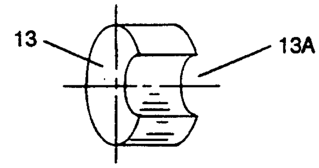

FIG. 6

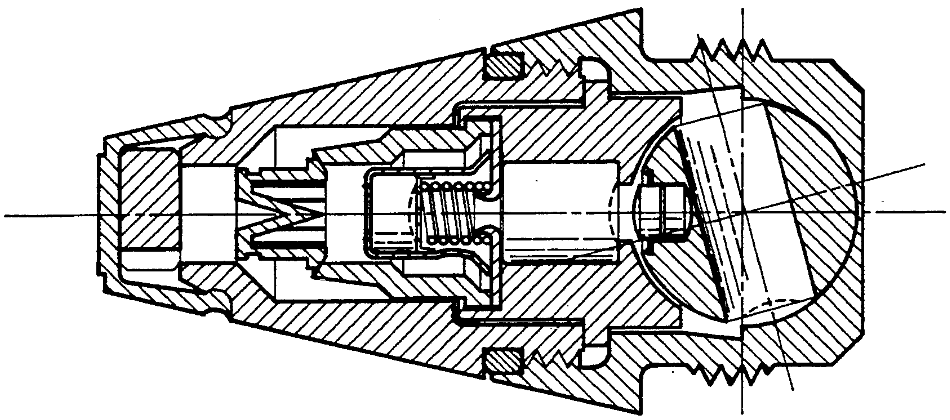

FIG. 7

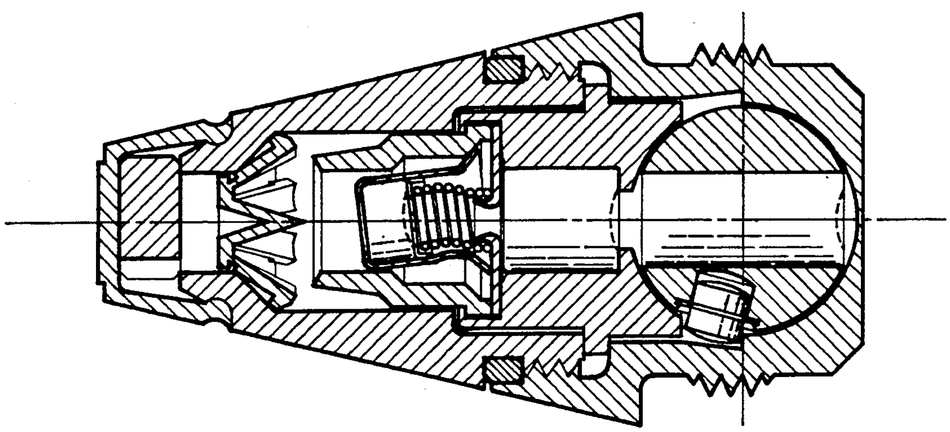

FIG. 8

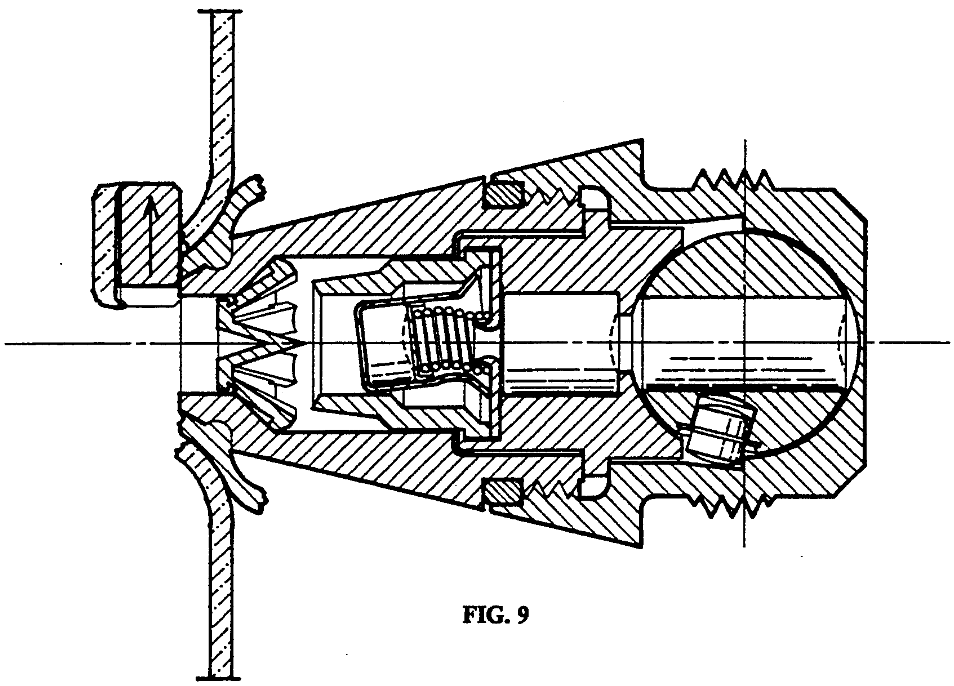

FIG. 9

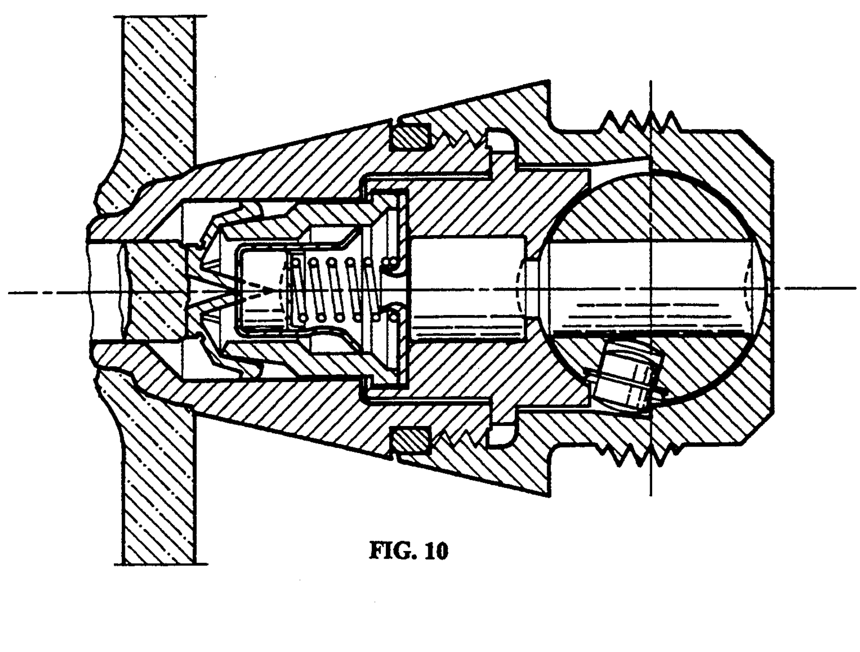

FIG. 10

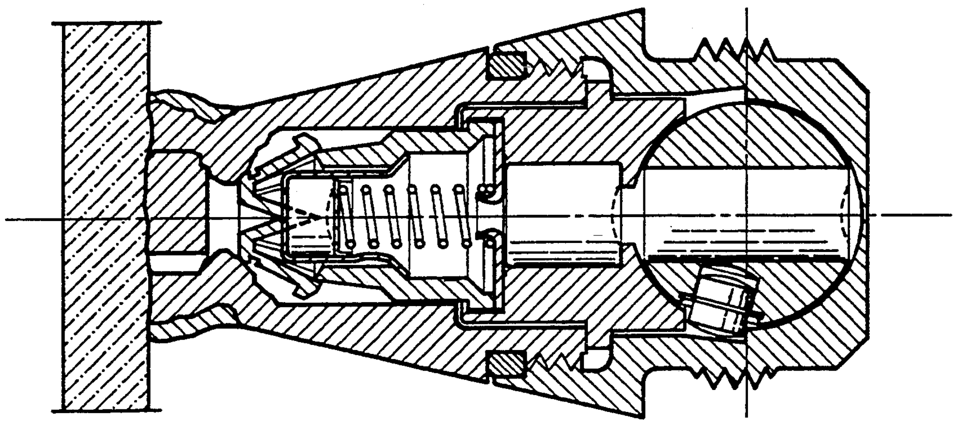

FIG. 11

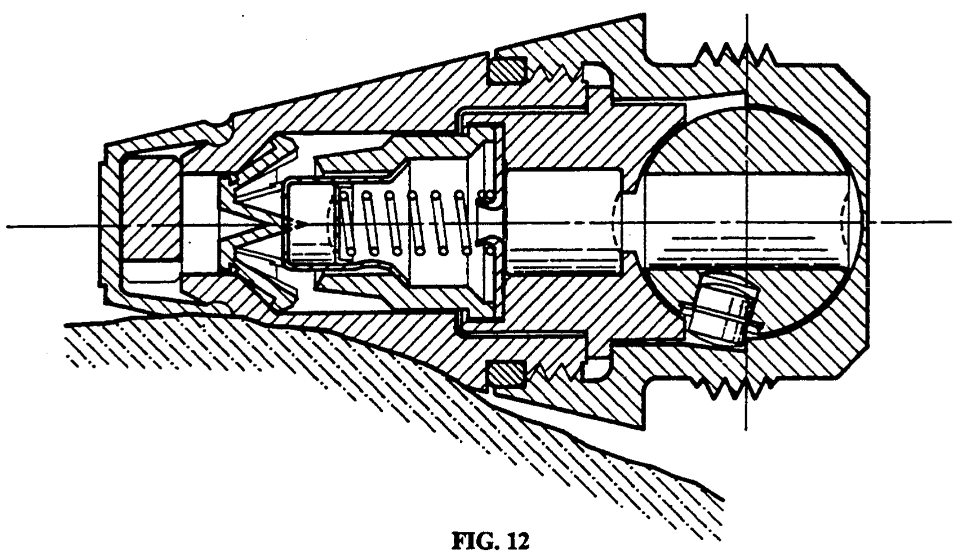

FIG. 12

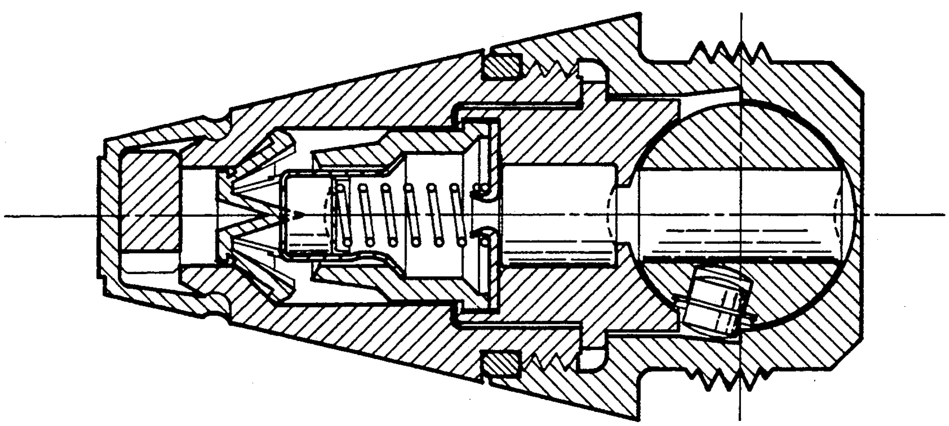

FIG. 13

SMALL CALIBER FUZE WITH ARMING DELAY, SECOND IMPACT AND GRAZE SENSITIVITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to mechanical impact fuzing of rifle fired munitions and more specifically, to such fuzing of shells with diameters 40 mm and under as used in anti-aircraft defense, air-to-air, air-to-groiund, and ground-to-ground systems

2. Description of Prior Art

A mechanical impact fuze has been developed for 20 mm fuzes which meets current safety and arming requirements for the U.S. military, but leaves considerable room for improvement. Current requirements include the detection of two independent firing signatures, traditionally set back and spin, before completely arming the fuze. Two other characteristics that have been desired, but not satisfactorily implemented are second impact detonation and an arming delay, not only to prevent premature firing in the barrel, but to protect friendly forces close to or in front of the weapon. Second impact detonation has meant the ability to poke through the skin of an aircraft and explode them inside on impact with a wing spar or other structural member.

The current fuzes for 20 mm ammunition use out-of-line detonators and fire on the first impact. An earlier model of this type of fuze had provisions for second impact detonation by virtue of adjusted detonator sensitivity to shock, but was found to be unreliable. To provide additional arming delay a number of techniques have been investigated. These include time escapement mechanisms, as first used in watches and clocks; slow burning pyrotechnic trains and fluid dashpots using gases and liquids. The dashpots have shown the most promise, but there are still problems with temperature, viscosity, aging and costs. Another desirable characteristic is the ability to detect and fire on a grazing impact.

SUMMARY OF THE INVENTION

According to the invention, the fuze uses an out-of-line booster section, wherein the arming is delayed by controlled torsion and/or shearing of a malleable delay member. A first light impact detonation is thwarted by an eccentric firing pin shield that spins off at impact. Additional actions are achieved by using a deformable firing pin assembly and spin sensitive structures that fire on graze impact. All of the above structures collapse on an impenetrable target for immediate detonation. The spin sensitive structures release the firing pin and firing spring to cause self destruction, when sufficient time has elapsed to permit the spin to decay.

An object of the present invention is, therefore, to provide a new small caliber fuze, which includes an improved safing and arming mechanism; wherein the chemical booster is rotated into line, instead of the detonator, for greater safety.

A further object of the present invention is, to provide a new small caliber fuze, which includes a cheap and reliable arming delay, to prevent damage likely to be caused by prematures.

A still further object of the present invention is, to provide a new small caliber fuze including second impact detonation that has a high probability of occurring within the aircraft skin.

Yet another object of the present invention is to provide a new small caliber fuze, which provides a graze detonation capability, to further increase its reliability.

A final object of the present invention is, to provide a new small caliber fuze which includes a novel self destruction capability, when the spin has decayed to a preselected value.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

FIG. **1** is a view of the new fuze normally sectioned through its spin axis, with all interior components in their initial safe and unarmed positions;

FIG. **2** is a view of the right or rear end of FIG. **1** showing the complete rotor, one trunnion, a trunnion support and a torsion wire delay member;

FIG. **3** is a similar view with the fuze rotated 180° about its axis showing the other complete end of the rotor, the remaining trunnion, another trunnion support and a shear plate delay member;

FIG. **4** is a similar view looking into the top of FIG. **3**. or the bottom of FIG. **2** with the rotor turned to its armed position and a full view of the torsion wire delay member;

FIG. **5** is an exploded isometric view of the shear plate and its trunnion on one end of the rotor;

FIG. **6** is an isometric view of the eccentric firing pin shield for the nose of the fuze;

FIG. **7** is a view as in FIG. **1** showing the position of internal members after sensing set back;

FIG. **8** is a view as in FIG. **1** showing the position of internal members after sensing both set back and spin;

FIG. **9** is a view as in FIG. **1** showing the position of internal members after the fuze experiences a first impact with a light target;

FIG. **10** is a view as in FIG. **1** showing the position of internal members after the fuze experiences a second impact with a light to medium target;

FIG. **11** is a view as in FIG. **1** showing the position of internal members after the fuze experiences impact with a heavy or an impenetrable target;

FIG. **12** is a view as in FIG. **1** showing the position of internal members after the fuze experiences a graze impact with a target.

FIG. **13** is a view as in FIG. **1** showing the position of internal members after the fuze experiences sufficient spin decay to initiate self destruction.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings, and more particularly to FIG. **1**, there is shown a side view in section of the fuze according to the present invention. The outer covering of the fuze consists mainly of a rigid hollow conical ogive **10** that tapers from a large diameter open rear end to a smaller diameter open front or nose end. The outer rear end has external threads **10A**. These threads are covered by a cup shaped rotor cover **11** with internal threads that match and engage them. Just in front of the threads the surfaces of the ogive and rotor covers are relieved to capture an o-ring seal **12**, which prevents moisture from seeping through this joint. The outside surface of the rotor cover has threads **11A** that match those found in 20 mm or similar small calibre ammunition. The nose end of the ogive has an axial hole **10B** surrounded by a circular groove **10C**. The nose hole is substantially covered by a rigid eccentric firing pin shield **13**, which is generally disk shaped, but has a notch **13A** cut in the edge to provide spin imbalance. This shield is covered by a nose cover **14** of soft material e.g. aluminum or plastic, which is formed into a groove **10C** around to keep it in place.

The inner surface of the ogive defines three cylindrical chambers decreasing in diameter from the large end. The nose hole **10B** or front chamber is separated from the middle chamber **10E** by a short tapered chamber **10D**. The center chamber and rear chamber **10G** are separated by a step **10F**. Inside of and rearward of this ogive are the usual three elements of the chemical firing train, which ignite the main charge in an attached 20–40 mm shell. Beginning at the nose end, behind the point of a firing pin, these elements are, respectively, the primer **15**, the detonator **16** and the booster **17**. All are cylindrically shaped. They decrease in sensitivity and increase in total energy from the nose end.

A spherical arming rotor **18** carries the booster element **17**. The latter occupies a cylindrical hole **18A** drilled coaxially through the center of the rotor. The axis of the hole is normal to the rotation axis of the rotor and the hole opens out of opposed surfaces thereof. The ends of the booster have a concave cavity **17A** or lens at each end to improve energy transfer along the train.

A blind hole **18B** is also drilled coaxially toward the center of said rotor. The axis of the blind hole is normal to the axis of the rotor, but is about 15 degrees less than normal to the axis of the booster hole. The blind hole is slightly counterbored and a detent pin **19** with a thin integral shear flange **19A**, the latter being staked into the counter bore. The detent pin has a length slightly less than that of the blind hole, but a substantial portion projects beyond the rotor surface. The inner surface of the rotor cover defines a rear concave hemispherical surface **11B**. A similar front concave surface **20A** is supplied by the rear end of a detonator support **20** to complete a spherical chamber closely surrounding the rotor. The front concave surface has an axial hole **20B** drilled into it having a slightly larger diameter and length than the protruding portion of the detent pin. With the detent pin captured in this hole the rotor is rotated 15 degrees from its unstable equilibrium axis, so as to respond more reliably to spin.

The detonator support is a generally cylindrical member having a small diameter end **20C** that slides snugly but freely into rear ogive chamber **10G**. This support, which is usually die cast, also has a slightly larger diameter rear end **20D**, which fits snugly but freely into the rotor cover **11** to provide the rear concave surface **20A** above. Between these two ends is a little larger diameter circumferential flange **20E** one side of which engages the large end of the ogive, when the support is fully inserted therein. The rear cover **11** has an internal corner **11C** formed by a diameter change just behind its inside threaded portion. This corner engages the opposite side of the same flange, to secure the support as the ogive and rear cover are screwed together.

The detonator support has a cylindrical coaxial tunnel, that periodically varies in diameter along its length. The rear end or chamber of the tunnel is formed by the detent hole **20B** above. The center chamber of the tunnel is dimensioned to be filled by the detonator **16**. The counterbored blind hole is coaxial with and equal in diameter with the rear chamber of said tunnel. A front section has a length that is only a fraction of its diameter, the latter leaving only a thin support wall **20G** at the front end. A washer **21** of substantially equal outside diameter is pressed into this chamber. The washer has a center hole **21A** smaller in diameter than the detonator and a round boss **21B** surrounding the center hole that projects to the front. The ends of the detonator are concave lenses like the booster to focus the explosive energy through the adjacent apertures in a manner well known in the art.

In front of the detonator support is the primer assembly. This includes a spring **22** with its rear end surrounding the washer boss. A primer cup **23**, essentially a hollow tube with a narrow flat annular crimped front wall **23A**, is fitted with the disk shaped primer **15**. This primer **15** is held in place in the primer cup **23** by a retaining ring **24** crimped or bonded to the interior cup wall by epoxy or the like. The primer forms the rest of the front end of the cup, except for the crimped front wall **23A**. This cup is placed over the spring, so that the front end of the spring presses against the rear face of the retaining ring. A support sleeve **25** is then placed over the primer cup. The sleeve has a small diameter front chamber **25A** joined by a short reducing shoulder **25B** to a large diameter rear chamber **25C**. The rear chamber has a flare **25D** at the open rear end that expands to the outside diameter of the washer. The rear edge of the cup's cylindrical sidewall terminates in a flare **23C** that matches the inside of shoulder **25B** between the front and rear portions of the sleeve, so that two engage to compress the spring slightly as the sleeve is pressed against the front surface of the washer. The thin wall **20G** is crimped or staked over the flared end of the sleeve **25** to complete the assembly.

The cup flare **23C** also matches the flare **25D** at the rear end of the sleeve, in cross-section, so that the two will nest, when the cup is moved backward and off axis. An aperture **23B** is formed in one side of the cup to induce a spin imbalance in this member.

Just ahead of the primer is the conical firing pin **26** with its point facing the primer. The pin, which is extruded from a metal like an alloy of aluminum, is surrounded by an integral castellated shroud. This shroud consists of n tines **26A** extending from the base of the firing pin to a plane a short distance ahead of the point. The tines are equally spaced around the circumference of the base. Each tine has a thinned portion **26B** at the base that acts as a hinge. The rear ends **26A** of the tines have added mass for greater spin moment. The annular front surface **25E** of the primer support sleeve is conically chamfered to slope to the rear and the center. The ends of the tines have radially outward areas **26C** that are shaped to conform to this surface when the tines and primer support are pressed together. The tine ends also have radially inward areas **26D** normal to the spin axis that conform to the crimped edge **23A** of the primer cup. In this configuration the pin cannot contact the primer. Initially the pin is slipped into the small hole in the front of the ogive which is dimensioned to properly position and cover all but the massive ends of the tines.

Referring to FIG. 2 a rearward extending journal ear **20H** of the detonator support is shown. A similar ear is defined by the support on the opposite side of the rotor. These ears have journal slots **20I**, opening through the rear edge to permit insertion of the rotor. Opposed annular surfaces **18D** of the rotor normal to its axis of rotation are flattened to provide space for the ears, which have mating flat surfaces. The center of the annular surface, which is not changed, defines a trunnion **18C** with a diameter slightly less than the width of the journal slot. The trunnion has an axial hole **18E** drilled through to freely admit a torsion delay wire **27**. The ears have a wire groove **20J** extending from the hole toward the root of the ear, into which the outer end of the delay wire is bent. The opposite or inner end of the delay wire extends into the hole for the booster and is bent into an axially parallel wire groove **18G** in the booster hole wall, before the booster is inserted. The bent portions initially have a 75 degree angular relationship, but become parallel, when the rotor moves to its armed position. When the fuze spins the rotor is urged to rotate on its trunnions, to align the axis of the booster with the spin axis, which strongly urges the rotor into its armed position. The delay wire is made of a malleable material such as alloys of soft non-ferrous metals, elastomers or other plastics. These wires, which can be used on one or both trunnions, do not provide enough resistance to prevent arming, but can provide adequate safety delays. The delay time depends on the material or alloy used and the diameter of the wire, which of course should not be so close to the diameter of the trunnion as to weaken it. Tests of 50/50 lead-tin solder have indicated that such a delay wire could have a diameter of about 1 mm to produce a 300 foot arming delay with an accuracy of ± 15 feet.

FIG. **3** shows a different embodiment of a cutter trunnion **18H** opposite the one described above. This trunnion is axially grooved, so it provides one or more cutting edges that move in the direction of rotation as the rotor arms. The inner surface of the ear is relieved enough to admit a thin plate **28** of malleable material between the flat surface of the rotor and its journal support ear which provides an opening for the trunnion, but which is also shaped to periodically obstruct its rotation. The cutting surfaces permit the rotor to remove the obstructions, but only after a specified time delay. Various time delays can be provided by using different materials, different thicknesses of the plate, and by varying the geometry of the obstructions.

As shown in FIG. **4**, the front edge of the plate contacts a relief step **20K** in the detonator support to prevent its rotation during the arming function. This type of delay can also be applied to both trunnions. This figure also shows a view of the rotor and adjacent structures rotated 90 degrees about the spin axis of the fuze from that of FIG. **2** or FIG. **3**. The torsion delay wire is shown in full view and the delay shear plate as a cutaway edge view. Also shown is a small step **18F** in the annular flat surfaces of the rotor around the base of the trunnions, This step reduces friction between the rotor and the adjoining surfaces.

FIG. **5** shows an isometric view of the cutter trunnion and its delay plate, exploded for added clarity. The toothed geometry permits smoother cutting digitized delays. Note that opposed cutters are provided which allows the use of dead soft materials for the delay plate. This insures sufficient resistance to arming without resorting to a critical tempering process. But more importantly it should be noted that the rotor structure is intentionally designed with a symmetry that requires no special orientation during assembly. As can be seen neither the delay plate structure nor the torsion wire shown has inherent left or right handedness.

FIG. **6** shows the firing pin shield or slug in isometric view. These are easily stamped by a circular punch using overlapping cuts. This also saves material. The shield may made of steel which is also the presently preferred material for the ogive and rotor housing. The primer cup **23** can be drawn from aluminum. The sleeve, detonator support and the rotor may be die cast from zinc or aluminum, preferably zinc for the rotor. The washer can be punched from a variety of materials. The detent pin is turned on automatic screw machines. The nose cover is extruded from soft aluminum and best attached by roll crimping over a layer of liquid latex.

FIG. **7** shows the same view as FIG. **1** after the fuze reacts to firing setback of the shell. Note that the shear flange on the detent pin has failed allowing that pin to move back and the primer cup has moved back against the washer on the front of the detonator support greatly compressing the firing spring. The rotor has not turned, because the slotted journal structure permits maximum rotor contact with the rotor housing during set back. This additional friction is sufficient to overcome the torque induced by spin. The shroud on the firing pin has moved back against the chamfered end of the sleeve on the primer assembly and pushed back the primer cup, but the pin's point cannot reach the primer. The preferred pin has six tines, which provides a convenient geometry that gives good function and is simple to manufacture. The chamfer of the nearest edge of the primer sleeve and the mating chamfer of the tines causes a locking action between the two that resists separation by the onset of spin. This relationship holds until set back decays and a short time thereafter as the spin forces overcome the friction between the inclined surfaces. If no spin is encountered the primer moves forward pressing against the tines of the firing pin to return it to its recess.

FIG. **8** shows the same view of the fuze after spin is fully induced and the effects of setback have disappeared. After the fuze has flown about one tenth of a second or 300 feet the rotor has moved to its armed position with the axis of the booster coaxial with the spin axis. The detent once off the spin axis picks up centrifugal force that eventually overcomes the decaying set back force. As the rotor turns it begins to slide over the concave face of the detonator support until it drops off the edge and locks in a space **29** between this edge and a shoulder formed at the edge of the hemispherical inner face in the rotor housing. The tines of the firing pin have dislodged themselves from the detonator support pushing the pin gently forward into the nose hole. The tines, however, have spread to the walls of the center ogive chamber the conical wall in front guiding the pin into its exposed position. The primer cup is displaced due to the hole in one side and has lodged itself under the inner shoulder between the flared rear end of the primer sleeve and the washer in front of the detonator.

FIG. **9** shows the same view after the fuze has made a light impact as with an aircraft's skin. The main effect is on the nose cap which is sheared by the harder skin material. This frees the eccentric nose shield which is driven off axis by spin induced force. Since little spin is lost the primer cup remains lodged under the flared end of the primer sleeve and the tines of the firing pin resist the slight tendency to move into the nose.

FIG. **10** shows the same view after a second impact with a light to medium target. Such targets are soft and thin enough to have a piece coined out of them by the relatively sharp front edge of the ogive. The coined fragment should have sufficient momentum to drive the firing pin into the primer crumbling the shroud. If spin is sufficiently reduced due to the first and second impact the primer cup may also dislodge and permit the firing spring to extend.

FIG. 11 shows the same view after a first impact with an impenetrable target. In this situation the firing pin shield is driven into the nose hole collapsing the front of the ogive and the firing pin into the primer. Since spin is lost at the same time the cup escapes the flared end of the primer sleeve allowing the firing spring to expand.

FIG. 12 shows the same view after a first grazing impact. The nature of this impact involves both a large loss in spin as well a fair amount of deceleration. Both of these factors operate to free the cup from the sleeve and the spring drives the primer onto the firing pin. The same fuze configuration applies to the self destruction situation (FIG. 13). Once there is enough spin decay the cup is freed by the pressure of the firing spring which then drives the primer onto the firing pin.

While this invention has been described in terms of preferred embodiment consisting of a 20 mm fuze, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

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

1. A fuze for an explosive shell having diameter of 40 mm or less, which comprises:

a body that tapers from a large diameter rear end, with an external portion threaded to mate with said shell, to a small diameter at the front or nose end;

a conical firing pin mounted in said nose end pointing to the rear of the body;

a detonator housing mounted centrally in said body defining a tunnel from the front to the rear of said body with front, rear and center chambers, said center chamber being filled with detonator material to form a detonator;

a primer assembly mounted on the front end of said detonator housing, supporting a primer cup with a cylindrical sidewall and a circular endwall, the rear surface of said endwall being covered with a primer disk and the front surface thereof being adjacent to said pin;

an out-of-line spin actuated arming rotor loaded with booster material mounted on the rear end of said detonator housing;

said rotor including a mechanical means to allow said booster to come in line with the said primer disk and detonator only after setback, spin and a minimum safety delay of one tenth of a second has occurred in that order.

2. A fuze according to claim **1** wherein said mechanical means includes:

a short rod of malleable material aligned with the axis of said rotor affixed at one end to said rotor and at its opposite end to said detonator support, whereby the twisting of said rod by said rotor produces said safety delay.

3. A fuze according to claim **1** wherein said mechanical means includes:

a key shaped trunnion on said rotor;

a thin plate of malleable material fixed at its edges to said detonator support and keyed at its center to said rotor, whereby the tearing of said plate by said key shaped trunnion produces said safety delay.

4. A fuze as set forth in claim **1**, wherein said fuze includes;

an overlapping rear cup-shaped rotor housing with mating threads;

said detonator housing having a centrally defined external circumferential flange locked between inner edges of said tapered body and said housing when threaded together; and

an O-ring locked between outer edges of said tapered body and said housing.

5. A fuze as set forth in claim **4**, wherein

said rotor is generally spherical and said mechanical means includes two aligned trunnions on opposite sides thereof and a cylindrical booster chamber with an axis through the center of said rotor normal to the axis of said trunnions;

the rear surface of said detonator housing and the inner front surface of said rotor housing each defining one-half of a generally spherical rotor chamber concentric with and slightly larger than said rotor and centered on the axis of said tunnel;

said detonator housing further defining two radially thin and rearwardly projecting rotor supports adjacent opposite sides of said rotor chamber defining journals for said trunnions;

said rotor further defining a cylindrical slightly counterbored blind hole equal in diameter and coaxial with said rear chamber of said tunnel with its axis at 75° with the axis of said booster chamber;

a cylindrical locking detent slightly less in length and diameter to said blind hole, said detent extending into both said hole and said rear chamber, with an integral thin shear flange staked into said counterbore.

6. A fuze according to claim **1** wherein the nose end of said body defines an axial nose hole having substantially the same length and diameter as said pin, said hole opening into a body chamber of much larger diameter, said pin being housed in said hole and further including:

an integral castellated shroud of n tines that project rearward from the circular base of said pin to a normal plane slightly beyond the apex of said pin, said tines each having a narrow flexible hinge portion adjacent said pin base and a massive distal end initially oriented and shaped to engage 1/n of the annular front end surface of said primer assembly, to prevent said pin from prematurely penetrating said primer cup.

7. A fuze as set forth in claim **6**, wherein:

said body defines an axial hole through said nose end, with a groove surrounding the external opening to said hole and said pin located in said hole;

said external opening of said nose hole being covered by a disk shaped steel slug axially aligned with said hole but having an off center portion removed to produce spin instability; and

a soft metal cover over said slug pressed into a groove around said hole defined by the exterior surface of said ogive.

8. A fuze as set forth in claim **6**, wherein:

said distal ends and the front edge of said primer assembly are conically chamfered to force said tines radially inward on set-back and to delay spin separation of said tines until shortly after set-back ends.

9. A fuze as set forth in claim **1**, wherein said primer assembly further includes:

a flared rear edge on said cup sidewall, said sidewall having a substantial opening on one side to produce spin instability for radial displacement;

an axial primer support sleeve surrounding said cup, the inside of said sleeve having a front diameter greater than the diameter of said circular endwall but less than the diameter of said flared end, a center diameter slightly larger than said flared cup end and a flared sleeve end shaped to nest said flared cup end when said cup is radially displaced by spin;

a washer equal in diameter to the flared end of said sleeve contacting and covering said flared end;

an axial firing spring within said sleeve compressed between said washer and said primer disk causing, the flared edge of said primer cup to engage the shoulder at the diameter change in said sleeve.

10. A fuze according to claim **9**, wherein:

the edge of the washer around its center hole is raised to engage the inner edge of said spring to center it.

11. A fuze according to claim **9**, wherein:

said flared sleeve end and said washer are pressed into a front cylindrical chamber of said detonator support with the front edge of chamber crimped over said sleeve.

* * * * *

United States Patent [19]

Popovitch

[11] **4,230,042**

[45] **Oct. 28, 1980**

[54] **POINT-DETONATING IMPACT FUZE**

[76] Inventor: **Dragolyoub Popovitch,** 37 Myers Ave., Denville, N.J. 07834

[21] Appl. No.: **927,126**

[22] Filed: **Jul. 26, 1978**

[51] **Int. Cl.**[3] **F42C 9/00;** F42C 9/14

[52] **U.S. Cl.** **102/233;** 102/270; 102/271

[58] **Field of Search** 102/230–233, 102/235, 238, 248, 249, 270, 271

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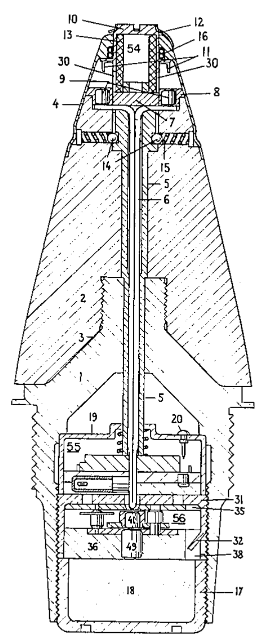
Primary Examiner—David H. Brown

[57] **ABSTRACT**

This is a new point-detonating fuze for spin-stabilized munitions. The fuze has three modules housed in a two-piece body, designed to optimize the penetration capability and to adjust the weight of the fuze. The upper body carries the point-detonating module which has a double-initiation feature, designed to function on impact against the target but preventing detonation on impact against rain droplets and against the foliage of wooded areas. The explosion, initiated at the top of the point-detonating module, is propagated by a mild-detonating fuze, first axially inside the shaft of the point-detonating module, then axially through the time-delay module, to reach the detonator in the safing-and-arming module. The point-detonating module acts as a selector designed to provide either a super-quick function or a time-delay function with several time-delay options. The desired choice is made by rotating the moving portion of the time-delay module to one of several pre-indexed positions.

13 Claims, 8 Drawing Figures



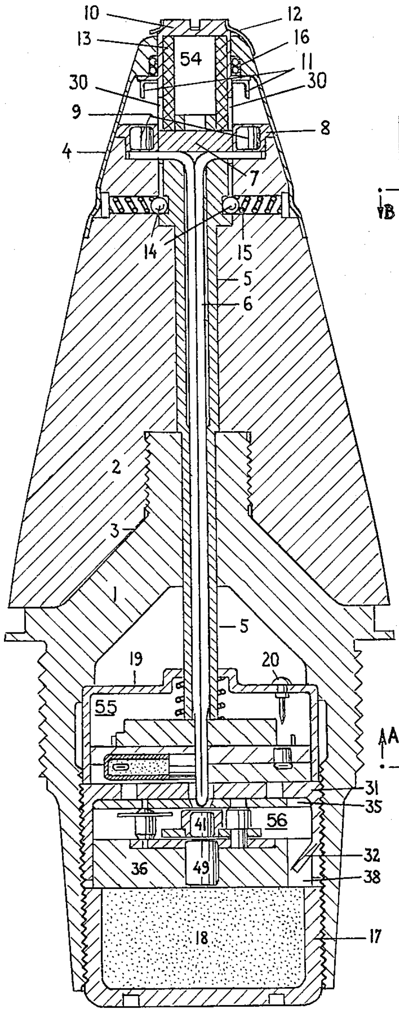


FIG. 1

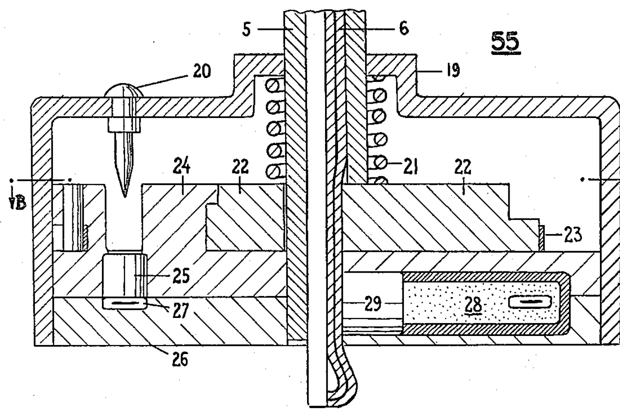


FIG. 4:

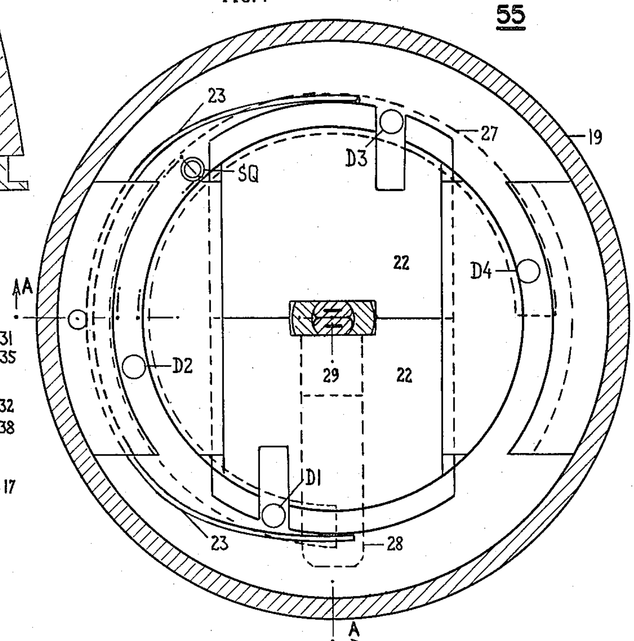


FIG. 3:

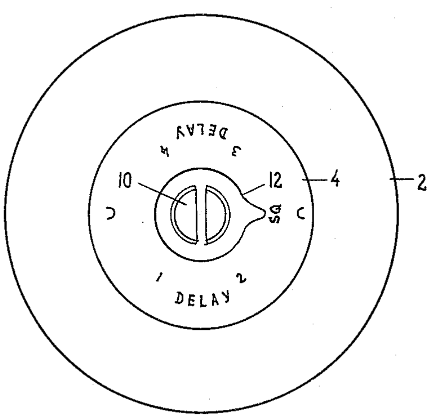


FIG. 2

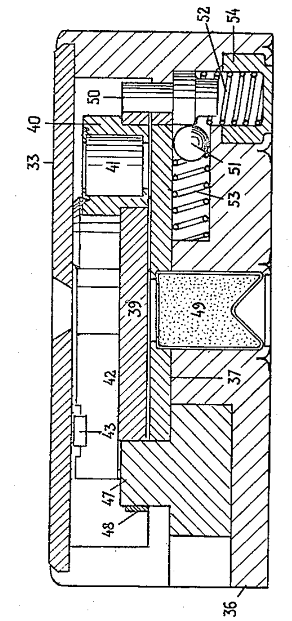
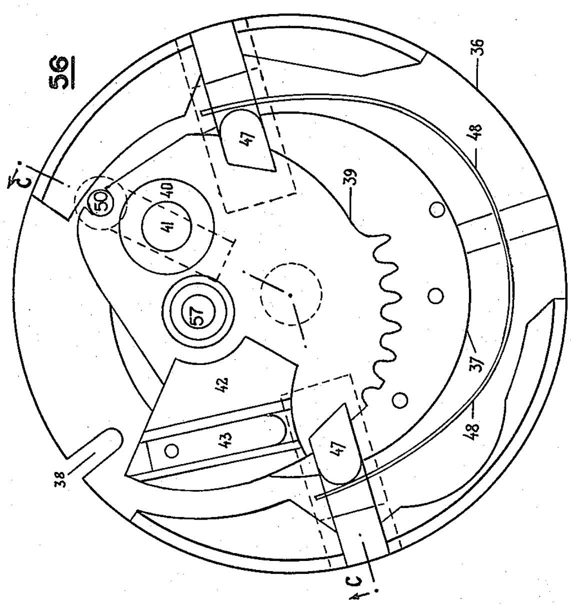


FIG. 6:



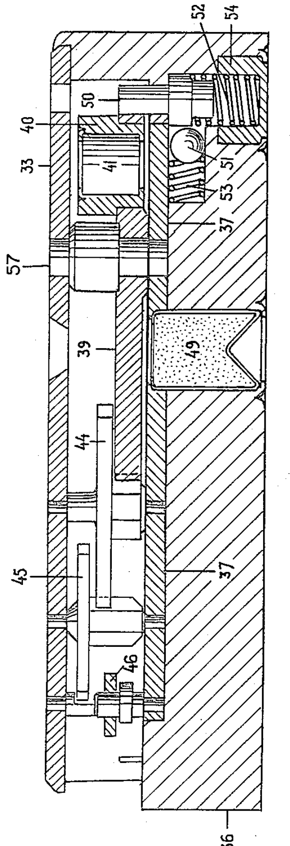
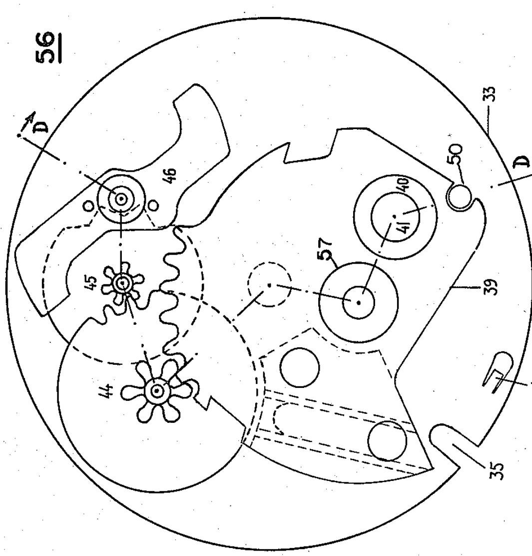


FIG. 8:



POINT-DETONATING IMPACT FUZE

SUMMARY OF THE INVENTION

The present invention relates to a completely new point-detonating fuze for spin-stabilized artillery munition, designed to be used in all existing and future tube-artillery weapons of medium and large caliber.

The invention was conceived to achieve several objects, as follows:

1. To provide a fuze with maximum flexibility for optimizing the penetration capacity and for adjusting the weight of the fuze, by using a two-piece body so that each part could be made of materials best suited to satisfy variable requirements without changing the shape and dimensions of constituent parts.

2. To increase the reliability of the fuze in the super-quick mode of function, by using a mild-detonating fuze (MDF) to insure a double initiation at the tip of the point-detonating module and to propagate the explosion directly to the detonator in the safing-and-arming (S&A) module, instead of jumping a gap of up to three inches as in the existing PD fuzes.

3. To increase the reliability, the timing accuracy and the number of options in the time-delay mode of function, by using a small-delay column (SDC) in combination with several primers and one output detonator, whose explosion is received and further propagated by the same MDF used to transfer the explosion from the point-detonating module to the detonator in the S&A module.

4. To provide a fuze with a simple mechanism for selecting the desired mode of function, by using the point-detonating module, with its axially-located MDF-carrying shaft as a rotating selector which causes the moving portion of the time-delay module to bring the appropriate primer into firing position.

5. To improve the safety, the reliability and the universality of the S&A module, by using: a novel, high-setback, returnable, setback-pin arrangement; an anti-mal-assembly feature; a novel spin-detents design; all in an envelope packaging the whole module in a volume which meets the requirements for a universal S&A.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal-section view of the fuze incorporating the present invention, with the point-detonating module in position for the SQ mode of function, the time-delay module in safe position and the S&A module in armed position.

FIG. **2** is a top view of the fuze as stockpiled, with the indicator showing the fuze set for the SQ mode of function.

FIG. **3** is a transversal-section view of the time-delay module, at the level B—B just above the module's moving portion, showing the module in safe position set for the SQ mode of function.

FIG. **4** is a longitudinal-section view of the time-delay module, along the contour A—A indicated in FIG. **3**, showing the module in the same position as FIG. **3**.

FIG. **5** is a top view of the S&A module with the top plate and the gear train removed, showing the module in safe position.

FIG. **6** is a longitudinal-section view of the S&A module along the contour C—C indicated in FIG. **5**.

FIG. **7** is a bottom view of the S&A module with the bottom plate and the insert plate removed, showing the module in safe position.

FIG. **8** is a longitudinal-section view of the S&A module along the contour D—D indicated in FIG. **7**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. **1** is a longitudinal cross-section view of the fuze incorporating the present invention. The upper body **2** is threaded onto the lower body **1** and glued at their interface **3**.

The upper body **2** and the cap **4** form a cavity, within which is located the point-detonating module comprising the following parts:

- a shaft **5**, carrying two strands of mild-detonating fuze (MDF) **6**, and a setting plate **7**, pressed into a slot in the shaft **5**;
- a detonator holder **8**, carrying two detonators **9**;
- a setting key **10**, carrying a firing plate with two firing pins **11** and an indicator **12**, and housing a crush-element **13**;
- two orientation balls **14**, with their springs **15**; and, finally.
- two O-rings **16**, to seal off the cavity.

As shown in FIG. **2**, the cap **4** has marks indicating five setting options: one for the SQ mode and four positions for the time-delay function.

The upper body **2** is made of a material best suited to satisfy the fuze requirements. For example, it could be made of a plastic material, so that appropriate fillers could be used to satisfy the weight requirements for a complete fuze while keeping unaltered the shape and the dimensions of constituent parts.

The lower body **1** is made of a metal which best satisfies the penetration requirements at a minimum possible cost.

Instead of two pieces, the body could consist of one piece, if a material is available which could satisfy both weight and penetration requirements at a smaller production cost.

The lower body **1** is essentially a hollow cup, open at the bottom end while closed with a conical shape at the top end. The outside shape of the body and the shape of the cavity can be adjusted to achieve maximum penetration capability with a given quantity of metal.

Inside the lower body **1** are mounted: a time-delay module **55**, a safing-and-arming module (S&A) **56**, and a booster comprising a booster cup **17** and a pellet **18**.

The time-delay module is shown at a bigger scale and with more details in FIG. **3** and FIG. **4**. It comprises the following parts:

- a housing **19**, carrying a firing pin **20**;
- a creep spring **21**;
- two spin detents **22**, with one leaf spring **23**;
- an upper plate **24**, carrying five primers **25** (D1, D2, SQ, D3, D4), and a lower plate **26**, carrying a circular small-delay column **27** (SDC), a transfer charge **28** and an output detonator **29**.

The small-delay column is a continuous core of pyrotechnic delay material encased in a seamless metal sheath, which is placed within a circular groove in the plate **26**.

The housing **19**, with the firing pin **20**, is pressed into the lower body **1** and does not move, while all other parts, except the creep spring **21**, are assembled into one entity forming the moving portion of the time-delay module.

Both the upper plate **24** and the lower plate **26** have in the center a hole, through which passes the lower end of the shaft **5**, and their shape is such that the moving portion of the time-delay module must rotate together with the shaft **5**. The upper end of the shaft **5** has six shallow holes at 60° intervals. Into those holes can engage two orientation balls **14**, designed to hold the shaft **5**—and, through it, the moving portion of the time-delay module—in one of five possible positions, in which one of the five primers **25** is aligned with the firing pin **20**. The setting is accomplished by turning the setting key **10**, which has two diametrically opposed slots **30** engaging the setting plate **7**, through which the rotation of the setting key **10** is transmitted to the shaft **5** and, through it, to the moving portion of the time-delay module. The indicator **12**, carried by the setting key **10**, shows which position has been selected, as can be seen in FIG. **2**.

The time-delay module is supported and held in place by the cup **31**, threaded tight inside the lower body **1** against the housing **19**. One small segment of the cylindrical portion of the cup **31** is cut out and bent inside to form the finger **32**, whose role will be described later in connection with the S&A module.

The safing-and-arming module (S&A) is shown in detail in FIGS. **5**, **6**, **7** and **8**. It comprises the following parts:

- an upper plate **33**, exhibiting a finger **34** and a slot **35**;
- a lower plate **36**, with an insert plate **37** and a slot **38**;
- a rotor **39**, carrying a detonator holder **40** with a detonator **41** and a weight **42** with a locking spring **43**;
- a standard gear train, consisting of two gear-and-pinion subassemblies **44** and **45**, and a lever **46**;
- two spin detents **47**, with their leaf spring **48**;
- an explosive lead **49**; and, finally,
- a setback-pin arrangement consisting of a setback pin **50**, a ball **51**, two springs **52** and **53**, and a closing cup **54**.

When the S&A module is mounted on the fuze, it must be oriented so that the finger **32** can pass through the slot **35** in the upper plate **33** and into the slot **38** in the lower plate **36**, thus making sure that the rotor **39** is in safe position. The finger **32** and the slots **35** and **38** constitute the anti-mal-assembly feature of the S&A.

When manufactured and delivered for a stockpile, the fuze is set for SQ, because that corresponds to the most often-used mode of function. The resulting configuration is as follows:

- in the point-detonating module, the two firing pins **11**, the two detonators **9** and the two upper ends of the MDF **6** are aligned in the same plane as shown in FIG. **1**;
- in the time-delay module, the SQ primer **25** is aligned with the firing pin **20**, the creep spring **21** is compressed, and the two spin detents **22** are in the safe position, interlocked with the shaft **5** as shown in FIG. **3** and FIG. **4**;
- in the S&A module, the rotor **39** is in safe position, held by two spin detents **47** and the setback pin **50**, in compliance with the double-safety requirement.

The arrangements of the spin detents and of the setback pin are conceived to maximize the safety of the munition during the handling, transportation and firing.

The spin detents are diametrically opposed, and stay so if and when they move, so that a shock could never push both detents out of engagement.

The setback-pin arrangement makes it possible to design for as high a setback as desired to maximize the handling safety. In case of shock, the setback pin always returns to safe position, because the spring **52** is designed to reliably overcome the opposing force of the spring **53** and to push the ball **51** out of its way. Hence, that safety feature always stays effective until the moment of firing. However, when the fuze is fired, the following sequence takes place: first, the setback pushes the setback pin **50** against the spring **52**, while the spring **53** and the spin push the ball **51** against the smaller diameter of the pin **50**; but then, upon setback decay, in addition to the force of the spring **53**, the ball **51** continues to be pushed by the centrifugal force due to the spin, so that the spring **52** can no longer overcome the opposition of these two forces; the setback pin **50**, therefore, does not return, and the rotor **39** is free to arm. In order to maximize the relative value of the centrifugal force acting on the ball **51**, the setback pin **50** should be made of a light material and the ball **51** of a heavy material.

When the spin reaches the required value, the spin detents **47** in the S&A and **22** in the time-delay module are pushed out by the centrifugal force against their respective springs **48** and **23**, until they hit the walls of the housings. Then the rotor **39**, driven by the centrifugal force acting through unbalanced weight, rotates with its eccentrically located shaft **57** while the lever **46** controls the movement acting as a runaway escapement and, when the arming time has elapsed, it snaps into armed position, while the locking spring **43** goes over the hump of the finger **34** and locks the rotor **39** in armed position. Meanwhile, in the time-delay module, when the spin detents **22** reach their out-positions, the creep spring **21** extends until it reaches the upper plate **24** and locks the spin detents **22** in their out-positions; thus, at impact against the target, the spin detents **22** cannot come back to stop the moving portion of the time-delay module from sliding forward and causing one of the primers **25** to hit the firing pin **20**.

If the fuze is set for the SQ function, the impact against the target causes the setting key **10** to crush the crush-element **13** and the pins **11** to hit the detonators **9**, initiating the explosion which is received and further propagated by the MDF **6** to the input face of the detonator **41**, whose explosion is amplified by the lead **49** and the pellet **18**, resulting finally in the explosion of the main charge of the projectile.

If the fuze is set for the delay function, the pins **11** and the receiving ends of the MDF **6** are out of line with the detonators **9**, so that the crushing of the point-detonating module can no longer cause a SQ function. In that case, the moving portion of the time-delay module—well protected inside the lower body **1** and with the spin detents **22** locked by the creep spring **21**—slides forward under influence of inertia until the selected primer **25** hits the firing pin **20**. The output of the primer **25** initiates a burning inside the SDC **27**, eventually setting off the chain explosion of the transfer charge **28** and the detonator **29**, from where the explosion is received by the MDF **6** and propagated, through the same sequence as before, to the main charge of the projectile.

There are four options for the time-delay function. The shortest is D1 and the longest is D4, as shown in FIG. **3**. The primer **25** marked by letters SQ on FIG. **3** is a back-up for SQ function, to cause the projectile to explode even if—because of a soft target or a glancing impact, or for some other reason—the point-detonating module fails to function.

I claim:

1. A point-detonating impact fuze for spin-stabilized projectiles, having a two-piece body and comprising:
- a point-detonating module housed in the upper portion of said two-piece body including an axially located shaft;
- a time-delay module housed in the lower portion of said two-piece body having means for setting a preselected mode of function;
- a safing and arming module housed in the lower portion of said two-piece body below said time-delay module;
- said axially located shaft communicating said point-detonating module with said time-delay module and said safing and arming module;
- an explosive train located in said modules and inside said shaft;
- a means in said point-detonating module to engage said axially located shaft communicating with said time-delay module to set the fuze for a preselected mode of function.

2. A fuze as in claim 1, wherein the upper portion of said two-piece body is made out of light soft material and the lower portion of said two-piece body is made out of hard heavy material, with the two portions attached to each other to form a solid body.

3. A fuze as in claim 1, wherein the time-delay module positioned in a housing and having an upper and a lower plate includes:
- a fixed firing pin attached to said housing;
- spin detents carried by said upper plate;
- primers attached to said upper plate;
- a helical spring positioned between said housing and said spin detents;
- a time-delay column carried by said lower plate;
- an output detonator positioned on said lower plate;
- a transition charge located between said time-delay column and said output detonator.

4. A fuze as in claim 3 said, wherein explosive train includes:
- two detonators located in said fixed ring in said point-detonating module;
- two strands of mild detonating fuze inside said axially located shaft;
- a time-delay column carried by said lower plate of said time-delay module;
- an output detonator positioned on said lower plate of said time-delay module;
- a transition charge located between said time-delay column and said output detonator;
- a detonator carried by said safing and arming module;
- a lead located in said lower plate of said safing and arming module;
- a booster charge in a cup threaded into lower portion of said two-piece body below said safing and arming module.

5. A fuze as in claim 1, wherein the means in said point-detonating module includes:
- a setting key;
- said point-detonating module further including a crush element located inside said setting key;
- a firing plate having two firing pins and carried by said setting key;
- a fixed ring carrying two detonators;
- a means of locking said axially located shaft in preselected position.

6. The combination of claim 5, wherein said setting key has two longitudinal slots engaging said axially located shaft.

7. A fuze as in claim 5, wherein said; axially located shaft includes:
- a setting plate engaged in said two longitudinal slots of said setting key;
- a slot at the upper end in which said setting plate is pressed;
- holes or flat surfaces at the upper end to hold said axially located shaft in a preselected position;
- two flat surfaces at the lower end engaging said time-delay module to rotate said time-delay module into a preselected position and guide said time-delay module in its forward motion at impact.

8. A fuze as in claim 1, wherein said time-delay module is supported by a cup threaded into lower portion of said two-piece body and said cup having a finger cut out of its cylindrical wall.

9. A fuze as in claim 1, wherein safing and arming module includes:
- an upper and a lower plate;
- timing means between said upper and lower plates;
- a setback pin arrangement engaging said timing means;
- two spin detents engaging said timing means.

10. The combination of claims 8, or 9, wherein said upper and lower plate each have a slot allowing passage of said finger.

11. The combination of claim 9, wherein timing means includes:
- a rotor carrying a detonator and engaging a gear train;
- a runaway escapement controlling the movement of said rotor through said gear train.

12. The combination of claim 9, wherein setback pin arrangement includes:
- a helical spring located eccentrically in said lower plate and parallel to the fuze axis;
- a ball with its helical spring located radially in said lower plate and pressing against said setback pin arrangement.

13. The combination of claim 9, wherein two spin detents are located in said lower plate in diametrically opposed cavities sliding radially against the two ends of a leaf spring.

* * * * *

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Apotheloz [45] **Feb. 13, 1973**

[54] IMPACT FUZE FOR PROJECTILES

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[21] Appl. No.: **137,213**

[30] **Foreign Application Priority Data**

May 1, 1970 Switzerland 6593/70

[52] **U.S. Cl.** **102/84,** 58/116, 74/1.5
[51] **Int. Cl.** **F42c 9/04**
[58] **Field of Search** 102/84; 58/116, 117; 74/1.5

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Primary Examiner—Samuel W. Engle
Attorney—Wenderoth, Lind & Ponack

[57] **ABSTRACT**

An impact fuze for projectiles of the type containing a controllably adjustable escapement regulator for determining the post-bore safety period, i.e. the safe period of the fuze after leaving the barrel. Means are provided for adjusting the running time of the escapement by altering the depth of engagement between the escapement wheel and the escapement lever. These means may comprise a bearing pin having portions of different diameters which is displaceable so that the different diameters can be selectively engaged by the bearing bore of the escape lever to vary the depth of the engagement. The bearing pin may form the striker pin of the fuze. Thus it is possible for the post-bore safety period of the projectile to be adjusted by a gun crew before the firing of the gun to defend gun positions against a surprise attack launched from nearby.

2 Claims, 2 Drawing Figures

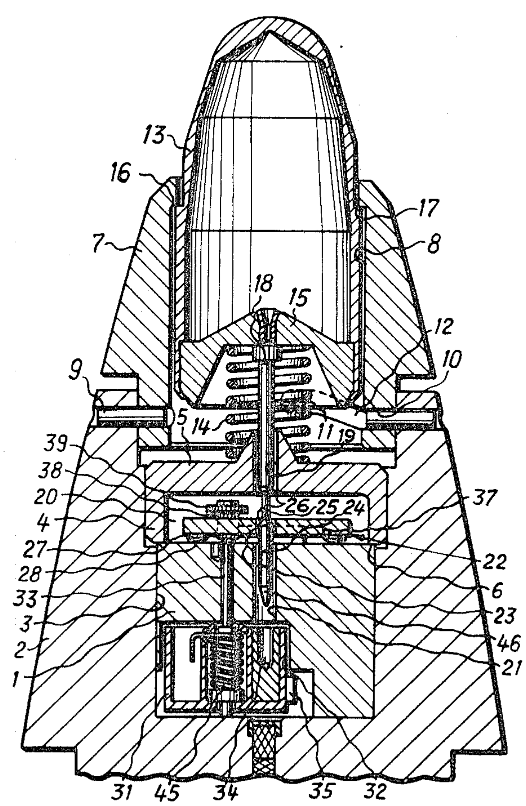

Fig.1

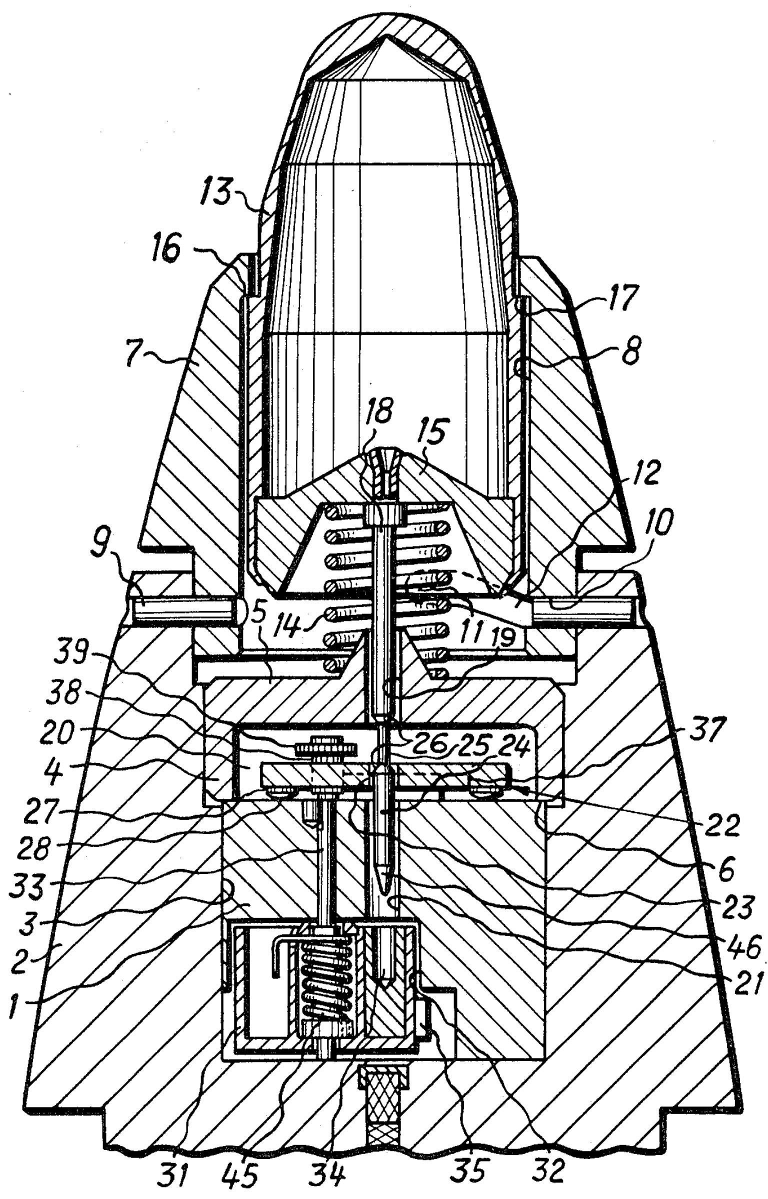

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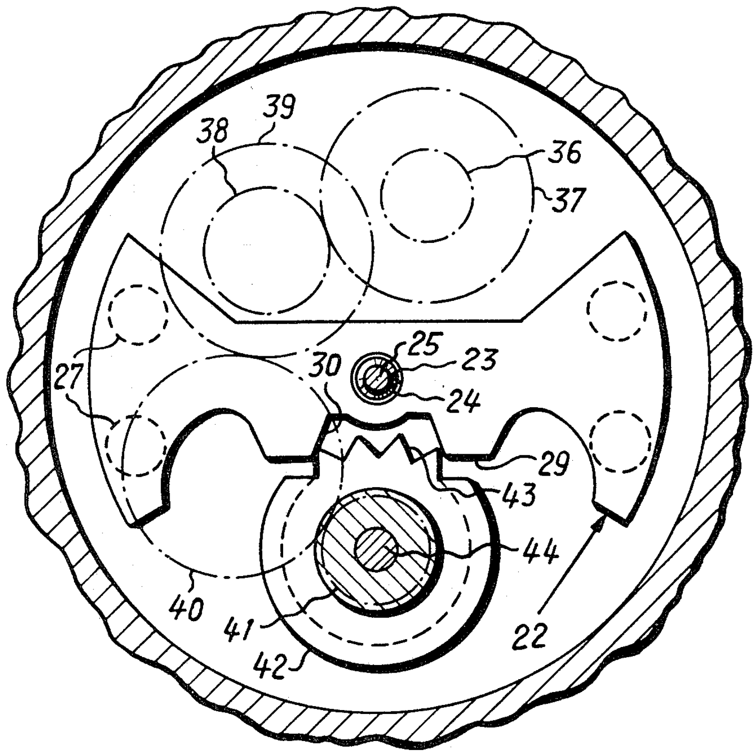
Fig. 2



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forced away from the escape wheel **42** by the thrust exerted by the teeth **43** of the wheel on the pallet faces **29**, **30** and that side of the bore **23** which faces away from the wheel will therefore make contact with the reduced section **25** of the bearing pin. The distance between the fulcrum of the escape lever and the center of the escape wheel is thereby slightly increased and the depth of engagement of the escape wheel **42** with the escape lever **22** is now less than when the lever **22** works on the section **24** of the bearing pin **18**. This change in the geometrical relationships reduces the amplitude of oscillation of the escape lever **22** and hence raises the running speed of the escapement regulator **22**, **42**. The time needed for the fuze to be armed is therefore reduced and the safety period after leaving the barrel is shorter.

In fuzes intended for spin-stabilized projectiles the movement of the escape lever **22** away from the escape wheel **42** can be assisted by offsetting its center of gravity from the axis of rotation. The centrifugal forces which then act on the escape lever **22** when the projectile spins will throw the lever away from the escape wheel **42** against the portion **25** of the bearing pin and retain the lever at this greater radial distance.

The disadvantages achieved by the invention reside more particularly in that by merely turning the head of the fuze the safety period of projectiles after leaving the barrel can be adjusted to desired values so that the same projectile can be used for firing at distant and at close targets.

I claim:

1. An impact fuze for rotating projectiles of the type containing a controllably adjustable escapement regulator comprising an escapement wheel; an escapement lever having its center of gravity offset from the axis of rotation, said escapement lever being engageable with said escapement wheel; a bearing pin axially shiftable in relation to said escapement lever, said escapement lever being pivotally mounted on said bearing pin, said bearing pin having a first section with a first diameter and a second section with a second diameter smaller than said first diameter; whereby in a first position of said bearing pin said escapement lever pivots around said first section of said bearing pin and in a second position of said bearing pin said escapement lever pivots around said second section of said bearing pin; and whereby under the centrifugal forces acting during rotation of said projectile on said escapement lever in said second position of said bearing pin the escapement depth between said escapement wheel and said escapement lever is smaller than in said first position of said bearing pin, said escapement depth being determinative of the running time of said regulator; and means to axially shift said bearing pin from said first position into said second position to change said running time.

2. An impact fuze for projectiles of the type containing a controllably adjustable escapement regulator comprising an escapement wheel; and escapement lever engageable with said escapement wheel; a bearing pin axially shiftable in relation to said escapement lever, said escapement lever being pivotally mounted on said bearing pin, said bearing pin having a first section with a first diameter and a second section with a second diameter smaller than said first diameter; whereby in a first position of said bearing pin said escapement lever pivots around said first section of said bearing pin and in a second position of said bearing pin said escapement lever pivots around said second section of said bearing pin; and whereby under the forces actuated by said escapement wheel on said escapement lever in said second position of said bearing pin the escapement depth between said escapement wheel and said escapement lever is smaller than in said first position of said bearing pin said escapement depth being determinative of the running time of said regulator; and means to axially shift said bearing pin from said first position into said second position to change said running time.

* * * * *

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LAND MINE FUSE

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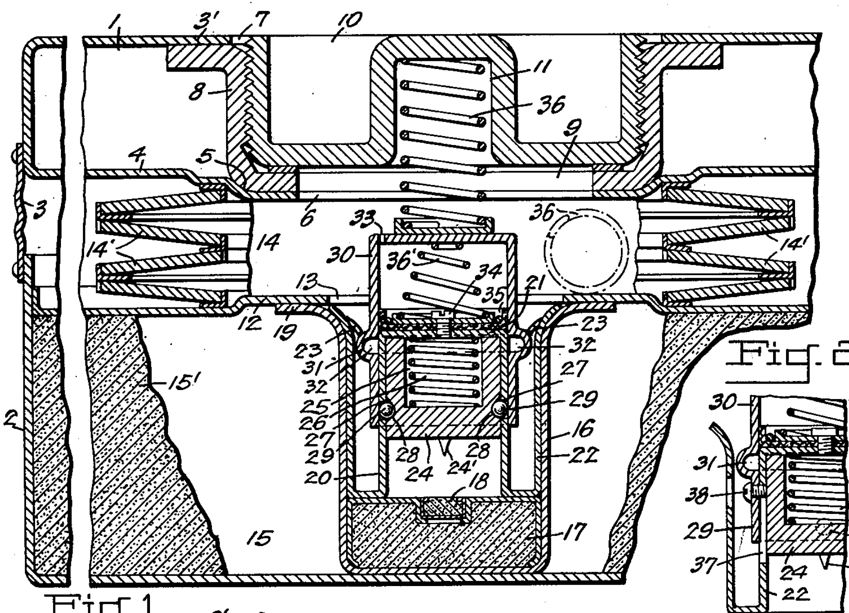

Fig. 1

Fig. 2.

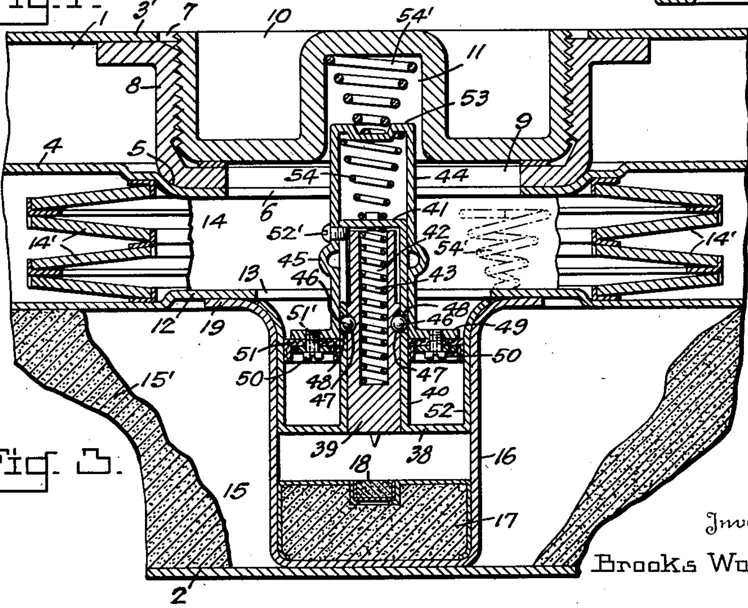

Fig. 3.

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LAND MINE FUSE

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Fig. 4.

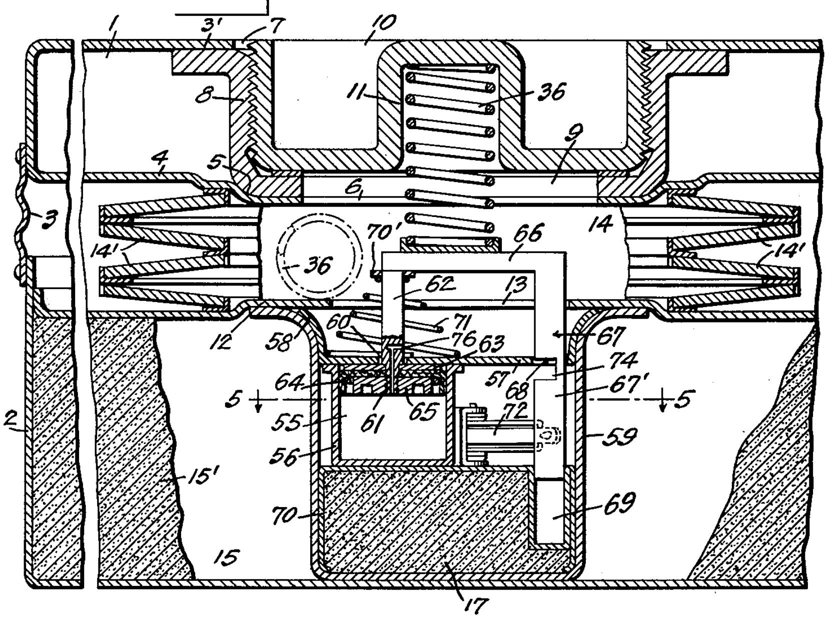


Fig. 5.

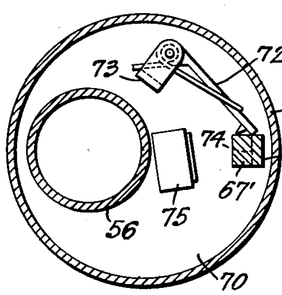
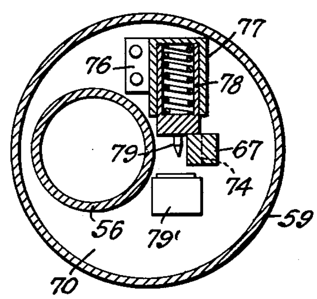


Fig. 6.



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[redacted]

groove 32 into which the balls are crowded at the time of the explosion of the mine, and at no other time, for reasons that will appear later on. The top of the dashpot cylinder is closed with exception of a breather hole 33, and secured to the top of the housing 20 by a screw 34 is a cup-leather dashpot piston 35, between which and the top of the cylinder 30 is a conical return or elevating spring 36' normally maintaining the cylinder in raised position and adapted to return it to such position from any position it might reach in telescoping over the striker housing short of that in which the mine is operated, or short of that position wherein the balls are cammed out of the pockets in the striker and into the groove 32 in the rib 31, the pockets in the striker being inclined upwardly and outwardly as shown, to effect the camming action at the time the striker spring 26 is released.

Within one end in the dome 11 and abutting the under side of the top thereof, is the arming spring 36 whose lower end rests in a shallow cup on the top of the dashpot cylinder. This spring is the intermediary between the top and bottom sections of the mine casing and without this spring the fuse will not operate. The extent of movement of the dashpot cylinder by the arming spring, for a given force acting for a given time is governed by the size of the breather ports or apertures in the dashpot. Provided for the convenient removal and replacement of the springs is the readily detachable flexible band 3 which connects the top and bottom sections of the mine casing.

Referring to Figure 2, which is a fragmentary section of a slight modification of the dashpot cylinder and closely associated parts, the striker housing is provided with a slot 37 entered by the shank of a screw 38 carried by the dashpot cylinder to limit the upward movement of said cylinder under the influence of the return spring. These screws perform the same function as the detents 23 of Figure 1, and for better balance of movement between the parts there will preferably be a slot and screw on each side of the assembly.

In the modification shown in Figure 3, the dashpot cylinder is formed as a part of the striker housing. Its bottom is closed as indicated at 38 and its outer side walls fit snugly against the inner wall of the casing 16. In this form the striker 39 is elongated and housed in the cylindrical housing 40, the latter being open at its lower end and closed at its upper end, as indicated at 41. Like the striker in Figure 1, this striker has a bore 42 terminating short of its bottom and forming a seat for a prestressed spring 43, which bears at its upper end against the closed end of the striker housing. Telescoping over the striker housing is an operating cylinder 44, like, in many respects, the operating dashpot cylinder 30 of Figure 1. The cylinder is provided with an annular rib 45 having an annular groove therein to receive balls 46 resting normally partially in pockets 47 and partially in holes 48 in the striker housing, the arrangement, so far as these elements are concerned being substantially like their corresponding parts in Figure 1. The operating cylinder 44 has a laterally extending flange 49 at its lower end to the under side of which is secured by screws 50, a cup-leather piston 51 reciprocable in the dashpot cylinder 52. The dashpot will have appropriately sized breather holes, and in the construction illustrated in this figure these are made through one or more of the screws that attach the piston to the flange 49, as indicated at 51'. To limit the upward movement of the operating cylinder 44 relative to the striker housing, the housing is provided with a vertical groove entered by a screw 52' carried by the cylinder. This cylinder is closed at its top as at 53, and between the under side of said top and the top of the striker housing is interposed the return spring 54 functioning precisely like the spring 36' in Figure 1. Between the top of the operating cylinder and the under side of the dome 11 is the arming spring 54' serving the same purpose as the spring 36 in Figure 1.

It will doubtless have been observed that forms of Figures 1 and 3 differ mainly in the dimensions of the various parts and in the locations of the dashpots, the dashpot in Figure 1 being wholly above the striker, and that in Figure 3 being laterally disposed with respect to the lower portion of the striker, the operation in both instances being substantially the same.

The forms of the fuse shown in Figures 4, 5 and 6 differ somewhat from the other forms. In this case the dashpot is arranged eccentrically of the axis of the mine casing. It is indicated by the numeral 55 and comprises the cylinder 56, whose upper end is secured to the under side of a plate 57 whose curved peripheral flange 58 is secured to the similarly shaped flange of the outer casing 59 secured to the under side of the stationary plate 12 in the lower section of the casing. There is an aperture 60 that is eccentrically positioned in plate 57 for the passage of the threaded shank 61 of the piston rod 62, which shank passes through a disc 63 and through a flanged leather dashpot piston 64 into a member 65 between which and the disks the piston is clamped. The rod 62 extends upwardly through the central opening 13 in the plate 12 into engagement with the horizontal arm 66 of a control bar 67 whose vertical arm 67' extends downwardly through an opening 68 in the plate 57 and into a well 69 formed in the booster casing 70, in which opening and well the control rod is guided in its vertical movements.

The arming spring 36 is interposed between the arm 66, and the under side of the dome 11. A flange 70' is provided at the upper end of the rod 62 and between this flange and the plate 57 is interposed a cone-shaped spiral return spring 71.

The firing means of the fuse just above described, is of the grenade type and comprises a spring urged horizontally swingable striker 72 pivoted in a bracket 73 secured to the top of the booster charge casing. In cocked position the firing pin end of the striker engages the vertical portion 67' of the control bar, thus holding the striker cocked. Cooperating with the striker 72 is a notch 74 in the control bar, which, when said bar is depressed sufficiently, allows the striker arm to pass through it and reach the primer 75 attached to the top of the booster casing to detonate the booster charge.

In Figure 6, there is shown a modification of a firing mechanism. In this case there is a bracket 76 mounted on the booster casing and formed with an open cylinder 77 for reception of a plunger 78 carrying firing pin 79, there being a spring in the plunger urging the plunger out of the cylinder and against the control arm 67 adjacent the notch 74, and ready to be forced through the notch by the spring when the control arm has been sufficiently depressed to allow such movement. On the opposite side of the control arm from the plunger, is a primer 79' appropriately positioned relative to the booster charge to ignite the charge at the proper time.

All of the dashpots have breather holes and these are of a size to permit egress of air at a rate corresponding to the pressure exerted by the arming spring when a weight or pressure depresses the upper section of the mine casing by contact with the pressure plate 3'. In Figure 4, a hole 76 is shown drilled through the dashpot piston rod 62 and communicating at one end with the dashpot and at the other with the space above the plate 57, or with the space above the piston as the piston descends, as the case may be. It will be understood that breather holes may be located in any suitable part of the dashpot cylinders or their pistons, the idea being to permit the escape of air from the dashpot and to replace it, according to the movement of the pistons shown in the several views.

To arm the fuse and the mine, the arming spring 36 in the forms of Figures 1 and 4, and 54' in Fig. 3, must be in place between the depressible top section of the mine casing and the dashpot assemblies.

It is believed that a description of the operation of the mechanism shown in Figure 1 will suffice for the other forms, since in all of them are obvious equivalents that function in the same manner. Pressure upon the top plate 3' of the upper mine casing section will be communicated to the arming spring 36, and in a degree to the heavy spring 14'. This pressure will be communicated through the arming spring to the dashpot operating cylinder, which will be depressed against the conical return spring 36' in the dashpot, forcing the cylinder to telescope over the striker housing against the resistance of the return spring and the column of air in the dashpot. Weight applied for a shorter time duration than that for which the mine is adapted by size of its aperture, depresses the operating cylinder to a certain extent through the instrumentality of the arming spring and when such pressure is relieved the return spring 36 will return the operating cylinder to normal position, but when the weight is sufficient and applied for a sufficient time duration, the arming spring will be depressed sufficiently to exhaust all, or enough of the air from the dashpot to allow the operating cylinder to be moved down to a point where the balls in the pockets in the striker and in the holes in the striker housing come opposite the annular groove 32 in the dashpot cylinder when the striker will be released and driven by spring 26 into contact with the primer to explode the mine.

As stated, all of the dashpots have breathing ports or apertures. These will be of a size to permit egress of the air from the dashpots at a rate proportionate to the pressure exerted by the arming spring 36. The rate at which the air is let out under the pressure of the arming spring is such that the striker will not be released if the pressure plate 3' and arming spring are depressed only momentarily, as is the case while, for instance, the mine is subjected to the blast effect of an explosion. However, a long duration of pressure, such for instance as created by the passage of heavy wheels or tracks will expel enough air from the dashpot to release the firing mechanism. Any part of movement of the dashpot piston which may be caused by blast effect or other

transient force will be compensated for by the return spring.

It will be noted, therefore, that the essence of my invention resides in a means for releasing the firing mechanism of the mine in response to depression of the contact or pressure plate, which means includes a spring and a dash-pot in series. Thus, pressures of relatively short duration act only to stress the spring without substantial movement of the dash-pot elements and without releasing the striker. On the other hand, the same pressures, when acting for longer periods stress the spring and cause the dash-pot to move into position releasing the firing mechanism.

In handling the mine or in shipment, safety is assured so long as the arming springs are absent from their appropriate places, at which time the springs may be conveniently stored in the spaces between the plates 4 and 12, where they are shown in dotted lines in Figures 1, 3 and 4.

I claim:

1. In an explosive mine comprising a casing proper for the reception of the main charge and a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure contact operated element, a fuse in said casing in pressure receptive relation with said element including firing means, a dash pot comprising a cylindrical member closed at one end with the open end slidably embracing a firing means housing and interposed between said pressure plate and said firing means housing, having resilient operative connections with said pressure plate and with said firing means, means for normally locking the firing means, said locking means being responsive to dashpot movement to release the locking means only upon the application of a substantial pressure applied for a substantially predetermined delay period to the contact pressure element, and means for returning the dashpot to normal operative position from any position short of that in which the locking means is released.

2. The invention of claim 1 characterized in that there is a means for limiting the dashpot return movement from the point short of that in which the firing means is released.

3. In an explosive mine comprising a casing proper for the reception of the main explosive charge including a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a fuse in the casing proper in pressure receptive relation with said element and comprising a booster and a primer for detonating it, a dashpot comprising a cylindrical member closed at one end with the open end slidably embracing a firing means housing and interposed between said pressure plate and said firing means housing, firing means controlled by said dashpot in response to the pressure applied to said dashpot, resilient means having operative connection with the contact pressure element and the dashpot through which pressure applied to the pressure element is communicated to the dashpot, means for locking the firing means in normal position away from the primer, and means responsive only to dashpot operation beyond a predetermined distance to release the firing means, and automatic means for returning the operative dashpot element to normal position from any position short of said predetermined distance.

4. In an explosive mine comprising a casing proper for the reception of the main explosive

charge and a pressure plate yieldingly supported with respect to said casing and forming a part thereof, said pressure plate constituting a pressure contact operated element, a fuse in said casing in pressure receptive relation with said element and comprising a booster charge and a primer for detonating it, a striker housing in said casing, a striker slidable in said housing, a closed top operating cylinder telescoping over said housing and forming with said housing a dashpot, releasable means interposed between the striker and the housing to normally prevent movement of the striker toward the primer, resilient means interposed between the pressure operated contact element and operating cylinder whereby pressure applied to said element is communicated to said cylinder to move the cylinder, said cylinder acting to release said locking means only when said cylinder has been moved by said yielding means a substantially predetermined distance against the column of air in the dashpot, and automatic means for returning the operating cylinder to normal position from any position short of that position in which the striker locking means is operated.

5. In an explosive mine comprising a casing proper for the reception of the main explosive charge and a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a fuse in the casing proper in pressure receptive relation with said element and comprising a booster charge and primer therefor, a closed top striker housing in the casing, a striker slidable therein, a pre-stressed firing spring between the top of the housing and the striker, a cylinder telescoping over the striker housing and forming with the top of said striker housing a dashpot, a spring interposed between said cylinder and the pressure operated element whereby when pressure is applied to said element it is communicated to said cylinder, striker locking means carried partly by the striker, partly by said housing and normally locking the striker away from the primer, means carried by the dashpot cylinder cooperating with the striker locking means to release said locking means only when the dashpot cylinder has been moved by said spring a substantially predetermined distance against the column of air in the dashpot, and means in the dashpot for returning the cylinder to normal position from any position short of that position in which the striker means is operated.

6. In an explosive mine comprising a casing proper for the reception of the main explosive charge, a pressure plate yieldingly supported with respect to the casing proper, said pressure plate constituting a pressure operated contact element, a booster charge in the casing and a primer therefor, a cylindrical fuse casing in the casing proper, a dashpot cylinder within the fuse casing and

formed with an open bottom centrally positioned cylinder constituting a striker housing, a striker in said housing, a pre-stressed firing spring interposed between the striker and said housing, means carried partly by the housing and partly by the striker for locking the striker in normal position away from the primer, an operating cylinder telescoping over said housing and carrying a dashpot piston on its lower end within said dashpot cylinder, a spring between the pressure operated contact element and said operating cylinder whereby when pressure is applied to said element it will be communicated to said cylinder, means carried by the operating cylinder cooperating with the striker locking means to release said locking means only when the dashpot piston is moved a substantially predetermined distance by a pressure applied to the contact pressure element for a substantially predetermined delay period, and means for returning the operating cylinder and striker piston to normal position from any position short of that in which the striker means is operated.

7. In a land mine, a casing, a primer in said casing, a striker housing fixed within said casing and having a cylindrical portion, a striker guided for movement in and along said portion, a pin on said striker and adapted to contact said primer to detonate the same when said striker is moved from a first to a second position in said cylindrical portion, a dash-pot cylinder fitting over said portion, a piston fitting said dash-pot cylinder and secured to said housing, first spring means urging said striker into said second position, releasable means normally locking said striker in said first position, said locking means being released in response to movement of said dash-pot cylinder from a first to a second position, yielding means urging said dash-pot cylinder into its said first position, a pressure plate on said casing, resilient means urging said plate outwardly of said casing, and a spring interposed between said pressure plate and dash-pot cylinder, whereby said cylinder is moved to its said second and striker-releasing position only in response to a predetermined minimum force acting upon said plate for a definite appreciable time.

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United States Patent

[11] 3,608,494

[72] Inventor Richard T. Ziemba
Burlington, Vt.
[21] Appl. No. 804,443
[22] Filed Mar. 5, 1969
[45] Patented Sept. 28, 1971
[73] Assignee General Electric Company

[54] **TIME DELAY FUSE**
5 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **102/79,** 102/82, 102/71
[51] **Int. Cl.** **F42c 9/02,** F42c 7/00, F42c 9/00
[50] **Field of Search** 102/79, 82, 71

[56] **References Cited**

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ABSTRACT: A time delay fuse has a ball rotor carrying the detonator charge in a bore along the axis of mass symmetry, and normally held safe, out of line by a detent clip. Release of the clip requires both adequate set back force and centrifugal force. Once the rotor has rotated into the armed, in-line disposition, it is interlocked in this disposition.

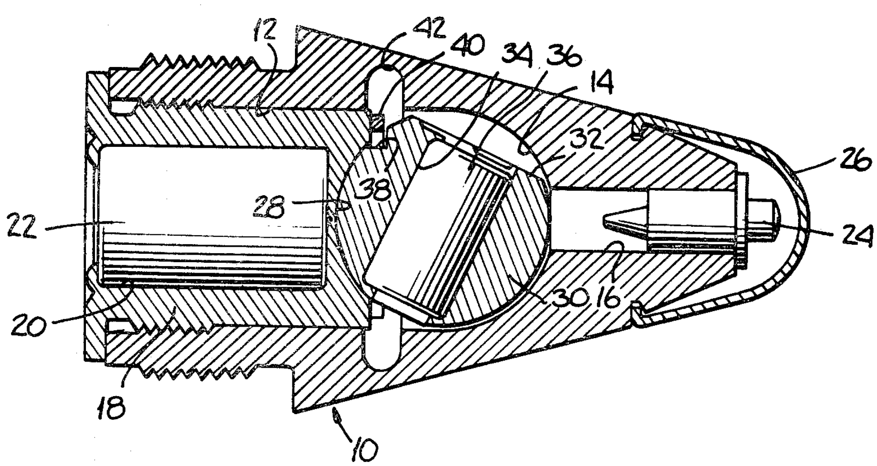


Fig.1.
Prior Art

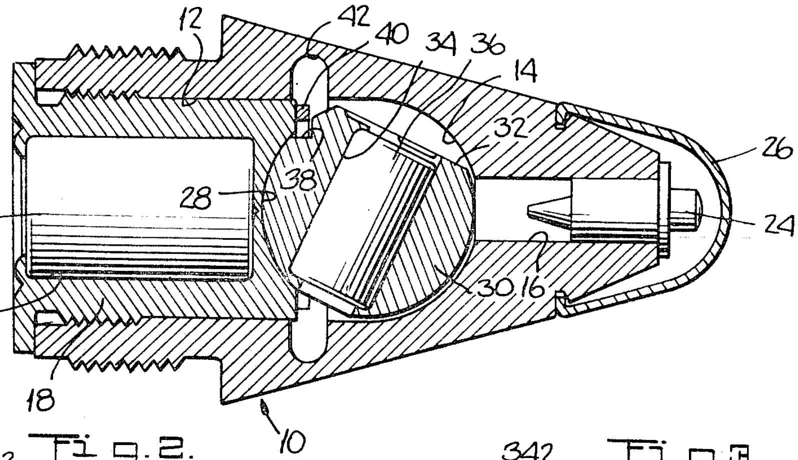


Fig.2.

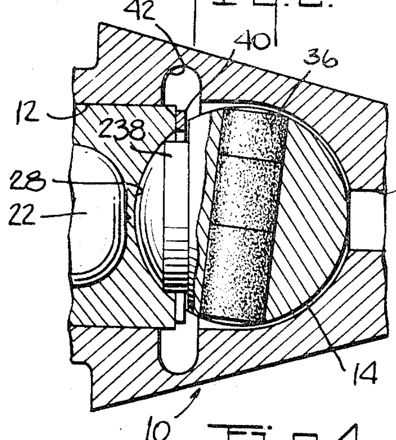


Fig.3.

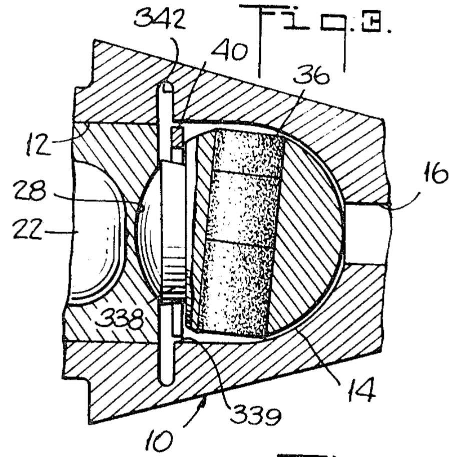


Fig.4.

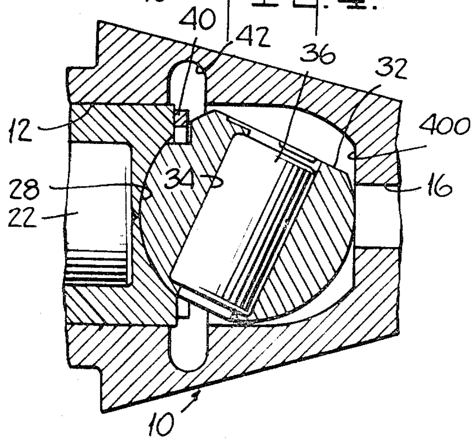
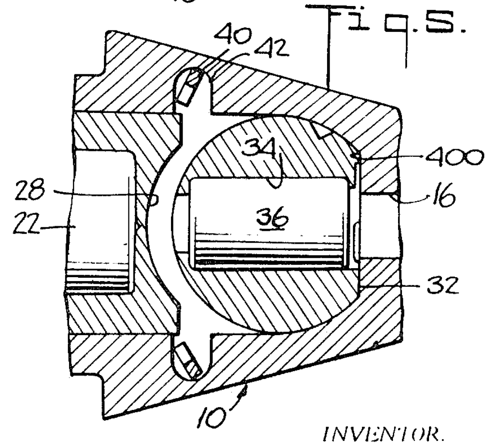


Fig.5.



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TIME DELAY FUSE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is related to time delayed fuses for ammunition of relatively small calibre, and especially to devices for maintaining the safe or the armed status of the fuse.

2. Prior Art

The fuse of this invention is an is an improvement on the fuse shown in my earlier U.S. Pat. No. 3,397,640, issued Aug. 20, 1968. In that patent I disclosed a fuse which has a ball rotor supporting and normally disposing a detonator out of alignment with the firing pin and the booster charge, and disposing the detonator in alignment with the firing pin and the booster charge after the application over a predetermined period of time of a predetermined centrifugal force. Specifically, the rotor is held in an out-of-line position by means of a rotor detent spring. This spring locks the rotor in an out-of-line position until projectile spin is sufficient to cause the spring to open, thereby releasing the rotor. Once the rotor is free of the spring, it is free to rotate, due to its dynamic mass unbalance, to an in-line position. Since the diameter of the detonator within the rotor is usually relatively large, the difference in the moments between the principal axes of the rotor is large and, therefore, the driving torque is high. Thus, the rotor aligns itself in a very few milliseconds once the projectile emerges from the gun muzzle. Accordingly, it is an object of this invention to reduce the driving torque to increase the time delay to alignment. Another object of this invention is to precondition arming on the simultaneous presence of both adequate spin and setback forces.

For normal target impact conditions, the firing pin is driven into the detonator to provide fuse function, i.e., initiation. However, at low target impact angles, the projectile and the fuse fixed thereon tend to rotate relative to the ball detonator, and, thereby, cause a misalignment between the firing pin and the detonator. This occurs because the ball rotor cannot change its alignment fast enough to follow the shift of the fuse at the time of target impact. A gross misalignment will result in a failure of fuse function. Therefore, another object of this invention is to lock the ball rotor into alignment with the firing pin.

SUMMARY OF THE INVENTION

A feature of this invention is a time delay fuse for a projectile including a ball rotor journaled for rotation within a cavity in the fuse. The firing pin, said cavity and the booster charge lie along the longitudinal axis of the fuse. The rotor carries a detonator in a diametral bore, and a retaining ring mounted on a set cut into the ball normally fixes the ball with the detonator out of alignment with the longitudinal axis of the fuse. To release the rotor, the ring must be moved aft by setback force and must be enlarged by centrifugal force. After the rotor has rotated into alignment with the longitudinal axis, it is locked into alignment by mating surfaces on the ball and the cavity.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects, advantages and features of this invention will be apparent from the following specification thereof taken in conjunction with the accompanying drawing in which:

FIG. 1 is a longitudinal cross section of the prior art fuse, substantially as shown in U.S. Pat. No. 3,397,640;

FIG. 2 is a longitudinal cross section of one aspect of the present invention, showing an improved low mass ball rotor assembly, providing a relatively long time delay to arm, compared to the fuse of FIG. 1;

FIG. 3 is a longitudinal cross section of another aspect of the present invention, showing an improved ball rotor assembly requiring both setback and centrifugal forces to arm;

FIG. 4 is a longitudinal cross section of another aspect of the present invention, showing an improved ball rotor assembly having a surface to mate with the cavity to block the ball in the armed disposition and

FIG. 5 is a view similar to FIG. 4 showing the ball rotor assembly locked in the armed disposition.

DESCRIPTIONS OF THE EMBODIMENTS

The prior art fuse is shown in FIG. 1 to include a fuse body **10** of substantially conical shape. The body has a longitudinal bore having an aft portion **12** or relatively large diameter terminating in a medial subportion **14** of hemispherical shape, and a forward position **16** of relatively small diameter. The aft bore portion is internally threaded to receive a booster housing **18** having a central cavity **20** containing a booster charge **22**. A firing pin assembly **24**, which may be of the self-destruct type shown in U.S. Pat. No. 3,397,640 supra, is disposed in the forward bore portion, and covered by a nose cap **26**. The forward end **28** of the booster housing **18** has a semispherical recess therein, so that, in conjunction with the fuse body bore medial subportion **14**, a substantially spherical cavity is formed when the booster housing is screwed into the fuze housing. A ball rotor **30** is disposed within the spherical cavity **28/14**. The ball has a fore flat **32** subtending a diametral bore **34** in which is captured a detonator cartridge **36**. A horseshoe-shaped groove **38** is cut into the surface of the ball and receives a horseshoe-shaped retaining clip **40**. An internal, annular groove **42** is cut into the fuze housing bore adjacent the fore end of the detonator housing. In use, the ball rotor is held with the detonator in the out of line, safe, disposition. As the projectile is fired through the tube of the weapon it is spun by the rifling in the tube. The clip **40** locks the rotor in the out of line disposition shown in FIG. **1** until the rotor assembly spin is sufficient to cause the clip to expand into the groove **42**, thereby releasing the ball rotor. Once the ball rotor is free of the spring, it is free to rotate, due to dynamic mass unbalance to an in-line, armed disposition. Since the diameter of the detonator within the rotor is larger, the difference in the moments between the principal axes of the rotor is large and, therefore, the driving torque is high. Thus, the rotor aligns itself in a very few milliseconds after the projectile emerges from the tube of the weapon.

The conditions which govern the arming delay in a ball rotor fuze mechanism are the following:

1. Spin rate of the projectile;
2. Difference in the moments of inertia of the rotor's principal axes;
3. Initial angular displacement of the detonator relative to the flight axis of the projectile;
4. Mass of the rotating parts; and
5. Coefficient of friction between the rotor and the cavity surfaces.

To increase the arming delay by reducing the mass of the rotating parts, the ball rotor has been modified as shown in FIG. **2**, inter alia, by changing the horseshoe-shape groove **38** to a circular cut **238** around the entire perimeter of the ball. The horseshoe-shaped clip **40** is retained. The circular cut allows the ball rotor to spin independently of the retaining clip, therefore, more slowly, during its travel through the tube of the weapon.

The prior art fuze requires only adequate spin to shift from its safe to armed disposition. The possibility of an inadvertant arming of the fuse is further minimized by requiring both adequate spin and adequate setback simultaneously to shift the fuse from its safe to armed disposition, as shown in FIG. 3. The annular groove in the fuse housing has been narrowed and has been located relatively aft, adjacent to the fore end of the booster housing, and is here shown as an annular groove **342**. The horseshoe-shaped groove in the ball rotor has been changed to an annular groove **338** around the entire perimeter of the ball. The horseshoe-shaped clip **40** is retained. The bottom of the groove **338**, however, is not cylindrical but rather is conical, to hold the clip **40** forward, out of transverse alignment with the groove **342**. An additional annular groove **339**, contiguous to groove **342**, is provided to accommodate the clip **40** in its forward disposition. The ball retaining clip **40** can no longer open directly into the groove **342**. Projectile set back force is required to move the clip aft, up the cone, adjacent the booster housing fuse end, to be in transverse alignment with the groove **342**. If the set back force is present, but sufficient spin is not present to open the clip, the ball rotor will remain locked in its out-of-line, safe, disposition. If sufficient spin is present, but sufficient set back force is not present, the clip will not be able to open because it will not be aligned with the groove **342**.

To insure that once armed, the fuse remains armed, the ball rotor has been modified, as shown in FIGS. **4** and **5**, to lock the ball to the housing after alignment. A mating flat chordal surface **400** is formed in the hemispherical bore portion of the fuse housing to mate with the fore flat **32** on the ball rotor. During arming, the ball rotor rotates into alignment with the firing pin **24** until the flat **32** mates with the seat flat **400**. At this point, the forward creep effect developed by rotation of the ball rotor will hold the parts together. At target impact, the deceleration of the projectile will provide an additional locking force between the rotor and the housing to preclude misalignment between the detonator cartridge and the firing pin. Thus, low angle target entries are possible without the probability of fuse function failure.

Although they have been illustrated separately, it will be obvious that the cone shaped groove **338** on the ball rotor, with the aft mating groove **342** in the housing, may be combined with the flat **32** on the ball rotor, with the mating flat **400** in the housing, in a single fuse which requires both adequate setback force and spin to arm, but which once armed, remains armed.

It may be noted that while the diameter of the rotor has been illustrated as almost equal to the transverse diameter of the cavity, it may be made significantly smaller to allow a volume for coupling material, such as a layer of silicone.

What is claimed is:

1. A time delay fuse mechanism having a safed disposition and an armed disposition, for ammunition, comprising:
- a housing having a longitudinal axis extending fore and aft, and a substantially spherical cavity therein which is symmetrical about said axis;
- a substantially spherical rotor disposed in said cavity having an axis of mass symmetry and a diametral bore coaxial therewith and adapted to receive a detonating charge therein;
- a first annular groove formed into the periphery of said rotor perpendicular to a first diameter which is angularly displaced from said axis of mass symmetry and which first diameter, in the safed disposition is coaxial with said housing longitudinal axis, said groove defining a cone having a portion of relatively smaller diameter proximate to the center of said rotor and a portion of relatively larger diameter remote from said center of said rotor;
- a second annular groove formed into the wall of said housing cavity perpendicular to said housing longitudinal axis and adjacent to said cone portion of relatively larger diameter;
- a third annular groove formed into the wall of said housing cavity perpendicular to said housing longitudinal axis, adjacent to said cone portion of relatively smaller diameter, and contiguous to and of smaller diameter than said second annular groove;
- and an expansible element, normally disposed on and embracing said cone portion of relatively smaller diameter, and extending at least in part into said third annular groove thereby precluding rotation of said rotor in said cavity;
- said expansible element adapted, upon the application of an adequate setback force, to ride aft along said longitudinal axis from the disposition normal disposition adjacent said third annular groove to an intermediate disposition adjacent said second annular groove, and when in said intermediate disposition, upon the application of an adequate centrifugal force, to expand into said second annular groove to free said rotor for rotation within said cavity into the armed disposition.

2. A time delay fuse mechanism, having a safed disposition and an armed disposition, for ammunition, comprising;
- a housing having a longitudinal axis extending fore and aft, and a cavity therein which is symmetrical about said axis;
- a substantially spherical rotor disposed in said cavity having an axis of mass symmetry and a diametral bore coaxial therewith and adapted to receive a detonating charge therein, and a first diameter which is angularly displaced from said axis of mass symmetry;
- spin releasable interlocking means disposed in part in said rotor and in part in said cavity for normally retaining said rotor with said first diameter coaxial with said longitudinal axis, and adapted, under adequate centrifugal force to release said rotor for rotation in said cavity to the armed disposition with said axis of mass symmetry coaxial with said longitudinal axis;
- additional interlocking means disposed in part on said rotor and in part on a surface of said cavity for retaining said rotor, upon rotation into said armed disposition, in said armed disposition.

3. A fuse according to claim **2**, wherein:
- said cavity has a forward portion of substantially hemispherical shape, with a chordal flat surface perpendicular to said longitudinal axis; and
- said rotor has a mating chordal flat surface perpendicular to said axis of mass symmetry; said flat surfaces serving as said additional interlocking means.

4. A fuse according to claim **1**, further including:
- interlocking means disposed in part on said rotor and in part cavity for retaining said rotor, upon rotation into said armed disposition, in said armed disposition.

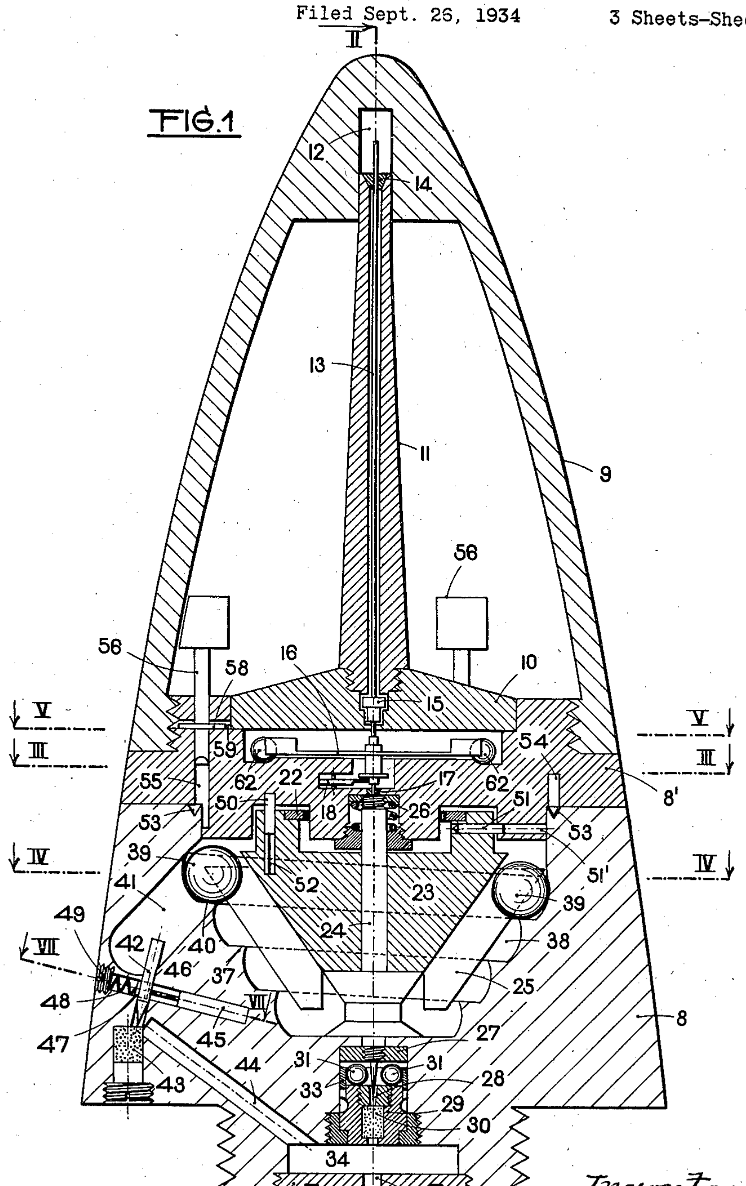
5. A fuse according to claim **4**, wherein:
- said cavity has a forward portion of substantially hemispherical shape, with a chordal flat surface perpendicular to said longitudinal axis; and
- said rotor has a mating chordal flat surface perpendicular to said axis of mass symmetry;
- said flat surfaces serving as said additional interlocking means.

April 30, 1935. C. ARAGONE 1,999,747

PROJECTILE

Filed Sept. 26, 1934 3 Sheets-Sheet 1

FIG.1



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PROJECTILE

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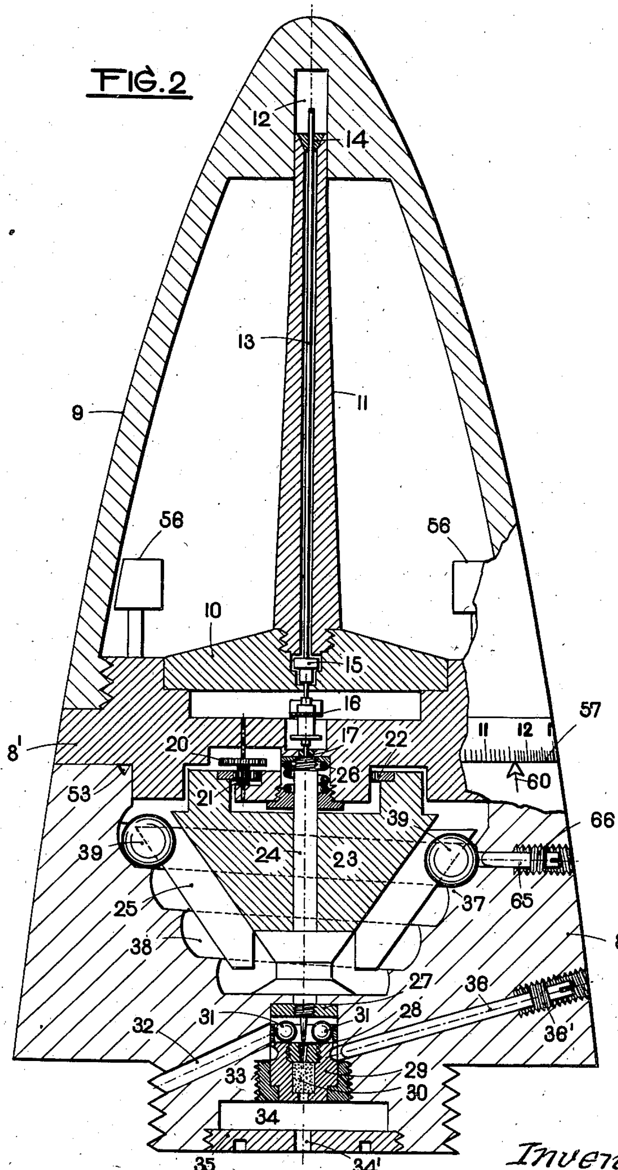
FIG. 2



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PROJECTILE

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FIG.3

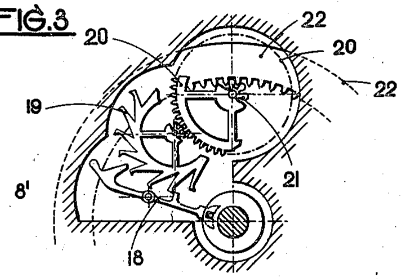


FIG.7

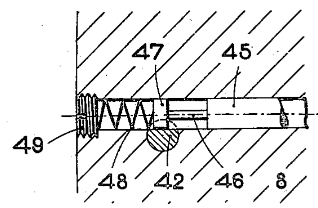


FIG.4

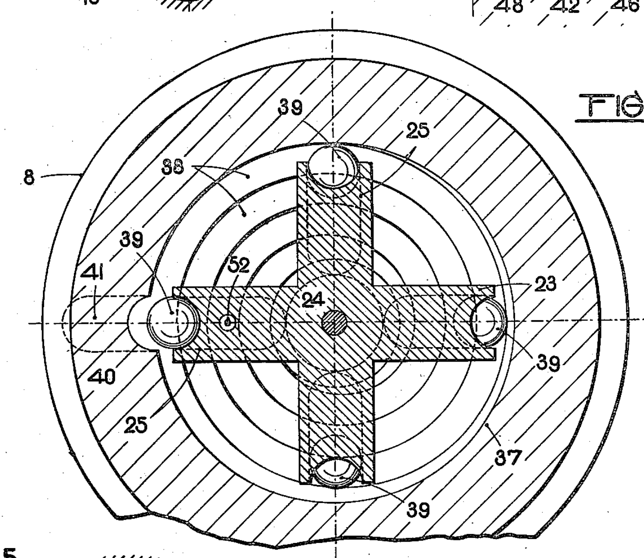


FIG.5

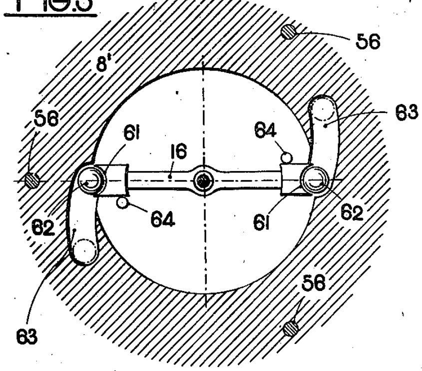
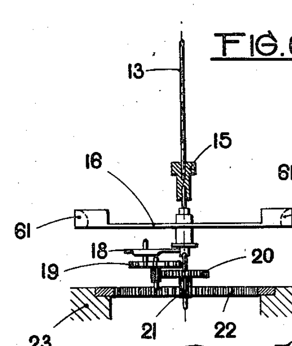


FIG.6



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UNITED STATES PATENT OFFICE

1,999,747

PROJECTILE

Carlo Aragone, La Spezia, Italy

Application September 26, 1934, Serial No. 745,633
In Switzerland October 17, 1933

6 Claims. (Cl. 102—37)

The subject of the present invention is a fuse for an artillery projectile comprising a timing mechanism adapted to control a percussion mechanism in such manner that the latter determines, as a function of the time, the bursting of the projectile.

The fuse is characterized in this that it comprises at least one body, the initial position of which is regulatable and which under the influence of centrifugal force produced by the rotation of the projectile is displaced on a helicoidal path of progressive radius, entrains in its movement the first timing wheel of the timing mechanism and, at the end of its travel, actuates the percussion member causing deflagration of a percussion cap.

In the fuse of the present invention, the oscillations of the balance wheel regulating the timing mechanism are thus maintained by one or more masses subjected to centrifugal force which the rotation of the projectile produces, but, in lieu of being connected by gearing to the clockwork movement and of effecting a translatory radial and rectilinear movement relatively to their support, as in certain known constructions, the mass or masses traverses or traverse a helicoidal path of progressive radius, for example, on a race or track formed as a groove on the surface of a recess in the support. This race or track is preferably developed on the surface of a recess in the support of approximately conical or parabolic form.

The annexed drawings illustrate by way of example one embodiment of the invention.

Fig. 1 shows in longitudinal section the head of the projectile.

Fig. 2 is a section on the line II—II of Fig. 1.

Fig. 3 is a part section, to enlarged scale, on the line III—III of Fig 1.

Fig. 4 is a section on the line IV—IV of Fig. 1.

Fig. 5 is a section on the line V—V of Fig. 1.

Fig. 6 is a diagrammatic view, in elevation, of the timing mechanism.

Fig. 7 is a section to enlarged scale on the line VII—VII of Fig. 1.

In the drawings is shown the head of an artillery projectile comprising a double acting fuse. The head includes a base 8 intended to be screwed on the base of the projectile, a seating 8′ and a cap or ogive 9 which is screwed on the seating 8′. The seating 8′ forms the support for the timing mechanism and comprises a bridge 10 in which is screwed a tubular sheath 11 the front end of which is fitted in a cylindrical recess 12 in the ogive 9. The sheath 11 is located axially of the projectile and encloses a torsion spring 13 formed by a steel wire of circular section. This spring is fixed at its front end in a bearing 14 and is connected at its rear end by means of a joint 15 to the axis of the balance wheel 16, the front pivot of which is connected to the joint 15. The rear pivot of the balance wheel 16 rotates in a bearing 17 in the seating 8′. The spring 13 is protected within the tubular sheath 11 and may oscillate therein freely about its axis to impart an oscillating movement to the balance wheel 16. The joint 15 permits the spring 13 to expand axially without adversely affecting the operation of the balance wheel.

The timing mechanism comprises, in addition to the spring 13 and the balance wheel 16, a lever-escapement comprising a side lever 18 (Fig. 3), the fork of which actuates the pin on the plate fixed on the axis of the balance wheel, an escapement wheel 19, the pinion of which engages with a counting wheel 20 in one with the pinion of the counter 21, and a timing wheel formed by an internally toothed crown 22 meshing with the pinion of the counter 21. The balance wheel, the parts of the escapement and the movable member 20, 21, are disposed in recesses or cavities in the seating 8′, while the toothed crown 22 is fitted in the first timing wheel 23 forming the driving wheel. This driving wheel is mounted loosely on a spindle 24 having four blades disposed in cruciform and each of which is formed on its periphery with a groove or channel 25 inclined towards the axis of rotation 24 of the wheel along the generatrix of an inverted cone.

The axis of rotation 24 is mounted at its front end in the seating 8′ by means of a spring shock absorbing fitting 26 and, at the other end, in the base 8 to which it is fixed by a nut 27. This inner end of the spindle 24 terminates in a striker 28, intended to cooperate with a cap or cup 29 carrying a pellet of fulminate 30 in order to ignite the charge by percussion, when the projectile strikes an obstacle. The cap 29 is held in place by two balls 31 interposed between the nut 27 and the cup. These balls are located in a compartment communicating with a passage 32, the opening of which is closed by a safety spring 33 intended to surround, by inertia, on discharge, the cap 29. Due to this fact, the opening of the passage 32 is uncovered so that the balls 31 may leave their seating by the passage 32, under the action of centrifugal force as soon as the projectile receives a tangential acceleration. Then, the cap 29 will be able to move forward by inertia so that the pellet 30 strikes the point 28 to produce ignition of the charge, the pellet 30 communicating with the detonating chamber 34 which communicates in turn by an orifice 34′ provided in a diaphragm 35 with a flame passage connected to the explosion chamber of the charge.

The cap 29 may be locked externally of the projectile by means of a locking rod 36 comprising a screw-threaded head 36′ which can be turned by means of a screw driver to advance or retract the rod 36.

The driving wheel 23 is encased and can rotate freely by its blades in a paraboloidal recess 37 in the base 8. On the paraboloidal wall of the recess 37 is a grooved helicoidal race or track 38 of progressive radius developing from the inner end to the outer end of the recess on a regular pitch. On this helicoidal race or track are disposed four balls 39 offset by 90° from one another and each of which is freely engaged in one of the channels 25 of the driving wheel 23. The outer end of the helicoidal race or track 38 communicates by a lateral opening 40 with a recess 41 inclined to the plane of rotation of the projectile and allowing passage to one of the balls 39. In the bottom of the recess 41 is disposed a striker 42 intended to strike a fulminate percussion pellet 43 communicating with the detonating chamber 34 by a flame passage 44. The striker 42 (Figs. 1 and 7) is normally held by a cylindrical locking member 45 connected by means of a rod 46 to a head 47. This locking member is held in the bottom of its recess by a recoil spring 48 located between the head 47 and a plug 49. In this position of the striker 42, the head 47 of the locking member engages in a notch in the striker in such manner that the latter is held locked; but as soon as the locking member 45 is projected forwards due to inertia, against the spring 48 and under the action of tangential acceleration of the projectile, the head 47 disengages the notch in the stricker releasing the latter.

The driving wheel 23 is held to the seating 8′ normally i. e. before discharge of the shot, by means of two locking pins 50, 51 or the like constituting two movable bolts, one 50 of which is disposed parallel to the axis of rotation of the projectile, while the other 51 is disposed radially. The locking pin 50 is held engaged in an opening in the seating 8′ by a deformable metal wire 52 in such manner that the locking pin may be released from the seating 8′ and moved rearwards, by inertia, breaking the wire 52, under the action of the axial acceleration of the projectile on explosion of the charge. The locking pin 51, in turn, is moved outwards by inertia and is lodged in a recess 51′ under the action of centrifugal force as soon as the projectile is given a tangential acceleration. Displacement of the locking pins or the like 50, 51 ensures that the driving wheel 23 is released from the seating 8′. The latter, with the ogive 9, may turn on the base 8 which is provided for this purpose with a circular guide groove 53 in which a pin 54 fixed to the seating 8′ is engaged and [illegible]

row 60 marked on the base 8 of the head, may be indicated by the indicator. The latter, the construction of which is usual, will be arranged in the base 8 and its indicating member will be visible through an opening formed in the base 8. It may have a stop member against which the pin 54 will abut after a definite number of turns of the seating 8′, in order to limit the direct rotary movement of the latter.

The inner edge of the groove 53 forms a sharp corner on which abut three recesses 55, located in the seating 8′. In each of these recesses is fitted, by its rod, a locking pin 56, the truncated head of which permits the ogive 9 to be screwed on the seating 8′. The stem of the pin 56 is bevelled at its end and carries a flange 58 of soft metal disposed in a lateral notch 59 in the seating 8′. This flange of U-form engages with its limbs in two corresponding notches of the stem of the locking pin; it is held in place by the ogive 9. The flange 58 holds the pin, but at the moment of discharge of the gun, the pin 56, due to inertia, deforms the corresponding flange 58 and is forced to the bottom of the recess 55 so that the bevelled end of the pin is forced onto the sharp inner corner of the groove 53 to lock the seating 8′ on the base 8 of the head.

On the periphery of the seating 8′ is marked, opposite the indicating arrow 60, a scale 57, the divisions of which indicate seconds and fractions of a second. They may, however, also indicate a unit of length, for example, metres, decametres, hectometres, etc.

The balance wheel 16 is disposed in a recess in the seating 8′ and has at the ends of each of its arms a notch 61, in which is engaged a ball 62 located at the entrance to a lateral passage 63 in the recess serving as a seating for the balance wheel. These passages are diametrically opposed to one another in relation to the centre of rotation of the balance wheel and extend apart in a slight curve from the field of gyration of the balance wheel. Before the shot is fired the balance wheel is locked by two locking pins 64 disposed on opposite sides of the balance wheel and the operation of which is the same as that of the locking pin 50, i. e. these pins 64 are forced by inertia on firing, into their corresponding recess in the seating 8′, under the action of the axial acceleration of the projectile, so that the balance wheel is released. Immediately the balls 62 are brought under the action of centrifugal force to the end of their passage 63 imparting an impulse to the balance wheel.

In the base 8 of the head is mounted a locking rod 65 having a screw threaded head 66 engaging in a screw-threaded hole in the base 8. This pin, when screwed to the bottom, is brought either between the wings 25 of the driving wheel 23 or against one of the balls 39 in order to lock the driving device of the timing mechanism.

The fuse described has a dual purpose, that is to say, the projectile may be used as a contact shell, for a timed shell or for both combined. The operation is as follows:—

For use of the projectile as a contact projectile, the driving wheel 23 is locked by the rod 65, while the cap 29 is released by means of the rod cussion system 28, 30 is released by the fact that the safety spring encloses by inertia the pin 29 and the balls 31 are released from their seats and pass into the passage 32 under the action of centrifugal force, as soon as the projectile receives a tangential acceleration. When the projectile strikes the obstacle, the cap 29 is forced forward by inertia so that the striker 28 acts on the percussion charge 30 and produces the explosion of the charge of the projectile.

For timed firing where the projectile is to explode at a definite moment, explosion of the projectile is caused by the percussion system 42, 43 controlled by the timing mechanism. In this event, the percussion system 28, 30 may or may not be locked; if the latter is not locked, the projectile is double acting, i. e. acts as a time and a contact projectile. The interval of time elapsing between the discharge and the explosion of the projectile may be regulated precisely by means of the timing mechanism formed by a clockwork movement, the train of gearing of which and the frequency of vibrations of the balance wheel which are suited to the large initial velocities of modern artillery projectiles. For this purpose, the seating 8' may be turned with the ogive in relation to the base 8 of the head. The angular displacement of the seating 8' may be noted by means of the scale 57 and the arrow 60. The driving wheel 23 of the clockwork movement being connected with the seating 8' by means of locking pins 50, 51, it participates in the movement of rotation of the seating 8', as a result of which the blades or wings 25 carry with them the balls 39 over their helicoidal track 38 into a definite position in relation to the lateral opening 40. This reciprocal position of the balls on the one hand and of the orifice, on the other, determines the path which the balls will have to traverse over their helicoidal track during the interval of time elapsing between the discharge and the bursting of the projectile. This path is, on the other hand, proportional to the length of the trajectory of the projectile up to the point of explosion of the latter. It is evident that only the ball nearest to the orifice 40 is adapted to operate on the striker 42, the other balls of the driving system being provided only for balancing purposes.

At the moment of discharge, the pin 50 is lowered by inertia into its seat, under the action of the axial acceleration of the projectile. The same applies to the three locking pins 56, which, by deforming their flange 58, are driven to the bottom of their recesses 55 and are forced on the corner of the groove 53 to lock the seating 8' on the base 8 of the head of the projectile.

When the projectile has left the mouth of the gun and the axial acceleration is terminated, the tangential acceleration of the projectile ensures that the locking pin or pins 51, (since several may be provided), are thrown to the bottom of their seatings 51', as a result of which the driving wheel is released from the seating 8' forming the support for the clockwork movement. The same remark applies to the locking pin 45 which by inertia is thrown outwards against the action of the recoil spring 46, so that the striker 42 is released. Finally, the two balls 62, always under the action of centrifugal force, roll towards the bottom of their respective passages 63, imparting an impulse to the balance wheel 16 which is set in oscillation under the action of the regulating spring 13. The oscillations of the balance wheel and, consequently, the operation of the clockwork movement, are then maintained by the driving action of the balls 39 on the blade wheel 23. The balls 39 subjected to the action of centrifugal force are displaced on their helicoidal track 38 of increasing radius and rotate the driving wheel 23 which, in turn, drives through the toothed crown 22 the time pinion 21, the wheels the escapement and the balance wheel of the clockwork movement. When the most advanced ball 39 reaches the orifice 40, it is projected under the action of centrifugal force to the bottom of the recess 41 and strikes the striker 42, which ignites the percussion pellet 43 and, consequently, produces the explosion of the charge of the projectile. The orifice 40 could be closed by a flexible diaphragm to prevent the ball from prematurely entering the opening. The ball will pass through the inlet of the recess when it is subjected to centrifugal force.

It is to be understood that the driving device which has just been described is given solely by way of example and its construction may differ from the form illustrated. Thus the device might have only one driving ball. The pitch or the inclination of the helicoidal track for the balls could be regular or irregular and more or less rapid. Finally, the track could be formed on the surface of a conical or substantially conical recess, but always on a helicoidal line of progressive radius.

I claim:

1. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism, including a helicoidal track within the projectile, a body movable along said track under the action of centrifugal force on discharge of the projectile, said body being regulatable as to its initial position on said track, means for driving the timing mechanism, said driving means adapted to be driven by the movement of said body on said track, a passage leading from said track for the escape of said body from said track, a percussion fuse and a striker for operating said percussion fuse, said striker extending into said passage and adapted to be operated by said body escaping into said passage.

2. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism including a helicoidal track within the projectile, said track having a progressive radius, a ball movable along said track under the action of centrifugal force on discharge of the projectile, said ball being regulatable as to its initial position on said track, means for driving the timing mechanism, said driving means adapted to be driven by the movement of said ball on said track, a passage leading from said track for the escape of said ball from said track, a percussion fuse and a striker for operating said percussion fuse, said striker extending into said passage and adapted to be operated by said ball.

3. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism, said timing mechanism including a train of wheels, an escapement and a regulating means including a balance wheel and a torsion spring, a helicoidal track within the projectile, a ball movable along said track under the action of centrifugal force produced on discharge of the projectile, said ball being regulatable as to its initial position on said track, means for driving the timing mechanism, said driving means adapt-

ed to be driven by the movement of said ball on said track, a passage leading from said track for the escape of said ball from said track, a percussion fuse and a striker for operating said percussion fuse, said striker extending into said passage and adapted to be operated by said ball.

4. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism, a helicoidal track within the projectile, a plurality of balls movable along said track under the action of centrifugal force on discharge of the projectile, the initial position of said balls on said track being regulatable, means for driving the timing mechanism, said driving means including a rotatable member formed with channels engageable by said balls whereby said rotatable member is rotated by the movement of said balls in said track, a passage leading from said track for the escape of one of said balls from said track, a percussion fuse and a striker for operating said fuse, said striker having a portion extending into said passage and adapted to be operated by said ball in said passage.

5. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism, said timing mechanism supported on the ogive of the projectile, said ogive normally rotatable on but adapted to be locked to the body of the projectile on discharge by locking means, said locking means including locking pins movable into locking position due to axial acceleration of the projectile, a helicoidal track within the projectile, a plurality of balls movable along said track under the action of centrifugal force produced on discharge of the projectile, the initial position of said balls on said track being regulatable, means for driving the timing mechanism, said driving means consisting of a spindle disposed axially of the projectile and a rotatable member mounted loosely on said spindle, said rotatable member formed with channels engageable by said balls and driven thereby, a passage leading from said track for the escape of one of said balls from said track, a percussion fuse and a striker for operating said fuse, said striker having a portion extending into said passage and adapted to be operated by said ball in said passage.

6. A mechanical fuse for an artillery projectile comprising a timing mechanism and a striking mechanism controlled by said timing mechanism, said mechanism including a helicoidal track within the projectile, a plurality of balls movable along said track under the action of centrifugal force produced on discharge of the projectile, means for driving the timing mechanism, said driving means consisting of a rotatable member formed with channels engageable by said balls and driven thereby, means for holding said rotatable member against rotation before discharge of the projectile, said means comprising locking pins releasable on discharge of the projectile by the axial and tangential acceleration imparted to the projectile by the propelling charge, a passage leading from said track for the escape of at least one of said balls from said track, a percussion fuse and a striker for operating said fuse, said striker having a portion extending into said passage and adapted to be operated by said ball.

CARLO ARAGONE.

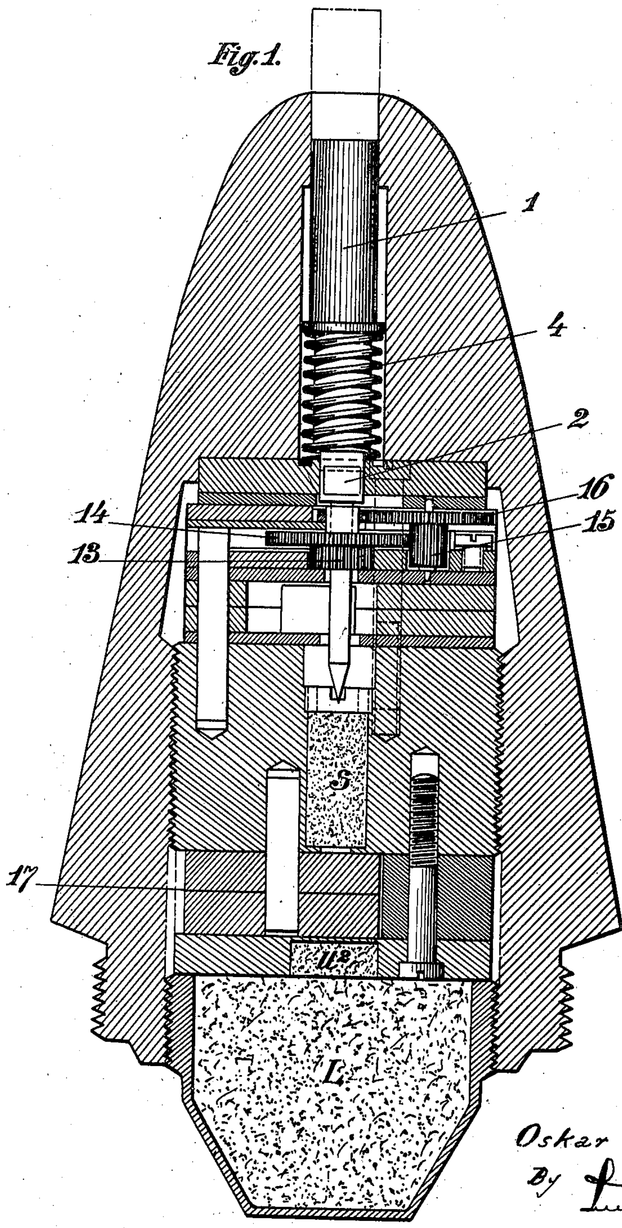
April 10, 1928. 1,665,666

O. JUNGHANS

PERCUSSION FUSE

Filed Oct. 7, 1926 2 Sheets-Sheet 1

Fig. 1.



Inventor:

Oskar Junghans

By [signature]

Attorney

April 10, 1928. **1,665,666**

O. JUNGHANS

PERCUSSION FUSE

Filed Oct. 7, 1926 2 Sheets-Sheet 2

Fig. 2.

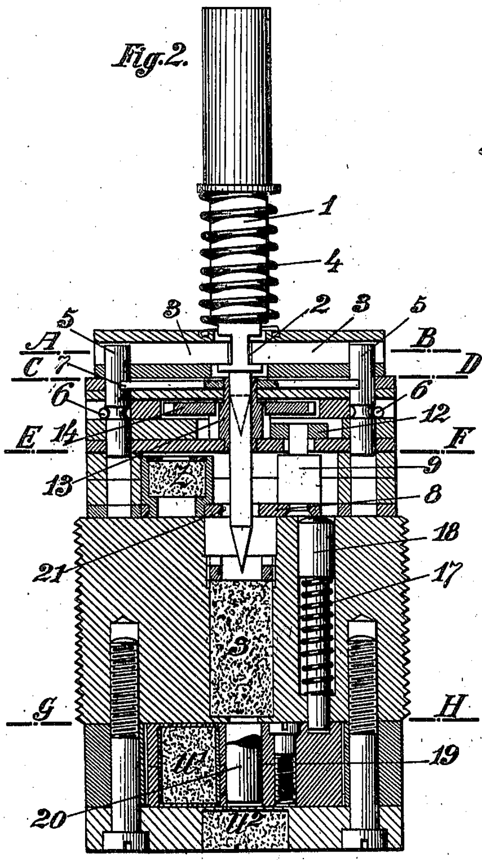


Fig. 3.

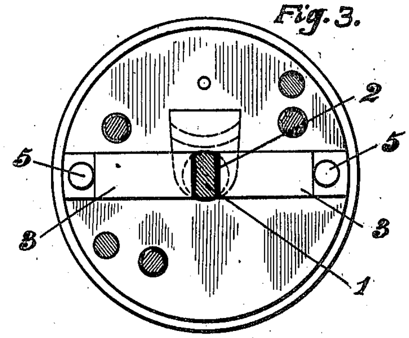


Fig. 4.

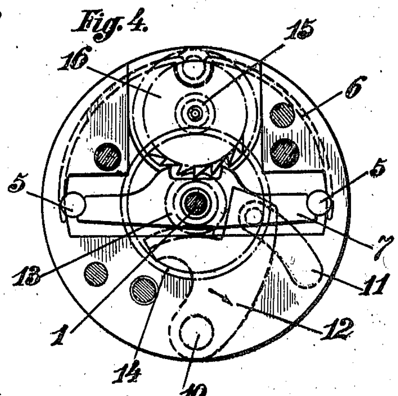


Fig. 5.

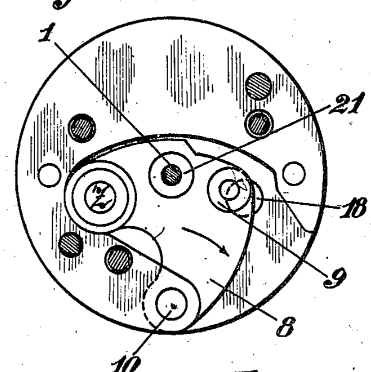
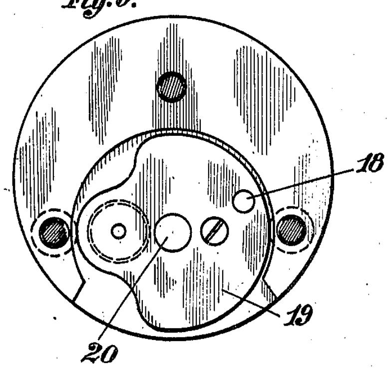


Fig. 6.



Inventor:

Oskar Junghans

By [signature]

Attorney

Patented Apr. 10, 1928. **1,665,666**

UNITED STATES PATENT OFFICE.

OSKAR JUNGHANS, OF SCHRAMBERG, GERMANY; SIEGFRIED JUNGHANS ADMINISTRATOR OF SAID OSKAR JUNGHANS, DECEASED.

PERCUSSION FUSE.

Application filed October 7, 1926, Serial No. 140,106, and in Germany May 21, 1926.

My invention relates to percussion fuses and more particularly to that sort of fuses in which the igniting or percussion pin normally is located entirely within the casing so as to be concealed and out of sight but is removed from such position so as to project from the top face of the fuse, upon firing.

The object of my invention is to provide a percussion fuse of the stated type with a safety mechanism adapted to act in a most reliable manner so that there will be no danger or risk of ignition at the transport or handling or in the gun upon firing.

With this object in view the safety mechanism of the fuse is constructed and arranged, according to the invention, in a manner that both the usual percussion cap and the igniting charge or body employed for transmitting the explosion of the said cap to the explosive charge of the projectile are held in a safe position and prevented from occupying the firing position upon firing of the gun or ordnance, until a certain period of time controlled by a clockwork, will have elapsed.

With the above recited object in view, reference is had to the following specification and drawings in which there is exhibited one example or embodiment of the invention which is in no way intended as a limitation upon the scope of the appended claims as it is to be clearly understood that variations and modifications which fairly fall within the true scope of said claims may be resorted to when found expedient.

In the accompanying drawings forming a part of this specification wherein like characters designate like parts throughout the several views:

Figure 1 is a longitudinal central section of the fuse with the improved safety device;

Figure 2 is a similar section but displaced for 90° and with the outer casing removed;

Figures 3 to 6 are cross-sections taken on the lines A—B, C—D, E—F and G—H, respectively.

The igniting or percussion pin 1 is axially mounted in the top end of the fuse in the usual manner, that is so as to be displaceable lengthwise therein. The upper part of the pin is preferably made of a suitable light metal whilst the lower part thereof forming the striking point, is made of steel and provided with two diametrically opposed recesses 2 for the reception of two sliding bars 3 which normally, that is prior to firing and subsequent impact, engage in said recesses so as to lock the pin and hold the same in safe position, as clearly shown in Figures 2 and 3. In this locked position of the pin 1 the spring 4 encircling the same and abutting against a collar of the pin is under tension, while the two sliding bars 3 are in turn locked by two lengthwise displaceable vertical rods 5 having each an annular recess for the accommodation of the two ends of a yoked spring 6 which thus acts to hold the two rods 5 in their locking positions, as will be seen in Figures 2 and 4. Engaged with the two bolts 5 are the ends of the balance 7 of a clockwork so that the bolts are properly arrested and prevented from accidental movement.

I desire to have it understood that the particular mechanism which I have described thus far, for the purpose of locking the percussion pin, is simply one which has commended itself to me, but which is not at all necessary, since other locking means may be used in lieu thereof.

The percussion cap Z is mounted on a plate 8 supporting a fly-weight 9 and pivotally mounted so as to be capable of rotation about the pivot 10. The fly-weight 9 is elongated to form a stud engaging, through a segmental slot 11 of an intermediate plate of the fuse body, in a toothed sector 12 which is likewise pivotally mounted on the pin or pivot 10. The said toothed sector 12 is positively connected with the balance 7 by means of a train of wheels comprising a pinion 13, a spur gear 14, a pinion 15 and a balance wheel 16, so as to be controlled by the latter, the balance 7 being mounted on the upper journal of the pinion 13 and capable of oscillating thereabout.

In the position of the movable parts of the fuse shown in the drawings, the percussion pin 1 is locked by the sliding bars 3 with its lower end extending through an axial bore of the pinion 13 and centrally through an aperture 21 of the plate 8, see Fig. 5, which aperture is spaced from the axis of the pivot 10 the same distance as the percussion cap Z mounted in the plate 8 or in other words, the centres of the aperture 21 and of the cap Z lie in the same arc of a circle described about the axis of the pin 10 so that when the axis of the pin 1 coincides with the centre of the aperture 21 as shown in the drawings, the percussion cap Z necessarily must occupy a position laterally or out of the path of the pin 1 as will be readily understood on inspection of Figure 2.

The plate 8 is in contact with the head of a locking pin 18 controlled by a spring 17 coiled about the lower end thereof, and engaging with its lower extremity in a bore of a disc-shaped heavy plate 19 mounted on a pin 20 so as to be revoluble thereabout. The plate or disc 19 carries an explosive body U^1 for transmitting ignition from the cap Z and the igniting charge S to the explosive charge of the projectile. As will be seen the movable igniting body U^1 normally lies eccentrically displaced with relation to the axis of the fuse or the pin 1 or, in other words, in staggered relationship to the upper portion S of the igniting charge and the lower portion U^2, see Figure 2, the two igniting explosive bodies S and U^2 being stationary and occupying a central position in axial alinement with the pin 1.

It will be seen that in the described arrangement the igniting charge of the fuse is divided to comprise three portions S, U^1 and U^2 and is normally interrupted inasmuch as the portion U^1 thereof is eccentrically displaced therefrom and the heavy body of the plate 19 is interposed between the portions S and U^2 of the igniting charge in substitution for the intermediate portion U^1 thereof, with the result that should ignition of the main ignition charge S occur accidentally in manipulating the projectile, on transport or untimely upon firing, there will be no danger of an explosion of the projectile since the ignition will remain limited to the charge S and cannot be transmitted to the explosive charge of the projectile, as there is no communication between the explosive bodies S and U^2.

The clockwork obtains its motive power by the retarding effect of the rotor 8.

The operation of the safety mechanism in the fuse is as follows:

Upon firing the two axially displaceable locking rods 5 will fly back owing to shock action, so that the two sliding bars 3 and the balance 7 of the clockwork are unlocked. Due to centrifugal action evolved by the rotation of the projectile, the two sliding bars 3 then slide radially outwards and away from the pin 1 which thus will be free to fly forwards under the action of the spring 4 to occupy the impact position indicated in dot-and-dash lines in Figure 1. At the same time the weighted plate 8 carrying the percussion cap Z is released and caused by centrifugal action to turn about the pivot 10 in the direction of the arrow depicted in Figure 5, but the rotation of the plate 8 is retarded by the mentioned clockwork so that the cap Z will not at once be brought to the igniting position or in coaxial alinement with the pin 1 but after a predetermined length of time depending upon the adjustation of the clockwork. Simultaneously therewith the aperture 21 of the plate 8 through which the pin 1 projected prior to its movement into the impact position, will occupy a position over and above the top of the locking pin 18 so that the latter can rise under the pressure of its spring 17 and thereby be disengaged from the disc-shaped heavy plate 19. The thus liberated plate or disc 19 then will be free to turn about its pivot 20 due to centrifugal action, to occupy a position in which the igniting body U^1 will be in axial alinement with the pin and with the igniting bodies S and U^2 so as to form a uniting link between the two bodies S and U^2.

In this way the igniting charge of the fuse comprising the three portions or bodies S, U^1 and U^2 will form, upon the firing of a shot, an uninterrupted communication between the percussion cap Z and the main igniting charge L, see Figure 1, so that upon impact of the projectile the explosive charge of the latter will be ignited.

What I claim is:

1. A percussion fuse in which the percussion pin normally lies concealed within the casing of the fuse comprising a percussion cap, a divided igniting charge composed of a plurality of single explosive bodies which normally occupy safe positions so as not to communicate with each other, but which upon firing are permitted to communicate with each other for the purpose of igniting the explosive charge of the projectile, means for ensuring the safe and active positions of the said explosive bodies, forming the igniting charge, and means including a clockwork for retarding the interconnection of the said bodies to active position for a predetermined length of time after firing.

2. A percussion fuse in which the percussion pin normally lies concealed within the casing of the fuse, comprising a percussion cap, a divided igniting charge composed of a plurality of single explosive or igniting bodies, a plate carrying the said cap and adapted to rotate about a stationary pivot, an aperture in said plate for the percussion pin to normally engage therein, so that the percussion cap will occupy a lateral position out of the way of the said pin, a flyweight attached to the said plate, a clockwork operatively connected with the said plate through the agency of the said flyweight, a disc adapted to rotate about a stationary pivot and carrying one of the several igniting bodies and a spring-controlled locking pin adapted to normally lock the said disc with the igniting body thereon in safe or eccentric position, and to be arrested

in locking position by the said plate, the arrangement being such, that the said disc is prevented from rotation and from placing the igniting body thereon in central active position that is in axial alinement with the other igniting bodies until the cap has been previously moved to occupy such central active and alined position.

3. A percussion fuse comprising a casing; a percussion pin concealed within the casing; a plurality of single explosive bodies arranged in spaced relation in the casing, said bodies being in communication with each other so that upon firing the explosive charge will be ignited; and means including a clockwork for retarding the interconnection of the said bodies to activity for a predetermined length of time after firing.

In testimony whereof I affix my signature.

DR. OSKAR JUNGHANS.

United States Patent [19]

Berlin et al.

[11] **3,782,288**

[45] **Jan. 1, 1974**

[54] **REMOVABLE FIRING PIN ASSEMBLY MUNITION**

[75] Inventors: **Aaron S. Berlin,** Wilmington, Del.; **Vincent C. Little,** Fallston; **Toney Leadore,** Havre De Grace, both of Md.

[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

[22] Filed: **Dec. 21, 1971**

[21] Appl. No.: **210,422**

[52] **U.S. Cl.** **102/64**
[51] **Int. Cl.** **F42b 27/00**
[58] **Field of Search** 102/64, 65

[56] **References Cited**

UNITED STATES PATENTS

2,356,389 8/1944 Decker et al. 102/64

Primary Examiner—Verlin R. Pendegrass
Attorney—Harry M. Saragovitz et al.

[57] **ABSTRACT**

A munition for delivery of a payload to an adverse target site wherein the munition has a firing pin assembly which separates from the munition after actuation of the primer means by the firing pin to prevent reuse of the firing pin assembly after delivery of the munition to the adverse target site.

3 Claims, 4 Drawing Figures

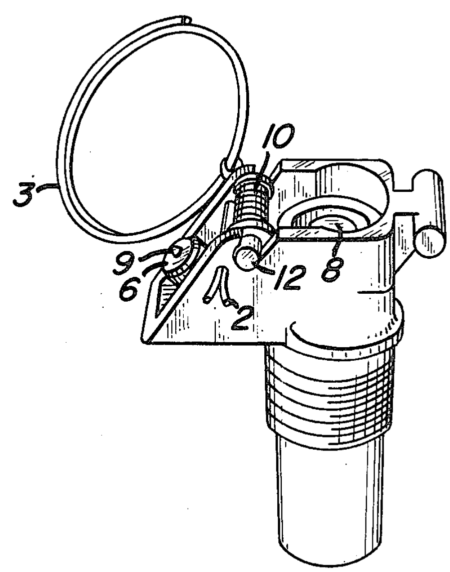


Fig.1 PRIOR ART

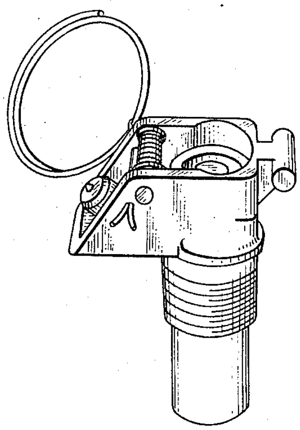


Fig.2

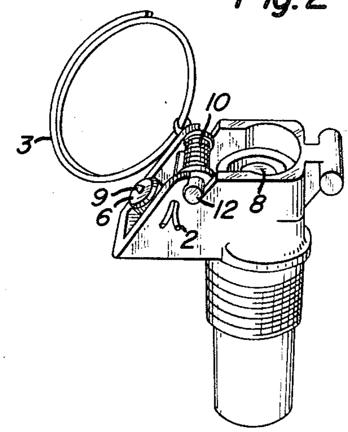


Fig.3

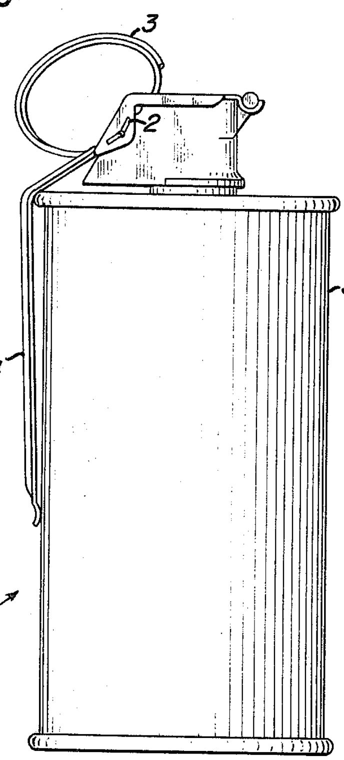
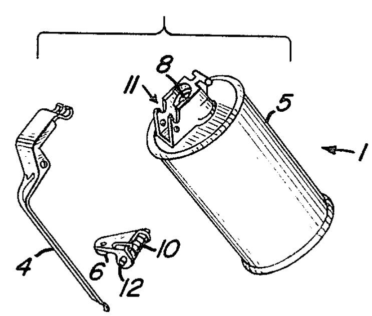


Fig.4



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BY Bernard J. Ohlendorf
ATTORNEYS

REMOVABLE FIRING PIN ASSEMBLY MUNITION

DEDICATORY CLAUSE

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to us of any royalty thereon.

Our invention relates to a new munition, such as a grenade, and method for delivering a payload to a target site; the payload being a material such as chemical agent composition, explosive composition, or incendiary composition.

Prior art munitions, such as grenades, utilized a fuze assembly wherein the fuze assembly remained intact and integral with the munition after the munition was delivered to the target site; such as the prior art munition disclosed in U. S. Pat. No. 3,434,421. The prior art munitions presented the problem that the fuze assembly could be removed from the munition at the adverse target site and reused in munitions by adverse interests. Our invention was conceived and reduced to practice to solve the foregoing problem and to satisfy the long felt need for a munition, such as a grenade, which can be delivered to an adverse target site without a firing pin assembly.

A principal object of our invention is to provide a munition, such as a grenade, and a method of delivery thereof wherein the firing pin assembly is automatically removed from the munition after the primer is activated by the firing pin; the munition being delivered to an adverse target site without the firing pin assembly.

Other objects of our invention will be obvious or will appear from the specification hereinafter set forth.

FIG. **1** is a view of the prior art firing pin and fuze head assembly.

FIG. **2** is a view of our inventive firing pin and fuze head assembly.

FIG. **3** is a view showing the utility of our invention in a munition.

FIG. **4** is an exploded view of the munition shown in FIG. **3.**

Our invention, as shown in FIGS. **2** to **4,** will now be described in detail as follows. The invention will be described in terms of a hand thrown grenade, as shown in the drawing, but it is to be understood by those of skill in the art that our inventive concept is applicable to any munition delivered to a target site by any suitable launching means.

When it is desired to prepare to deliver the munition shown at **1** in FIG. **3** to a target site, safety pin **2** is removed by pulling pull ring **3** fixedly connected to safety pin **2** while holding safety lever **4** against the grenade container **5**; safety lever **4** serving to hold firing pin assembly **6** under tension and to prevent the acuation of primer means **8** by striker point **9** of the firing pin assembly. When it is desired to deliver the munition to a target site, the grenade is hand thrown toward the target site which permits tension imparted by torsion spring **10** to cause firing pin assembly **6** to rotate in a clockwise direction to the point where striker point **9** activates primer means **8**; the rotation of the firing pin assembly causing safety lever **4** to be ejected from the munition. Upon striker point **9** striking primer means **8,** the impact force produced by the striking causes pin **12** integral with firing pin assembly **6** to be ejected from the notch shown at **11** and the firing pin assembly to thereby be removed from the munition. After striker point **9** activates primer means **8,** the fuze and payload, not described herein and not a part of our invention, is activated in the conventional manner, as described in U. S. Pat. No. 3434421. Any conventional payload can be used with our invention; such as chemical agent composition, explosive composition, or incendiary composition.

It is obvious that other modifications can be made of our invention, and we desire to be limited only by the scope of the appended claims.

We claim:

1. In an improved munition for delivering a payload to a target site comprising a container means to contain the payload, a fuse means having a fuse head assembly and being permanently affixed and mounted within the container means to activate the payload, a primer means to activate the fuse means juxtaposed adjacent thereto, and a spring actuated firing pin assembly means rotatably mounted on pin means and said pin assembly means having a striker point means to activate the primer means, the improvement in combination therewith being an ejection mounting means to permit ejection of the firing pin assembly at said pin means from the munition after activation of the primer means by the strikes point means and prior to delivery of the munition to the target site.

2. The munition of claim **1** wherein the payload is a material selected from the group of materials consisting of a chemical composition, an explosive composition, and an incendiary composition.

3. The munition of claim **1** wherein the ejection mounting means is a notch formed in the upper surface of the fuse head assembly, said notch being adapted to receive said pins means integral with the said firing pin assembly and to permit ejection of the pin means from the notch by the impact force of the striker point means striking the primer means.

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FUZE FOR DEPTH CHARGE

Filed Dec. 5, 1952

5 Sheets-Sheet 1

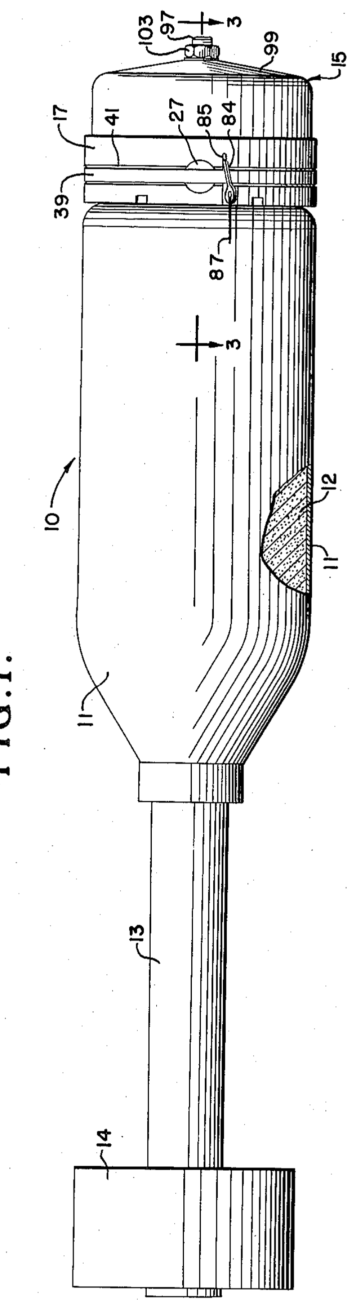

FIG.1.

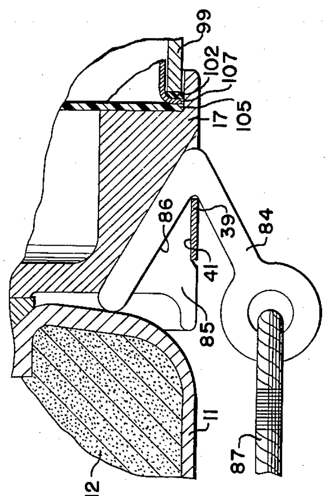

FIG.9.

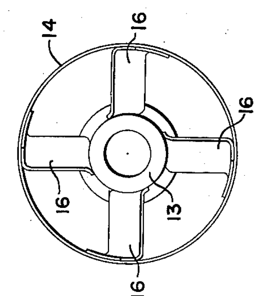

FIG.2.

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FUZE FOR DEPTH CHARGE

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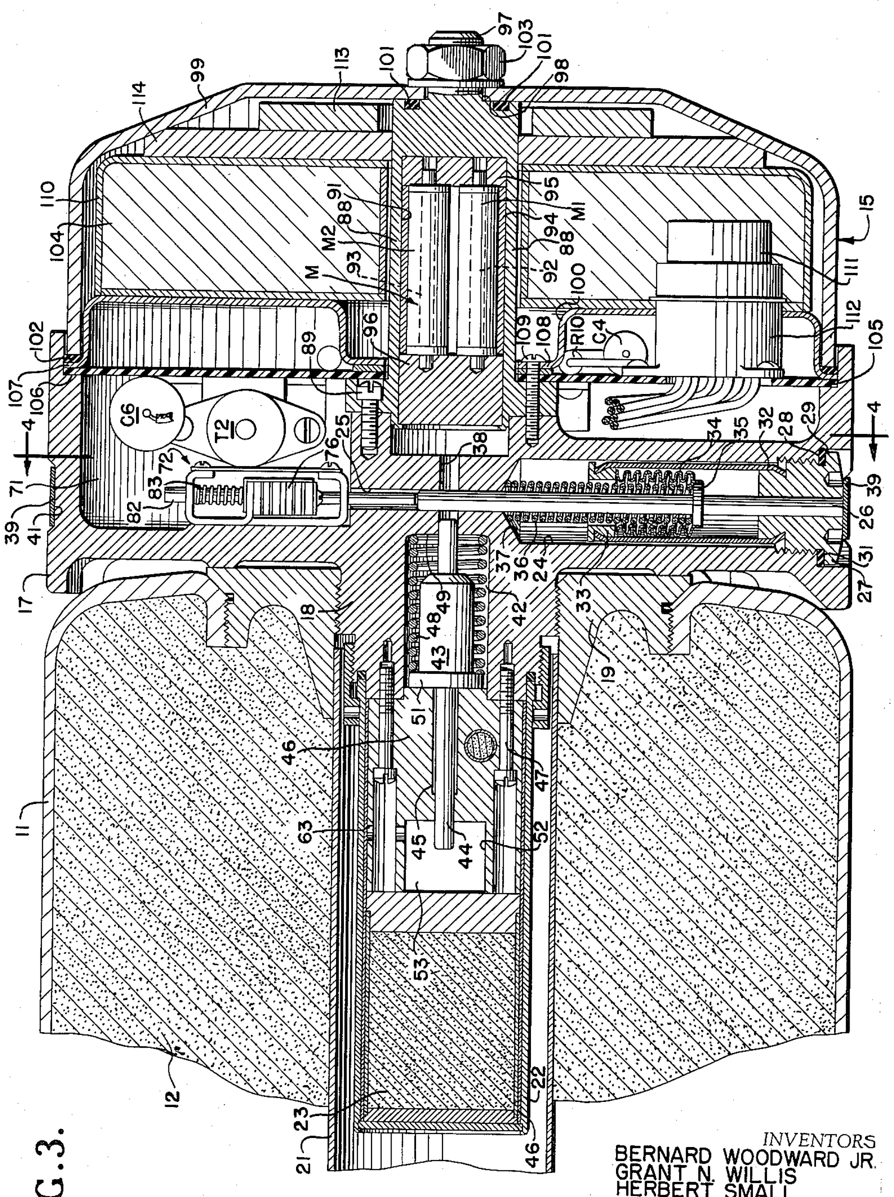

FIG. 3.

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FIG. 4.

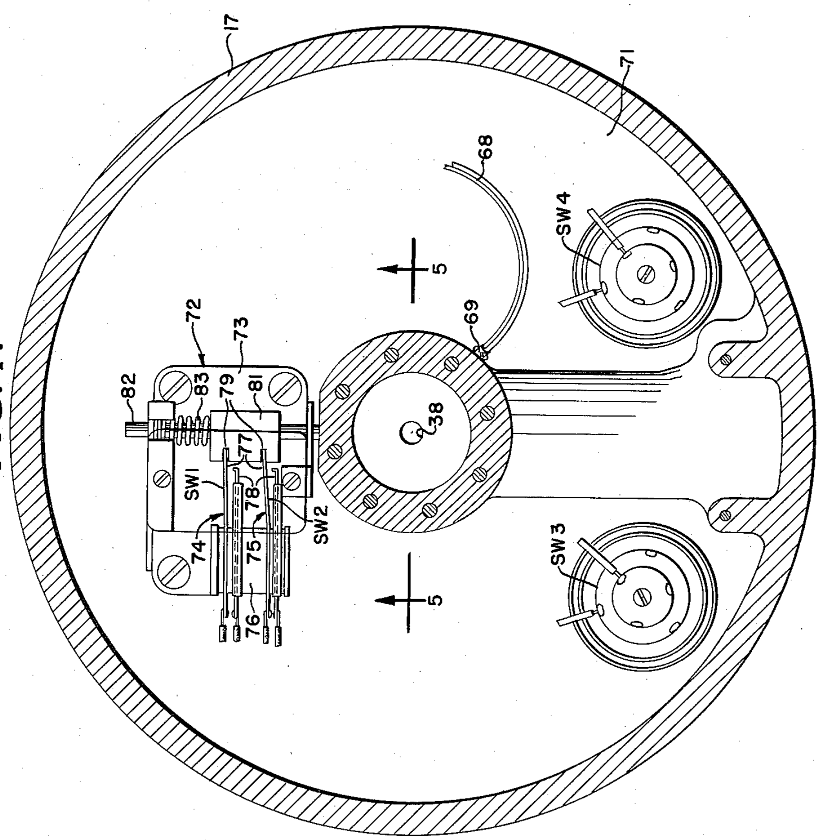

FIG. 6.

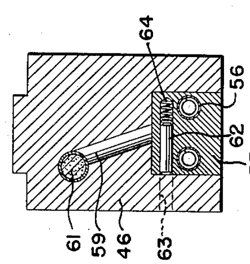

FIG. 7.

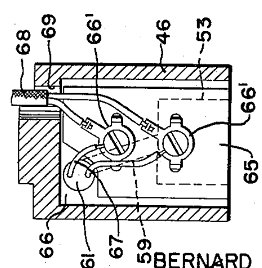

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FIG.10.

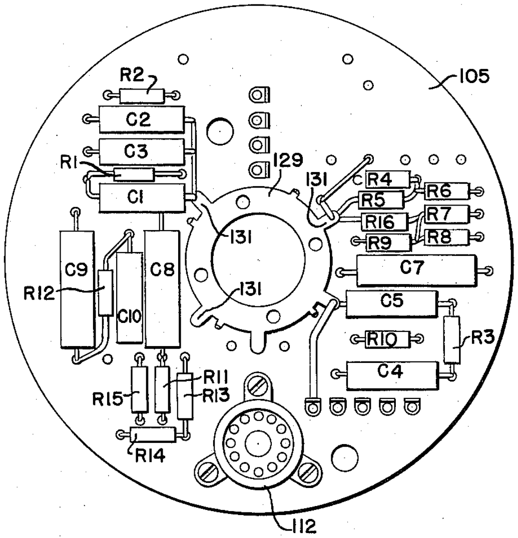


FIG.5.

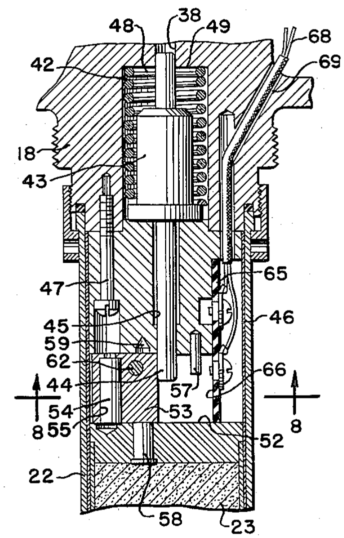


FIG.11.

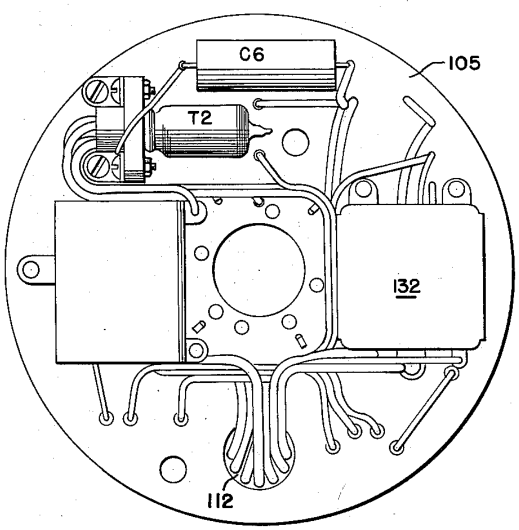
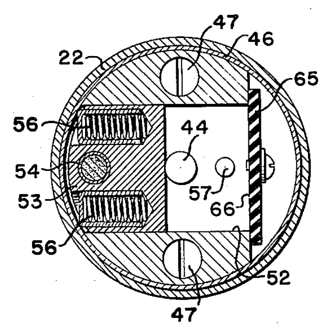


FIG.8.



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FUZE FOR DEPTH CHARGE

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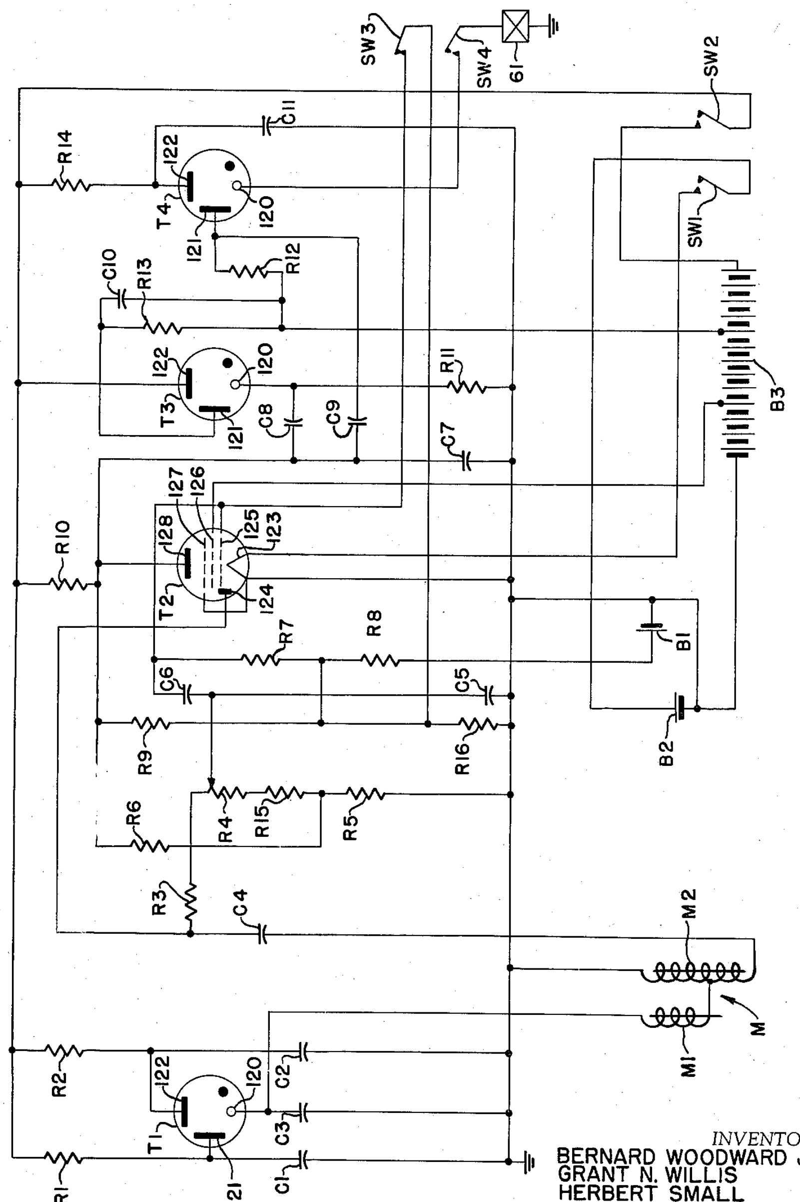
FIG. 12.



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FUZE FOR DEPTH CHARGE

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Filed Dec. 5, 1952, Ser. No. 324,428

4 Claims. (Cl. 102—7)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a magnetically influenced fuze for a depth charge. More particularly, the invention relates to a fuze mechanism having a magnetically influenced firing circuit for an ahead-thrown rocket propelled projectile containing a depth charge.

The depth charge device for which the mechanism and circuit of the present invention is employed is of the type launched from a vessel, is propelled during the forward travel thereof by a rocket motor and is armed by a plurality of devices which operate at appropriate times during the travel of the device, the warm-up of the electrical circuit being initiated as the device is launched, the detonator of the firing train of the fuze being mechanically alined with the primer and lead-in thereof as the device strikes the surface of a body of water, and the primer being connected to arm the firing circuit in time-delayed relation to entry of the device into a body of water when the device reaches a state of stable downward travel in the body of water. A magnetometer coil assembly is employed to detect changes in the earth's magnetic field as the device approaches a target formed of magnetic material such, for example, as a submarine which causes operation of the firing circuit to ignite the primer, thus firing the detonator, the lead-in, the booster charge and finally the main charge of the depth charge. The aforementioned delayed arming of the firing circuit is provided to prevent premature firing of the depth charge during the period of instability immediately following entry of the device into the body of water, such premature firing being caused by the angular variations of the magnetometer coils with respect to the earth's magnetic field, thus causing spurious signals to be picked up thereby sufficient to operate the firing circuit.

An object of the device of the present invention is to provide a new and improved magnetically influenced depth charge device having safety features which prevent firing thereof by spurious magnetic signals.

Another object is to provide a new and improved magnetically influenced depth charge device having a magnetometer detector which is highly efficient in detecting anomalies in the earth's magnetic field.

Still another object is to provide a new and improved detecting, amplifying, and firing circuit for a depth charge which is dependable, has low current consumption, and high efficiency in detecting anomalies of the earth's magnetic field.

A further object is to provide a fuze for a depth charge which combines novel mechanical and electrical elements to produce a depth charge device which meets service conditions with safety and efficient operation.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a side elevational view of the device of the present invention attached to the nose of a rocket-propelled depth charge device;

Fig. 2 is an end elevation of the fin portion of the depth charge device;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 4;

Fig. 6 is a sectional view showing the locking detent for the detonator holder;

Fig. 7 is a sectional view showing the connector block for the primer leads;

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 5;

Fig. 9 is a detail sectional view of a portion of the mechanism casing and showing the cutting tool and lanyard therefor;

Fig. 10 is a detail elevation of the mounting plate with circuit components mounted thereon and showing one side thereof;

Fig. 11 is a detail elevation of the other side of the mounting plate with other circuit components mounted thereon; and

Fig. 12 is a diagram of the pulse oscillating, detecting, amplifying, and firing circuits employed in the present invention.

Referring more particularly to the Fig. 1 of the drawings a rocket-propelled depth charge is indicated generally at **10** and has a casing **11** containing a main explosive charge **12**, a rocket motor **13** extending rearwardly therefrom, and a tail fin assembly **14** mounted adjacent the end of motor **13**. Mounted on the nose of casing **11** is a magnetic influence firing mechanism indicated generally at **15**.

The fins **16** of assembly **13** are mounted at an angle in order to impart a spinning motion to the depth charge **10**.

Mechanism **15** is enclosed in a mechanism casing **17** having a threaded extension **18** which is threaded into adapter **19** of casing **11**. Tubular casing **21** is fixed to adapter **19** and extends within the main charge **12**. Mounted on extension **18** of member **17** is a booster charge housing **22** containing booster charge **23**.

A transverse bore **24** having a reduced extension **25** is formed in casing **17** and receives pin **26**. A plug **27** having an axial bore is screwed into the outer end of bore **24** and forms an outer support for pin **26**. Bore **24** is enlarged to form shoulder **28** and plug **27** has a head forming a shoulder **29**, gasket **31** being interposed between shoulder **28** and **29** to form a watertight joint at the periphery of plug **27**. A tubular member **32** is mounted on the inner end of plug **27** and extends inwardly in bore **24**. A ring **33** is mounted in the end of member **32** and has secured thereto and extending within member **32** a metallic bellows **34**. Bellows **34**, at the other end thereof is secured to a flange **35** of pin **26**. Thus a positive watertight seal is formed between pin **26** and plug **27** which permits endwise movement of pin **26**. An expansion spring **36** is mounted around pin **26** between flange **35** and a shoulder **37** defined by reduced extension **25** of bore **24** thus urging pin **26** outwardly of casing **17**.

Casing **17** is provided with an axial bore **38** which intersects bore extension **25**, pin **26** normally extending across and slightly beyond bore **38** thus closing off the bore. Pin **26** is retained in the aforementioned position by a metal strap **39** recessed in groove **41** around the periphery of casing **17**. Axial bore **38** is enlarged to form a chamber **42** which accommodates an inertia weight **43** formed on shaft **44**. Shaft **44**, at one end thereof is mounted in axial bore **38** while the other end thereof is mounted in bore **45** of fuze casing **46**. Fuze casing **46** is secured to the end of extension **18** by screws **47** and is enclosed by booster housing **22**. A spring **48** is interposed between the wall **49** of chamber **42** and flange **51** of weight **43** to urge shaft **44** away from pin **26**.

A transverse guideway **52** is formed in casing **46** adjacent booster charge **23** and has slidably mounted therein a detonator holder **53** containing detonator **54** in bore **55** and having a pair of springs **56** urging the holder **53** in a direction toward fixed pin **57**. Shaft **44** normally extends out of bore **45** and into the path of holder **53** thus retaining detonator **54** in a safe position and out of alignment with lead-in **58** mounted in fuze casing **46** between guideway **52** and booster charge **23**. Shaft **44** also retains detonator **54** out of alignment with bore **59** which leads to electrically fired primer **61**. When holder **53** is released by shaft **44**, in a manner to be hereinafter more fully described, springs **56** move holder **53** into contact with fixed pin **57** which aligns detonator **53** with lead-in **58** and bore **59** thus arming the detonator. In the armed position a detent **62** mounted in holder **53** is forced into bore **63** in casing **47** by spring **64** thus locking the detonator **54**.

A connector block **65** of insulating material is mounted in recess **66** of fuze casing **46** and supports a pair of connectors **66'** thereon for leads **67** of electrical primer **61**. Leads **68** connect to lead **67** at connectors **66'** and extend through bore **69** in extension **18** into mechanism chamber **71** in casing **17**.

Mounted adjacent bore **25** is a switch assembly **72** which includes a frame member **73** on which is mounted a pair of switches **74** and **75** fixedly mounted at one end thereof and insulated from the frame **73** by insulator blocks **76**. Each of the switches comprises a movable member **77** and a substantially fixed member **78**.

The free ends of movable members **77** are set in notches **79** of insulator block **81**. Insulator block **81** is fixed to and movable with shaft **82** which is slideably mounted in frame **73**. Shaft **82** extends into bore **25** and is urged against the end of pin **26** by spring **83**. As aforesaid pin **26** is held in the initial safe position by strap **39**. In this position switches **74** and **75** are held in the open position. Switches **74** and **75** form a part of a circuit to be hereinafter more fully described.

A cutting tool **84** is mounted in slot **85** in casing **17** and has a cutting edge **86** which engages the strap **39**. One end of a lanyard **87** is attached to one end of tool **84**, the tool **84** severing the strap **39** as the depth charge is launched, the other end of the lanyard **87** being fixed to the vessel or launching device from which the depth charge is launched. When strap **39** is severed pin **26** moves outwardly of casing **17** under action of spring **36**, releasing shaft **82** which is moved by spring **83** thus causing movable members **77** of switches **74** and **75** to contact members **75** thereof thus closing the switches. In the closed position shaft **82** is stopped short of the bore **38** while pin **26** moves beyond bore **38** thus leaving bore **38** clear and permitting shaft **44** and inertia weight **43** to move to the armed position thereof on impact of the depth charge with the surface of the water. The detonator is thus moved to the armed position as will be hereinafter more fully described.

An axially mounted cylinder **88** is bolted to member **17** at **89**. Mounted within bore **91** of cylinder **88** is the magnetometer indicated generally at M. Magnetometer M comprises a pair of coils M1 and M2, provided with Permalloy cores **92** and **93** respectively. The magnetometer coils M1 and M2 are enclosed by a tubular non-magnetic casing **94** having end plates **95** and **96** which support the coils M1 and M2 and the cores **92** and **93** therefor. Cylinder **88** is provided with a threaded extension **97** which extends through bore **98** of cup-shaped housing **99**. Housing **99** is secured to cylinder **88** and drawn against sealing gasket **101** (adjacent bore **98**) and gasket **102** (at the periphery of **99**) by nut **103** which is threaded on extension **97**. Housing **99** encloses battery assembly **104** and the components of the circuit mounted on plate **105**. The components of the circuit mounted on one side of the plate **105** are additionally enclosed by a circular dished housing **100**, the outer flange **107** thereof being gripped between gasket **102** and plate **105**, while the inner flange **108** is secured to casing **17** by bolts **109**. Plate **105** which is formed of a suitable insulating material is interposed between flange **107** and shoulder **106** of casing **17**.

It is to be understood that casing **17**, casing **94**, housings **99** and **100** and as many as is practical of the elements, both mechanical and electrical, which make up the firing mechanism **15** are formed of non-magnetic materials suitable for the purpose such, for example, as aluminum, brass, bronze and plastic materials.

Battery assembly **104** is housed in casing **110** and comprises batteries B1, B2, and B3. Battery assembly **104** is provided with multiple connector plug **111** while a mating plug **112** is mounted on plate **105** for connection therewith, plugs **111** and **112** carrying leads from battery assembly **104** to the various circuit components mounted on plate **105**.

If desired the leading face of housing **99** may be reinforced with filler discs **113**, **114** against forces encountered when the surface of a body of water is struck thereby.

Referring to Fig. 10 plate **105** has a common ground ring **129** having tabs **131** to which ground wires of the circuit are attached, the ring **129** having positive connection with housing **100** thus establishing a ground connection with other major metallic portions of the device.

As shown in Fig. 11, it is desirable that all three glow tubes be shielded and T3 and T4 be illuminated by T1 in order to stabilize their firing voltages. Thus these tubes are placed in metallic enclosure **132** mounted on plate **105** with T1 between T3 and T4.

Referring particularly to the diagram of Fig. 12, preferably four tubes T1, T2, T3, and T4 are employed in the circuits of the present invention. Tubes T1, T3 and T4 are gas-filled glow tubes having a cold cathode **120**, starter anode **121**, and anode **122**. Tube T2 is a detector-amplifier of the diode-pentode type having a filament-cathode **123** and diode plate **124** comprising the diode or detector portion of the tube; filament-cathode **123**, control grid **125**, screen grid **126**, suppressor grid **127**, and plate **128** forming the pentode or amplifier portion of the tube. If desired, the detector and amplifier circuits may each have a separate tube individual thereto.

The pulse oscillating, detecting, amplifying and firing circuits for the device of the present invention are disclosed in Fig. 12 and comprise the pick-up magnetometer M which obtains the excitation thereof from a glow tube oscillator circuit including glow tube T1 and associated elements, the operation of the magnetometer depending on the magnetic saturating properties of the Permalloy cores **91** and **92** of the coils M1 and M2 when acted on by the pulse excitation of the oscillator circuit and the external magnetic field. The positive pulses from the magnetometer M operate a shunt diode circuit made up of the diode-detector portion of a diode-pentode tube T2 and associated elements. The rectified voltage produced by tube T2 is negative with respect to ground and varies from about 45 volts to about 60 volts as the field strength detected by the magnetometer M varies between -600 and $+600$ milligausses.

Changes in the diode output voltage are applied to the amplifier portion of tube T2 through coupling condenser C6. Condenser C6 is preferably of the mineral oil-filled type to ensure a negligible spurious signal (less than one volt) when grid switch SW3 opens as will be hereinafter more fully described. In order that the charge on condenser C6 will stabilize quickly to a value determined by the diode voltage produced by the undisturbed field along the axis of the magnetometer M, the amplifier grid resistor R7 is kept shorted by hydrostatic switch SW3 until the depth charge is armed by immersion in the water. The hydrostatic arming switches SW3 and SW4 are set to operate when the depth charge has reached a sufficient depth to be in substantially stable downward travel thus preventing the picking up of spurious signals by the magnetometer and the attendant operation of the firing circuit until a large ferromagnetic body such, for example, as a submarine is approached by the device of the present invention. The amplifier stage is capable of producing about three times the gain necessary so that a moderate amount of stabilizing voltage feedback is incorporated therein.

The firing circuit is of the single-look variety, that is, the primer **61** is fired when a signal of sufficient strength of either positive or negative polarity is received by the magnetometer. Glow tubes T3 and T4 and associated apparatus comprise the firing circuit, the nominal breakdown voltage of these tubes being, for example, 77 volts.

The starters **121** of T3 and T4 are battery biased, for example, to 58.5 volts, thus a nominal increase of starter-cathode voltage of 18.5 volts is required to fire these tubes. As is clear from an inspection of Fig. 12, a positive signal from the amplifier circuit increases the starter-cathode voltage of tube T4 and decreases the starter cathode voltage of tube T3. Conversely, a negative signal from the amplifier increases the starter-cathode voltage of tube T3. Thus, tube T4 is fired by a positive signal and tube T3 is fired by a negative signal. If tube T3 fires, the cathode **120** thereof jumps to a positive voltage which charges condensers C8 and C7 positively before the main gap between cathode **120** and anode **122** of T3 extinguishes due to lack of sufficient sustaining current. This applies sufficient positive voltage to the starter **121** of T4 to fire the tube. Thus tube T4 is fired directly on positive signals and through tube T3 on negative signals. When the main gap between cathode **120** and anode **122** of T4 breaks down, condenser C11 discharges therethrough and primer **61** is fired provided switch SW4 is closed. If detonator holder **53** has been moved to the armed position, detonator **54** will be ignited by the firing of primer **61** thus igniting lead-in **58**, firing booster charge **23** and the main charge **12**.

Referring in greater particularity to the diagram of Fig. **12**, the relaxation oscillator circuit comprising tube T1, condenser C1, C2 and C3 resistors R1 and R2 and the magnetometer M are to be considered together, as the magnetometer forms the load for the oscillator. The time constant of the starting gap resistor R1 and condenser C1 is considerably higher than the time constant of the main gap resistor R2 and condenser C2 which permits the main gap condenser to charge up nearly to the supply battery voltage before breakdown, thus causing the timing of the oscillator to depend on the starting gap breakdown and extinction voltages and the values of resistor R1 and condenser C1, but not on the values of R2 and C2. The amount of excitation energy supplied the magnetometer M during each pulse depends mainly on the voltage build-up in C2 and the capacity thereof. The resistance of R2 is made small so that C2 will charge to the maximum voltage before the main gap breaks down. R2 is, of course, of sufficient size to ensure operation of the oscillator tube. This circuit preferably provides a pulse rate of about 150 cycles per second.

In order to provide for a substantially constant sensitivity over the background range with the low excitation energy per cycle available, it is desirable that the load presented to the oscillator by the magnetometer M be made substantially constant. This is effected by employing in the circuit a pair of Permalloy core magnetometer coils M1 and M2 and connecting the magnetometer M across

the oscillator with the coil M1 in series with the tapped portion of the coil M2. Two identical Permalloy cores having the windings M1 and M2 thereon are mutually positioned parallel in close adjacency and the windings thereon are phased so that the magnetizing forces of the external field and current pulse add for one core and oppose each other for the other core. Since the number of turns on coil M1 is equal to the number of turns to the tap on M2, the oscillator load is substantially balanced against changes in background field, a change of external field increasing the amount of magnetic saturation produced by the oscillator pulses in one core while decreasing this saturation in the other core. The output of the magnetometer to the diode circuit is provided by the whole of the coil M2, thus the unbalanced effect of a single coil, single core, magnetometer is preserved. The use of a part of the coil M2 for excitation purposes and the whole of the coil for connection to the diode rectifier results in amplification of the output voltage pulses of the coil by auto-transformer action. Such unbalance is desirable for the reason that it makes unnecessary the use of magnetic bias to prevent the magnetometer output from going through a minimum and the sensitivity from going through zero near zero background field.

The two coil, two core arrangement provides a stable circuit wherein slight variations in the various components have no appreciable effect on the effectiveness thereof. It has also been found that the use of condenser C3 from the oscillator cathode of tube T1 to ground stabilizes the voltage output of the oscillator, increases the overall sensitivity of the circuit, and increases the uniformity of performance for different oscillator tubes.

The D.C. diode circuit comprises the diode portion of diode-pentode tube T2, condensers C4 and C5, and resistors R3, R4, R15 and R5. It is a conventional shunt diode circuit with C4 the diode condenser, R3, R4, R15 and R5 forming the D.C. diode load resistance and C5 furnishing the A.C. filtering. Resistor R4 is made variable so that sensitivity adjustments may be made and parts having standard tolerances employed.

The amplifier circuit makes use of the pentode portion of tube T2 and is provided with two degenerative feedback networks. Resistors R8 and R9 provide stabilization of the amplifier plate voltage operating point. This is desirable where the grid bias is fixed and the screen voltage is fixed as in the present instance. In order to operate the firing circuit, the amplifier plate voltage must swing as much as 18.5 volts, as aforesaid, and considerably in excess thereof for firing on slow signals. Thus the plate voltage operating point must be held within a narrow range in order that such wide swings in plate voltage in either direction may be possible. The feedback provided by resistors R8 and R9 has the effect of reducing the effective time constant of the coupling circuit between the diode of tube T2 and the amplifier thereof. In order to offset such an effect, the degenerative feedback from resistors R5 and R6 has been provided which has the effect of increasing this time constant. Negative bias for the grid at the pentode portion of tube T2 is furnished by battery **131** and the voltage divider made up at resistors R8 and R16.

The shunt condenser C7 is provided in the circuit to produce additional filtering out of the magnetometer output voltage pulses. The effect of these voltage pulses reaching the firing circuit would be to tend to nullify the effect of the condenser-resistor coupling circuit between the diode and amplifier. C7 also furnishes a low impedance transfer current path for the firing circuit tubes T3 and T4.

The firing circuit comprises negative tube T3 and positive tube T4, condensers C8, C9, C10 and C11, and resistors R11, R12, R13 and R14. The transfer of firing from negative tube T3 to positive tube T4 depends on the impedance, looking back into the amplifier, being high enough so that the positive charge generated when negative tube T3 fires is not excessively attenuated before reaching the starter 121 of positive tube T4.

Condenser C10 is employed to permit sufficient transfer current to flow in the starting gap of T3 when the starter-cathode voltage thereof reaches breakdown value. The impedance of all other transfer current paths is made amply low by the low impedance of the amplifier output and the network of condensers C7, C8 and C9. The operation of the firing circuit has been described more fully elsewhere in this description.

Battery assembly 104, comprising B1, B2, and B3 supplies all electrical power requirements of the circuit employed in the present invention for detecting the signal of a magnetic anomaly, amplifying the signal, and firing the primer.

In operation the device of the present invention is launched from a vessel or other launching medium, the device being preferably thrown or launched for flight ahead of the vessel toward the target, for example, a submarine. As the depth charge 10 is launched the lanyard 87, which has one end thereof fixed to the vessel, causes the cutting tool 84 to sever strap 39. When strap 39 is severed pin 26 moves outwardly closing switches SW1 and SW2 thus warming up the circuit sufficiently to ensure operation thereof when arming is completed.

When depth charge 10 strikes the surface of the water inertia weight 43 moves forward compressing spring 48 thus freeing detonator holder 53 which moves to align detonator 54 with bore 59 and lead-in 58 thus arming the detonator. Shaft 44 of weight 43 is held against return to the initial position thereof by holder 53 at one end thereof and shaft 44 extends across bore 25 at the other end thereof to prevent return of pin 26 to the initial position thereof, thus maintaining switches SW1 and SW2 in the closed position. The hydrostatic switches SW3 and SW4 are provided with sufficient time delay to prevent operation thereof until the depth charge 10 is in stable downward travel through the water thus preventing firing to the primer 61 of the firing mechanism by a spurious signal developed by angular gyrations of the pick-up or magnetometer coils M1 and M2 in the earth's magnetic field during the period of turbulence immediately succeeding entry of the depth charge into the water. If desired switches SW3 and SW4 may be combined in a single hydrostatic unit rather than the pair of units disclosed in the drawings.

When the megnetometer coils M1 and M2 come into proximity with the target either a positive or negative signal is produced in the detector or diode portion of tube T2 the signal being amplified by the amplifier or pentode portion thereof, thus causing firing of negative tube T3 and positive tube T4, in case of a negative signal and in case of a positive signal only positive tube T4 is fired. When either tubes T3 and T4 are fired or tube T4 alone is fired, the primer 61 is ignited which through bore 59 ignites detonator 54, lead-in 58, booster charge 23 and thus firing main charge 12.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is desired to be secured by Letters Patent of the United States is:

1. A depth charge adapted to be launched from a launching medium on a trajectory through the air into a body of water and comprising, a casing for said depth charge, a main explosive charge mounted in said casing, a fuze housing mounted on said casing, a booster charge mounted on said housing and extending into said casing in close adjacency to said main charge, an electroresponsive firing train for said booster charge, inertia operated means mounted in said train for initially interrupting said firing train and for subsequently completing said firing train, a strap encircling said casing, a spring-urged rod mounted in said casing and retained by said strap, means for severing said trap and operable to release said rod as said depth charge is launched, said rod releasing said interrupting means as the rod is operated thereby to complete said firing train, a circuit for firing said firing train, closing means for said circuit in operative engagement with said rod, said closing means closing said circuit to warm said circuit as said rod is released, a pair of hydrostatic switches carried by said casing, means for operating said switches in time delayed relation as the depth charge descends in the water, one of said switches being normally closed and the other of said switches being normally open, and a magnetometer mounted in said housing having a pair of coils and magnetically saturable cores therefor whereby a current is produced in said coils when said cores are influenced by a magnetic anomaly in the earth's magnetic field, said circuit having detecting, amplifying and firing means including a primer carried by said casing and connected to said coils for operation of said firing means to fire said primer when a current is produced in said coils, said normally closed switch being connected in said detecting means and preventing spurious firing of the circuit when said closing means is closed and opening to render said detecting means effective when one of said hydrostatic switches is operated, said normally open switch maintaining said firing means open with respect to said primer and rendering said firing means closed with respect to said primer when operated by the other of said hydrostatic switches.

2. A depth charge adapted to be launched from a launching medium and comprising, in combination, a casing for depth charge having main charge, rocket, and tail portions, a main charge contained in said main charge portion, a fuze housing secured to the leading end of said main charge portion, a plurality of canted fins mounted on said portion for stabilizing and imparting rotation to said depth charge, a booster charge mounted in said main charge, an electroresponsive primer for initiating the firing of said booster charge, a firing train interposed between said primer and said booster charge, a strap encircling said fuze housing, a yieldable arming rod mounted in said fuze housing and retained by said strap, means controlled by said arming rod for initially interrupting said firing train, cutting means engaging said strap and secured by a lanyard to said launching medium, said cutting means severing said strap when said depth charge is launched thereby to release said arming rod which in turn releases the interrupting means to cause the completion of said firing train, a magnetometer axially mounted in said fuze housing, said magnetometer comprising a pair of coils having magnetically saturable cores individual thereto, a pulse oscillating circuit including a glow tube, said pulse circuit being connected to said coils for exciting said cores, a detector circuit connected to said coils for detecting changes in either direction of the amplitude of the magnetometer output voltage pulses, said changes being induced by a change in the earth's magnetic field caused by a magnetic anomaly, an amplifier circuit connected to said detector circuit for amplifying the output of said detector circuit, a firing circuit including a positive firing glow tube and a negative firing glow tube for receiving the output of said amplifier circuit, said negative tube firing and thereby firing said positive tube whereby said primer is fired when a current of negative polarity is received, said positive tube firing said primer directly when a positive current is received, switch means operatively connected to said arming rod and operated thereby to warm said circuits as the depth charge is launched, and hydrostatic means for arming said circuits when said depth charge has entered a body of

water and has reached a condition of stable downward travel.

3. A depth charge adapted to be launched from a launching medium and rocket-propelled on a trajectory through the air into a body of water comprising, in combination, a casing, a rocket motor mounted in the trailing end of said casing, a main charge adapted to be fired underwater mounted in the leading end of said casing, a non-magnetic housing secured on the leading end of said casing, a magnetometer having a plurality of coils and magnetically saturable cores therefor axially mounted in said housing, pulse oscillating means connected to said magnetometer for applying a measured pulse oscillating current to said coils, detecting means connected to said magnetometer for detecting signal currents generated by said magnetometer in response to a magnetic anomaly in the earth's magnetic field, amplifying means connected to said detecting means for amplifying said signal currents, firing means connected to said amplifying means, an electroresponsive primer connected to said firing means and adapted to be ignited when said firing means is energized, means for energizing said pulse oscillating means, said detecting means, said amplifying means and said firing means when the depth charge is launched, and hydrostatic time-delay arming means for connecting said primer to the firing means when the depth charge reaches a state of stable downward travel in the water whereby said primer is armed to fire when said firing means operates.

4. A depth charge comprising, in combination, a casing for said depth charge, a main charge for the depth charge mounted in said casing, a fuse housing mounted on the forward end of said main charge casing, a booster charge mounted on said housing and extending into said casing in close adjacency to said main charge, an electroresponsive primer mounted in said housing and mounted at one end of a bore formed therein and communicating with said booster charge, a lead-in mounted adjacent said booster charge in said housing in the other end of said bore, a slideable detonator assembly interposed between said lead-in and said primer initially blocking said bore and holding said detonator out of alignment with said bore and spring-urged to bring said detonator into alignment therewith when released, an inertia actuated device responsive only to a setforward force suddenly applied thereto initially engaging said detonator assembly for retaining said detonator assembly and releasing said detonator assembly for movement of the detonator into alignment with said primer and said lead-in when subjected to said setforward force as the depth charge enters a body of water, a band encircling said housing, a yieldable member retained by said band for retaining said inertia actuated device in the initial position thereof and releasing said device for action by inertial setforward force when said yieldable member is released, and a circuit including a magnetometer for detecting a magnetic anomaly in the earth's magnetic field whereby said circuit energizes said primer to fire the detonator, lead-in booster charge and thus the main charge.

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[11] **3,884,151**

[45] **May 20, 1975**

[54] **DETONATOR FOR LAND MINES**

[75] Inventors: **Paul Madlener**, Karlsruhe-Durlach; **Otto Pecksen**, Herrenalb near Karlsruhe, both of Germany

[73] Assignee: **Industrie-Werke Karlsruhe Augsburg Akt.**, Karlsruhe, Germany

[22] Filed: **June 15, 1966**

[21] Appl. No.: **559,043**

[52] **U.S. Cl.**...... **102/19.2**; 102/70.2 R; 200/61.45 R
[51] **Int. Cl.**.. **F42b 23/26**
[58] **Field of Search**............... 102/8, 16, 19.2, 70.2, 102/70.2 P, 70; 200/61.45, 61.52, 33.2

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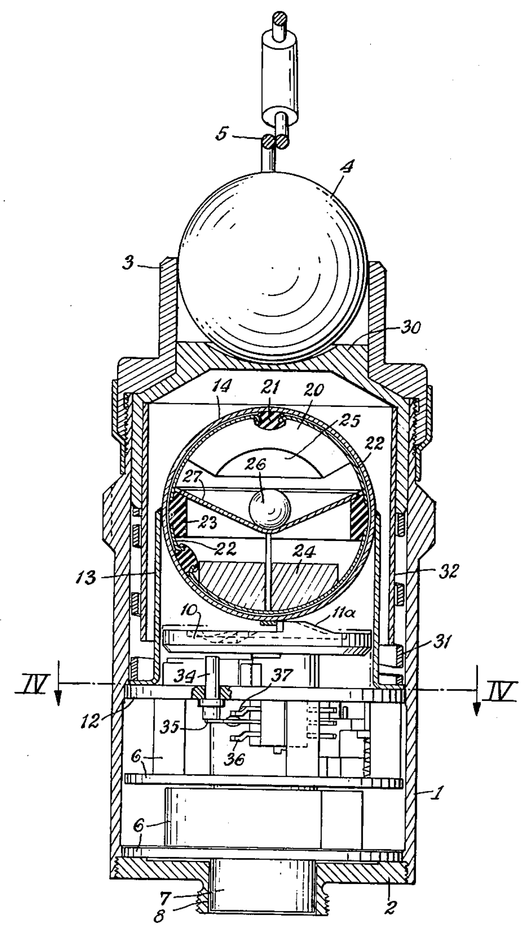
Primary Examiner—Robert F. Stahl
Attorney, Agent, or Firm—McGlew and Tuttle

[57] **ABSTRACT**

A detonator for a land mine containing electric circuit means for controlling and effecting the ignition of a detonator pellet, a driving mechanism controlled by said electric circuit for delaying the ignition of said pellet for a predetermined period of time, and a movable contact device subject to a change of position away from a gravity induced initial position for closing a portion of said electric circuit means. A slidable member in the housing of said detonator when moved in one direction actuates a switch member which starts the operation of said driving mechanism and at the same time moves another movable contact member into a position between two spaced fixed contacts, both of which are connected with said electric circuit means. Upon applying an external force to said slidable member, the same is moved an additional amount and the movable contact member is brought into engagement with one of said fixed contacts, thereby closing said electric circuit means for effecting the ignition.

7 Claims, 5 Drawing Figures



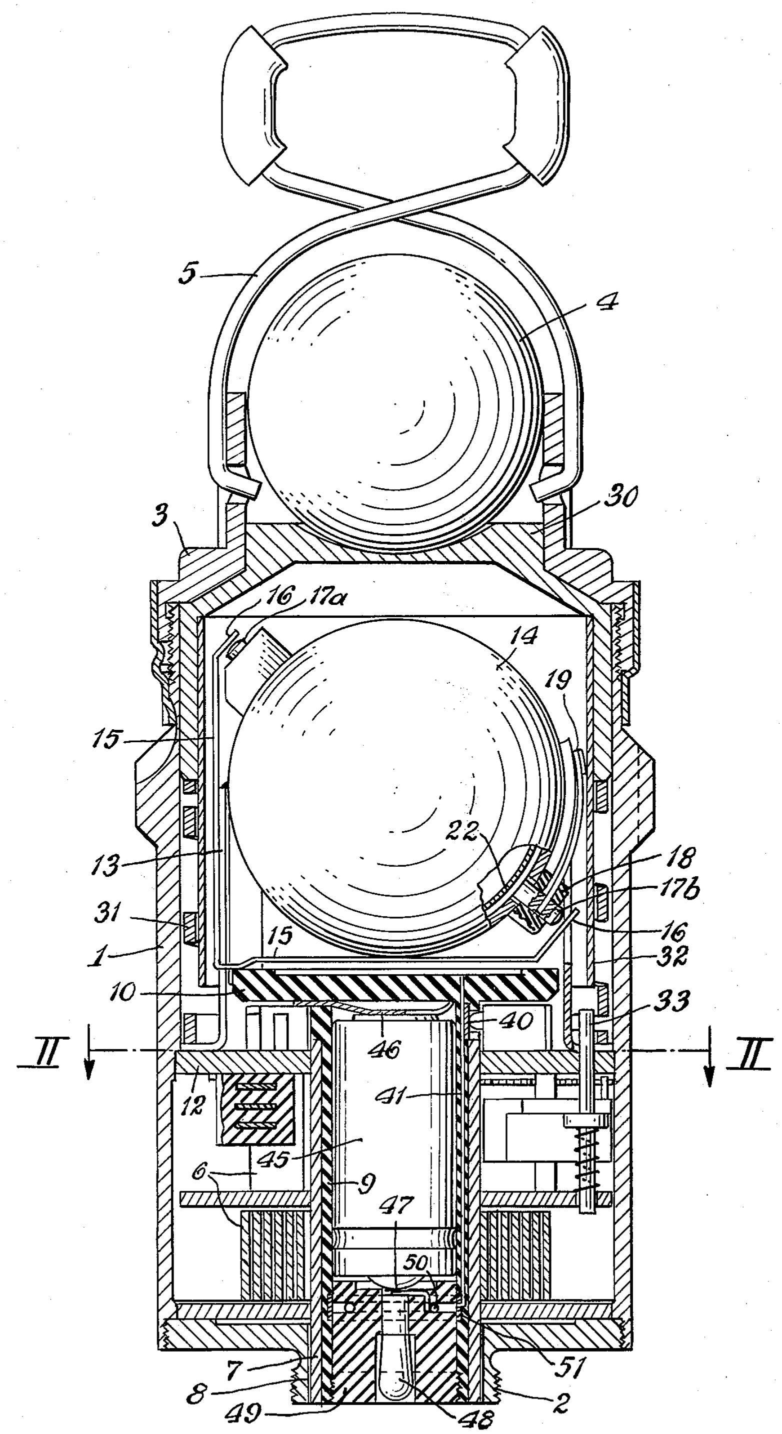

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Fig. 1

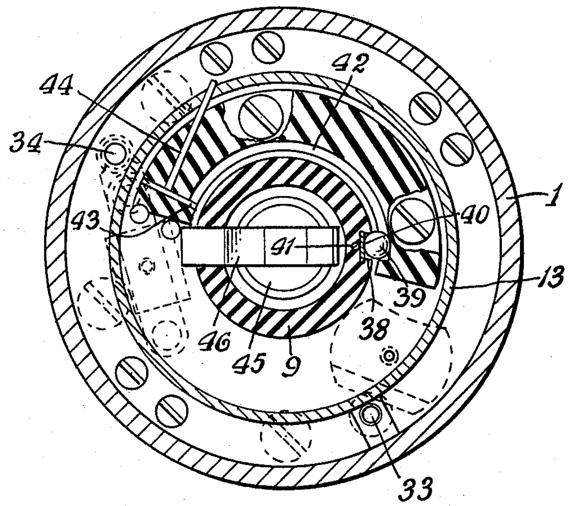

Fig. 2

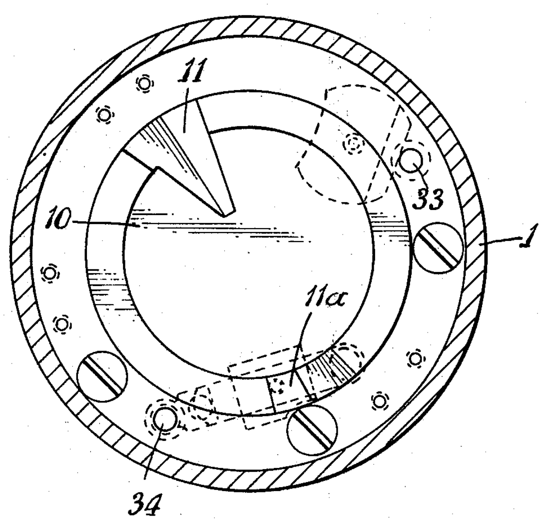

Fig. 4

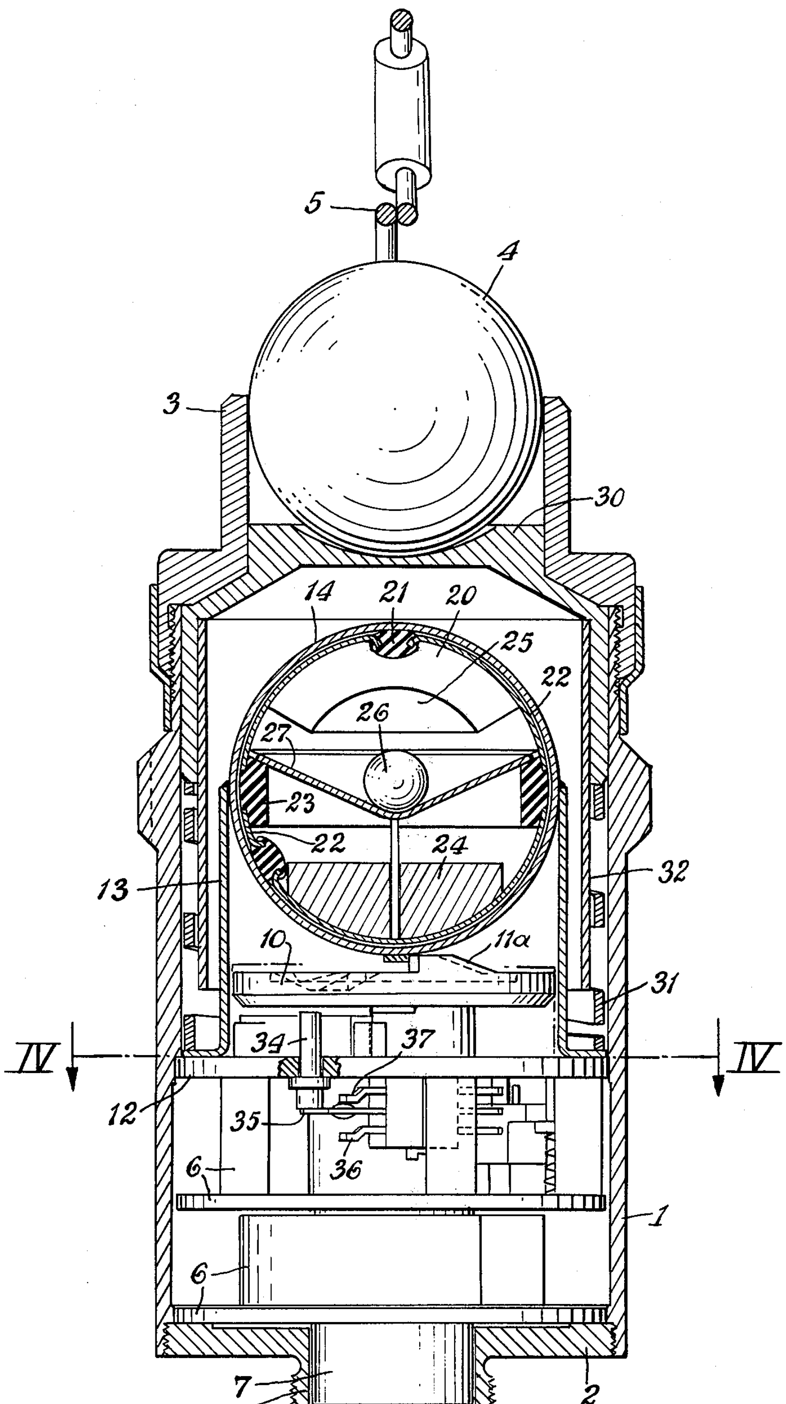
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Fig. 3

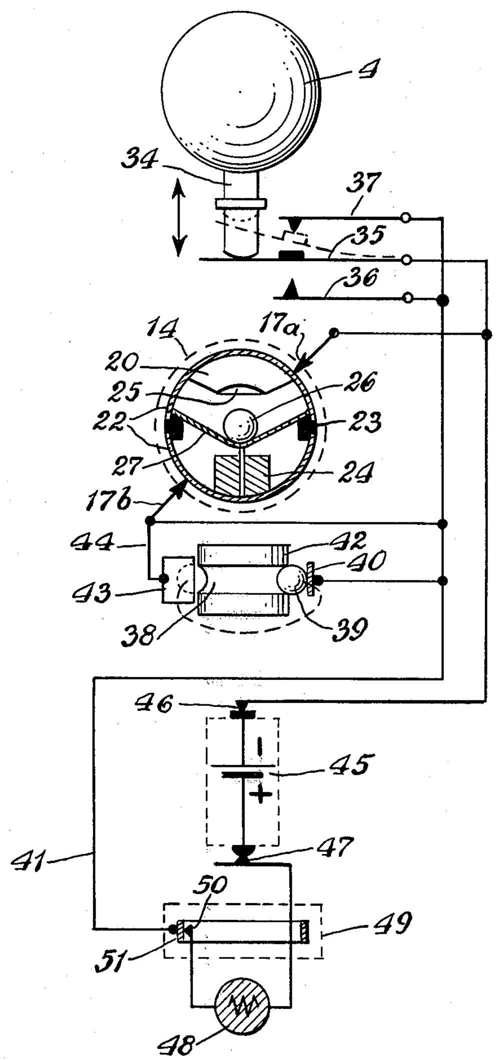
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Fig. 5

DETONATOR FOR LAND MINES

The invention relates to a detonator for land mines. The detonators ordinarily used in land mines are pressure actuated detonators, which cause an explosion of the mine when something or someone travels over the release mechanism of the mine. The mines may be rendered more or less free from danger by means of unscrewing a certain part by friend and foe so that the mine is unprimed or disarmed. In order to prevent the disarming of the mines by the enemy, or at least make it difficult a series of supplemental means is known, which are placed under the mine and which upon raising of the mine body detonate. All these devices may be discovered rather rapidly by an expert — as they are located outside of the actual mine body — and may be rendered harmless by suitable procedures. In order to prevent an unscrewing of the detonator from the mine body, already detonator constructions have been employed, which upon unscrewing, are caused to bring the mine to detonation.

Al these constructions are not ideal solutions, as they mean additional expenditures to the actual detonator mechanism and mainly comprise supplemental devices placed outside the mine.

In order to overcome these disadvantaqes, the invention is characterized in this, that the detonator reacts to normal load, upon unauthorized unscrewing of the mine screw coupling detonates, and ignites the mine upon a change in position of the latter, in that by a depression of a pressure member with a pressure ball in direction of the axis of the detonator a driving mechanism of known construction is set in motion, — and depending upon the distance of the movement an actuating bolt or a switch spring engages either a lower bracket or on an upper bracket and causes the mine to detonate by means of a primer pellet whereby at the same time a control disc is rotated about the detonator axis and operates a switch bracket by means of cams, which switch-bracket urges two oppositely disposed contact bolts into a hollow sphere connected with the detonator housing against a freely movable contact sphere lying therein and holds the latter in position, whereby the upper one carries two gilded spherical-cups separated from each other by an insulating intermediary annular member. One of said spherical cups carries a gilded conically-shaped contact plate, on which lies a gilded ball freely rolling as connection element.

Further details of the invention are described in the following description and in the claims.

This invention combines three functions of the detonator into one, which makes the ignitor economical to manufacture and furthermore, a reliable operation of the detonator is obtained.

In order on one hand, to increase the reliable manipulation of the detonator, and on the other hand, to make possible the launching of mines with such detonators, the present detonator construction is provided with a delay-drive mechanism which from the moment the drive mechanism is set in operation up to the readiness of the detonator for ignition insures a predetermined period of safety.

The invention by way of example is illustrated in the drawings by five figures.

In these drawings:

FIG. **1** is a longitudinal sectional view of the detonator.

FIG. **2** is a cross-sectional view along the line II—II of FIG. **1.**

FIG. **3** is a longitudinal sectional view of the detonator with hollow ball in section.

FIG. **4** a sectional view along the line IV—IV of FIG. **3,** and

FIG. **5** an electric circuit diagram of the detonator.

The detonator consists in its outer construction of a detonator housing **1,** a bottom member **2,** an upper screw-cap **3,** a pressure actuated ball **4** and a safety bracket **5.**

In the interior of the detonator housing **1** is arranged a driving mechanism **6** of customary construction, whose hollow shaft **7** extends loosely into the center bore **8** of the bottom member **2.** This hollow shaft **7** is lined and fixedly connected with a control bushing **9** consisting of insulating material. The upper end of the control bushing **9** extends upwardly beyond upper end of the hollow shaft **7** in the form of a control disc **10** with control cams **11** and **11***a* (see FIG. **4**) on its upper face.

On a plate portion **12** of the driving mechanism **6** is fixedly attached a supporting sleeve **13,** on whose upper end a hollow sphere **14** extending halfway into sleeve **13** is soldered. On the lower end of the hollow sphere **14** is fixed a double-armed switch-bracket **15,** which is so formed, that two offset free arms **16** (switch-bracket-ends), may be actuated by the control cams **11** on the control disc **10.** Each of the free ends of the arms **16** of the switch-bracket **15** acts upon a contact bolt **17***a* and **17**b, (FIG. **1**) which are slidably mounted in an insulating member **18** and by means of a leaf spring **19** are urged outwardly against the switch-bracket ends **16.**

In the interior of the hollow sphere **14** is freely movably arranged a contact sphere **20** composed of two almost semi-spherical parts, which contact sphere is provided with projections **21** which engage the inner wall of the hollow sphere **14.** The surface of the contact sphere **20** is gilded in form of two metal-cups **22,** and between these two cups **22** lies an intermediate annular insulating member **23,** which is wider than the diameter of the contact bolts **17***a* and **17***b*. In the contact sphere **20** is inserted one-sided a lead weight **24,** which causes the sphere **20** to swing inside the sphere **14** in accordance with the force of gravity.

The interior of the contact sphere **20** forms a hollow chamber **25,** which is divided by means of a truncated upwardly open cone of predetermined conical inclination. The cone is formed by a conical contact plate **27** made of sheet metal. It is metallically connected with the lead core **24** and with the lower cup **22** containing the lead core **24.** The inner surface of the upper metal cup **22** is gilded, — likewise the inner surface of the conically shaped contact plate **27** which rests with its outer edge upon the annular insulating member **23** but remains out of metallic contact with the upper cup **22.**

A pressure member **30** is pushed over the hollow sphere **14** and by a helical-pressure spring **31** is urged upwardly against the screw-cap **3.** On the pressure member **30** is disposed the pressure sphere **4,** which is loosely held in an extension of the screw-cap **3.**

The safety bracket **5** engages with its two ends two oppositely arranged bores in the screw-cap **3** and resiliently engages from below the center of the pressure sphere **4** and prevents an unintentional actuation of the detonator. Upon removal of the safety-bracket **5**, the pressure sphere **4** is moved a predetermined distance downwardly, and an extended sleeve **32** of the pressure member **30** presses upon a vertically arranged resilient switch-bolt **33** (FIG. 1), which releases the driving mechanism **6**.

At the same time, the extended sleeve **32** of the pressure member **30** reaches an actuating bolt **34** (FIG. 3), which is pressed downwardly upon a switch spring **35** and moves the latter into a position in the center between the switch brackets (see also FIG. 5). Means are provided to retain the sleeve **32** and the switch spring **35** in this position. If now an additional pressure is exerted upon the pressure sphere **4**, the pressure member **30** is moved farther downward so that the switch spring **35** engages the lower switch bracket **36** and the result is, as will be explained hereinafter, that the ignition circuit is closed when the same is in an armed condition. A closing of the ignition circuit, when the mine is armed, also takes place when the pressure member **30** owing to the upwardly directed inner tension of the switch spring **35** is moved upwardly so that the switch spring **35** engages the upper switch bracket **37**.

In the portion of the control bushing **9** projecting from the upper end of the hollow axis **7** is seated loosely in a depression **38** a gilded steel ball or sphere **39** (FIG. 2); the latter is supported on a contact plate **40**, which is soldered to a conductor wire **41**. During the run-off of the driving mechanism **6**, the sphere or ball **39** rolls along a stationary insulating guide-way **42**, until it touches or rolls up against a contact disc **43** and stops the operation of the driving mechanism **6** for example after five minutes. The contact disc **43** is soldered to a conductor wire **44**, which leads to the contact **17***b*. The detonator is now alive.

In the interior of the control bushing **9** is preferably arranged a gastight miniature battery in the form of a rod element **45** as source of energy for the release of the detonator. The one pole of the rod element is supported on a contact spring **46**, which is connected with the contact pin **17**a and is conductively connected with the central switching spring **35** (FIG. 5). The other pole engages a contact **47** which is conductively connected with the one conducting wire of an electric detonator pellet **48**. The detonator pellet **48** is inserted in a threaded detonator plug **49** of insulating material. The second conductor wire of the detonator pellet **48** by means of a conducting expansion spring **50** and a contact ring **51** inserted in the control bushing **9** is conductively connected with the conductor wire **41**, contact plate **40** and the sphere **39**. The conductor wire leaving the contact disc **43** is connected with the contact pin **17***b* and simultaneously with the switch-spring **36** and **37**. After the run-off of the driving mechanism, a conducting connection is produced by a rotation of the axis of the driving mechanism between the contact plate **40** and the contact disc **43** and the sphere **39**.

The operation is as follows:

As the detonator is screwed into the mine and, after removal of the safety bracket **5**, the mine is screwed closed, the pressure ball or sphere **4** is being pressed downward a determined amount. Thereby, the extended slidable sleeve **32**, urges the switch bolt **33** downwardly, which releases the driving mechanism **6**, which begins to operate. After a predetermined rotative movement limited by means of the radially directed contact disc **43**, the steel ball **39** closes a part of the electric circuit.

Simultaneously the control disc **10** has rotated, and has actuated by the cams **11** the switch brackets **15**, which press the contact bolts **17***a* and **17***b* into the hollow sphere **14**, where they are seated on the cups **22** of the previously freely movable ball or sphere **20**, which on account of the one-sided lead weight **24** has adjusted itself according to the force of gravity. The contact bolts **17***a* and **17***b* hold the ball **20** in this position. The two parts insulated from one another, contact-cone **27** and upper contact-semi-sphere **22**, now are connected with the battery **45**.

If now a change in position of the deposited mines takes place, the ball **26** rolls outward and connects the two parts namely the contact-cone **27** and upper semi-spherical contact member **22** with one another. Thereby a circuit-closure is produced through the electric detonator pellet **48** and it is ignited. The sensitivity against a changè of position may be attained by means of a corresponding inclination of the conically shaped contact plate **27**. If due to ground shocks as a result of detonations occurring in the vicinity, in the mines at rest the contact ball **26** should jump up, it is thrown into the hollow chamber **25** and, without having any effect, drops back into the conical tip of the contact plate **27**.

If a load moves over the mine, the pressure ball **4** is pressed a predetermined amount farther into the detonator. The extended slidable sleeve **32** shifts the actuating bolt **34** downward, which presses the contact spring **35** against the switch bracket **36**. Thereby the circuit is again closed through the detonator pellet **48** and the mine detonated.

If the enemy attempts to disarm the mine, in that he unscrews the mine in order to remove the detonator, the pressure spring **31** shifts the alidable member **32** upwardly. The actuating bolt **34** is relieved of its load and permits the contact spring **35** to engage the switch bracket **37**. Again the circuit through the detonator pellet **48** is closed and the mine detonated.

What we claim is:

1. In a detonator for a land mine, a detonator housing having mounted therein an electrically ignitable detonator pellet, electric circuit means for controlling the ignition of said pellet, a drive mechanism controlled by a switch member (**33**) in said circuit means for delaying the ignition of said pellet for a predetermined period of time, a movable contact device subject to a change of position of said housing with respect to an initial position for closing a portion of said electric circuit means when a change of the position of said housing from its initial position takes place, gravity controlled means for moving said movable contact device into said initial position in which said portion of said circuit means is open, a slidable member (**32**) in said housing, said electrical circuit means also including two spaced fixed contact members (**36, 37**) and a movable contact member (**35**) therebetween, said slidable member when moved in one direction actuating said switch member (**33**) to start the operation of said driving mechanism and at the same time moving said movable contact member (**35**) into a position midway between and out of engagement with said two spaced fixed contact members.

2. A detonator according to claim 1, including means for slidably moving said slidable member (32) in one direction by a pressure transmitted to it by an external force, whereby said movable contact member (35) is brought into engagement with one of said spaced fixed contact members (36, 37) to effect a closing of said electric circuit, said movable contact member upon cessation of said external force being adapted to move in the opposte direction into engagement with said other fixed contact member.

3. A detonator according to claim 1, in which said slidable member comprises a sleeve movable in the axial direction of said housing, said sleeve surrounding said movable contact device, and a slidably mounted actuating bolt (34) between one end of said sleeve and said movable contact member (35) for engaging the latter when said sleeve is axially moved by an external force, so that said movable contact member is moved in engagement with one of said two spaced fixed contact members.

4. A detonator according to claim 1, including a bottom wall at one end of said housing, said driving mechanism being attached to said bottom wall and including a tubular shaft (7) extending through a central aperture in said bottom wall, a control bushing (9) of insulating material extending through said tubular shaft and provided at one end which extends beyond the end of said tubular shaft into the interior of said housing with a recess (38), a steel ball (39) within said recess and in electrical connection with said electric circuit, a stationary guideway extending concentrically about said bushing and along which said ball is adapted to roll when said driving mechanism is operating, a contact disc at the end of said guideway for stopping said ball and the operation of said driving mechanism, and means conductively connecting said contact disc with said electric circuit to arm said detonator.

5. Detonator according to claim 1, in which said movable contact device includes a freely rotatably mounted hollow ball (20) comprising two semi-spherical metal cups (21, 22) and an intermediate annular insulating member (23) uniting said cups, means for connecting each of said cups to said electric circuit,

a metallic conical plate (27) with its circumference facing upwardly being mounted on said insulating member, means for conductively connecting said conical plate with the cup below said annular insulating member, said last named cup containing a lead weight tending to rotate said contact device by gravity into said initial position, a contact ball (26) loosely positioned in the cavity formed by said conical plate and adapted to make electrical contact with the upper cap when said hollow ball is caused to rotate about its center, thereby connecting both said semi-spherical cups by means of said conical plate in series in said electric circuit.

6. Detonator according to claim 5, including a fixedly mounted hollow spherical casing (14) in which said hollow ball (20) is freely rotatably mounted, two yieldably mounted contact members (*17a* *17b*) arranged on said casing and adapted to be brought into engagement with said two semi-spherical cups respectively, said two contact members forming part of said means for connecting each of said cups with said electric circuit, and means operated by said driving mechanism for urging said two yieldably mounted contact members into engagement with their respective semi-spherical cups so as to arrest the hollow ball (20) in the prevailing position.

7. Detonator according to claim 5, including a fixedly mounted hollow spherical casing (14) in which said hollow ball (20) is freely rotatably mounted, two yieldably mounted contact members (17a, 17b) arranged on said casing and adapted to be brought into engagement with said two semi-spherical cups respectively, said two contact members forming part of said means for connecting each of said cups with said electric circuit, and means operated by said driving mechanism for urging said two yieldably mounted contact members into engagement with their respective semi-spherical cups so as to arrest the hollow ball (20) in the prevailing position, said last named means including a cam-carrying control disc (10) rotated by said driving mechanism and a switch bracket (15) actuated by the same, said switch bracket having means thereon for engaging said yieldably mounted contact members.

* * * * *

Aug. 4, 1925. 1,548,693

F. R. WEAVER

FIRING MECHANISM FOR PYROTECHNICS AND THE LIKE

Filed May 15, 1924

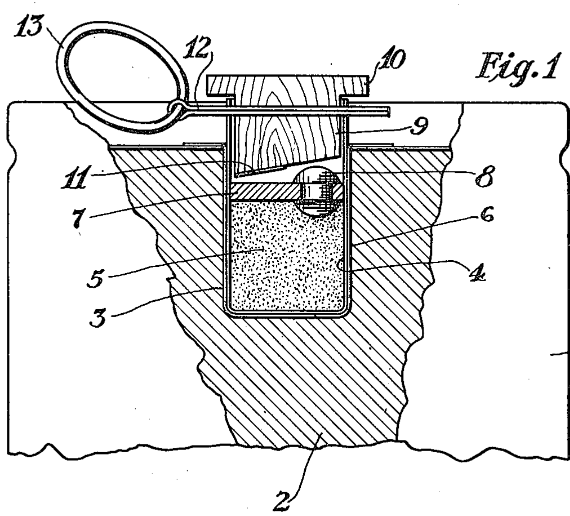

Fig. 1

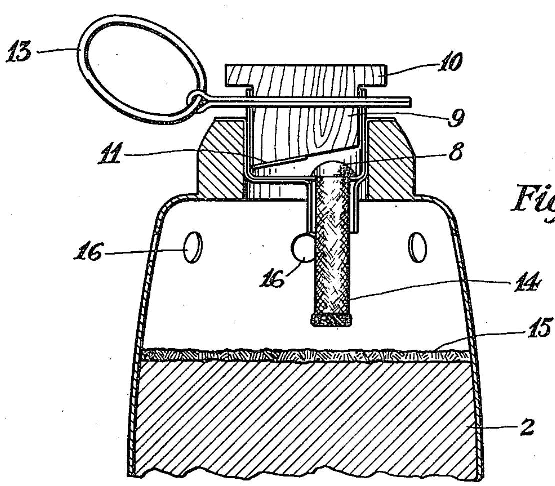

Fig. 2

Fleming R. Weaver
Inventor

By Chas. Silver
Attorney

Patented Aug. 4, 1925. **1,548,693**

UNITED STATES PATENT OFFICE.

FLEMING R. WEAVER, OF EDGEWOOD, MARYLAND.

FIRING MECHANISM FOR PYROTECHNICS AND THE LIKE.

Application filed May 15, 1924. Serial No. 713,515.

To all whom it may concern:

Be it known that I, FLEMING R. WEAVER, a citizen of the United States, residing at Edgewood, in the county of Harford and State of Maryland, have invented certain new and useful Improvements in Firing Mechanism for Pyrotechnics and the like, of which the following is a specification.

This invention relates to a mechanism for firing pyrotechnics and the like and has specific reference to a construction for use with devices for setting off pyrotechnic mixtures, explosives, fuels, etc.

Among the objects of this invention is to provide a firing mechanism for pyrotechnics, which is efficient, reliable, easy to operate and which can be made to function when desired and prevented from functioning at other times.

A further object of this invention is to provide a firing mechanism for pyrotechnics employed with grenades, bombs, rockets, signals, candles, etc.

Other, further and more specific objects of the invention will become readily apparent to persons skilled in the art from a consideration of the following description when taken in conjunction with the drawings, wherein:—

Fig. 1 is an elevation, partly in section, showing the preferred form of my device for use with a candle, for example, a smoke generating candle.

Fig. 2 is an elevation, partly in section, showing the same device in use with a grenade, for example, a toxic or irritant smoke generating grenade.

Referring to Fig. 1, a portion of the candle (1) is shown, the candle being provided with the smoke mixture (2). This smoke mixture (2) is usually cast or molded in the form of cakes and has a recess (3) adapted to receive a tube or receptacle (4) containing the pyrotechnic mixture (5). This receptacle (4) may rest directly in the smoke mixture (2). I prefer however to provide a thimble (6) which is securely embedded in the smoke mixture (2) and by properly regulating the sizes of the thimbles (6) and receptacle (4), the receptacle may be made to remain tightly in the thimble, so that it will not fall out from the candle.

Above the pyrotechnic mixture (5), there is provided a cap or disc (7) secured to the receptacle (4) and this disc supports a match composition (8) which is in contact with the pyrotechnic (5). Extending into the receptacle (4) is the plug (9) provided with a head (10). This plug (9) may be rotated within the tube or receptacle (4). The inner surface of this plug (9) is preferably obliquely inclined to the axis of the receptacle and partially covered with an abrasive or scratcher composition (11). In the construction shown the scratcher composition (11) is out of contact with the match composition (8) and this is the "safe" position of the device. The device is maintained in this "safe" position by means of the pin (12) passing through the plug (9) and the receptacle (4).

When it is desired to operate the firing mechanism, the pin (12) is withdrawn by pulling the ring (13) and on turning the plug (9), the scratcher is brought in frictional contact with the match composition, causing the latter to fire. The fire is communicated to the pyrotechnic (5), and as this burns, the receptacle (4) and thimble (6), which are preferably made of a low fusible metal, such as zinc, melt and the burning pyrotechnic ignites the smoke mixture (2), causing smoke to be evolved therefrom and issue from the candle.

In the grenade shown in Fig. 2, as the plug (9) is rotated, the scratcher (11) will frictionally engage and fire the match composition (8) and set off the fuse (14). This will ignite the starter (15) upon the smoke mixture (2) causing the latter to volatilize and issue from the grenade through the openings (16).

A suitable match composition may be made from potassium chlorate (6 parts) and black antimony sulphide (3 parts), mixed intimately and bound into a solid mass with dextrine (2 parts). These materials should be acid-free as much as possible.

A suitable scratcher composition consists of red phosphorus (5 parts) and ground glass of 150 mesh (3 parts), bound together by dextrine (2 parts).

Although I have for purposes of illustration shown my device in use with smoke candles and grenades, my device is not limited in this respect and may be employed in other pyrotechnic uses, for example, rockets, signals, etc. My device may also be employed in connection with delayed or time action fuses for setting off detonating and fulminating mixtures. It may also be adapted to other mixtures sensitive to the frictional action of the scratcher composition.

The present invention is not limited to the specific details set forth in the foregoing examples which should be construed as illustrative and not by way of limitation, and in view of the numerous modifications which may be effected therein without departing from the spirit and scope of this invention, it is desired that only such limitations be imposed as are indicated in the appended claims.

I claim as my invention:

1. A firing mechanism for pyrotechnics and the like comprising a receptacle having a pyrotechnic adjacent to a match composition supported in said receptacle and a rotatable member provided with a scratcher composition to which said match composition is sensitive, said scratcher composition being in the vicinity and out of contact with said match composition when the device is in the "safe" position and said scratcher composition being disposed to frictionally engage said match composition when said rotatable member revolves, and means for preventing frictional movement between the adjacent match and scratcher compositions when the device is in the "safe" position.

2. A firing mechanism for pyrotechnics and the like comprising a receptacle having a pyrotechnic at one end adjacent to a match composition supported in said receptacle, a rotatable member projecting into the other end of said receptacle, the inner end of said rotatable member being provided with a scratcher composition to which said match composition is sensitive, said scratcher composition being in the vicinity of and out of contact with said match composition when the device is in the "safe" position and said scratcher composition being disposed to frictionally engage said match composition when said rotatable member revolves in the receptacle, and means for preventing frictional movement between the adjacent match and scratcher compositions when the device is in the "safe" position.

3. A firing mechanism for pyrotechnics comprising a tube having a pyrotechnic at one end in contact with a match composition supported in said tube and a rotatable plug projecting into the other end of said tube, said plug having the base within said tube partly surfaced with a scratcher composition to which said match composition is sensitive, said scratcher composition being in the vicinity of and out of contact with said match composition when the device is in the "safe" position and said match composition being disposed in the path of said scratcher composition when the plug is rotated in the tube, and means for preventing rotation of the plug in the tube and frictional movement between the adjacent match and scratcher compositions when the device is in the "safe" position.

4. A firing mechanism for pyrotechnics comprising a receptacle having a pyrotechnic in contact with a match composition supported in said receptacle and a rotatable member adjacent to said match composition and having the surface near said match composition obliquely inclined to the axis of said receptacle and partly surfaced with a scratcher composition to which said match composition is sensitive, said scratcher composition being out of contact with said match composition when the device is in the "safe" position and said match composition being disposed in the path of the said scratcher composition when the rotatable member revolves.

5. A firing mechanism for pyrotechnics comprising a tube having a pyrotechnic at one end in contact with a match composition supported in said tube and a closely-fitting, rotatable plug projecting into the other end of said tube, said plug having the base within said tube obliquely inclined to the axis of said tube and partly surfaced with a scratcher composition to which said match composition is sensitive, said scratcher composition being out of contact with said match composition when the device is in the "safe" position and said match composition being disposed in the path of the said scratcher composition when the plug is rotated in the tube.

6. A firing mechanism for pyrotechnics comprising a tube having a pyrotechnic reaction mixture at one end, a match composition in close proximity to said pyrotechnic mixture, a rotatable member supporting a scratcher composition to which said match composition is sensitive extending into the other end of said tube, said scratcher composition being in the vicinity of and out of contact with said match composition when the device is in the "safe" position and said scratcher composition being disposed to frictionally engage said match composition when said member is rotated within the tube, and means for preventing frictional movement between the adjacent match and scratcher compositions when the device is in the "safe" position.

FLEMING R. WEAVER.

United States Patent [19]
Shea

[11] **3,988,989**
[45] **Nov. 2, 1976**

[54] **HIGH-PRESSURE, ELECTRICALLY INITIATED EXPLOSIVE IGNITER**

[75] Inventor: **John W. Shea,** King George, Va.

[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

[22] Filed: **Sept. 10, 1975**

[21] Appl. No.: **611,953**

[52] **U.S. Cl.** .... **102/28 R**
[51] **Int. Cl.**[2] **C06C 3/00**
[58] **Field of Search** .... 102/28, 46, 70.2 R; 60/39.82 E, 39.82 P, 256; 89/1 B

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Primary Examiner—Samuel Feinberg
Attorney, Agent, or Firm—R. Sciascia; R. Beers; S. Sheinbein

[57] **ABSTRACT**

An electrical explosive igniter, or initiator, of the cylindrical type having electrical leads coming through to a bridge wire in an ignition mix container. An anvil cutter of cylindrical shape is force-fitted into the center of the igniter and a movable piston is spaced therefrom. The piston has a tapered internal boring. When the piston is forced sharply backward by the internal pressures of the ignited explosives, it shears the wires against the anvil cutter and the tapered portion forms a tight metal-to-metal seal between the anvil cutter and the igniter wall. The greater the pressure, the better the seal becomes.

7 Claims, 4 Drawing Figures

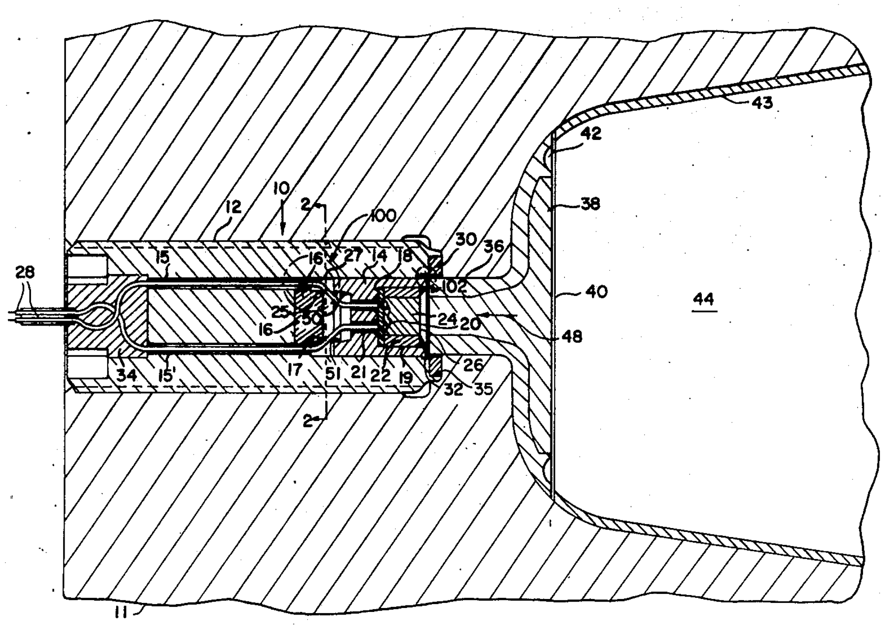

FIG. 1

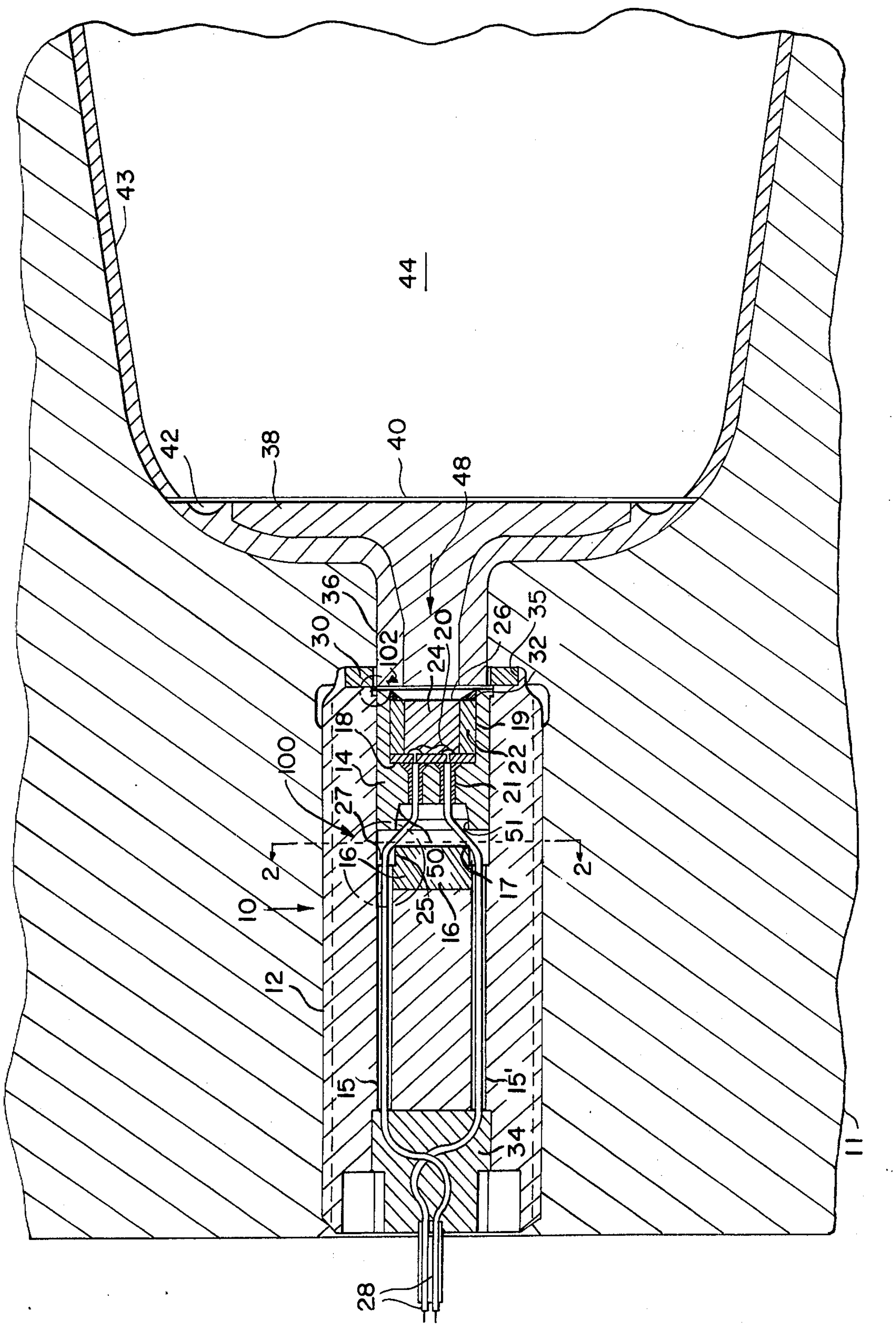

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FIG.3

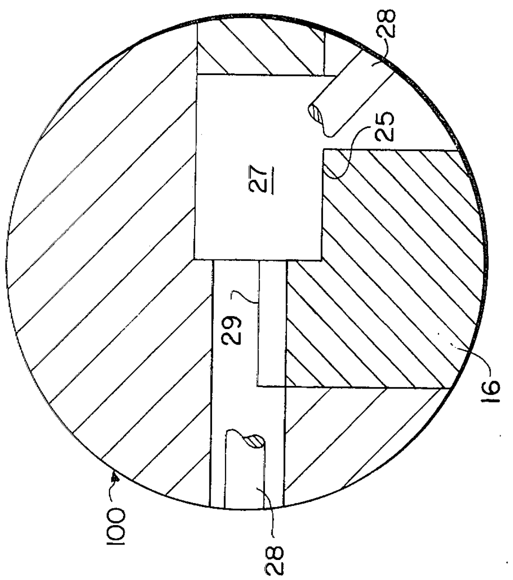


FIG.4

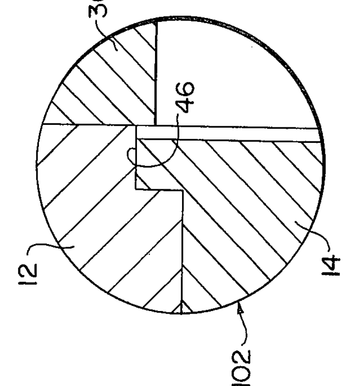
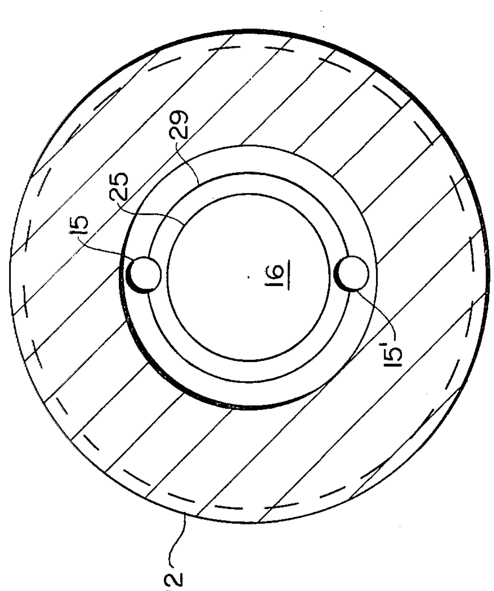


FIG.2



HIGH-PRESSURE, ELECTRICALLY INITIATED EXPLOSIVE IGNITER

BACKGROUND OF THE INVENTION

This invention relates to improvements in electrical explosive initiators and especially to an electrical explosive initiator with improved high-pressure capability.

In the testing and evaluation of explosives and rocket propellants, it is desirable to obtain data dealing with burning rate and burning characteristics. Presently available means of obtaining such data are limited to a maximum pressure of about 40–50 thousand pounds per square inch gage (psig) because the electrical explosive initiators (or igniters) are limited to this maximum pressure.

The pressure limitation of present initiators is based on the means of sealing the electrical lead penetrations of the initiators. There are many conventional methods of sealing the electrical leads, the most common being the ceramic seal, such as used in the Mark 17, Mod 0, igniter. This method offers a peak capability of about 50,000 psig. As the pressure increases towards the maximum the reliability of the igniter decreases. The ceramic seal method of sealing the electrical leads probably offers the maximum pressure confinement available at this time in electrically initiated igniters.

SUMMARY OF THE INVENTION

The objects and advantages of this invention are obtained by enclosing a movable piston and an anvil cutter in an electrical explosive initiator. The pressure buildup in the booster or ignited explosive forces the piston back against the anvil, cutting the electrical lead wires and sealing their entrance openings by a metal-to-metal seal between the anvil and a tapered internal bore of the piston.

An object of this invention is to improve the pressure confinement capability of electrical explosive initiators.

A further object is to increase the reliability of electrical explosive initiators at high pressures.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional view of an embodiment of the invention in conjunction with a booster explosive head and a main-charge container.

FIG. 2 is a cross-section of FIG. 1 taken along the line 2—2.

FIG. 3 is an enlarged view of the portion of FIG. 1 within the circle numbered 100, the wire 28 being broken away for clarity.

FIG. 4 is an enlarged view of the portion of FIG. 1 within the circle numbered 102.

DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1, an embodiment of an improved high-pressure, electrical explosive initiator 10 is shown in conjunction with a booster-explosive head 36 and container 43 for a main explosive charge 44, all contained within a container 11 which is shown only partially. The initiator 10 is sealed to the container 11 by means of a high-pressure seal 30 which may, for example, be

a copper washer pressed into the boring 35 of the initiator body 12. The booster-explosive head 36, which may be made of aluminum, for example, is bonded to a closure disc 40. The booster-explosive head 36 and closure disc 40 may be part of the container 43 for the main charge 44. The bonding agent 42 may be an epoxy resin, for example. The central area of the booster head 36 contains a material such as thermite, for example, for igniting the main charge. Such a material may, or may not, be necessary.

The electrical explosive initiator 10 has a cylindrical body, or housing, 12. The body 12 is sealed at the left by the rear environmental seal 34 through which the electrical ignition leads 28 are brought in. The seal is placed in a boring in the body 12 and may, for example, be made from an epoxy resin which will bind to a metal. The body 12 may be made from a hardened steel, for example.

The following description should be read in relation to all the figures.

The leads 28 are brought forward through a pair of holes 15, 15′ in the initiator body and around a circular anvil cutter 16 close to, or touching the front corner 17 of the cutter. Spaced forwardly of the cutter 16 and forming a sliding fit with the inner diameter of the initiator body 12 is a cylindrical piston 14. At its rear end, the piston 14 has an internal boring comprising a cylindrical rear portion 51 and a tapered front portion 50. The inner diameter of the rear portion 51 is slightly greater than the outer diameter of the front part of the anvil cutter 16. The front portion of the piston boring tapers inwardly from a maximum diameter which is the same as that of the rear cylindrical portion 51. The anvil cutter 16 and the piston 14 may, for example, be made of hardened and mild steel, respectively.

It may be noted that the anvil cutter has a cylindrical front section 25 which has a smaller diameter than its rear section 29, the rear section 29 being pressed into a boring in the body of the initiator by a force fit. The anvil cutter is made as a separate piece because boring out the area 27 (into which the rear end of the piston will fit, as explained later) is difficult to do. Theoretically, the anvil cutter could be simply an integral part of the initiator body. The holes 15 and 15′ are drilled after pressing the anvil cutter 16 in the initiator body 12.

The front part of the piston 14 has another central cylindrical boring 19 in which there is a container 22 for an explosive ignition mix 24. The container 22 is tubular and may be made of nylon or polyethylene, for example. The disc 18 is a low-pressure end seal made of an electrical insulating material, such as a ceramic, which has to be capable of holding up to a pressure a little above what the piston lip 46 will shear at.

The electrical leads 28 are brought into the mix container through insulator collars 21 which may be of epoxy resin, for example. The wires are brought through holes in the low-pressure seal 18 and connected to a bridge wire 20.

The forward end of the ignition mix container is sealed by a closure disc 26 which has an epoxy bead 32 around its periphery, the bead comprising a front environmental seal of the initiator. The disc may also be secured by a crimping or staking process.

The front end of the piston 14 has a lip, or flange, 46 encircling it. This lip 46 abuts a shoulder on the inner diameter of the initiator body 12 and locks the piston in place.

The front boring in the initiator body consists of three parts. From front to rear, and in order of decreasing diameter, these parts are:

a. the part which receives the piston lip **46**;

b. the part which receives the remainder of the piston; and

c. the part which receives the rear section of the anvil cutter.

In operation, a current through the electrical leads **28** heats the bridge wire **20** which ignites the explosive ignition mix **24**. Ignition is transferred to the secondary booster explosive **38** and then to the main charge **44**. The low-pressure seal **18** resists pressure leakage until the internal vessel pressure **48** reaches a predetermined amount which causes the piston lip **46** to shear. Shearing of the lip **46** allows the piston **14**, under considerable acceleration, to move to the rear. The rearward movement of the piston cuts the electrical leads on the sharp circular corner of the anvil cutter **16**. The interference fit between the cutter and the boring in the piston causes the piston to begin to expand. The tapered portion of the piston aids the piston expansion causing a compressive metal-to-metal seal between the piston, anvil cutter and initiator body. Increasing internal vessel pressure increases the compressive forces aiding the seal.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In an electrical explosive initiator having a cylindrical body, a rear seal, electrical ignition leads coming into said body through said rear seal, a container for an explosive ignition mix located within said body at the front end and a bridge wire within said container, said electrical ignition wires being connected to said bridge wire, the improvement comprising:

cylindrical cutting means having a front corner and being located within said initiator body, said electrical leads running through the body into a space between the cutting means and the body; and

cylindrical piston means located within and abutting said initiator body in front of and spaced from said cutting means, said piston means being formed with a central front boring, a central rear boring, and a peripheral lip which engages said piston,

said ignition mix container being located in said front boring and said electrical leads running through said rear boring and said piston means to said ignition mix container,

said rear boring being formed with a cylindrical rear portion and a tapered front portion, the inner diameter of the rear portion being slightly larger than the outer diameter of the corner section of said cutting means,

whereby, when the piston means is moved to the rear, the electrical leads are sheared off between the edge of said rear boring and the corner of said cutting means, and the rear of the piston is driven into the space between the cutting means and the initiator body and the tapered portion is driven against said corner to form a tight seal between the corner, the piston means and the initiator body.

2. An initiator as in claim **1**, wherein said piston means, said initiator body and said circular means are made of metal, and the seal formed between them is a metal-to-metal seal.

3. An initiator as in claim **1**, wherein said initiator body is formed with a boring at its front end which is somewhat greater in diameter than the inner diameter of the body, said lip of said piston fitting into this front end boring of the body, said lip being sheared off by the corner formed by this front end boring if the piston means is moved to the rear by a sufficient force.

4. An initiator as in claim **1**, wherein said circular means is shaped like a pair of cylinders of different diameters abutting each other with a common axis, the cylinder with the smaller diameter being in front of the other.

5. An initiator as in claim **1**, further including an annular sealing means, the initiator body having an outstanding ring-shaped member at its front end, the sealing means being retained in the ring-shaped member for pressure-sealing any cylindrical object of the proper size which is placed within the sealing means.

6. An initiator as in claim **1**, wherein the initiator body is formed with a front boring of three sections,

the front section having the greatest diameter and receiving the lip of the piston means,

the middle section receiving the rest of the piston means, and

the rear section having the smallest diameter and receiving the cutting means.

7. An initiator as in claim **4**, wherein the initiator body is formed with a front boring of three sections,

the front section having the greatest diameter and receiving the lip of the piston means,

the middle section receiving the rest of the piston means, and

the rear section having the smallest diameter and receiving the section of the cutting means with the greater diameter.

* * * * *

United States Patent [19]

Damon et al.

[11] **3,754,511**

[45] **Aug. 28, 1973**

[54] **FUEL AND FUEL IGNITER FOR RAM JET AND ROCKET**

[75] Inventors: **Glenn H. Damon**, Pittsburgh; **John Ribovich**, McKeesport; **Joseph A. Herickes**, Pittsburgh, all of Pa.

[73] Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, D.C.

[22] Filed: **Mar. 26, 1959**

[21] Appl. No.: **802,260**

Related U.S. Application Data

[62] Division of Ser. No. 478,949, Dec. 30, 1954, Pat. No. 2,895,788.

[52] **U.S. Cl.** **102/102**, 60/256, 60/270, 86/1, 102/49.7

[51] **Int. Cl.** **F42b 1/00**, F02k 7/08

[58] **Field of Search** .... 102/39, 90, 49, 35.6 RS, 102/65, 66, 6, 35.2, 35.4, 35.6, 35; 60/35.6 RR, 35.6 RS; 86/1, 19, 20

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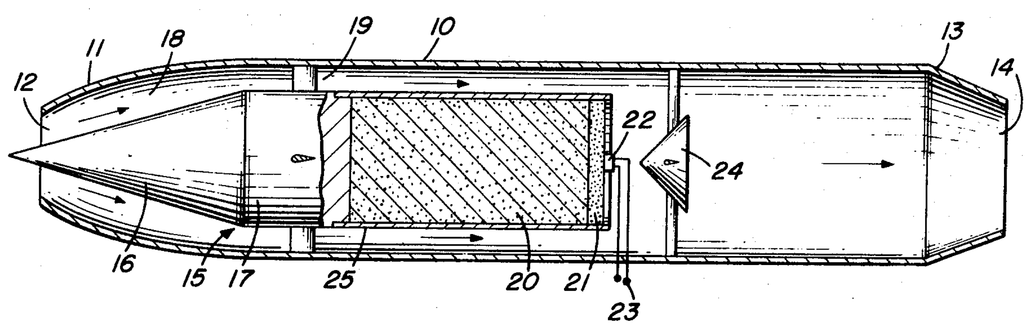
Primary Examiner—Robert F. Stahl

Attorney—W. O. Quesenberry and Claude Funkhouser

EXEMPLARY CLAIM

1. A fuel unit for forced air flow ram jet combustion chambers comprising a briquet of compressed mixed powdered oxidants and reductants, a magnesium shell encasing said briquet, and a film of plasticized nitrocellulose consisting of 25 percent by weight of alcohol-wet nitrocellulose in 75 percent by weight of Dibutylphthallate between the briquet and shell.

2 Claims, 2 Drawing Figures



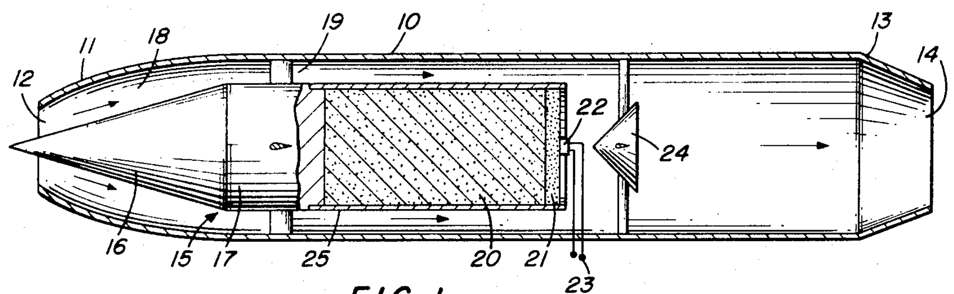


FIG. 1

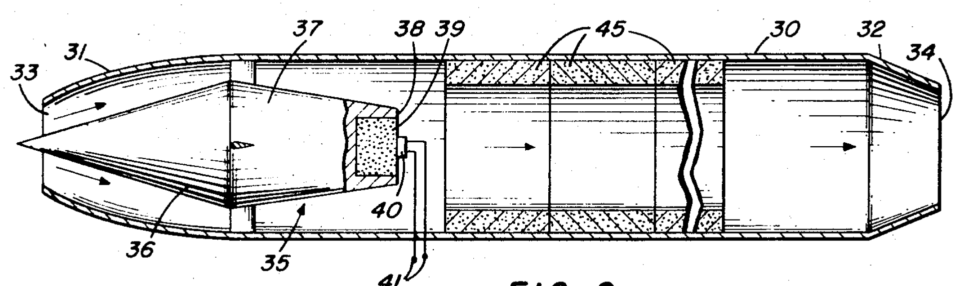


FIG. 2

INVENTORS
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JOHN RIBOVICH
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BY R. I. Tompkins
ATTORNEY

FUEL AND FUEL IGNITER FOR RAM JET AND ROCKET

This application is a division of application Ser. No. 478,979, filed Dec. 30, 1954, now U.S. Pat. No. 2,895,788.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to fuels suitable for thermal jet engines, such as the ram jet and turbo jet, as well as for force-feed furnaces, rockets, and similar apparatus.

It is customary to use liquid fuel for jet engines, but such use is known to have certain pronounced disadvantages. For example, while liquid fuels have a high energy content per unit weight their relative low densities necessitates large fuel tanks, they tend to burn erratically at high altitudes and, in general, they require complex controls to secure satisfactory regulation of flow. In addition, liquid fuel ram jets have poorer performance than solid fuel ram jets of comparable size, the former requiring approximately twenty percent increase in length and twenty percent increase in weight to secure equivalent net thrust and thrust coefficients.

It is accordingly an object of this invention to provide a solid fuel usable for jet engines and the like which is efficient in use as compared to liquid fuels.

A further object is to provide a solid fuel which is readily ignitable in the rpesence of high speed air flow.

An object, also, is to provide a solid fuel which, although independent of air flow for ignition, normally requires air flow for complete combustion.

Still other objects are to provide a solid fuel which is readily controlled as to rate of combustion, which does not require binders, and which burns readily upstream from a point of ignition.

An important object of the invention is to combine boron in the fuel composition in such a manner as to secure exceptionally high burning rate. This inventive feature is the subject of our co-pending application Ser. No. 478,949, filed 30 Dec. 1954 of which this is a divisional application.

An object also is to provide a solid fuel furnace arrangement, including gas mixing apparatus, which will secure approximately complete combustion of the fuel.

Other objects and features of the invention will appear on consideration of the following description of the fuel composition and apparatus reference being made to the accompanying drawing in which:

FIG. 1 is a view of a ram jet with a solid fuel charge therein; and

FIG. 2 is a view of a ram jet with a modified fuel arrangement.

The arrangement of FIG. 1 includes a cylindrical casing **10** having an entrance section **11** tapered toward the casing axis to form an inlet **12**, and an outlet section **13** also tapered toward the casing axis to form a constricted outlet **14** for high pressure fuel gas.

In the upstream end of the casing is an axially positioned diffuser **15** having a conical section **16** and a cylindrical skirt section **17**, the cone tip lying forward on the casing axis and the cone surface forming with the entrance section **11** an inlet passage way **18** of progressively decreasing thickness terminating at a point adjoining an annular passageway **19** formed by the casing wall and the cylindrical skirt section **17**. Passageway **19** is continued by the space formed between the casing wall and the fuel charge in the form of a solid cylindrical briquet **20** having a diameter equal to that of the diffuser skirt **17** and such length as may meet the purpose of the jet engine. The briquet is encased in a thin shell **25** formed of combustible metal, plastic or paper. Magnesium, being both readily combustible in air and heat liberating, has been found to be particularly useful. The downstream end of the briquet is formed with a terminal layer **21** of igniter material and an electric squib **22** actuated by power from electric power lines **23** is used to kindle the igniter. The igniter material may be identical to the fuel in composition but more loosely compacted so as to permit more rapid heat spread. Increased proportions of oxidants may also be used to increase the burning rate.

Downstream of the charge igniter is a turbulator **24** consisting of a conical mass with its main axis coinciding with the casing axis and its cone point upstream, thus forming a gas flow diverting and mixing element for securing approximately complete combustion of the fuel.

In operation, after the desired airflow in the arrow direction is established, the squibb is actuated thus energizing the igniter **21** and igniting the fuel **20** adjacent the igniter. The fuel then burns as a cigarette, moving upstream at a rate predetermined by the quantity of fuel oxidant, the particle size of the oxidant, the compactness of the charge and the composition ingredients of the fuel. Burning particles are blown off the charge mass by the air flow and carried past the turbulator **24** where they are thoroughly mixed with the air to complete combustion. The heated gases are then projected through the constricted outlet **14**, thus developing thrust for jet propulsion.

In the use of the described burner, the nature of the fuel becomes an important consideration since it must have high energy content, develop thrust rapidly and function without complete dependence on air flow. A fuel found adequate to these demands may be selected from one of the following compositions, parts by weight being given:

MATERIAL	A	B	C
Aluminum	37.5	55.0	15.0
Magnesium	37.5	—	45.0
Boron	—	10.0	10.0
Potassium nitrate	17.9	25.0	21.4
Copper sulphate	7.1	10.0	8.6

Preferably pyrotechnic aluminum and anhydrous copper sulphate are used. The constituent ingredients are ground to particle size, this being important as affecting efficiency through complete reaction and uniformity in the rate of burning. Particularly, the rate of burning increases with decrease in size of the oxidant particles, (potassium nitrate, copper sulphate). The substances are them mixed thoroughly in appropriate equipment and then pressed, as briquets, into the desired forms. For the solid briquet of FIG. 1, the powder is placed in a thin-walled shell of magnesium which, in turn, is encased by a heavy-walled steel mold. A case hardened steel-tipped plunger is then applied, gauge pressures up to 45,000 pounds per square inch being used. Desirably a lubricant such as a plasticized nitrocellulose is coated over the inner surface of the magnesium tube to facilitate assembly, to prevent tube shrinkage and to retard or prevent accelerated peripheral burning in the combustion process. Furthermore, by preventing powder from entering the clearance space between plunger and shell, an easy sliding action of the plunger is secured and avoidance of tube compression and contraction.

The significant factor of the mentioned compositions is that each is formed of reductants and oxidants, the proportional amounts of reductants and oxidants being noncritical but the oxidant proportions being always less than the stoichiometric value of the compounds produced by the combination of the oxidant and reductant. In other words, both classes of ingredients are required, but the percentage of oxidants depends on the rate of combustion and the thermal energy per unit volume desired, having in mind that air supplies part of the needed oxygen. In general, self propagation of fuel is obtained with oxidant concentrations as low as five percent by weight, with the fastest burning rates occurring in the range of 25 to 35 percent, at all densities. The composition examples, therefore, are typical and not restrictive, except with reference to boron, which will now be considered.

To insure optimum heat energy content in the fuel it is usually desirable to eliminate a binder as not contributing importantly either to flow rate or energy. Consequently, high pressures are required to secure coherence of the forming powders, and the resultant high density tends to slow down combustion below the 0.3 to 2.0 inch per second rate required for efficient use of the described burner form of FIG. **1**. It has been discovered, however, that the addition of a small percentage of boron not only adds appreciable heat energy to the composition but also markedly increases the rate of heat flow. For example, if 15 percent boron is substituted for aluminum in a composition of 70 percent aluminum and 30 percent oxidants, the flow rate is increased 20 to 50 percent. In a similar composition containing 70 percent magnesium and 30 percent oxidants, 15 percent boron substituted for magnesium increases the burning rate of the solid briquet from 0.6 inch to 1.2 inch a second, an increase of 100 percent. In addition the heat release of boron is high, approaching the theoretical limit of some 25,000 BTU/lb. Peculiarly, boron functions in the composition as above described only in the absence of a binder as an ingredient.

The heat flow from the solid fuel type charge is dependent upon the burning surface area, the inherent burning rate of the fuel mixture and the pressure prevailing in the engine. An important advantage of the cigarette type charge, therefore, lies in its constant burning area, this giving a basis for close control of burning rate. Further, this type charge by its central and symmetrical placement has a low drag coefficient; and the use of the turbulator in the flow stream below the charge enforces a thorough mixing of the burning fuel particles with air and final complete combustion. Through this turbulator use, it has become possible to decrease the length of the engine combustion chamber to practical limits, to increase the combustion efficiency from about 25 percent to about 75 percent and to increase the overall engine performance. Air specific impulses of 100 to 185 lb/secs. per pound of air have been attained for fuel-air ratios in the range of 0.5 to 0.3.

While the fuel composition including oxidants and reductants, as hereinabove described, has particular utility in the arrangement of FIG. **1**, such compositions are also usable in other arrangements, as shown for example, in FIG. **2** and set out in detail in the copending application of Glenn H. Damon and John Ribovich, Ser. No. 423,262, filed 14 Apr. 1954.

In this alternative arrangement the cylindrical casing **30** is fashioned for ram jet use with the constricted inlet and outlet sections **31** and **32**, defining the inlet and outlet **33** and **34**, respectively. The diffuser **35** is formed with a cone section **36** and a coaxial truncated cone section **37**, these sections having abutting bases with the cone section apex upstream and extending beyond the inlet opening, and the truncated section **37** extending a short distance downstream. The downstream end **38** of the truncated section is recessed to receive an igniter **39** composed of a loosely pressed mixture of the fuel material, of the same proportion of oxidants and reductants or of increased oxidants to speed the igniting action.

An electric squib **40**, adapted for actuation through power lines **41**, kindles the igniter.

Downstream of the igniter is the fuel bed in the form of tubular briquets **45**. These briquets are made from oxidants and reductants as in the previously described fuels but differing in the absence of boron and the use of a binder. Typical compositions follow, parts by weight being given:

MATERIAL	D	E
Aluminum	—	31.9
Magnesium	30	31.9
Coal	45	—
Potassium nitrate	10	15.2
Copper sulphate	—	6.0
Binder	15	15.0

The binder may be a plasticized nitrocellulose, rubber cement, asphalt, latex, linseed oil or polymerizable resins. The copper sulphate is anhydrous.

In making the briquets, the finely ground component substances are mixed thoroughly and pressed into form, obtaining densities ranging from about 1.4 to 1.9 gm/cc, in accordance with the particular composition and pressures used. A curing procedure, dependant on the type of binder, is then employed and the briquets are then ready for end to end insertion in the combustion chamber of the casing **30**.

In operation, air is passed through the casing as indicated by the arrows, and at the desired speed of flow the squib is activated to kindle the igniter. Whereupon, burning igniter particles in molten form are caught up by the air-stream and sprayed over the inner surfaces of the briquets igniting the same, the briquets burning radially. The small concentration of oxidant in the fuel promotes rapid ignition and ready propagation of the burning front, while the airstream completes the oxidation of the fuel. Thus, oxygen in both oxidant and air has a necessary function in the combustion of the fuel, as in the modification of FIG. **1**.

In describing the invention two structural forms have been indicated with specified substances forming the fuel and igniter. Obviously, modifications and substitutions are available, not only in the structure and materials but in the proportions of substances used. For example, the ratio of oxidants to reductants may be varied over a wide range, self propagation of burning being secured with oxidant concentrations as low as five percent. Also, while aluminum, magnesium and other reductants and potassium nitrate and other oxidants are specified, these are mentioned by way of example, many other reductants and oxidants being usable.

Thus, all or part of the aluminum included in the described compositions may be replaced by magnesium or one or more of the following reductants: boron, carbon, boron carbide (B_4C), magnesium carbide (MgB_6), sulphur, lithium boron hydride ($LiBH_4$), titanium, titanium hydride (TiH_2), zirconium, zirconium hydride (ZrH_2), and other similar metals, hydrides and metallic alloys. All or part of the magnesium may be replaced by aluminum or one or more of the substances mentioned in the above sentence. All or part of the coal may be replaced by magnesium, boron, carbon, zirconium, boron carbide (B_4C) magnesium boride (MgB_6), sulphur, lithium boron hydride ($LiBH_4$), titanium, titanium hydride (TiH_2), lithium hydride (LiH), zirconium hydride (ZrH_2), and other similar metals, hydrides and metallic alloys. All or part of the copper sulphate and potassium nitrate may be interchanged or replaced by potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), ammonium perchlorate (NH_4CLO_4), potassium perchlorate ($KCLO_4$), or the nitrates, chlorates, sulfides and oxides of other metals having similar properties.

Plasticized nitrocellulose has been specified as the lubricant used on the inner magnesium tube wall, this term being used since a large variety of plasticizers may be used, over twenty which were examined being found satisfactory. Dibutyl-phthallate may be mentioned by way of example, as a specific plasticizer. The lubricant is made by dissolving 25 percent by weight of the alcohol-wet nitrocellulose in 75 percent by weight of plasticizer, and subjecting the solution to agitation for several hours, to obtain a homogeneous, viscous product.

In structure, while an outwardly deflecting turbulator is shown in FIG. 1, wall deflectors moving the air into a central fuel stream may obviously be employed. Also, while electric squibs are described as initiators, other devices, such as gas flames, black powder, electric sparks and spontaneous chemical reactions, such as that of glycerin on powdered potassium permanganate ($KMnO_4$), may be used. In addition, the use of a single axial charge in the combustion chamber is illustrative, a bank of parallel small diameter charges being an effective alternative arrangement. Also, the hollow briquet may be used jointly with the solid cigarette type, either in series or the briquet enclosing the other charge. To modify the fuel rate, also, the charge may be in series segments of different specific compositions and burning rates.

Dominant advantages of the fuel systems, as described, include the following items:

By using air as a collateral oxydizing agent in fuel combustion, it is necessary only to employ sufficient oxidants to obtain the desired burning rate, thereby insuring a high thermal fuel capacity. A pronounced flexibility in control of the fuel burning rate is possible by variation in the proportion and particle size of oxidants in the fuel. By use of boron, compressed powdered fuels without binders may be burned successfully in ram jets, giving increased heat content per unit volume of fuel. With boron, the rate of burning is largely increased without reduction in the heat release of the fuel. By using a magnesium enclosure on the solid type briquet erratic peripheral burning of the charge is prevented.

Modifications of the heating unit and compositions other than herein above stated may be made and hence no restriction of the disclosure is intended other than may be required by the claims hereto appended.

What is claimed is:

1. A fuel unit for forced air flow ram jet combustion chambers comprising a briquet of compressed mixed powdered oxidants and reductants, a magnesium shell encasing said briquet, and a film of plasticized nitrocellulose consisting of **25** percent by weight of alcohol-wet nitrocellulose in **75** percent by weight of Dibutyl-phthallate between the briquet and shell.

2. A fuel unit for use in a forced air flow ram jet combustion chamber comprising a solid cylindrical briquet of compressed powder, said powder being a mixture of reductant particles and oxidant particles with the oxidant particle concentration being less than the stoichiometric value for the compounds resulting from the combination of said oxidant concentration with the reductant concentration, a cylindrical combustible metal shell having open ends, said shell surrounding the periphery of said briquet, a film of plasticized nitrocellulose between said shell and said briquet, a solid cylindrical igniter inserted in one end of said shell so as to abut against the full cross-sectional area of one end of said briquet, an electric squib mounted on said igniter, the other end of said shell being adapted to fit over a cylindrical skirt section mounted in said combustion chamber, said shell and film being exothermally combustible in air whereby upon ignition of said one end of said briquet said briquet and shell burn at a controlled rate throughout the length of said briquet, with the burning proceeding toward the opposite end of said briquet over constant successive cross-sections of said fuel unit, said cross-sections being taken in planes substantially perpendicular to the axis of said briquet.

* * * * *

Sept. 18, 1962 A. R. APODACA ETAL 3,054,351

IGNITER

Filed Jan. 12, 1959

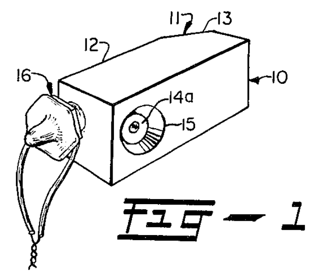

Fig — 1

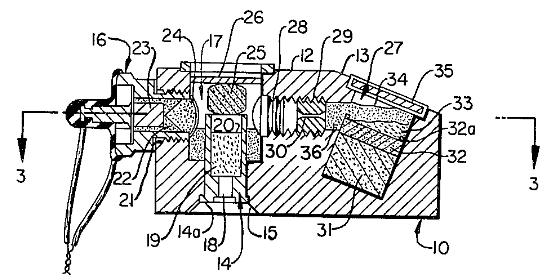

Fig — 2

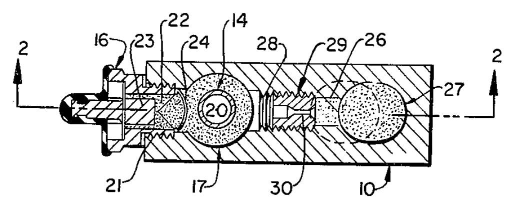

Fig — 3

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3,054,351

Patented Sept. 18, 1962

3,054,351

IGNITER

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Filed Jan. 12, 1959, Ser. No. 786,349
13 Claims. (Cl. 102—70)

The present invention relates generally to ignition means for equipment operated by a charge of propellant, and particularly to apparatus such as flame throwers or liquid fuel rockets or the like in which a portion of the fuel is fed into a flame cone under pressure and ignited therein to effect ignition of the main stream of fuel.

The invention will be hereinafter described with relation to the flame thrower generally described in copending patent application Serial No. 786,350, filed January 12, 1959, and the gas generator specifically described in the same application, to which copending applications reference may be made for information on parts having cooperative relation to the ignition means to which the present invention specifically relates.

In the flame thrower for use with which the igniter of this invention is particularly adapted, the fuel tank is pressurized by a gas generator containing a charge or grain of solid propellant, and the nozzle from which the pressurized fuel is projected in a rod-like stream is positioned adjacent the gas generator.

The issuing stream of fuel requires ignition for which purpose the nozzle is arranged within a flame cone or combustion chamber into which a small secondary jet of fuel is sprayed. The combustion of the secondary jet is initiated by the ignition means, and is thereafter supported by air flowing into the flame cone.

It is therefore the principal object of the present invention to provide a novel method of and improved means for ignition of a pressurized liquid fuel stream.

Another object of this invention is to provide a novel method of and improved means for dual ignition from a single source of separate and individual gas generating means.

And another object is to provide a novel method of and improved means for ignition from a single source of a pressurizing charge of propellant and a stream of fluid expelled by the pressure generated therefrom.

With the above objects in view and further objects and features of the invention which will hereinafter appear from the following specification read with reference to the accompanying illustrative drawings, the invention comprises an igniter device containing a pair of chambers one of which is charged with pyrotechnic material developing sufficiently intense heat when ignited to cause the propellant grain to start burning to generate a sufficient volume of gas at a pressure capable of pressurizing a tank of fuel to expel a rod-like stream of fuel from a nozzle. The other chamber is charged with an incendiary oxidizing combustible mixture furnishing flame for a length of time sufficient to cause ignition of a spray of fuel bled into a flame cone surrounding a nozzle arranged in a flame cone to ignite the surface of said fuel rod in the flame cone. The chambers are connected by a fine aperture which is effective to cause ignition of the material in the second chamber without passing sufficient gas from the first chamber to cause smothering of the flame in the flame cone or disruption of the stream of fuel.

In the drawings:

FIG. 1 is a perspective view of the igniter device of this invention.

FIG. 2 is a section on the line 2—2 in FIG. 3.

FIG. 3 is a section on the line 3—3 in FIG. 2.

Referring now to FIG. 1, the igniter, indicated by the numeral 10, comprises a rectangular steel block having one corner 11 angled off.

A first chamber containing a pyrotechnic material together with means for initiating the combustion thereof opens into the face 12. This acts to ignite the grain in a gas generator containing a solid propellant (not shown). A second chamber containing an incendiary oxidizing combustible mixture opens into angled face 13, serving to ignite the jet of fuel sprayed into the flame cone (not shown).

The pyrotechnic materials in the first chamber may be ignited by a conventional black powder cartridge 14, the base 14*a* of which is shown mounted in a flared opening 15 serving to receive the head of a hollow clamping screw (not shown) by which the igniter is positioned in a stirrup projecting from the base of the gas generating chamber and through which the firing pin of a trigger device extends. The flame of the ignited pyrotechnic material in the first chamber is directed against the grain to furnish sufficient heat to cause the grain of propellant to start burning after which it will generate the temperature and pressure to continue burning until completely consumed.

The material in the first chamber may be ignited alternatively by the glow plug indicated at 16.

As shown in FIG. 2, the first chamber comprises a bore 17 which is narrowed to closely fit the base 14*a* of the blank cartridge 14 which is fired by the percussion cap 18 in the base, which ignites the charge of black powder 19 in the cartridge case. The surface of the powder is covered by a film 20 of "Mylar," a polyester plastic film produced by the Du Pont Company, or other suitable material to retain the powder in place.

An opening 21 in which the glow plug 16 is mounted is also filled with black powder 22 into which the heating filaments 23 of the plug extend and the inner end of the opening is covered with a thin film of highly inflammable cement 24 consisting of a mixture of cellulose nitrate and black powder in an acetone solvent.

A pellet 25 of pyrotechnic material consisting of powdered aluminum and ammonium perchlorate, is secured in position on the end of the cartridge by a nitrocellulose adhesive and the open end of the first chamber beyond the pellet 25 is closed by a waterproof plastic closure 26. The whole of the space in the first chamber except that shut off by the films of inflammable material is filled with powdered aluminum and ammonium perchlorate which, though not easy to ignite, produces high temperatures when burnt. The purpose of the pellet 25 is to prolong the period of combustion in chamber 17 to ensure ignition of the grain of propellant contained in the gas generator. Other pyrotechnic materials such as thermit or the like may be used.

The second chamber 27 is connected to the first chamber 17 by a passage 28 which is threaded for a portion of its length, and a threaded plug 29 is screwed into the passageway. Plug 29 is axially drilled with a fine hole 30, the diameter of the hole being important since it should be plugged as soon as the inflammable material placed in the second chamber has been ignited by flame or white hot gas from the combustion of the material in the first chamber 17. A plug of copper drilled with a No. 80 drill which has a diameter of .0135" works well.

The use of a drilled removable plug has the advantage of enabling different sized passages to be provided to suit different materials.

The second chamber 27 is formed as a bore extending in from the sloped face 13. An incendiary pellet 31 of cylindrical shape is positioned on the bottom of the chamber, a starter pellet 32 being preferably placed above it and the two elements held in place by a snap ring 32*a* and a layer of starter paste 33, leaving a space 34 communicating with passageway 28. The opening of chamber 27 in the side 13 is closed by a frangible cover or closure 35 and the space in the passage and above the starter paste 33 is packed with black powder 36.

The cylindrical incendiary pellet 31, starter pellet 32 and starter paste 33 may be composed of an incendiary oxidizing combustible mixture such as, for example, cellulose nitrate and black powder in acetone solvent. Alternatively, a pyrotechnic type material may be employed. The apparatus of the present invention is particularly adapted to employ within the second chamber 27 a solid propellant having a higher temperature of burning than the pyrotechnic material by virtue of provision of means to close the second chamber 27, raising the pressure therein to ensure continued burning. As used herein a solid propellant material shall be understood to mean generally a mixture of an organic resin binder material acting as a fuel, combined with an inorganic oxidizing salt.

The closures 26 and 35 are destroyed immediately on the activation of the igniter but until that time ensure that the igniter materials are protected from dampness.

Operation

When it is desired to cause operation of the igniter an electrical contact is closed sending current through the fine wires 23 of the plug 16 and making them red hot, thus igniting the black powder in which the wires are embedded, destroying closure 24 and igniting the inflammable powder in chamber 17, thus generating a sufficient degree of heat to cause the pyrotechnic pellet 25 to burn, the heat and pressure destroying seal 26 and providing the conditions required to start combustion of the propellant grain notwithstanding a slight loss of pressure through the small aperture communicating with the second chamber of the igniter.

It it is preferred to initiate operation manually, the percussion cap 18 is fired and the black powder in the blank cartridge 14 is ignited and the above-described sequence of events takes place.

The incendiary oxidizing combustible mixture in the chamber 27 burns vigorously with a long tongue of flame momentarily but no high pressure rush of gas into chamber 27 due to the pressure of the burning grain takes place since the small diameter of the passage between the chambers of the igniter acts to both throttle the pressure and reduce the temperature of the fine stream of gas.

In actual practice it was found that the small diameter hole 30 became clogged very quickly and that combustion of the auxiliary fuel around the nozzle took place under steady conditions after initiation thereof by the igniter.

A preferred embodiment has been specifically described and shown by way of illustration only and not as limitative of the invention since various modifications in the described embodiment may be made by those skilled in the art without departing from the scope of the invention as defined by the appended claims.

We claim:

1. A dual purpose igniter comprising: an igniter body provided with a first and a second chamber communicating with the surface of the body; a charge of gunpowder positioned in said first chamber together with a charge of loose powdered aluminum with potassium perchlorate; a diaphragm within said first chamber separating said gunpowder from the powdered aluminum with potassium perchlorate; a pellet of compressed powdered aluminum and potassium perchlorate positioned in the loose powdered aluminum with potassium perchlorate to be ignited by the combustion thereof and prolong the flame of said combustion; said igniter body having a first port directing the products of combustion in the first chamber; said igniter body having a restricted passageway means leading products of combustion from the first chamber to said second chamber and adapted to be clogged by the products of combustion; a charge of an incendiary oxidizing combustible mixture positioned in the second chamber; said igniter body having a second port directing the flame issuing from the second chamber when the material therein is ignited; a diaphragm of rupturable material closing said first port until destroyed by the combustion of material in the first chamber; and means for igniting the gunpowder within the first chamber.

2. Apparatus as in claim 1 wherein said incendiary oxiding combustible material comprises a cellulose nitrate and black powder in acetone solvent.

3. Apparatus as in claim 1 wherein said incendiary oxidizing combustible material comprises a pyrotechnic mixture.

4. Apparatus as in claim 1 wherein said incendiary oxidizing combustible material comprises a solid propellant material.

5. A dual purpose igniter as set forth in claim 1 in which said igniting means comprise: a percussion cap fitted in the base of a cartridge containing gunpowder extending into the first chamber; and an opening in a wall of the first chamber in which said base of said cartridge is mounted in pressure-tight relation therewith.

6. A dual purpose igniter as set forth in claim 1 in which said igniting means comprise: a glow plug mounted in a passage leading from the surface of said body to said first chamber and in pressure-tight relation with said passage; and a charge of gunpowder in said passage between the glow plug and the inner end of said passage.

7. A dual purpose igniter as set forth in claim 1 in which said igniting means comprise: a percussion cap fitted in the base of a cartridge containing gunpowder extending into the first chamber; and said first chamber having an opening therein in which said base of said cartridge is mounted in pressure-tight relation therewith; a glow plug mounted in a passage leading from the surface of said body to said first chamber and in pressure-tight relation with said passage; and a charge of gunpowder in said passage between the glow plug and the inner end of said passage.

8. A dual purpose igniter comprising: an igniter body provided with a first and a second chamber communicating with the surface of the body; a charge of pyrotechnic material positioned in said first chamber and adapted to produce an intense flame when ignited to ignite said charge of propellant; said igniter body having a restricted passage of such a size to be clogged by the passage of products of combustion connecting the first and second chambers; a charge of gunpowder positioned in said second chamber to be ignited by products of combustion from said first chamber; a cohesive layer of pyrotechnic material contacting said charge of loose gunpowder and positioned above and adhered to a charge of incendiary oxidizing combustible mixture positioned between said layer of pyrotechnic material and the bottom of said second chamber, said incendiary charge being effective to provide a large volume of flaming gas at low pressure; means for holding said layer of pyrotechnic material in place in said second chamber; a port in the surface of the igniter body directing the flaming gas generated by said incendiary material in the second chamber; a closure for said port disrupted by the ignition of the loose gunpowder positioned between the closure and the layer of pyrotechnic material; and means for igniting the pyrotechnic material in the first chamber.

9. A dual purpose igniter as set forth in claim 8 and in which said means for holding said layer of pyrotechnic material in the second chamber and incendiary oxidizing combustible mixture in place comprises a snap ring engaging with the periphery of the chamber and bearing against the upper edge of said cohesive layer of pyrotechnic material.

10. A dual purpose igniter as set forth in claim 8 and in which said cohesive layer of pyrotechnic material posi-

tioned in the second chamber is formed from a paste consisting of cellulose nitrate and gunpowder with an acetone solvent mixture, and a quantity of the paste form of the material is positioned in contact with the cohesive layer of the pyrotechnic material and with the gunpowder.

11. A dual purpose igniter as set forth in claim 8 and in which said charge of pyrotechnic material is thermit.

12. An igniter comprising a block having a first chamber and a second chamber separated from each other within the block, each of said chambers communicating separately with the exterior of said block, a pyrotechnic material in said first chamber and a combustible material in said second chamber, means for igniting said pyrotechnic material to cause flame to leap from said first chamber to the exterior of said block and a duct interconnecting said chambers within the block, said duct comprising a passageway of sufficiently large cross section to enable heat and soot from the first chamber to pass through it to the second chamber to ignite the combustible

material in said second chamber, but sufficiently small to become clogged by said soot after the combustible material ignites, whereby a tongue of flame extends from said second chamber to the exterior of said block.

13. An igniter according to claim 12 in which a plug is situated in said duct and said passageway is a hole through the plug.

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US005088412A

United States Patent [19]

Patrichi

[11] **Patent Number: 5,088,412**

[45] **Date of Patent: Feb. 18, 1992**

[54] **ELECTRICALLY-INITIATED TIME-DELAY GAS GENERATOR CARTRIDGE FOR MISSILES**

[75] Inventor: **Mihai D. Patrichi**, Los Angeles, Calif.

[73] Assignee: **Networks Electronic Corp.**, Chatsworth, Calif.

[21] Appl. No.: **556,636**

[22] Filed: **Jul. 16, 1990**

[51] **Int. Cl.**^{5} **F42C 9/10**; F42C 19/02

[52] **U.S. Cl.** **102/202.13**; 102/202.5; 149/19.3; 149/37

[58] **Field of Search** 102/202, 202.5, 202.13; 149/37, 19.3, 22

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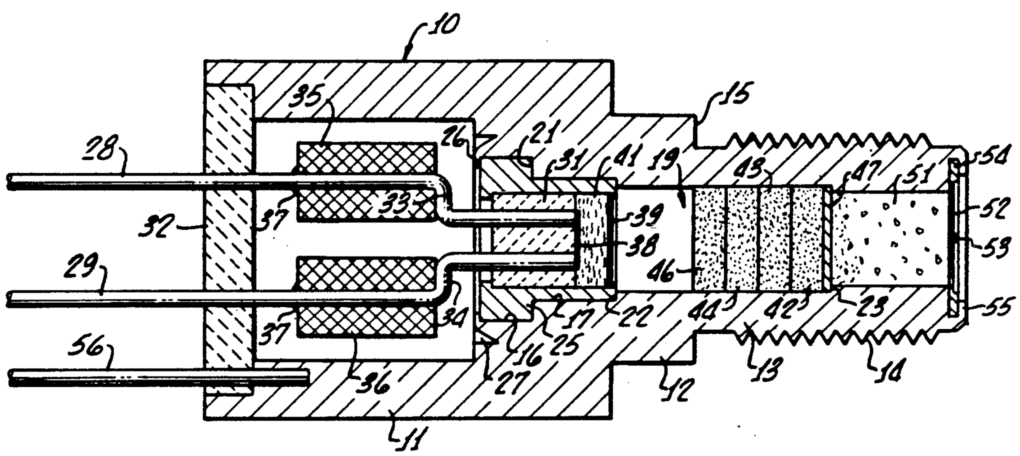
Attorney, Agent, or Firm—Poms, Smith, Lande & Rose

[57] **ABSTRACT**

A time delay gas generator for military missiles, characterized by very long shelf life and accurately-determined time delay. Time delay powder is layered at high pressure, and causes heating of a metal disc at the end of a time delay interval that is accurately known. Such heating ignites an output charged to generate gas, the gas breaking a closure and performing a function in the missile.

20 Claims, 1 Drawing Sheet



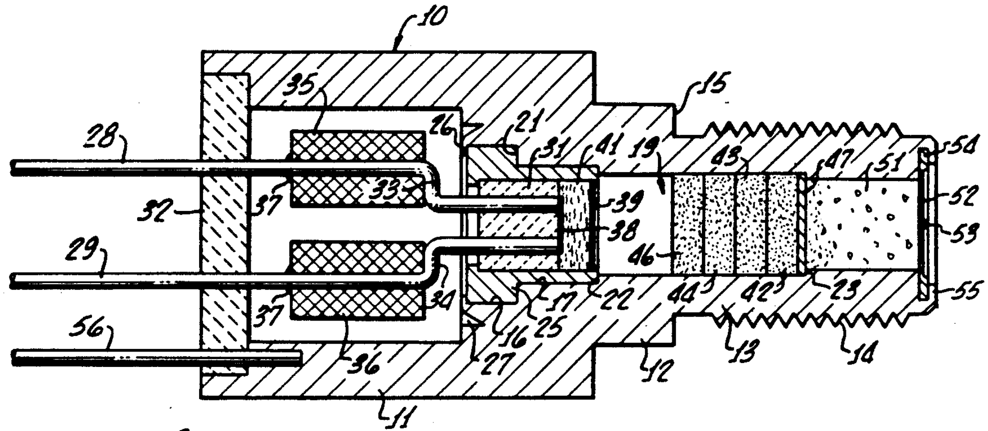


FIG. 1.

FIG. 2.

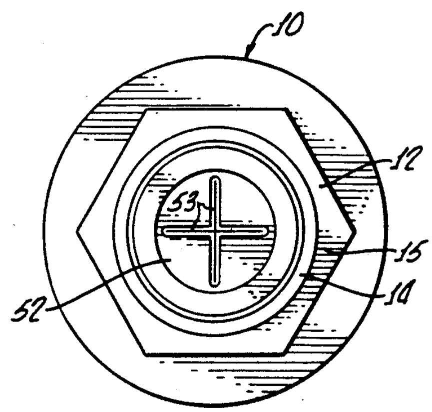
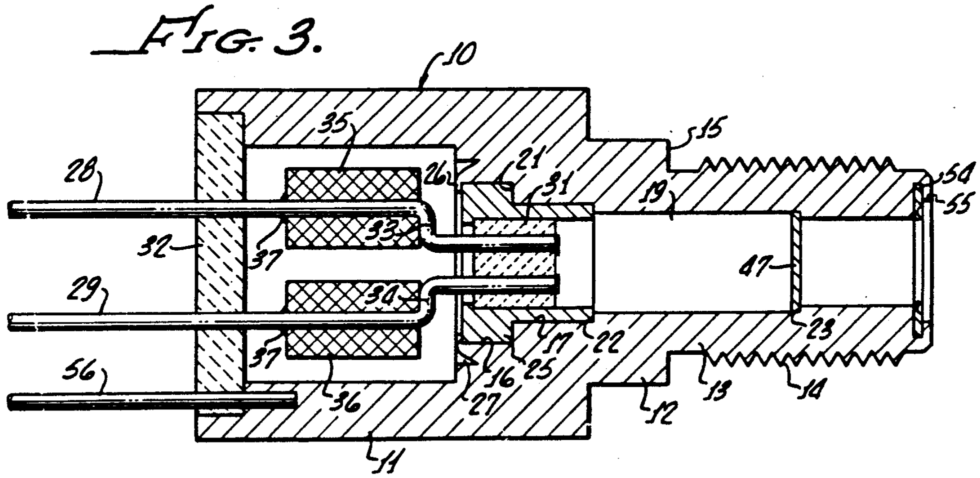


FIG. 3.



ELECTRICALLY-INITIATED TIME-DELAY GAS GENERATOR CARTRIDGE FOR MISSILES

BACKGROUND OF THE INVENTION

Historically, in commercially-used military gas generators for missiles, it has been conventional to employ electric circuits to create the time delays. Such arrangements, however, have distinct disadvantages a major one of which is short shelf life. The capacitors employed in the delay circuits tend to change characteristics over time, and this makes the gas generators unreliable vis-a-vis delay times.

It is known to use powders to generate time delays in gas generators. However, in one such device the chamber containing the delay powder was vented to the atmosphere so as to prevent the device from being fully sealed. Accordingly, and for other reasons, there was a tendency toward unreliability and lessened shelf life.

Another major disadvantage of the prior art was inability to achieve highly precise powder-column time delays in a gas generator for missiles.

SUMMARY OF THE INVENTION

The present device, which generates precisely-timed delays for the Stinger and other missiles, is believed to have a very long shelf life, of many years.

It is electrically ignited through a circuit which includes electrical filters so as to prevent ignition caused by spurious radiation.

When an ignition signal is delivered to the device, an ignition charge is ignited. The resulting heat is transferred through a void, after disintegrating a seal, to effect ignition of a delay igniter charge. The igniter charge, in turn, ignites the adjacent one of a plurality of layers of delay charges that are packed very tightly under great pressure so as to be highly uniform.

A combination of various factors creates a precisely known reliable time delay, even after passage of many years on the shelf.

Toward the expiration of the delay period, the delay powders heat to red hot condition a barrier disc against which the delay powders were compressed. The hot disc ignites a gas generating output charge, which charge includes an output ignition powder. The gas generator ruptures a sealing disc having a cruciform slot therein, so that gases at hundreds of psi are transmitted to a desired region of the Stinger or other missile.

The gas generator device generates pressures of, for example, 400 psi to 700 psi. It will operate with a function time of 170 msec, with a reliable and reproducible tolerance of +18 msec (milliseconds) and −10 msec.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal central sectional view showing the present time delay gas generator cartridge for missiles, in its condition prior to firing;

FIG. 2 is an elevational view of the output end of the unfired cartridge, namely the right end of FIG. 1; and

FIG. 3 corresponds to FIG. 1 but shows the cartridge in its condition after firing.

DETAILED DESCRIPTION OF THE INVENTION

The device comprises an elongate metal housing **10** that is preferably quite small, for example 1⅓ inches long and ⅔ inch in maximum diameter. The larger-diameter portion of housing **10** is a hollow cylindrical body **11**. Body **11** connects coaxially through a smaller diameter hexagonal neck **12** (FIGS. **1** and **2**) with a head **13** of still-smaller diameter. Head **13** is externally threaded at **14** so that the device may be threaded into an internally threaded opening, such threading continuing until a shoulder **15**, namely a radial forward face of neck **12**, engages the component into which the device is threaded.

The chamber defined within the hollow cylindrical body **11** is cylindrical and coaxial of such body **11**, and communicates coaxially with a much smaller-diameter chamber having a cylindrical peripheral wall **16**. Such chamber connects coaxially with a still smaller-diameter chamber having a cylindrical peripheral wall **17**. The last-mentioned chamber communicates coaxially with a stepped elongate passage **19** that extends clear to the inner or forward end of the housing **10**. Such passage preferably extends for about ½ the length of such housing.

There is a radial shoulder **21** extending between walls **16** and **17**, and a second radial shoulder **22** extending inwardly from cylindrical wall **17** to the cylindrical wall of the elongate stepped passage **19**. An additional shoulder, indicated at **23**, separates a larger diameter cuter portion of passage **19** from a smaller diameter inner or forward portion thereof.

An ignition subassembly, including means to prevent undesired ignition of the device by stray electromagnetic fields, is provided and inserted into the above-described chambers outwardly of passage **19**. This comprises a metal eyelet **25** having a tubular body and a thick flange. Such body and flange fit snugly in the described cylindrical chambers having walls **16**, **17**, being in close contact with such walls. The flange seats against shoulder **21**, while the forward end of the body seats against shoulder **22**, thus effectively determining the exact position of eyelet **25** in the chambers.

The eyelet and associated parts are held tightly in the chambers by a crimped neck **26** that is crimped around the outer corner of the eyelet flange. Such neck is formed from the metal of body **11** peripherally of the eyelet, there being an annular groove for this purpose as illustrated at **27**.

Relatively large diameter leads or wires **28**, **29** are fixedly secured in the housing **10** and in eyelet **25**, the inner or forward ends of the wires being fused in a mass **31** of glass. Portions of the wires **28**, **29** at the outer end of housing **11** are held in position, in sealed relationship, by an epoxy disc **32**. Such disc is seated at the outer end of body **11** adjacent shoulder portion provided at such outer end.

The wires **28**, **29** are kinked or offset outwardly at **33**, **34**. Filters **35**, **36** are threaded coaxially on wires **28**, **29** and abutted with the offset regions **33**, **34**, being held there by adhesive indicated at **37**.

The filters **35**, **36** are thus effectively and economically held in the chamber defined within body **11**, and are effectively sealed by epoxy **32** and other sealing elements. The filters are preferably of the ferrite type, 200 Mhz. They operate to prevent melting of the small-diameter bridge wire **38** that extends between wires **28**, **29** at the inner face of glass **31**, until such time as a signal is intentionally transmitted through such wires **28**, **29** when ignition is desired.

The forward or inner ends of wires **28**, **29** are ground flush with the inner face of glass **31**, and the plane of such face and the wire ends is spaced inwardly from the shoulder **22**. A Mylar disc **39** is provided in spaced relationship from such face, being held in mounted and sealed relationship by suitable adhesive.

The space between Mylar disc **39** and the forward face of glass **31** contains ignition powder **41**. The ignition powder **41** may be an of numerous ignition systems known in the art with the appropriate ignition sensitivity, heat generating characteristics, and storage properties. An oxidant/fuel pair consisting of boron/calcium chromate is particularly suitable. However, mixtures of magnesium, aluminum, titanium, or zirconium with oxidants such as ammonium or potassium perchlorate, barium or potassium nitrate, barium or lead chromate, or cupric or lead oxides may be formulated to meet the ignition requirements of this device.

Provided in passage **19**, outwardly of shoulder **23** in such passage, is the delay column for achieving a precise desired time delay, such delay column having a very long shelf life as above stated. The layers of the delay column are packed against each other, and the inner (forward) one is packed against a metal barrier disc **47** that is provided across passage **19**. Stated more specifically, the periphery of disc **47** is seated against the shoulder **23** at the junction between the larger diameter and smaller diameter portions of the stepped elongate passage **19**.

In the illustrated embodiment there are three layers **42**, **43** and **44** of delay powder, layer **42** being in direct engagement with the barrier disc **47**. The layers **42–44** are preferably of equal thickness relative to each other. Layer **42** is pressed against disc **47** at a pressure on the order of 30,000 psi. Thereafter, layer **43** is pressed against layer **42** at the same pressure, following which layer **44** is pressed against layer **43** at the same pressure.

Thereafter, a delay igniter powder **46** is pressed against the outermost delay layer **44**, in substantially spaced relationship from the Mylar disc **39** and ignition powder **41**. Thus, a substantial void is present between delay igniter powder **46** and ignition powder **41**. Such void operates, for example, to provide extreme uniformity of temperature across the outer face of igniter powder **46** after ignition powder **41** is fired.

Delay igniter **46** may be any of several suitable ignition systems which achieve uniform and substantially instant generation and transfer of igniting caloric energy to the delay discs **42–44**. Additionally, the delay igniter must be capable of ignition at the temperatures supplied by the powder **41** and transferred through the void in the delay column housing. Preferably, lead mononitroresorcinate utilized for this purpose, however; a zirconium/barium chromate igniter pair also provides the required heat transfer characteristics.

The delay powders which form layers **42–44** are crucial to the function time of the gas generator. Such delay powders must burn reliably to provide a predetermined function time at a temperature which is sufficient to ignite the output initiator powder described below. Function times are determined by 1) the burning properties or sensitivity to caloric energy of the powder, 2) the ratio of the amount of oxidant to fuel in the powder, 3) the packing density of the delay column powders, and 4) the height (length) of the delay column (or the number of layers of delay powder). The volume in the housing passage which is available for packing is also a factor, since a particularly small volume may limit the height of the delay column.

Accordingly, the function time may be altered by varying any of the determining parameters within the limits of the available volume. For applications which do not require function time tolerances of less than **25** msec, the powder mixtures and packing densities are less critical than they are relative to more demanding tolerance requirements. For example, tungsten powders combined with oxidants such as barium chromate and potassium perchlorate with a diatomaceous earth binder will burn reliably with the desired caloric energy, and with meticulously uniform packing densities and column packing heights, function time tolerances of somewhat less than 25 msec can be achieved. However, the tungsten fuel systems are better suited for less demanding applications. Additionally, such fuel systems are somewhat s sensitive to moisture and will lose activity with long term storage.

For systems demanding function times with tolerances of +/− about 10 to 20 msec, the packing density and the fuel and oxidant in column layers **42–44** are especially critical. In accordance with the present invention, columns with function times having tolerances which vary by less than **18** msec can be achieved, in a practical manner with long shelf life for the device. Such columns are suitable as reliable functional replacements for delay circuits, which contain capacitors. When appropriately stored the present delay columns will, it is predicted, remain active for at least 15 to 20 years. Similar systems which utilize capacitor circuits to achieve a delay in function are subject to failure, producing a "dud", within 5 years. Such circuit failures are caused by capacitor discharge or the inability of the capacitor to continue to hold a charge with time.

Function times of less than 300 msec, with reliably reproducible tolerances of less than 18 msec, are achieved by using as delay powders zirconium metal in combination with a red iron oxide (Fe203) and a diatomaceous earth binder. This preferred combustion system has a low sensitivity to moisture, which results in no or very little function time change with storage. Additionally, it is believed that as the oxides of zirconium form during combustion they flake off easily, thereby exposing fresh metallic surfaces to attack by the oxidizer. The constant availability of the metallic fuel element probably provides a dependable and reproducible function time for each device, provided there is a particular packing density, column height, and fuel/oxidizer ratio.

In general the delay powders do not generate substantial gases. However, at the temperatures at which the fuel burns the combustion products will expand. The additional volume, namely the described void, in the stepped elongate passage provides an expansion volume without requiring a vent system for the gas generator.

Once the delay powder has fired, the heat is transferred to barrier disc **47** in contact with an output charge **51**. The output charge comprises a mixture of output ignition powder and gas generator powders. The temperature of disc **47** is increased to red hot condition, which ignites an output ignition powder portion of the output charge. The output ignition powder is sensitive to the heat from the disc and easily ignites to provide an even and instant heat transfer to the gas generator powders. These latter powders ignite as a result of the heat transfer from the ignition powder, and burn explosively with a gas and heat output sufficient to generate pressures of several hundred psi.

The output charge **51** is determinative of the gas pressures generated by the device. The nature of the output charge powders, the ratio of fuel to oxidant in the charge, and the amount of each which is present, all contribute to the final pressure.

Output ignition powders are contained in the output charge. These have sensitive ignition properties suitable for efficient and instant transfer of the caloric energy from disc **47** to gas generator powders. Ignition powders include potassium dinitrobenzofuroxan in a diatomaceous earth binder. Lead mononitroresorcinate is also a suitable igniter.

The heat transferred by this ignition powder effectively ignites the gas generator powders which consist of gas producing explosive materials in combination or alone. A particularly suitable explosive material consists of a mixture of approximately 5% nitroglycerine and about 95% nitrocellulose. The nitrocellulose, nitroglycerine pair burns with an explosive burst producing gases from the burning hydrocarbons. Other output charges which may be used in combination include a number of fuel/oxidants which burn evenly and at a rate which produces sufficient gases to develop the desired pressures.

To achieve gas generating devices which will generate pressures in the range of 400 psi to 700 psi, the fuel/oxidant mixture of boron/potassium nitrate/zinc oxide combined with a fluoroelastomer such as Viton (TM) available from Dupont are particularly suitable. The fluorocarbon gases emitted from the output charge provide the pressure within the desired range. Additionally, the boron provides burning temperatures within a range sufficient to decompose the fluorocarbon which vaporizes to form the output gases.

Gases generated upon burning of the output charge pass instantly out the inner end of passage **19**, through a sealing disc **52** having cruciform groove means **53** therein, reference being made to FIG. 2. The peripheral region of disc **52** is relatively thick, as shown at **54**, and is held in position by a crimped annular region **55** at the inner end of head **13** of the housing.

The post-fired position of the present device is shown in FIG. 3. It is pointed out that the barrier disc **47** is still in position, after firing, despite the fact that there is no vent communicating with the portion of passage **19** upstream from the barrier disc **47**.

PREFERRED EXAMPLE

A gas generator having the construction shown in the present drawings was produced using the following procedure and materials:

The housing **10** was first manufactured, following which the disc **47** was disposed against shoulder **23**. The delay column was then formed by packing three layers **42**, **43**, **44** of powder. First layer **42** was packed first, by applying a pressure of about 30,000 psi against the powder introduced into the passage adjacent the disc **47**. In the same manner, the second layer **43** was packed against the first layer **42**. Thereafter, in the same manner, the third layer **44** was packed against the second layer **43**. Thereafter, the delay ignition powder **48** was packed against delay layer **44**.

The three separate delay powder layers **42**–**44** each consisted of a combination of zirconium/red iron oxide/diatomaceous earth. The preferred delay powders are commercially available under the designation AIA from Pyrotechnics Specialties Co. of Georgia. The three delay powder layers are of equal mass and height and total approximately 500 mg (milligrams) in weight.

The delay igniter powder **46** consisted of approximately 30 mg of zirconium/barium chromate oxidant fuel pair.

The ignition subassembly described above was manufactured, and filled adjacent glass **31**, with approximately 40 mg of boron/calcium chromate oxidant fuel pair mixture. Such powder was packed into the eyelet **25**, following which the Mylar disc **39** was positioned and adhesively sealed in place.

The ignition subassembly was then inserted into the end of housing **10** remote from the head **13**. It was held in position by crimping the above-indicated neck as indicated at **26**. Epoxy **32** was provided to seal the chamber containing the filters **35**, **36**, and to seal around the wires **28**, **29**. A third wire **56** was also provided, being inserted into a bore in the hollow cylindrical body **11** of housing **10** so as to provide a ground.

The output charge was placed adjacent the disc **47**. It comprised a mixture of approximately 20 mg of a combination of potassium dinitrobenzofuroxan/diatomaceous earth, approximately 15 mg of a combination of nitroglycerine and nitrocellulose, and approximately 30 mg of a combination of boron/potassium nitrate/Viton/zinc oxide. The sealing disc **52** was then positioned, and was held in position by crimping the extreme inner end of housing **10** around the relatively thick peripheral region **54** of such disc.

The gas generator described in such example generates pressures of from 400 psi to 700 psi. It will also operate with a function time of 170 msec with a reliable and reproducible tolerance of +18 msec and −10 msec.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

What is claimed is:

1. An electrically-initiated time-delay gas generator, which comprises:

(a) a housing having an elongate passage therein, said passage having an inner end portion that extends to an end of said housing. said housing having a relatively large diameter hollow body portion and a relatively small diameter head portion, said body portion having a relatively large chamber therein, said body portion and said head portion being coaxial, said elongate passage extending from said relatively large chamber to the inner end of said head portion,

(b) filter means provided in said relatively large chamber in circuit with said igniter assembly to prevent undesired firing of said igniter assembly,

(c) a metal barrier disc mounted in said passage transversely thereof so as to block said passage, said barrier disc being spaced from the inner end of said passage, the portion of said passage on the opposite side of said barrier disc from said inner passage end being unvented,

(d) an output seal provided in sealing relationship across said inner end of said passage so as to seal the portion of said passage between said barrier disc and said inner end, said output seal being adapted to rupture and permit rapid escape of gas from said last-mentioned passage portion,

(e) an electrically-operated igniter assembly communicating with the outer end of said passage, said igniter assembly including ignition powder and means to effect burning of said powder when an electric current is delivered to said igniter assembly,

(f) a delay column comprising a plurality of layers of delay powder provided in said passage between said igniter assembly and said barrier disc, said layers being compressed in place in said passage at pressures, sufficiently high to provide function time tolerances of less than 25msec, the outer one of said layers being packed against said barrier disc,

(g) an igniter layer provided in said passage between said delay column and said igniter assembly, said igniter layer being packed against said delay column, and

(h) an output charge provided in said passage between said barrier disc and said output seal, said delay column being adapted to burn over an accurately predetermined time period and then to heat said barrier disc, said barrier disc being thus heated to ignite and generate high-pressure gas.

2. The invention as claimed in claim **1**, in which a neck portion is provided on said housing between said body portion and said head portion, said passage passing through said neck portion, and in which said head portion is externally threaded.

3. The invention as claimed in claim **1**, in which said hollow body portion also has a relatively small chamber therein, and in which said igniter assembly comprises an eyelet inserted into said relatively small chamber, said eyelet and said relatively small chamber being coaxial with said passage, said eyelet having wires extended herein after passing through said relatively large chamber in said hollow body of said housing, said wires in said relatively small chamber being fused in glass, the outer face of said glass being spaced from an outer end of said eyelet, said eyelet containing outwardly of said glass an ignition charge, and in which a seal is provided to maintain said ignition charge in said eyelet.

4. The invention as claimed inn claim **3**, in which said eyelet is spaced a substantial distance from said igniter layer to thereby provide a void in a portion of said passage, said void causing uniformity of temperature of products of combustion that pass from said eyelet to said igniter layer.

5. The invention as claimed in claim **4**, in which means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough.

6. The invention as claimed in claim **4**, in which means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough, and in which said igniter layer comprises monitroresorcinate powder.

7. The invention as claimed in claim **4**, in which means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough, in which said igniter layer comprises mononitroresorcinate powder, and in which said output charge comprises a mixture of powders, said powders being boron/potassium nitrate/zinc oxide combined with a fluoroelastomer.

8. The invention as claimed in claim **7**, in which said delay layers are highly compressed, the amount of compression being that achieved by packing them at a pressure of about 30,000 psi.

9. The invention as claimed in claim **1**, in which said igniter layer comprises monitroresorcinate powder.

10. The invention as claimed in claim **1**, in which said output charge comprises a mixture of powders, said powders being boron/potassium nitrate/zinc oxide combined with a fluoroelastomer.

11. An electrically-initiated time-delay gas generator, which comprises:

(a) a housing having an elongate passage therein, said passage having an inner end portion that extends to an end of said housing,

(b) a metal barrier disc mounted in said passage transversely thereof so as to block said passage, said barrier disc being spaced from the inner end of said passage, the portion of said passage on the opposite side of said barrier disc from said inner passage end being unvented,

(c) an output seal provided in sealing relationship across said inner end of said passage so as to seal the portion of said passage between said barrier disc and sad inner end, said output seal being adapted to rupture and permit rapid escape of gas from said last-mentioned passage portion,

(d) an electrically-operated igniter assembly communicating with the outer end of said passage, said assembly including ignition powder and means to effect burning of said powder when an electric current is delivered to said igniter assembly,

(e) a delay column comprising a plurality of layers of delay powder provided in said passage between said igniter assembly and said barrier disc, said plurality of layers in said delay column comprising a combination of zirconium metal powder, red iron dioxide powder, and diatomaceous earth binder powder, said layers being compressed in place in said passage at pressures sufficiently high to provide function time tolerances of less than 25 msec, the outer one of said layers being packed against said barrier disc,

(f) an igniter layer provided in said passage between said delay column and said igniter assembly, said igniter layer being packed against said delay column, and

(g) an output charge provided in said passage between said barrier disc and said output seal, said delay column being adapted to burn over an accurately predetermined time period and then to heat said barrier disc, said barrier disc being thus heated to ignite and generate high-pressure gas.

12. The invention as claimed in **11**, in which each of said layers of said delay column is highly compressed, the amount of compression being that resulting from packing at a pressure of about 30,000 psi.

13. An electrically-initiated time-delay gas generator, which comprises:

(a) a housing having an elongate passage therein, said passage having an inner end portion that extends to an end of said housing,

(b) a metal barrier disc mounted in said passage transversely thereof so as to block said passage, said barrier disc being spaced from the inner end of said passage, the portion of said passage on the opposite side of said barrier disc from said inner passage end being unvented,

(c) an output seal provided in sealing relationship across said inner end of said passage so as to seal the portion of said passage between said barrier disc and said inner end, said output seal being adapted to rupture and permit rapid escape of gas from said last-mentioned passage portion,

(d) an electrically-operated igniter assembly communicating with the outer end of said passage, said igniter assembly including ignition powder and means to effect burning of said powder when an electric current is delivered to said igniter assembly,

(e) a delay column comprising a plurality of layers of delay powder provided in said passage between said igniter assembly and said barrier disc, said layers of delay powder comprising a combination of zirconium metal powder, red iron oxide powder, and diatomaceous earth binder powder and said layers being compressed in place in said passage at a high compression pressure of about 30,000 psi, the outer one of said layers being packed against said barrier disc,

(f) an igniter layer provided in said passage between said delay column and said igniter assembly, said igniter layer being packed against said delay column, and

(g) an output charge provided in said passage between said barrier disc and said output seal, said delay column being adapted to burn over an accurately predetermined time period and then to heat said barrier disc, said barrier disc being thus heated to ignite and generate high-pressure gas.

14. The invention as claimed in claim **13**, in which said housing has a relatively large diameter hollow body portion and a relatively small diameter head portion, sad body portion having a relatively large chamber therein, said body portion and said head portion being coaxial, inn which said elongate passage extends from said relatively large chamber to the inner end of said head portion, and inn which filter means are provided in said relatively large chamber in circuit with said igniter assembly to prevent undesired firing of said igniter assembly.

15. The invention as claimed in claim **14**, in which a neck portion is provided on said housing between said body portion and said head portion, said passage passing through said neck portion, and in which said head portion is externally threaded.

16. The invention as claimed in claim **14**, in which said hollow body portion also has a relatively small chamber therein, and in which said igniter assembly comprises an eyelet inserted into said relatively small chamber, said eyelet and said relatively small chamber being coaxial with said passage, said eyelet having wires extended herein after passing through said relatively large chamber in said hollow body of said housing, said wires in said relatively small chamber being fused in glass, the outer face of said glass being spaced from an outer end of said eyelet, said eyelet containing outwardly of said glass an ignition charge, and inn which a seal is provided to maintain said ignition charge in said eyelet.

17. The invention as claimed in claim **16**, in which said eyelet is spaced a substantial distance from said igniter layer to thereby provide a void in a portion of said passage, said void causing uniformity of temperature of products of combustion that pass from said eyelet to said igniter layer.

18. The invention as claimed in claim **17**, in which a means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough.

19. The invention as claimed in claim **17**, in which means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough, and in which said igniter layer comprises mononitrorescorcinate powder.

20. The invention as claimed in claim **17**, in which means are provided to close and seal the end of said housing remote from said head, said seal means having said wires passed therethrough, in which said igniter layer comprises mononitrorescorcinate powder, and inn which said output charge comprises a mixture of powders, said powders being boron/potassium nitrate/zinc oxide combined with a fluoroelastomer.

* * * * *

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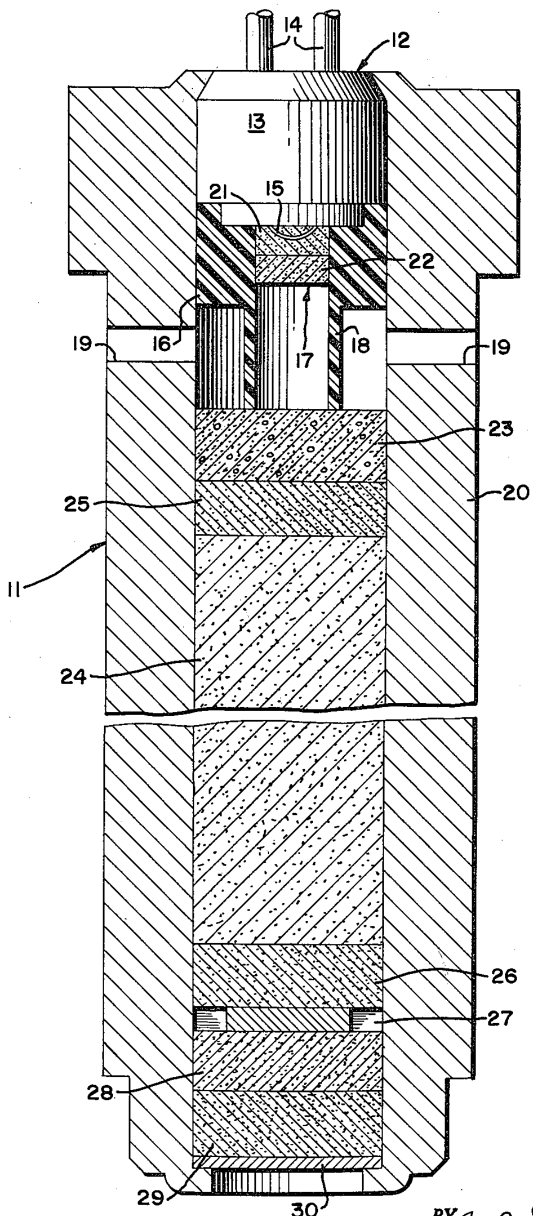
DELAY SYSTEM

Filed Sept. 29, 1960



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DELAY SYSTEM
Irving Kabik, Hyattsville, Md., assignor to the United States of America as represented by the Secretary of the Navy
Filed Sept. 29, 1960, Ser. No. 59,464
8 Claims. (Cl. 102—28)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to an improvement in fuses and more particularly to an improvement in the method of holding and igniting a time delay fuse train.

Heretofore it has been common practice in a vented fuse to provide an initiator plug on one end of the fuse, a time delay fuse column on the other with a chamber in between having vent holes for allowing the gases to escape. This construction did not always achieve the desired result for the following reasons:

(1) Part of the hot gases utilized in the fuse initiator to ignite the fuse train escaped directly out of the vent holes on ignition without coming into contact with or igniting the delay fuse train; and

(2) Possible separation in the delay fuse column due to a decrease in density exhibited by the products of combustion of the "gasless" delay composition, the separation resulting primarily due to the evolved gases acting against the unsupported column.

Any separation in the fuse delay column may result in extinction of the burning of the column, resulting in a dud unit.

The general purpose of this invention is to provide a time delay fuse which embraces all the advantages of similar prior art devices but possessing none of the aforedescribed disadvantages. To attain this, the present invention contemplates a unique single continuous column thereby avoiding any separation of the delay fuse column, a labyrinth path for the initiating hot gases, combined in such a manner so as to assure ignition of the delay column before venting. The porous disk also allows an escape path for any gases given off by the delay powder.

An object of this invention is to provide a fuse with a new and improved delay fuse column having a uniform density.

Another object is to provide a new and improved fuse having all parts in continuous contact during ignition and burning.

A further object is to provide a new and improved positive method of igniting the delay fuse train prior to venting of the igniting gases.

A still further object is to provide a unique construction for maintaining the delay powder in a compressed condition while allowing the gases given off by the delay powder a path of escape.

Further objects and the entire scope of the invention will become further apparent in the following detailed description and in the appended claims. The accompanying drawing displays the general construction and operational principles of an embodiment of the invention. It is to be understood, however, that the drawing is furnished only by way of illustration and not in limitation of the invention and in which the single figure is a side elevational view of the invention showing the general construction of a preferred embodiment thereof.

Referring now to the drawing, there is illustrated a time delay fuse 11. The time delay fuse 11 has an initiator assembly 12 which comprises an initiator plug 13. The plug 13 may be made of any insulator material, for example, a phenolic, or Kovar glass, depending upon the

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design. Plug 13 has a pair of electrical contacts 14 extending therethrough which are connected to a bridge wire 15. The initiator plug 13 is snugly seated in a charge holder 16. A charge 17 is centrally located in the charge holder 16 and in contact with the bridge wire 15. The charge holder 16 has a chimney 18 which is designed and seated on the porous disk 23 so as to allow gases to be vented from the delay body within which it will be used. The chimney 18 also directs the hot gases from the blast of the charge 17 of the initiator assembly 12, past the vent holes 19, in the fuse container 20, through the porous disk 23 to the next succeeding explosive increment. The charge 17 in the charge holder 16 may contain various mixtures 21, for example, lead styphnate surrounding the bridge wire followed by an ignitor mixture 22. The initiator assembly 12 is placed upon the porous disk 23 in the uper end of fuse container 20. The fuse container 20 may be either crimped or soldered onto the initiator plug 13 substantially as shown. The delay powder 24 is the so-called gasless powder and may be loaded from the other end of the fuse container. A gasless powder for example, is composed of a barium chromate, lead chromate and a manganese mixture. A heat sensitive powder 25 which is well known to those skilled in the art is located adjacent to or may be pressed into the pores of the porous disk 23 followed by the delay powder 24 having a time delay characteristic which is pressed into the column until a predetermined height is achieved dependent upon the desired delay time. This is followed in the order named by a similar heat sensitive igniter material 26, a forced fitted slotted baffle 27, another heat sensitive igniter material 28, a base charge 29 and a copper disk 30 which is crimped over the bottom of the container to complete the delay fuse. The delay charge may, for example, be an actuator charge, a propellant charge or a detonator. The upper and lower ends of the container are to be interpreted with reference to the drawing.

When sufficient electrical energy is passed through the wire bridge 15, the temperature of the wire is raised high enough to initiate the lead styphnate 21. This in turn initiates the ignitor mixture 22 causing the hot particles and gases to pass down the chimney 18 into and through a labyrinth path in the porous disks 23 thereby initiating the next ignitor increment 25 and then passing out the vent holes 19 in the cylinder. The small amount of gas formed by the delay charge also will pass out of the porous metal disk 23 and through the vent holes 19.

The delay powder 24 is pressed to a uniform density and held in place by the slotted baffle 27. As the delay powder 24 burns it tends to expand having a residue or slag material which is compressed by the porous disk 23 and slotted baffle 27 into the same volume as the powder originally occupied. The residue products of combustion of the delay powder 24 would in the absence of such confinement be substantially less dense than the delay powder 24 thereby occupying more volume and would tend to separate if it was not held in place by the porous disk 23 and slotted baffle 27.

The porous disk 23 thereby provides support for the delay column so that it cannot separate and at the same time allowing any gases resulting from the burning powder to escape. A heat sensitive ignition powder 26 and 28 is loaded on both sides of the baffle 27 to ensure that the fuse will continue to burn through the baffle 27. The base charge 29 may be used to explode a larger device or operate a switch as shown in a copending application Serial Number 62,511, filed October 13, 1960.

The porous disk 23 is composed of stainless steel sintered material which may be obtained in various porosities. The porosity found most suitable for this application is P.S.S. grade c with a mean pore opening of 165 microns.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An electrically detonated time delay fuse for an explosive device, said fuse including a container having apertures located therein, an electrical initiator means located in one end of said container for initiating the fuse column when energized, a chimney type charge holder located in said container and partially surrounding said initiator means, a charge located in said charge holder and responsive to said initiator means when energized, a porous disk of substantially the same area as the inside area of said container and in contact with said charge holder, a gasless time delay powder column located in said container adjacent said porous disk, a slotted baffle restraining said gasless delay powder at a uniform density between said porous disk and said slotted baffle before initiating the fuse, said slotted baffle and porous disk maintaining the unburned portion of said gasless delay powder at a uniform density after initiating the fuse, a disk sealing the end of said container and forming a chamber between said slotted baffle and said sealing disk, base charge means located in said chamber and ignitible by the burning of said time delay powder, said electrical initiator means igniting said charge means causing the hot gases to flow down the chimney through a plurality of labyrinth paths in the porous material thereby igniting the delay powder before being vented out the apertures in said container.

2. A time delay fuse for an explosive device comprising a container member for holding the component parts of the fuse in continuous contact with each other and having venting apertures therein, an initiator means located at one end of said container member for initially igniting said fuse, a chimney-type charge holder located in said container and in contact with said initiator means, a charge located in said charge holder in contact with and responsive to said initiating means for creating a large quantity of hot gases when ignited, a porous disk press fitted in said container and in contact with and closing the exposed portion of said chimney-type charge holder in such a manner that the hot gases flow through the porous disk to reach the venting apertures of said container, a slotted baffle, a time delay charge of a predetermined length held at a uniform density by said slotted baffle at one end and said porous disk at the other end of said delay charge before ignition of said fuse, said slotted baffle and porous disk maintaining the unburned portion of said delay charge at a uniform density after ignition of said fuse, a metallic disk closing the other end of said container and forming another chamber at said other end thereof, a base charge located in said chamber and ignitible by said delay charge for actuating the explosive device.

3. A time delay fuse for actuating an explosive device comprising a container having a plurality of apertures therein, an electrical igniting means for initiating the time delay fuse and located at one end of said container, a chimney-type charge holder, a charge located in said charge holder and being responsive to said igniting means for creating a quantity of hot gases when ignited, a porous disk in contact with said chimney-type charge holder and forming a plurality of labryinth paths for the hot gases prior to being vented through the apertures in said container, a time delay charge located in said container and held compressed at a uniform density before ignition against said porous disk and being ignited by said hot gases passing through said porous disk, a slotted baffle for maintaining the unburned portion of said delay charge at a uniform density after ignition, said slotted baffle forming a chamber with a metallic disk at the other end of said container, and a base charge completely filling said chamber.

4. A time delay fuse for an explosive device comprising a container having apertures therein, a base charge in said container, a time delay column adapted to ignite said base charge, a porous disk means for holding the time delay column at a uniform density before ignition and maintaining the unburned portion of said delay column at a uniform density after ignition, said porous disk providing an igniting path to said delay column, an initiating means for providing a quantity of hot gases which are forced through said porous disk prior to being vented through the apertures in said container thereby igniting said time delay column.

5. A time delay fuze according to claim 4 in which the initiating means includes an electrical initiator plug, a chimney-type charge holder having one end thereof mounted on said porous disk means, a charge located in said holder for giving off hot gases when ignited, said electrical initiator being mounted on the other end of said charge holder and in contact with said charge whereby when said charge is ignited by said electrical initiator the hot gases pass down the chimney-type charge holder through the porous disk to ignite said time delay column.

6. A fuze for an explosive device comprising a container having apertures therein, a base charge located in one end of said container, an actuator train located in close proximity to said base charge and adapted to ignite said base charge, a baffle plate located between said base charge and said actuator train, a disk of sintered material for initially compressing said actuator train to a uniform pressure between said disk and said baffle plate, an electrical initiator plug located in the other end of said fuze, a pair of electrodes extending through said plug into the fuze, an electrical responsive bridge wire connected between said pair of electrodes, an initiator charge located in close proximity to said bridge wire and responsive thereto for generating a quantity of hot gas when ignited, a chimney type charge holder with one end incasing said charge and one end of said plug and the other end of said charge holder abutting said disk whereby the hot gas of the initiator charge is directed by the charge holder into and through the sintered material to ignite the actuator train.

7. A time delay fuze for an explosive device comprising a cylinder having a bore along the longitudinal axis thereof, said cylinder having a plurality of apertures normal to said bore and connected thereto, a base charge located at one end of the bore, a time delay column adjacent said base charge and adapted to ignite said charge, a sintered disk means for compressing said delay column and providing an igniting path to said delay column, an initiator means located at the other end of the bore for generating a quantity of hot gases, and a chimney-type charge holder with one end incasing one end of said initiator means and the other end abutting said sintered disk means, said charge holder directing all the hot gases into and through a plurality of labryinth paths in said sintered disk to ignite said delay column.

8. A fuze for an explosive device comprising a cylinder having a bore along the longitudinal axis thereof, an initiator means located in one end of the bore for initiating the fuze when energized, a chimney-type charge holder located in the bore with one end partially surrounding said initiator means, a charge means located in said charge holder responsive to said initiator means for generating a quantity of hot gas, a porous disk of sintered material of substantially the same area as the inside area of the bore and abutting the other end of said charge holder, a slotted baffle located near the other end of said bore, a time delay column compressed to a uniform density between said porous disk and said slotted baffle, a disk sealing said other end of the bore and forming a chamber between said slotted baffle and said sealing disk, and a base charge located in said chamber and ignitable

by the burning of said delay column whereby the initiator means ignites said charge generating a quantity of hot gas which is entirely directed by the charge holder into and through a plurality of labyrinth paths in said porous disc to reliably ignite the delay column.

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PRIMING DEVICE FOR LIQUID OXYGEN EXPLOSIVE CARTRIDGES

Filed July 3, 1950

Fig. 1

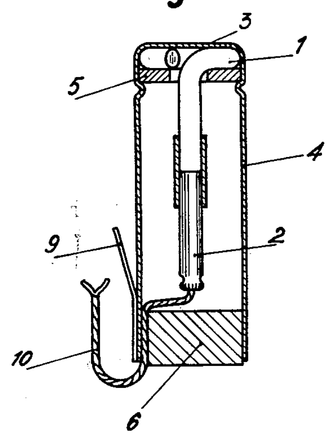
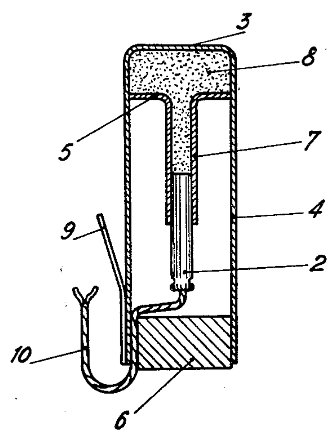


Fig. 2



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By Stone, Boyden & Mack.
Attorneys

Patented June 29, 1954 2,682,221

UNITED STATES PATENT OFFICE

2,682,221

PRIMING DEVICE FOR LIQUID OXYGEN EXPLOSIVE CARTRIDGES

Henri Sauvage, Paris, France, assignor to L'Air Liquide, Societe Anonyme pour l'Etude et l'Exploitation des Procedes Georges Claude, Paris, France

Application July 3, 1950, Serial No. 171,933

Claims priority, application France July 11, 1949

1 Claim. (Cl. 102—28)

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My invention relates to a priming device for liquid oxygen explosive cartridges used in bore holes for blasting.

The evolution of the technique of mining by means of explosives makes it more and more necessary to fire in one single operation a large number of blasts, an operation termed "large-volley blasting," in which electric primings are used with several timings, so as to spread out the shooting of the blasts. In such a blasting operation, the charging of the blast holes generally consists in the following steps: in each blast hole, explosive cartridges are successively introduced, the first one or the last one introduced being provided with a delayed electric priming; if a detonating fuse is used instead of this priming, the cartridges are placed against the fuse, which comes out of the blast hole; in both cases, tamping is effected in each blast hole, then, in case electric detonators are used, the electric wires issuing from all blast holes are connected together, then to an electric line and said electric line is tested. In case detonating fuses are used, the fuses from each blast hole are connected to a master fuse on which a priming is placed; then, firing is effected. The time necessary for tamping and for setting up the connections between the electric wires of the fuses and for checking the electric line is relatively long as compared to the time necessary for introducing explosive cartridges in the holes; it is difficult, at the present time, to shorten it sufficiently to allow, in the case of "large-volley firing" the use of liquid oxygen explosives because of the spontaneous evaporation of liquid oxygen, even if long life liquid oxygen cartridges are available. On the other hand, the delayed electric primings which are necessary do not always operate satisfactorily when they are cooled at low temperature.

The priming device according to my invention makes it possible to obviate the above mentioned drawbacks. It consists in an electric priming abutted against a detonating powder charge, characterized in that the detonating powder is completely or partly lining the face of the device in contact with the liquid oxygen cartridge.

The priming device makes it possible to apply "large-volley firing" to liquid oxygen explosives. To this effect, the loading of each one of the blast holes begins with the introduction of the above mentioned priming device, said device being held at the bottom of the blast hole by a support, for instance a socket or hollow sleeve so that the face provided with the detonating powder comes out towards the entrance to the blast hole; then connections are established between the electric wires of the primings together and also with the electric line; following this, a liquid oxygen cartridge is introduced in each hole until it rests on the face of the device provided with detonating powder; the contact between the detonating powder charge and the cartridge is thus very close and the transmission of the explosion wave is perfectly ensured; other cartridges may then be introduced and finally the usual tamping is effected in each hole.

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Due to the fact that the priming device is placed separately and before the liquid oxygen cartridges, plenty of time is available first for introducing the priming devices, then for establishing and checking electrical connections and, after any time lapse, for the loading proper of said liquid oxygen cartridges, which loading, of course should be effected, as well as the tamping, as rapidly as possible. In the same manner, immediately after tamping, the shot should be fired by connecting the electric line to a current source. In this manner, there is obtained a saving, for the evaporation of the liquid oxygen, of all the time required for the introduction of the priming device and for the establishing and checking of electrical connections. In practice, for a blast hole 2 meters deep, the time necessary thus for the operations starting with the placing in position of the first cartridge until ignition, is half a minute whereas, in known methods, this time, which necessarily includes the placing in position of the priming devices and the establishing of electrical connections, is about three times longer.

Another advantage of the priming device thus used is that it is not necessary to use, in its manufacture, a special electrical priming designed for low temperatures. The electrical priming is not licked by cold gases evaporated from the cartridges and, consequently is subjected only to a very slight cooling.

In the above priming device, the charge of detonating powder may be placed in the form of an element of a detonating fuse wound in a spiral on the face of the device.

The figures in the appended drawing show, by way of example, types of embodiments of the present invention.

Figure 1 is relative to the priming device comprising an element of detonating fuse, and Figure 2 is relative to the priming device comprising a charge of detonating powder. In these two figures the device comprises a socket **4** having a diameter slightly smaller than that of the blast hole, which may be tight or not, and which is closed at its end facing the bottom of the hole by a plug **6**; between said plug **6** and the socket **4** are passed the wires **10** of the electric priming. In the vicinity of the axis of the socket is arranged the electrical priming **2**, abutted in the known manner to the end of the detonating fuse **1** in the case of Figure 1, and to the charge of detonating powder **8** in the case of Figure 2. According to Figure 1, the fuse is wound, at its end, in the shape of a spiral bent against the bottom of the socket and held by a plate **5**, of wood for instance, crimped inside the socket. According to Figure 2, the charge of detonating powder **8** is enclosed in a cylinder formed by the bottom of the socket and a crosspiece **5** continued by an axial tube **7** extending down to the detonator. The first liquid oxygen explosive cartridge is placed against the bottom **3** of the socket.

In the case of an ascending blast hole, the device is preferably provided with a spring metal blade **9**, of brass for example, for anchoring the device at the bottom of the blast hole and preventing it from falling back towards the hole entrance.

What I claim is:

In a detonator for liquid oxygen cartridges, a tubular shell having a closed upper end and an

open lower end, a detonating fuse wound in the shape of a flat spiral the central portion of which extends as a rod at right angles with the plane of said flat spiral, means adapted to hold the spirally wound portion of said fuse applied against the inner face of the shell closed end while allowing said rod to extend axially in said shell, thus forming a free insulating space between said rod and the shell, an electric priming device with igniting wires, coupling means for connecting end to end said priming device to said axial rod, and a removable plug adapted to close the open end of the shell by clamping the igniting wires and allowing them to pass outside the shell.

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R. E. BETTS ET AL

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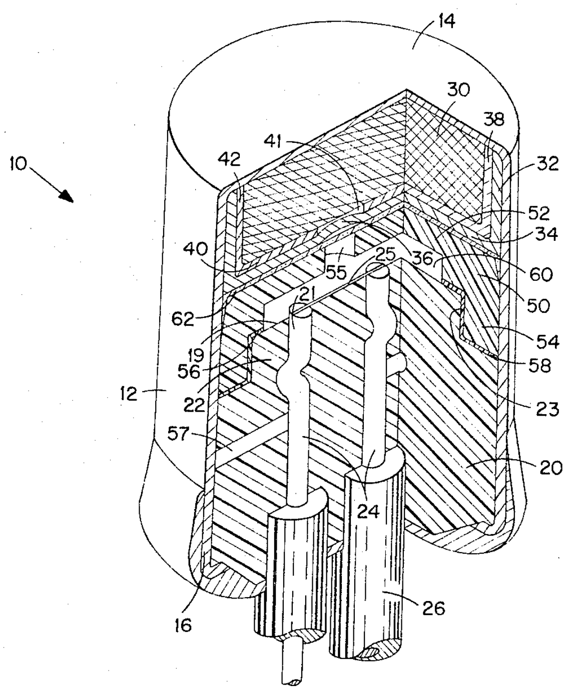

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3,272,127

Patented Sept. 13, 1966

3,272,127

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Filed Aug. 5, 1963, Ser. No. 300,114

5 Claims. (Cl. 102—70.2)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to an ignitor squib and more particularly to an improved ignitor squib of the general class disclosed in an application filed by Robert E. Betts for "Ignitor Squib" filed August 31, 1960, Serial Number 53,314, and now Patent No. 3,100,447.

It is an object of this invention to provide an improved ignitor squib of the indicated class.

Another object of this invention is to provide an ignitor squib wherein products of bridge wire ignition are concentrated on a desired portion of the pyrotechnic.

These and other objects of the invention will become more apparent upon consideration of the following detailed description and accompanying drawing which is a perspective view, partly in section, of the ignitor squib.

In the illustration the ignitor squib **10** is shown to include a housing **12** having a closed end **14** and an open end **16**. Open end **16** is adapted to receive a phenolic bridge plug **20**. One end **22** of the plug is reduced so as to provide an annular space **23** between the plug and the sides of housing **12**.

To provide an electrical connection to the squib, a pair of crimped lead wires **24** are molded in plug **20** so that they do not extend beyond the face **19** of end **22**, of plug **20**. These wires are joined at the ends **21** thereof by a resistance containing bridge wire **25**. The bridge wire extends adjacent the face **19** of plug **20** and connects to wires **24**. The other end of wires **24** are covered by suitable insulating material **26** which is molded in plug **20**.

A pyrotechnic **30** is retained in the closed end **14** of the housing by a cup-shaped diaphragm **32** and a cup-shaped metal die **38**. The diaphragm is force-fitted with housing **12** and is spaced from end **22** of plug **20**. Diaphragm **32** acts a Faraday shield, protecting the pyrotechnic from ignition by static charges passing through or building up on the surface of material **30**. Base portion **34** of the diaphragm is provided with a center section having a dimple **36** formed therein.

Die **38** is form fitted within diaphragm **32** and includes a base **40** and a peripheral wall **42**. Base **40** has a central hole **41** formed therethrough concentric with dimple **36** for purposes explained hereinbelow. Wall **42** is disposed to direct the exploding force of the pyrotechnic **30** out through the end **14** of housing **12**.

An element **50**, formed of a dielectric material, is placed between plug **20** and diaphragm **32**. The function of element **50** is threefold; to insure diaphragm **32** remains spaced from plug end **22**, to prevent arcing between the bridge wire and the diaphragm, and to concentrate the products of bridge wire ignition on the diaphram. Element **50** is substantially cup-shaped having a base **52** and a downward projecting wall **54**. The element is disposed so as to have its base **52** adjacent diaphragm base **34** and its wall **54** extended into annular space **23**. An annular lip **56** formed in element wall **54** seats the element on the face of plug end **22**. A dielectric sealant **58** bonds the element to plug **20**. The disposition of element **50** defines a compartment **60** enclosed by element wall **54**, element base **52** and the face of plug end **22**. A bore **55** defines a passage through the element base to the area of dimple **36**.

To prevent arcing from the bridge wire through the bore in element **50** to the diaphragm, an insulator **62** is disposed between element **50** and the diaphragm and extends across the bore. And to provide a means for the discharge of static electricity from the ignitor, a plurality of air gaps **57** are formed in the phenol plug **20** and are disposed in communication with the lead wires **24** and housing **12**, to form a path of lowest resistance between the housing and lead wires.

The ignitor squib is mounted in any known manner and the power for operating the squib and the control means (not shown) are connected to lead wires **24**. Power for exploding the bridge wire of an embodiment having, for example, a bridge wire of .1 ohm resistance, can be achieved by charging a one microfarad capacitor to 2000 volts. The capacitor is then discharged to the bridge delivering a voltage in excess of 500 volts in approximately one microsecond and a current density of one million amperes per square centimeter of cross sectional bridge wire area.

The squib is actuated by operation of the control means which connects an electrical source to the bridge wire. When the required electrical energy reaches the bridge wire it is converted to heat, thereby developing pressure in the bridge wire and compartment. This action causes the bridge wire to explode increasing the heat and pressure in compartment **60**. This heat and pressure is then directed by bore **55** to the diaphragm. As the area of bore **55** is relatively small compared to the area of compartment **60**, the force produced by the heat and pressure is intensified. This intensified force, after first rupturing insulator **62**, encounters the lower area of dimple **36**. The dimple is forced, by the heat and pressure, to expand upward through hole **41** to shear against die **38**. Shearing of dimple **36** allows heat and pressure from the exploding bridge wire to contact the pyrotechnic.

The burning pyrotechnic then produces heat and pressure within the squib. The die wall **42** effectively contains the lateral pressure forces produced by the burning pyrotechnic and directs the total heat and pressure force to the closed end **14** of housing **12**. The closed end is then ruptured forcing hot gases and burning particles into contact with surrounding material.

As the volume of compartment **60** is a factor in determining the pressure produced by the burning bridge wire, various modifications can be made in the configuration of focusing element **50** to control pressure in the compartment. For example, the surface of element base **52** forming the top of compartment **60** can be generally dome-shaped to increase compartment volume. A dome or surface inclined toward bore **55** would also provide a means to direct the products of bridge wire ignition to the bore.

Thus it will be appreciated that this invention provides an improved ignitor squib of the class indicated.

It is also to be understood that various modifications of the ignitor squib described herein can be resorted to that is within the spirit and scope of the appended claims.

The invention claimed is:

1. An improved igniter squib comprising:

(a) a housing having a closed end and an open end;

(b) a metal container having a pyrotechnic therein disposed in said housing adjacent said closed end and cooperating therewith for complete enclosure of said pyrotechnic for shielding thereof from static charges;

(c) a bridge plug extending into said housing through said open end;

(d) a firing circuit carried by said plug including a pair of lead wires extending through said plug and into said housing, and a bridge wire carried by said plug and connected to said lead wires, said bridge wire being disposed in spaced relation with said pyrotechnic;

(e) focusing means carried in said housing and disposed for concentrating the igniting energy from said bridge wire to said pyrotechnic responsive to a predetermined build-up of said igniting energy, said focusing means including a substantially cup-shaped member of dielectric material having the wall thereof partially surrounding said bridge plug and the base thereof adjacent said pyrotechnic, said base having a bore therethrough for directing the ignition energy from said bridge wire to said pyrotechnic.

2. A device as set forth in claim **1** in which said bore is centrally located in said base.

3. An improved igniter squib comprising:

(a) a housing having a head end and an open end;

(b) a pyrotechnic disposed in said head end;

(c) a cup-shaped retaining member mounted in said head end for retention of said pyrotechnic between said head end and said retaining member;

(d) a bridge plug extending into said housing through said open end and provided with a face disposed in spaced relation with said cup-shaped retaining member;

(e) a bridge wire carried on said face of said bridge plug and connected to a source of energy for energization to explode said bridge wire and produce a force therefrom;

(f) force focusing means including a substantially cup-shaped spacer provided with a base having a bore therethrough, said cup-shaped spacer disposed adjacent said retaining member and provided with an annular wall depending from said base and partially enclosing said bridge plug to form a compartment between said bridge plug and said spacer;

(g) said compartment being closed by the face of said bridge plug; and

(h) said bridge wire being disposed in said compartment.

4. An improved igniter squib comprising:

(a) a housing;

(b) a pyrotechnic material disposed in said housing;

(c) a diaphragm mounted in said housing for support of said pyrotechnic material, said diaphragm being cup-shaped and having the wall thereof force fitted with said housing and partially enclosing said pyrotechnic material and provided with a base having a rupturable portion in the form of a dimple disposed therein;

(d) a firing circuit extending into said housing in spaced relation with said diaphragm; and,

(e) a member interposed between said diaphragm and said pyrotechnic material and provided with a bore adjacent said rupturable portion to serve as a die against which said rupturable portion can shear responsive to energization of said firing circuit to concentrate substantially total ignition energy to said pyrotechnic.

5. A device as set forth in claim **4** in which:

(a) said die is cup-shaped to form fit with said diaphragm and includes a base having said bore centrally disposed therethrough; and

(b) said dimple disposed in mating contact with the periphery of said bore to shear thereagainst responsive to ignition of said firing circuit.

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June 28, 1966 E. E. MALLORY 3,257,947

SHOCK FOCUSING EXPLOSIVE INITIATOR

Filed Dec. 17, 1964

Fig. 1

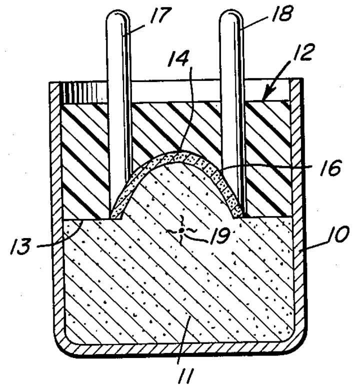


Fig. 2

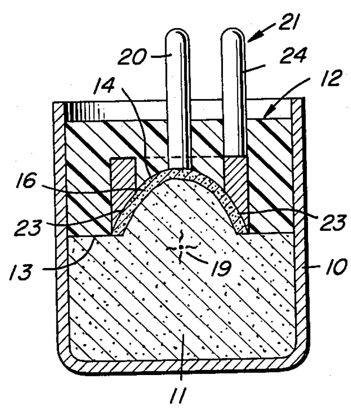
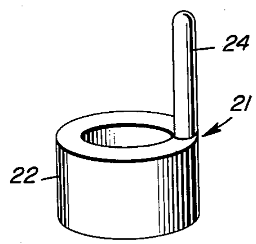


Fig. 3



INVENTOR

Ernest E. Mallory

BY ATTORNEY

AGENT

United States Patent Office

3,257,947

Patented June 28, 1966

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3,257,947
SHOCK FOCUSING EXPLOSIVE INITIATOR

Ernest E. Mallory, Sunnyvale, Calif., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Filed Dec. 17, 1964, Ser. No. 419,255
4 Claims. (Cl. 102—28)

This invention relates to an electric detonator for explosives. More particularly, the invention relates to an electrically actuated squib of the exploding film type.

Various types of exploding squibs have been described in the prior art. The main problem in the art has been that of accidental actuation of such squibs by induced radio frequency fields or inadvertently applied low sources, for example. One of the common types of exploding detonators is the so-called exploding bridgewire squib in which the explosion is initiated by means of a small round wire called a bridgewire to which is applied a high value of electrical energy in a very short time, causing the wire itself to explode and thus producing a high pressure shock wave. Inadvertently applied currents are usually not of this kind and are ordinarily dissipated through the bridgewire without any adverse effects. Bridgewires in the squibs are not, however, completely resistant to accidental destruction without causing initiation of the squib. For example, currents may be applied to the bridgewire which are of a value below that necessary to explode the bridgewire but yet sufficient to heat it to a melting temperature thereby destroying its electrical function. Also, if the bridgewire has been placed adjacent to a heat sensitive explosive, detonation may result. With some explosives, the heat tends to increase the sensitivity of the explosive, and sometimes increases it to the point at which the explosive will detonate under the influence of mechanical shock.

Accordingly, it is an object of the invention to provide an improved electric detonator for explosives which will not be set off by stray currents, but will respond positively to a current of the proper intensity, wave shape and time interval.

It is a further object of the invention to provide an improved electrical squib which combines greater resistance to accidental actuation with positive and reliable response.

The objects of the invention are achieved by substituting for the conventional exploding bridgewire an exploding conductive film disposed in a cup-shaped depression in the insulating contact support in proximity to the main charge which depression is shaped to focus the shock produced by the explosion of the film into a small volume of the main charge. The use of a film of large surface area and large cross-sectional area provides conduction path for inadvertently applied currents which is such that high temperatures are not generated and any heat that is generated is dissipated over a broad area. By means of the shock focusing arrangement, an initiating shock of greater energy density is produced, which permits the use of a main charge of decreased sensitivity.

Other objects and advantages will occur to those skilled in the art from a consideration of the following description when read in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a vertical section through a squib according to the invention;

FIGURE 2 is a cross-section through another embodiment of the invention; and

FIGURE 3 is a detail perspective view of one of the electrical contacts of FIGURE 2.

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Referring now to FIGURE 1, one of the embodiments of the present invention is there shown as consisting of a cup-shaped metallic housing **10** containing an explosive charge **11**, and having the upper, open end thereof closed by a plug **12** made of electrically insulating material. Lower surface **13** of plug **12** is machined or otherwise formed to provide a depression **14** which may take various shapes. Depression **14** may be paraboloid or spheroid, or any other shape, as long as it is capable of producing a convergent shock wave. A spheroidal surface, for example, produces a shock convergent on the center of curvature of the surface.

The surface of depression **14** is coated, prior to assembly of the device, with a conductive film **16** of any suitable material, such as graphite. In order to provide electrical connection to film **16**, conductors **17** and **18** are embedded in plug **12** and contact film **16** near its periphery to provide electrical connection thereto.

As will be understood by those skilled in the art, conductors **17** and **18** are intended to be connected to a high voltage pulse generator which is capable of providing electrical energy of high intensity in a pulse of short duration. Commonly, such a pulse generator would provide a pulse of about one-half Joule in about 5 microseconds. When such a pulse is applied to the device of the invention, film **16** undergoes an explosion similar to the explosion of a bridgewire in a conventional squib. Because of the shape of depression **14**, however, the shock wave produced by the explosion of film **16** is focused on a small volume of the main charge, as suggested at point **19** within the body of the charge **11**. Thus, a mechanical shock of increased energy density is produced, and the sensitivity of charge **11** may be accordingly reduced over that now commonly employed.

In FIGURE 2 an alternative embodiment of the invention is shown in which the contact arrangement has been varied. In this arrangement, the depression **14** is provided as in the embodiment of FIGURE 1, but electrical contact is made thereto by means of a centrally disposed contact, **20**, and a peripheral contact **21**. Contact **21** is shown in detail in FIGURE 3 as consisting of an annular ring **22**, which is shaped at **23** to conform to the shape of depression **14**. A terminal connector **24** is provided to connect contact **22** with the power supply.

The embodiment of FIGURE 2 operates in much the same way as the embodiment of FIGURE 1, except that the current path through the film **16** is different because of a different arrangement of the contacts. In the case of each embodiment, the shock focusing effect is present to enable the sensitivity of the main charge to be reduced. The objects of the invention as set forth above are therefore fulfilled by this device.

Obviously, many modifications and variations of the invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as herein specifically described.

What is claimed is:

1. An explosive squib consisting of
   a container,
   a low sensitivity explosive material in said container,
   an insulating electrode support in said container in contiguous relation to said explosive, said electrode support having a centrally located cup-shaped depression with a curved bottom surface formed therein,
   a conductive film deposited over the surface of said depression, contacting a portion of said low sensitivity explosive which projects into said depression, and
   electrode means coupled to said film for connecting

said film to a source of high voltage electrical energy, whereby when said conductive film is exploded by the application thereto of a high voltage, short time pulse of electrical energy, the resulting shock wave will be focused into a limited volume of said low sensitivity explosive to provide an energy density sufficient to initiate said explosive.

2. An exploding film initiator for low sensitivity explosives as recited in claim 1 wherein said electrode means consists of a pair of conductors, each connected to the peripheral edge of said film.

3. An exploding film initiator for low sensitivity explosives as recited in claim 1, wherein said electrode means consists of one contact connected to said film at its center and another contact comprising a ring connected to the peripheral edge of said film.

4. An exploding film initiator for low sensitivity explosives as recited in claim 3, in which said ring contact is separate from said container.

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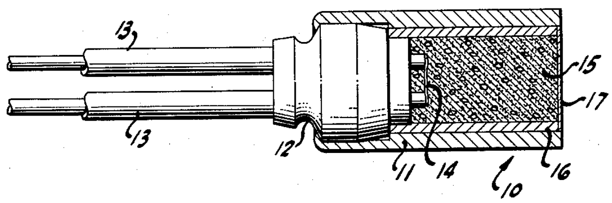
May 4, 1965 W. C. MORGAN ET AL 3,181,463

EXPLOSIVE DEVICE CONTAINING CHARGE OF ELONGATED CRYSTALS AND AN EXPLODING BRIDGEWIRE

Filed March 17. 1961

FIG-1



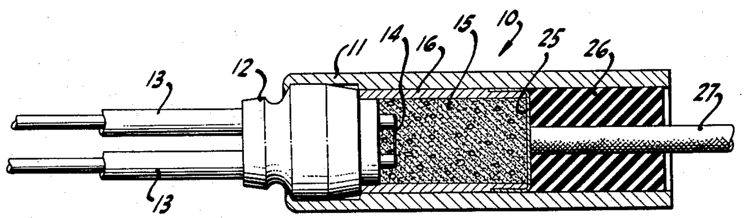


FIG-2

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3,181,463

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3,181,463

EXPLOSIVE DEVICE CONTAINING CHARGE OF ELONGATED CRYSTALS AND AN EXPLODING BRIDGEWIRE

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Filed Mar. 17, 1961, Ser. No. 96,440
6 Claims. (Cl. 102—28)

This invention relates to explosives and propellants. More particularly, this invention relates to a method of producing explosive and propellant compositions in a more desirable form; to the end products of such method; and to explosive or propellant devices employing the same.

In the manufacture of detonators (such as used to initiate a propellant or an explosive, or to initiate an explosive cord or cordeau) it is a common practice to provide a body of explosive material such as PETN (which is pentaerythritol tetranitrate) encased in a suitable housing, and to initiate the explosive material in the detonators by means of an exploding bridgewire. This practice avoids the use of highly sensitive primary explosives such as fulminates, lead azide and lead styphnate. As is well known in the explosive art an exploding bridgewire unit comprises a short length of wire of small diameter and a power source which stores electrical energy and releases it upon demand in the form of a short pulse at a high voltage. This results in vaporization of the wire, explosion of the metal vapor, the release of a large amount of heat and the creation of a shock wave which together detonate the explosive.

PETN is useful for this purpose but, when it is used in this manner and is initiated by an exploding bridgewire (hereinafter referred to as an "EBW"), it is important that the PETN be insensitive to stray currents which may heat (but not explode) the bridgewire, yet remain sensitive to an EBW.

It is known that the sensitivity of PETN is related to its density. It is desirable to pack PETN in a casing or housing at a relatively high density in order to obtain a greater energy output and to maintain a uniform, intimate contact of the bridgewire with the PETN.

If PETN is packed loosely within a detonator, it may separate from the wire during handling or storage with resultant failure to initiate. On the other hand, as the density increases it reaches a point at which the detonator fails to function. This presents the manufacturer with the problem of working between relatively close lower and upper limits of density. This requires much greater production control and it results in a greater proportion of rejects or of products which may pass inspection but fail in service.

It is an object of the present invention to provide improvements in explosive and propellant materials.

It is a further object of the invention to provide PETN and other explosives in a more desirable physical form than has been available heretofore.

It is a particular object of the invention to provide a means of treating PETN, and other explosives which are susceptible to initiation by an EBW, whereby the explosive material can be packed to a higher density without failure to perform.

The above and other objects of the invention will be

apparent from the ensuing description and the appended claims.

FIG. 1 illustrates a first embodiment of the invention.

FIG. 2 illustrates a further embodiment of the invention primarily adapted for use as an initiator for an explosive fuse.

We have discovered that when PETN and other explosive or propellant materials are employed in the form of elongated, e.g. needle-like or rod-shaped crystals of small size (rather than in the usual amorphous, globular or spherical form as produced by mechanical grinding), the explosive has substantially superior properties.

For example, in the case of PETN, if it is of suitably small particle size and if the particles are needle-like crystals rather than spheres or globules, the material is much less sensitive to density and can be packed more tightly. Also, PETN in this form can be packed into a mass having greater structural strength than the previously available product, and it presents a larger surface area per unit of weight than previously available.

These and other properties are among advantages of the needle- or rod-like crystalline shape when the explosive is PETN. Some or all of these advantages exist with other explosives if they have a similar particle structure, e.g., RDX, HMX, TNT and even inorganic explosives such as ammonium nitrate. (RDX is cyclotrimethylene trinitramine, HMX is cyclotetramethylene tetranitramine, and TNT is trinitrotoluene.) It will be understood that the advantages of the crystalline form differ somewhat from one explosive to another, particularly when the type of explosive differs radically. For example, with PETN the crystalline form of the invention has, as an important advantage, the fact that the material can be packed within a relatively wide range of density, yet it remains susceptible to initiation by an exploding bridgewire. With TNT this advantage is absent because TNT is insensitive to an exploding bridgewire regardless of density. However, the crystalline form of the invention is advantageous in the case of TNT when mixed with an oxidizer such as NH_4NO_3 or $KClO_4$. Such mixtures can be initiated by an EBW at energy inputs of 3000 volts from a 12 micro farad source, giving rise to low order detonations. Also, ammonium nitrate is benefitted by the crystalline structure of the invention because of the resulting small particle size; for example, it produces better ammonal explosives with powdered aluminum. In general, any explosive or propellant material is benefitted by the crystalline form of the invention because, for a given particle size, the material presents a greater surface area per unit of weight and because packed bodies of the material have greater structural strength.

The explosive material of the present invention preferably has a small particle size, e.g., a length (L) of about 30 to 200 microns and a width (W) of about 5 to 20 microns.

We have also discovered an advantageous method of producing the crystalline particles of the invention, such method being as follows:

The explosive or propellant material is dissolved in a solution in which it has a substantial solubility. Preferably, the amount dissolved is substantially less than the saturation concentration at the temperature involved, preferably not more than about 1 to 5% of the saturation concentration. Then a nonsolvent or precipitant is added which is miscible with the solvent but in which the solute is insoluble or in which the solute has a relatively low solubility. This addition of nonsolvent to solution is continued, preferably slowly and with constant agitation, until the solute begins to precipitate and until the desired or optimum yield of precipitate has been obtained.

By this means—i.e., by gradually reducing the solubility of the solute in a solvent-nonsolvent system—we are able to produce an explosive or propellant material which is in the form of small rod-like or needle-like crystals.

We have also discovered that the process and product are greatly benefitted by conducting the precipitation in the presence of a surfactant which is dissolved or dispersed in the solvent-nonsolvent system.

Therefore, in the preferred form of our invention we dissolve the exposive or propellant material in a suitable solvent, but only to a concentration which is a small fraction of the saturation concentration; we also incorporate in the solution a surfactant; and we then add a nonsolvent slowly and with agitation to produce a crop of small needle-like or rod-like crystals.

The following specific examples will serve further to illustrate the practice and advantages of the invention:

EXAMPLE 1

12.5 grams of PETN were dissolved in 3,125 ml. of reagent grade acetone at 72° F. with stirring and 25 ml. of Tergitol Non-ionic NPX were added and dissolved with stirring (Tergitol Non-ionic NPX is the trademark of Carbide and Carbon Chemicals Corp. of New York, New York, for a nonyl phenyl ether of polyethylene glycol). Then 6,000 ml. of distilled water were added with constant stirring at the rate of 250–300 cc. per minute, the temperature remaining 72° F. After about 5,000 ml. had been added, PETN commenced to precipitate as shown by the cloudy appearance of the solution. Meanwhile the temperature of the solution rose to about 82–84° F. After 6,000 ml. of water had been added an additional volume of water was added equal to that in the vessel. Such additional increment was added at the rate of 1,000 ml. per minute. Stirring was continued meanwhile and for 15 minutes thereafter to complete the precipitation of the PETN, which was separated by filtration and was washed repeatedly with small volumes (100 mls.) of distilled water. The washed PETN was air dried under suction for 15 minutes and then dried in an oven at 70° C. for 24 hours.

The PETN as received prior to dissolving and precipitation as described in Example 1, was in the form of globules of irregular shape. As precipitated by the process of Example 1 this same material was in the form of needle-like crystals. The "as received" PETN was minus 325 mesh and had a typical particle size of 15 microns minimum, 60 microns maximum. The recrystallized product of the invention, by way of contrast, has typically a maximum dimension (length of the needle) of about 40 to well over 100 microns and a width of about 5–15 microns. Thus, notwithstanding the fact that the average particles of the improved product of the invention are larger in volume, the cross sectional area of the needles is smaller than the minimum cross sectional area of the "as received" PETN. Accordingly, the product of the invention has a smaller mesh size than the "as received" PETN.

As a measure of sensitivity or adaptability to an exploding bridgewire detonator, a test structure of the character shown in FIGURE 1 was constructed. This test detonator is generally indicated by the reference numeral **10**. It has an aluminum case **11** and a header **12** of known construction. Insulated wires **13** are provided whose inner ends are connected to a bridgewire **14**, which is of small diameter and whose composition and construction are well known. The other ends of the wires **13** are connected to a suitable power supply which is capable, upon being triggered, of creating a very high, instantaneous voltage drop across, and a very high surge of current through the bridgewire **14**, whereby the latter is exploded

to create intense heat and a shock wave. Suitable circuits employing banks of condensers are well known and require no description herein.

Within the casing **11** is a body of explosive (e.g., PETN as produced by the present invention) and between this body of explosive and the casing **11**, there is a steel sleeve **16**. A tape or other sealing closure which is readily ruptured is applied to the outer end (i.e., to the right hand end as viewed in FIGURE 1) of the structure.

Referring now to FIGURE 2 in which like reference numerals indicate like parts, the casing **11** is longer, the outer (right-hand) end of sleeve **16** is closed by an aluminum cap **25**, a body of rubber **26** is molded into the outer (right-hand) extension of casing **11**, and an explosive cord such as a Primacord **27** is embedded within the rubber **26** and is in contact with the cup **25**. Such an article is a commercial detonator having wide utility, e.g., as an initiator for an explosive fuse or cord, to initiate or ignite mix in a rocket motor, etc.

Test detonators constructed as in FIGURE 1 were used in steel dent tests. In each test the taped end of the detonator was placed on a ⅝" steel plate with no external confinement and the detonator was fired (or an attempt was made to fire it) with a pulse of current from a 2,000 volt, 1 mfd. source. Conditions were identical in each case except that the loading density and the character of the PETN were varied from test to test. In one series of tests, globular minus 325 mesh PETN as purchased was loaded into the detonator at densities of 0.8, 0.9, 1.0, 1.1 and 1.2 grams per cc. In another series of tests the PETN was prepared from the same lot of purchased PETN but was processed in accordance with the present invention and had, accordingly, the crystal structure and particle size described hereinabove. This processed PETN was loaded at densities of 0.8, 0.9, 1.0, 1.1, 1.18, 1.2, 1.27 and 1.32 grams per cc. In the first series of tests with "as received" PETN the detonators exploded and dents were made in the steel plates up to a density of 1.1. But at a density of 1.2 the detonator would not explode. In the second series of tests, with the same PETN processed in accordance with the invention, the detonators exploded and dents were made in the steel plate up to and including a density of 1.27, failure occurring with a density of 1.32.

Therefore, it will be apparent that a considerably greater packing density (1.27—1.1=an increment of 0.17 gram per cc.) is possible with the PETN of this invention. This is important because higher packing densities are desirable. Among other things, at higher densities more explosive and more energy are available. Also, the more tightly the explosive is packed the less likely it is to separate from the bridgewire during handling and storage. Also, the present invention permits a wider range of operable densities, which means that density control is more easily achieved. If, for example, a piston is used to pack the explosive in a detonator it may not apply precisely the same pressure during each loading cycle. Moreover the explosive itself and other factors will offer more or less resistance to compaction. The higher packing densities made possible by the present invention, and the broader operating range made possible thereby greatly facilitate production control.

Detonators of the type shown in FIGURE 1, loaded with PETN of the present invention and having a density of 0.9 gram per cc., were subjected to and passed a series of safety tests as follows:

(1) Passage of current through the bridgewire at 500 volts D.C. and 1.0 microfarad. Sixteen detonators were tested, none were initiated and there were no outward physical changes. All the bridgewires fused.

(2) 37 volts D.C. and 0.1 W impedance. Sixteen tests produced no initiation of physical change.

(3) A current of 1.5 amperes (calculated bridgewire temperature of 245° C.) and a current of 1.62 amperes (calculated bridgewire temperature of 299° C.). Many tests were made under these conditions and none of them

produced initiation. All bridgewires were intact after the tests. Ten of the detonators were then tested at 2,000 volts and 1.0 microfarad but no initiation occurred.

(4) Nine detonators were subjected to 5 milliamp. current through the bridgewire for 10 minutes. No initiation occurred. All but one of these units were then successfully fired with 2,000 volts and 1 microfarad.

EXAMPLE 2

RDX was processed by the following procedure:

5.5 grams of RDX were dissolved in 1,000 ml. of acetone and 6 ml. of Tergitol NPX (the same surfactant as used in Example 1) were also dissolved in the acetone solution. The solution was filtered and the filter paper was washed with 500 ml. of acetone to bring the total volume of acetone to 1,500 ml. Then the acetone solution was aspirated into a stream of tap water at the rate of 1 gallon per minute of water with a pickup of 400 ml. per minute of the acetone solution. That is to say, the acetone solution was diluted by a factor of about 9.5. The temperature was 73° F. The resulting dilute solution of acetone in water was allowed to stand 30 minutes and was then filtered. The recovered precipitate of RDX was washed with water and dried.

Needle-like crystals of RDX were obtained by this procedure. The crystals were rhombic and had a Coulter size of 10–100 microns with a mean size of about 50 microns. ("Coulter size" refers to the Coulter test which is well known and is a measure of volume of the individual particles whereas the usual sieve test gives a mesh size which is a measure of the smallest cross sectional area.) The RDX from which these rhombic needles were made had no crystalline structure observable through a microscope.

EXAMPLE 3

This example relates to the application of the invention to a radically different type of explosive, namely ammonium nitrate. Five grams of ammonium nitrate were dissolved in 10 ml. of distilled water and 500 ml. of acetone were added slowly and with shaking and stirring. This procedure was repeated with another 5 gram quantity of ammonium nitrate but with the addition of 10 drops of Tergitol Anionic No. 4 (a trademark of Carbide and Carbon Chemical Corporation of New York, New York for a branched chain sodium alkylsulfate) to the aqueous solution of ammonium nitrate.

The acetone caused precipitation of ammonium nitrate which, after filtering and drying, was examined under the microscope. The crystals made without the surfactant were needle-shaped and had a size of about 60–100 microns in length and about 10 microns in width. The crystals made with the surfactant were rounded rhombic crystals, contained a few needles and had a length dimension of 20–50 microns and a width of 10–20 microns.

The method of the invention has also been applied to HMX and TNT, both of which yielded needle-like crystals.

Other solvents have also been employed. For example, methyl ethyl ketone has been used instead of acetone in the case of RDX. Needle-like crystals were obtained but were of a larger size than with acetone. Also, dimethyl sulfoxide was used as the solvent for RDX as follows: 5 grams of RDX and 2 ml. of Tergitol NPX were dissolved in 946 ml. of dimethyl sulfoxide and the solution was aspirated into a stream of tap water as in Example 2. Prismatic leaflet crystals were obtained with a small proportion of needles. Crystal length was 20–80 microns and width was 5–10 microns.

As will be seen the method of the invention does not always produce needle-like crystals, but the crystals are in any event elongated.

Many other solvent-precipitant combinations are available depending on the solute which is to be precipitated. The following table shows explosive materials in the left hand column, suitable solvents in the middle column, and suitable precipitants in the right hand column.

Table 1

Explosive	Solvent	Precipitant
PETN	Acetone	Water.
	Methyl ethyl ketone	Do.
	Methyl alcohol	Do.
	Methyl acetate	Do.
	Benzene	CCl_4.
RDX	Acetone	Water.
	Ethyl alcohol	Water or isopropanol.
	Methyl alcohol	Water.
	Ethyl acetate	Do.
	Methyl ethyl ketone	Do.
HMX	Dimethyl sulfoxide	Do.
	Acetone	Do.

In addition to the surfactants described hereinabove, others may be used which are nonionic, anionic and cationic such as the ordinary soaps such as sodium stearate and oleate; other anionic surfactants such as turkey red oil, the various alkyl sulfates, alkyl benzene sulfonates such as the Oronite Detergents (Oronite Chemical Co., San Francisco, California) and the Nacconols (Allied Chemical & Dye Corp., New York, N.Y.); cationic surfactants such as the higher alkyl, alkaryl, etc. quaternary ammonium salts; and various nonionic surfactants such as the polyethenoxy ethers of alkyl phenols, the polyethenoxy ethers of alcohols, pentaerythritol monostearate, polyethenoxy esters of tall oil acids, polyethenoxy alkalolamides of fatty acids such as the Ethomids of Armour and Co., and the fatty acid esters of sugar alcohols such as sorbitol and mannitol (e.g., the Spans of Atlas Powder Co.).

In practicing the invention the dilution of the starting solution (i.e., solution of the explosive material in the selected solvent before the precipitant is added) may vary considerably. Very dilute solutions, produce the smallest crystals, but more concentrated solution may be used. The degree of dilution of the solvent with precipitant will also vary depending upon the yield desired and the problem of solvent recovery if it is to be recovered.

It will, therefore, be apparent that a novel method of processing explosive and propellant materials has been provided; that explosive and propellant materials have been provided in a novel and useful form; and that certain novel and useful fabricated explosive articles have been provided.

We claim:

1. An article of manufacture comprising a housing having a cavity therein, a bridgewire within said cavity capable of exploding upon application of sudden high voltage, and an explosive solid in said cavity and in intimate contact with said bridgewire, said explosive being of a type which is initiated by an exploding bridgewire and substantially all of said explosive being in the form of small, elongated crystals having a density within the range of 1.2 to 1.27 grams per cc.

2. The article of claim 1 wherein said explosive is PETN.

3. The article of claim 2 wherein the PETN crystals have a length-to-width ratio not less than about 10 and a width not greater than about 20 microns.

4. The article of claim 1 wherein the explosive is RDX.

5. An explosive device comprising a housing, a charge of PETN within said housing and means for initiating said charge, substantially all of said PETN being present in the form of elongated crystals having widths of about 5 to 20 microns, said crystals being coated with a nonylphenyl ether of polyethylene glycol surfactant, said PETN elongated crystals being packaged within said housing at a density within the range of 1.2 to 1.27 grams per cc.

6. An EBW device comprising a housing having a cavity therein, a charge of PETN in said cavity and an exploding bridgewire in contact with said charge and capable, upon application of a high voltage from an

EBW power source, of initiating said charge of PETN, substantially all of said PETN being in the form of elongated crystals having a width not exceeding about 20 microns, said charge of PETN having a density within the range of 1.1 to 1.27 grams per cc., said crystals being coated with a surfactant.

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SAMUEL FEINBERG, *Primary Examiner.*

BENJAMIN A. BORCHELT, *Examiner.*

MOLYBDENUM TRIOXIDE-ALUMINUM EXPLOSIVE AND EXPLODING BRIDGEWIRE DETONATOR THEREFOR

Filed July 17, 1961

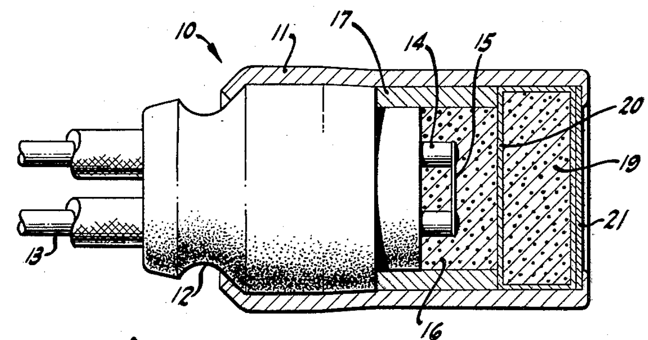

FIG-1

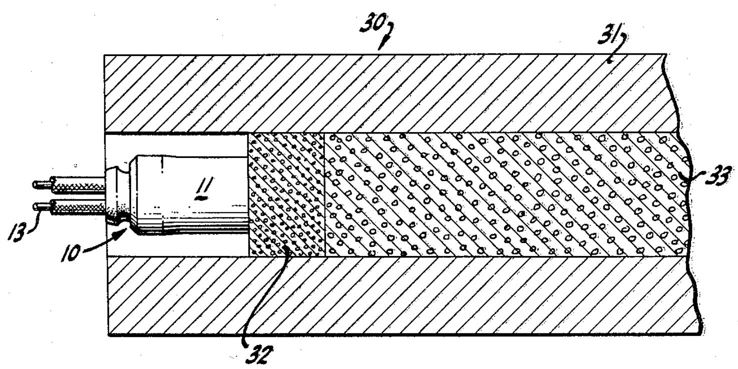

FIG-2

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3,160,097

MOLYBDENUM TRIOXIDE - ALUMINUM EXPLOSIVE AND EXPLODING BRIDGEWIRE DETONATOR THEREFOR

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2 Claims. (Cl. 102—28)

This invention relates to explosive materials and the like. More particularly it relates to a mixture of an oxidizing agent and a fuel or reducing agent which can be initiated by an explosive, a pyrotechnic composition or an exploding bridgewire; which is adapted to serve as a component in a train of explosive materials; and which is adapted to serve as an igniter to ignite a large body of propellant material, as in a rocket motor.

The oxidizer-fuel mixtures of the present invention have particular application to exploding bridgewire devices (EBW devices).

EBW devices have been developed to an extensive degree since the advent of guided missiles and rockets, space craft, etc. to serve as initiators in lieu of primary explosive devices which use relatively sensitive materials such as azides, fulminates and lead styphnate. These latter materials, which are known as primary explosives, are used in suitable devices as initiators to detonate or ignite less sensitive explosives and the like, such as T.N.T., but their use in rockets and missiles is undesirable because of their sensitivity and likelihood of premature explosion, as from thermal excitation.

EBW devices have, therefore, been substituted for primary explosive devices. An EBW device comprises a wire of small diameter extending between two terminals and a source of electrical energy capable of delivering a short pulse of high energy to the wire such that the wire melts, evaporates and explodes. The release of kinetic and thermal energy caused by such explosion acts to detonate or ignite an explosive or pyrotechnic material in contact with the wire. A typical material employed for this purpose is a mixture of aluminum and ammonium nitrate, which is relatively insensitive, therefore relatively safe to use but which is initiated by an exploding bridgewire. Another typical material used heretofore is a mixture of potassium perchlorate and aluminum.

As is also known in the art, to bring about explosion of a bridgewire it is necessary to supply sufficient electrical energy at a high voltage with a very fast rise time in the voltage curve.

It frequently happens that the EBW device contains a train of two or more materials between the wire and the main body of explosive or propellant. For example, it may be required to employ a mixture of aluminum powder and ammonium nitrate in contact with the wire, and a body of more sensitive material which is initiated by the explosion of the aluminum-ammonium nitrate charge. The second element in the train of materials may be used to ignite a large body of propellant, as in a rocket motor, or it may be used to ignite a larger body of similar igniter material which in turn ignites a rocket motor.

For such purposes it is desirable to provide an oxidizer-reducer mixture (or igniter mixture) which is reliably initiated by the explosion of a typical EBW mixture such as an aluminum-ammonium nitrate charge. (The latter is initiated by an exploding bridgewire as explained above.) It is also desirable that the igniter mixture be relatively insensitive to impact, friction and heat such as it is likely to encounter during service, storage and handling.

Igniter materials have been provided heretofore, e.g., a mixture of a lead oxide such as lead dioxide and aluminum or a mixture of a lead oxide and boron. However, these mixtures are overly-sensitive to impact and friction and they are frequently impaired by high temperatures which are sometimes caused by stray currents through the bridgewire or from other sources.

It is an object of the present invention to provide improved materials of the general character and for the general purpose described.

It is another and more particular object of the invention to provide a mixture of an oxidizer and a reducer or fuel which can be used in an EBW device downstream from the bridgewire, which is relatively safe from ignition or degradation caused by elevated temperatures of the character described, and which is reliably initiated by a suitable EBW mixture when the latter is initiated by an exploding bridgewire, and which will serve to ignite a larger body of similar material and/or the main body of propellant in a rocket.

The above and other objects of the invention will be apparent from the ensuing description and the appended claims.

In accordance with the present invention, we provide a mixture of molybdenum trioxide and a suitable fuel or reducer. The preferred fuel or reducer is powered or otherwise finely divided aluminum but any other oxidizable fuel of suitable physical and chemical characteristics may be used, for example, boron, zirconium, magnesium, zinc and iron and mixtures or alloys of these and other materials, in finely divided form. Less susceptible fuels such as silicon and carbon (i.e., fuels which are very difficult to initiate) may be used if a more energetic initiator is used, or if they are mixed with a suitable proportion of a more susceptible fuel such as powdered aluminum or boron. Somewhat more exotic and sensitive fuels such as lithium, sodium and potassium may be used if they are kept in an inert atmosphere. Also metal hydrides such as lithium hydride may be used.

In the case of the preferred mixture (molybdenum trioxide and aluminum), the preferred proportions are approximately 74 parts by weight of molybdenum trioxide and 26 parts by weight of aluminum, which is approximately the stoichiometric ratio, there being a small excess of molybdenum trioxide. Similarly in the case of other mixtures wherein other fuels are used in place of, or in admixture with aluminum, approximate stoichiometric proportions are preferred. However, in all such cases a considerable variation is permissible. In general, the molar ratio of molybdenum trioxide to fuel may vary from as little as one-half the stoichiometric ratio or less to one and one-half times the stoichiometric ratio or more. Where the fuel, as in the case of iron, has more than one state of oxidation, it is assumed that the highest stable oxide is formed.

Mixtures of this character are suited for use in an EBW device wherein the initiating energy is supplied by the explosion of a bridgewire, wherein a less sensitive explosive such as a mixture of aluminum powder and ammonium nitrate is used adjacent the wire, and wherein the molybdenum trioxide-fuel mixture of the present invention is used adjacent the less sensitive explosive but remote from the wire. The reason is that the molybdenum trioxide-fuel mixtures of the present invention are more sensitive to a hot wire than may be frequently desired. However, the molybdenum trioxide-fuel mixture of the present invention can be used adjacent the bridgewire if safety requirements permit. Also, certain mixtures are less sensitive, hence may be used adjacent a wire. Even the more sensitive mixtures, such as the preferred 74%

MoO_3-26% Al mixture may be used adjacent the bridge of a modified exploding bridge device wherein the bridge, instead of being a continuous length of metallic conductor such as a wire of small diameter, is in the form of a dispersion of a conductor in a dielectric material. A suitable bridge of this type consists of aluminum dispersed in an inorganic cement and cast into the form of a rod. Such exploding bridge systems are non-conducting or substantially non-conducting except when high voltages are applied with a fast rise from a sufficient energy source. Accordingly, they are not as likely to be heated by stray currents and to initiate an adjacent explosive material. Therefore, it is within the scope of the present invention to employ the molybdenum trioxide-fuel mixtures herein described and claimed in direct contact with or juxtaposition to an exploding bridge of such modified character.

Among the numerous advantages of molybdenum trioxide-fuel mixtures of the present invention, may be mentioned the following: They are resistant to shock and friction. For example in an impact sensitivity test a 6 kilogram weight was dropped 50 centimeters onto a given quantity of explosive material contained in a cup. In one-third of these tests the molybdenum trioxide-aluminum mixture of the present invention produced sparks, but no explosion occurred. In 75% of identical tests carried out with a potassium perchlorate-aluminum mixture, explosion occurred.

Furthermore, the above molybdenum trioxide-aluminum mixture containing 74% of molybdenum trioxide and 26% aluminum has good temperature characteristics, e.g., it can be heated above 1100° F. without spontaneous ignition and to 900° F. for one hour without affecting its operability in an EBW device.

This mixture and many others within the scope of the invention are essentially gasless. That is to say, the products of combustion are solid rather than gaseous. Nevertheless a hot flame and hot particles are produced which are effective to ignite a rocket motor. This is advantageous because it avoids the production of excessive gas pressure with explosive violence such as might explode a rocket motor. Also the mixture of the invention can be ignited by a small charge, for example by a 0.05 gram charge of an aluminum-ammonium nitrate mixture, which itself is initiated by an EBW.

The mixture of the invention also has good properties with respect to heat output, maximum flame temperature and pressure-time relationship. Thus, the preferred molybdenum trioxide-aluminum mixture has a calorific value of 1,070 calories per gram, a flame temperature of 3,000° C. and a very fast rise of pressure with time when ignited in an EBW device.

As stated, the preferred mixture is relatively sensitive to a hot wire. Therefore, it is preferably not used in contact with the bridgewire of an EBW device. However, it can be used advantageously in contact with the bridge of a modified exploding bridge device as explained above, wherein the bridge is a rod of dielectric material having small particles if conductor dispersed therein. In an exploding bridge device of such character, the bridge is essentially a non-conductor at low voltages of the order of a few hundred volts. Therefore, it is not heated when subjected to stray voltages of that order. Accordingly, the more sensitive molybdenum trioxide-aluminum mixture (that is to say, more sensitive to a hot wire than aluminum-ammonium nitrate) can be used safely in direct contact with the bridge itself. Moreover, there is an advantage in using the molybdenum trioxide-aluminum mixture instead of an aluminum-ammonium nitrate mixture in such a device, in that the thermal and kinetic energy output of a dielectric bridge of the character described is not as great as the energy output of a wire. Therefore the fact that the molybdenum trioxide-aluminum mixture is more sensitive is an advantage because it is more dependably initiated by a dielectric bridge of the character described.

Certain structural embodiments of the invention will now be illustrated with reference to the accompanying drawings in which

FIGURE 1 is a view in longitudinal section of an EBW device in which the molybdenum trioxide-aluminum mixture of the present invention is employed remotely from the wire.

FIGURE 2 is a diagrammatic view showing how a device such as that shown in FIGURE 1 is employed in a rocket motor.

Referring to FIGURE 1 the EBW device there shown is generally designated by the reference numeral **10**. It comprises a metallic body **11** within which is secured a header **12**. Insulated wires **13** are connected to a suitable EBW power circuit (not shown) and at their inner ends the wires **13** are connected to terminals **14** which are connected by a bridge **15**. The bridge **15**, as stated above, is a wire of very small cross-section which, upon application of a sudden pulse of electrical energy, will melt, evaporate and explode, thereby releasing a pulse of thermal and kinetic energy. Adjacent the bridgewire **15** is a charge **16** of explosive material such as a mixture of aluminum and ammonium nitrate which is enclosed by a bushing **17**. This charge of explosive is in direct contact with and is initiated by the wire **15**. More remotely from the wire is a second body of explosive or pyrotechnic material **19** which is the molybdenum trioxide-aluminum mixture of the present invention and is contained in a cup **20** which is closed at one end and which is provided with a sealing cap **21** at its other end.

Initiation of the primary charge **16** will ignite the charge **19** which in turn can be used to ignite a rocket motor or for any other desired purpose.

As stated above, if the wire **15** is replaced by a dielectric bridge of low conductance, the charge **16** in direct contact with the birdge may be the molybdenum trioxide-aluminum mixture of the present invention. In that case the interior of the device to the right of the header **12** (as viewed in FIG. 1) will be filled with the molybdenum trioxide-aluminum mixture.

Referring now to FIG. 2, a rocket motor is there shown which is generally designated by the reference numeral **30**. It contains a body of solid propellant material **31**. An EBW device **10** of the type shown in FIG. 1 is shown in juxtaposition to a charge of igniter material **32** which in turn is in contact with a larger body of igniter material **33**. Typically, the igniter material **32** may be a small body of potassium perchlorate-aluminum mixture or a potassium nitrate-boron mixture of relatively small grain size. The main body of igniter material **33** may be of the same composition as the smaller body **32** but of larger grain size.

Upon application of a suitable voltage, with a sufficiently short rise time from a suitable energy source (e.g., 2000 volts, a rise time less than one microsecond and a 1.0 μf. power source) the EBW device **10** will initiate the body **33** which will initiate the body **32** and ignite the rocket propellant **31**.

It will, therefore, be apparent that a novel and advantageous explosive and/or igniter mixture has been provided and that novel and advantageous explosive and/or propellant devices have been provided which embody such mixture.

We claim:

1. A composition of matter consisting essentially of (1) molybdenum trioxide and (2) aluminum, said molybdenum trioxide and aluminum being in finely divided form and in intimate admixture, and being present in proportions of about one quarter to about three quarters of a mol of molybdenum trioxide per mol of aluminum.

2. An explosive device of the character described comprising a housing; a pair of terminals therein; a bridge of the exploding bridgewire type connecting said terminals; a first body of explosive in contact with said bridge and adapted to be initiated by a pulse of electrical energy

delivered to said bridge as a short pulse at a high voltage and with a short rise time whereby the bridge is vaporized and exploded and releases thermal and kinetic energy sufficient to initiate a charge of PETN; and a second body of explosive in sufficiently close proximity to said first body of explosive to be initiated by said first body but not in contact with said bridge, said second body of explosive consisting essentially of (1) molybdenum trioxide and (2) aluminum, said molybdenum trioxide and aluminum being in finely divided form and in intimate admixture and being present in proportions of about one quarter to three quarters of a mol of molybdenum trioxide per mol of aluminum.

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[45] **Sept. 23, 1975**

[54] **MINIATURE IGNITER**

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[73] Assignee: **The United States of America as represented by the United States Eneregy Research and Development Administration,** Washington, D.C.

[22] Filed: **July 30, 1974**

[21] Appl. No.: **493,007**

[52] **U.S. Cl.** .... **102/28 R**
[51] **Int. Cl.²** **F42B 3/12**
[58] **Field of Search** .... 102/28 R

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[57] **ABSTRACT**

The invention relates to a novel miniature igniter which comprises a pair of electrically conductive spaced apart members each having a complementary recess at one end, an electrically insulative plate intermediate the members also having a recess complementary to the recesses of the electrically conductive members, all of said recesses forming a cavity for receipt of charge, a bridgewire spanning the plate to electrically interconnect the conductive members, charge material in the recess over the bridgewire, and connector pins in electrical connection with the conductive members for electrically integrating the igniter in an electrical circuit.

7 Claims, 5 Drawing Figures

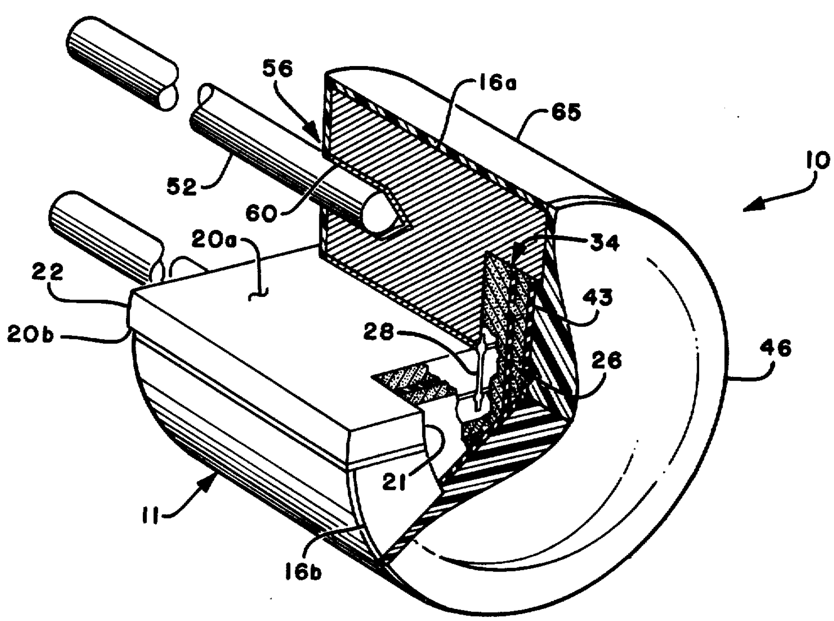


FIG. 1

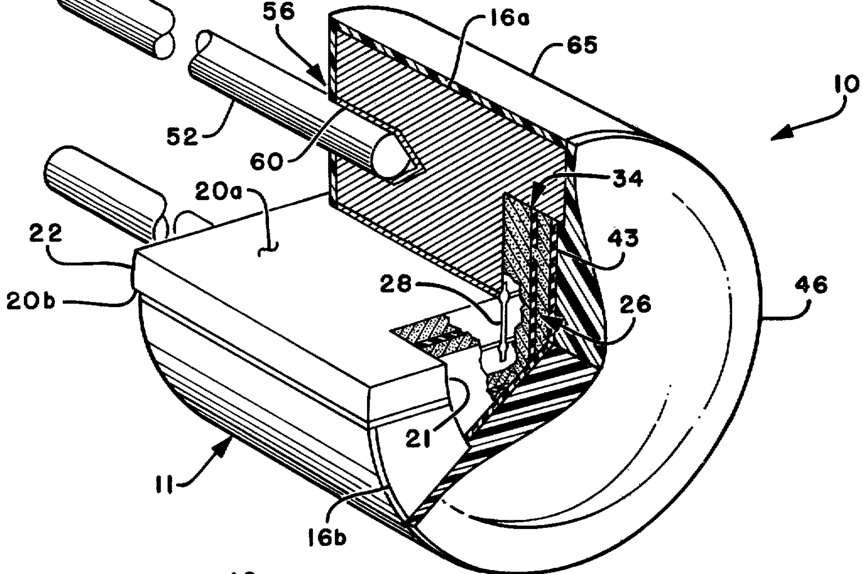


FIG. 2

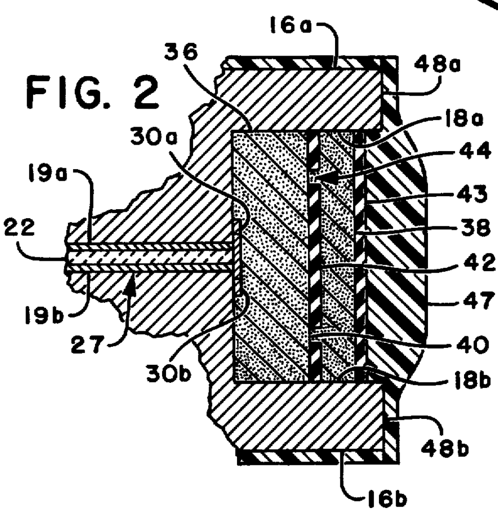


FIG. 3

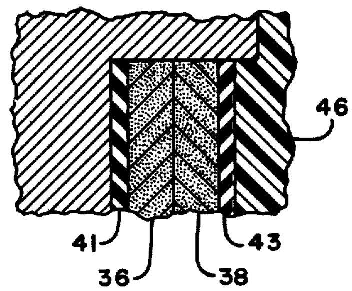


FIG. 4

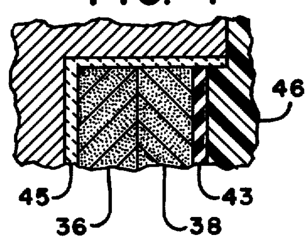
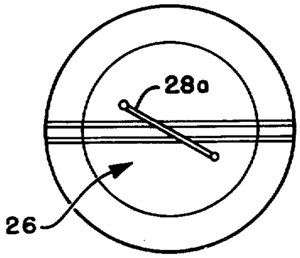


FIG. 5



MINIATURE IGNITER

BACKGROUND OF INVENTION

The invention relates to miniature electrical igniters or squibs.

Squibs or igniters for igniting explosive charges in ballistic missiles, thermal batteries, gas generators, and the like, are known. Generally, these comprise lead pins or wires disposed in holes in a suitable insulator and having a bridgewire connecting end portions of the pins at some point adjacent the explosive charge. The insulators may often be made of glass or ceramic materials.

It is desirable in some applications to minimize the size of the igniters to achieve a desired purpose. Problems may be encountered in attempting to minimize or reduce the size of these igniters due to various inherent constraints. For example, because of the limited ability of some prior art igniters to absorb pressure, it is generally not feasible to compress, within the igniter body, the explosive charge by application of high pressures in order to compact the explosive material into a small volume and achieve intimate, compressed and direct contact of the explosive charge with the bridgewire.

It is also difficult to reduce the pin spacing to control bridgewire length by drilling or otherwise forming holes in the glass or ceramic such that the ends of the lead pins or lead wires adjacent the explosive charge are closer than about **0.025** inches. Drilling may create concealed cracks which extend from one hole to adjacent holes beneath the surface, which cracks may subsequently create electrical shorts and other problems in operation of the igniter or squib.

Bridgewire pin spacing is important because as the fast pulse firing energy requirement is reduced in order to meet specifications for miniaturized systems and the bridge resistance is specified, the bridge volume must be reduced. It is difficult to comply with these specifications using prior art technology because of the limitations hereinabove described.

SUMMARY OF INVENTION

In view of the above limitations, it is an object of this invention to provide a miniature igniter suitable for use as the ignition source in thermal batteries, explosive cartridges, gas generators, and the like.

It is a further object of this invention to provide a novel igniter wherein bridgewire pin spacing may be as low as **0.010** inches.

It is a further object of this invention to provide an igniter having a recess wherein the explosive charge may be satisfactorily compressed to pressures in excess of **90,000** pounds per square inch (psi).

It is a further object of this invention to provide an igniter having massive, electrically conductive members to which the bridgewire is engaged to provide maximum heat dissipation capability.

It is a further object of this invention to provide an igniter having a one ohm bridge which reliably initiates upon delivery of **100,000** ergs in less than three microseconds without the use of extremely sensitive primary explosives.

Various other objects and advantages will become apparent from the following description of this invention and the most novel features will be pointed out with particularity hereinafter in connection with the appended claims. It is understood that various changes

in the details, materials and process steps which are herein described and illustrated to better explain the nature of the invention may be made by those skilled in the art without departing from the scope of this invention.

The invention comprises, in brief, an igniter having a pair of electrically conductive, spaced apart members each having a complementary recess at one end, an electrically insulating plate intermediate the members also having a recess complementary with the recesses of the conductive members, the members recesses and the plate recess forming a cavity receiving a charge, an electrically conductive bridgewire disposed in the cavity spanning the insulating plate and having opposite end portions electrically connected to the electrically conductive members, a closure disc disposed over the cavity, and connector pins in electrical connection with and projecting from the conductive members for connecting to an electrical circuit.

DESCRIPTION OF DRAWING

FIG. **1** illustrates, in a cutaway, partially cross-sectional and partially perspective view, an embodiment of this invention;

FIG. **2** is a cross-sectional representation of a portion of the embodiment shown in FIG. **1**;

FIGS. **3** and **4** are cross-sectional views of portions of alternate embodiments of this invention; and

FIG. **5** is a top view of an embodiment of an igniter of this invention, without the charge or end cover, illustrating an alternate mode for positioning the bridgewire.

DETAILED DESCRIPTION

The igniter **10** of this invention may be of generally cylindrical configuration **11** as illustrated in FIG. **1.** The elements of this igniter **10**, a portion of which is shown in greater detail in FIG. **2**, may include a pair of electrically conductive members **16***a*, **16***b* each having a recessed portion **18***a*, **18***b* at one end, the members having adjacent large planar surfaces **19***a*, **19***b* being spaced or separated from each other by a relatively thin, electrically insulative plate **22** having oppositely disposed planar faces **20***a*, **20***b* disposed intermediate and in direct contact with the electrically conductive members **16***a*, **16***b*. Electrically conductive members may be of any desirable shape, such as rectangular or of generally semicircular, elongated configuration. Electrically insulative plate **22** likewise has a recessed portion **21** at one end thereof which matches or complements adjoining or contiguous recessed portions **18***a*, **18***b* in electrically conductive members **16***a*, **16***b* and which forms therewith a cup, chamber or cavity **26** which receives or houses charge **34.** Walls forming cavity **26** may define any shape such as a generally semicircular or cylindrical shape illustrated in the drawings. Cavity **26** may preferably be in coaxial alignment with the longitudinal axis of the igniter assembly **10.**

Electrically conductive members **16***a*, **16***b* may be made of such materials as nickel and its alloys or clad materials such as copper-nickel and the like, and are preferably made of materials that are good electrical conductors such as nickel-iron and nickel-iron-cobalt alloys. Electrically insulative plate **22** may be made of any suitable ceramic material having good metallizing-brazing capabilities as known in the art. To obtain maximum heat dissipation, it may be made of alumina which contains at least **94.0** weight percent aluminum oxide (Al_2O_3). Ceramic plate **22** may be bonded or joined to members **16***a*, 16*b* through any suitable joining process such as a molybdenum-manganese brazing process. In this brazing process, a thin layer of molybdenum-manganese coating may be applied to the alumina ceramic plate **22** to a thickness of from about **0.002** to about **0.005** inches. An electrodeposition coating may thereafter be applied over the molybdenum-manganese coating. The electrodeposition coating may be to a thickness of about **0.0004** inches using a suitable material such as nickel. The ceramic may then be sintered in a protective atmosphere such as a hydrogen atmosphere at a temperature of about **1475°C** to improve adherence of the metal to the ceramic and reduce the tendency of the ceramic to oxidize. The electroplated surface may then be soldered or brazed onto the adjoining planar surfaces **19***a*, 19*b* of the electrically conductive members **16***a*, 16*b* using a suitable braze material such as **72** weight percent copper and **28** weight percent silver yielding a brazed connection or joint **27** which joins plate **22** and surfaces **19***a*, 19*b* of members **16***a*, 16*b*. Processes for applying the molybdenum-manganese coating, the nickel electroplating and sintering, and the soldering or brazing are generally known in the art. Prior art igniters had small diameter lead pin holes in the ceramic insulators which limited the use of these processes to deposit coatings within pin hole walls. The present igniter eliminates these pin holes and thereby does away with this coating limitation.

Disposed within cavity **26** is a bridgewire **28** which spans plate **22** and is suitably joined or connected to electrically conductive members **16***a*, 16*b* at opposite ends of the bridgewire **28.** The mode of joining bridgewire **28** to the conductive members may be such as by resistance spot welds **30***a*, 30*b*. Also disposed within cavity **26** is the charge or pellet **34** which may comprise one or more types of charges. For example, as illustrated in FIG. **2,** disposed within cavity **26** is an igniter charge **36** which is ignition sensitive to the electrical input stimuli and an output charge **38** which is an ignition source for use in thermal batteries or the like. The igniter charge **36** is disposed in recess **26** in direct contact with bridgewire **28,** electrically conductive members **16***a*, 16*b*, and plate **22.** The igniter charge may be compressed in place by applying a ram (not shown) at exposed surface **40** of igniter charge **36** at a suitable pressure such as from about **2,500** to about **90,000** psi and preferably at about **15,000** psi. It is understood that the amount of charge that may be contained in cavity **26** is related to the compression force employed.

It may be desirable to dispose intermediate igniter charge **36** and output charge **38** a perforate dielectric layer **42,** such as a mica layer, of a thickness of from about **0.002** to about **0.005** inches having one or more openings or apertures **44** to permit heat from igniter charge **36** to pass to output charge **38** and ignite same while reducing the potential of electrical shorting through conductive by-products generating from the combustion of igniter charge **36** and output charge **38.** Output charge **38** is in physical contact with igniter charge **36** through port, aperture or opening **44** of dielectric layer **42.** Depending upon the type and chemical composition of charges employed, mica layer **42** may not be required, or may be positioned intermediate conductive members and ceramic plate **22** and igniter charge **36,** as shown in FIG. **3,** in which output charge **38** is in direct contact with igniter charge **36.** Mica layer **41** shown in FIG. **3** may have an aperture to allow layer **41** to fit over the bridgewire **28** and thus be contiguous to the electrically conductive members and igniter charge **36.** An alternate method for effecting the same purpose as mica layer **42** recited hereinabove, i.e., reduce the potential of electrical shorting through conductive by-products generating from the combustion of igniter charge **36** and output charge **38,** may comprise depositing an insulative coating **45** by suitable vapor deposition techniques on the walls and bottom of cavity **26** as shown in FIG. **4.** Coating **45** may preferably be aluminum oxide at a thickness of from about **5,000** angstroms to about **50,000** angstroms and preferably about **10,000** angstroms. A suitable maskant may be employed to mask the bridgewire area to prevent deposition onto the bridgewire, or, alternatively the bridgewire area may also be coated and the coating subsequently abraded.

Output charge **38** may be disposed within cavity **26** to be contiguous with either igniter charge **36** (FIG. 3) or dielectric layer **42.** A ram may be placed within the periphery of cavity **26** and output charge **38** may be compressed at a suitable pressure of from about **2,500** to about **90,000** psi, and preferably at about **15,000** psi, in the same manner as igniter charge **36** was compressed. It may be desirable not to compress igniter charge **36** and output charge **38** individually but to compress them simultaneously. A suitable dielectric barrier, layer or disc **43** may be placed over output charge **38** to isolate charge **38** from the closure member or cover **46** material which seals cavity **26.** A suitable dielectric may be such as a polyimide resin.

A rupturable closure disc, pad, or cover **46** is disposed over igniter **10** sealing cavity **26** adjacent output charge **38** and against disc **43,** said closure member extending over the ends or nonrecessed portions **48***a*, 48*b* of electrically conductive members **16***a*, 16*b* respectively as well as the nonrecessed portions of the plate **22.** Disc **46** may be of any desirable configuration such as a flat disc, or may have a thickened central portion **47.** Disc **46** is made of a suitable dielectric material, such as synthetic rubber, which may be joined to the igniter members by a suitable adhesive. The sealing process seals the cavity contents from an external atmosphere. Dielectric disc **43** may be placed in cavity **26** contiguous to and overlying output charge **38** to prevent any moisture from touching output charge **38** in the sealing process. Disc **43** may likewise be from **0.002** to about **0.005** inches thick.

Members **16***a*, 16*b* also have, or are in electrical connection with, suitable means for engaging igniter **10** into an electrical circuit. For example, electrical connector pins **52** may be disposed within appropriate bores or cavities **56** at any part of the electrically conductive members **16***a*, 16*b* and may then be suitably joined to these members by suitable joining procedures or processes, such as brazing, to result in a brazed joint or interconnection **60.** Various other joining or connector means for interconnecting igniter **10** into an electrical circuit may be used. Electrical connector pins **52** may be made of the same material as electrically conductive members **16***a*, 16*b* or of other appropriate electrically conductive materials.

It may be desirable to apply a suitable dielectric coating **65** such as a fluorocarbon material or the like, which may extend over exterior walls of figniter igniter except those parts which are required to be exposed for electrical contact such as electrical connector pins **52.** The igniter end which is covered by cover or closure disc **46** may or may not be coated. Coating **65** provides electrical insulation as well as corrosion protection and the like properties. Cover **46** not only aids in retaining the explosive charge **34** within the cavity **26,** but also prevents moisture from entering explosive charge **34.**

Various materials such as nickel-chromium and gold alloys which are capable of being resistance spot welded or ultrasonically welded to electrically conductive members **16***a*, **16***b* may be used for bridgewire **28.** Bridgewires having a composition of **80** nickel-**20** chromium have been successfully employed. These bridgewires have a resistance of about one ohm and a diameter of about **0.0012** inches. The length of the bridgewire and diameter are selected from considerations of the no-fire, all-fire power encountered by the bridgewire, the bridge resistance specified and the like. The igniter of this invention may receive several different bridgewire lengths by positioning the bridgewires so as to diagonally span the electrically insulative ceramic plate as illustrated by bridgewire **28***a* in cavity **26** in FIG. **5.**

The igniter of this invention provides attainment of maximum no-fire electrical current standoff and firing sensitivity for a given pyrotechnic or explosive material which may be used. Igniter design offers maximum heat sinking to the bridgewire as well as permits consolidation or compression pressure of in excess of **90,000** psi directly against the bridgewire and its substrate. The laminate construction of this invention may advantageously use electrically insulative alumina ceramic plates having a thickness which may be as small as **0.010** inch. Spacing across the electrically insulative ceramic plate as noted above is an important factor because as the fast pulse firing energy requirement is reduced and the bridge resistance is specified at a low level, the bridge volume (length) may be reduced.

This invention permits the use of pyrotechnic or secondary explosive charges such as used in exploding bridge wire applications in lieu of the much more sensitive and potentially hazardous primary explosive charges. Examples of pyrotechnic materials that have been initiated with a one ohm resistance, **0.0012** inch diameter bridgewires include: boron/calcium chromate, zirconium/potassium perchlorate, potassium perchlorate/potassium hexacyanocobaltate, boron/potassium perchlorate/titanium, boron/potassium perchlorate/iron oxide, and boron/potassium perchlorate/-calcium chromate.

No-fire sensitivity tests, defined as the maximum energy level which may be applied to an electrical-explosive device for a given period without igniting or degrading the surrounding explosive material, were conducted on an igniter of this invention having electrically conductive members made of nickel-iron alloys, connector pins made of the same alloy, electrically insulative ceramic member made of about **94**% alumina, bridgewire made of nickel-chromium and being of one ohm resistance and **0.0012** inch diameter. Results using boron/calcium chromate as the igniter charge resulted in a mean no-fire current level at **5** minutes of **1.21** amperes with a sigma of **0.0285** ampere. Sigma refers to

a measure of the deviation of a number from measurements for the mean.

A higher no-fire current level may be obtained using clad material, or other suitable components instead of nickel-iron alloys because of the higher thermal conductivity. Bridgewire volume must be controlled to allow the pyrotechnic igniter to fire on microseconds duration/low energy pulse. Igniters of this invention having a one ohm bridge have been made with a sufficiently small volume to insure reliable initiation of the selected powder or ignition charge with **100,000** ergs delivered in microseconds, and in general will initiate in less than three microseconds. Assuming a normal distribution, the estimated energy level at which **99.9**% will fire is **70,000** ergs. This fast response is achieved by this invention while still maintaining a higher no-fire standoff as discussed hereinabove. Igniters of this invention wherein the electrically insulative ceramic plate length is about **0.180** inches and wherein the ignition charge is **20**% boron/**80**% calcium chromate at a weight of **4.5** milligrams and wherein the output charge is **40**% titanium/**60**% potassium perchlorate at a weight of **9.5** milligrams have been successfully employed.

What is claimed is:

1. An igniter comprising a pair of electrically conductive spaced apart members each having a complementary recess extending inwardly from one end thereof, an electrically insulative ceramic plate intermediate said members maintaining them spaced apart having a recess extending inwardly from one end thereof corresponding with said member recesses and forming therewith an open-ended charge cavity, an electrically conductive bridgewire disposed at the bottom of said cavity spanning said insulative ceramic plate and having opposite end portions electrically connected with said spaced apart members, an igniter charge in said cavity in contact with said bridgewire, and a closure disc extending over said cavity and sealed to said electrically conductive members and said insulative plate.

2. The igniter of claim **1** including connector pins in electrical connection with and projecting from said conductive members at end portions opposite said cavity.

3. The igniter of claim **1** wherein said ceramic member thickness intermediate said electrically conductive members is about **0.010** inch, said ceramic is alumina, and said electrically conductive members are selected from the group consisting of nickel, iron, and alloys thereof.

4. The igniter of claim **1** including an output charge disposed over said igniter charge in said cavity.

5. The igniter of claim **4** including a perforate dielectric member disposed intermediate said igniter charge and said output charge, heat from said igniter charge passing through said perforation in said perforate dielectric member to ignite said output charge.

6. The igniter of claim **5** wherein said bridgewire is a one ohm resistance bridgewire at a thickness of about **0.0012** inch, said bridgewire is made of nickel-chromium alloy, said insulating ceramic plate is **0.020** inches thick, said igniter charge is boron/calcium chromate, said output charge is titanium/potassium perchlorate, and said igniter has a mean no-fire current level at **5** minutes of about **1.21** amperes.

7. An igniter comprising a pair of electrically conductive, spaced apart semicircular members each having a complementary semicircular recess extending inwardly rom one end thereof, each of said members having a ›lanar surface extending to said semicircular recess; an :lectrically insulative, about 94% alumina ceramic ›late of thickness of at least 0.010 inches intermediate aid electrically conductive semicircular members at a liameter thereof maintaining them spaced apart and ıaving a recess extending inwardly from one end hereof corresponding with said member recesses and orming therewith an open ended charge cavity, said eramic plate having a pair of oppositely disposed plaıar faces for bonding to said conductive member plaıar surfaces; brazed bonds intermediate said insulative ›late planar faces and said conductive members planar urfaces; an electrically conductive bridgewire dis›osed at the bottom of said cavity spanning said ceamic plate and having opposite end portions electriılly connected with said spaced apart members; a ompressed igniter charge in said cavity in contact with said bridgewire, said igniter charge compressed in said cavity at from about 2,500 psi to about 90,000 psi, a compressed output charge disposed over said igniter charge in said cavity, said output charge compressed in said cavity at from about 2,500 psi to about 90,000 psi; a perforate dielectric layer disposed intermediate said igniter charge and said output charge, heat from said igniter charge after ignition passing through said perforations in said perforate dielectric layer to ignite said output charge,a closure disc extending over said cavity and sealed to said electrically conductive members and said insulative plate, a dielectric disc disposed in said cavity intermediate said output charge and said closure disc to separate said output charge and said closure disc material, and connector pins in electrical connection with and projecting from said conductive members at end portions opposite said cavity.

* * * * *

United States Patent [19]

Harnau

[11] **3,899,974**

[45] **Aug. 19, 1975**

[54] **ELECTRIC PROPULSIVE CHARGE IGNITER**

[75] Inventor: **Hans-Dieter Harnau,** Wuppertal-Barmen, Germany

[73] Assignee: **Rheinmetall GmbH,** Dusseldorf, Germany

[22] Filed: **July 31, 1973**

[21] Appl. No.: **384,389**

[30] **Foreign Application Priority Data**

Aug. 10, 1972 Germany 2239325

[52] **U.S. Cl.** **102/46**
[51] **Int. Cl.** **F42b 9/08**
[58] **Field of Search** 102/46

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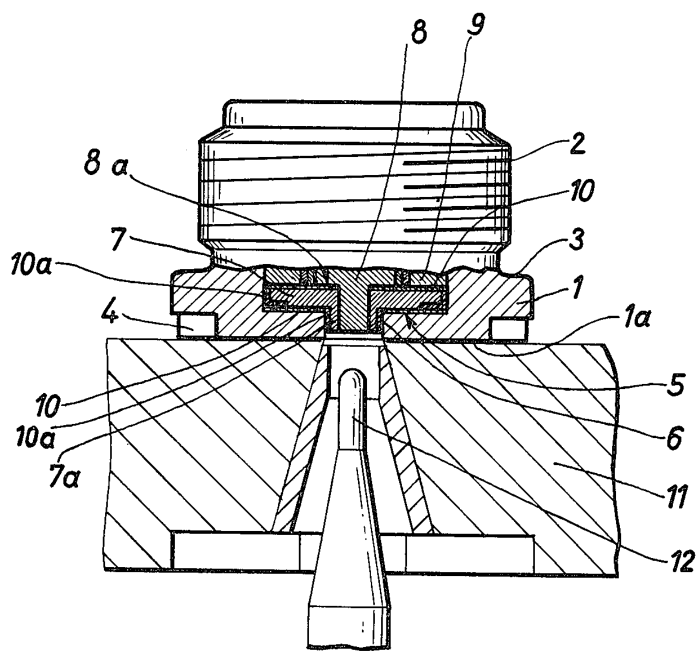
Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—C. T. Jordan
Attorney, Agent, or Firm—Ernest G. Montague; Karl F. Ross; Herbert Dubno

[57] **ABSTRACT**

An electric propulsive charge igniter comprising a primer body having a first shoulder. The primer body has a central bottom opening and an outer thread and is adapted to be screwed into a cartridge. The primer body has further a continuous axial opening provided with shoulders. A central contact is insulated from the primer body and combined with its ignition piece. A steel supporting annular disk and a central contact has a narrow shoulder and is associated with the steel supporting annular disk. The latter has a wide shoulder. The narrow shoulder is taken up by the wide shoulder. The supporting annular shoulder rests via its entire shoulder width against the shoulder of the primer body, and the primer body has a sleeve-like extension, passing through the central bottom opening up to the vicinity of the bottom as guide for the central contact.

1 Claim, 1 Drawing Figure



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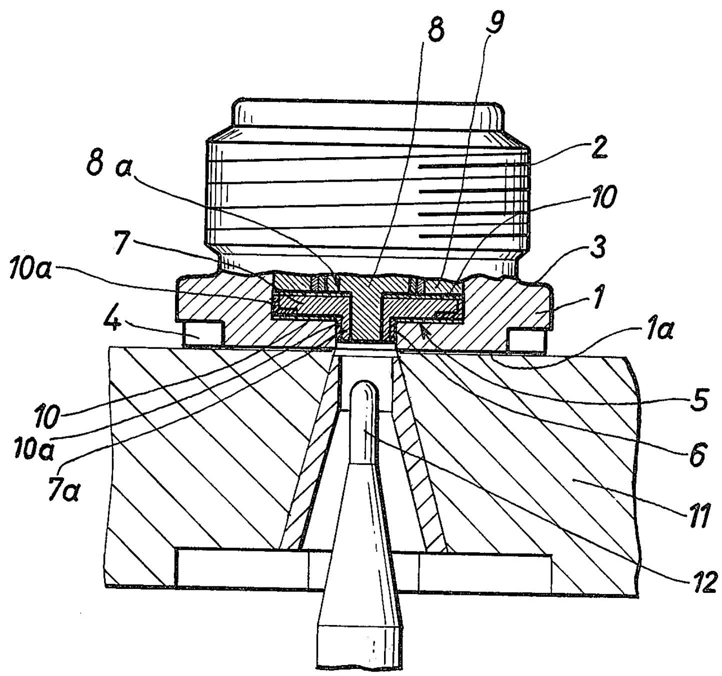

ELECTRIC PROPULSIVE CHARGE IGNITER

The present invention relates to an electric propulsive charge igniter consisting of a primer body which is adapted to be screwed into the bottom of the cartridge and has a continuous axial opening provided with shoulders. In the opening there are arranged in succession, starting from the bottom, a central contact, which is insulated from the primer body and combined with an ignition piece, the primer composition and a transmission composition.

In such electric propulsive charge igniters, also known as electric threaded primers, blowouts frequently occur as a result of the gas pressure which is built up upon the ignition of the propulsive charge. The central contact, with the shearing off of its shoulders, is pressed through the opening in the bottom against the breechblock of the weapon. Aside from the fact that, in this way, a part of the power gas is discharged from the projectile and is thus lost, the operation of the weapon is endangered by the hot gases, and finally the operation of the breech mechanism itself can be impaired or the breech mechanism even damaged.

In the search for the causes of this defect it has been found that the central contact is not supported by the breechblock at the moment of the ignition. With a gas pressure of 4500 kp/cm^2 and more, the dreaded blowouts can thus occur, although they could be avoided if the central contact could rest with a wider shoulder against the primer body.

Since, on the one hand, the central contact is a part of the ignition piece, which is combined to form a mounting unit, there is no possibility for any significant change in the central contact. On the other hand, the bore within the breechblock, which receives the movable firing pin cannot be arbitrarily narrowed, so that narrow limits are established in this case also with respect to the structural possibilities.

It is thus one object of the present invention to provide, while avoiding the mentioned drawbacks and defects, an electric propulsive charge igniter, which is characterized by an extremely flat construction, which makes possible the use of the previously customary central contact and of the breechblock, and which has an internal arrangement self-supporting in such a manner that it withstands maximum gas pressures.

According to the invention a steel annular supporting disk is associated with the central contact in such a manner, that the narrow shoulder of the central contact is taken up by a broad shoulder of the supporting annular disk, the full shoulder width of which rests against a shoulder on the primer body and the sleeve-like extension of which passes through an opening of the primer body up into the vicinity of the bottom of the primer to form a guide for the central contact.

In accordance with another feature of the present invention, the central contact is provided via the supporting annular disk with an insulation from the primer body, which insulation has reinforcing layers serving as a seal.

Upon the ignition of the cartridge charge, therefore, the high gas pressure acting on the inner device of the propulsive charge igniter is taken up via the narrow shoulder of the central contact, both by the wide shoulder of the steel supporting annular disk and by a shoulder on the primer body, which in its turn fully supports the supporting annular disk.

These and other objects will become more readily apparent from the following detailed description, reference being made to the accompanying drawing, in which the sole FIGURE shows the charge igniter inpartial axial section.

The propulsive charge igniter comprises essentially a cylindrical primer body **1**, preferably of brass, on which there are provided an outer thread **2** for screwing it into an outer cartridge bottom, a stop shoulder **3** and a wrench surface **4**.

On its inside, the primer body **1** has a continuous axial opening with a plurality of shoulders. Thus the inwardly facing shoulder **5** adjacent the bottom **1a** of the primer body **1** terminates at a comparatively narrow central bottom opening or bore **6**. A steel annular supporting disk **7**, whose diameter corresponds approximately to the outside diameter of the shoulder **5** rests on the latter and has the downwardly directed sleeve-like extension or boss ***7a*** which extends almost to the bottom or end face of bore **6**. In the interior there is inserted the central contact **8**, which terminates flush with end of the sleeve-like extension ***7a*** approximately in the vicinity of the bottom and whose narrow shoulder ***8a*** rests on the wide shoulder or upper face of the supporting annular disk **7**. The central contact **8** is, as is known, combined with an ignition piece **9** adjoining the top of which are the primer and transmission compositions. The upper end of the propulsive charge igniter is closed by a moisture-proof covering plate.

The outer surfaces of the supporting annular disk **7**, which come into contact with the primer body **1**, are insulated. The insulation **10** comprises preferably a thin layer of plastic or synthetic material, which has a reinforcing layer ***10a*** of a fiber-reinforced plastic or synthetic material, merely in the region of the transition from the end surface to the lower disk surface, and on the outside on the sleeve-like extension ***7a***.

Referring now to the drawing, it can be clearly noted, that the breechblock **11** of the weapon system requires a bore, serving to receive and advance the electric firing pin **12**, which is larger than the diameter of the central contact **8** and practically as large as the central bottom opening **6** of the primer body **1**. Thus a breech-sided supporting of the internal arrangement is not possible. Rather, the gas pressure which builds up in the charge chamber upon the ignition of the cartridge charge and which acts with the same force also rearward on the inner arrangement of the propulsive charge igniter can be distributed from the small surface of the central contact **8** to the large disk surface of the steel supporting annular disk **7**, in which connection it has been found by tests that the entire inner arrangement retains its position unchanged upon firing.

While this surprising effect is to be ascribed essentially also to the large shoulder of the supporting annular disk, nevertheless the sleeve-like extension ***7a*** serving as guide and mount for the central contact **8**, as well as the fact that the central bottom opening **6** is narrower than the width of the narrow shoulder **8a** of the central contact **8**, also serve to protect the internal arrangement of the propulsive charge igniter even in case of extremely high gas pressures. Therefore, the dreaded "setting" does not occur. Only the insulation **10** forms an exception, particularly at the places at which reinforcing inserts ***10a*** are provided, to the extent that as a result of the high gas pressure, the insulating material forces its way into the smallest gaps and channels and thereby, in addition to assuring electrical insulation, also provides a mechanical seal.

The surprising effect that the safety of the inner arrangement is assured by a very balanced distribution of pressure is thus not obtained at the expense of a particularly heavy development of the primer body. Rather, it has been found that even with an extremely flat construction of the propulsive charge igniter, the same excellent action can be obtained.

I claim:

1. An electric primer for a weapon having a breechblock with a passage for a firing pin and for mounting in a cartridge, the primer comprising:

a primer body formed at one end with an external thread receivable in said cartridge, an external shoulder at the other end forming a stop for said body, and a end face at said other end adapted to rest against said breechblock,

said body being formed with an axially extending chamber and with an internal shoulder defining said chamber at said other end, said other end being provided with an axially extending bore terminating at said internal shoulder and said face communicating with said chamber;

a steel annular supporting disc received in said chamber and overlying said internal shoulder while being formed with a boss extending axially into said bore and terminating short of said end face;

a central contact axially engageable with said pin and having a projection substantially filling said boss, said contact being formed with a body portion resting against a surface of said disc turned away from said internal shoulder, said projection terminating flush with said boss;

an ignition piece surrounding said contact and bearing against said surface of said disc within said chamber;

a layer of insulation on said surface of said disc, around the periphery thereof, between said disc and said internal shoulder and surrounding said boss for insulating said ignition piece and said body from said disc; and

reinforcing means for said insulation at least along the periphery of said disc for providing a sealing action.

* * * * *

United States Patent [19]
Kaszupski

[11] 3,828,677
[45] Aug. 13, 1974

[54] ELECTRIC IGNITION ELEMENT WITH SECONDARY IGNITION CAPABILITY

[75] Inventor: Stanley J. Kaszupski, Philadelphia, Pa.

[73] Assignee: The United States of America as represented by the Secretary of the Army, Washington, D.C.

[22] Filed: June 11, 1973

[21] Appl. No.: 368,927

[52] U.S. Cl. .... 102/46, 102/70.2 A
[51] Int. Cl. F42b 5/08, F42b 9/08
[58] Field of Search .... 102/46, 28 R, 70.2 A

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Primary Examiner—Samuel Feinberg
Assistant Examiner—C. T. Jordan
Attorney, Agent, or Firm—Edward J. Kelly; Herbert Berl; Samuel Kane

[57] ABSTRACT

An electric ignition element having primary and secondary ignition circuits. If the primary ignition circuit fails, the secondary ignition circuit is activated.

9 Claims, 2 Drawing Figures

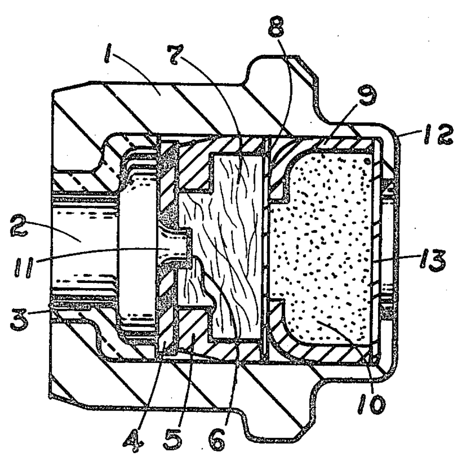

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FIG.1

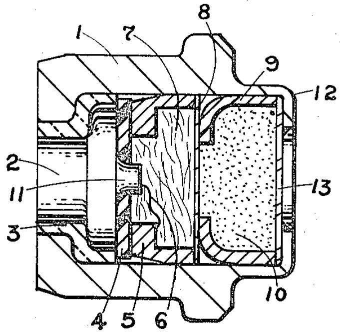
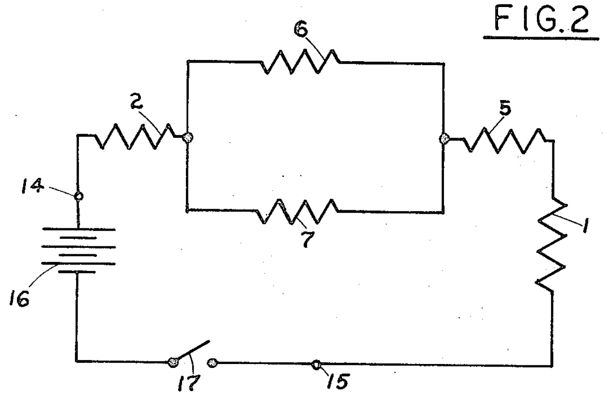


FIG.2



ELECTRIC IGNITION ELEMENT WITH SECONDARY IGNITION CAPABILITY

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND OF THE INVENTION

This invention relates generally to ignition elements and specifically to electric ignition elements for activating another device. While not limited thereto, the invention finds special application for igniting the propellant charge in a cartridge for ejecting a rocket or bomb from an aircraft.

There are several common types of electric ignition elements. These include the resistance and exploding wire types and the conductive mix, carbon bridge, and spark gap types. The resistance wire and the exploding wire types are characterized by usually good ignition response and good stability to electrical environments but are susceptible to mechanical environments that might break the wire and cause failure. The conductive mix, carbon bridge, and spark gap types are not susceptible to mechanical environments because no wire is used. However, these electric ignition element designs generally have poor stability to electrical environments. Because of these weaknesses, electric ignition elements are generally considered to have poor reliability.

When higher degrees of reliability are required in electric ignition element applications, redundancy is designed into the ignition system. This is accomplished by designing the ignition element with two wires (in the exploding wire and resistance wire designs) or by employing two ignition elements, either one of which can cause successful functioning of the system. These redundancies serve to increase the reliability of electric ignition element systems.

Increased reliability through the introduction of redundancy, however, introduces other problems. First, redundancy usually introduces increased costs and/or size. Second, because the redundancy usually incorporates two elements of the same type, both can be damaged by the same environments. Third, some redundant systems that use two ignition elements with individual ballistic trains, require ignition of both elements as well as synchronised ignition of both elements to obtain the optimum functioning of the system, requirements often difficult to fulfill. Because of these problems, the concept of redundancy does not always satisfy reliability requirements.

SUMMARY OF THE INVENTION

An object of the invention is to provide an electric ignition element with increased reliability.

Another object of the invention is to provide an electric ignition element with good ignition response.

A further object of the invention is to provide a low-cost ignition element of simple design.

A further, more specific object of the invention is to provide an improved electric ignition element for explosive cartridges.

In accordance with the above objects and considered first in one of its broader aspects, an electric ignition element according to the invention may comprise a housing, an electrically conductive explosive primer powder mix supported by the housing and effective to ignite upon receiving an energizing current, a nonexplosive impedance element in contact with the primer powder mix and effective when energized to ignite the primer powder mix prior to its ignition by an energizing current, and an electric circuit connected for supplying, when activated, energizing current to the primer powder mix and the impedance element.

The invention will be more clearly understood when the following detailed description of the preferred embodiment thereof is read in conjunction with the accompanying drawing which is described below.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a longitudinal sectional view of an electric ignition element constructed in accordance with the invention.

FIG. **2** is a schematic diagram of parts of the electric ignition element of FIG. **1**, and illustrates the manner of their connection in the circuit of an associated weapon or other apparatus in which the ignition element may be used.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The electric ignition element illustrated in FIG. **1** comprises a housing or sleeve **1** and a center contact **2** which is permanently sealed to the sleeve **1** by means of a solid insulator **3** which, for example, might be formed of glass. An insulating washer **4,** which may be Teflon, for example, separates the center contact **2** from a ground ring **5** which makes contact with the sleeve **1.** An impedance element, preferably in the form of a resistance wire **6,** has its ends connected, as by welding, for example, to the ground ring **5** and to a short extension **11** of the center contact **2** which project through an axial opening in the insulating washer **4** and is in contact with an electrically conductive explosive primer powder mix **7.**

The primer powder mix **7** is consolidated in the interior of and in contact with the ground ring **5** and is supported axially by an ignition disc **8** and a support cup **9.** The support cup **9** is filled with igniter powder **10,** and the entire assembly is sealed by crimping the end portion **12** of the sleeve **1** over a second ignition disc **13.**

When the electric ignition element of FIG. **1** is mounted in the apparatus in which it is to be used, such as a weapon, for example, it is connected electrically, as shown in FIG. **2,** to input terminals **14** and **15** of an electric circuit associated with the apparatus, the electric circuit comprising a source of energy such as a battery **16** and switch or trigger **17.**

The electric ignition element is operated to perform its function in the associated apparatus by closing the switch **17** so as to energize the circuit. This causes the resistance wire **6** to get hot and ignite the primer powder mix **7.** Ignition of the primer powder mix **7** causes the discs **8** and **13** to blow and the powder **10** to ignite. If the particular application of the ignition element is in an aircraft which uses a cartridge for ejecting a rocket or bomb, then, in that case, ignition of the powder **10** is used for igniting the propellant charge in the cartridge.

If the resistance wire **6** should initially be broken prior to or upon closing of switch **17**, the primer powder mix **7** will get hot to the point of ignition, however, the resistance wire **6** will still conduct to some extent due to a portion of the primer powder mix **7** closing the gap at the break in the resistance wire **6**.

By controlling the ratio of resistances of the resistance wire **6** and primer powder mix **7**, the conductive mix **7** is shielded from all electrical environments including the ignition pulse. This results in a threefold effect.

First, in an electrically sound ignition element, the primary ignition mode is always the resistance wire. Second, the mechanical weakness of the resistance wire is compensated for and negated by, the ignition capability of the conductive mix circuit when the wire is broken. Third, the susceptibility of the conductive mix circuit to electrical environments is reduced by the protective shunting effect of a good resistance wire. The resultant ignition element has characteristics of electrical stability and good ignition response common to the resistance wire type of ignition element without the loss of reliability normally attributed to the mechanical weakness of resistance wire systems.

In an exemplary electrical ignition element which was constructed in accordance with the invention, the impedance element or resistance wire **6** had a 1.5 mils diameter and a resistance of **1** ohm, and the primer powder mix **7** had a resistance of 20 ohms. The primer powder mix **7** was composed of 71.5 percent Barium nitrate 23 percent Stabilized Red Phosphorus, and 5.5 percent Graphite.

I claim:

1. An electric ignition element comprising a housing,

an electrically conductive explosive primer powder mix supported by said housing and effective to ignite upon receiving an energizing current,

a nonexplosive impedance element in contact with said primer powder mix and effective when energized to ignite said primer powder mix prior to ignition of the primer powder mix by an energizing current, and

an electric circuit having input terminals coupled to the primer powder mix and the impedance element for supplying energizing current thereto.

2. An electric ignition element according to claim **1**

wherein said housing is electrically conductive and connected to one of said input terminals and to said primer powder mix and said impedance element.

3. An electric ignition element according to claim **2** wherein said primer powder mix and said impedance element are connected in parallel.

4. An electric ignition element according to claim **3** wherein the parallel combination of said primer powder mix and said impedance element is connected in series with said housing.

5. An electric ignition element according to claim **4** wherein said impedance element is a resistance wire.

6. An electric ignition element comprising an electrically conductive sleeve,

an electrically conductive tubular ground ring supported in the interior of and in contact with said sleeve,

an electrically conductive explosive primer powder mix supported in the interior of and in contact with said ground ring and effective to ignite upon receiving an energizing current,

an electrically conductive contact member supported in the interior of said sleeve and having a portion in contact with said primer powder mix,

a nonexplosive impedance element connected to said ground ring and said contact member and effective when energized to ignite said primer powder mix prior to ignition of the primer powder mix by an energizing current, and

an electric circuit for providing energizing current to said primer powder mix and said impedance element, one input terminal of said electric circuit connected to said contact member and another input terminal of said electric circuit connected to said sleeve.

7. An electric ignition element according to claim **6** wherein said impedance element is a resistance wire and is embedded in said primer powder mix.

8. An electric ignition element according to claim **6** wherein said impedance element and said primer powder mix are connected in parallel.

9. An electric ignition element according to claim **6** wherein said impedance element and said primer powder mix are connected in parallel and the parallel combination connected in series with the contact member, the ground ring, and the sleeve.

* * * * *

United States Patent [19]
Werner

[11] **3,710,719**
[45] **Jan. 16, 1973**

[54] **DETONATOR FOR AN EXPLOSIVELY OPERATED CONNECTOR**

[75] Inventor: **Walter Myers Werner,** Downingtown, Pa.

[73] Assignee: **AMP Incorporated,** Harrisburg, Pa.

[22] Filed: **Jan. 8, 1971**

[21] Appl. No.: **104,898**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 18,152, March 10, 1970, abandoned.

[52] **U.S. Cl.** ....**102/28 R**
[51] **Int. Cl.** **F42b 3/14**
[58] **Field of Search** 102/28, 46

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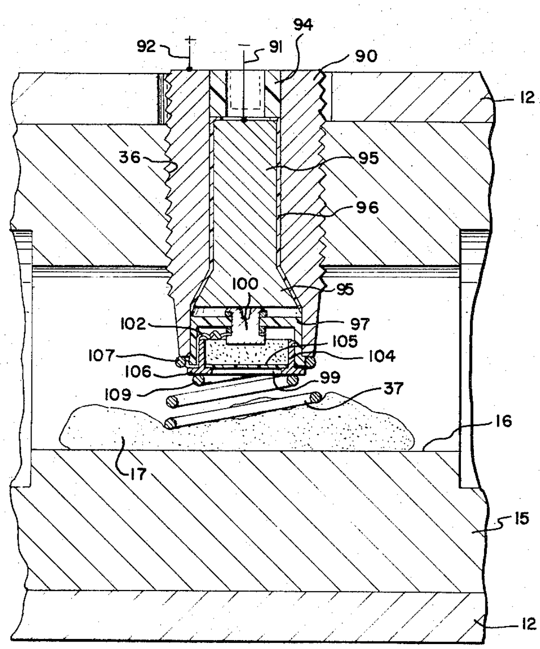
Primary Examiner—Verlin R. Pendegrass
Attorney—William J. Keating, Ronald D. Grefe, Gerald K. Kita, Frederick W. Raring, Jay L. Seitchik and John P. Vandenburg

[57] **ABSTRACT**

In a connector device for splicing or providing terminal anchoring means for a large diameter electrical cable, the connector including a shell, a firing chamber and, upon firing an explosive charge with a detonator device, securely engages the cable inserted into the connector, the novel combination residing in a detonator threadably secured internally of the connector and provided with a negative electrode and a positive electrode connected together through an insulator cap having an interior transmission stem, with a spring in contact with an explosive charge within the connector additionally contacting both the positive and the negative electrodes of the detonator, the detonator further including a firing cap and a plastic plug carrying a contact rivet engaged with the stem, together with a nichrome wire engaging the spring and a primer retained in a primer holder covered by a thin firing membrane.

2 Claims, 2 Drawing Figures



PATENTED JAN 16 1973 3,710,719

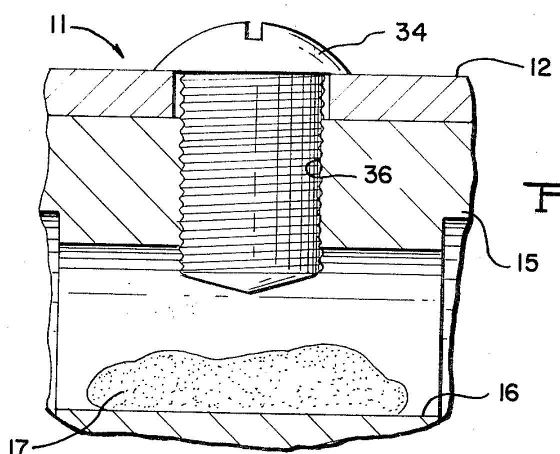


Fig. 1

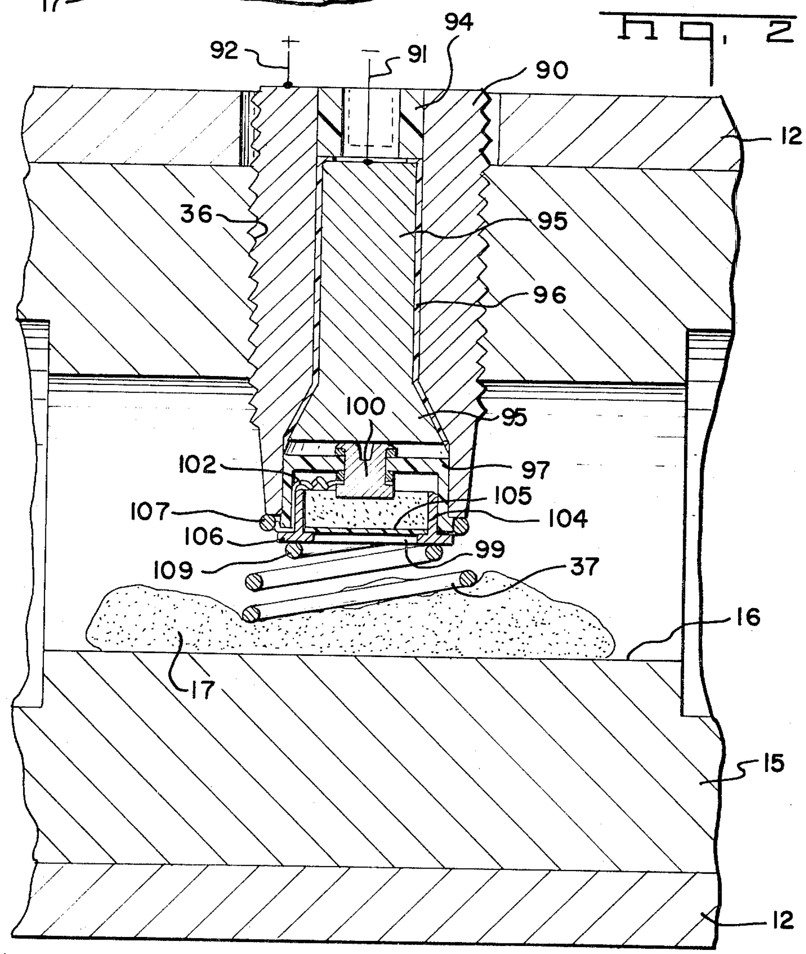


Fig. 2

DETONATOR FOR AN EXPLOSIVELY OPERATED CONNECTOR

CROSS REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of U.S. Pat. application, Ser. No. 18,152, filed Mar. 10, 1970 and now abandoned.

The present invention relates generally to a detonator employed with an internally fired electrical connector, such as the connector described and claimed in the above related application.

An object of the present invention is to provide a detonator which may be threadably inserted with an internally fired explosive electrical connector, which detonator includes a positive electrode and a negative electrode connected together by a heater element, with a primer substance triggered upon heating of the NICHROME wire in order to set off an explosive charge within the electrical connector.

Another object of the present invention is to provide a specific detonator structure which may be inserted into an explosively operated electrical connector containing an explosive charge, the detonator being characterized by a negative terminal and a positive terminal connected together by a heating element secured to a contact rivet engaging one of the electrodes, together with a primer substance contained within a primer holder covered by thin firing membrane.

Another object of the present invention is to provide a detonator which may be secured internally of an explosive electrical connector containing an internal explosive charge, the detonator structure including a positive electrical terminal and an electrical negative terminal connected together by a heating element, a primer substance retained by a thin firing membrane within the detonator with a coil spring engaging the heater wire, one of the terminals and the explosive charge of the connector.

Other objects and many attendant advantages of the present invention will become apparent upon perusal of the following detailed description taken in conjunction with the accompanying drawing.

In the drawing:

FIG. **1** is an enlarged fragmentary section of an electrical connector containing an explosive charge and having associated therewith a removable detonator plug; and

FIG. **2** is an enlarged fragmentary section of the connector illustrated in FIG. **1**, and further illustrating the detonator according to the preferred embodiment of the present invention together with a coil spring engaging the explosive charge and the detonator.

With more particular reference to the drawings, there is shown in FIG. **1** a fragmented portion of an electrical connector **11**, being provided with a cylindrical center section **12** encircling a firing barrel **15** which is of strong steel or aluminum having a firing chamber **16** in which an explosive charge **17** may be located. Such a connector may be of any type, for example, one type being disclosed in the above identified application, Ser. No. 18,152, filed Mar. 10, 1970. The connector **11** may also be provided with a threaded detonator plug opening **36** and closed with a threaded bolt or insert or detonator plug **34** when the container is stored or shipped.

With more particular reference to FIG. **2** of the drawing, there will be described in detail a specific embodiment of a detonator according to the present invention which may be utilized in conjunction with the exemplary electrical connector **11** shown in FIG. **1**. The specific detonator structure comprising the preferred embodiment of the present invention is shown in FIG. **2** and includes a detonator housing **90** having a negative electrode **91** and a positive electrode **92**. The negative electrode **91** is led through an insulator cap **94** to an interior transmission stem **95**, which interior stem is insulated from the other housing **90** by means of an insulator **96**. The insulator **96** terminates in a frustoconical portion of the transmission stem **95**. The detonator holds a firing cap **99** insulated from the positive electrode **92** by means of a plastic plug **97** which carries a contact rivet **100** engaging the transmission stem **95**. The contact rivet **100** in turn is in contact with the firing cap as well as a length of NICHROME wire **102**, a portion of which protrudes between the metallic firing cap holder **99** and the plastic plug **97**. A primer substance **104** is held in a primer holder **106** and is insulated from outside interference by a thin firing membrane **105**.

In operation, the detonator plug **34** is removed from the shell **11**. A spring **37** is first screwed into the opening **36** and is engaged with the explosive charge **17**, as shown in FIG. **2**. The detonator **90** is inserted into the outer housing, the threads of which secure sufficiently strongly the detonator **90** and confine the charge **17** in the firing chamber **16**. The first contact spiral **107** of the spring is engaged with the positive portion of the detonator, and the second spiral **109** of the spring is engaged with the negative electrode **91** of the detonator **90**. The Nichrome wire **102** protrudes between the metallic firing cap holder **99** and the plastic plug **97** to engage the first contact spiral **107** of the spring **103**. The firing is effected by a triggering device disclosed in Ser. No. 18,152, filed Mar. 10, 1970. This triggering device, when contact is made between the negative and the positive terminals **91** and **92**, heats the NICHROME wire **102** and triggers the detonating primer of primer substance **104** which in turn sets off the explosive charge **17**.

Thus a preferred embodiment of the detonator according to the present invention has been specifically described and disclosed in detail. However, other embodiments and modifications of the present invention without departing from the spirit and scope of the present invention are defined in the appended claims.

What is claimed is:

1. A detonator which comprises,

a. a shell member;

b. insulation in said shell member;

c. an electrically conductive stem positioned in said shell member, said stem insulated from said shell member by said insulation;

d. a plug positioned in said shell member adjacent said stem, said plug having therein a heater wire with a portion thereof protruding from said plug;

e. a contact electrically connecting said stem to said heater wire;

f. a cap positioned in said plug, said cap containing detonator primer substance therein and a relative thin membrane immediately adjacent thereto;

g. contact means electrically connecting said shell member and said wire, said contact means including a coil spring, at least a first coil of said spring removably engaging said shell and said heater wire and the remainder of said spring extending from said cap and engages thereagainst.

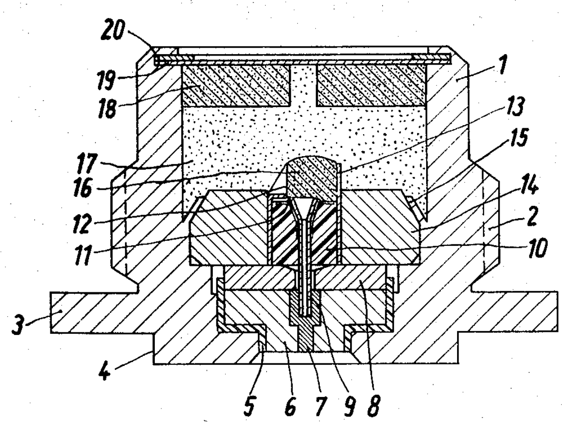
2. The structure as recited in claim **1**, wherein said shell member includes a frustoconical section, insulation in said frustoconical section, and said stem is seated in said frustoconical section.

* * * * *

Jan. 3, 1967 HANS-DIETER HARNAU 3,295,446

ELECTRIC PRIMER

Filed March 5, 1965



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3,295,446

Patented Jan. 3, 1967

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ELECTRIC PRIMER

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Claims priority, application Germany, Mar. 12, 1964, R 37,434
6 Claims. (Cl. 102—28)

This invention relates to an electric primer of the type having an electric priming element consisting of a central electrode mounted within a cylindrical outer electrode whose rim is bent towards the centre electrode and terminates in at least one contact point. There is an insulating element between these two electrodes which is coated on its surface between the central electrode and the contact points with a thin homogeneous metal film connecting the electrodes. This metal film is in contact with the contact points and the central electrode. The action of the priming element is based on the knowledge that, in operation, at the point of contact between the surface of a thin homogeneous metal film connected to one terminal of a current source used to actuate the priming element and a conductive point connected to the other terminal of the current source, the metal film fuses owing to the high current density. The melting process takes place very rapidly, and appears as a mere spark. This phenomenon is exploited in the case of a conventional priming element. It offers the advantage that the priming composition is arranged to be in contact with the spark-producing area, and this is a basic condition for proper ignition. Moreover, the number of individual components in the above-mentioned known priming element is low, and these components are of simple construction.

The present invention has for its object to provide a suitable detonator for a priming element of the type just described which when fitted to a primer, suitable, for example, for fitting in cartridge cases, constitutes an improvement in comparison with conventional electric primers.

A further known concept on which this invention is based is that the outer electrode of a wound or spiral capacitor at whose end face a multiplicity of spark gaps is formed, can be arranged in a metallic retaining ring which also functions as the outer terminal, and that the inner electrode of the capacitor can be slipped over a metallic core constituting the inner terminal. The retaining ring rests on the core, an insulating washer being interposed, so that the wound capacitor, the retaining ring, the core and the insulating washer form a unit capable of being installed in a primer. According to prior art, this installation is accomplished by caulking.

The task which the present invention is to solve is the installation in a primer of a priming element, known per se, by means of a support arrangement whose several constructional components have already been disclosed in connection with a priming element basically operating in a different way. This object is achieved by arranging the outer electrode in a metallic retaining ring which is held in a stepped bore in the primer body in such a way that it presses an insulating washer against an anvil, the inner electrode projecting through the insulating washer being electrically connected to the anvil.

A primer constructed in this way offers the advantage that the insulating washer cannot be compressed beyond a required degree, and the priming element cannot be shifted from its axial position by a jammed retaining ring, so as to render the insulating effect of the washer uncertain and possibly giving rise to undesirable short-circuits.

A threaded electric primer embodying the invention will now be described in greater detail with reference to the accompanying drawing which is a cross-section of the primer.

The primer comprises a cylindrical metal body **1**, preferably of brass, which is externally screw-threaded as at **2**, a stop flange **3**, and a key-receiving extension **4**. By means of a key (not shown), which engages the key extension **4**, the threaded primer can be screwed, for example into a cartridge case, up to its stop flange **3**, the case being provided with a counter-thread matching the thread **2**.

Internally, the metal body of a threaded primer has an open-ended axial bore with several internal shoulders. As seen in the drawing, the lowest shoulder supports a sleeve-like insulator **5** into which an anvil **6** of T-shaped cross-section is forced. The anvil **6** has an open-ended axial bore whose diameter is preferably smaller at the narrower portion of the anvil than it is in the wider portion of the anvil. When the insulating sleeve **5** and the anvil **6** have been introduced into the lower part of the metal body **1**, the lower opening of the bore of the threaded primer, which is tapered in the manner of a funnel, is closed. The insulating sleeve **5** projects internally beyond the anvil **6**, so that it engages an insulating washer **8** which rests on the anvil. The insulating washer **8** as well as the insulating sleeve **5** consist of synthetic material, but the insulating washer may be of a ceramic material.

In the bore of the anvil **6**, an inner electrode **9** of a priming element is held by a solder **7**. The electrode **9** is hollow and is of steel. That end of the electrode **9** facing away from the anvil **6** is funnel-shaped. By devising the inner electrode in this way, it becomes possible to introduce the solder together with the anvil. The bore in the anvil allows air to escape downwardly during soldering. A further advantage of this electrode design is that the inner electrode is not normally in contact with the comparatively hard brass, but only the solder, thus being allowed to penetrate more deeply and to achieve better contact for initiating the ignition process.

Surrounding the inner electrode is a ceramic insulator **10**. The funnel-shaped upper portion of the inner electrode offers the advantage that adhesive friction between the inner electrode **9** and the surrounding ceramic insulator **10** is ensured.

Around the insulator **10** is an outer electrode **13** with a contact point **12** and those portions of the surface of the insulator **10** which are in contact with the contact point **12** of the outer electrode **13** are coated with a metal film **11**. The outer electrode **13** may have several contact points. The electrode **13** is forced into a metallic retaining ring **14** which rests on one of the internal shoulders of the bore in the metal body **1** of the threaded primer and is held in position by a caulking **15**. The design of the retaining ring **14** and its mounting ensure that the insulating washer **8** cannot be unduly compressed and the priming element shifted from its axial position, due to jamming of the retaining ring. This could lead to the insulating sleeve **5** becoming damaged, and undesirable contact being made when a voltage is applied, with a short-circuit and the elimination of the priming element being the result. The bearing pressure exerted by the caulked retaining ring **14** upon the insulating washer **8** can be determined in advance by selecting the thickness of the latter. To increase the spark length between components at different potential, the distance between the insulating washer **8** and the metal body **1** can be increased by increasing the inner diameter of the metal body at this point. In a device embodying the invention, even a narrow shoulder will give the retaining ring sufficient support.

Since the electric field is strongest at the edges and the risk of flash-over is therefore greatest at these points, the anvil **6**, as well as the portion of the metal body **1** in facial relationship therewith, is rounded at the edges by turning. This offers the additional advantage that the insualting sleeve **5** will not be damaged when the anvil **6** is introduced in the metal body **1**.

The outer electrode **13** projects in the axial direction beyond the metallic retaining ring **14** and the inner electrode **9**. In this way a hollow cylinder is formed above the insulator **10**—the cylinder being interrupted merely by the contact point **12**—and a primer pellet **16** is located in this cylinder. When a spark is produced by fusing the metal coating **11**, it is this primer pellet **16** which ignites first. Above the retaining ring **14** and the primer pellet **16** is a layer of loose black powder **17** which is followed, in the present embodiment, by a final layer of compressed black powder **18**. In the latter there is provided a central opening, also filled with loose black powder. At this end, the threaded primer is closed by a disc **19** engaging a groove provided in the metal body **1**. The sealing disc **19** is retained by a metal ring **20** engaging the same groove. The threaded primer of the invention is sealed off with shellac at this end.

The threaded primer described above is reliable in operation and is impact and acceleration proof, because it does not include any resilient contacts or connections, for example. The threaded primer is of simple construction and therefore suitable for cheap mass-production.

What I claim is:

1. A primer comprising in combination an electric priming element including a center electrode, a cylindrical outer electrode around said center electrode, a rim on said outer electrode bent towards said center electrode and terminating in at least one contact point, an insulator located between said center and outer electrodes and having a surface between said electrodes, a metallic coating on said surface in connection with said electrodes, means for holding said primer element including a sleeve-like body, said body having an open-ended axial bore therethrough and having a first end directed towards a mass to be primed by the primer and a second end opposite to said first end directed outwardly for electrical contacting purposes, an internal shoulder at said second end, a metallic retaining ring in said bore, said primer element being mounted in its entirety in said retaining ring by forcing in said outer electrode, an anvil located in said bore and residing on said shoulder, a thin insulating layer disposed between said shoulder and said anvil, an insulating washer disposed between said metallic retaining ring and said anvil, said retaining ring being pressed in a direction to said second end against said shoulder by means of said insulating washer, said anvil and said thin insulating layer, and said center electrode of said primer element projecting through said insulating washer and being connected electrically with said anvil.

2. A primer comprising in combination an electric priming element including a center electrode, a cylindrical outer electrode around said center electrode, a rim on said outer electrode bent towards said center electrode and terminating in at least one contact point, an insulator located between said center and outer electrodes and having a surface between said electrodes, a metallic coating on said surface in connection with said electrodes, means for holding said primer including a sleeve-like body, said body having an open-ended axial bore therethrough and having a first end directed towards a mass to be primed by the primer and a second end opposite to said first end directed outwardly for electrical contacting purposes, an internal shoulder at said second end, a metallic retaining ring in said bore, said primer element being mounted in its entirety in said retaining ring, an anvil located in said bore and resting on said shoulder, a thin insulating layer disposed between said shoulder and

said anvil, an insulating washer disposed between said metallic retaining ring and said anvil, said retaining ring being pressed in a direction to said second end against said shoulder by means of said insulating washer, said anvil and said thin insulating layer, said anvil extending outwardly through said second end and having an open-ended axial passageway extending outwardly therewith, said center electrode of said primer element projecting through said insulating washer and being secured in said passageway by electrically connecting solder, and said solder extending through said entire axial passageway to be struck for electrical contacting purposes.

3. A primer comprising in combination an electric priming element including a center electrode, a cylindrical outer electrode around said center electrode, a rim on said outer electrode bent towards said center electrode and terminating in at least one contact point, an insulator located between said center and outer electrodes and having a surface between said electrodes, a metallic coating on said surface in conection with said electrodes, means for holding said primer element including a sleeve-like body, said body having an open-ended axial bore therethrough and having a first end directed towards a mass to be primed by the primer, a second end opposite to said first end directed outwardly for electrical contacting purposes, an internal shoulder at said second end, a metallic retaining ring in said bore, said primer element being mounted in its entirety in said retaining ring by forcing in said outer electrode, said outer electrode being a force fit in said metallic retaining ring, an anvil located in said bore and resting on said shoulder, a thin insulating layer disposed between said shoulder and said anvil, an insulating washer disposed between said metallic retaining ring and said anvil, said retaining ring being pressed in the direction to said second end against said shoulder by means of said insulating washer, said anvil and said thin insulating layer and being held in said bore by caulking the inner wall of said bore in a direction from said first to said second ends, and said center electrode of said primer element projecting through said insulating washer and being connected electrically with said anvil.

4. A primer with an electric priming element comprising, a center electrode, a cylindrical outer electrode around said center electrode and having thereon a rim bent towards said inner electrode and terminating in at least one contact point, an insulator located between said center and outer electrodes and having a surface between said electrodes, a metallic coating on said surface connected with said electrodes, said primer having a shouldered bore therein, a metallic retaining ring in said bore, said outer electrode having a force fit in said metallic retaining ring, caulking holding said metallic retaining ring in said bore, an anvil provided in said bore and having an open-ended passageway therein, said center electrode being secured in said bore by solder, and an insulating washer disposed between said metallic retaining ring and said anvil, said center electrode projecting through said insulating washer.

5. A primer with an electric priming element comprising, a center electrode, a cylindrical outer electrode around said center electrode and extending axially beyond the latter, a primer pellet located in said axial extension of said outer electrode, a rim on said outer electrode bent towards said inner electrode and terminating in at least one contact point, an insulator provided between said center and outer electrodes and having a surface between said electrodes with a metallic coating thereon in connection with said electrodes, said primer having a shouldered bore therein with a metallic retaining ring therein, said outer electrode being mounted in said retaining ring, an anvil provided in said bore, and an insulating washer provided between said metallic retaining ring and said anvil, said center electrode projecting through said insulating washer and being connected electrically with said anvil.

6. A primer with an electric priming element comprising a center electrode, a cylindrical outer electrode around said center electrode and extending axially beyond said center electrode, a primer pellet located in said axial extension of said outer electrode, a rim on said outer electrode bent towards said inner electrode and terminating in at least one contact point, an insulator provided between said center and outer electrodes and having a surface between said electrodes with a metallic coating thereon in connection with said electrodes, said primer having a shouldered bore therein, a metallic retaining ring in said bore and having said outer electrode mounted therein, an anvil provided in said bore, said anvil having an open-ended passageway therein, said center electrode being secured in said bore by solder, and an insulating washer provided between said metallic retaining ring and said anvil, said center electrode projecting through said insulating washer.

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March 17, 1964 B. F. BOGGS ETAL 3,125,025

PYROTECHNIC IGNITER

Filed Jan. 4, 1960 2 Sheets-Sheet 1

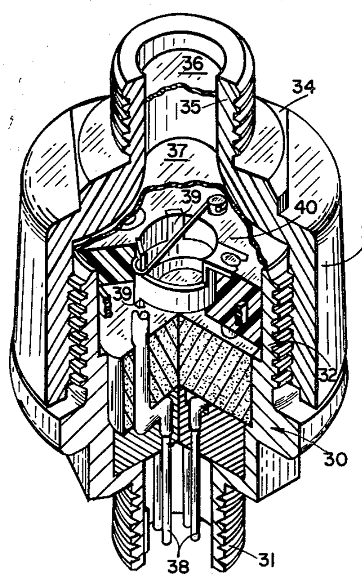

FIG. 4

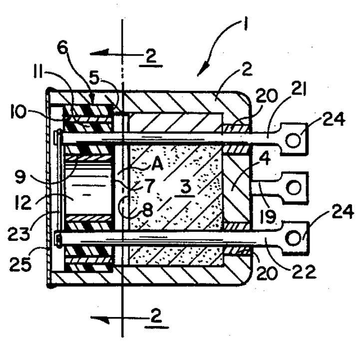

FIG. 1

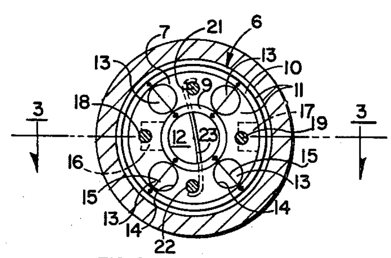

FIG 2

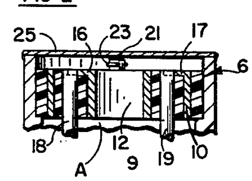

FIG. 3

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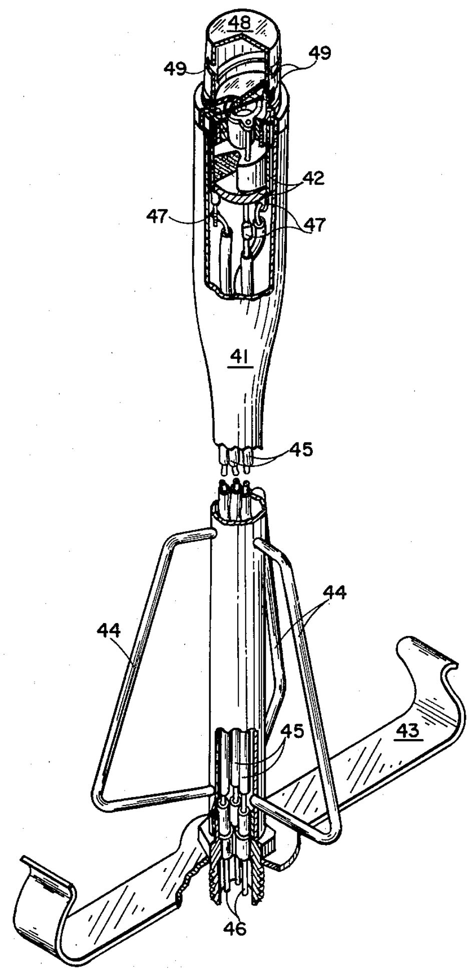

FIG. 5

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PYROTECHNIC IGNITER

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3 Claims. (Cl. 102—28)

This invention relates to an electrically actuatable pyrotechnic igniter or gas generator. More specifically, it refers to an hermetically sealed pyrotechnic igniter or solid propellant gas generator of simplified construction incorporating a squib plate adaptable to a variety of applications.

Solid propellant igniters and gas generators of the prior art have generally been constructed with a single squib retained adjacent a pyrotechnic charge, the squib being a conventionally constructed unit having a pyrotechnic surrounded by a plastic shell and a pair of high resistance lead wires connected through the pyrotechnic for ignition purposes. Such igniters and gas generators have had a low reliability factor in that the failure of the single squib has caused the ultimate failure of the entire igniter with a consequent failure of ignition of the entire system to which it was adapted.

Further difficulty has been experienced in the low resistance to humidity of such units. A low degree of humidity protection may be so detrimental to the pyrotechnic mixture that ignition cannot be initiated. Hence, reliability again suffers.

The present unit is usable either as a gas generator or igniter. However, its primary use is as an igniter and it will be generally discussed as such. It overcomes the above detrimental characteristics by providing a unit which utilizes a plurality of pyrotechnic squibs and which is easily hermetically sealed. This provides a simplified construction which assures a high degree of ignition reliability. A squib plate capable of containing the desired number of pyrotechnic squibs as an integral part thereof is insertable to a position adjacent the main pyrotechnic charge so that flame from the squib directly impinges upon the main charge surface.

It is a major object of this invention to provide a simple and reliable unit usable as a generator of hot combustion products.

It is a further object to provide a pyrotechnic igniter having reusable components.

Another object of this invention is to provide simplified means whereby a plurality of pyrotechnic squibs may be efficiently utilized for the ignition of a main pyrotechnic charge.

Yet another object is to provide a pyrotechnic unit which is completely and hermetically sealed and capable of reliable service after storage over extended time periods.

A still further object of this invention is to provide an igniter easily adaptable to utilization in a variety of igniter structures.

Another object is to provide a highly adaptable squib plate for collecting and distributing electrical charges, directing generator ignition flames and controlling combustion products.

Other objects will become apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a cross sectional view of the basic pyrotechnic unit of this invention;

FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a perspective view of a sealed structure including the basic FIG. 1 unit adapted for gas generator applications; and

FIG. 5 is a perspective view of a vernier engine igniter utilizing the basic unit of FIG. 1.

In detail, FIG. 1 illustrates the basic and central igniter or gas generator of the present invention. The overall unit is indicated as 1 and includes a cup-shaped body member 2 preferably of cylindrical shape. A pyrotechnic charge 3 is disposed within body member 2 against a closed end 4 of the body member. Charge 3 may be of any pyrotechnic composition such as a mixture of potassium perchlorate, ammonium perchlorate, boron aluminum powder and a binder composed of a polysulfide rubber polymer together with a polymer of a glycidyl polyether compound having terminal epoxy groups. An example of the polysulfide rubber polymer is LP–3, obtained by the reaction of dichloroethane and potassium sulfide. An example of a glycidyl polyether resin is one obtained by the reaction of 2,2-bis(4-hydroxyphenyl)propane and epichlorohydrin in an alkaline solution, as described in U.S. Patents 2,324,483 and 2,602,785. An example of a specific composition is 54% potassium perchlorate, 11% ammonium perchlorate, 8% boron, 8% aluminum powder, 9.4% Thiokal LP–3, and an epoxy resin made by the reaction of 1,2,3-trihydroxy propane and epichlorohydrin.

Body member 2 may be provided with an internal shoulder 5. A squib plate, generally indicated as 6, and more clearly illustrated in FIGS. 2 and 3, is inserted within body member 2 until it abuts shoulder 5 or a similar stop means. In such position, the squib plate internal surface 7 is adjacently spaced from an exposed surface 8 of pyrotechnic charge 3. This space is indicated as A. Plate 6 includes electrically conductive means in the form of an inner metal current collector ring 9 and an outer metal current collector ring 10. An electrical insulating compound 11, e.g. molded plastic, rubber, etc., is disposed between rings 9 and 10 and about ring 10, and a passage 12 is provided through the center of ring 9 communicating from space A to the external surrounding atmosphere as a means through which combustion products may exit from the unit. Pyrotechnic squibs 13, of a composition such as a mixture of lead peroxide, aluminum powder, boron powder and nitrocellulose lacquer, are inserted within cavities 14 extending into compound 11 from surface 7. As illustrated, four such squibs may easily be provided. However, a lesser or greater number might be utilized, dependent upon design criteria. It is generally desirable that the surfaces of squibs 13, compound 11, and metal rings 9 and 10 be flush across surface 7 in order that a series of electrical resistance or bridge wires 15 may be connected to rings 9 and 10 across and in contact with the surfaces of squibs 13. When desirable, bridge wires 15 may be positioned within the squibs proper. Rings 9 and 10 include nibs or protrusions 16 and 17 respectively extending from their outer edges to which electrically conductive means may be attached.

In fabricating the unit, a pair of pins 18 and 19 are inserted through closed end 4 of cup 2 and hermetically sealed by means of glass seals 20. A separate pair of pins 21 and 22 are similarly inserted and sealed at positions 90° removed from pins 18 and 19. Pins 18 and 19 extend through insulation 11 and make electrical contact with nibs 16 and 17. Pins 21 and 22 extend through and protrude beyond the insulation of plate 6, and are adapted to having a flame detector means applied thereto. Here, the means is supplied by a break link or ignition detection wire 23 electrically connected between the pin extremities across the exit of passage 12. Each of pins 18, 19, 21, and 22 may be termed a feed-through pin for conducting electricity. Each includes a terminal 24 adapted for electrical connection.

Igniter 1 is easily adaptable to being hermetically sealed through the simple expedient of placing glass seals 20, as noted, between the feed-through pins and end 4 of body 2, and by soldering or otherwise adhering a metal foil closure member 25 over the open end of body member 2 to act as a burst diaphragm. Body member 2 is preferably made of metal in order that closure 25 may be easily soldered to its surface. This complete hermetic seal enables the basic igniter unit to be stored for extended periods under adverse conditions of humidity with no resultant danger of pyrotechnic deterioration.

Operationally, the igniter is fired by connecting leads from conventional electrical source (not shown) to pins 18 and 19. When a remotely located switch (not shown) is closed, current is transmitted through the circuit completed by pin 18, ring 9, bridge wires 15, ring 10, and pin 19. Since bridge wires 15 are in actuality electrical heater means or resistance wires, the passage of electrical current causes them to be heated. The heat initiates ignition of squibs 13 against or within which they are positioned. Flames issuing from squibs 13 are directed toward surface 8 of pyrotechnic charge 3, causing that surface to be ignited. The plurality of squibs and their adjacently spaced relationship to surface 8, whereby they are caused to fire directly against specific portions of surface 8 and whereby hot combustion products may circulate over the balance of surface 8, assures a rapid and efficient ignition of the main pyrotechnic charge. Combustion products from the burning of squibs 13 and charge 3 issue with great force and high heat through restricted passage 12 in a confined flame pattern. As the flames and great quantities of hot gases leave passage 12 they impinge against break link 23 and closure member 25. The heat and pressure immediately bursts closure member 25, allowing the combustion products to escape from body 2 to accomplish their igniting function.

Break link 23 is burned through when the flames are sufficiently hot and/or have been burning a predetermined length of time. This is controlled by the heat resistance of the material from which link 23 is made and by the link thickness. An electric current normally flowing through pin 21, break link 23, and pin 22 from an electrical source (not shown) connected to terminals 24 of those pins is interrupted when break link 23 is burned through. This electrical circuit may be connected through a conventional electrical sensing device which detects the resistance increase when the wire burns through, indicating that combustion has been properly initiated and that an associated sequence of operations may begin.

It can be readily appreciated that a pyrotechnic unit having these characteristics is particularly adaptable to uses in rocket engines wherein a high degree of reliability is required to assure eventual functioning of the complete rocket engine system and wherein an indication of flawless ignition characteristics is required prior to actuation of further rocket engine functioning.

Squib plate 6 may be utilized as a unit in adaptation to variations of igniter 1 whenever the need for a squib retainer, including means for conducting electricity for squib ignition and a flame directing means (passage 12), are required.

The basic pyrotechnic unit of FIGS. 1 and 2 may be modified as illustrated in FIG. 4 for use in igniting a gas generator or for gas generating purposes per se. Here, the same essential components are utilized in a slightly changed configuration. A basic body or cup member includes a threaded shank 31 which is adapted to receive a conventional electrical connector. Upper portion 32 of body 30 is also threaded to accept a cap member 33. Cap member 33 may include, for example, a hexagon-shaped portion 34 adapted to receive a wrench for tightening cap member 33 upon body 30. A neck 35 is included in cap member 33 in order that combustion products issuing from the igniter might be confined to a circular pattern of desired diameter. Neck 35 is threaded for adaptation through the wall of a receptacle, e.g. a gas generator combustion chamber or a turbine housing. During operation the combustion products from the pyrotechnic unit are thereby directed internally of the ignition of propellants, driving of a turbine, or other similar functions.

A metal foil 36 may be sealed across neck 35 in essentially the same manner in which closure member 25 was adapted to body member 2 in the FIG. 1 configuration. This presents a double barrier to moisture since a similar seal or enclosure member 37 is also applied to body 30. The squib plate, pyrotechnic, and bridge wire of the FIG. 4 igniter are substantially the same as those of the FIG. 1 igniter. The feed-through pins, however, are shown to be somewhat different in their structural configuration in that they are jogged to match the shape of shank 31. Their extremities 38 are adapted for attachment to conventional electrical connectors of the socket variety. The current collector rings also vary in that they are narrower in their basic length, extension tips 39, only, extending from an embedded position into a position flush with the surfaces of squib plate 40. The sequence of operation of the FIG. 4 unit is essentially the same as that of the FIG. 1 unit.

The igniter of FIG. 5 is particularly adaptable to use with a small rocket engine of the vernier type. It is desirable that the combustion products be discharged adjacent the rocket engine propellant injector in such applications. Therefore, the basic FIG. 1 unit is installed within a case 41 which is sufficiently long to extend through the length of the thrust chamber to which it is adapted and properly position the pyrotechnic charge. The pyrotechnic and squib plate may be disposed directly within case 41 over a retainer plate, or within a separate case or cup, as at 42 (shown in a representative shape). Either may be referred to as a pyrotechnic retainer. A spring clip 43 may be provided to clamp upon the end of the rocket engine nozzle as a retainer. Brackets or spacers 44 are spaced circumferentially about the case 41 and shaped to match the internal contour of the rocket engine nozzle in order that the igniter unit might be positioned essentially upon the longitudinal axis of the rocket engine combustion chamber. A series of electrical leads 45 are provided to conduct electricity from conventional electrical receptacle pins 46 to terminals 47 within case 41. Cap 48 is attached to the extremity of case 41 about the igniter unit. Cap 48 contains slots 49 through which combustion products issuing from the igniter unit might be redirected approximately circumferentially over the face of the rocket engine injector. The specific shape of cap 48 and slots 49 may be varied dependent upon particular design requirements as dictated by the rocket engine injector and combustion configuration.

The material from which the metal foil closure members of this invention are constructed may be any metal which will prevent moisture passage, rupture easily and be easily susceptible of sealing to metal body. Thin aluminum foil has been found highly acceptable for this purpose.

The material of the feed-through pins and the rings of plate 6 may be any electrically conductive metal, e.g. copper or steel.

From the foregoing description it will be seen that the basic pyrotechnic unit of this invention provides a highly reliable ignition or hot gas source which is adaptable to a variety of applications when constructed and operated as set forth herein. It is simple and rugged in construction and can be manufactured economically.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

We claim:

1. A pyrotechnic generator of hot combustion products comprising a cup member, a pyrotechnic charge disposed within said cup member, a pair of electrical conductive rings substantially concentrically positioned and adjacently spaced from said pyrotechnic, spaced from said cup member, and concentrically spaced from one another, said rings being mounted within and insulated from said cup and from one another, pyrotechnic squib means mounted between said rings, two pairs of electrical conductive leads through said cup member between and insulated from said rings, a first pair of said leads connected to said rings, one of said last-mentioned leads connected to each said ring, electrical heater means contacting said squib means and connected to said rings, and combustion sensing means connected across a second pair of said leads.

2. A pyrotechnic unit for generating hot combustion products comprising a hollow body member having a closed end and an open end, a pyrotechnic charge disposed within said body against said closed end, a squib plate spaced from said pyrotechnic charge and recessed within said body adjacent said open end, said squib plate including a pair of metal rings concentrically spaced from one another and from said body member, an electrical insulating material disposed between said rings and said body member, means in said plate defining a gas exit passage through said plate within an inner one of said rings, a plurality of pyrotechnic squibs embedded in said insulator, electrical resistance wires connected to said rings and contacting each of said squibs, a separate feed-through pin electrically connected to each of said rings and extending through said pyrotechnic and said closed end of said body, a separate pair of feed-through pins substantially co-extensive with said first mentioned pins and insulated from said rings, a glass seal disposed between each of said pins and said closed body end, a break link wire connected to said pair of pins and across said passage for detecting combustion of said pyrotechnic charge, and a metal foil sealed across said open end of said body so as to hermetically enclose the contents of said body.

3. A pyrotechnic generator of hot combustion products comprising a cup member having an open end, a pyrotechnic charge disposed within said cup member contacting a closed end thereof, a squib plate in said cup member adjacently spaced from said pyrotechnic charge, said plate being perforated and communicating between said charge and said open end, squib means attached to said plate facing and spaced from said charge, and means to ignite said squib means, said squib means including a pair of substantially concentric rings electrically insulated from one another and from said cup member and connected to separate electrical conductors, said perforation being within an inner one of said rings wherein said means to ignite said squib means includes an electric resistance wire connected to said rings in contact with said squib means, and wherein said squib means is a multiplicity of pyrotechnic squibs extending between said rings in said plate.

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Dec. 7, 1954 W. E. SHEEHAN 2,696,191

ELECTRICALLY OPERATED PRIMER

Filed Oct. 17, 1951

FIG. 1

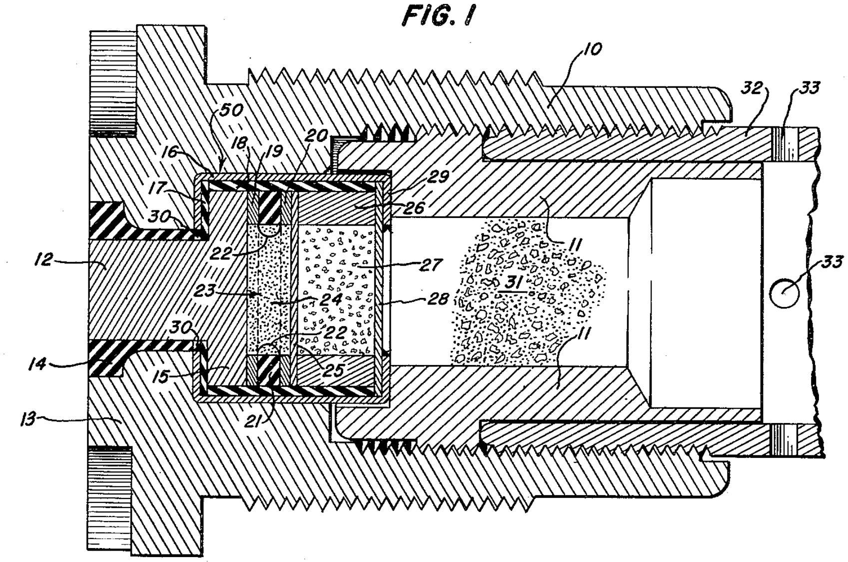
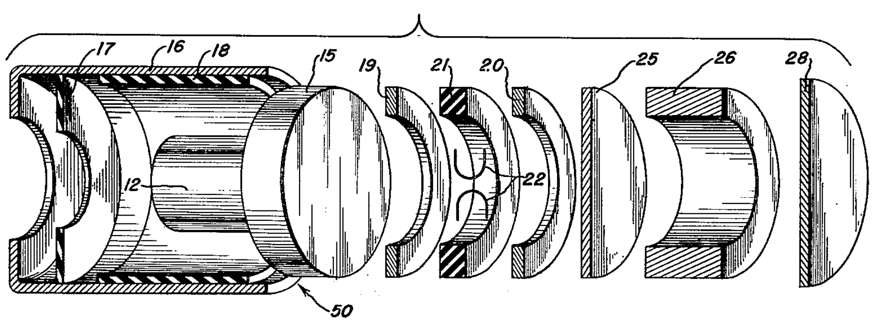


FIG. 2



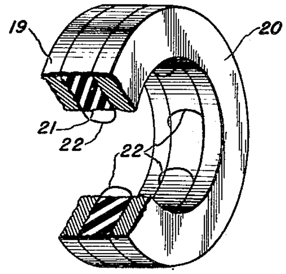


FIG. 3

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ELECTRICALLY OPERATED PRIMER

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Application October 17, 1951, Serial No. 251,806

1 Claim. (Cl. 102—86.5)

(Granted under Title 35, U. S. Code (1952), sec. 266)

This invention relates to explosive priming devices, and more particularly to an improved electrically activated igniter for initiating the explosion of larger charges of explosives.

Primers of the above character usually comprise a closed cup adapted to be secured in an explosive device adjacent the main explosive or propellant charge and contain a highly sensitive ignition composition and a flash charge. The ignition composition may be gun cotton or other sensitive compositions known in the art and is usually formed about a single high resistance filament known as a bridge wire, which is connected in the electrical firing circuit. The arrangement is such that as the bridge wire is heated upon closing of the firing circuit the sensitive composition ignites and develops sufficient heat to set off the flash charge which in turn fires the main explosive or propellant charge of the device with which the primer is used.

Prior art primers of the above character make use of a lead-in wire to connect a bridge wire to an external source of electricity and as such are subjetc to sealing problems about the lead-in wire or wires which may result in the entrance of moisture into the ignition compound, thus increasing the probability of misfires or adversely affecting the predetermined time delay, before teh main or propellant charge is fired. Another disadvantage in such devices resides in the possibility of one or both of the lead-in wires being broken thereby preventing the establishment of an electrical circuit at the desired time to fire the ignition charge. It will also be apparent that the single loop bridge wire which is usually made of flimsy material may be broken during rough handling, thus further increasing the percentages of misfires or duds. Since the bridge wire is inaccessible for inspection such a defect will go unnoticed until an attempt is made to fire the explosive charge.

Although the number of misfires encountered in a series of explosioins may be relatively small, each misfire constitutes a potential source of serious injury or possible death to the individual whose task it is to remedy the fault. The removal of the explosive material is extremely dangerous especially in blasting operations because the explosive material may be difficult to locate in some instances and may blow up accidentally due to various causes while searcihing for it. In ordnance equipment a misfire will reduce the fire power of the weapon used or in cases of automatic weapons the weapon itself may be jammed, thus subjecting those whose lives are dependent upon the operation of such weapons to imminent danger.

The present invention avoids the disadvantages of prior art devices of this character by providing a single electrode which forms an electrical circuit through a plurality of bridge wires and then to ground through the surface of the primer and also permits the use of a plurality of bridge wires which are readily affixed within the igniter cup so as to prevent misfires due to poor electrical contact within the igniter itself.

With the foregoing in mind it is an object of the present invention to provide an igniter which affords unform firing results by the establishment of mamixum contact between the initiating composition and the electrical bridge wires which serve to ignite the composition.

Another object is the provision of a preassembled hermetically sealed igniter element for use in detonator primers which is positive in action, rugged in construction, compact in design, and economical to manufacture.

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Still another object is to provide an igniter element which lends itself to quantity production.

Yet another object is the provision of an igniter bridge assembly which may readily be varied in size to provide for different ignition requirements.

These and other objects, and their attendant advantages will become more apparent from the following description when read in conjunction wdith the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view of an electrically actuated primer illustrating an embodiment of the present invention;

Fig. 2 is a sectional exploded view of a portion of Fig. 1 showing the detailed arrangement of parts that make up the electrical primer of the present invention; and

Fig. 3 is a perspective view of the igniter bridge assembly.

Referring now to the drawings wherein like numerals designate the same parts throughout the several views and more particularly to Fig. 1 wherein there is disclosed a casing **10** which is externally threaded for attachment to a projectile or any other great charge of explosive and internally threaded to receive a locking sleeve **11** which is adapted to hold a preassembled electrical ignition element or primer designated generally by the numeral **50**, firmly in place in a cavity formed in the casing **10**. The electrical ignition element comprises a flanged electrode **12** the neck portion of which extends through an opening in the base **13** of the casing **10** and is insulated from the edges of the opening by an annular insulating sleeve or bushing **14**. The electrode **12** is made of brass or any suitable electrically conductive material and is formed with an enlarged head portion **15** which is mounted within a metallic primer cup **16** and insulated therefrom by an apertured insulating disc **17** and a sleeve **18** composed of fiber, plastic, or any other insulating material and the neck portion of the flanged electrode **12** extends through the cup **16** and through an opening in the base of the casing **10**. The primer cup **16** serves to hold the elements of the primer in position and also to provide a ground connection through the casing **10**.

In juxtaposition and in electrical contact with said enlarged head portion **15** and insulated from the cup **16** is a bridge assembly shown in Fig. 3 which comprises a pair of annular laminae or washers **19** and **20** made of electrically conductive material such as copper, axially separated by and bonded to an insulating ring **21** made of laminated phenolics, or other suitable insulating material. Connecting the washers or laminae **19** and **20** are one or a plurality of looped bridge wires **22** made of a high resistant material such as platinum iridium alloy, nichrome tungsten or other similar materials which wires are attached to the inner periphery of said washers by soldering, brazing, staking or other suitable means. The looped portions of bridge wires **22** extend longitudinally through a chamber or cavity **23** formed by the assembled washers **19** and **20** and ring **21**. The chamber or cavity **23** is filled with a nonconductive igniter composition **24** such as gun cotton or diazodinitro phenol surrounding and in intimate contact with the looped portions of wires **22** which serve as igniters for the composition. An an alternative the chamber **23** may be filled with a conductive igniter composition such as lead styphnate-graphite which will eliminate the use of the bridge wires **22**. The chamber **23** is sealed on the left by the flange **15** of the electrode **12** and on the right by a relatively thin metallic disc **25** of electrically conductive material. Seated against the disc **25** is an ignition spacer sleeve **26** formed of brass or other conductive material and having an annular opening therein which carries a flash charge **27** of black powder or other suitable material to be set off by the igniter composition **24**. The flash charge chamber is closed at the right end by a second metallic disc **28**. The disc **28** is in electrical contact with an inturned flange portion **29** of primer cup or housing **16** which is formed by crimping or other similar means so as to complete an electrical circuit from a source (not shown) through electrode **12**, washer **19**, bridge wire or wires **22**, washer **20**, disc **25**, sleeve **26**, disc **28**, primer cup **16**, and thence to the grounded casing **10**.

The primer element **50** is assembled separately from casing **10** and hermetically sealed by coating an annular space **30** with Bakelite or any other suitable sealing compound and adding a fillet of the same material at the junction of flange **29** and disc **28**.

The assembled primer element **50** is inserted in casing **10** and held in position by locking sleeve **11** as disclosed above. Booster charge **31** is added in a chamber of the locking sleeve **11** and the chamber closed off by an exteriorly threaded cylinder **32** having apertures **33** in the walls thereof which permit the flash of booster charge **31** to reach a propellant charge (not shown). The assembled casing **10** and primer element **50** are then placed in contact with a large charge of explosives or inserted in an ordnance sleeve and ignited by closing any well known firing circuit. The closing of the circuit causes current to flow through the elements as described above which, due to the high resistance of bridge wires **22**, produces sufficient heat in the wires to ignite the composition **24**. The ignition of composition **24** will burn through disc **25** to explode flash compound **27** which in turn burns through disc **28** to explode the booster charge **31** thereby setting off the large charge of explosives.

While the device disclosed herein is a preferred embodiment of the invention it is to be understood that the invention may be embodied in other forms without departing from the spirit or scope of the invention as defined by the appended claim.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

An electrically operated primer for firing a propellant charge comprising; a metallic cup, an electrode having an enlarged head portion mounted partially within said cup and insulated therefrom and a neck portion extending

beyond said cup for connection to a source of electricity, an electrically conductive annular lamina in juxtaposition and in electrical contact with said electrode and insulated from said cup, a second conductive annular lamina spaced axially from the first lamina and insulated from said cup, an insulating ring disposed between said conductive laminae, said laminae and said ring forming a cavity, a first igniting composition charge in said cavity, a plurality of high resistance loop bridge wires spaced from each other on the inner periphery of said laminae for igniting said first charge electrically, the ends of said wires being connected to said laminae and a portion of said wires extending longitudinally through said cavity in contact with said first charge, a first conductive disc in electrical contact with the second lamina and enclosing one end of the cavity, an electrically conductive ignition spacer sleeve seated against the first disc and having an annular opening therein, a second flash composition charge within said annular opening, said first disc and the sleeve being insulated from the cup, a second destructible conductive disc in electrical contact with the spacer sleeve and the cup for enclosing the annular opening containing the second charge, and means on said cup in electrical engagement with the second disc, said means restraining axial movement of the component parts to maintain operative engagement.

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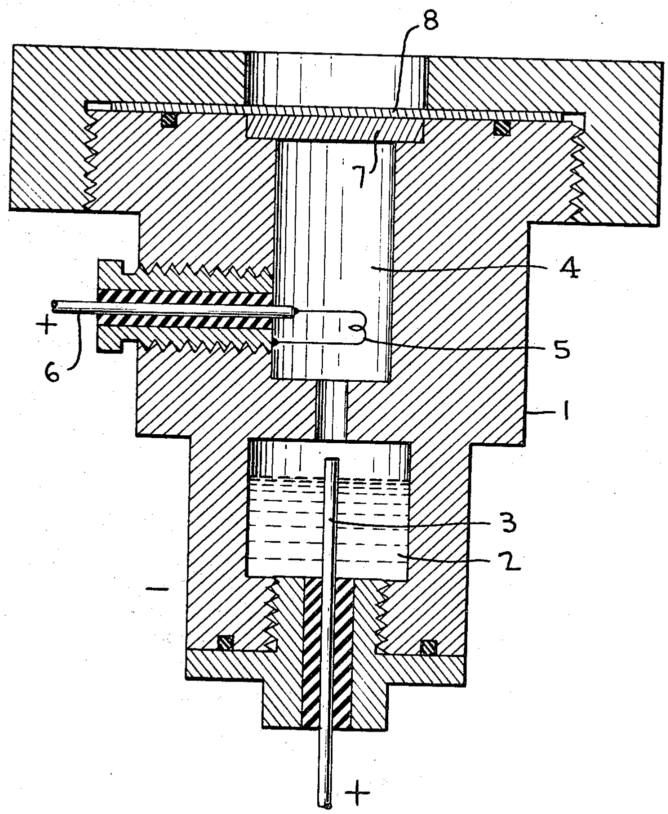
EXPLOSIVE ACTIVATOR

Filed Feb. 9, 1965



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United States Patent Office 3,351,015
Patented Nov. 7, 1967

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3,351,015
EXPLOSIVE ACTIVATOR

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Filed Feb. 9, 1965, Ser. No. 431,367
7 Claims. (Cl. 102—70.2)

This invention relates to improved actuating devices. More particularly, the invention embraces explosive actuating devices of the type used in military and commercial detonators, electric switches, and the like.

Actuating devices based on the explosion of a small charge are known in the art. These devices are used extensively in military operations as detonators in weapons of war such as bombs, artillery shells, and numerous other objects of destruction. Additionally, they are used in civilian blasting operations employed in the excavation of road beds, construction of commercial buildings, and the like. Particularly when used in military weapons, these devices must be sufficiently sensitive to be triggered by a simple act expending only minor amounts of energy, In addition, however, the devices must be highly trustworthy from the standpoint of accidental discharge. As is apparent, the accidental discharge of a modern weapon could have devastating results.

In view of their importance to national defense, actuating devices of the type described have been the subject of considerable investigation and have reached a high degree of perfection. In spite of the fine state of development of such devices, an actuating or fuze system which is completely inert prior to initiation is still unavailable in the art. Electric initiators of the type known are sensitive to electromagnetic and radio frequency waves. Therefore, in the military, various means of alleviating the problem, including the use of low-pass radio frequency filter circuits, incorporated RF attenuators in the circuitry, and similar techniques, are being investigated. However, while the aforesaid devices and techniques are of some utility, all of the RF and EM hazard is not eliminated.

Although the problem of premature detonation of an explosive is primarily encountered in the military, the difficulty is known in civilian operations as well. A well-recognized hazard in civilian excavations is the accidental triggering of an explosive charge by the EM radiation and/or RF fields emitted by two-way radios in nearby cars or low-flying airplanes passing overhead.

Accordingly, a primary objective of the present invention is to provide an actuating device for use in detonators, explosive switches, explosive motors, and the like, which is completely inert prior to initiation of the actuating cycle. The device which is the object of this invention is designed to eliminate the hazards of accidental discharge due to EM radiation and RF fields and also offers numerous other advantages over conventional electric actuators.

The presently described initiators are designed and operated in order that prior to the starting of the actuating cycle, accidental initiation cannot occur because the device does not contain an explosive material. According to the invention, during the activation, an explosive material is generated electrochemically by passage of a current through a suitable conductive medium. Inasmuch as an electrochemical reaction requires DC current, the device is completely insensitive to any RF or alternating current fields.

The herein described concept of generating the explosive material at the time of use can be applied to a variety of configurations and systems. The reaction may be a true electrochemical reaction or synthesis or simply

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the electrolytic decomposition of a substance to yield an explosive material or mixture. The conductive material can comprise a liquid, paste, gel, or solid. Final actuation of the explosive mixture can be accomplished by means of a heated filament, electric spark, or application of energy in other forms.

The drawing which forms a material part of this disclosure illustrates an actuating device according to the present invention. In the drawing, element **1** is a stainless steel housing which also serves as an electrical ground. Element **2** is a chamber containing the material which is to undergo electrochemical reaction to provide the explosive. Element **4** constitutes a second chamber leading from chamber **2** for collection of the explosive material when generated. When the actuating cycle is initiated, current is applied to electrode **3** which decomposes or otherwise electrochemically changes the material in chamber **2** forming the explosive material. As a continuation, or separate phase of the actuating cycle, current will be applied to electrode **6** in order that glow wire **5** will trigger the explosive material. The explosion will cause piston **7** to rupture membrane **8** which will trigger a further reaction. Membrane **8**, while being sufficiently strong to withstand the pressure of the explosive material prior to explosion, must be readily rupturable by the explosion of the charge. Suitable materials are the lightweight metals and plastics.

As will be apparent, numerous modifications are possible in the above cycle. For example, referring to the drawing, it is not essential to have the second chamber **4**. It may be desirable from the standpoint of conserving space and to simplify construction to have the explosive material collect directly above the electrolyte and in this way eliminate the second chamber. Furthermore, it is not essential to have piston **7**. The device, according to the invention, can be constructed to have rupturable membrane **8** in direct contact with explosive area **4**, whether it be in a single chamber or a double chamber construction. In such a device, the explosive force will work directly on the membrane. Again, the explosive force may work directly upon a piston, with the motion of the piston closing one or more contacts for actuating further reactions. In such modifications, the membrane is not essential. Numerous other modifications in the design will be apparent to one skilled in the art, depending upon whether the reaction employed to generate the explosive material is a true electrochemical reaction or merely an electrolytic decomposition.

In the operation of the presently described initiators, the device can be rigged in order that the closing of a single contact will initiate the formation of the explosive material and also the exploding of the material. In such an embodiment, the actuation of ignition means, such as glow wire **5**, can be tied into a timing device in order that the wire will glow substantially immediately, or hours, or even days later to explode the material formed. Alternatively, the device can be wired in order that two separate and positive acts are necessary to actuate the mechanism. Thus, referring to the drawing, one act will initiate the reaction in the first or electrolyte chamber to form the explosive material and a second act will actuate the glow wire for setting off the explosive material. An example of utility for the former mechanism will be in an electrical switch where a delayed action is intended. In the switch, the closing of a contact will provide current to electrode **3** starting the formation of the explosive material. A suitable time later, through a relay timer, current will be applied to electrode **6** which will cause glow wire **5** to explode the material so formed. The explosion will either break or close an electrical contact as desired. On the other hand, an actuating mechanism where two separate acts are necessary to complete the initiating cycle has utility in weapons of war, such as nuclear warheads, where it is undesirable to charge the device until it is in its final position or installation. Thus, the actuating or arming mechanism will remain uncharged until the warhead is in its final location, at which time DC current will be applied to the electrochemical or electrolysis reaction to generate the explosive material. No current, however, will be applied to the electrode attached to the glow wire until the actual triggering of the warhead is desired. Such a device provides a completely dependable fuzing system.

Having described the invention in general terms, the following example is set forth to more particularly illustrate the invention. Referring to the drawing, five normal (5 N) potassium hydroxide was added to chamber **2**. 0.8 amp. direct current at 3 volts was applied between the ground and electrode **3** for a period of three minutes. Hydrogen and oxygen was formed which collected in combustion chamber **4**. Current was applied between the ground and electrode **6** causing glow wire **5** to ignite the explosive mixture of hydrogen and oxygen in chamber **4**. The explosion created a pressure of greater than three-hundred atmospheres upon detonation. In the embodiment described, the housing was stainless steel and the membrane a sheet of steel 0.5 mm. thick.

In the above example, rather than electrolyzing potassium hydroxide, materials such as Glaubers salt

$$(NaSO_2 \cdot 7H_2O)$$

aqueous hydrochloric acid or aqueous hydrobromic acid can be decomposed to provide, respectively, gaseous mixtures of hydrogen and oxygen, hydrogen and chlorine, or hydrogen and bromine. Furthermore, other electrochemical reactions can be employed to provide the explosive mixture. Additionally, as is apparent, other triggering devices can be employed in place of the glow wire, such as an electric spark.

As a further modification of the invention, the detonation pressure from the explosive mix can directly initiate a primary explosive, or this pressure may activate the explosive through an intermediate mechanical element such as a stab detonator.

Additionally, as noted hereinbefore, rather than employing the presently described actuator as a detonator, the mechanism can be used in explosive switches or the like. For example, the explosive force can work upon a plunger to activate an electrical switch. Similarly, the explosive force can be utilized to effect useful mechanical motion in an explosive motor of the caterpillar or dimple type. In practice, all electro-explosive devices can be actuated with the presently described mechanism, and the invention is not to be limited by the drawing or example set forth. In its most generic sense, the concept disclosed herein comprises the generation of an explosive in situ in a confined space and the explosion of this material to initiate a second reaction. Although emphasis is placed in the present specification upon the electrochemical formation of the explosive in view of its practical utility, it is possible to produce the explosive material by other means. Thus, two or more chemicals reactive with each other to form an explosive can be maintained out of contact with one another in a suitable chamber; and, at the time the explosive is to be effected, admixture of the chemicals can be accomplished, as for example with an electrical solenoid. Furthermore, the explosive can be formed by exposing a suitable material to gamma or beta radiation. Thus, as is apparent, numerous methods can be utilized in the preparation of the in situ explosive. A skilled technician, with the present disclosure as a guide, will be able to produce various embodiments without departing from the inventive concept herein disclosed. Such embodiments will be apparent to and are within the ability of one skilled in the art.

What is claimed and desired to be secured by Letter Patent.

1. A primary explosive comprising in combination a device for actuating said primary explosive comprising a housing constructed and arranged to form a chamber within said housing, a conductive material within said chamber, electrode means positions within said chamber to react upon said conductive material to form a secondary explosive, ignition means constructed and arranged in said chamber to ignite said secondary explosive, a rupturable membrane in association with said chamber constructed and arranged to rupture upon ignition of said secondary explosive to actuate said primary explosive.

2. The actuating device of claim **1** wherein the ignition means is a glow wire attached to a means for providing DC current.

3. The actuating device of claim **1** wherein the ignition means comprises means for providing an electric spark.

4. The actuating device of claim **1** wherein the membrane is a lightweight metal.

5. The actuating device of claim **1** wherein the membrane is a plastic.

6. The actuating device of claim **1** wherein the conductive material is a solution of potassium hydroxide and the explosive is a mixture of hydrogen and oxygen.

7. The method of detonating a primary explosive comprising the steps of:

(1) reacting a conductive material electrochemically to produce a secondary explosive,

(2) collecting said secondary explosive in a confined area, and

(3) igniting said secondary explosive in said confined area to detonate said primary explosive.

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