Jan. 4, 1949. J. D. JORDAN 2,458,474

CENTRIFUGALLY OPERATED CONTROL DEVICE

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FIG. 1

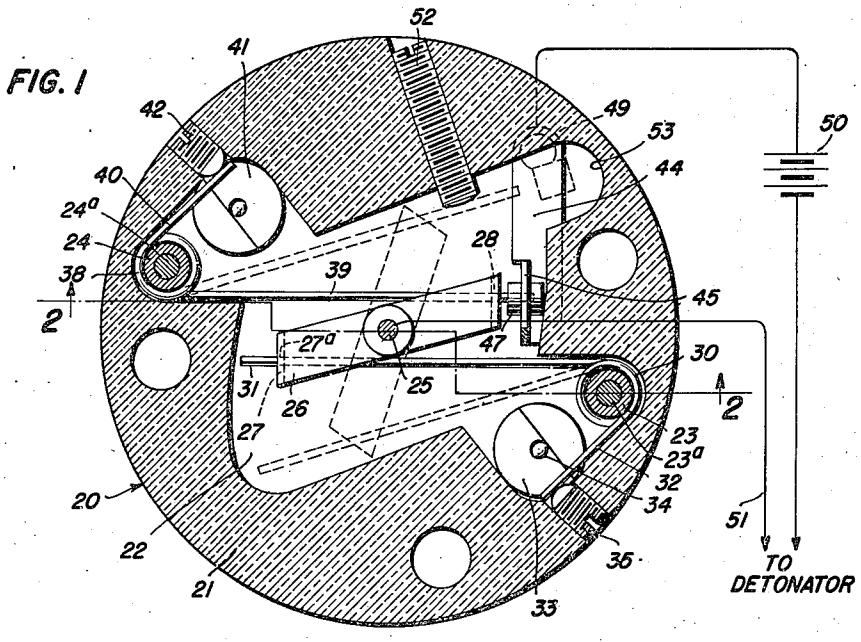


FIG. 2

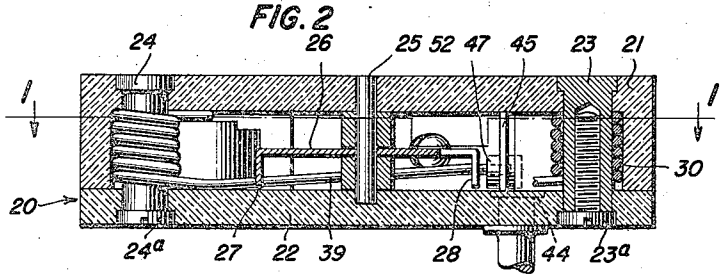


FIG. 3

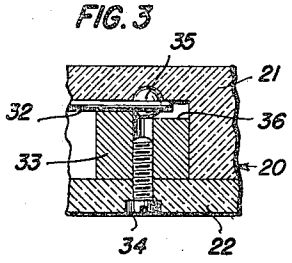


FIG. 4

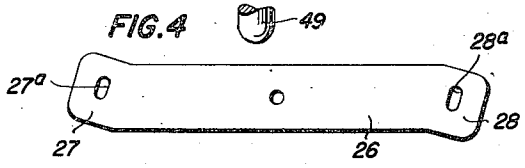


FIG. 5

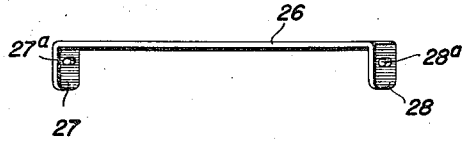
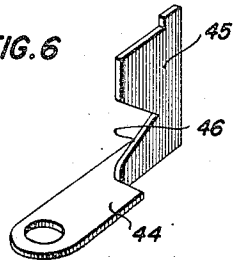


FIG. 6



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FIG. 7

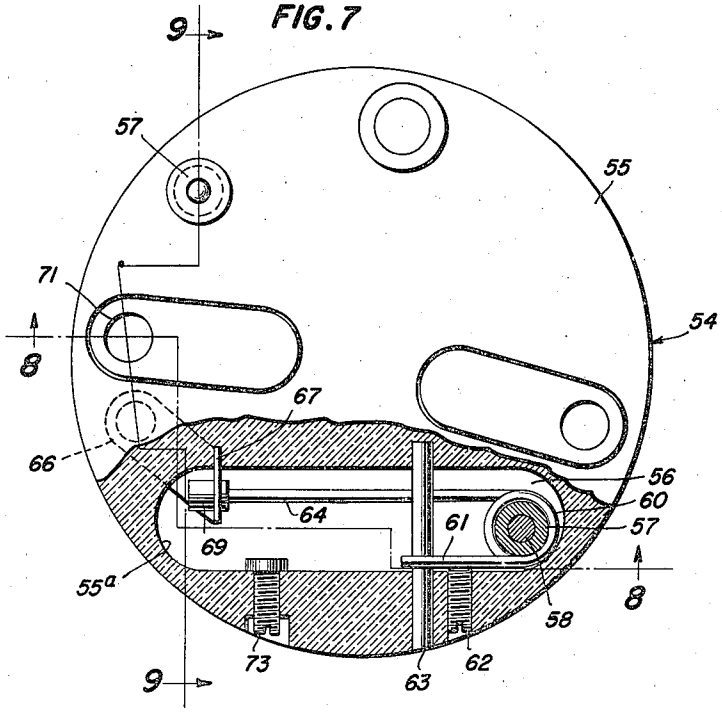


FIG. 8

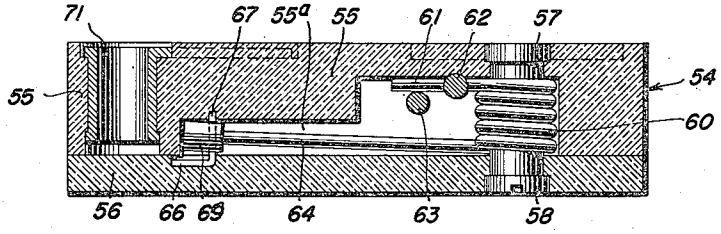
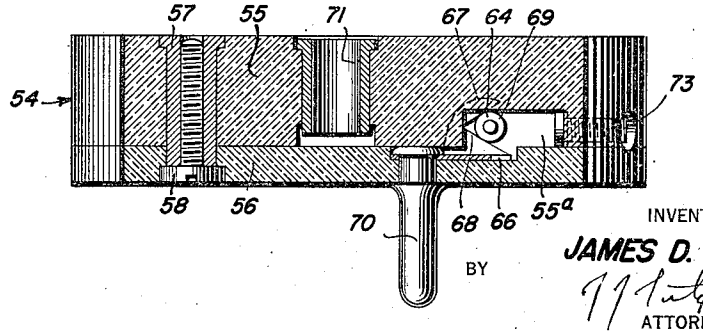


FIG. 9



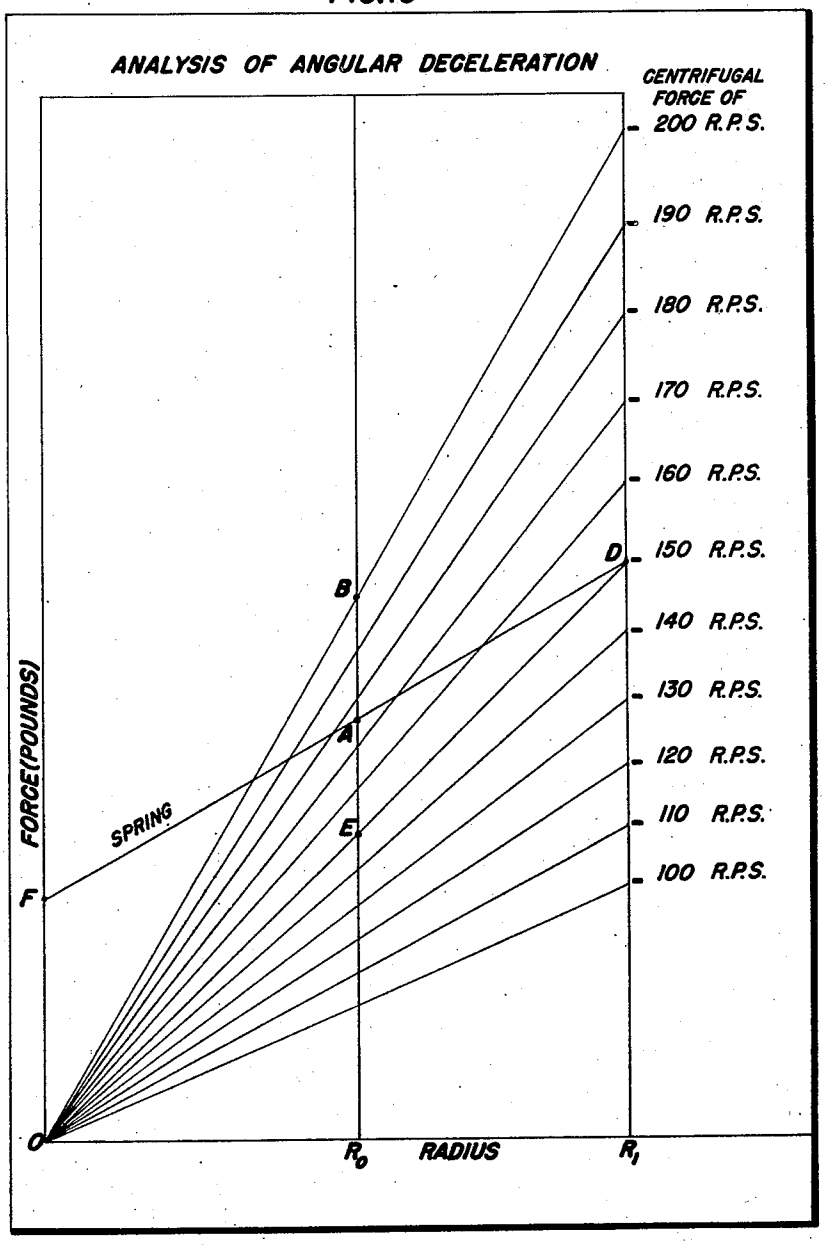
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FIG. 10



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UNITED STATES PATENT OFFICE

2,458,474

CENTRIFUGALLY OPERATED CONTROL DEVICE

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Application February 23, 1943, Serial No. 476,871

8 Claims. (Cl. 200—80)

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This invention relates to centrifugally operable control devices and has particular reference to a novel control device which is initially maintained inoperative by centrifugal force and operates upon a decrease in the centrifugal force below a predetermined value.

While the new control device is adapted for various uses, it may be used to particular advantage in the form of a safety switch for explosive projectiles of the rotary type. Accordingly, for illustrative purposes, the invention will be described in the form of a centrifugally controlled switch for this purpose, although it will be understood that the invention may take other forms as well.

One object of the invention is to provide a novel control switch having means for securing it against operation due to an initial centrifugal force, but which operates in response to a decrease of the centrifugal force. A switch made in accordance with the invention comprises a movable contact and means normally biasing the movable contact toward a fixed contact and operable by centrifugal force to move it away from the fixed contact. Closing of the contacts is normally prevented by an element which is rendered inoperative when the movable contact is initially actuated by centrifugal force. Accordingly, when the centrifugal force diminishes sufficiently to allow the biasing means to return the movable contact toward the fixed contact, the contacts are closed to operate an electrical device.

Another object of the invention resides in the provision of a novel centrifugally operated switch for automatically closing the circuit to a projectile detonator after the projectile has traversed the useful part of its trajectory but before it is dangerously close to the earth.

A further object of the invention is to provide a switch operable by centrifugal force for use in measuring the muzzle velocity of a projectile.

These and other objects of the invention may be better understood by reference to the accompanying drawings, in which:

Fig. 1 is a transverse sectional view of one form of the new control device for use in a rotary projectile;

Fig. 2 is a sectional view on the line 2—2 in Fig. 1;

Fig. 3 is a transverse sectional view of part of the device shown in Figs. 1 and 2;

Fig. 4 is a plan view of another part of the device in one stage of its manufacture;

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Fig. 5 is a side view of the part shown in Fig. 4 after it is bent into final form;

Fig. 6 is a perspective view of one of the switch contacts;

Fig. 7 is a plan view, partly in section, of a modified form of the device;

Figs. 8 and 9 are sectional views on the lines 8—8 and 9—9, respectively, in Fig. 7, and

Fig. 10 is a chart illustrating the operation of the device.

The control device in Figs. 1 to 6, inclusive, comprises a cylindrical housing 20 made of metal or of an insulating material, such as lucite, the housing having a body 21 recessed in its rear face, and a disk 22 secured to the rear face of the body and forming a cover for the recess. The cover may be secured to the body in any desired manner, and by means of studs 23 and 24 extending through the body and the cover and held by screws 23a and 24a threaded into the studs. A shaft 25 extends through the recess axially of the housing and is seated at its ends in the body 21 and the cover. Rotatably mounted on the shaft 25 is a rotor arm 26 having a central opening through which the shaft extends. The arm is provided at its ends with rearwardly extending ears 27 and 28 inclined at an angle to the longitudinal axis of the arm, as shown in Fig. 4, and having elongated openings 27a and 28a, respectively.

A spring 30 is coiled around the stud 23 in the housing recess and terminates at one end in a leg 31 extending through the opening 27a in the rotor arm, that is, through the ear of the rotor arm which is remote from the spring. The other end of the spring terminates in a leg 32 projecting along one side of the recess and confined between the bottom of the recess and the end of a cylindrical guide 33 secured to the cover 22 by a screw 34. Due to the tension in the spring 30, the leg 31 normally exerts a thrust on the rotor arm tending to move it in a clockwise direction, and the force of the thrust may be adjusted by a screw 35 threaded in the side wall of the housing and engaging the leg 32 in a cutaway portion 36 of the cylindrical guide. By turning the screw 35, the position of the spring leg 32 may be varied so as to adjust the tension in the spring and the thrust on the rotor arm 26. Diametrically opposite the spring 30 is a similar spring 38 coiled around the stud 24. One leg 39 of the spring 38 extends through the rotor opening 28a, that is, through the ear 28 which is remote from the spring 38. The other spring leg 40 extends along the side of the recess and is

confined between the bottom of the recess and the end of a cylindrical guide 41. The leg 39, due to the tension in spring 38, normally exerts a thrust on the rotor arm tending to rotate it in a clockwise direction, and the force of the thrust may be adjusted by a screw 42 engaging the spring leg 40.

The free end of the leg 39 constitutes the movable contact of a switch having a cooperating fixed contact 44. The contact 44 has a base secured to the cover 22, and an arm 45 extending at right angles to the base through the housing recess and embedded in the bottom of the recess. A notch 46 is formed in the contact arm 45 opposite the free end of spring arm 39, and the latter is provided with an insulating element 47 normally held in the notch by the thrust of spring leg 39. The insulating member 47 fits loosely in the end of leg 39 and prevents closing of the switch by maintaining the leg 39 in spaced relation to the contact 44. It will be apparent that clockwise rotation of the rotor 26 (Fig. 1) is limited by engagement of insulator 47 with contact arm 45.

A terminal plug 49 is connected through the insulating cover 22 to contact 44 and is adapted to be received in a terminal socket of an electrical detonating means (not shown) for the projectile. Thus, the switch is connected through the plug 49 in a detonating circuit including a battery 50, the detonator (not shown) and a wire 51 electrically connected to the spring leg 39 through shaft 25 and rotor arm 26.

Because of its cylindrical shape, the housing 20 may be readily fitted into the cylindrical casing of the projectile. The detonator circuit is normally broken by the insulating element 47 on the free end of the switch contact formed by the spring leg 39. The thrust of the leg 39 due to the tension in the spring wedges the element 47 into the notch 46 of the fixed contact, so that the insulating element cannot be accidentally displaced due to rough handling of the projectile. When the gun is fired, the projectile attains a high rate of spinning in the gun barrel, and the resulting centrifugal force on the spring legs 31 and 39 overcomes the spring thrust of these legs and moves them outwardly from the axis of rotation of the projectile, which corresponds to the shaft 25. As a result, the spring legs move to the position shown in dotted lines in Fig. 1 and rotate the arm 26 counterclockwise to the position shown in dotted lines (Fig. 1). The outward movement of the spring legs is limited by a screw 52 forming an adjustable abutment for the leg 39, and when this leg engages the abutment 52 the free end of the leg lies opposite an enlargement 53 of the housing recess. When leg 39 engages abutment 52, the action of centrifugal force on the insulating element 47 moves the element off the end of leg 39 into the recess extension 53. As the projectile continues its flight, the rate of its spin decreases and when the centrifugal force on legs 31 and 39 decreases to the point where it is overcome by the spring thrust of the legs, the legs snap the rotor arm 26 clockwise toward its starting position. However, since the insulating member 47 is no longer on the free end of spring leg 39, the latter moves beyond its initial position and is wedged in the notch 46 of contact arm 45, where it is held by the thrust of the spring legs 31 and 39. As a result, the switch is closed and causes energizing of the detonating circuit so as to explode the projectile.

It will be apparent that as soon as the centrifugal force on the spring legs 31 and 39 is sufficiently great to overcome the biasing force of the springs, the legs move outwardly with a snap action, since the centrifugal force on the legs increases as the legs move away from the axis of rotation at the shaft 25. While the biasing force of the spring legs also increases, due to distortion of the springs, as the legs move outwardly under centrifugal force, the rate of increase of the biasing force is not as great as the rate of increase of the centrifugal force on the legs. When the rate of spin of the projectile decreases so that the centrifugal force on the spring legs 31 and 39 is overcome by the biasing tension in the springs, the latter return to their initial positions with a snap action, since the centrifugal force on the spring legs decreases faster than the biasing tension in the springs as the legs move toward the axis of rotation. Thus, the switch contact formed by the free end of the spring leg 39 moves in both directions with a snap action so that fluttering of the switch is prevented. By employing two springs 30 and 38 on opposite sides of the axis of rotation, I provide automatic compensation for any off-center rotation of the device.

Referring now to the chart shown in Fig. 10, the abscissae are the radial distances of the spring legs 31 and 39 measured from the axis of rotation 25, O on the chart, and the ordinates are the centrifugal and the spring biasing forces on the legs 31 and 39. The vertical line from the point R_0 on the abscissa represents the normal positions of the spring legs 31 and 39, and the line AD represents the increase in the spring biasing tension on legs 31 and 39 as the legs move from their normal positions to their outermost positions at R_1, the slope of the line AD being the spring constant in pounds per inch of deflection. The inclined lines radiating from the point O represent the centrifugal force acting on the spring legs 31 and 39 at different rates of spin of the projectile and for different positions of the legs with reference to the axis of rotation O. With the projectile at rest, the spring legs are held in their normal position at R_0 with a spring biasing force equal to OA measured vertically. Assuming that the muzzle spin of the projectile is 200 revolutions per second, the centrifugal force on the spring legs 31 and 39 is in excess of the spring tension by an amount represented by AB, and the legs move away from the axis of rotation to the stop 52 at R_1, the spring tension in this position of the legs being represented by R_1D. The rate of spin now decreases, and as soon as it falls to 150 R. P. S. the centrifugal force becomes equal to the spring tension. Accordingly, a further reduction in the rate of spin leaves the springs with a tension greater than the centrifugal force, so that the spring legs start back toward the axis of rotation. As the radial distance R decreases, the excess of spring tension over centrifugal force increases so that the spring legs return to their initial position at R_0 with a snap action. The area of the triangle ADE is a measure of the kinetic energy of impact when the switch is closed by return of the spring legs, and the distance AE represents the force holding the switch contacts together at the instant they close. The total area under the line FD is a measure of the total resilience of the springs when deflected to their outermost positions, and the area R_0ADR_1 represents the energy required to deflect the springs from their initial positions at R_0 to their outer positions at R_1. The device may be calibrated by exerting the proper force against the spring legs 31 and 39, as by the use of a weight or

other suitable means, and then adjusting the screw 52 to touch the leg 39.

It has been found that a 5''/38 caliber projectile usually does not rotate about an axis greater than .01" from the projectile's geometric axis, and, therefore, R_1 in the above analysis might vary ±.01''. However, the distance OR_1 would normally be of such length that the percentage error due to this deviation is of no consequence.

It should be noted that the angular deceleration of a projectile at the higher altitudes is less than at the lower altitudes, due to the decreased air resistance to its spin at the higher altitudes, and, therefore, the projectile has a more or less constant spin when it returns to earth, regardless of the angle of fire. Accordingly, if the device of my invention is made to operate at a predetermined rate of spin occurring at a safe altitude, there is no necessity for making it adjustable by means of the screws 35, 42, and 52. However, the new device lends itself admirably to such adjustment if it is desired. The adjustment could be accomplished in a fuze setter by means of a cam operable to shift the screw 52 (R_1 in Fig. 10) or change the pre-tension on the springs 32 and 38 by shifting the screws 35 and 42.

The modified form of the device shown in Figs. 7, 8, and 9 comprises a housing 54 adapted to be received in a projectile casing and made up of a body 55 having an elongated recess 55*a* in its rear face near one side, and a cover 56 for the recess. The cover 56 is secured to the body 55 by headed studs 57 extending through the body and held by screws 58 in the cover, one of the studs being disposed near one end of recess 55*a*.

A spring 60 is coiled around the stud 57 and terminates at its front end in a leg 61 extending along the side of the recess adjacent the periphery of the body 55. The position of leg 61, and therefore the tension in spring 60, may be adjusted by means of a screw 62 threaded through the side wall of body 55 and engaging the leg. At its free end position, the leg 61 is confined between the bottom of the recess 55*a* and a guide bar 63 extending across the recess, whereby the leg is maintained in line with adjustment screw 62. The rear end of the spring terminates in a second leg 64 extending longitudinally of the recess adjacent the cover 56.

The free end of spring leg 64 forms a movable switch contact coacting with a fixed contact 66 secured to the cover 56. The contact 66 projects into recess 55*a* and has an arm 67 extending across the recess and embodied in the bottom thereof. Intermediate its ends, the arm 67 is formed with a notch 68 which normally receives an insulating element 69 loosely mounted on the free end of the spring leg 64. The insulating element 69 prevents closing of the switch 64, 66 and is normally wedged in the notch 68 by the biasing force of spring 60, so that the switch cannot be accidentally closed by displacement of the element 69 due to rough handling of the device.

A terminal plug 70 on the cover 56 is electrically connected to the fixed contact 66 and is adapted to be received in a suitable socket for connecting the switch in circuit with a battery and a detonator (not shown). The circuit may be completed through a socket 71 in the body 55 electrically connected through a suitable conductor (not shown) to the spring leg 64.

In operation, when the projectile is fired from a gun, the high rate of spin acquired by the projectile as it moves through the rifled gun barrel results in a centrifugal force on the spring

leg 64 which moves the leg outwardly against the biasing force of the spring and away from the axis of rotation of housing 54. Since the centrifugal force on the leg 64 as it moves outwardly increases at a greater rate than the biasing tension of the spring, the leg moves outwardly with a snap action. The outward movement of the spring leg 64 may be limited by a suitable abutment, such as an adjusting screw 73 threaded through the side wall of the body 55. When the insulating element 69 is withdrawn from notch 68, due to outward movement of the spring leg, the element moves off the free end of the spring leg under the action of the centrifugal force. Accordingly, when the rate of spin of the projectile decreases to the point where the centrifugal force on spring leg 64 is overcome by the biasing tension in the spring, the leg 64 moves back toward contact 66 and closes the switch by engagement with the arm 67. As the leg 64 moves inwardly, the rate of decrease of the centrifugal force on the leg is greater than the rate of decrease of the biasing tension of the spring, and, therefore, the switch is closed with a snap action. The biasing tension in the spring wedges the free end of leg 64 in the notch 68 so as to prevent accidental opening of the switch due to vibration, or the like. If the energy required to deflect the spring from its initial position is in excess of the kinetic energy acquired by dropping the device a distance of 40 feet, the device can be prevented from operating accidentally without the use of a safety pin actuated by set-back.

The control device of my invention is simple and compact in construction, includes relatively few moving parts, and is positive and reliable in operation. While I have described and illustrated the new device in the form of a switch for a self-destruction circuit in a projectile, it will be understood that the device may be used for other purposes as well. For example, the movable spring leg or legs may be arranged to open a squib unshorting device instead of closing a self-destruction switch, or to trigger a firing pin. Also the device in the form illustrated may be used as an instrument for indicating the muzzle velocity of a gun. More particularly, since a projectile may be considered as being geared to the rifling of a gun barrel while it passes through the barrel, the rate of spin of the projectile at the muzzle is proportional to the projectile's linear velocity. The device of my invention may be set to explode the projectile when it attains a predetermined rate of spin, and if the initial muzzle velocity is low, as occurs with a worn gun, the initial spin will be low and the elapsed time between firing and bursting will be correspondingly low. By using a stop watch to measure this elapsed time and plotting a curve to show the relationship between time and muzzle velocity, the muzzle velocity of the gun may be determined. Knowledge of the muzzle velocity of the gun is desirable in the field to permit correction of the trajectory so that the projectile will hit the target. The advantage of my control device when used in this manner is that no auxiliary equipment is needed. Even when the position of the gun is isolated, a box of fuzes containing the new device could always be kept near the gun for periodic checks on the muzzle velocity as the gun wears.

I claim:

1. In an initially inactive, centrifugally operated, and automatically activated electrical switch, the combination with a fixed contact, of a movable contact having a separable insulator

in frictional engagement with the fixed contact, and yieldable activating means constantly tending to maintain said engagement, whereby the movable contact is operated to separate the insulator, and at deceleration of centrifugal force the movable contact is automatically moved into electrical connection with the fixed contact.

2. In an initially open, centrifugally operated and automatically closed electrical switch, the combination with a fixed contact, of a resiliently mounted movable contact and a separable insulator thereon in frictional engagement with the fixed contact, whereby the movable contact is operated to separate the insulator, and at deceleration of centrifugal force the movable contact automatically moves into electrical connection with the fixed contact.

3. In an initially open, centrifugally operated and automatically closed switch, the combination with a fixed contact, of a pivoted rotor-arm and a movable contact operable therewith, a separable insulator mounted on the movable contact and in frictional engagement with the fixed contact, and resilient means co-acting with said arm constantly tending to maintain said engagement.

4. A safety device for rotary projectiles which comprises an open switch including a movable contact and a fixed contact, means constantly biasing the movable contact into engagement with the fixed contact, and said means actuated by centrifugal force to disengage the contacts, and an insulating element initially disposed between the contacts to secure the switch against closing and movable to an inoperative position on centrifugal actuation of said biasing means.

5. An initially open, centrifugally operated and automatically closed electrical switch for a rotary projectile, which comprises a body, a fixed contact and a movable contact in the body, a spring for biasing the movable contact toward the fixed contact and operable by centrifugal force to separate the contacts, and an insulated element co-acting with and normally securing said contacts against electrical connection and rendered inoperative upon movement of the spring by centrifugal force, whereby the spring causes the contacts to engage upon a decrease in the centrifugal force.

6. A control device for a rotary projectile, which comprises a body rotatable by the spin of the projectile, a rotor pivoted on the axis of rotation of the body and having arms projecting laterally from said axis, a pair of springs mounted in the body connected to the rotor arms and normally biasing the rotor in one direction, the springs being operable by centrifugal force to turn the rotor in the opposite direction, an open switch including a fixed contact, and a movable contact operatively connected to the rotor and normally biased by the rotor toward the fixed contact, and an insulating element carried by the movable contact and movable to an inoperative position on actuation of the springs by centrifugal force, whereby the springs close the switch on reduction of the centrifugal force.

7. An initially open control switch for projectiles, which comprises a body, a rotor-arm in the body, a fixed contact, a spring having an operating leg forming a movable contact and connected with the rotor-arm, and an insulating sleeve mounted on said leg and displaceable therefrom, the spring normally urging the leg toward the fixed contact for retaining the sleeve in engagement with said fixed contact, the spring and arm being movable on rotation of the body for displacing the sleeve from the leg, and the spring being operable to engage the contacts upon a reduction in the speed of rotation of the body.

8. In an open centrifugally operable and automatically closed switch for a rotary projectile, a fixed contact, a movable contact, and means movable by centrifugal force for initially shifting the movable contact from initially open position to a second open position, and automatic means for returning the movable contact to closed engagement with the fixed contact upon a decrease in the centrifugal force.

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