Feb. 1, 1955 P. H. THOMPSON 2,700,934

CENTRIFUGAL FUZE UNLATCHED BY SETBACK

Filed Aug. 29, 1945 2 Sheets-Sheet 1

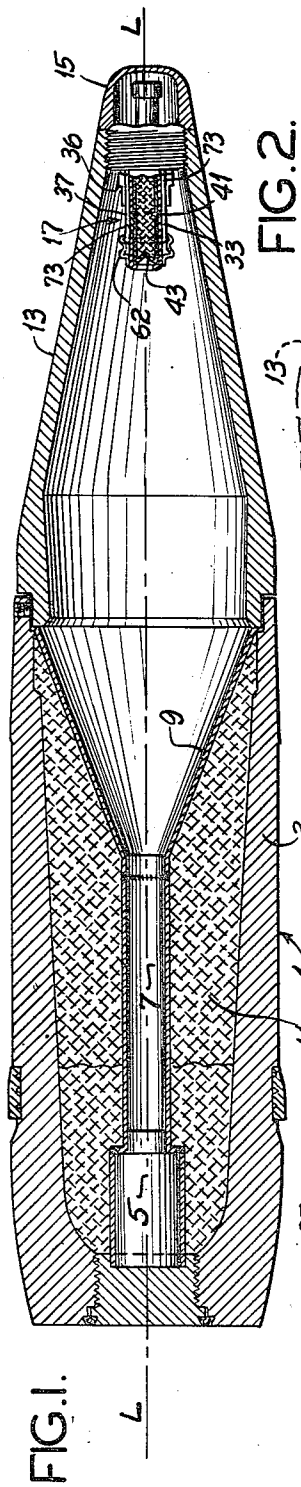

FIG. 1.

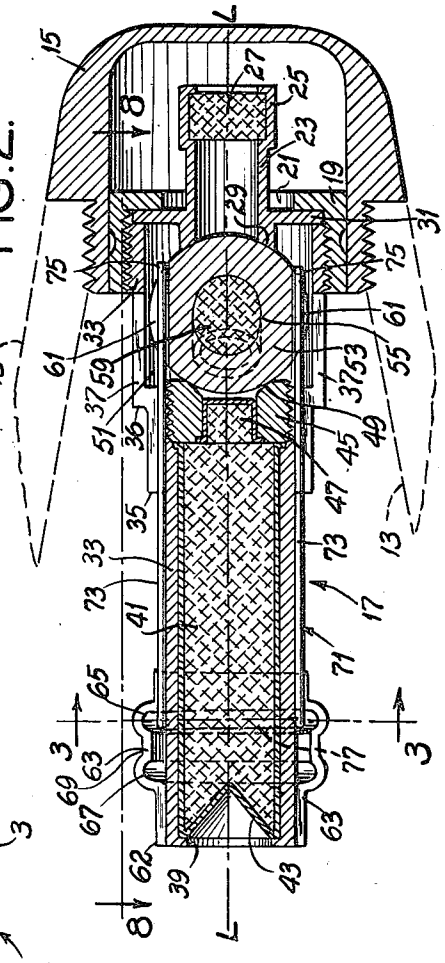

FIG. 2.

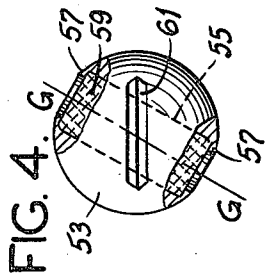

FIG. 4.

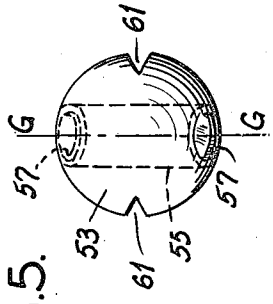

FIG. 5.

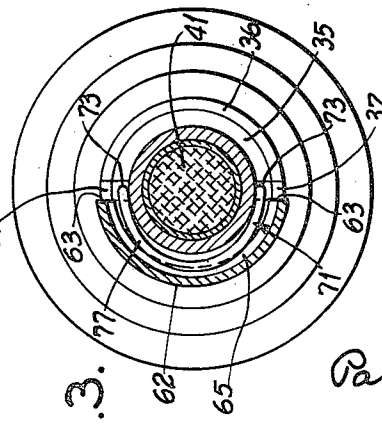

FIG. 3.

Parke H. Thompson,
Inventor.
Haynes and Koenig
Attorneys.

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CENTRIFUGAL FUZE UNLATCHED BY SETBACK

Filed Aug. 29, 1945 2 Sheets-Sheet 2

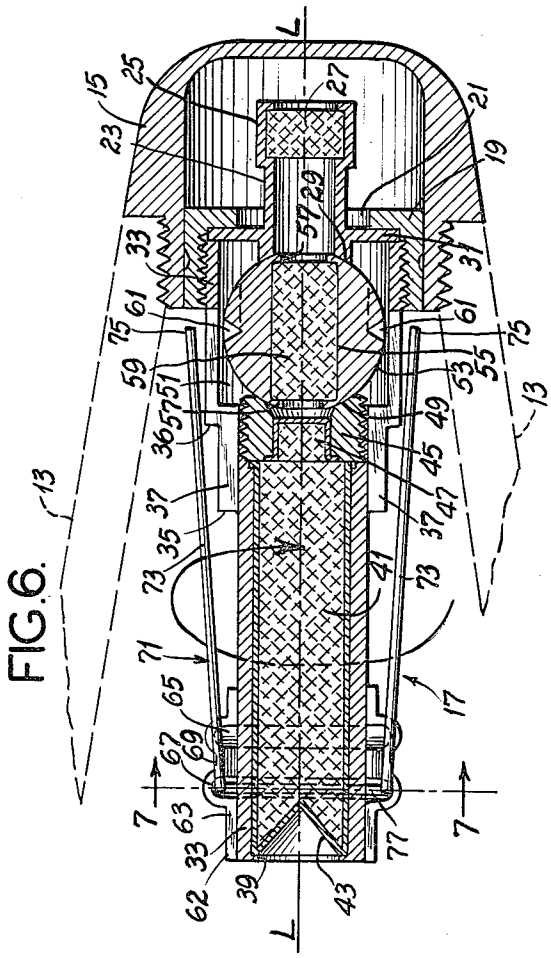

FIG. 6.

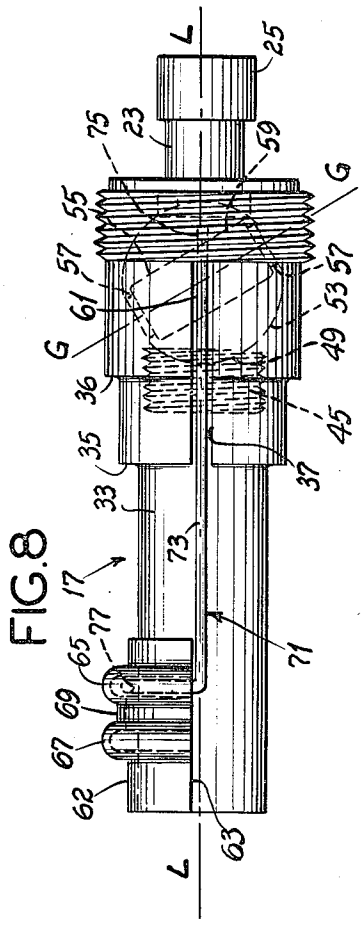

FIG. 8

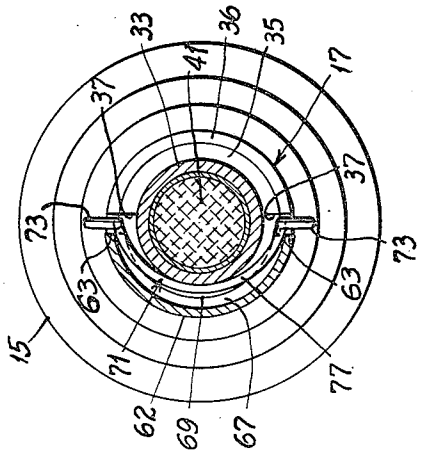

FIG. 7.

Parke H. Thompson,
Inventor.
Haynes and Koenig
Attorneys.

United States Patent Office 2,700,934 Patented Feb. 1, 1955

2,700,934

CENTRIFUGAL FUZE UNLATCHED BY SETBACK

Parke H. Thompson, Kirkwood, Mo., assignor, by mesne assignments, to Marion L. J. Lambert, doing business as Crystal-Flo Products Company, St. Louis, Mo.

Application August 29, 1945, Serial No. 613,299

9 Claims. (Cl. 102—80)

This invention relates to fuzes, and with regard to certain more specific features, to safety fuzes for projectiles and the like.

The present invention is an improvement upon the invention disclosed in my United States patent applications Serial No. 537,563, filed May 27, 1944, for Fuze, eventuated as Patent No. 2,495,431 and Serial No. 592,131, filed May 5, 1945, for Fuze, eventuated as Patent No. 2,564,797.

Among the several objects of the invention may be noted the provision of a fuze which is armed in response to combined set-back and centrifugal action; the provision of a fuze of the class described which will reliably arm at low angular velocity without making it unsafe in response to handling before loading, thus making it useful for artillery producing low angular projectile velocities, such as mortars, howitzers and the like; the provision of a fuze of this class which obtains a sensitive release with a high degree of safety by employing a relatively high ratio of spring rate to centrifugally deflected mass; and the provision of a fuze of this class, the manufacturing constants of which are easy to maintain, consistent with a high degree of accuracy and reliability in performance. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

Fig. 1 is a longitudinal section of an exemplary projectile to which the fuze may be applied;

Fig. 2 is an enlarged longitudinal section of the nose of said projectile showing details of the invention, the parts being shown in unarmed safety position;

Fig. 3 is a cross section taken on line 3—3 of Fig. 2;

Fig. 4 is a detail side elevation of a ball rotor gyroscopic element of Fig. 2;

Fig. 5 is a left side view of Fig. 4;

Fig. 6 is a view similar to Fig. 2 but showing the parts in spinning armed condition;

Fig. 7 is a cross section taken on line 7—7 of Fig. 6; and,

Fig. 8 is a plan view of the fuze in unarmed condition and removed from the ammunition, the view being observed on line 8—8 of Fig. 2.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

In prior centrifugally initiated fuzes a high rate of spin of the ammunition was depended upon for arming. This was for the purpose of excluding chance movements from arming the ammunition prior to loading for firing. For the purpose, a relatively low ratio of spring rate to centrifugally actuated mass was employed. This required rather critical manufacturing control in order to maintain accuracy. It also reduced the usefulness of said fuzes for mortars, howitzers, etc. which produce relatively low angular velocities of their projectiles. As will be seen hereinafter, the stated ends are obtained by the use of a novel set-back and centrifugally initiated fuze.

Referring now more particularly to Fig. 1, there is shown, by way of example, at numeral 1 a projectile which is exemplary of various types to which the invention may be applied. This happens to be a piece of base-detonated ammunition but it is to be understood that the invention is also applicable to point-detonated ammunition. In any event the fuze is preferably, though not necessarily, nose-initiated.

In particular, the projectile 1 consists in a shell 3 carrying at its base a booster charge 5. This charge 5 is at the rear end of a tube 7. The tube 7, together with a conical member 9 and the shell 3, defines the space for the explosive charge 11. The cone 9 so shapes the front of the charge 11 that a forwardly directed Munroe effect is obtained upon explosion of the charge. On the front of the shell 3 is a tapered nose 13. Upon the front end of this is screwed a pilot head 15 which carries the fuze per se, the latter being indicated generally at numeral 17 and shown separately in Fig. 8. When the fuze is set off, it directs explosive energy through the cone 9 and tube 7 to the base-detonating booster 5, which in turn sets off the charge 11, the latter firing forward by reason of its Munroe effect. It is to be understood that if the invention were to be applied to a point-detonating booster charge the booster 5, instead of being at the base of the shell, would be built into the tapered nose just behind the fuze. These alternatives refer only to the surroundings of the invention, which per se are in the fuze or initiator 17.

Fastened into the inside rear of the head 15 is an internally threaded cup 19 in which is an opening 21. Centered within this cup is a holder 23, a forward extension 25 of which passes through the opening 21. In the extension 25 is a primer charge 27. The rear end of this holder 23 constitutes a spherical seat 29. It has a centering flange 31 which is held in place by the threaded front end of a tubular body 33 threaded into the cup. As will appear, body 33 serves as a catch. The tubular body 33 is stepped as shown at 35 and 36 and in the region of these steps is provided with two oppositely located slits 37 (see Figs. 2, 3, 6 and 8 particularly).

The rear portion of the tubular member 33 is flanged as shown at 39 for supporting at the rear end a main initiator charge 41. The latter is hollow tapered at the rear, as shown at 43, for providing a rearwardly directed Munroe effect toward the tube 7 and cone 9 (Fig. 1). At its forward end the initiator charge 41 is held in position by a ring 45 threaded into the enlargement formed at the smallest step 35. This ring 45 also holds in place an auxiliary pellet 47 which sets off the initiator charge 41, this pellet being in the nature of a booster for the initiator charge. The forward end of the ring 45 is made in the form of a spherical seat 49. This seat is in the rear of the enlarged cylindric chamber formed by the larger step 36. At the front end of this enlargement is held said spherical seat 29. The enlarged cylindric chamber is indexed 51. In it is carried a spherical ball rotor or gyroscopic element 53. This rotor, unless locked (unarmed), is free to rotate within the seats 49 and 29. Under released (arming) conditions it may move from the unarmed position shown in Figs. 2 and 8 to the armed position shown in Fig. 6. This movement, when unlocked, is brought about gyroscopically under the spin of the shell 1, for reasons which will appear. The rotor has a diametral opening 55 flanged at its ends as shown at 57. Between the flanges 57 and in the opening 55 is carried a detonator charge 59. For the reasons given in the above-mentioned patents and in United States Patent 2,155,100, a ball rotor gyroscopic element of this type, under spinning action of the projectile on its longitudinal axis L—L, will tend to precess the gyroscopic axis G—G of the ball rotor into position parallel with said axis of spin L—L. Thus, when unlocked the gyroscopic ball rotor will move from the position shown in Figs. 2 and 8 to that shown in Fig. 6, moving anticlockwise (Fig. 8) in the process. The problem, however, is to prevent such movement to an arming position prior to firing the projectile.

In order to lock the ball rotor into the position shown in Figs. 2 and 8, it is provided on opposite sides with notches or grooves 61. These have sloping sides to make them V-shaped, as indicated, and are parallel. They are angled with respect to the gyroscopic axis G—G through the hole 55 (see Figs. 4 and 5). In the unarmed position of the rotor (Fig. 2) the notches are parallel with the

axis of spin of the projectile. This places the hole 55 and axis G—G at an angle as indicated in Figs. 2, 4 and 8 wherein, even if the primer 27 accidentally explodes, the detonator 59 will not, since the latter is out of explosive communication with the primer tube 23. The detonator only comes into explosive communication with the primer after it has been rotated from the Fig. 2 (or 8) to the Fig. 6 position. To prevent such rotation before firing, I provide at the rear of the tubular body 33 a semicircular and grooved detent sleeve 62 which is welded into position on the surface of the body 33. The edges 63 of this sleeve 62 lie substantially in a plane including sides of the slots 37 (see Fig. 8). The sleeve 62 is also formed with two spaced grooves 65 and 67 which are joined by a part 69 of smaller diameter. This part 69, however, is spaced from the tube 33 to provide a semicircular passageway.

At numeral 71 is shown a generally hairpin-shaped spring wire which has two normally parallel cantilever spring legs 73 lying on the surface of the tube 33 and in a plane passing through its axis. The normally free end portions of these cantilever legs 73 may thus be made to lie in the slots 37 (Fig. 8). Their tips 75, as shown in Figs. 2 and 8 may be made to lie beyond the forward ends of said slots 37 under conditions which will appear. Under such conditions, if the grooves 61 of the ball rotor 53 are made to lie under the slots 37, then the spring legs 73 will also lie in said grooves 61 and hold the gyroscopic ball rotor in unarmed position as shown in Figs. 2 and 8.

In order to hold the safety spring wire 71 in said safe position of Figs. 2 and 8, the rear end is formed with a half loop 77 which reaches around the tube 33 and is located in the foremost grooves 65 of the semicircular sleeve 62. The shape of the loop 77, as indicated in Fig. 3, is such that there is a detent holding action of the loop in the groove 65. However, under high enough axial or linear acceleration, as when the projectile is fired, the entire safety spring wire 71 may move backward from the Fig. 2 position. This will occur with a snap action, since the semicircular loop 77 is resilient and will pass from the foremost groove 65, under part 69 and into the rearmost groove 67. It will end up its relatively rearward travel by snapping into the groove 67 with a second detent action.

When the safety spring wire 71 is forward with its loop 77 in groove 65, its tips 75 are locked against any substantial outward travel, even under high-speed spin of the projectile. These tip portions cannot leave the grooves 61 in the ball rotor 53 and hence the latter is safely locked in its unarmed position of Figs. 2 and 8. The legs 73 are each supported at both ends like simple beams and wire 71 may then be referred to as a positive latch. However, after the spring 71 has moved back to the position shown in Fig. 6, any rotation of the projectile on its longitudinal axis L—L (due to firing) will cause the now unlocked legs 73 to become spring cantilevers which spring out from the grooves 37 as shown in Fig. 6. This releases the gyroscopic ball rotor 53 so that it may function dynamically to move from the Fig. 2 to the Fig. 6 position. This places the fuze in its armed (Fig. 6) position.

Complete operation is as follows:

Starting with the device in its safe, unarmed position such as shown in Fig. 2, it may be assumed that the projectile 1 is loaded into a suitable firing mechanism such as a gun, rocket launcher or the like. It is presumed that either the gun or the projectile, or both, incorporate means whereby the projectile is spun during flight. Upon firing, set-back forces due to linear acceleration along axis L—L immediately cause the spring latch means 17 relatively to move backward so that the loop 77 moves with snap action from groove 65 to groove 67. This is due to the inertia of member 17. These forces also hold the rotor 53 tightly against the seat 49. Thus the latch members 75 move from the catch 33.

At, about or soon after the time that the initial linear acceleration takes place, the angular acceleration sets in which causes the projectile to rotate on its longitudinal axis, thus also causing the spring latch 71 to be rotated, as well as the gyroscopic ball rotor 53. The spring latch 71 cannot lag in its rotation on the tube 33, since the edges 63 of the semicircular sleeve 62 drive the legs 73 (Fig. 7). Slots 37 also have a driving action on legs 73. Thus at a predetermined angular velocity, the legs 73 deflect out through the grooves 37 to their releasing positions shown in Fig. 6. At this time they function as spring cantilevers. After the projectile has cleared the barrel, or when so-called "creep" or set-forward forces set in, the then spinning ball rotor 53 precesses gyroscopically from its angular position of Fig. 2 to the coaxial position (Fig. 6). This arms the fuze so that when the head 15 strikes an object and collapses upon the primer 27 the latter under impact will fire into the detonator 59. Thereafter a train of explosions is set off through the materials 47, 41, 5 and 11 to explode the projectile.

From the above it will be seen that the device is quite simple. The parts are easy to manufacture in quantity. Extreme accuracy is not necessary for consistent and safe operation. The long spring legs 73 inherently have a very high spring rate with respect to their own masses which, through centrifugal action, deflect them. Thus at relatively low angular projectile velocities the masses of the legs 73 cause large deflections of the same as indicated in Fig. 6. This is what is meant above by the device having a relatively large ratio of spring rate to centrifugally operating mass. With such a construction a quick and definite release of the ball rotor is obtained at low angular velocity, without sacrificing safety before such values are reached. For example, one form of the present device will arm reliably between 1500 and 2000 R. P. M. of the projectile.

While I have shown the primer 27 as being in the extension 23, it is to be understood that instead of this primer I may employ in this extension a firing pin which upon impact may be pushed back into the armed rotor along the lines described in said application. In such a case the primer to be struck by the firing pin would be loaded into the rotor along with the detonator shown. Such construction would be an operating equivalent, so far as the impact operation is concerned, and some of the appended claims are intended generically to cover such a construction.

It will be seen that when the latch spring 71 is forward as indicated in Fig. 2, its legs 73 act as beams supported at both ends, namely in the groove 65 and within the chamber containing the rotor. As such, these legs 73 positively lock the rotor against movement from its unarmed to its armed position. On the other hand, after set-back, when the loop 77 is in the groove 67, then the spring legs 73 are converted into spring cantilever beams supported only at the end near the loop 77. As such these legs 73 are loaded as cantilever springs or beams under centrifugal force and therefore may move out to the position shown in Fig. 6 under rotation of the projectile.

It should be observed that the sides of the notches 61 in the ball rotor 53 have sloping sides. Such sides are preferable to parallel or undercut sides since either of the latter would tend to effect a locking action between the rotor and the legs 73 under tendency of the rotor to move from unarmed to armed position. With the sloping sides on the notches 61 they tend to cam out the legs 73 without binding. This action is especially desirable where higher cantilever spring rates are used.

It should be understood that, although the ball 53 is shown as being of substantially spherical form, other equivalent forms may be used for the purpose of bringing it from its unarmed position of Fig. 2 to the armed position of Fig. 6 under spin of the projectile which carries it. So far as the present invention is concerned, the primary criterion for the ball 53 is that it shall carry and position a detonator or similar charge so that the charge is safe under unarmed conditions and exposed for detonation under armed conditions. To this end the ball in effect constitutes a gyroscopic element having the axis G—G around which is the maximum moment of inertia, which axis under unarmed conditions is at an angle to the axis of the projectile and parallel thereto when armed under spin conditions. Therefore in the appended claims the ball rotor 53 or its equivalent will therefore be referred to broadly as a gyroscopic rotor element.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying draw-

ings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A fuze for projectiles comprising a gyroscopic rotor adapted under spin of the projectile to precess from an unarmed to an armed position, a tubular holder for the rotor, a two-legged hairpin type spring latch having a semicircular connecting part slidable on the holder in response to set-back forces, said rotor being oppositely notched and said holder having openings adapted to expose the notches to cooperation with the legs of the latch in an initial position of the latch, means for locking the legs of said latch against movement under centrifugal force in its initial position when it is latched with the rotor, the legs of the latch retracting from said last-named means when the latch is set back thereby to release the legs of the latch so that under centrifugal force they may spring out through said holder openings away from latching positions in said notches.

2. A fuze for projectiles comprising a gyroscopic rotor adapted under spin of the projectile to precess from an unarmed to an armed position, a tubular holder for the rotor, a two-legged hairpin type spring latch having a semicircular connecting part slidable on the holder in response to set-back forces, said rotor being oppositely notched and said holder having openings adapted to expose the notches to cooperation with the legs of the latch in an initial position of the latch, means for locking the legs of said latch against movement under centrifugal force in its initial position when it is latched with the rotor, the legs of the latch retracting from said last-named means when the latch is set back thereby to release the legs of the latch so that under centrifugal force they may spring out through said holder openings away from latching positions in said notches, and a detent means on the tubular holder cooperating with said connecting part of the latch resiliently to hold it in latching position.

3. A fuze for projectiles comprising a gyroscopic rotor movable under spin of the projectile from an unarmed to an armed position, a support for said rotor providing a holding means on the support and providing a guide, said rotor having notch means and said support having openings with which said notch means align when the rotor is in unarmed position, a spring latch comprising a pair of oppositely located spring legs movable radially through said openings, the ends of said legs being movable axially into said holding means to be locked positively against movement from the openings under centrifugal force, means connecting said spring legs and sliding on said guide, detent means on said guide and engageable by said connecting means for normally holding the latch against axial movement whereby it is locked in said second holding means against centrifugal force but permitting movement of the latch under set-back forces to a second position wherein the legs of the latch are movable from said holding means to a position in which they may move under centrifugal force out through said openings.

4. A fuze for projectiles comprising a gyroscopic rotor movable under spin of the projectile from an unarmed to an armed position, a support for said rotor providing a holding compartment for the rotor, and providing a cylindric extension therefrom, said rotor having opposite notch means and said support having openings with which said notch means align when the rotor is in unarmed position, a spring latch comprising a pair of oppositely located spring legs movable laterally through said openings, the ends of said legs being movable axially into said compartment and into a position to be locked positively against movement from the slots under centrifugal force, a spring loop joining said spring legs and at least partially surrounding said extension, detent means on said extension engaged by said loop for normally holding the latch against axial movement and wherein it is locked against centrifugal force but permitting movement of the latch under set-back forces to a second position wherein the legs of the latch are movable from said chamber to a position in which they may under centrifugal force move out through said openings.

5. A fuze for projectiles comprising a gyroscopic ball rotor having a diametral opening containing a detonator and movable under projectile spin from a position in which the detonator is in an unarmed position to a position in which the detonator is in its armed position, parallel notches on opposite sides of said rotor and at an angle to the axis of the opening in which the detonator is located, a holder forming a relatively large diameter chamber within which are forwardly and rearwardly located seats for the rotor, said detonator aligning with said seats when in armed position, impact-initiated means associated with the front seat for exploding the detonator when the latter is in armed position, said holder forming a sleeve behind the rearmost seat of diameter smaller than that of said chamber, said holder having opposite slots providing openings into the chamber with which said rotor grooves may align when the rotor is in unarmed position, a spring latch comprising cantilever spring arms lying parallel to and movable radially into and out of said slots and said grooves and when in the grooves being movable axially into said chamber to be locked against movement by centrifugal force, and a semicircular loop joining said spring legs and slidable on said sleeve.

6. A fuze for projectiles comprising a gyroscopic ball rotor having a diametral opening containing a detonator and movable under projectile spin from a position in which the detonator is in an unarmed position to a position in which the detonator is in its armed position, parallel notches on opposite sides of said rotor and at an angle to the axis of the opening in which the detonator is located, a holder forming a relatively large diameter chamber within which are forwardly and rearwardly located seats for the rotor, said detonator aligning with said seats when in armed position, impact-initiated means associated with the front seat for exploding the detonator when the latter is in armed position, said holder forming a sleeve behind the rearmost seat of diameter smaller than that of said chamber, said holder having opposite slots providing openings into the chamber with which said rotor grooves may align when the rotor is in unarmed position, a spring latch comprising cantilever spring arms lying parallel to and movable radially into and out of said slots and said grooves and when in the grooves being movable axially into said chamber to be locked against movement by centrifugal force, and a semicircular loop joining said spring legs and slidable on said sleeve, a semicircular detent cylinder having spaced detent grooves, said detent cylinder being attached to said sleeve, the edges of the detent cylinder lying next to said spring legs and said loop having a detent engagement with either of said grooves whereby when the loop is in the forward detent groove said latch arms are locked in said rotor compartment against action by centrifugal force and being locked in said rotor grooves to hold the latter positively in unarmed position, and whereby linear acceleration of the projectile will set back the spring latch to place said loop in the second groove and releasing the spring legs so that under centrifugal force they may move from the rotor groove through said slot to free the rotor for gyroscopic precession to armed position.

7. A fuze for projectiles comprising a gyroscopic safety rotor movable under spin of the projectile from an unarmed to an armed position, a support for the rotor, a latch beam slidable near one end on the holder, said rotor having notch means engageable by the latch beam when the rotor is in unarmed position, holding means on the support for receiving the other end of the latch beam in one position wherein it engages said notch to hold the rotor in safe position, detent means associated with the first-mentioned end of the beam adapted resiliently to hold it, said beam being movable under set-back forces out of the detent into a position where its second-mentioned end is released from the holding means on the support, said beam being thus converted from one supported at both ends to one supported only at one end whereby the other end may be moved centrifugally out of said notch under spin of the projectile.

8. A fuze for projectiles comprising a gyroscopic safety rotor movable under spin of the projectile from an unarmed to an armed position, a support for the rotor, a spring latch beam slidable near a first end of the beam on the holder, said rotor having notch means engageable by the spring latch beam when the rotor is in unarmed position to hold the rotor safe, means associated with the support for receiving a second end of the spring latch beam in one position wherein it engages said notch, detent means associated with the first end of the spring latch beam adapted resiliently to hold it, said beam being movable under set-back forces out of the detent into a position where its second end is released from the holding means on the holder, whereby said spring beam is

converted from one supported at both ends to one supported only at one end to function as a cantilever spring adapted to be moved centrifugally out of said notch under spin of the projectile.

9. A fuze for a projectile comprising a gyroscopic rotor adapted under projectile spin to precess from an unarmed to an armed position, a latch mounted for substantially axial movement from an initial position to a set-back position in response to set-back forces, said latch including an axially extending spring cantilever having a free end biased substantially radially toward engagement with the rotor to prevent precession of the rotor but movable against bias by centrifugal force, a catch engageable with said free end in its initial position to prevent radial movement of the free end in response to spin of the projectile before set-back forces occur, the latch being disengaged from said catch during movement of the latch from its initial to its set-back position, said latch being disengaged from the rotor during subsequent spin, and detent means for holding the latch first in its initial position with its free end in the catch and then in its set-back position with its free end released from the catch.

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