United States Patent

Krupa

[15] **3,670,655**

[45] **June 20, 1972**

[54] TIMING MECHANISM

[72] Inventor: **Thomas J. Krupa**, Willingboro, N.J.

[73] Assignee: **Delaware Valley Armaments, Inc.**, Mount Laurel, N.J.

[22] Filed: **June 9, 1970**

[21] Appl. No.: **44,698**

[52] **U.S. Cl.** **102/79**, 102/83

[51] **Int. Cl.** **F42c 15/24**

[58] **Field of Search** 102/79, 80, 83, 84

[56] **References Cited**

UNITED STATES PATENTS

2,448,228	8/1948	McCaslin et al.	102/80 X
2,975,711	3/1961	Brown et al.	102/80
2,446,545	8/1948	McCaslin	102/80
3,334,589	8/1967	Simmen	102/79
2,479,851	8/1949	McCaslin	102/79

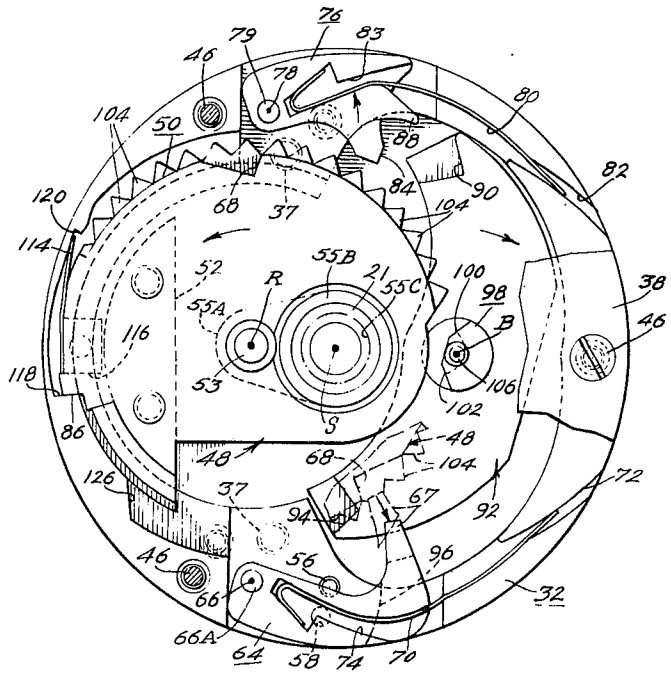
Primary Examiner—Samuel W. Engle

Attorney—Howson and Howson

[57] **ABSTRACT**

An arming-delay mechanism suitable for use in artillery shells to prevent premature arming and explosion of the shell, employing an escapement including a balance which is "unbalanced" in that its pivot axis is radially further outward than its center of gravity with respect to the spin axis about which the mechanism spins after the shell is fired. It also includes two sequentially operating centrifugal detents for preventing accidental starting of the operation of the timing mechanism prior to firing of the shell, with the balance arranged to serve as an interlock between the two detents whereby the second detent cannot be actuated to its open position until after the first detent has been actuated. Arming is produced, after spinning of the shell releases both detents in sequence, by means of a centrifugally operated rotor having escapement teeth on it, which teeth engage the balance directly rather than through a gear train. The unbalanced balance responds to centrifugal forces produced during spinning to resist motion of the rotor more strongly than a "balanced" balance of the same mass, making possible a smaller, lighter and simpler mechanism for a given amount of delay, and the sequentially operating arrangement of detents provides a high degree of safety from premature accidental arming.

9 Claims, 16 Drawing Figures



PATENTED JUN 20 1972

3,670,655

SHEET 1 OF 4

FIG. 1.

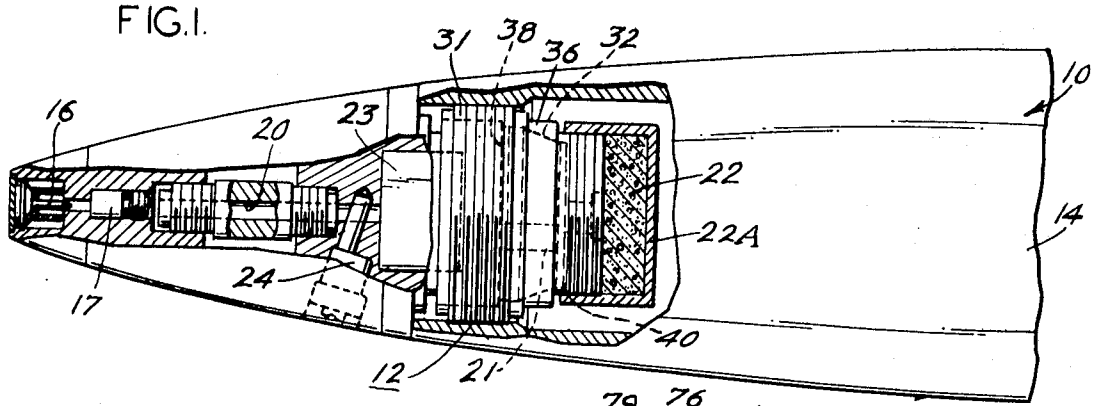


FIG. 5.

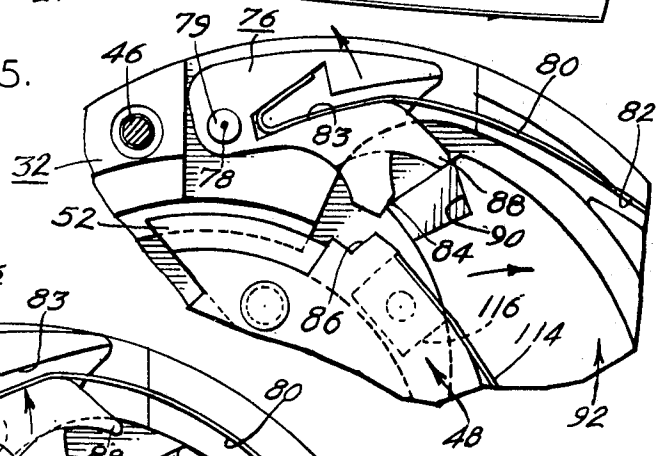
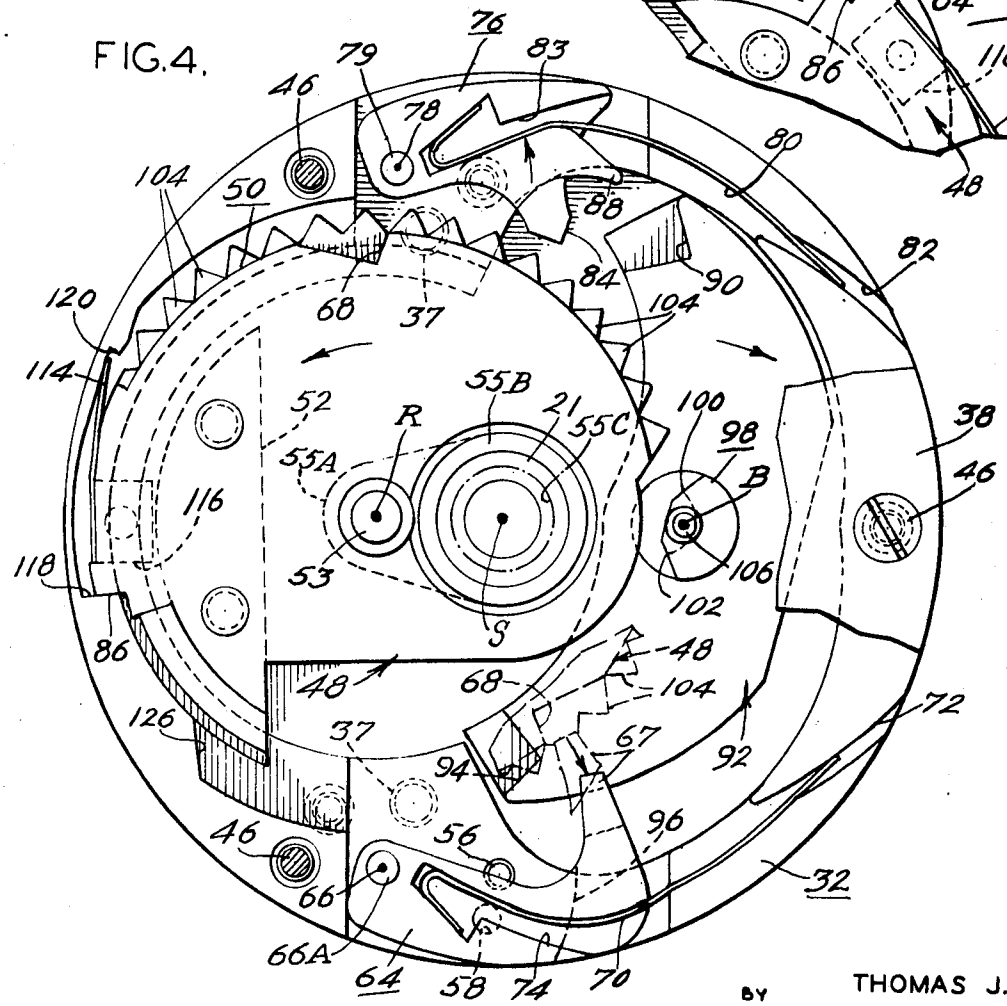


FIG. 4.



INVENTOR:
THOMAS J. KRUPA

BY Howson & Howson

ATTYS.

FIG.2.

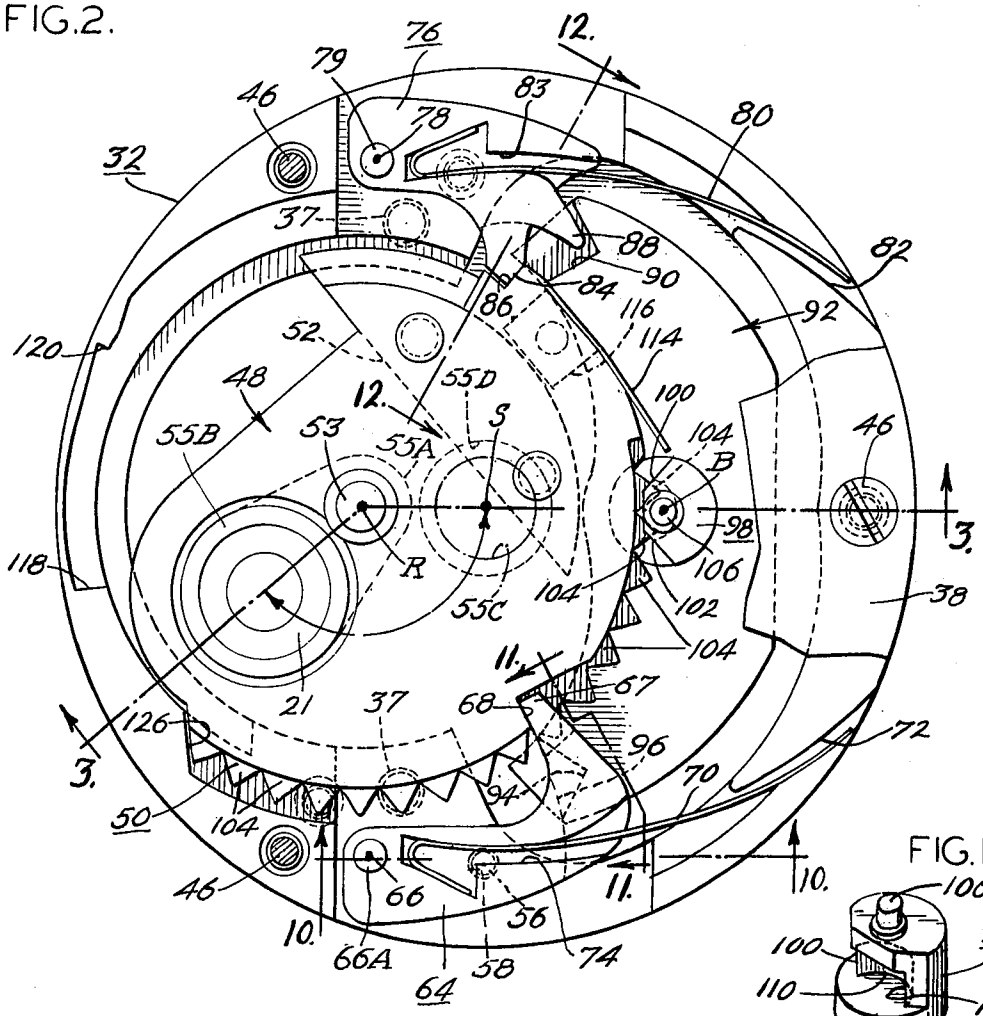
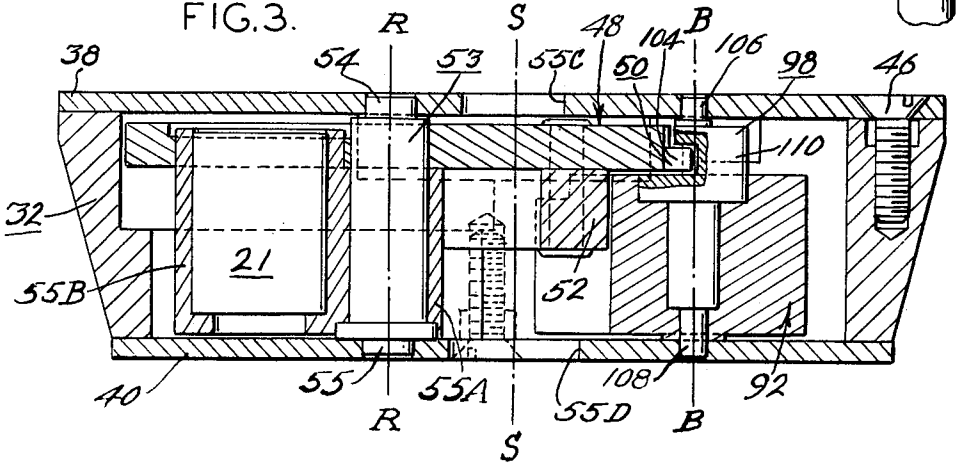


FIG.13.

FIG.3.



INVENTOR:
THOMAS J. KRUPA

BY

Howson & Howson

ATTYS.

FIG. 6.

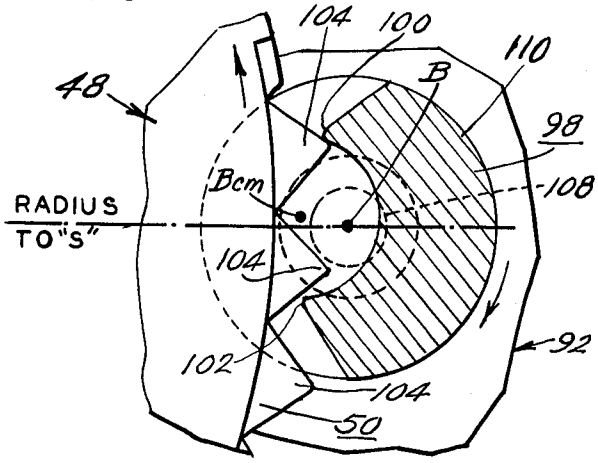


FIG. 7.

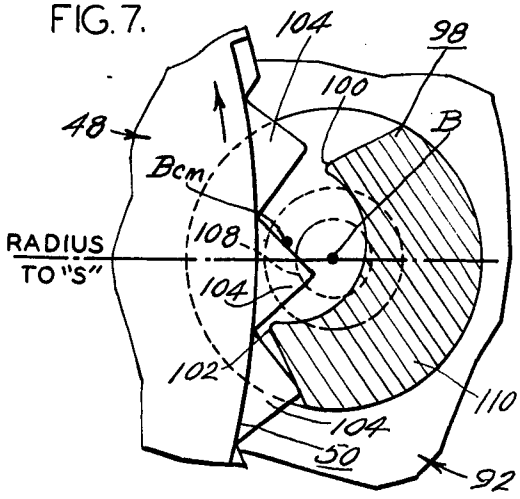


FIG. 8.

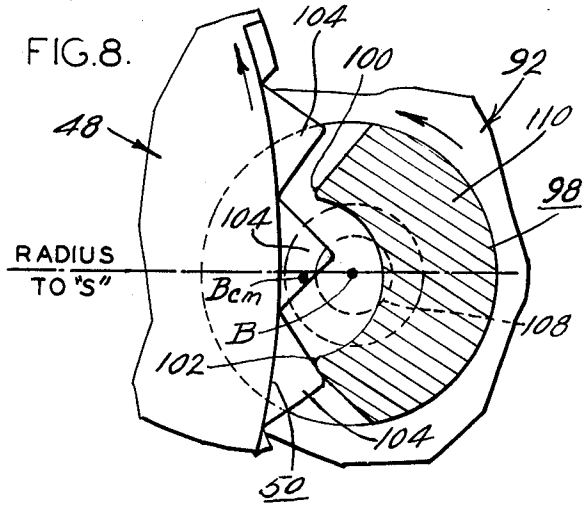


FIG. 9.

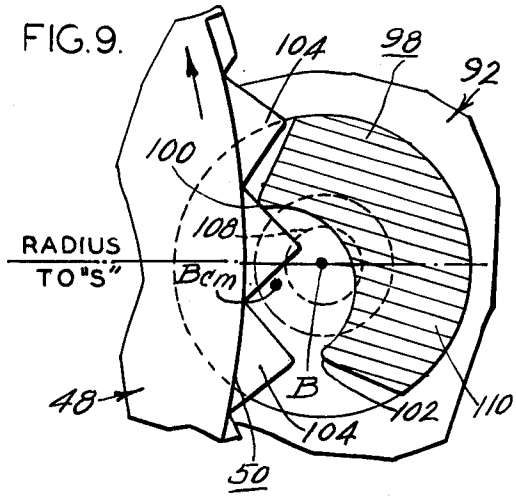


FIG. 10.

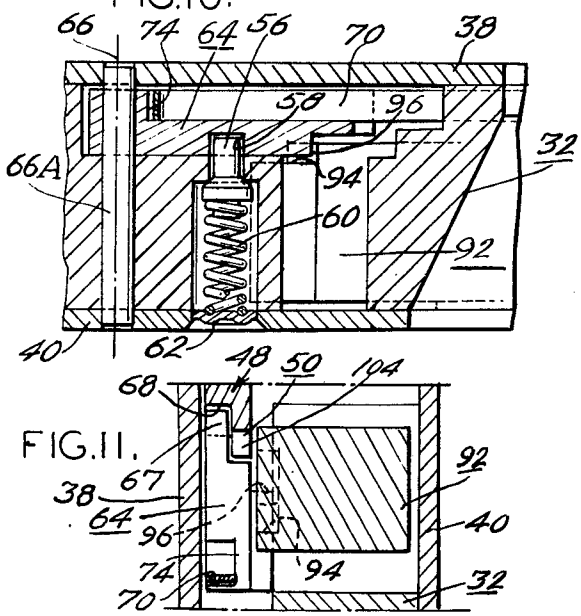
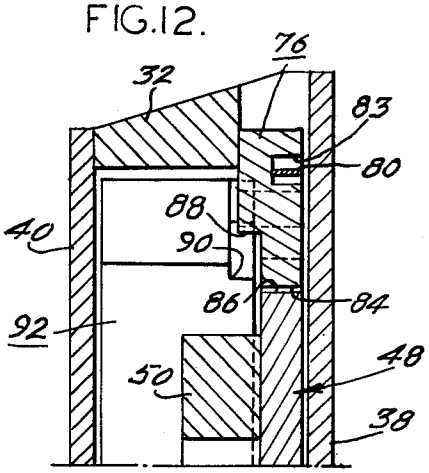


FIG. 11.

FIG. 12.

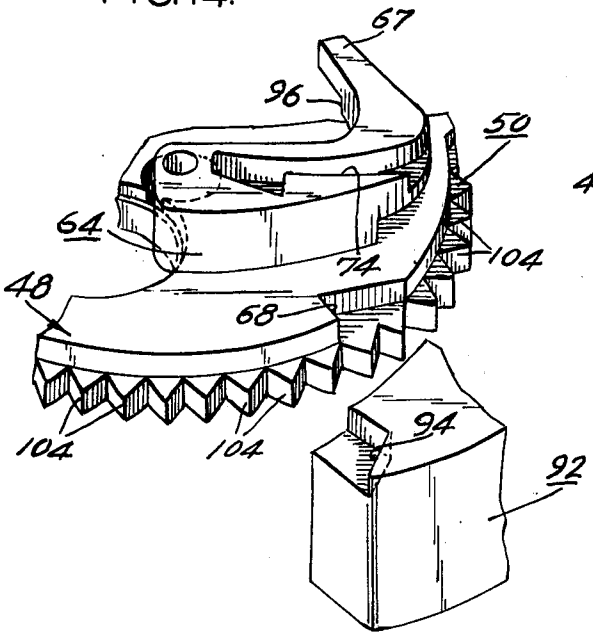


INVENTOR:
THOMAS J. KRUPA

BY
Howson & Howson

ATTYS.

FIG. 14.



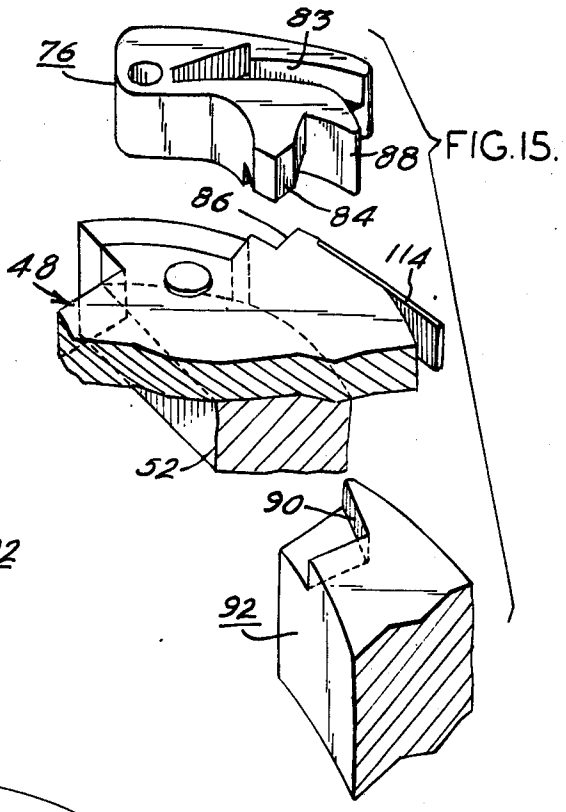


FIG. 15.

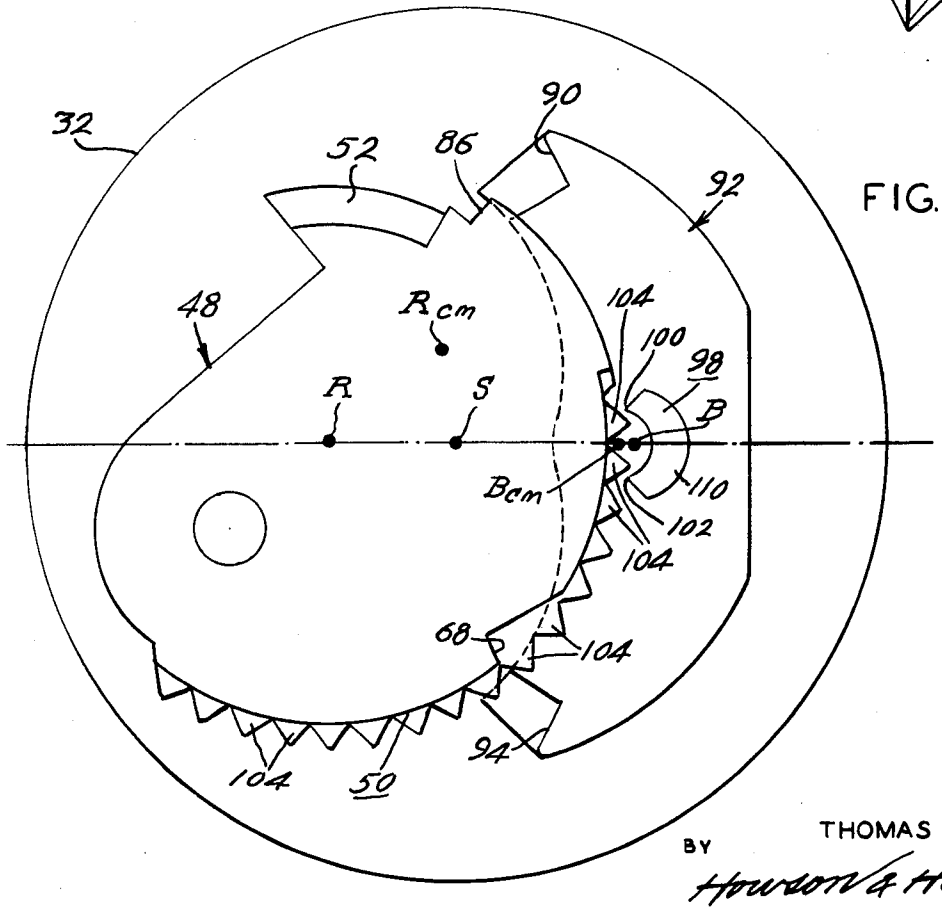


FIG. 16

INVENTOR;
THOMAS J. KRUPA

BY Howson & Howson

ATTYS.

TIMING MECHANISM

BACKGROUND OF THE INVENTION

Various timing mechanisms are known in the prior-art which are useful, for example, in preventing premature arming of an explosive shell of the type to which a spinning motion is imparted as it moves along the muzzle of the gun from which it is fired. Typically, some form of centrifugally operable detent means is employed normally to prevent motion of the mechaniam from its armed toward its unarmed condition, and which is responsive to centrifugal forces, generated by spinning of the mechanism after firing of the shell, to free the mechanism and permit it to advance toward its armed position. Typically also, the driving forces for the timing mechanism are provided by a rotor device pivoted off-center from its center of mass, and also off center from its spin axis, so that the spinning of the mechanism causes the rotor to turn after the detent arrangement releases. The rotational motion of the rotor is typically communicated through a set of gears to an escapement wheel which engages, and causes oscillation of, a balance, the inertia of the balance serving to resist rotation of the escapement wheel and of the rotor, so as to slow the advance of the rotor from its unarmed to its armed position. By such arrangements it is intended to provide a relatively long delay between a time when the gun is fired and the time when the shell becomes armed, thereby to prevent premature explosion of the shell. The copending application of Oliver J. Cheney, Ser. No. 833,007, filed June 13, 1969 and of common assignee herewith, shows and describes one known form of such timing mechanism.

It is desirable to make such a timing mechanism as small, lightweight, compact and simple as possible while reliably providing the desired delay, and at the same time to reduce the risk of premature arming of the mechanism, for example due to shocks and vibration occurring prior to firing, during handling or transportation for example. In most previously known systems it is possible for such shocks to release the detent arrangement, in which case subsequent shocks and vibration or other mechanical effects may advance the timing mechanism toward its armed condition, with resultant later premature arming of the mechanism.

Accordingly it is an object of the invention to provide a new and useful timing mechanism.

Another object is to provide such a timing mechanism which produces an increased delay time for the same size and mass balance, or the same delay time with a lighter or smaller balance.

It is also an object to provide such a timing mechanism in which intermediate gears between the rotor and the balance are eliminated.

A further object is to provide an improved detent arrangement which reduces the chance of premature undesired release of the detent arrangement.

It is also an object to provide a time-delay mechanism having a new balance arrangement providing longer delays for a given inertial moment of the balance, and at the same time operating in connection with an arrangement of plural detents to provide greater protection against premature accidental detent release.

SUMMARY OF THE INVENTION

These and other objects of the invention are achieved by the provision of a centrifugally operable timing mechanism employing balance means having a pivot axis which is further from the spin axis of the mechanism than is the center of mass of the balance means, and further comprising first and second centrifugally operable detent means for preventing operation of the timing mechanism prior to spinning of the mechanism about its spin axis together with interlock means acting between the first and second detent means to restrain the second detent means from opening until the first detent means has moved to free the mechanism. While either the unbalanced arrangement of the balance means or the construction of sequentially operating detent means may be employed to advantage by itself without the other, in a preferred form of the invention the balance means is not only unbalanced as described, whereby centrifugal forces acting on the balance means during spinning of the mechanism provide additional resistance to, and slowing of, the operation of the timing mechanism, but it is also arranged and configured to provide the desired interlock action by preventing release of the second detent means until operation of the first detent means permits the balance means to move so as then to free the second detent means. Also in the preferred embodiment, a centrifugally operable rotor with its center of mass displaced from its pivot axis is used to drive the balance means directly by means of escapement teeth on the rotor, without intervening gear means.

The above-described construction of balance means increases the time delay produced by the mechanism, other things being equal, and in practical applications makes possible reductions in the mass of the balance and/or elimination of intervening gears between rotor and balance means; the sequential detent arrangement makes the timing mechanism much less susceptible to premature undesired release, since unless the time delay mechanism is spinning as it is after firing of the shell, it would require a plurality of specially time-spaced and specially directed shocks to release the timing mechanism fully, an occurrence which is extremely unlikely.

BRIEF DESCRIPTION OF FIGURES

Other objects and features of the invention will be more readily understood from a consideration of the following detailed description taken with the accompanying drawings, in which:

FIG. 1 is a fragmentary elevational view, with parts broken away, showing one possible installation of the timing mechanism of the invention in an artillery shell;

FIG. 2 is a front view of a timing mechanism in accordance with the invention, with the usual front cover plate removed, shown in its initial unarmed condition;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a view like that of FIG. 2, but showing the time delay mechanism after it has completed its motion to its armed condition;

FIG. 5 is a fragmentary view, taken like FIGS. 2 and 4, showing a portion of the timing mechanism as the second detent means thereof is released;

FIGS. 6, 7, 8, and 9 are enlarged fragmentary views, illustrating four different relative positions of the escapement teeth with respect to the pallet arrangement of the balance means, at four different corresponding angular positions of the balance means during its oscillation;

FIGS. 10, 11 and 12 are fragmentary sectional views taken along lines 10—10, 11—11 and 12—12 of FIG. 2;

FIG. 13 is a perspective view of the pivot and pallet portions of the balance means of FIG. 2;

FIG. 14 is an exploded fragmentary perspective view illustrating some of the parts of the first detent means employed in the arrangement of FIG. 2;

FIG. 15 is a fragmentary exploded perspective view illustrating portions of the second detent means employed in the construction of FIG. 2; and

FIG. 16 is a schematic view illustrating relative positions of the centers of mass of rotor and balance, with respect to the pivot axis of the rotor and of the balance means and with respect to the spin axis of the entire mechanism, to which reference will be made in explaining the principle of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring now to the specific embodiments of the invention shown in the drawings by way of the example only, FIG. 1 illustrates an explosive shell 10 containing as a component thereof an arming delay-device 12 of a type using the ap-

paratus of the invention. The shell may be of the type comprising a main body portion 14 containing a main explosive charge intended to explode in response to impact of the firing pin 16 against the ground or similar object. Actuation of firing pin 16 by impact detonates the adjacent detonator 17 to produce an impulse which, when the system is fully armed, travels along the interior of a flash tube 20 to the front surface of the delay device 12 and through a central opening in the delay device 12 to a detonator 21, which in turn explodes to detonate a booster-charge pellet 22 and, in turn, the main explosive charge contained in the rear of the shell behind the booster cup 22A.

However, arming delay-device 12 has an unarmed condition in which the central opening through it is blocked and detonator 21 not aligned with bore 20, and contains a timing mechanism responsive to rotation of the shell to move progressively toward its armed position in which the central opening is unblocked and detonator 21 aligned with bore 20. In use, the arming delay device 12 in its unarmed condition is installed in the shell before the shell is to be used and, when the shell is fired, the rotation of the shell due to the barrel rifling causes the arming delay device to move progressively toward its armed condition and to reach the armed condition when the shell is at an appropriate distance away from the gun.

Typically the shell assembly may also comprise an auxiliary delay plunger assembly 23 which closes off communication between flash tube 20 and delay device 12 until the shell begins to rotate in the gun, at which time assembly 23 is promptly actuated centrifugally to open the path to delay device 12. Also sometimes employed is an interrupter assembly 24 which can be manually adjusted either to open the central bore from the flash tube to the assembly 23, or to divert the explosive impulse through a parallel path (not shown) thereby to introduce a further fixed delay in explosion of the shell.

In this example the timing mechanism is mounted within an outer housing 32 having three progressively stepped outer diameters, the largest diameter portion being externally threaded so as to mount the casing within the shell main body 14 by screw-threaded engagement therewith, and the smallest diameter portion being externally threaded to receive and mount the booster cup 22A. The timing delay mechanism of the invention is supported on a casing 32 positioned generally within the unthreaded casing portion 36 of intermediate diameter, by appropriate screws such as 37 securing it to housing 31. It is this timing delay mechanism which is shown in the remaining figures and which constitutes one preferred embodiment of the present invention.

Since all of the FIGS. 2–17 relate to the same example of embodiment of the invention, corresponding parts in the various Figures are designated by corresponding numerals.

Referring first particularly to FIGS. 2 and 3, showing the time delay mechanism in its completely unarmed condition as it would normally appear when placed in an explosive shell prior to firing, it will be seen that the elements of the mechanism are mounted between the cover plates 38 and 40 by means of appropriate pivots and connectors. More particularly, front cover plate 38 is held to a shoulder on a casing 32 by screws such as 46. The mechanism includes an escapement rotor 48 pivoted about an axis R and comprising a toothed escapement portion 50, a rotor weight 52 and a pivot 53 having stub shafts 54 and 55 at its opposite ends fixed in corresponding holes in the front and rear cover plates, respectively. A sleeve bearing 55A integral with the rotor surrounds the pivot 53 to permit turning of the rotor about its axis R. The detonator 21 is supported on the rear of the rotor in a closely fitting cylinder 55B also integral with the rotor. The rotor axis R is displaced radially outwardly with respect to the central spin axis S about which the mechanism spins when the shell is fired from the gun. In this example spin axis S coincides with the longitudinal axis of the cylindrical casing 32. Furthermore, and as is particularly clearly shown in FIG. 16, the center of mass R_{cm} of the rotor is displaced from its pivot axis R and, in the initial unarmed condition of the mechanism shown in FIGS. 2 and 16, is positioned other than directly radially outward from the pivot axis R with respect to spin axis S, so that when spinning of the mechanism occurs the centrifugal forces operating urge the center of mass of the rotor from its initial position toward the position in which it is radially outwardmost with respect to the spin axis, i.e. toward a position on a straight line through the spin axis S and the rotor axis R. Such spinning of the entire timing mechanism therefore causes the rotor 48, when released, to rotate in the counterclockwise direction as viewed in FIGS. 2 and 16, toward the armed position shown in FIG. 4 in which detonator 21 is aligned with the spin axis S and with openings 55C and 55D in the front and rear cover plates, respectively.

Initially such rotation of the rotor 48 is prevented by several mechanisms. The first of these is a set-back arrangement, shown particularly clearly in FIG. 10, comprising a set-back pin 56 spring urged into a corresponding recess 58 in the underside of a detent arm 64 by means of a spring 60 acting between pin 56 and a spring washer 62 secured in the rear cover plate 40. When the shell is fired, the forward motion of the shell and the inertia of the pin 56 cause the pin to be pulled backward, out of its recess, thus freeing the detent arm from the set-back mechanism. As will presently be explained, this permits later operation of the detent arm 64 in response to centrifugal forces. Such set-back arrangements are well known in the prior art and need not be described further herein.

Also initially restraining rotational motion of rotor 48 is a first detent means which include the above-mentioned detent arm 64 pivoted about an axis 66 parallel to the spin axis S by means of a pivot 66A on a wall of the casing 32. The shape of this detent arm 60 is shown particularly clearly in the exploded perspective view of FIG. 14. The tip 67 of the detent arm 64 extends radially inwardly of the rotor, adjacent the shoulder 68 formed by a notch in the edge of the rotor, and is normally so held by means of the flat-spring 70, one end of which is secured in a slot 72 in the casing 32 and the other hooked end of which is retained in a slot 74 in the detent arm 64. Detent arm 64 is so shaped and pivoted, and the flat-spring 70 so configured and mounted, that the spinning of the timing mechanism which occurs immediately after firing of the shell produces centrifugal forces on detent arm 64, whose center of mass is off axis from its pivot axis 66, such that the latter arm rotates outwardly to the position thereof shown in FIG. 4, where the tip 67 of the detent arm no longer restrains the rotor 48 and instead frees it for subsequent rotation.

Also employed initially to restrain rotation of the rotor 48 are second detent means comprising detent arm 76, shown particularly clearly in the perspective view of FIG. 15, pivoted about a pivot axis 78 extending parallel to spin axis S by means of a pivot 79 on the wall of the casing 32. Detent arm 76 is biased radially inwardly by means of the flat spring 80 held at one end within a slot 82 in casing 32, and having an opposite hooked end held in a corresponding slot 83 in arm 76. The tip 84 of detent arm 76 then abuts the shoulder 86 on the rim of rotor 48 to prevent it from executing its counterclockwise rotation. When the entire timing delay mechanism is spun about spin axis S, the detent arm 76, which is pivoted off axis from its center of mass, is centrifugally urged outwardly toward the position shown in FIG. 4. However, initially detent arm 76, is also prevented from rotating outwardly to free the rotor 48 by a projection 88 integral with detent arm 76, which encounters a shoulder 90 at one end of balance 92 when the detent arm 76 attempts to rotate outwardly while the balance is in the position shown in FIG. 2. As will be described more fully hereinafter, before said spinning begins, the balance 92 is held in the position shown in FIG. 2 by a shoulder 94 formed by a notch at the opposite end of the balance, which bears against a corresponding downwardly extending shoulder 96 on detent arm 64.

The balance **92** includes an integral pivot arrangement **98** shown in perspective in FIG. **13**, on which are provided a pair of pallet horns **100** and **102** which are engaged by the successive teeth such as **104** on the edge of rotor **48** when the rotor rotates, thereby to produce an oscillatory back-and-forth motion of balance **92** about the balance axis B. The pivot portion **98** of the balance includes a front pivot pin **106** and a rear pivot pin **108**, pivoted respectively in corresponding recesses in the front and rear cover plates **38** and **40**. The large, generally crescent-shaped mass of metal **110** constitutes the main balance weight. It is so configured and arranged that the center of mass B_{cm} of the entire balance means, including the balance weight portion and the pivot and pallet portions, is positioned radially inwardly toward the spin axis S with respect to the pivot axis B of the balance means, as shown particularly clearly in FIG. **16**. As will be explained more fully hereinafter, the effect of this arrangement is that, whenever in the oscillatory motion of the balance of center of mass departs from radial alingment with the pivot axis B of the balance and the spin axis, the spinning of the timing mechanism produces centrifugal forces tending to rotate the balance means farther from its initial position of alignment, and this is taken advantage of in the present invention to enhance the slowing effect which the balance has on rotation of the rotor **48**.

Also included on the rotor **38** in this embodiment of the invention is the ratchet flat spring **114** extending generally tangent to the edge of the rotor, but having a folded-under tab **116** extending under the rotor for securing the spring to the rotor in the position shown. When the rotor has turned to its armed position as shown in FIG. **4**, the shoulder **86** thereon is stopped by a corresponding shoulder **118** formed on the interior circumference of the casing **32**; at this point the free end of the ratchet flat spring **114** has just passed the shoulder **120**, also formed on the interior surface of the casing **32**, so that the rotor is thereafter prevented from springing back rotationally in a clockwise direction by abutment of the free end of the flat spring **114** against shoulder **120**.

In one use of the timing mechanism of the invention, it is placed in the unarmed condition illustrated in FIG. **2**, with the set-back pin and detent arms in their restraining positions to prevent rotation of the rotor. Under these conditions the balance means **92** is held in an initial position in which it and the pallet horns **100** and **102** are disposed substantially symmetrically about a radius from the spin axis S, as shown in FIG. **2**. The pallet horns **100** and **102** then just bridge the tips of the first two of the teeth **104** on the edge of the rotor **48**. This position of the rotor is established by a shoulder **126** on the interior of casing **32**, which engages the trailing edge of the last of the teeth **104**, and maintained by the two detent arms **64** and **76**. When in this condition, for the rotor **48** to be freed and possibly advanced toward the armed position, it would be necessary to encounter shock and vibration of a form which would draw the set-back pin **56** from the recess in the detent arm **64**, simultaneously to jar the first detent arm **64** outwardly to free it from the rotor, cause the balance means **92** to rotate sufficiently clockwise to release the second detent arm **76**, and thereafter provide a form of shock to move the second detent so it can move to free rotor **48** therefrom, these conditions being maintained simultaneously while a force also occurs to effect a rotation of the rotor **48**. The possibilities of this occurring by chance are extremely remote, particularly since a shock to be effective in releasing the second detent arm **76** must occur while the first detent arm is free of the rotor. Accordingly a high degree of safety is provided with respect to possible motion of the rotor toward an armed position in response to shock or vibration.

When the shell containing the timing mechanism is fired, the shell and timing mechanism are accelerated longitudinally and spun about the spin axis S by rifling on the interior of the gun barrel. Very early in this motion, any of the auxiliary centrifugally operable safety devices mentioned with respect to FIG. **1** are operated, the set-back pin **56** is retracted to release the detent arm **64** from it, and the first detent arm **64** is rotated outwardly to the position shown in FIG. **4** by centrifugal forces acting against the flat spring **70**. When this occurs, the rotor **48** begins to rotate counterclockwise and the first tooth thereon acts against pallet horn **100** to turn the balance means **92** slightly clockwise to the position illustrated in FIG. **5**, permitting the second detent arm **76** to respond to centrifugal forces and move outwardly through the position shown in FIG. **5** to the position shown in FIG. **4**, whereafter the rotor **48** is free to rotate except for the resisting effects of oscillation of the balance means **92**.

FIG. **6** illustrates successive relative positions of the escapement teeth **104** and the pallet horns **100** and **102** during this first rotational motion of rotor **48**. As mentioned previously, in this example the horns are spaced about 1 ½ times the distance between the peaks of the teeth **104** so as to bridge the peaks of two adjacent teeth, although other horn spacings may be used instead. At the point in the cycle shown in FIG. **6**, the center of mass of the entire balance means has been moved away from a radius through balance pivot axis B, and centrifugal forces are therefore urging the balance means in a clockwise direction. However, shortly after the peak of the first tooth passes beyond pallet horn **100**, pallet horn **102** encounters the leading edge of the third tooth, thereby arresting further clockwise angular rotation of the balance means. While under this momentary condition the centrifugal forces acting on the balance means tend to accelerate the rotor **48**, this condition lasts only briefly, since very shortly thereafter the peak of the third escapement tooth forces the balance means to rotate counterclockwise to the position shown in FIG. **8**, against the torque produced by centrifugal forces acting on the center of mass of the balance means. Accordingly, during this phase of operation, the centrifugal forces acting on the balance means exert strong retarding torques on the rotor **48**, slowing its movement accordingly. This continues until the balance has turned sufficiently counter-clockwise so that the center of mass is now on the opposite side of a radius through the balance pivot axis B, and shortly thereafter the horn **100** falls against the leading edge of the second escapement tooth and, again by camming action, the balance means is forced by that tooth to rotate clockwise against centrifugal forces acting on the center of mass of the balance as illustrated in FIG. **9**.

The net effect of this arrangement is that the rotary motion of the rotor is resisted not only by the inertia of the balance as it is accelerated during its oscillatory motion, but is further resisted by torques exerted on the rotor by the pallet horns in response to centrifugal forces acting on the center of mass of the balance during portions of its cycle of oscillation due to displacement of said center of mass from the pivot axis of the balance. This results in a substantial increase in the slowing effect on the rotor obtainable with a given mass and inertial moment of balance, and in practical arrangements has been found also to make possible the elimination of the usual intermediate gear train which has sometimes been used in an effort further to slow the motion of the rotor. Accordingly, an arming delay of sufficient duration is provided in this relatively simple, compact and lightweight timing mechanism to permit the fuse to become armed only when the shell is well away from the gun, as desired.

This motion of the rotor and the oscillation of the balance means continues until all the escapement teeth have passed through the horns, after which the rotor drops free for the remaining angular travel until the detonator **21** is aligned with the spin axis and with the openings in the front and rear cover plates of the timing mechanism, i.e. until the armed state is attained. As mentioned previously, at this time the free end of the ratchet flat spring **114** has passed the shoulder **120**, preventing any substantial back-lash or counterclockwise motion of the rotor after it is arrested by striking the stopping shoulder **118**, thereby to assure that the rotor remains in the angular position corresponding to arming.

While in the interest of definiteness the invention has been described with particular reference to specific forms thereof, it will be understood that it can be embodied in a variety of

forms differing substantially from those specifically shown and described, without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. In a centrifugally operable arming delay mechanism comprising a centrifugally operable rotor rotatable between an initial unarmed position and a final armed position in response to spinning of said mechanism about an axis therein, and first centrifugally operable detent means for preventing rotation of said rotor prior to said spinning but responsive to said spinning to move so as to free said rotor therefrom, the improvement comprising:

second centrifugally operable detent means for preventing rotation of said rotor prior to said spinning but responsive to said spinning, when released, to move so as to free said rotor therefrom; and

interlock means acting between said first and second detent means for restraining said second detent means until said first detent means has moved to free said rotor therefrom, and for releasing said second detent means in response to said moving of said first detent means, thereby to permit subsequent freeing of said rotor from said second detend means.

2. Apparatus in accordance with claim 1, in which said interlock means comprises balance means responsive to rotation of said rotor to oscillate about a pivot axis therein thereby to slow said rotation of said rotor, said balance means extending between said first and second detent means and configured and held by said first detent means prior to said spinning to restrain said second detent means from moving so as to free said rotor from said second detent means, said moving of said first detent means to free said rotor therefrom permitting said balance means to move in response to said rotor thereby permitting said second detent means to move so as to free said rotor therefrom.

3. Apparatus in accordance with claim 2, in which said pivot axis of said balance means is farther from said axis of spinning than is the center of mass of said balance means.

4. In a centrifugally operable arming delay mechanism for a projectile which spins about a predetermined spin axis therein after firing of the projectile, and comprising a pivoted balance, a rotor pivoted off-center from its center of mass and from said spin axis so as to rotate, when free, in response to centrifugal forces generated by such spinning of said projectile, toothed means connecting said rotor to said balance to cause said balance to oscillate and to slow said rotation of said rotor, and first centrifugally operable detent means having a first position in which it normally blocks said rotation of said rotor and a second position to which it is operable in response to said spinning in which said rotor is freed of said first detent means, the improvement in accordance with which:

said mechanism comprises second centrifugally operable detent means having a first position in which it normally blocks said rotation of said rotor and a second position toward which it is urged by centrifugal forces during said spinning and in which said rotor is freed of said second detent means, said balance means being configured to extend between said first and second detent means and having restraining means thereon for holding said second detent means in said first position thereof despite said urging by said centrifugal forces when said balance means is in one rotational position thereof and for freeing said second detent means when said balance is in a second rotational position thereof, and releasable means for holding said balance means in said first position prior to said spinning and responsive to movement of said first detent means from said first position thereof to said second position thereof to release said releasable means and thereby permit said balance means to assume said second position thereof, whereby said spinning causes said rotor to be freed of said second detent only after said rotor has been freed from said first detent.

5. Apparatus in accordance with claim 4, in which said balance means is pivoted about an axis further from said spin axis than is the center of mass of said balance means.

6. In a centrifugally operated time-delay mechanism for a projectile of the type which spins about a predetermined axis after firing, thereby also to spin said mechanism about a spin axis in said mechanism, and comprising centrifugally operated rotor means and escapement means including a pivoted balance means for resisting and slowing the operation of said escapement means and said rotor means, the improvement according to which said balance means has a pivot axis which is further from said spin axis than is the center of mass of said balance means, whereby centrifugal forces acting on said balance means due to spinning of said mechanism about said spin axis produce a decrease in the rate of rotation of said rotor means.

7. Apparatus in accordance with claim 6, in which said escapement means comprises a plurality of teeth integral with said rotor means and said balance means comprises pallet means engaged successively by different ones of said teeth as said rotor means rotates to cause said balance means to oscillate about said pivot axis.

8. A rotation-responsive runaway-escapement time-delay mechanism, comprising:

a support rotatable about a first axis therein;

a centrifugally operable rotor pivoted about a second axis displaced from said first axis and having a center of mass displaced from said second axis, whereby rotation of said support about said first axis urges said rotor centrifugally toward an outwardmost angular position in which said center of mass is at its maximum distance from said first axis;

balance wheel teeth mechanically connected in torque-transmitting relation with said rotor so as to rotate with rotation of said rotor and so as to respond to torques applied to said teeth to accelerate or decelerate rotation of said rotor toward said outward-most position; and

balance means pivoted about a third axis and having a center of mass displaced radially inwardly from said third axis toward said first axis, said balance means comprising pallet means positioned to be engaged by successive ones of said balance wheel teeth as said rotor rotates about said second axis toward said outwardmost angular position so as to oscillate said balance means about said pivot means in response to motion of said teeth and in response to centrifugal force due to rotation of said support, thereby to slow the rotation of said rotor toward said outwardmost angular position.

9. In a centrifugally operated time-delay arming mechanism for use in an explosive shell to delay the arming of said shell until after it has been fired and has executed a predetermined number of revolutions of spin about a spin axis extending through said mechanism, said mechanism comprising:

a centrifugally operable rotor mounted to pivot about a first axis displaced from said spin axis and having a center of mass displaced from said first axis whereby spinning of said mechanism about said spin axis urges said rotor from an unarmed angular position in which said center of mass is relatively nearer said spin axis toward an armed angular position in which said center of mass is relatively farther from said spin axis; camming teeth on said rotor; and balance means mounted to pivot about a second axis displaced from said first axis and from said spin axis and positioned to oscillate back and forth about said second axis in response to engagement by successive ones of said camming teeth as said rotor moves toward said armed position;

the improvement wherein said balance means has a center of mass nearer said spin axis than is said second axis, whereby the oscillations of said balance means are opposed at least in part by centrifugal forces acting on said balance means in response to rotation of said mechanism about said spin axis.

* * * * *