

May 5, 1959

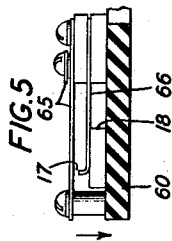
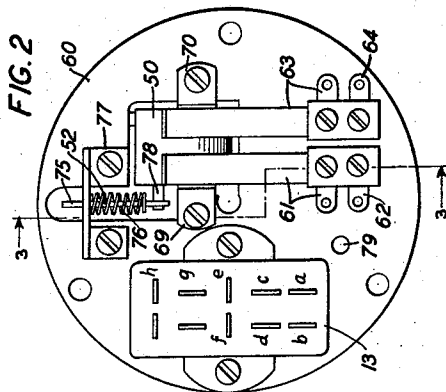
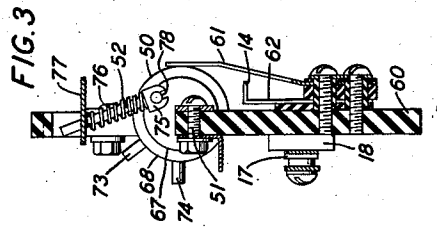
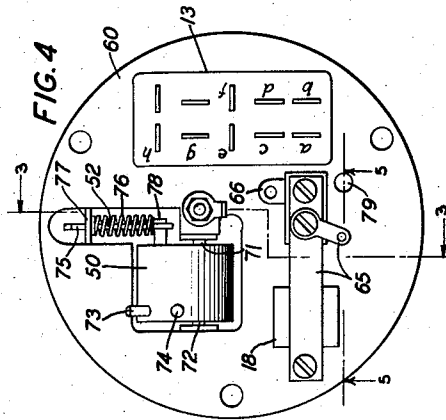
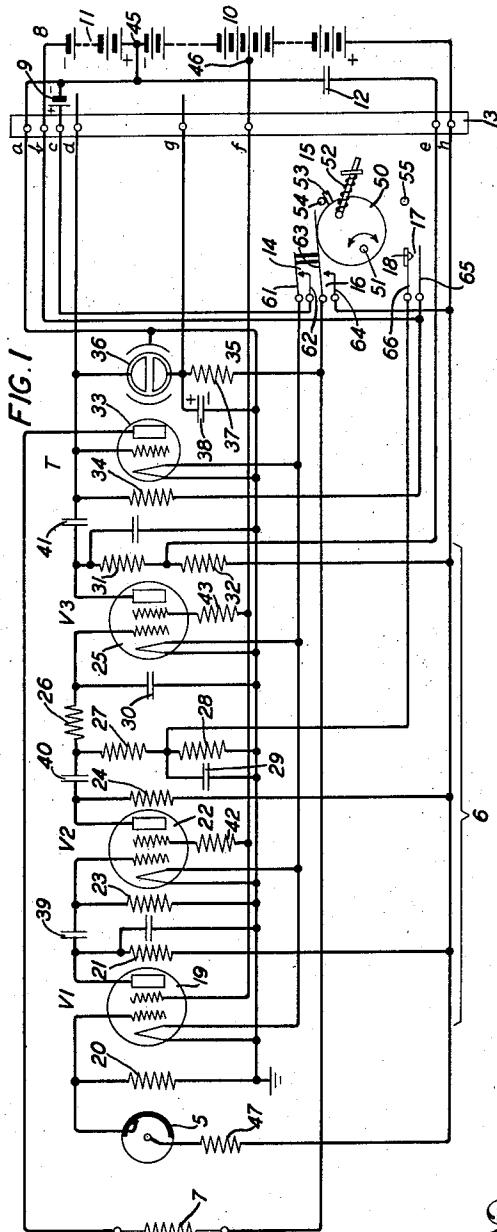
K. D. SMITH

2,885,503

SWITCHES CONTROLLED BY FORCES OF ACCELERATION

Original Filed April 19, 1943

7 Sheets-Sheet 1



INVENTOR
K. D. SMITH

BY

Stanley B. Kent
ATTORNEY

May 5, 1959

K. D. SMITH

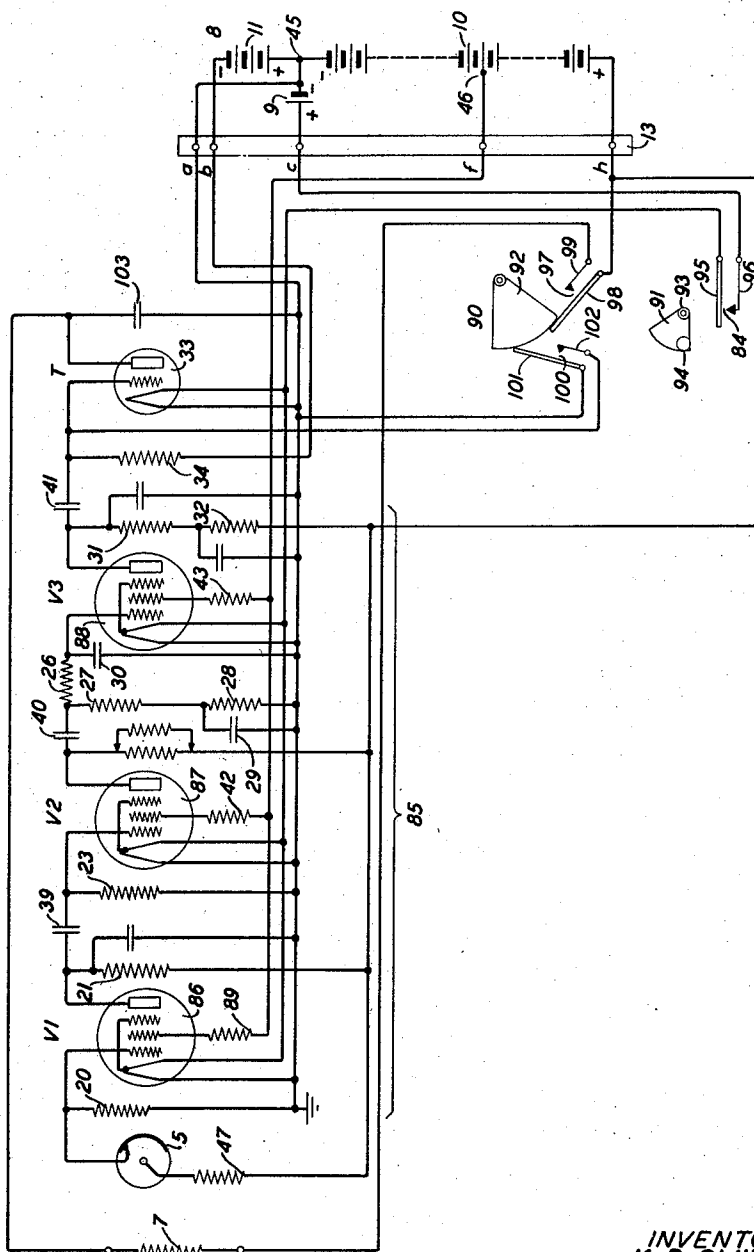
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SWITCHES CONTROLLED BY FORCES OF ACCELERATION

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FIG. 6



INVENTOR
BY K. D. SMITH
Stanley B. Kent.
ATTORNEY

May 5, 1959

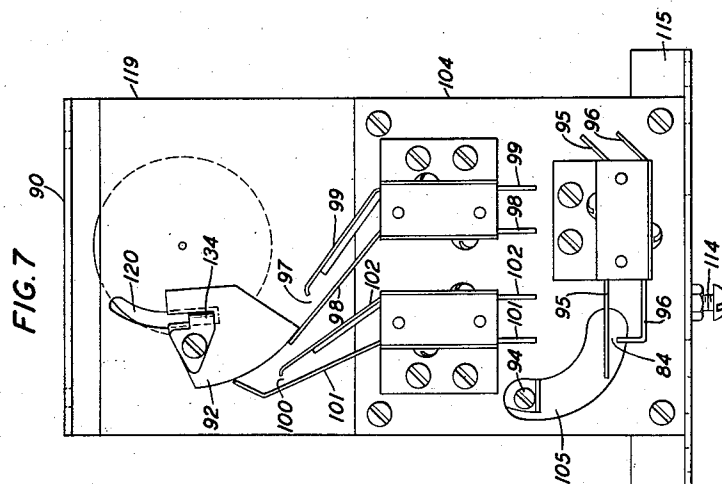
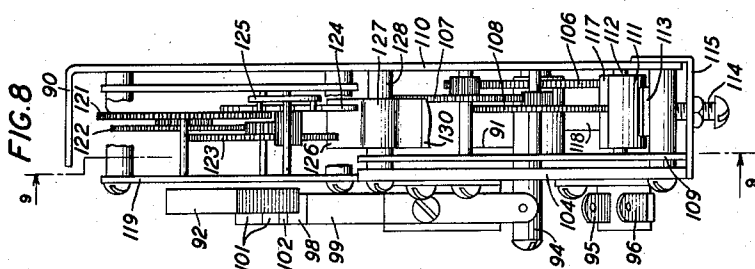
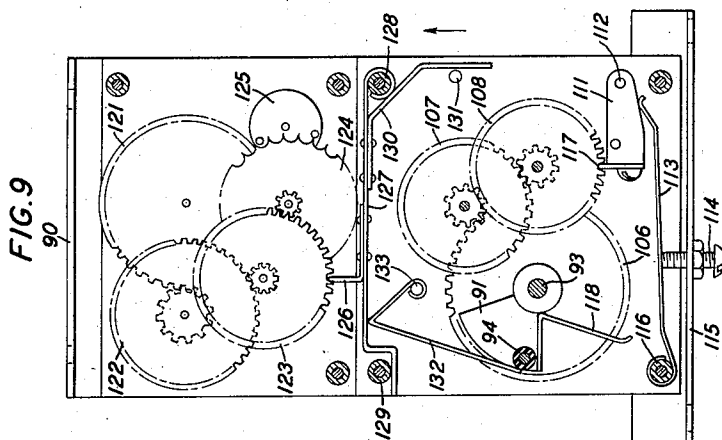
K. D. SMITH

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SWITCHES CONTROLLED BY FORCES OF ACCELERATION

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7 Sheets-Sheet 3



INVENTOR
BY K. D. SMITH

Stanley B. Kent.
ATTORNEY

May 5, 1959

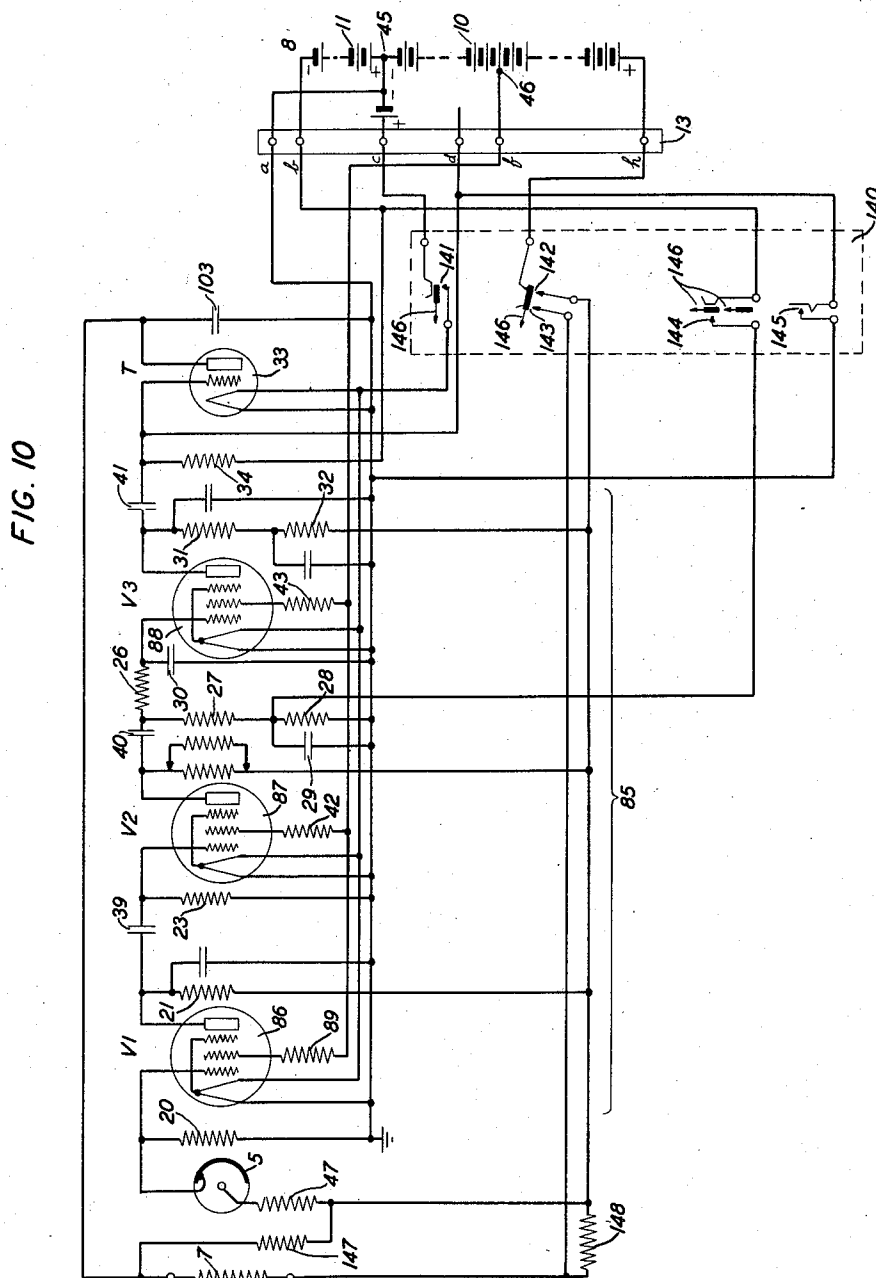
K. D. SMITH

2,885,503

SWITCHES CONTROLLED BY FORCES OF ACCELERATION

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INVENTOR
K.D. SMITH
BY

Stanley B. Kent.
ATTORNEY

May 5, 1959

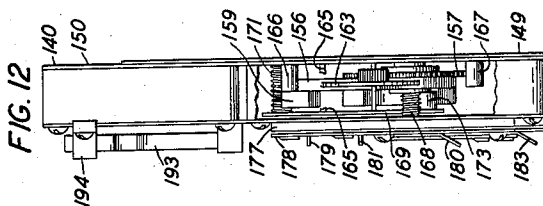
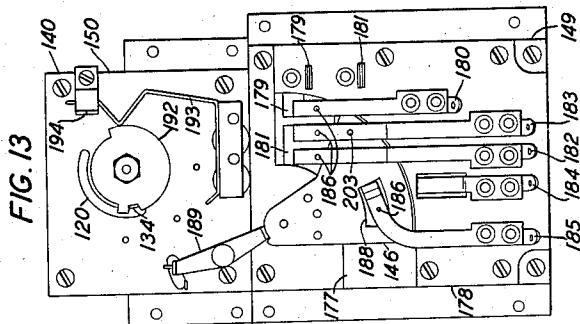
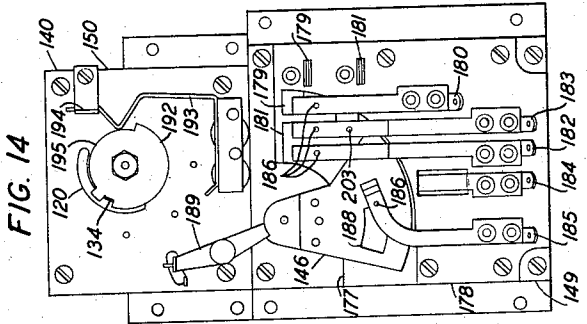
K. D. SMITH

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SWITCHES CONTROLLED BY FORCES OF ACCELERATION

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K. D. SMITH

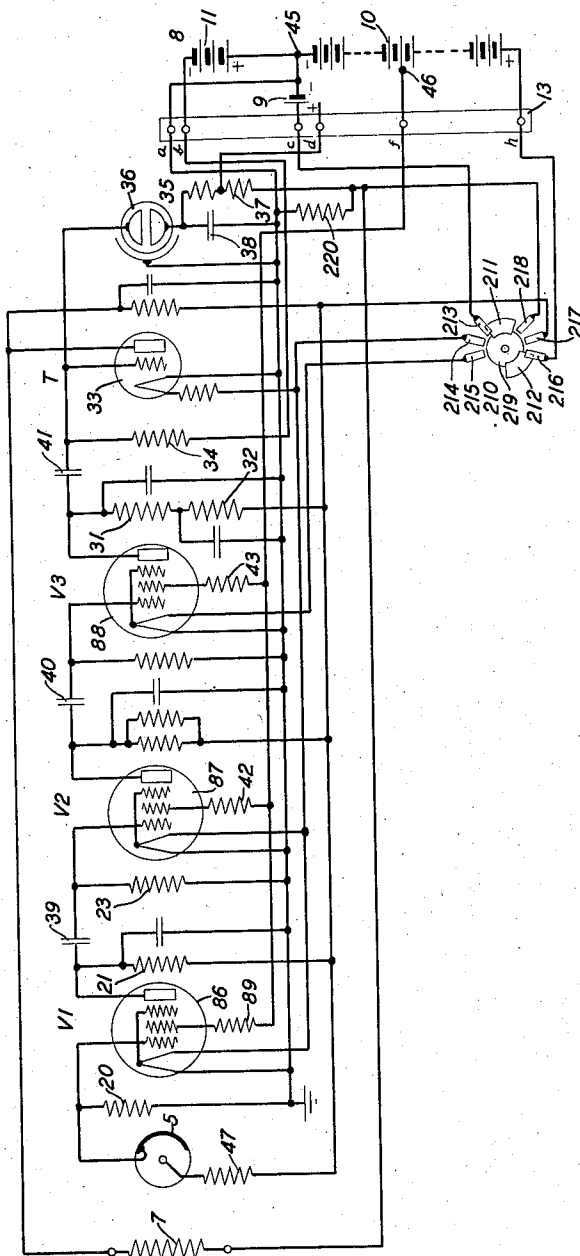
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SWITCHES CONTROLLED BY FORCES OF ACCELERATION

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FIG. 20



INVENTOR
BY K.D. SMITH
Stanley B. Kent
ATTORNEY

May 5, 1959

K. D. SMITH

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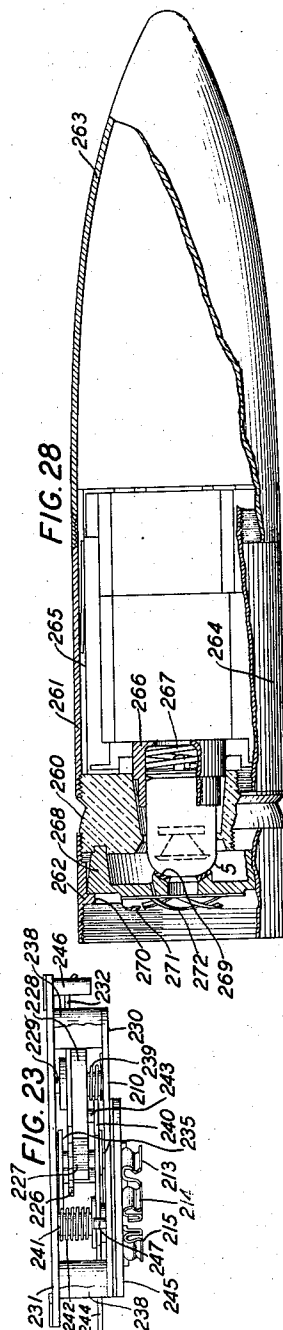
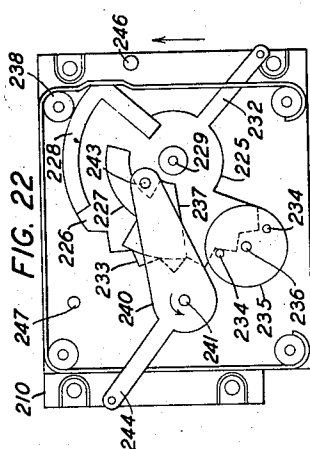
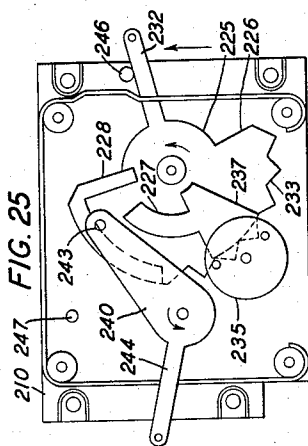
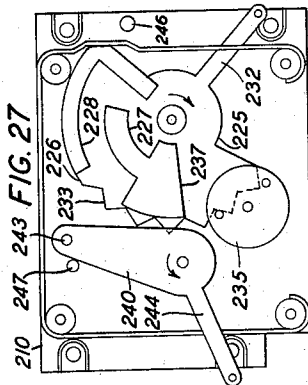
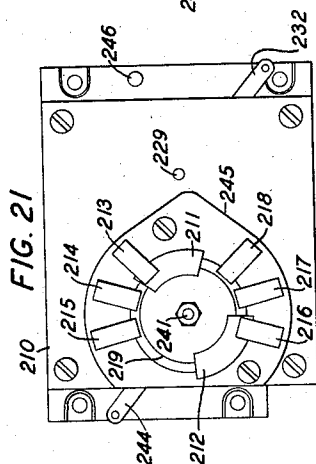
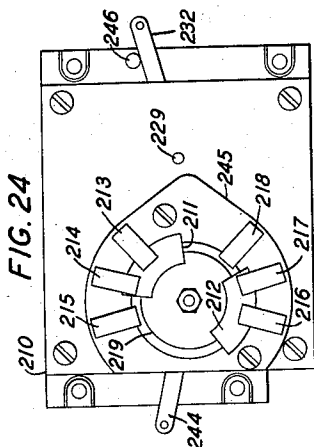
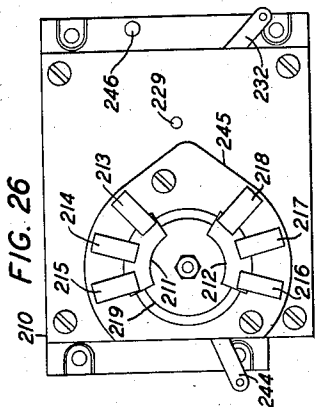


FIG. 28

FIG. 23

INVENTOR
K. D. SMITH

BY *Stanley B. Kent*
ATTORNEY

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SWITCHES CONTROLLED BY FORCES OF ACCELERATION

Kenneth D. Smith, White Plains, N.Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Original application April 19, 1943, Serial No. 483,605. Divided and this application November 30, 1943, Serial No. 512,328

11 Claims. (Cl. 200—61.45)

This application relates to switches and more particularly to switches controlled by forces of acceleration.

This application is a division of application Serial No. 483,605, filed April 19, 1943 for Electro-Optical Apparatus which parent application is a continuation in part of application Serial No. 460,013, filed September 28, 1942 for Electro-Optical Apparatus.

An object of the invention is to provide improved circuit control means adapted to be operated by changes in acceleration of a moving body carrying such means.

In an example of practice of the invention a photoelectric cell and vacuum tube amplifier arrangement is housed in a casing which is adapted to be connected to the head end of a projectile containing an explosive charge. The function of this photoelectric unit is to detect the presence of an object, such as an aeroplane, in proximity to its path of travel due to an impulsive reduction in the amount of light incident on the photoelectric cell and to cause the explosion of the explosive charge. Prior to actual use the unit must be kept inoperative so as to prevent premature explosions during handling and during the initial stages of the travel of the projectile toward the target. An energizing switch operated by forces of acceleration acting on an inertia member is adapted to maintain the unit inoperative until the projectile has entered the target zone when the switch operates to arm the projectile, that is, energize the photoelectric unit making it sensitive to impulsive changes in light incident on the photoelectric cell of the unit. If no object is encountered in the target zone, the explosive charge is exploded by other means before the projectile approaches near enough to the earth to cause damage by its explosion.

In one embodiment of the invention the energizing switch comprises an eccentric cam for controlling the cathode and output circuits of the vacuum tube amplifier having a thyatron tube in the output stage and weight actuated contacts for applying a blocking potential to an intermediate stage of the amplifier during periods of acceleration of the unit in a forward direction. The cam and weight actuated contacts are both actuated when the switch is given a predetermined acceleration above a given value, as when the projectile is projected toward the target zone. The rotation of the cam closes two contacts, one of which closes the filament circuits of the vacuum tubes and the other the output circuit of the thyatron through the load. These cam controlled contacts remain closed even after acceleration has ceased. The weight actuated contacts are closed only during such time as the acceleration continues above a predetermined value. The blocking circuit comprises a condenser and resistance connected in parallel in the grid circuit of an intermediate stage of the amplifier, the blocking circuit condenser being charged quickly upon the closure of the weight actuated contact and discharging slowly through the resistance when the contact is opened. By this arrangement the amplifier is unblocked relatively slowly, obviating danger of firing

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the thyatron by transient currents caused by suddenly closed or opened contacts.

In a second embodiment of the invention the energizing switch is ineffective to close any contacts until the acceleration has continued long enough for the projectile to be removed from any danger zone. Furthermore, this switch is protected against a limited number of accidental accelerations of short duration such as might occur if the unit were accidentally dropped during handling. In this embodiment an acceleration lock is provided to prevent undue movement of the main acceleration member during accidental acceleration. A spring driven timing gear mechanism which is released by the main acceleration member at the terminal position of its movement under forces of acceleration, closes the output circuit of the thyatron through the load a short time after it is released and after a further interval short-circuits the biasing potential of the grid of the thyatron to cause it to fire providing it has not previously been fired by passing the target.

In a third embodiment of the invention the energizing switch operates only on sustained acceleration for a predetermined period of time regardless of the number of accidental accelerations of short duration to which it might have been subjected previously. This switch operates in two distinct steps. During acceleration in the forward direction an acceleration member rotates in one direction against an opposing spring. After the acceleration drops below a predetermined value the acceleration member is rotated by the spring in the opposite direction. At the conclusion of the first movement contacts are closed first to energize the cathodes of the vacuum tubes, second to close the output circuit of the thyatron through the load and a protective high resistance, and third to apply a blocking potential to an intermediate stage of the amplifier. At the conclusion of the second movement contacts are closed to short-circuit the protective high resistance and to disconnect the source of blocking potential from the blocking circuit. Also at the conclusion of the second movement a contact controlling timing gear mechanism is mechanically unlocked to short-circuit the potential on the thyatron after a predetermined interval of time to fire the thyatron and destroy the projectile.

It will be noted that these embodiments have similarities and differences. The first embodiment is the simplest but it lacks certain of the protective features of the other described embodiments. Still other embodiments are possible as will appear from the detailed description to be given hereinafter.

The invention will now be described more in detail having reference to the accompanying drawings:

Fig. 1 is a schematic drawing of the circuit of a photoelectric unit according to this invention;

Fig. 2, 3, 4 and 5 are views of the energizing switch which is shown schematically in Fig. 1;

Fig. 6 is a schematic drawing of the circuit of another embodiment of the invention;

Figs. 7, 8 and 9 are views of the energizing switch which is shown schematically in Fig. 6;

Fig. 10 is a schematic drawing of the circuit of a third embodiment of the invention;

Figs. 11 to 19, inclusive, are views of the energizing switch which is shown schematically in Fig. 10;

Fig. 20 is a schematic drawing of the circuit of a fourth embodiment of the invention;

Figs. 21 to 27, inclusive, are views of the energizing switch which may be used in the circuit of Fig. 20; and

Fig. 28 is a side view of a photoelectric unit according to this invention with the casing partly cut away.

The same reference characters are used to designate identical elements in the several figures of the drawings.

Referring now to Fig. 1 the circuit of one embodiment of the invention comprises a photoelectric cell 5 coupled to an input stage V1 of a three-stage vacuum tube amplifier 6, a thyatron stage T being coupled to an output stage V3 of amplifier 6 and a load circuit 7 which may be a heater resistance coupled to the output circuit of the thyatron T. Energizing current is furnished by a battery unit 8. Battery unit 8 comprises a filament heating battery 9, a plate battery 10, a negative biasing battery 11 and a by-pass condenser 12. The battery 8 is connected to the remainder of the circuit by means of multiple contact connector 13 which comprises contacts a, b, c, d, e, f, g and h. The filament heating circuits are controlled at contacts 14 of acceleration switch 15. The output circuit of the thyatron T including the load circuit 7 is controlled at contacts 16 of switch 15. The application of negative blocking potential for the input circuit of the output stage V3 of amplifier 6 is controlled by contacts 17 which may be closed by the forces of acceleration operating on a mass 18 mounted on the relatively movable spring 66.

The input stage V1 of amplifier 6 comprises vacuum tube 19, input resistance 20 and plate resistance 21. The circuit of photoelectric cell 5 comprises a protective resistance 47. The intermediate stage V2 of amplifier 6 comprises vacuum tube 22, input resistance 23 and plate resistance 24. The third or output stage V3 of amplifier 6 comprises vacuum tube 25, series input resistance 26, shunt input resistances 27 and 28, arming condenser 29, input condenser 30 and output resistances 31 and 32. Thyatron stage T comprises thyatron tube 33, input resistance 34 and a self-destruction network 35 which includes a gaseous discharge tube 36, resistance 37 and condenser 38. The stages V1 and V2 are coupled by condenser 39, stages V2 and V3 by condenser 40 and stages V3 and T by condenser 41. The screen grids of tubes 22 and 25 are energized through resistances 42 and 43, respectively, from a portion of battery 10 extending from the grounded terminal 45 to the intermediate connection 46.

The circuit elements of Fig. 1 are mounted within a casing comprising an annular optical lens for directing light to the photoelectric cell 5. This casing in use is secured to the head end of a projectile.

The operation of the circuit of Fig. 1 is as follows:

When the projectile to which the casing is connected is in storage or normal transportation prior to use the switch 15 is in the condition illustrated in Fig. 1 with contacts 14, 16 and 17 open. A cam 50 pivoted at 51 is held against movement by the spring locking mechanism 52 which holds the pin 53 against the stop 54. The circuit is deenergized since the filament heating circuit is open at contacts 14 and the output circuit of thyatron stage T is open between the load 7 and the positive terminal of plate battery 10 at contacts 16. When flight of the projectile begins large forces due to acceleration are exerted on the cam 50 which causes this cam to move in a clockwise direction in Fig. 1 around the pivot 51 until the pin 53 comes against stop 55. The cam 50 is then held in the new position by the spring locking mechanism 52. In this new position contacts 14 and 16 are closed. At the same time the forces of acceleration acting on mass 18 causes contacts 17 to be closed. Due to the closure of contacts 17 the negative potential of battery 11 is impressed on the grid of tube 25 through resistances 26 and 27 to block this third amplifier stage V3 and arming condenser 29 is quickly charged to the voltage of battery 11, the upper terminal of condenser 29 being connected through contacts 17 and contact b of connector 13 to the negative terminal of battery 11 and the lower terminal of condenser 29 being connected through contact a of connector 13 to the positive terminal of battery 11. Since amplifier stage V3 is blocked the closure of the filament heating circuit at contacts

14 and the thyatron output circuit through load circuit 7 at contacts 16 is merely preparatory. When the acceleration drops below a predetermined value, contacts 17 are opened as the closing forces of acceleration on mass 18 are reduced. The circuit is rendered effective gradually or armed as arming condenser 29 discharges at a predetermined rate through resistance 28. This gradual arming of the circuit precludes a premature firing of thyatron 33 due to transients which might be generated by a sudden arming of the circuit. The circuit is now under control of photoelectric cell 5. The circuit constants are so proportioned that a small reduction of light on the cell 5 at the rate of approximately the wave front of a 40-cycle sine wave will trigger off the thyatron 33. When contacts 16 are closed the charging of condenser 38 through resistance 37 of the self-destruction circuit begins and continues until the charge on condenser 38 reaches a potential sufficient to break down tube 36. At the time of breakdown of tube 36 a positive potential is impressed on the grid of thyatron 33 which is sufficient to trigger off the thyatron. It is thus seen that this circuit is deenergized during ordinary handling and transportation. During the early stages of acceleration in use the filament and output circuits are energized but the circuit as a whole is ineffective due to the blocking potential on the third amplifier stage. When the acceleration is reduced the circuit is gradually armed and remains armed during a predetermined interval before its self-destruction is effected by the breakdown of discharge tube 36 providing that the projectile has not previously been exploded due to coming into proximity with a target.

The mechanical construction of switch 15 is illustrated in Figs. 2, 3, 4 and 5. The switch illustrated in these figures differs slightly from the schematic showing of Fig. 1 as will appear from the following description. The switch elements are mounted on a circular insulating disc 60 of a size to fit transversely within the cylindrical casing of the photoelectric unit. Figs. 2 and 4 are views of opposite faces of the disc 60 with the switch elements assembled thereon. Fig. 3 is a cross-section of this switch along the lines 3—3 in Figs. 2 and 4 looking in the direction of the arrows. Fig. 5 is a partial cross-section of a portion of Fig. 4 along the lines 5—5 looking in the direction of the arrows but omitting the cam 50 and associated elements. The direction of travel of this switch when mounted as a part of the photoelectric unit and attached to the projectile while traveling as intended in use is shown by the arrows in Figs. 3 and 5. The plug portion only of the multiple contact connector 13 is shown in Figs. 2 and 4. The terminal numbering applied to this connector is the same in Figs. 1, 2 and 4. Also, the springs of contacts 14, 16 and 17 are numbered the same wherever they appear in Figs. 1 to 5.

The insulating disc 60 is provided with holes therethrough to accommodate the eccentric cam 50 and its associated elements and the plug portion of connector 13. The eccentric cam 50 comprises an inner cylindrical metallic portion 67 and an insulating cylindrical shell 68. Contact springs 61 and 63 bear against the surface of shell 68. Cam 50 is supported in bearings 69 and 70 through the intermediary of pins 71 and 72 driven into holes in the ends of the portion 67 at the position of pivot point 51. Two stop pins 73 and 74 are driven into holes in the periphery of portion 67 through corresponding holes in shell 68. These stop pins 73 and 74 limit the angular movement of cam 50 by contacting disc 60 just as pin 53 coming against stops 54 and 55 limits the angular rotation of cam 50 in Fig. 1. The cam 50 is held in one or the other of its limiting positions by spring locking member 52 which comprises a locking arm 75, a locking arm spring 76 and a locking arm support 77. The locking arm 75 controls the cam 50 through pin 78 driven into an off-center hole in the end of metallic por-

tion 67 of cam 50. The locking arm support 77 is so positioned that the cam 50 will remain in the position shown in Fig. 3 until the switch is given a predetermined acceleration in the direction of the arrow in Fig. 3. The forces of acceleration acting on the cam 50 in opposition to the locking spring 52 moves the cam 50 in a counter-clockwise direction in Fig. 3 to its actuated position in which position contacts 14 between springs 61 and 62 and contacts 16 between springs 63 and 64 are closed. The connections to the plug portion of connector 13 of Figs. 2 and 4 are all made to the terminals on the side shown in Fig. 4. Therefore the wires from terminals 61, 62, 63 and 64 in Fig. 2 pass through a hole 79 in disc 60. The contacts 17 for temporarily blocking the stage V3 of amplifier 6 comprise relatively fixed spring 65 which is supported at both ends and weighted spring 66 which is supported at one end only, the weight 18 being secured to the other end as by soldering. As the switch is accelerated in the direction shown by the arrow in Fig. 5 the forces of acceleration acting on the weight 18 cause the spring 66 to move toward spring 65 to effect the closure of contacts 17.

A second embodiment of the invention is illustrated in Fig. 6. This embodiment is similar to that of Fig. 1. Pentode tubes 86, 87 and 88 are used for the three stages V1, V2 and V3 of amplifier 85. The suppressor grid of tube 86 is supplied with battery through resistance 89. The energizing switch 90 comprises an inertia member 91 and a timing gear driven member 92. In use the photoelectric unit is given a sustained acceleration so that the forces of acceleration operating on the inertia member 91 cause this member to rotate in a counter-clockwise direction in Fig. 6 around pivot 93 until pin 94, engaging the top of spring 95, forces spring 95 against spring 96 to close contacts 84. The closing of contacts 84 completes the cathode energizing circuits from battery 9 by way of contacts *a* and *c* of connector 13. At this stage the photoelectric unit is still ineffective or unarmed because the output circuit of thyatron T through load 7 is still open at contacts 97. As soon as inertia member 91 has reached the limit of its movement the timing gear mechanism is unlocked to rotate the member 92 in a clockwise direction in Fig. 6. After a short interval, say two seconds, switch spring 98 is disengaged by driven member 92 and engages spring 99, closing contacts 97. By this time the projectile is within the effective or target zone and the firing of thyatron T is under control of the photoelectric cell 5 because the output circuit of thyatron T has been closed through the load 7 by the closing of contacts 97. The timing gear mechanism continues to rotate member 92 in a clockwise direction. After a further predetermined interval of time contacts 100 are closed as switch spring 101 is disengaged by member 92 and engages spring 102. The closing of contacts 100 short-circuits the biasing potential on the grid of thyatron T to fire the thyatron and explode the projectile unless the projectile has previously been exploded by an impulsive reduction in light on the photoelectric cell 5 due to its coming into proximity to the target.

In this embodiment the amplifier is not blocked at an intermediate stage. It is to be noted, however, that the circuit through the load 7 is kept open until the projectile has arrived in the target zone while the photoelectric cell 5, amplifier 85 and input circuit of the thyatron T are fully energized at the termination of the predetermined period of sustained acceleration necessary to release the timing gear mechanism. Furthermore, any transient high voltage which might be impressed on the anode of thyatron T on the closing of contacts 97 is obviated by the condenser 103.

Further details of the mechanical construction of switch 90 are illustrated in Figs. 7, 8 and 9. Fig. 7 is a front view of the switch looking toward the side on which the contact springs are mounted. Fig. 8 is a side

view of Fig. 7. Fig. 9 is a cross-section along the lines 9—9 in Fig. 8 looking in the direction of the arrows. Certain mechanical supports and certain of the details of the gear mountings are omitted for simplicity of illustration.

The switch springs 95, 96, 98, 99, 101 and 102 are mounted on a brass plate 104 which has an arcuate slot 105 cut therethrough. The pin 94 carried by the inertia member 91 extends through slot 105. Inertia member 91 is secured to gear 106 which, through a pinion, drives gear 107. Gear 107, in turn, through a pinion, drives fast gear 108. The shafts of gears 106, 107 and 108 have bearing supports in plates 109 and 110 which are secured to plate 104 by suitable screws and spacers. Gear 108 is prevented from rotating by an inertia lock 111 pivoted on a pin 112 and held against gear 108 by spring 113, the tension of spring 113 being controlled by adjusting screw 114 passing through bottom plate 115. Spring 113 is pivoted on support spacer 116. The pressure of spring 113 on inertia lock 111 is such that the dog 117 engages the teeth of gear 108 unless the switch is being accelerated above a predetermined value in the direction of the arrow in Fig. 9. When accelerated above such predetermined value the inertia lock 111 rotates away from the gear 108 allowing inertia member 91 to rotate with gear 106 in a counter-clockwise direction at a speed controlled by the inertia of gears 107 and 108. secured to the inertia member 91 is a brake spring 118, the free end of which presses upon the teeth of gear 108 to stop both the inertia member 91 and the gear 108 after the pin 94 has pressed spring 95 into contact with spring 96 to close contacts 84. This braking action of spring 118 on the teeth of gear 108 precludes the stripping of the teeth from gears or pinions so that the inertia member 91 may be locked through the gear train after the acceleration has dropped sufficiently to allow the dog 117 again to engage the teeth of gear 108.

The gear train comprising gears 121, 122, 123 and 124 and the escapement oscillating member 125 are driven by a main spring attached to main gear 121 and the switch frame. Gear 121 drives gear 122 through a pinion on the shaft of gear 122. Similarly, gear 122 drives gear 123, gear 123 drives gear 124 and gear 124 drives the escapement member 125. An arm attached to the shaft of main gear 121 and having a projection 134 extending through the arcuate slot 120 in the front plate 119, carries member 92 which is rotated in a clockwise direction in Fig. 7 by the main spring. This gear train is locked by a dog 126 which engages the teeth of gear 123 in the position shown in Fig. 9. Dog 126 is carried by a spring 127 pivoted on spacer member 128. Rotation of spring 127 in a clockwise direction is stopped by contact with spacer member 129. Spring 130 is secured at one end to spring 127 and pressing against pin 131 at the other end is tensioned to tend to rotate spring 127 in a counter-clockwise direction. Spring 127, however, is held against rotation in a counter-clockwise direction by lever 132 which is pivoted on pin 133 at one end and stopped by inertia member 91 at the other end so long as the inertia member 91 has not been rotated sufficiently to close contacts 84. However, when inertia member 91 has rotated past the free end of lever 132, lever 132 is free to rotate about pin 132 in a counter-clockwise direction under pressure of spring 127 moved by tensioned spring 130. Such movement of spring 127 disengages dog 126 from gear 123 which allows the gear train to move through its timing cycle, rotating member 92 in a clockwise direction. The escapement mechanism 125 driven by gear 124 is so adjusted that the driven member 92 disengages spring 98 to close contacts 97 after a short predetermined period of time, say one and one-half or two seconds, after the timing gear train has been unlocked and disengages spring 101 to close contacts 100 after a longer predetermined period of time, say seven and one-half

or eight seconds, after the timing gear train has been unlocked.

From the foregoing description of the second embodiment of the invention it is seen that the second described embodiment of the invention comprising switch 90 can be subjected to a considerable number of accidental high accelerations of short duration without being energized. This is due to the fact that inertia member 111 unlocks gear 108 for only an exceedingly short interval of time on an accidental high acceleration. This second embodiment, therefore, requires less careful handling after being attached to a projectile than the so-called first embodiment. However, under sustained acceleration for a relatively short period this switch will sensitize the photoelectric unit in a manner to carry it through its cycle of operations.

The third embodiment of the invention is illustrated in Fig. 10. This embodiment is similar to that of Fig. 6. An energizing switch 140, the contacts of which are shown within the dotted line block in Fig. 10 comprises an inertia member having a cam for controlling a sequence switch including the contacts 141, 142, 143 and 144 and a timing gear mechanism controlling contacts 145. The construction of switch 140 is illustrated in Figs. 11 to 19. The operation of switch 140 is such that none of the contacts 141 to 145 are closed on accelerations of short duration no matter how many may occur nor of how high a value they may be if within the limits for which the switch is designed. The acceleration member of the switch may rotate a considerable amount without affecting the contacts and always returns to its initial position after the acceleration has fallen below a predetermined value. However, if the acceleration continues for a predetermined period of time so that the acceleration member rotates to its first actuating position, the sequence switch is stopped to its first actuated position and contacts 141, 142 and 144 are closed. The contact controlling insulator cam 146 of switch 140 is shown schematically in separate parts in Fig. 10 for convenience of illustration. Actually these parts are portions of a single member and move as a unit. As the switch 140 is actuated the insulator cam travels in a direction shown by the arrows in Fig. 10. In the first actuated position, that is, in the position assumed after acceleration has continued for a predetermined period of time above a predetermined value, contacts 141, 142 and 144 are closed. Contacts 141 close the heating circuits for all the vacuum tubes from battery 9. Contacts 142 apply anode potential from the whole of battery 10 to photoelectric cell 5, vacuum tubes 86, 87 and 88 of amplifier 85 and thyatron 33 through resistance 147. Contacts 142 also close the load circuit 7 for thyatron stage T through protective resistance 148. Contacts 144 impress negative blocking potential on the input circuit of amplifier stage V3 from battery 11. As soon as contacts 144 are closed condenser 29 is charged to the full potential of battery 11. If for any reason contacts 144 fail to close, the unit is protected against premature operation by protective resistance 148 in series with load resistance 7. It may be noted that premature energization of load resistance 7 resulting in a pre-explosion is more to be guarded against than failure of the projectile to explode in the target zone.

When the acceleration falls below a second predetermined value, switch 140 is actuated to its second operated position and contacts 143 are closed, contacts 144 opened and contacts 141 and 142 maintained closed. Furthermore, the timing gear mechanism is tripped and starts running eventually to close contacts 145. Contacts 143 short-circuit protective resistance 148 while the opening of contacts 144 initiates the removal of blocking potential from the input circuit of amplifier stage V3 of amplifier 85. This blocking potential is gradually removed as condenser 29 discharges through resistance 28. The photoelectric unit is thereby gradually armed or

brought to full sensitivity. Premature explosion is obviated even if the sudden short-circuiting of resistance 148 at contacts 143 might otherwise have caused transient voltages of sufficient value to fire thyatron 33. Condenser 103 gives further protection against false operation by high voltage transients. The projectile has now moved within the target zone and the photoelectric unit is fully armed or sensitized.

The timing gear mechanism is set to run for a predetermined time interval sufficient for the projectile to pass through the target zone if no target has caused the projectile to explode. At the end of this interval contacts 145 are closed, short-circuiting the grid to cathode circuit of the thyatron stage T and thereby causing the thyatron 33 to fire to explode the projectile. This explosion is designed to occur before the projectile falls near enough to the earth to cause damage by its explosion. Contacts 145 may be called the self-destruction contacts.

The mechanical construction of switch 140 is illustrated in Figs. 11 to 19. This switch 140 comprises two units, namely, an acceleration unit 149 which is actuated by the forces of acceleration acting on an inertia member and a self-destruction unit 150 which is actuated by timing gear mechanism tripped by the acceleration unit at the completion of a sequence of operations. Fig. 11 is a front view of both units 149 and 150 of switch 140. Fig. 12 is a side view of Fig. 11. Fig. 15 is a top view of unit 150 of Fig. 11 with the protective edge strip removed. Fig. 16 is a top view of unit 149 of Fig. 11 with unit 150 removed. Figs. 13 and 14 are front views of switch 140 in its first and completely actuated positions, respectively. Figs. 17, 18 and 19 are front views of unit 149 of switch 140 with the front plate and sequence switch elements removed showing the set or unactuated position, the first actuated and completely actuated positions, respectively. Thus, Fig. 17 shows the position of the inertia member and pivoted member controlled thereby corresponding to the contact spring positions in Fig. 11. Figs. 18 and 13 and Figs. 19 and 14 are similarly related, respectively.

Referring now particularly to Figs. 11, 12, 16 and 17 an inertia member 155 comprises an arcuate-shaped metallic member 156 secured to a gear wheel 157 and carrying stop members 158 and 159. Gear 157 is mounted on shaft 160 supported in bearings in plates 161 and 162. Gear 157 drives the pinion of an escapement wheel 163 which in turn drives oscillating escapement member 164. Member 164 is pivoted on shaft 165. Inertia member 155 is held against stop pin 166 by a helical spring 163 surrounding shaft 160 and tensioned in such a manner as to tend to cause inertia member 155 to rotate in a clockwise direction as viewed in Fig. 17. If the switch 140 is accelerated above a predetermined value for a predetermined period of time, the forces of acceleration acting on inertia member 155 will cause this member to rotate in a counter-clockwise direction until member 156 engages stop pin 167. The speed of rotation is determined by the adjustment of escapement member 164. When the acceleration falls below a predetermined value the inertia member 155 is returned to its normal position against stop pin 166 by helical spring 163. The adjustment is such that inertia member 155 will rotate only a small amount on accidental accelerations of small duration even though such accelerations are of high value. As soon as the acceleration is reduced below the lower predetermined value inertia member 155 returns to its normal position against stop pin 166.

Stop members 158 and 159 control a lever 169 which is supported on a shaft 170. A spring 171 surrounding shaft 170 is connected at one end to lever 169 and at the other end to a spacer 172 and tensioned in such a way as to tend to rotate lever 169 in a clockwise direction. At the end of lever 169 remote from shaft 170 a roller 173 is mounted by means of a pin on lever 169. With the

inertia member 155 in the position shown in Fig. 17, that is, in the normal unactuated position the roller 173 rests against the inner curved surface of stop member 158 and holds the lever 169 from rotating.

Sequence switch cam 175 is secured to the outer end of shaft 170 on the side of plate 161 opposite from lever 169. This sequence cam 175 comprises a metallic member 176 which is secured to the shaft 170 and the insulating member or cam 146 secured as by riveting to the metallic member 176. As noted in connection with Fig. 10 cam 146 controls the closure of contacts 141, 142, 143 and 144. The contact members which form contacts 141, 142, 143 and 144 are mounted on insulator sheets 177 and 178 partly between the sheets and partly on top of sheet 178, the sheets 177 and 178 being secured by screws to plate 161. Sequence cam 146 moves between the pairs of contact members opening the contacts when the cam 146 encounters bosses on the undersides of the outer spring members. Inner contact member 179 and outer spring contact member 180 form contacts 141. Inner contact member 181 and outer spring contact member 182 form contacts 142. Inner contact member 181 and outer spring contact member 183 form contacts 143. Spring contact member 184 and outer spring contact member 185 form contacts 144. In the position of the sequence cam 146 in Fig. 11 the bosses on the undersides of springs 180, 182, 183 and 185 all ride on the sequence cam 146 holding these springs out of contact with members 179, 181 and 184, thus keeping open the contacts 141, 142, 143 and 144. Spring contact member 184 is mounted on the outer face of insulator sheet 178 but the contact end of this member 184 lies below sequence cam 146 and above the inner insulator sheet 177. Spring contact member 184 is offset intermediate its ends to pass through a hole 187 in insulator sheet 178. A hole 188 in sequence cam 146 is provided for the closing of contacts 144. The operation of the timing gear mechanism controlling contacts 145 of the self-destruction unit 150 is controlled by lever 189 pivoted on pin 190, the lower end of which is adapted to be engaged by projection 191 on the member 176 of sequence switch 175 as the switch 175 is rotated to its second operated position.

The self-destruction unit 150 comprises, in addition to the control lever 189, a spring driven insulator cam 192 for controlling the closure of contacts 145 in Fig. 10. A bent spring contact member 193 bears against the periphery of cam 192 holding spring 193 out of contact with fixed contact member 194 until cam 192 has rotated in a clockwise direction sufficiently to allow spring 193 to drop into the cut-away portion 195 of cam 192. The timing gear mechanism of unit 150 is much like that of switch 90 shown in Figs. 7, 8 and 9. The projection 134 on the arm attached to the shaft of main gear 121 and extending through arcuate slot 120 fits into a notch cut into the periphery of cam 192 and drives cam 192 by pressure against the edge of the slot. Main gear 121 is driven by a spring in housing 198 and drives, through a pinion, gear 199. Gear 199 drives, through a pinion, gear 200. Gear 200 drives, through a pinion, escapement gear 201 which drives escapement member 202. A projection on the upper end of lever 189, Fig. 11, extending through slot 196 engages the teeth of gear 199 due to the pressure of a spring 197 until forced out of engagement by the knob 191 on sequence switch 175 pushing against the lower end of lever 189 and rotating lever 189 in a counter-clockwise direction.

As hereinbefore noted the normal positions of the elements of switch 140 are illustrated in Figs. 11 and 17. This may be known as the set position of switch 140. In this position contacts 141, 142, 143 and 145 are all open and from Fig. 10 it is seen that the photoelectric unit is deenergized so far as its operation to fire the projectile is concerned. This is the normal condition of switch 140 while the photoelectric unit of which it is a component part is attached to a projectile with which it is to be used.

It may be connected to such projectile for a considerable period of time and subjected to a large amount of handling before actually being projected toward the target zone.

When the projectile with the photoelectric unit attached is projected toward the target zone, switch 140 is given a sustained acceleration for a considerable period of time in the direction indicated by the arrow in Fig. 18. The tension of spring 168 and the adjustment of the escapement member 164 is such that the forces of acceleration acting on inertia member 155 during the early stages of acceleration will rotate the member 155 in a counter-clockwise direction until member 156 comes against stop pin 167. The position of the inertia member 155 including member 156 and stop members 158 and 159 is shown in Fig. 18. In this position roller 173 has been freed from stop member 158. Lever 169 under pressure of spring 171 has rotated in a clockwise direction until roller 173 has come against stop member 159. With lever 169 in the position shown in Fig. 18 the sequence switch 175 is in the position shown in Fig. 13. Bosses 186 on springs 180 and 182 have been disengaged by sequence cam 146 at its rear edge to contact members 179 and 181 closing contacts 141 and 142, respectively. A second boss 203 on spring 183 still engages cam 146 keeping contacts 143 open. Boss 186 on spring 185 has been disengaged from cam 146 at the left-hand side of hole 188 allowing spring 185 to contact member 184 through hole 188 closing contacts 144. The timing gear mechanism of unit 150 is in condition to be unlocked by lever 189 upon any further rotation of sequence cam 175 in a clockwise direction but this gear mechanism 150 is not unlocked at this stage of the operation.

When the acceleration of the projectile drops below a predetermined value acceleration member 155 returns to its original position under pressure of spring 168 until member 156 again engages stop pin 166. This position is shown in Fig. 19. Acceleration member 155 returns at a predetermined rate dependent upon the tension in spring 168 and the adjustment of escapement member 164. Very soon after such return movement has started roller 173 is disengaged by stop member 159 and lever 169 under the pressure of spring 171 rotates another step in the clockwise direction against stop pin 204 carrying sequence cam 146 to the position shown in Fig. 14 and moving lever 189 to unlock the timing gear mechanism of unit 150. Boss 203 on spring 183 has been disengaged by sequence cam 146 at its rear edge allowing spring 183 to contact member 181 thereby closing contacts 143. Boss 186 on spring 185 has again been engaged by sequence cam 146 at the right-hand side of hole 188 to open contacts 144. At the end of a predetermined period of time after the sequence switch has assumed its second actuated position cam 192 of unit 150 will have rotated in a clockwise direction to allow spring 193 to engage the periphery of small radius of cam 192 and contact member 194 closing contacts 145.

The fourth embodiment of the invention comprises a modified form of the switch used in the circuit of Fig. 10. This embodiment is illustrated in Fig. 20. The construction of the modified switch is illustrated in Figs. 21 to 27. The switch 210 during use assumes three positions in sequence, namely, the original or set position, a first actuated position and a second actuated position, which positions correspond to the three positions assumed by the inertia member 155 of the inertia unit 149 of switch 140 as illustrated in Figs. 17, 18 and 19. The six terminals of switch 210 are mounted around the circumference of a circle in two groups of three terminals each. Connection between the terminals of a group is made by movable contact plates 211 and 212 mounted on an insulating disc 219 which rotates with a pivoted member controlled by the inertia member. The upper group of terminals 213, 214 and 215 controls the cathode heating circuits of the vacuum tubes. The lower group of terminals 216, 217 and 218 controls the anode circuits of

the photoelectric cell and the vacuum tubes. In the set position shown in Fig. 20, the filament heating circuits and the anode circuits are all open. The circuit, therefore, is effectively deenergized even though battery is connected to certain of the elements of the vacuum tubes. When the photoelectric unit of which switch 210 is a component part is attached to a projectile and is projected toward a target zone, the switch 210 assumes its first actuated position due to the forces of acceleration on the inertia member. In this first actuated position, contact plate 211 bridges terminals 213 and 214 closing the filament heating circuits of all the vacuum tubes except tube 88 of stage V3 and contact plate 212 bridges terminals 216 and 217 impressing anode potential on the photoelectric cell and all of the vacuum tubes including the thyatron 33. The load resistance 7, however, is not connected to battery at this time. When the acceleration of the projectile drops below a predetermined value as it approaches the target zone, switch 210 assumes its second actuated position as the acceleration member returns to its original position. In this second actuated position, contact plate 211 bridges all three terminals 213, 214 and 215 additionally closing the filament circuit of tube 88 in amplifier stage V3 and contact plate 212 bridges all three terminals 216, 217 and 218 additionally connecting the load resistance 7 in the output circuit of thyatron 33 and impresses plate battery voltage on the self-destruction network 35 which includes gaseous discharge tube 36, resistance 37, and condenser 38. An additional high resistance 220 is bridged across the plate battery 10 in this second operated position to obviate transients which might conceivably trigger off thyatron 33 prematurely. Condenser 38 is charged relatively slowly through high resistance 37 until the breakdown voltage of gaseous discharge tube 36 is reached after a predetermined period of time when tube 36 breaks down applying a positive impulse to the grid of thyatron 33 and causing thyatron 33 to fire and explode the projectile thereby causing its self-destruction after it has moved out of the target zone but before it approaches near enough to the earth to cause damage by its explosion.

In the embodiment of Fig. 20 it is seen that the gradual arming of the unit is effected by the relatively gradual heating of the filament of tube 88 in amplifier stage V3. Self-destruction of the unit in this embodiment is effected by the slow charging of condenser 38 and the sudden breakdown of gaseous discharge tube 36 as in the embodiment of Fig. 1, instead of by a timing gear mechanism as in the other specifically described embodiments. This embodiment is a relatively simple unit which includes all of the protective features of the other embodiments, among which features are protection against any number of accidental accelerations of short duration, gradual arming of the unit to prevent false firing due to unwanted transient voltages and self-destruction at a predetermined time after the unit has been armed providing it has not been fired previously by coming into proximity with a target.

The mechanical construction of switch 210 as already noted is illustrated in Figs. 21 to 27. Fig. 21 is a front view of the assembled switch showing particularly the arrangement of the contact members. Fig. 22 is a front view of the switch with the front plate and contact members removed to show the operating members. Fig. 23 is a top view of Fig. 21 which includes a top view of Fig. 22. The similarity of switch 210 to the acceleration unit 149 of switch 140 should be borne in mind as the description proceeds.

Referring now particularly to Figs. 21, 22 and 23, the inertia member 225 comprises a rotatable support member 226 to which are secured two stop members 227 and 228. The member 226 is supported on a shaft 229 having bearings in face plates 230 and 231. Integral with member 226 is a handle 232. A portion of the periphery of member 226 is provided with teeth 233 which engage

bars 234 on an escapement member 235 pivoted on shaft 236. In this embodiment, inertia member 225 is designed to rotate rapidly under the forces of acceleration when the switch is accelerated in the direction of the arrow in Fig. 22, obviating the need for an intermediate gear train to speed up the oscillation of escapement member 235. The inner stop member 227 includes a head 237 which provides the necessary additional mass required to produce the operating forces of acceleration during acceleration of the switch. In the normal or set position of switch 210, stop member 228 is stopped against the inner surface of enclosing plate 238 under pressure of helical spring 239, surrounding shaft 229 which tends to rotate inertia member 225 in a clockwise direction.

Stop members 227 and 228 control lever 240 which is supported on shaft 241. A helical spring 242 surrounding shaft 241 is connected at one end to lever 240 and at the other end to plate 231 and tensioned in such a way as to tend to rotate lever 240 in a counter-clockwise direction in Fig. 22. At the end of lever 240 remote from shaft 241, a roller 243 is mounted by means of a pin on lever 240. With the inertia member 225 in the position shown in Fig. 22, that is, in the set or normal unactuated position, the roller 243 rests against the inner curved surface of stop member 227 and holds the lever 240 from rotating under the tension of spring 242. Lever 240 is provided with a handle 244 which is used for moving lever 240 while resetting the switch 210.

Insulating disc 219 of switch 210 is secured rigidly to the shaft 241 in front of face plate 230, that is, on the side opposite to lever 240. Disc 219 carries the contact plates 211 and 212 which are secured to disc 219 as by riveting. Terminals 213 to 218 are secured separately to a ring of sheet insulation 245 as by riveting which sheet in turn is secured to the face plate 230 by screws. Contact plates 211 and 212 make sliding, non-chattering contact with the groups of terminals 213, 214, 215 and 216, 217, 218, respectively, as the shaft 241 rotates in a counter-clockwise direction carrying lever 240 and disc 219 around with it. Contact plates 211 and 212 are insulated from each other.

As hereinbefore noted, the normal or set position of the elements of switch 210 is illustrated in Figs. 20, 21 and 22. In this position all of the terminals 213 to 218 are insulated from each other and the photoelectric unit is deenergized so far as its operation in energizing load resistance 7 is concerned.

When the projectile to which the photoelectric unit is attached is projected toward the target zone, switch 210 is given a sustained acceleration in the direction of the straight arrows in Figs. 22 and 25. The tension on spring 239 and the adjustment of escapement 235 are such that the forces of acceleration acting on inertia member 225 at least during the early portion of such acceleration period will rotate inertia member 225 in a counter-clockwise direction until the handle 232 comes against stop pin 246 in Fig. 25. The positions of the inertia member 225, stop members 227 and 228 and lever 240 with the handle 232 against stop pin 236, are shown in Fig. 25. In this first operated position of switch 210, lever 240 under the pressure of spring 242 has been rotated in a counter-clockwise direction to engage the inner curved surface of stop member 228 after having been disengaged by the inner curved surface of stop member 227. Corresponding positions of contact plates 211 and 212 with respect to the terminals 213 to 218 are shown in Fig. 24. Contact plate 211 bridges terminals 213 and 214, and contact plate 212 bridges terminals 216 and 217.

When the acceleration of the projectile drops below a predetermined value, acceleration member 225 returns to its original position under pressure of spring 239. This second actuated position is shown in Fig. 27. Acceleration member 225 returns at a predetermined rate depending upon the tension of spring 239 and the adjust-

ment of escapement 235. Just before stop member 228 has reached its original position which is a predetermined period after the acceleration has dropped below a predetermined value, roller 243 is disengaged by stop 228 and lever 240 rotates in a counter-clockwise direction against stop pin 247. The corresponding positions of contact plates 211 and 212 with respect to terminals 213 to 218 are shown in Fig. 26. Contact plate 211 maintains the bridging of terminals 213 and 214 and additionally bridges these terminals and terminal 215. Contact plate 212 maintains the bridging of terminals 216 and 217 and additionally bridges these terminals and terminal 218.

In the process of setting switch 210 from the fully operated position, as shown in Fig. 27, handle 244 is first moved upward rotating lever 240 in a clockwise direction until roller 243 engages the outer curved surface of stop member 227. Handle 232 is then moved upward rotating inertia member 225 in a counter-clockwise direction until handle 232 engages stop pin 246. Handle 244 is then moved upward still farther, rotating lever 240 in a clockwise direction until handle 244 is stopped against cover plate 238. Handle 232 is then released and inertia member 255 returns to its original position as in Fig. 22 under pressure of spring 239. Handle 244 is finally released allowing spring 242 to rotate lever 240 in a counter-clockwise direction until stopped by roller 243 coming against the inner curved surface of stop member 227.

Referring now to Fig. 28 one form of encased photoelectric unit, according to this invention, comprises an annular lens 260 to which is secured a hollow metallic cylinder 261 through the intermediary of an externally threaded section of the lens and another hollow metallic cylinder 262 secured to the left-hand side of the lens by another externally threaded section of the lens. A stream-lined generally cylinder cup-shaped metallic member 263 is secured to cylinder 261 by a threaded connection to complete the casing. The lens 260, metallic cylinders 261 and 262 and the metallic member 263 form a container 264 for the photoelectric cell 5 and associated electrical apparatus including the amplifier and the switch unit 265. The amplifier unit 265 is secured to the face of the lens 260 within cylinder 261 by studs (not shown). The unit 265 carries a photoelectric cell guide 266 which fits into the central opening of the lens 260. The photoelectric cell 5 slides into this guide 266 against a stiff spring 267. The cell 5 is held in position against the spring 267 by insulator block 268. A rubber washer 269 is cemented to block 268. Block 268 is held between the lens 260 and an internal ridge 270 in cylinder 262. Output connectors 271 and 272 are mounted on block 268. It is thus seen that the lens 260 is the sole means for securing cylinders 261 and 262 in relative position with respect to each other. All of the surfaces of lens 260 except the external polished surface and internal polished ridged surface and the screw threads are coated with an opaque dull black weather-proof lacquer. The lens 260 will gather light from a given solid angle which light is transmitted through the polished surface of the inner ridge to the cathode of photoelectric cell 5. The battery unit 8 is supported within the casing member 263. The casing 264 is secured to the projectile by the internal threads on the left-hand end of casing member 262 and contact is made with the load resistance by contact terminals 271 and 272.

The masses of the inertia members, the tension of the springs and the adjustment of the escapements are dependent upon the time elements involved and the accelerations to which the switches are subjected both in ultimate use and prior handling. Certain data regarding the several specific embodiments of the invention which have been described hereinbefore, will now be given to enable persons skilled in this art to readily construct the devices. It is to be understood of course that this data

is merely illustrative and that the structures may be modified greatly dependent upon the conditions attendant upon their use.

In the embodiment illustrated in Figs. 1 to 5 the inner cylindrical metallic portion 67 of the inertia cam 50 is a brass cylinder $\frac{5}{8}$ inch long with pins 71 and 72 located $\frac{1}{8}$ inch off center. The cylindrical shell 68 is of phenol fibre which just fits over the metallic portion 67 and is $\frac{3}{4}$ inch outside diameter and $\frac{5}{8}$ inch long. The weight 18 secured to spring 66 is of brass $\frac{1}{2}$ inch by $\frac{1}{2}$ inch by $\frac{1}{8}$ inch thick. It is secured to the free end of spring 66 in such a position that it extends $\frac{3}{32}$ inch beyond the free end of the spring, the spring being of Phosphor bronze sheet $1\frac{1}{4}$ inches long by $\frac{1}{4}$ inch wide by 0.010 inch thick.

In the embodiment illustrated in Figs. 6 to 9 the inertia member 91 is of brass in the shape of a sector of an annulus 70 degrees long, $\frac{7}{16}$ inch outside radius, $\frac{1}{8}$ inch inside radius and $\frac{5}{16}$ inch thick. The inertia lock 111 is made of a piece of brass $\frac{1}{2}$ inch long, $\frac{3}{8}$ inch wide and $\frac{3}{16}$ inch thick. The inertia member 91 will operate through its cycle if subjected to forces of acceleration one hundred times gravity continuously applied for 0.1 second or longer, yet it will be safe from operation on an accidental bump producing a force on the inertia member 91 as great as one thousand times gravity lasting for about 0.001 second. The inertia lock 111 operates quickly to lock gear 108 when the force ceases. The values of one thousand times gravity and 0.001 second correspond roughly to the values encountered in dropping the device 16 feet and stopping it in a distance of $\frac{3}{16}$ inch.

In the embodiment illustrated in Figs. 10 to 19 the arcuate-shaped metallic member 156 of inertia member 155 is of brass $\frac{3}{32}$ inch thick having a $\frac{63}{64}$ inch outer radius, a $\frac{7}{32}$ inch inner radius and a length of 135 degrees except for a corner which is cut off at an angle of 45 degrees with the radius corresponding to the end of inner stop member 158 and starting at the outer surface of stop member 158. Stop member 158 is a sector of an annulus of brass 90 degrees long, $1\frac{3}{32}$ inch inner radius, $\frac{5}{8}$ inch outer radius and $\frac{1}{8}$ inch thick. Stop member 159 is a sector of an annulus of brass 40 degrees long, $\frac{25}{32}$ inch inner radius, $\frac{63}{64}$ inch outer radius and $\frac{1}{8}$ inch thick. The proximate ends of stop members 158 and 159 are angularly displaced five degrees. This inertia member 155 will operate on forces of acceleration 25 times gravity sustained for a period of 0.5 to 0.7 second to assume its first operated position. This switch will not operate under a force of fifteen times gravity or less no matter how long the force is sustained. The switch mechanism will not be injured on sustained accelerations as high as one hundred thirty times gravity.

In the embodiment illustrated in Figs. 20 to 27 the dimensions are such that the switch 210 will operate to its first operated position in 0.02 second to 0.05 second under forces of acceleration of 200 times gravity. It will be operated to its second actuated position in 0.10 second to 0.20 second from the time acceleration ceases. Forces of acceleration up to fifty times gravity will not operate the switch to its first actuated position no matter how long the force is sustained. Furthermore, the switch will not be injured if subjected to forces of acceleration up to one thousand times gravity for periods of 0.001 second nor will it be operated to its first operated position under the same forces no matter how many times such forces are applied.

Pentode tubes may be used in the circuit of Fig. 1 in place of the vacuum tubes shown for amplifier 6. Other types of vacuum tubes could be used in all of the circuits provided that the load resistance 7 is heated sufficiently to explode the projectile on an impulsive change of light on the photoelectric cell of the kind hereinbefore described. Pentode tubes for the amplifier and a thyratron tube for the last stage are preferred. As an indication

of the size of a typical photoelectric unit according to this invention it may be stated that the encased unit as illustrated in Fig. 28 is $3\frac{1}{4}$ inches in diameter and approximately $15\frac{1}{2}$ inches long over-all.

What is claimed is:

1. A switch adapted to be moved in a given direction with acceleration comprising a support, circuit controlling contacts mounted on said support, a member pivotally mounted on said support and adapted to have rotary movement about one axis only with respect to said support, the pivot being mounted to one side of the center of gravity of said member and outside the path traversed by the center of gravity when said switch is moved in said given direction, a stop for said pivotally mounted member positioned to hold said member stationary with respect to said support when said switch is moved in a direction opposite to said given direction, a resilient member restraining said pivotally mounted member against movement relative to said support, said pivotally mounted member having a mass sufficient to cause rotation of said member about said axis in opposition to said restraining member when said switch is moved with acceleration above a predetermined amount in said given direction, and means controlled by said member to operate said circuit controlling contacts upon rotation of said member about said pivot.

2. A switch adapted to be moved through space in a given direction with acceleration greater than that of gravity comprising a support, circuit controlling contacts mounted on said support, a member pivotally mounted on said support and adapted to have rotary movement about one axis only with respect to said support, the pivot being positioned to one side of the center of gravity of said member and outside the path traversed by the center of gravity when said switch is moved in said given direction, a stop for said pivotally mounted member positioned to hold said member stationary with respect to said support when said switch is moved in a direction opposite to said given direction, a resilient member restraining said pivotally mounted member against movement relative to said support, said pivotally mounted member having a mass sufficient to cause rotation of said member about said axis in opposition to said restraining member when said switch is accelerated above a predetermined amount greater than gravity in said given direction, and means controlled by said member upon rotation about said pivot to operate said circuit controlling contacts.

3. A switch adapted to be moved through space in a given direction with acceleration greater than that of gravity comprising a support, circuit controlling contacts mounted on said support, a member pivotally mounted on said support and adapted to have rotary movement about one axis only with respect to said support, the pivot being positioned to one side of the center of gravity of said member and outside the path traversed by the center of gravity when said switch is moved in said direction, a stop for said pivotally mounted member positioned to hold said member stationary with respect to said support when said switch is moved in a direction opposite to said given direction, a resilient member restraining said pivotally mounted member against movement relative to said support, said pivotally mounted member having a mass sufficient to cause rotation of said member about said axis in opposition to said restraining member when said switch is accelerated above a predetermined amount greater than gravity in said given direction, means operated by said member upon rotation about said pivot to operate said circuit controlling member, and means to maintain said pivotally mounted member in the rotated position.

4. Circuit control means comprising a gear train having a low speed gear and a high speed gear, an inertia member secured to said low speed gear in an off-center position, a pivoted inertia lock normally engaging said

high speed gear, a spring member secured to said low speed gear in a position to engage the teeth of said high speed gear to limit the travel of said gear train, a second spring driven escapement controlled gear train, means to lock one of the gears of said second gear train thereby preventing movement of said second gear train, and means to unlock said second gear train when said first gear train has moved to a certain position under forces of acceleration acting on said inertia member during acceleration of said device in a predetermined direction, and circuit control means operated by certain of said movable members.

5. Circuit control means comprising a toothed member driving an escapement mechanism, an inertia member secured to said toothed member, two stop members in the form of sectors of annuli of different diameters angularly displaced, a spring adapted to rotate said inertia member in a direction opposed to the rotation effected by forces of inertia as the device is accelerated in a predetermined direction above a predetermined value, a pivoted lever having a member adapted to be spring-pressed against one of said stop members in normal position of said inertia member, against another of said stop members in the position assumed under forces of acceleration acting continuously for a predetermined time interval and against the stop pin in the normal position which the inertia member assumes when the forces of inertia are reduced, and circuit control means operated by said pivoted lever.

6. Circuit control means comprising a toothed member driving an escapement mechanism, an inertia member secured to said toothed member, two stop members in the form of sectors of annuli of different diameters angularly displaced, a spring adapted to rotate said inertia member in a direction opposed to the rotation effected by forces of inertia as the device is accelerated in a predetermined direction above a predetermined value, a pivoted lever having a member adapted to be spring-pressed against one of said stop members in normal position of said inertia member, against another of said stop members in the position assumed under forces of acceleration acting continuously for a predetermined time interval and against the stop pin in the normal position which the inertia member assumes when the forces of inertia are reduced, and a sequence switch controlled by the rotation of said pivoted lever controlling the closure of contacts in sequence.

7. A switch adapted to be moved through space in a given direction with acceleration greater than that of gravity comprising a support, circuit controlling contacts mounted on said support, a member pivotally mounted on said support and adapted to have rotary movement about one axis only with respect to said support, the pivot being positioned to one side of the center of gravity of said member and outside the path traversed by the center of gravity when said switch is moved in said given direction, a stop for said pivotally mounted member positioned to hold said member stationary with respect to said support when said switch is moved in a direction opposite to said given direction, a resilient member adapted to oppose the movement of said pivotally mounted member relatively to said support, means to overcome the opposing action of said resilient member when said switch is accelerated in said given direction above a predetermined value greater than gravity effecting by the forces of acceleration rotation of said pivotally mounted member about said axis, and means controlled by said member upon rotation about said pivot to operate said circuit controlling contacts.

8. A circuit controlling arrangement comprising a set of circuit controlling contacts to be controlled, a second set of circuit controlling contacts, first means operated by forces of acceleration if greater than that of gravity to close both said sets of circuit controlling contacts, and second means to maintain said first set of

circuit controlling contacts closed under forces of deceleration equal to or less than that of gravity, said first means operating to open said second set of circuit controlling contacts when the forces of acceleration are reduced below the value of the closing forces.

9. Circuit control means comprising a pivoted inertia member rotatable by forces of acceleration against the tension of a spring whereby said member will rotate in one direction when its pivot support has accelerated translational movement and in the reverse direction when the acceleration is decreased, an escapement element driven by said inertia member for controlling the angular velocity of said member, a second pivoted member, a spring tending to rotate said second pivoted member, said inertia member engaging said second pivoted member to control movement of the latter preventing it from freely rotating under tension of said spring until said inertia member is rotationally displaced a predetermined amount from its initial position, then permitting it freely to rotate a fixed amount, then again preventing it from freely rotating until said inertia member is displaced to a predetermined position by reverse rotation thereof and then permitting said second member freely to rotate further, and a circuit control means operated by said second pivoted member.

10. An inertia arming device for use with a projectile subject to acceleration comprising a base, a switch mounted on said base and normally urged toward one

position, locking means mounted on said base for movement transverse of the direction of acceleration of the projectile to secure said switch in a second position, and means movable in response to continuous setback action upon sustained acceleration and including an element initially contacting and holding the locking means in its locking position but movable to release the locking means and thus release the switch.

11. An inertia arming device comprising a switch normally biased toward one position, a rotatable member, biasing means acting to turn said rotatable member in one direction, a weight off-centered on said member and responsive to setback to turn said member in the reverse direction under sustained acceleration, and locking means coacting with the rotatable member to hold the switch in a second position during a predetermined amount of reverse turning of the rotatable member.

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