United States Patent

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[72] Inventors **Dragolyoub Popovitch**
Denville, N.J.;
Roy B. Nystrom, East Northport; Melvin Eneman, New York, N.Y.

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[73] Assignee **the United States of America as represented by the Secretary of the Army. by mesne assignments**

[54] **MECHANICAL TIME FUZE**
15 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **102/71,** 102/84
[51] **Int. Cl.** **F42c 9/02,** F42c 9/04, F42c 9/00
[50] **Field of Search** 102/71, 83, 84, 74, 75

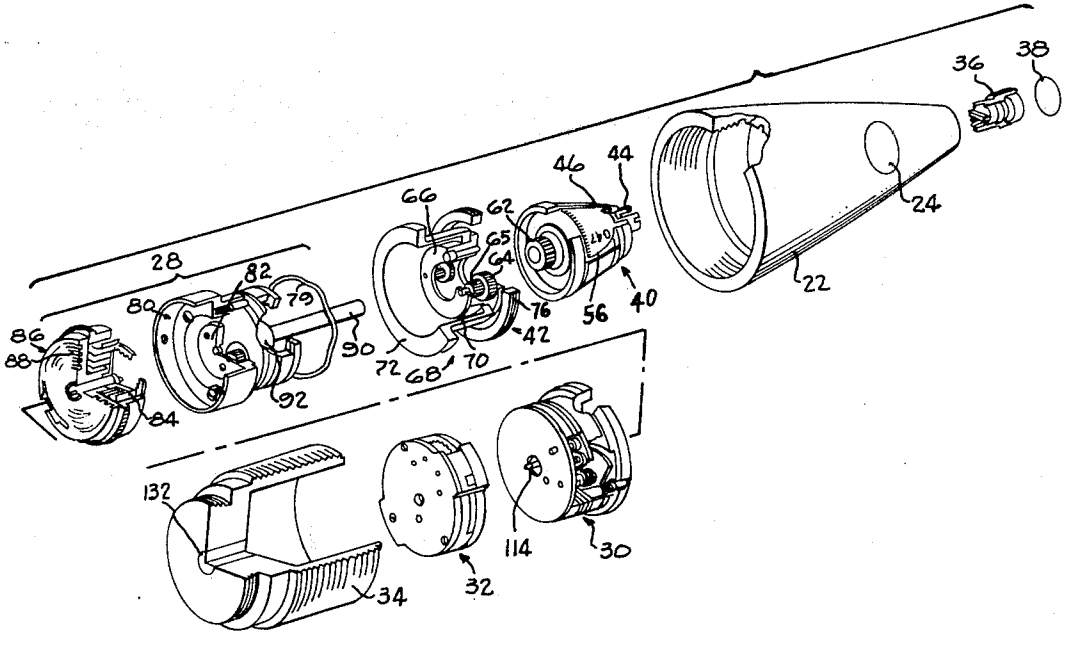
[56] **References Cited**

UNITED STATES PATENTS

2,356,554	8/1944	Weisz	102/84X
2,397,055	3/1946	Sekella	102/84
2,640,418	6/1953	Thomson	102/84
2,911,915	10/1959	Gibbs et al.	102/71
2,991,717	7/1961	Kollmeyer	102/84X
3,286,632	11/1966	Potts, Jr. et al.	102/84

Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—Thomas H. Webb
Attorneys—Harry M. Saragovitz, Edward J. Kelly, Herbert Berl and Lawrence S. Epstein

ABSTRACT: The invention is designed to be an all-purpose fuze and consists of four mechanical modules and an explosive train, all housed in a two-piece body. The modules comprise a digital setting module including a setting gear housing in order to set the time for exploding, a timing mechanism module which contains a timing movement and a scroll operative with the digital module, an arming and firing trigger module, and a boresafe arming delay movement. The fuze is set in a safe position for delivery and stockpile. For function it can be set to detonate on impact or after a timing delay which in one instance is from 0.3 to 200 seconds after firing.



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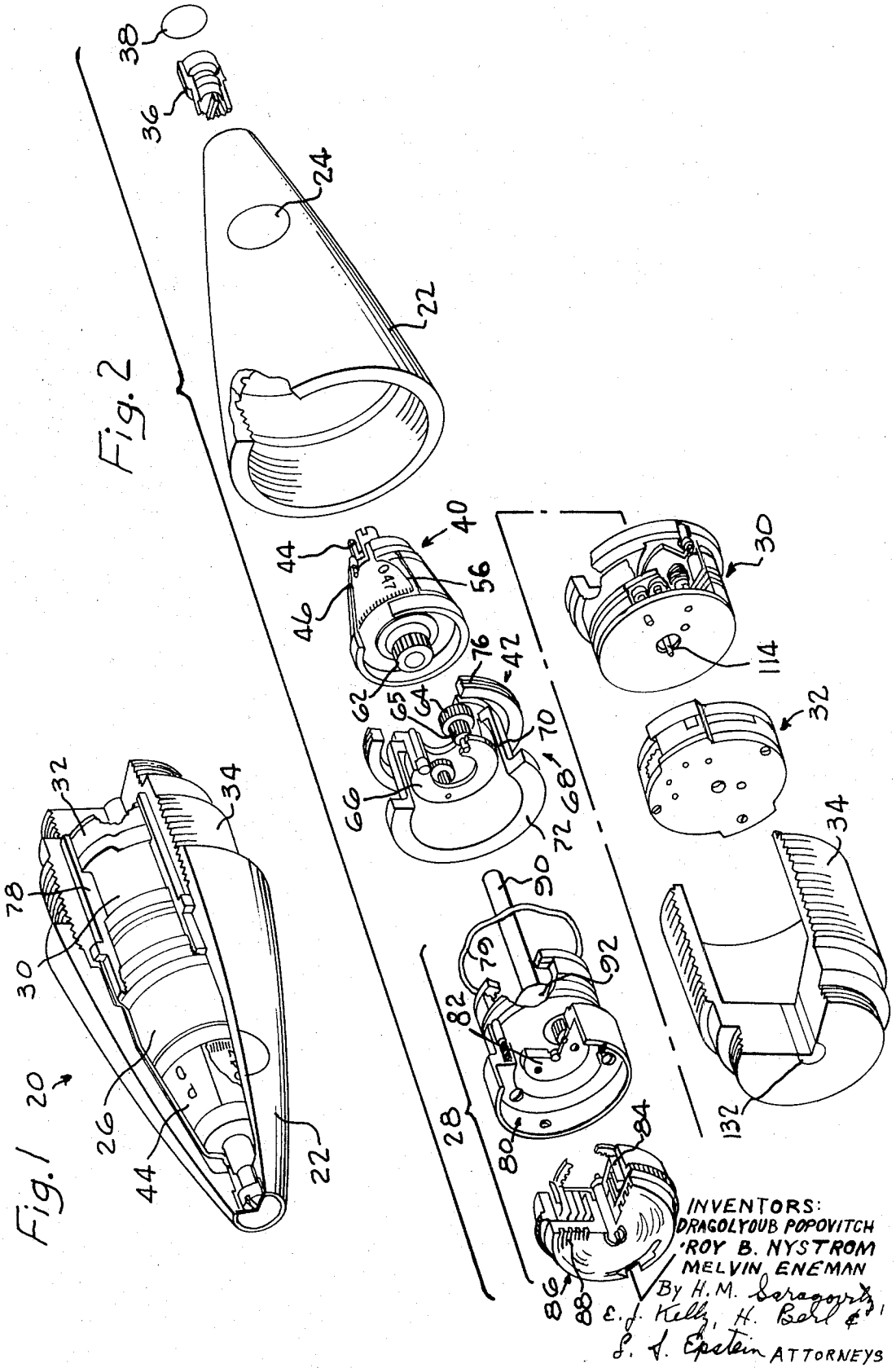
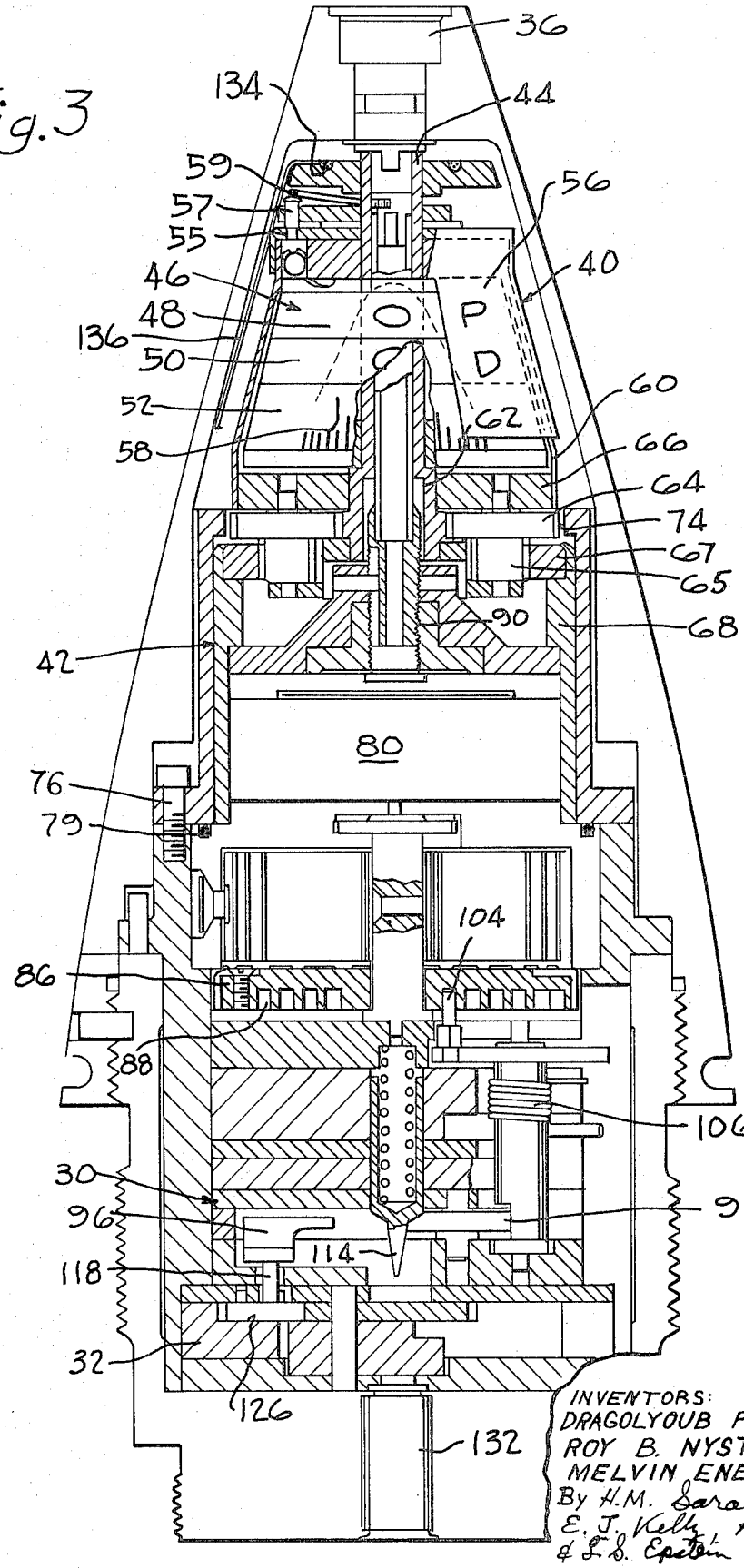


INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN
By H. M. Saragovitz, E. J. Kelly, H. Bell & S. A. Epstein ATTORNEYS

Fig. 3



INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN
By H.M. Saragovitz,
E.J. Kelly, H. Bert
& L.S. Epstein ATTORNEYS

Fig. 4

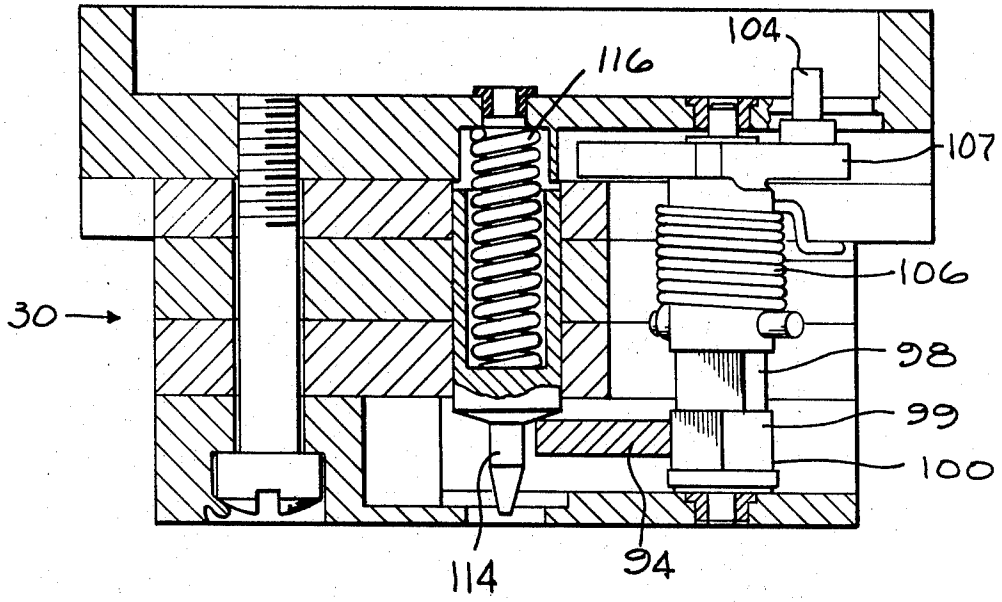
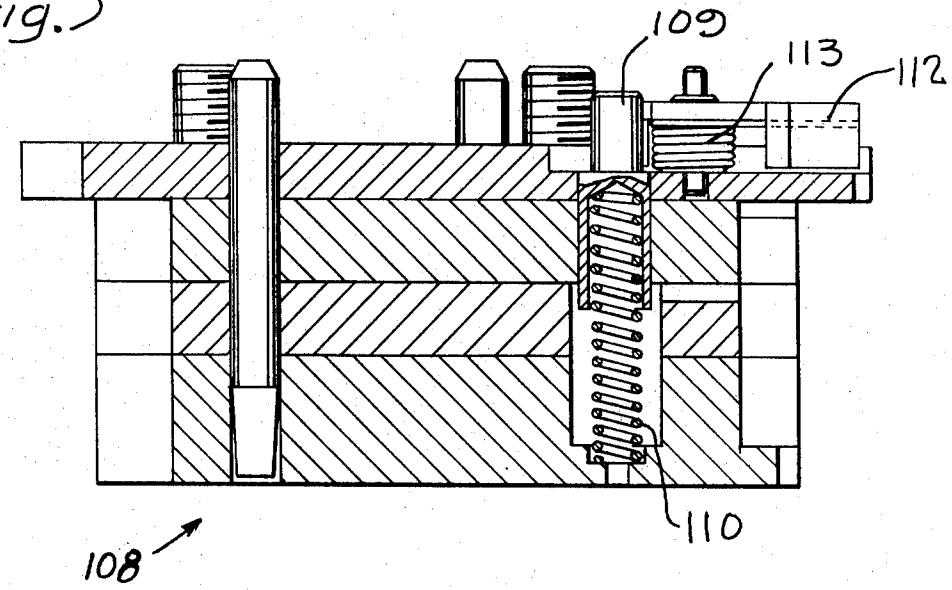


Fig. 5



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DRAGOLYOUB POPOVITCH
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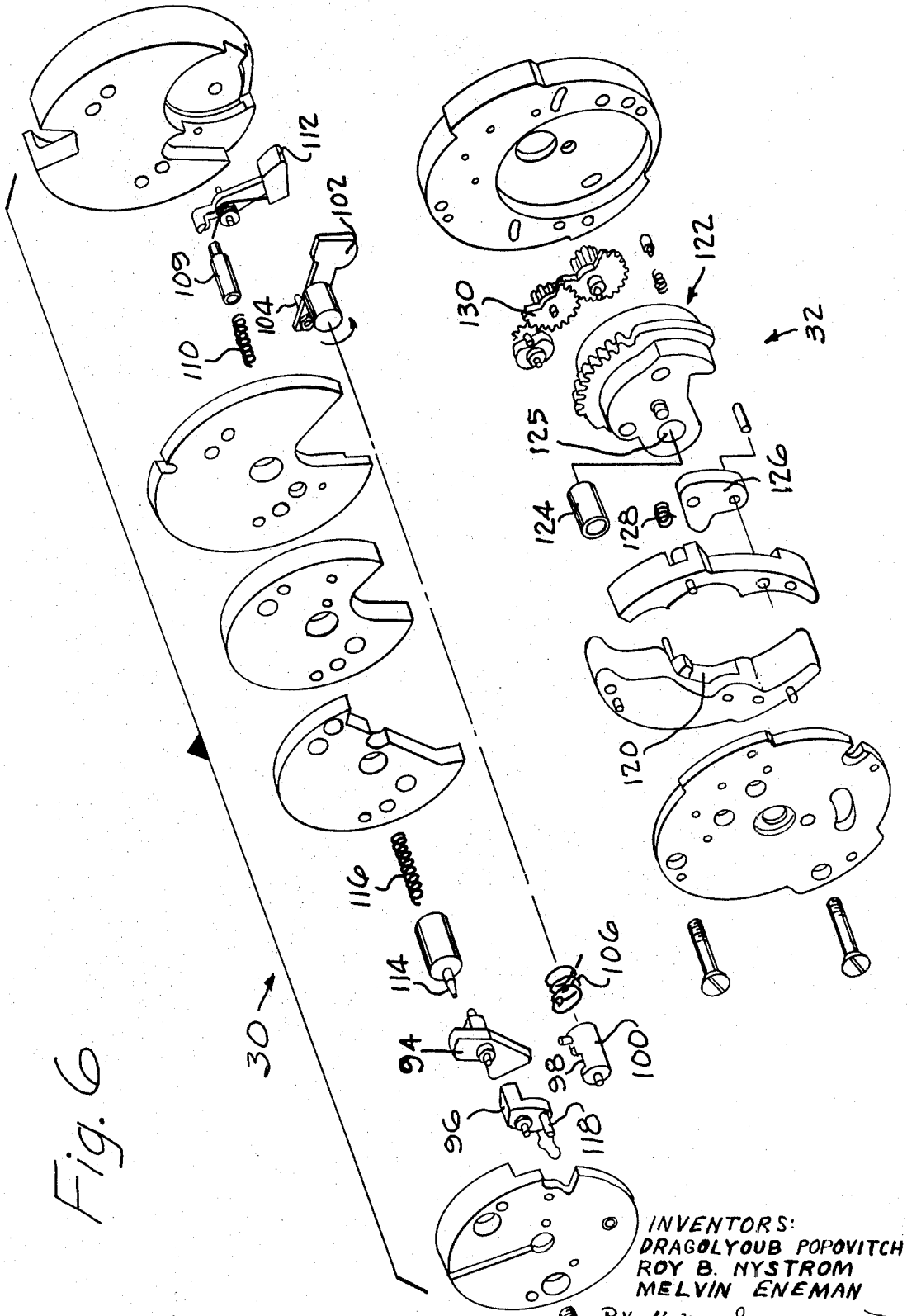
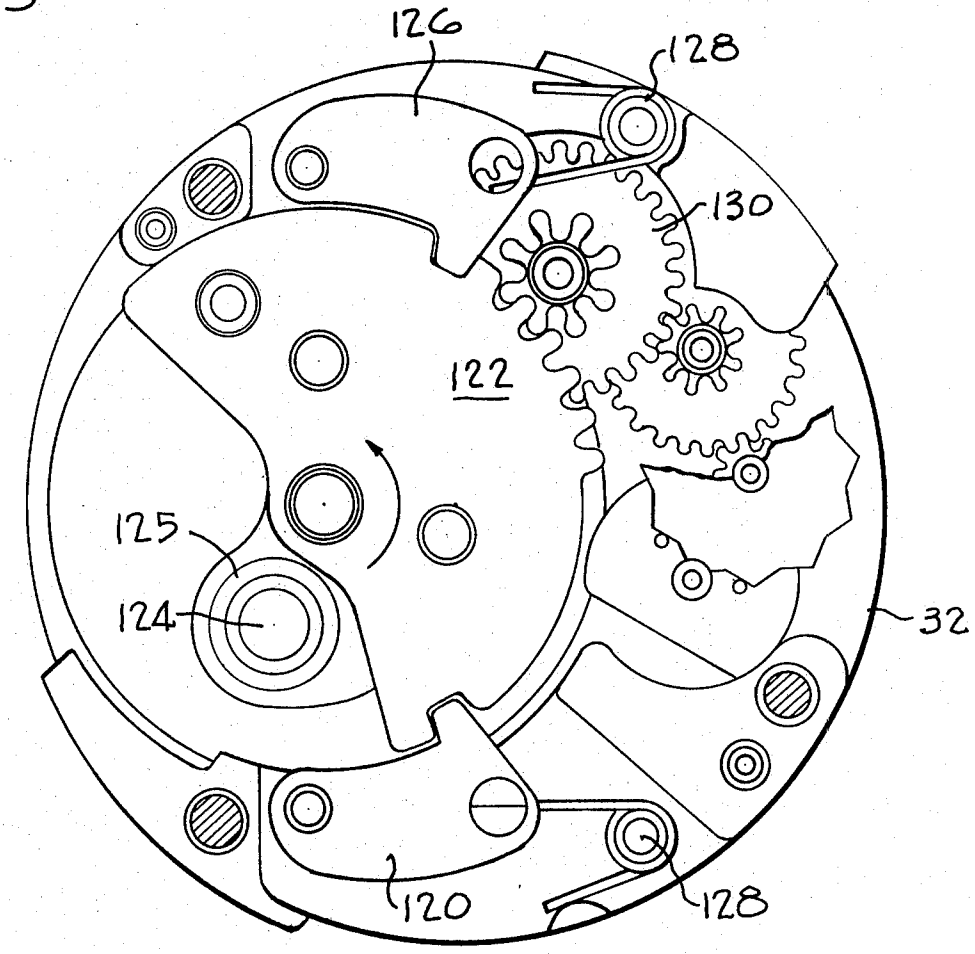


Fig. 6

INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN

BY H. M. Seragovitz
E. J. Kelly H. Berl
& S. S. Epstein
ATTORNEYS

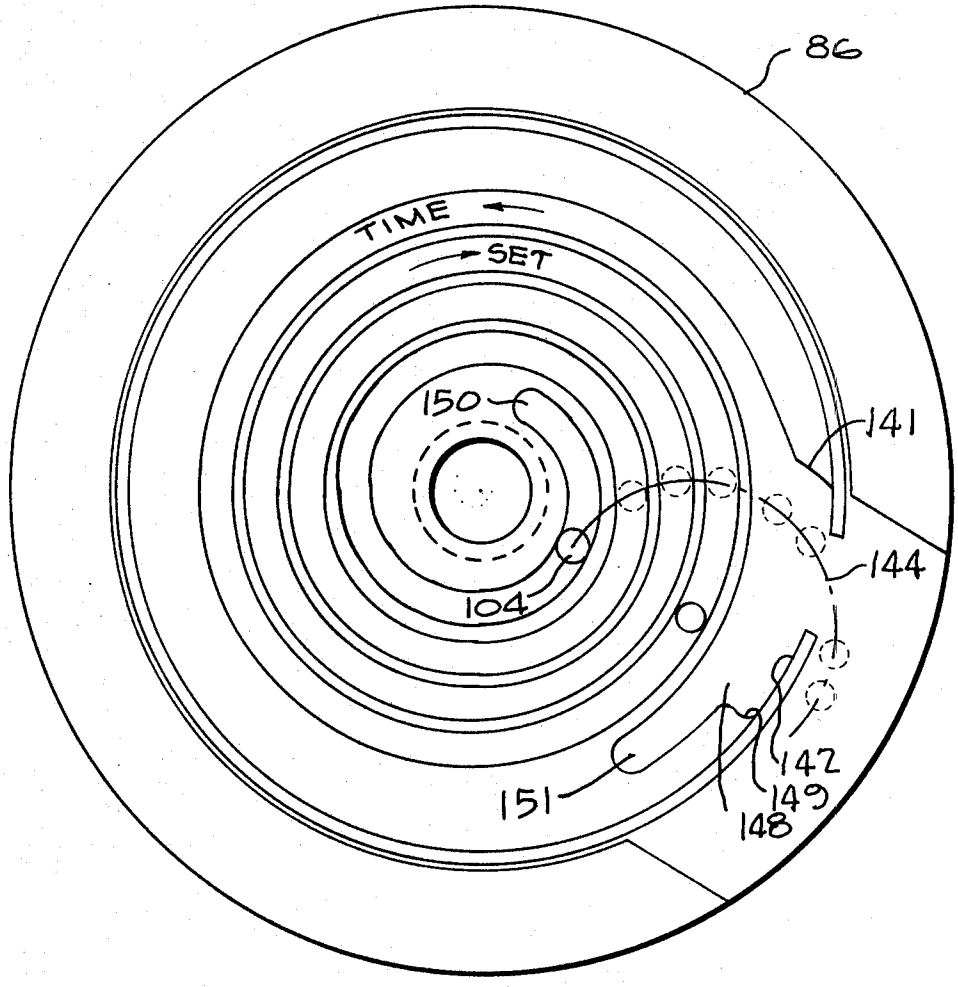
Fig. 7



INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN

BY N. M. Saragovitz,
E. J. Kelly, H. Berl
L. S. Epstein ATTORNEYS

Fig. 8



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ROY B. NYSTROM
MELVIN ENEMAN

By H. M. Saragovitz,
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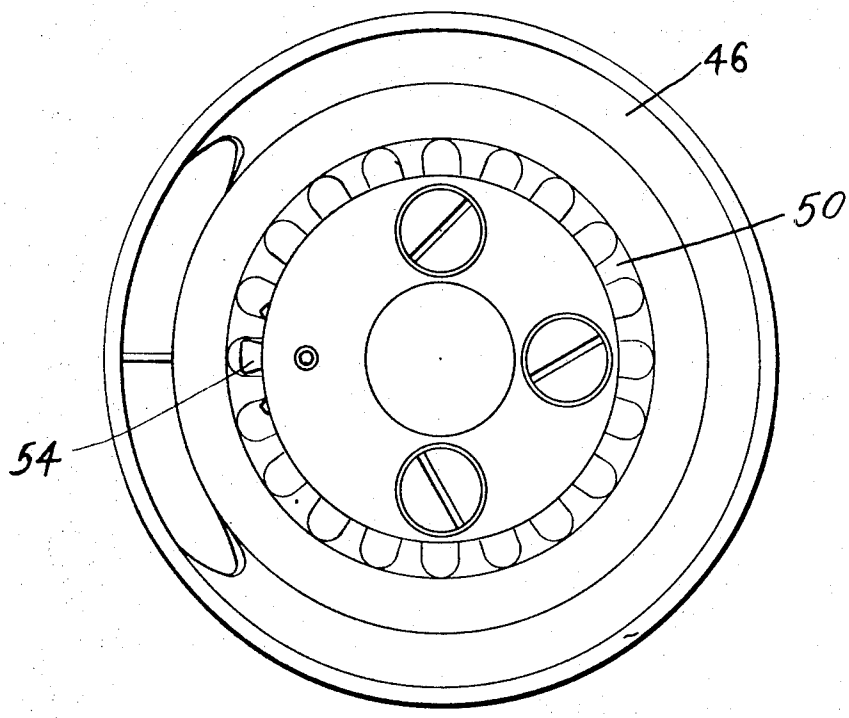
L. S. Epstein ATTORNEYS

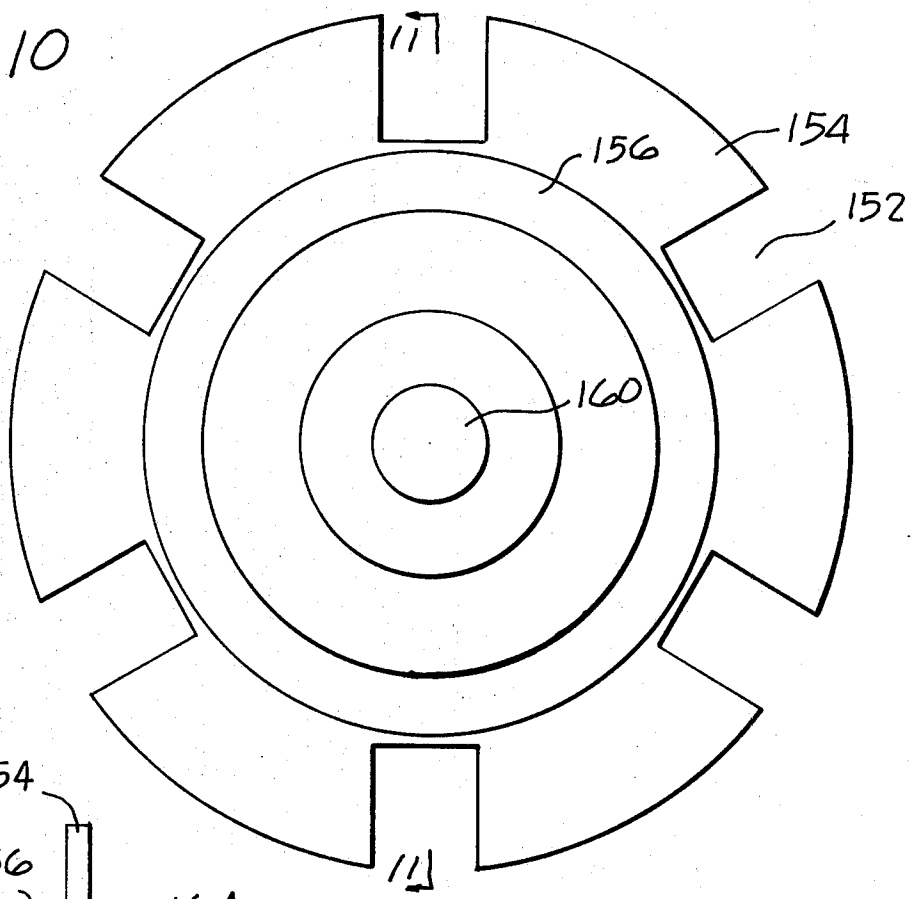
Fig. 9



INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN

BY H. M. Sargoury,
E. J. Kelly, H. Berl
L. S. Epstein ATTORNEYS

Fig. 10



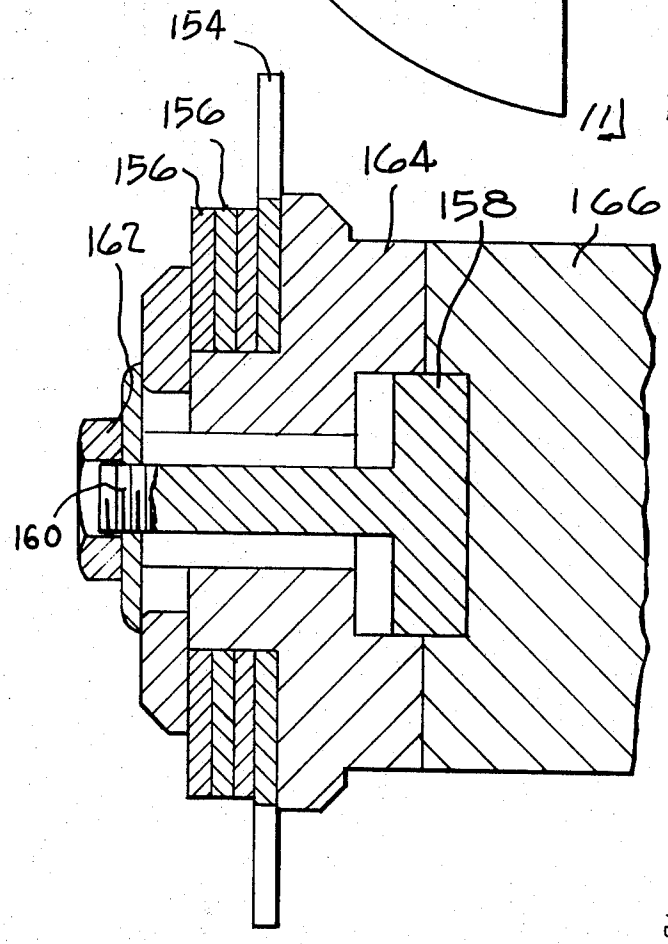


Fig. 11

INVENTORS:
DRAGOLYOUB POPOVITCH
ROY B. NYSTROM
MELVIN ENEMAN

BY H. M. Seragovitz,
E. J. Kelly, H. Berl
L. S. Epstein ATTORNEYS

MECHANICAL TIME FUZE

Progress in artillery long ago had made inadequate the conventionally utilized fuze known as the "Junghans fuze". This fuze is a high frequency adaptation of the cylinder type escapement, which originated in about 1695. It was extensively used in World War I and World War II as the timing movement in almost all mechanical time fuzes for artillery ammunition. However, the fact that it is spin sensitive, since the performance of the mechanism is a function of spin rate, causes the actual functioning time to differ from the set time for different spin rates of the round. This spin varies from one weapon to another and from one charge to another for the same weapon. Further, its best performance is about 0.5 to 1.0 percent accuracy under the most severe new weapon conditions. It thus is necessary to stock a variety of different versions of the basic mechanism to optimize the performance in different shells. Some recent modifications made the Junghans escapement substantially spin insensitive and rugged enough to withstand extreme ranges of firing environments. However, this did not change the basic nature of the escapement, nor did it improve the basic accuracy characteristics of the Junghans escapement.

A more accurate detached lever escapement was conceived about 1750. Later refinements made it extremely accurate in time and now has completely replaced the older cylinder type movement in ordinary watches and clocks. The principles of this detached lever escapement have been utilized in the instant invention. Thus, both spin insensitivity and accuracy in time are now accomplished.

The fuze of the invention is a mechanical time fuze comprising a setting module, a timing mechanism module, an arming and firing trigger module, a boresafe arming-delay module, and an explosive output element all housed in a two piece body. Additional features include a direct-acting point-detonating element and a dual-purpose explosive output element suitable to initiate either high explosive by detonation or pyrotechnic materials without detonation.

Thus, several significant advances in the state of the art are provided by the invention:

1. Safety - Setback and spin, in that order, are required to initiate fuze timing and arming after the fuze is first set from its safe-locked condition. Further, when set for time, fuze arming is withheld until a preset built-in interval prior to the set time;
2. Versatility - The fuze can function accurately and reliably when fired with shell from guns and mortars having less than 1,000 g.'s setback to more than 30,000 g.'s setback and spin rates from less than 2,000 r.p.m. to more than 30,000 r.p.m. It can be set to function from zero time after firing to 200 seconds. Greater duration, to multiples of 200 seconds would require relatively small design changes if longer durations are needed. It can reliably initiate high explosive, propellant or black powder. It conforms to the shape of the shortest intrusion standardized American-British-Canadian-Australian (ABCA) fuze contour and mounting configuration for 75mm. and larger shell. These characteristics permit this single fuze to be used with all known ABCA shells which use time fuzes;
3. Accuracy - The fuze can be set to a fraction of 0.1 second throughout its timing range. The mean time of fuze functioning has characteristically been within 0.1 second of set time at 5 second settings and within 0.25 second of set time at 115 seconds. This should greatly facilitate its use without extensive range tables. The standard deviation of fuze functioning time is relatively invariant from non-spinning laboratory conditions to 15,000 r.p.m. and 30,000 r.p.m. in the shell. This standard deviation has been from about 0.03 second at 5 seconds setting to about 0.2 second at 115 seconds. This greatly improved fuze accuracy permits the most economic exploitation of currently available ballistic accuracy;
4. Handling - The fuze is a completely sealed package which can be set through an arrangement similar to that of a waterproof watch. Setting requires very low torque such as may be obtained by use of a small screwdriver, or even a small coin. The setting of Safe, PD, or time is directly visible; and in particular, the time settings are direct reading digits in seconds with direct reading line markings to tenths of seconds. These improvements reduce the care needed in handling; the special wrenches or other tools needed for setting; the training needed to handle time fuzes; and the time, care and number of personnel needed to set fuzes at the gun battery.

The primary object of the invention is to provide a fuze which is versatile in use and which may be retained in storage or at the gun in a safe-set condition, or preset for point detonation or preset for a specific functioning time delay.

Another object is to provide a fuze which is extremely accurate in its timing range to obtain substantially an overall negligible error. As a result, the need for extensive range tables is no longer required.

Still another object is to provide a fuze contained as a completely sealed package capable of being set through an arrangement similar to that of a waterproof watch.

An advantage of the invention is to permit settings requiring very low torque.

Another feature of the invention is to provide time settings which are visible as direct reading digits.

And yet another object is to reduce the time required to train personnel to handle fuzes as well as the number of personnel required to set fuzes at the gun battery.

It is still yet another object to provide a multipurpose lead capable of being initiated by a relatively small detonator and one which may be used interchangeably with different types of explosives and propellants.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings which show, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein:

FIG. 1 is a perspective view, partly broken away, of the fuze of the invention,

FIG. 2 is an exploded view of the fuze with the several component modules separately shown,

FIG. 3 is a vertical section of the fuze of FIG. 1,

FIG. 4 is section of the arming and firing trigger module showing the firing arm and firing pin assembly,

FIG. 5 is a section of the arming and firing trigger module showing the setback spin arrangement,

FIG. 6 is an exploded view of the arming and firing trigger module and the bore safe arming delay module,

FIG. 7 is a plan view of the bore safe arming delay module with the top plate removed,

FIG. 8 is a bottom view of the scroll disc member and the various positions for the scroll pin follower,

FIG. 9 is a bottom view of the digital counter with the seconds wheel element removed,

FIG. 10 is a plan view of another form of setting arrangement showing a slip clutch construction, and

FIG. 11 is a section taken on the line 11–11 of FIG. 10.

Referring to the FIGS. and particularly to FIG. 2, the mechanism of the fuze 20 is housed in an upper body (fuze ogive) 22 having a window area 24 at the nose portion. The mechanism of the fuze 20 is composed of a digital setting module 26, a timing mechanism module 28, an arming and firing trigger module 30, and a boresafe arming delay module 32 - the modules given from the nose-end of the fuze to the base, respectively. The mechanism is retained in the upper body by a threaded lower body member 34, which has additional threaded portions for fuze-to-shell and booster-to-fuze mounting (the latter is conventional and need not be further described). An external setting key 36 is seated in the nose of the fuze ogive 22 under the seal 38 and acts as the firing pin to the primer ring.

The digital setting module, located at the nose-portion of the fuze **20**, simultaneously sets and indicates the safe, point-detonating (PD), or timing functions of the fuze. The setting module is designed to accommodate either the inclusion or the omission of the PD element without modification. The external setting key functions also as the striker or firing pin for the PD function. Dual redundant lengths of mild detonating fuze (MDF) lead from the PD primer to the input face of the bore safe module. This arrangement was conceived to be, and has been demonstrated to be, significantly faster functioning than the more conventional flash-through PD explosive trains used with current U.S. time fuzes. This greater speed affords improved performance when used with HE shell intended to provide antipersonnel or antilight structure fragmentation and blast. The greater speed should also improve burst point visibility when the PD feature is used for registration of fire. The digital setting module consists of a digital counter mechanism **40** and a setting gear housing **42**. (See FIGS. **2** and **3**) The digital counter mechanism **40** consists of hollow setting shaft **44**, the three digital counter wheels **46**, the hundreds wheel **48**, the tens wheel **50** and the seconds wheel **52** and the two counter wheel index pinions **54**, (see FIG. **9**), and a PD/Safe indicator flag **56**. The index pinions **54** are located, one between the seconds and tens counter wheel and the other between the tens and hundreds counter wheel. They are generally placed in tandem. This arrangement is conventional in digital counters and need not further be described. The annular apex of the indicator flag **56** is slotted at **55** to receive the pin member **57** and is also provided with an axial aperture to receive therethrough the setting shaft **44**. The shape of the indicator flag conforms to the divergent shape of the housing **60** of the digital counter mechanism **40**. The reduced upper neck portion of the shaft **44** is slotted to receive thereon the setting key **36** to transmit torque from the setting key **36** to the setting shaft **44**. The digital counter mechanism housing **60** is seated in position by a suitable slot engaging a pin (not shown) extending laterally from the setting gear housing member **42**. The hollow setting shaft **44** is coupled directly to the setting pinion **62** which will turn the gear member **64** in the setting gear housing **42**. On turning the gear member **64**, the pinion member **65** in the setting gear housing **42** rotates and drives the ring gear **67** to thus turn the clock assembly **28**. The members **64** and **65** are shown mounted on the same shaft member. This gearing arrangement provides a 5:1 reduction ratio from setting key **36** to clock assembly **28**. Both the counter wheels **46** and the indicator flag **56** are observable through the fuze window **24** (see FIG. **2**). The setting gear housing is in two sections, with the gear members **64** and **65** rotatably retained in the housing **66**. (See FIG. **3**) The gear retaining housing **66** is adapted to seat in the timing movement housing section **68**. An annular axially bored ring **70** includes an extension flange **72** and is configured at **74** to receive the gear retaining housing **66**. The annular ring **70** retains the fastening ring **76** thereon in a freely movable manner. The fastening ring **76** is threaded to the mechanism outer housing **78** to retain the timing mechanism module **28**, the digital setting module **26** and the setting shaft **44** in cooperative position. Setting the fuze is accomplished by applying torque to the setting shaft **44** at the nose of the fuze through the setting key **36**. The torque is transmitted from the setting shaft through the gear and pinion set, in the setting gear housing **42** to the ring gear **67** attached to the top of the timing mechanism. The pinion member **65** engages the ring gear **67** of the timing mechanism module **28**. A vertical shaft **90**, extends from the timing mechanism into the hollow setting shaft **44** of the digital module. The applied torque rotates the timing mechanism module **28**, and thereby the timing scroll disc **86** for the set time desired.

The timing mechanism module **28** provides for the delay of fuze firing for a desired period of time (i.e., set time) and relates fuze settings made into the digital setting module to the arming and firing trigger module **30**. A torque washer **79**, between the two modules prevents slipping of the elements. The timing mechanism module **28** is located beneath the digital setting module **26** and consists essentially of a timing movement member **80** having a detached lever escapement and a gear train **82**, a prewound clock mainspring **84** and a timing scroll disc **86**. The mainspring arbor **84** is geared to the timing movement and is also fixed to the timing scroll **86**. This arrangement causes the timing scroll disc to rotate at the running rate of the timing movement, when the timing movement is permitted to run. The timing scroll disc **86** has a spiral cam surface **88** in its lower face which accommodates a scroll follower pin **104**, which is part of the arming and firing trigger module. The timing mechanism module represents a major advance in the art of mechanical time fuzes in that the much greater inherent accuracy of the detached lever escapement can now replace the five to ten times relatively poorer accuracy of the cylinder escapement which is now almost universally used in one or another of its many forms. In addition this inherently more accurate type of escapement has been applied in a form which is suitable for use under broader ranges of gun conditions and environments than any time fuze known to the inventors. A more detailed discussion of the timing mechanism module is provided in the copending application Ser. No. 774,231, filed Nov. 6, 1968.

The arming and firing trigger module **30** performs two functions: arming delay rotor release and firing pin release. (See FIGS. **2**, **3** and **4**) Both functions are performed at the desired times by the actuation of a rotor detent release lever **96** and or firing pin release lever **94**. These actuations are controlled by the D-slots **98** and **99** (see FIG. **4**) provided in a firing arm shaft **100**. A firing arm **102** on the upper end of the firing arm shaft **100** has a scroll follower pin **104** which is controlled by the rate at which the timing scroll disc **86** rotates (i.e., rate of the timing movement) p provided the scroll follower pin **104** is engaged along the spiral cam surface. A torsion spring **106** is retained on the shaft **100** to keep it against the control surfaces of the scroll member **86**. A combination setback-spin detent arrangement **108** prevents rotation of the firing arm shaft **100** (to release the arming delay rotor and firing pin) by restraining the firing arm **100**. The setback-spin detent arrangement **108** is one of the safety features incorporated into the fuze to provide safe handling and consists of a spin-actuated safety lever **112** restraining the firing arm and a setback pin **109** which is spring loaded at **110** and restrains the safety lever **112**. A firing pin **114** spring loaded at **116** is incorporated into this module and is restrained by the firing pin release lever **94** (see FIG. **4**). The rotor detent release lever **96** has a rotor release detent pin **118** which restrains one of the two boresafe arming delay rotor spin detents **120** in the boresafe arming module **32**. The D-slots **98** and **99** on the firing arm shaft are arranged to actuate the rotor detent release lever **96** a finite period of time prior to actuation of the firing pin release lever **94**.

The boresafe arming delay module **32** (shown in FIG. **6**) provides the major safety and arming feature of the fuze. The boresafe arming delay module uses an unbalanced eccentric rotor to normally hold a stab detonator out-of-line with an explosive output lead. Centrifugal force releases the two independent detent locks on the rotor and drives the rotor towards arming against the inertial restraint of a gear train and runaway escapement. The interlock from the arming and firing trigger module permits one of the detent locks to release only as determined by the position of the timing scroll. An arming delay rotor **122** carries a detonator **124** retained in the opening **125** and which is normally in an "out-of-line" position with respect to the firing pin **114**. The rotor is held in this position by the two spin detents **120** and **126**. The detents are held in place by the detent springs **128**, with the detent **120** restrained by the rotor detent release lever **96**. A properly sequenced firing environment (i.e., setback and spin) will actuate the rotor detent release lever **96** and the spin detents **120** and **126**, allowing the rotor **122** to rotate to the "in-line" (armed) position. Motion of the rotor is controlled by a runaway escapement **130** with its arming rate dependent upon the spin rate to which it is subjected. The physical relation is such that arming

distance is constant in any single weapon except for tolerances. The arming distance depends on the twist and the bore of the weapon only. Several improvements are thus provided by the boresafe arming-delay module. These include:

1. Increased strength to withstand at least 30,000 g. setback and to operate while driven by spin from less than 2,000 r.p.m. to at least 30,000 r.p.m.;
2. Redesigned center of gravity position to arm reliably when subjected to at least 0.060 inches spin axis eccentricity;
3. Increased angle of freewheeling stroke while disengaged from the gear train to reduce and almost eliminate the time of flight and, hence, the range, during which the fuze is no longer safe but is not yet reliably armed while the detonator is approaching its aligned position.

The explosive train consists of three major components: a detonator **124**, a multipurpose lead **132**, and the PD elements **134**. The detonator **124** is housed in the rotor **122** of the boresafe arming delay module **32**. The multipurpose lead **132** has the capability of properly initiating both high explosive and propellant and is housed in the lower body at the base of the fuze. The multipurpose lead is an explosive element that is to be initiated by a relatively small detonator element and in turn is to either initiate detonation of conventional high explosive boosters as used in artillery shell or to initiate without detonation black powder or propellant materials comprising expulsion charges, flare ignition materials, etc., as used in artillery shells. When the rotor **122** is in the armed position, the detonator **124** is "in-line" with the lead **132**. The detonator can be initiated either by the firing pin or by the PD elements. The PD elements consist of a percussion-sensitive ring primer **134** at the nose-end of the fuze, above the digital setting module and two mild-detonating (MDF) paths **136** (see FIG. 3) leading from the primer mix **134** to the the detonator **124**.

The design of the firing arm shaft portion of the arming and firing trigger module is arranged so that the angular orientation of the scroll follower pin **104**, mounted on the firing arm shaft **100**, is related to firing pin **114** and to the delay arming **122** rotor actuation (see FIG. 7). The timing scroll disc **86** controls the scroll follower pin position (i.e., angular orientation) and its rate of change of position. By incorporating the timing scroll disc **86** and the arming and firing trigger module **30** (i.e., firing pin and delay arming rotor actuation) into the fuze design, the various fuze functional requirements are achieved.

Referring to FIG. **8**, the timing scroll disc **86** rotates in a clockwise path with the scroll follower pin **104** following in a spiral groove **88** when it is operating to actuate the fuze when set for time. The scroll follower pin **104** extends from the firing arm lever **102** into the spiral groove **88**. The various scroll follower pin positions on the timing disc **86** and their relation to the fuze function is shown in the FIG. **8**.

A "safe-set" position is attained when the timing scroll disc **86** is turned to the extreme counterclockwise position (i.e., setting shaft in extreme clockwise position). This places the follower pin **104** at the "safe-set" position **140** where it is trapped and further movement of the follower pin **104** is not possible. The "safe" indicator flag will appear in the fuze window. The "safe-set" position prevents the firing arm shaft **100** from rotating and actuating the firing pin **114** and arming the delay rotor release mechanism **30**.

The PD settable position is next after the "safe-set" position (turning the setting shaft counterclockwise) that will enable the fuze to function by PD only. The position is shown at **148** in the FIG. **8**. It will remain in this position and, if the clock continues to run, it seats against the shoulder **149** and stops the clock. The follower **104** will travel in the timing scroll disc until it reaches arming delay rotor release cam surface **142**. The firing pin **114** is not released. This setting is indicated by the "PD" on indicator flag appearing in the fuze window. Upon experiencing the proper fuze environment (i.e., setback and spin), the arming rotor **122** is released and the detonator **124** is oriented to the "in-line" position. The detonator will then be fired by point detonation only.

The particular advantages of the PD element include providing a faster means of explosive detonation than is provided by the more usual blast or flash tube elements; providing a safer means of causing rapid explosive detonation than is provided by either an explosive pellet firing into a conventional blast tube or by a continuous explosive column of conventional size. The PD element could be fired readily by deforming the nose of the fuze as by dropping a fuzed shell on its nose. However, the explosive output of the entire PD element would be entirely contained within even the lightest fuze structure and would not be transmitted to the next element which would be out-of-line under such conditions; and, providing a relatively very compact and simple means of transmitting detonation through and around a mechanism without requiring extensive structural elements.

On setting for maximum time, the scroll disc **86** is rotated so that the follower pin **104** is at the inner end of the spiral at **150**. The preferred maximum time is 200 sec. When a firing environment is obtained (such as being fired out of a gun), the clock starts to run and the scroll rotates at a prescribed rate to reach the arming delay rotor release cam surface **141**. Rotation continues to the firing pin release position at which the follower **104** drops through opening **144** and releases the firing pin **114**. This hits the detonator **124** in the rotor assembly **122** and initiates an explosive lead **132**.

The T = "O" release position corresponds to the point at which the scroll follower pin **104** leaves the time scroll disc contour at **144**. With scroll follower pin motion unrestricted, the firing arm shaft **100** is free to rotate and actuate the firing pin release mechanism.

Intermediately, the 0.3 to 200 seconds positions are settable scroll follower pin positions on the timing scroll disc **86** that correspond to a delay time prior to firing pin mechanism actuation (i.e., T = "O"). These scroll plate pin positions will correspond to the appropriate digital counter settings which are observed in the fuze window. As the timing movement operates, the timing scroll disc **86** turns and the scroll follower pin **104** travels toward the T = "O" release position **144**. Any time setting from 0.3 seconds to 200 seconds can be made. The minimum time setting requirement (i.e., 0.3 seconds) assures that the minimum fuze set time for firing pin actuation delay will be greater than the fastest expected arming time of the rotor, thereby preventing a "dud" from occurring by having the firing pin released before the detonator **124** is "in-line."

When the scroll follower pin reaches the arming delay rotor release cam surface **141** on the timing scroll disc in its travel from a time setting to T = "O" release, the arming rotor **122** of the boresafe device **32** is released by the arming delay rotor release mechanism **30**. This cam surface allows the scroll follower pin to move out radially on the timing scroll disc **86**, allowing sufficient rotation of the firing arm shaft to actuate the arming delay rotor release mechanism.

To operate the digital counter assembly **26**, the setting key is rotated causing the pin **57** with its pring **59** to automatically pick up the flag **56**. When the fuze is set for delivery, the setting key **36** is rotated clockwise turning the digital counter below 0.00 time. Continued rotation below 0.00 time shows first the flag **56** at its PD position. Further rotation will bring the "safe" position into view.

The time setting feature for the fuze **20** provides a time-delay period before the arming delay rotor is actuated. Fuze setting is accomplished by mating a setting tool into the nose-portion of the fuze, engaging the setting key **36** and turning in a counterclockwise direction from the safe set position (manually or automatically). The time set into the fuze is read from the three digital counter wheels that are seen through the fuze window. Settings are read on the wheel **52** in seconds (numbered), tenths of a second (graduations) and hundreths of a second, estimated as fractions of a graduation. The wheel **50** indicates tens of seconds and the wheel **48** indicates hundreds of seconds. Thus, the range 0 to 200 seconds is obtained. This obviously could be varied to any range desired. As the digital counter is set, the entire timing mechanism module,

which includes the timing scroll disc **88**, is turned clockwise. One turn of the timing mechanism module (corresponding to 50 seconds running time), requires five turns of the setting shaft (a 5:1 ratio). As the timing scroll disc of the timing mechanism module turns clockwise, the scroll follower pin **104** travels inwardly along the spiral path **88** (i.e., the scroll follower revolves counterclockwise). Upon experiencing the proper fuze environment (i.e., setback and spin), the timing movement is allowed to function, the setback pin **109** moves clear of the safety lever **102**. The follower pin **104** is enabled to move to the surface **141** on the spiral disc **86**. This releases the rotor detent release lever **96**, and the release pin **118** travels with it. This then releases the rotor detent assembly **120** which in turn releases the arming delay rotor **122**. The timing scroll disc **88** continues to rotate until the scroll follower pin is free of the timing scroll disc, and passes through the slot **144**. The firing arm shaft **100** rotates and actuates the firing pin release lever **94** to release the firing pin **114**. This initiates the explosive train to explode the projectile.

The fuze is capable of functioning by Point Detonation (PD) under two conditions: (1) when the fuze **20** is fired in the PD set position after the rotor arming time has elapsed, and 2) when fired with a time setting, after the scroll follower pin has traveled beyond the arming delay rotor release cam surface **141** for a period of time equal to the rotor arming time. Both conditions will assure that the rotor of the boresafe arming delay module **32** is armed and can be fired by PD. PD is accomplished by initiation of the arming delay rotor detonator **124** by the explosive output of a mild-detonating fuze (MDF) **136** in lieu of the timing movement-actuated firing pin. The MDF is initiated by a special impact-sensitive primer **134** at the nose of the fuze, above the digital counter, when impact occurs. The setting key acts as the firing pin for the primer.

The fuze **20** incorporates redundant safety features to assure handling and bore safety. Bore safety is achieved by having the arming delay rotor detented (at **120** and **126**) to keep the detonator **124** in the "out-of-line" (unarmed) position with respect to the explosive lead **132**. Upon firing a properly set fuze, setback and spin detents **109** and **112** are released, and after a time, determined by the fuze setting, the arming delay rotor **122** will be released. (Other detents similar to **109** and **112** are in the timing mechanism **80** and are not shown). When released, the rotor **122** will rotate the detonator **124** to the "in-line" (i.e., armed) position in a finite period of time. The rotor will start to arm immediately. The arming delay feature eliminates the possibility of premature explosive train initiation by handling or in the gun bore.

Handling safety is provided by the "safe-set" position on the timing scroll disc **86** and by a variety of spin and setback detents in the various fuze modules. By keeping the fuze set to the "safe-set" position the scroll follower pin **104** is constrained on the timing scroll disc at **140**, thus preventing the firing pin and delay arming rotor mechanisms from actuating. (See FIG. **8**.)

Referring to the FIGS. **10** and **11**, another form of setting key construction is provided. In this form the setting key **36'** is provided with the V-shaped prongs (not shown) which fit into the slots **152** of the clutch assembly plate **154**. The spring discs **156** apply pressure for the clutch assembly to frictionally seat on the reduced neck portion **158** of the shaft **44**. The threaded extension **160** of the shaft **44** receives the lock nut **162**. The body portion **164** of the clutch assembly is keyed directly to the reduced neck portion **158** of the indicator pin portion **166**. This pin portion provides the function of the similar pin **57**. When the setting key **36'** has been rotated so as to turn the scroll member **86** in the maximum time position **150**, or in the safe-set position **140**, the clutch will slip at a present value to prevent breaking through the shaft **44**. This is a valuable safeguard in manual fuze setting. However, this safety feature is even more important with the use of automatic setting means, for the rapid acceleration will not be fatal to the structure, since the slip clutch will prevent breaking. It should be noted that thus the setting key **36'** not only serves to apply torque, but also provides PD firing for the fuze **20**. The prongs (not shown) of the setting key, by impact force, are driven into the primer **136**, and due to its firing pin shape, explodes the primer mix.

The substitution of certain equivalent elements for those selected, or the deletion of certain features, or repackaging inside another envelope shape would be within the scope of the conception. Examples of such changes would include the use of a sliding scale setting readout in place of the digital counter provided; the reduction of the four-turn timing and setting mechanism to one or more turns, or an equivalent increase of turns either with or without a change in a 50 -second setting time per turn; the provision of a winding-setting arrangement such that greater time settings would cause increased winding of the driving mainspring; the elimination of the arming-delay to timing-module interlock so that the resulting fuze would always start to arm immediately upon exit from the gun muzzle; the elimination of the PD option or employment of an independent inertial impact - detonating element in addition to, or in place of, the described direct acting PD element; the elimination or duplication of either of the interlocked setback-released or centrifugally released detent elements in either timing module or the arming and firing trigger module; or the elimination of the delaying gear train from the boresafe module; or substitution of an equivalent mechanism; or elimination of the boresafe module entirely.

We claim:

1. A fuze comprising:
- a digital counter setting module;
- a timing mechanism module;
  - said timing mechanism module including a time measuring member;
- means in said digital counter setting module engaging said timing mechanism module, to set the fuze for a preselected arming position;
- an arming and firing trigger module;
- said last named module including means engaging said time measuring member;
- a boresafe arming delay module engaging said arming and firing module;
- detonating means;
- a housing retaining said fuse modules; and
- said housing including a window whereby the setting of the digital counter setting module is visible.

2. A fuze for an artillery type shell able to withstand setback up to 30,000 g.'s and spin up to 30,000 revolutions, said fuze consisting of:
- a digital counter setting module, said digital counter module including shaft means;
- a flag member adjustably retained on said shaft means;
- digital counter means mounted on said shaft means;
- a setting gear housing retaining said digital counter module;
- said shaft extending therein;
- a first gear means affixed to the said extended shaft means gear means in said setting gear housing meshing with said first-named gear means;
- timing means extending through said setting gear housing and into said shaft means;
- an arming and firing trigger module operatively engaging said timing means;
- a firing pin in said arming and firing trigger module;
- an arming delay module operative with said arming and firing trigger module; and
- an explosive train including detonator means retained by said digital counter module and engaging said arming and firing trigger module.

3. The combination of claim **2** wherein said detonator means includes:
- a toroidal ring seated on said digital counter module;
- an annular groove in said ring to retain a primer mix; and
- lead means extending from said ring to said arming delay module, whereby a firing trigger module pin may stab an explosive.

4. The combination of claim 2 wherein the timing means includes:

a timing scroll disc member;

said timing scroll disc member having a spiral groove and said arming and firing trigger module includes a scroll follower pin;

said scroll follower pin riding in said spiral groove, whereby the detonator means is actuated when the follower pin has completed its path of travel in the spiral groove.

5. The combination of claim 4 wherein said timing scroll disc member includes a safe-set position and a point delay and arming delay release position.

6. The combination of claim 2 wherein the timing means includes:

a timing scroll disc member containing a spiral groove therein;

said arming and firing trigger module including a pin follower movable in said spiral groove;

firing pin release means retained in said firing trigger module; and

detent means in said firing pin release means to selectively release said firing pin release means.

7. The combination of claim 2 wherein said arming and firing trigger module includes:

a firing arm shaft operative with said timing means;

a firing pin;

detent release means on said firing arm shaft restraining said firing pin; and

firing arm means engaging said timing means whereby the firing pin is released after a predetermined period of time.

8. The structure of claim 7 wherein said firing arm means includes:

a scroll follower pin;

said timing means includes a timing scroll disc set for a preselected time of travel; and

said scroll follower pin riding on the surface of said timing scroll disc.

9. The combination of claim 8, wherein:

said detent release means comprises a firing pin release lever;

a first slot in said firing arm shaft restraining said firing pin release lever; and

a second slot controlling said arming delay module having an arming delay rotor.

10. The combination of claim 9, wherein said firing arm shaft includes a setback spin detent comprising:

a safety lever;

a setback pin restraining said safety lever; and

whereby release of said arming delay rotor and firing pin is restrained to insure safe handling of the fuze.

11. The combination of claim 2, wherein:

said arming and firing trigger module includes a firing pin and a rotor detent release lever;

said arming delay module comprises an eccentric rotor;

stab detonator means in said rotor;

said detonator means normally being with said firing pin; and

means actuating said eccentric rotor to rotate said detonator into line with said firing pin whereby said detonator actuates an explosive charge.

12. The structure of claim 11, wherein said actuating means comprises:

detent locks in said arming delay module retaining said rotor out-of-line with said firing pin;

said rotor detent release lever engaging said detent means to hold the rotor in position; and

escapement means in said arming delay module actuating said eccentric rotor in accordance with the spin rate of the fuze to arm the missile.

13. The combination of claim 12, wherein said timing means includes:

a timing disc scroll member having a spiral groove, and scroll follower means on said arming and firing trigger module riding in said spiral groove; and

the position of the timing disc scroll permitting the detent locks to release so that the rotor may operate to bring the detonator into line with the firing pin.

14. The combination of claim 2, wherein said explosive train means includes:

a ring primer retained on said digital counter setting module;

a detonator; and

a dual purpose lead actionable by said detonator, and mild detonating paths engaging said ring primer and said detonator whereby an explosive path to said dual purpose lead is provided.

15. In a fuze having a timing mechanism counter mechanism and firing mean:

a digital counter setting module providing preselected positions for the fuze, said counter setting module having counter wheels operatively arranged to provide time settings for the fuze;

a point detonator and safe-set flag member;

a setting shaft extending through said digital counter setting module in operative engagement with said counter wheels and said flag member, said setting shaft actuating said firing means; and

key means engaging said setting shaft to set the preselected positions for the fuze.