Dec. 16, 1969 J. BROTHERS 3,483,821

STANDOFF FIRE-CONTROL SYSTEM (U)

Filed Nov. 4, 1966 4 Sheets-Sheet 1

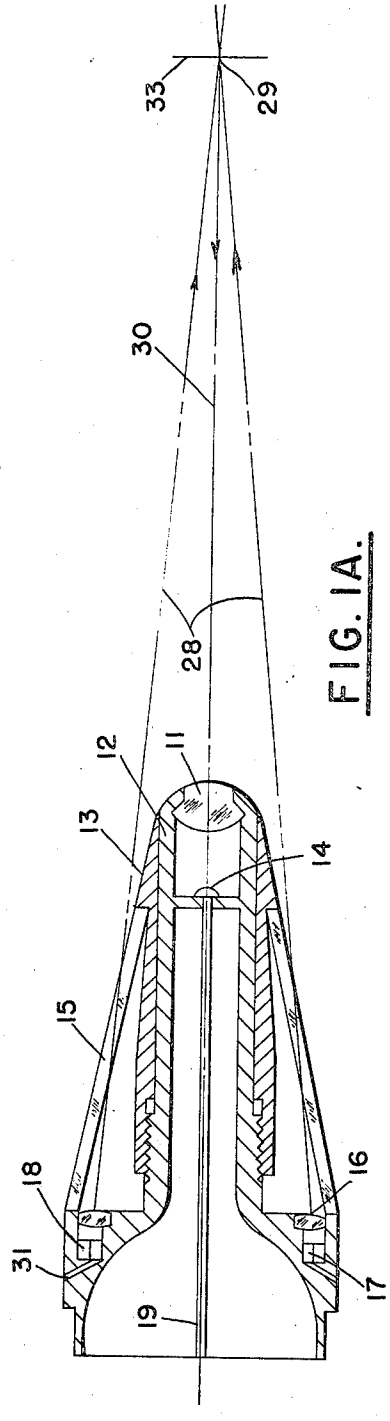



FIG. IA.

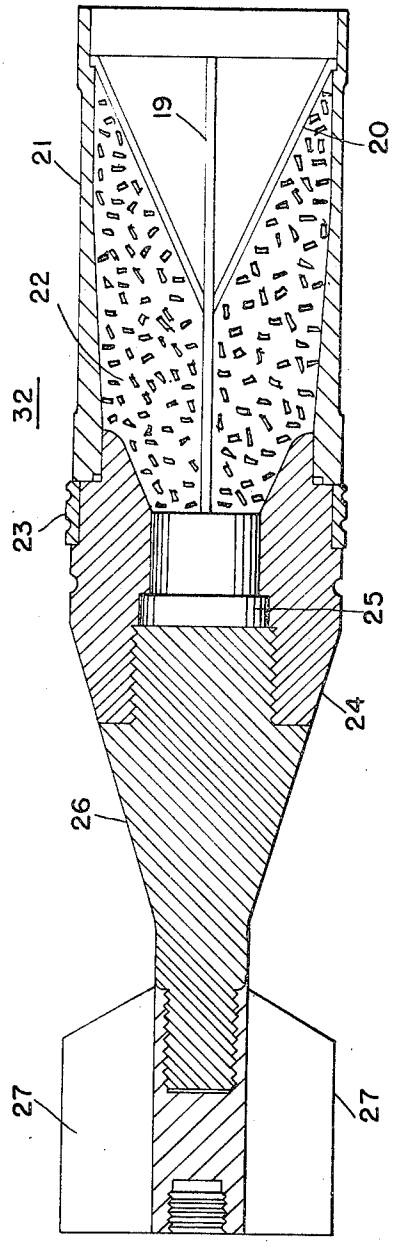



FIG. IB.

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STANDOFF FIRE-CONTROL SYSTEM (U)

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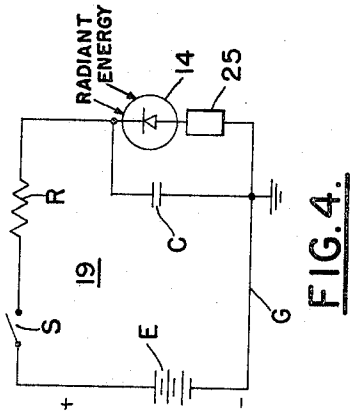



FIG. 4.

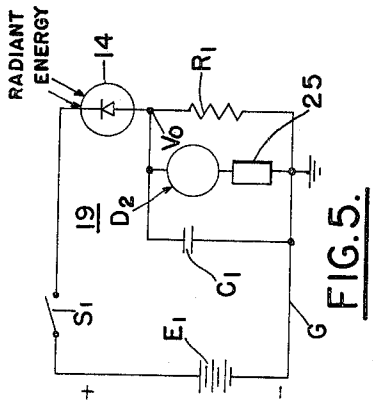



FIG. 5.

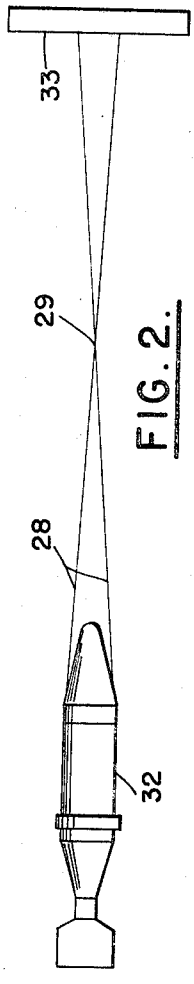



FIG. 2.

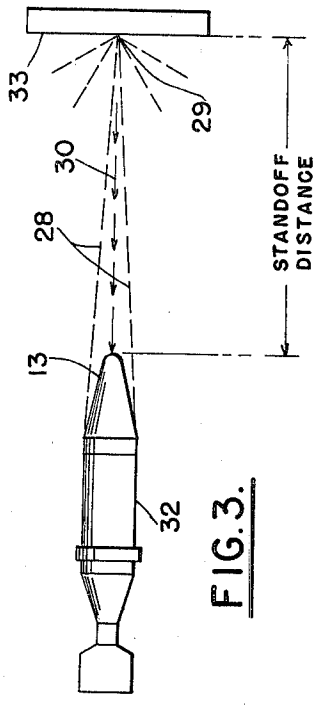



FIG. 3.

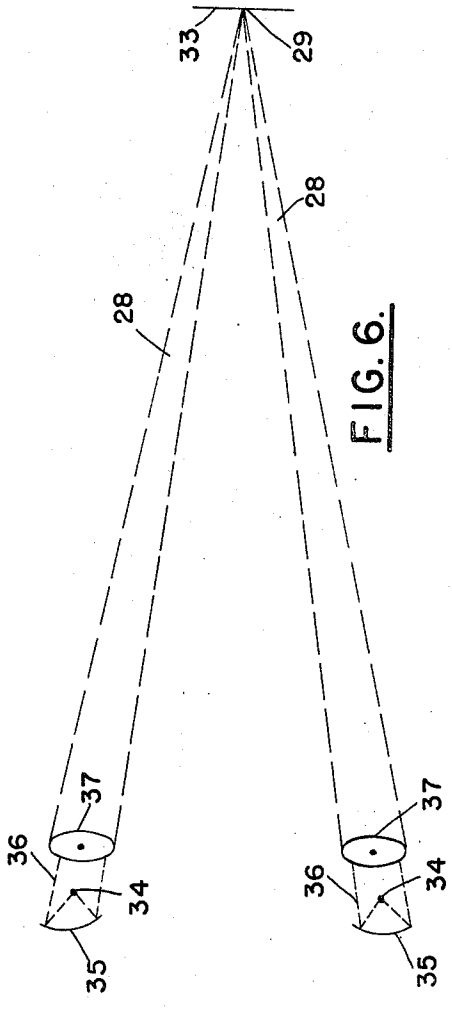



FIG. 6.

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STANDOFF FIRE-CONTROL SYSTEM (U)

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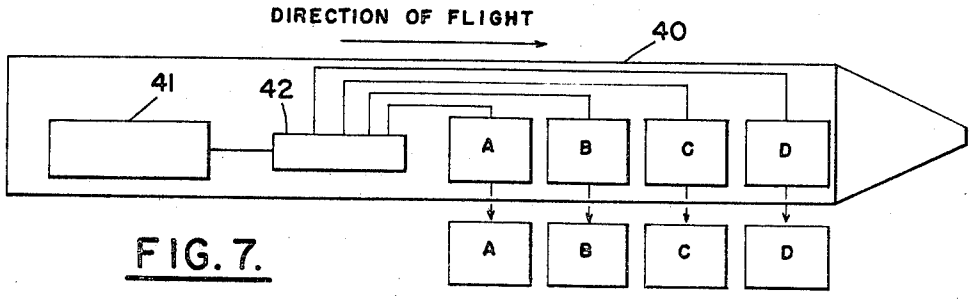



FIG. 7.

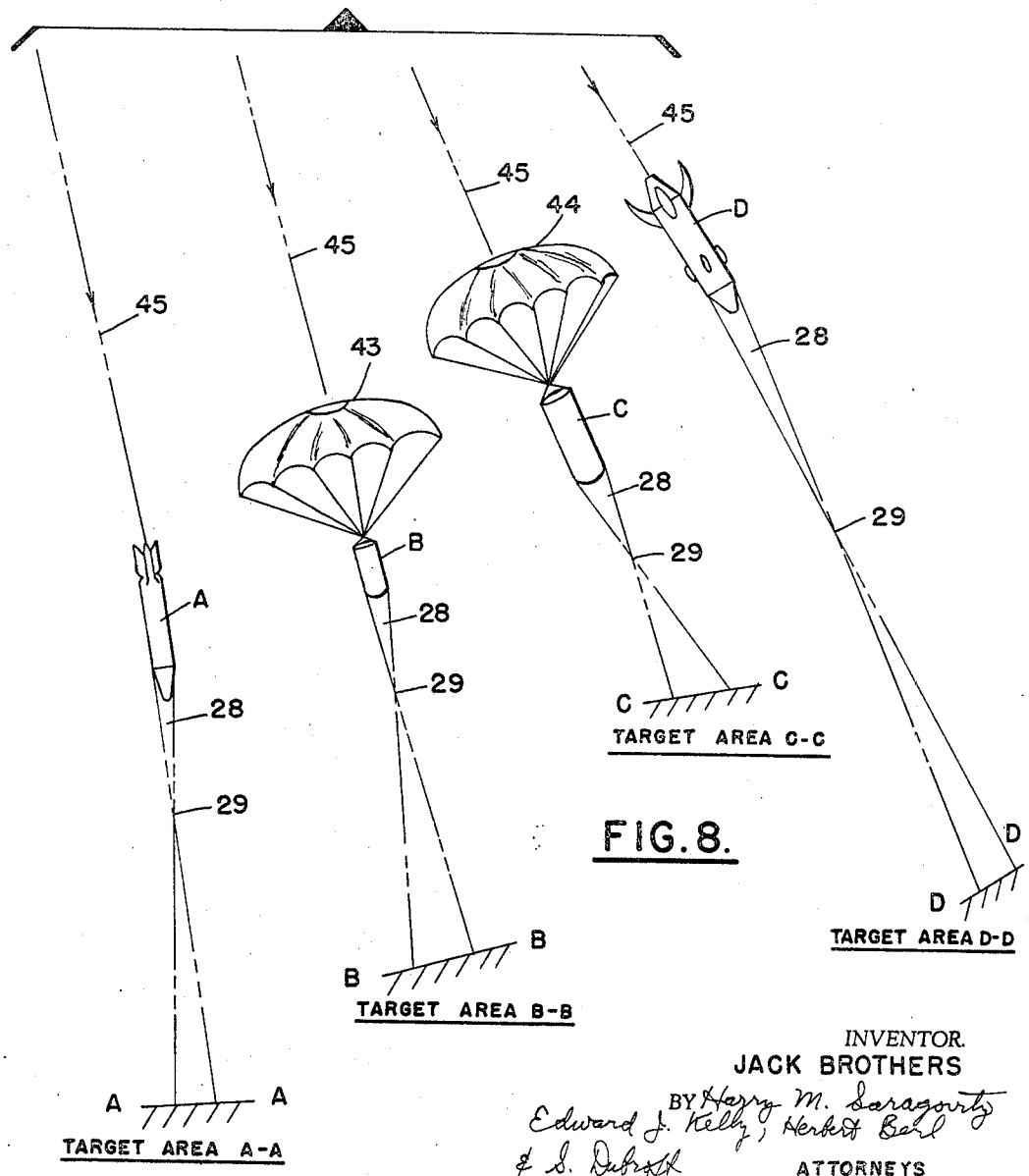



FIG. 8.

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STANDOFF FIRE-CONTROL SYSTEM (U)

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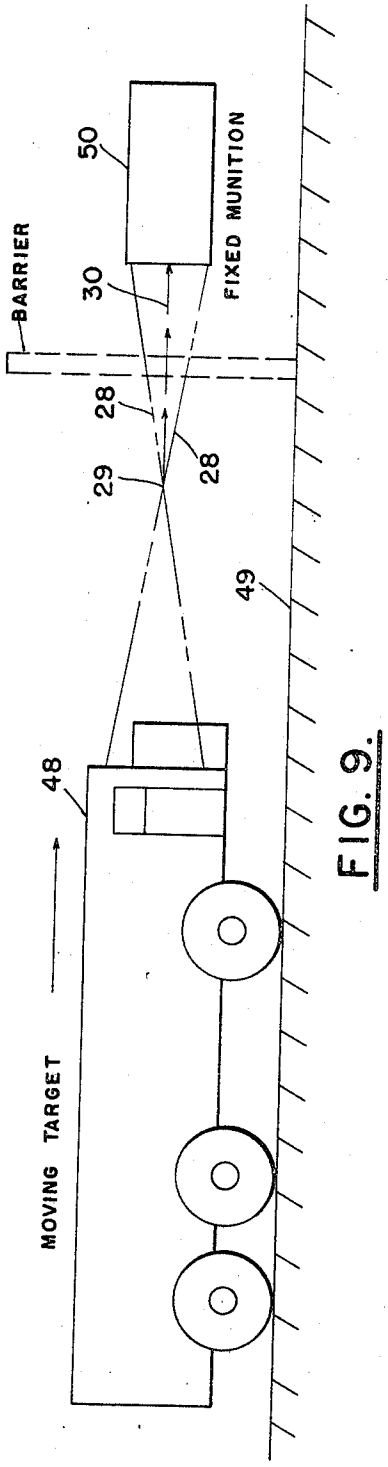



FIG. 9.

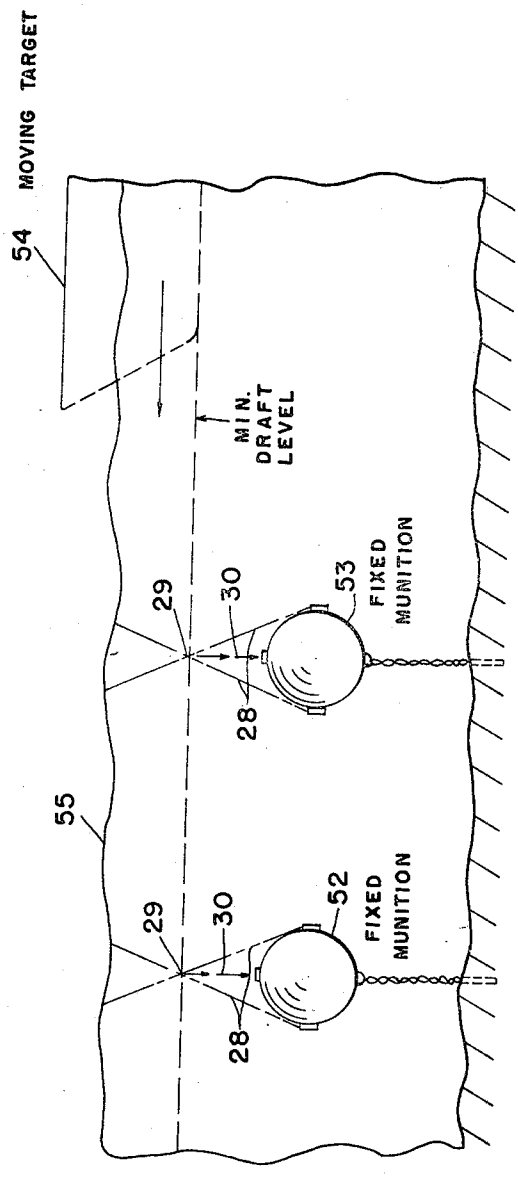



FIG. 10.

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United States Patent Office

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3,483,821

# STANDOFF FIRE-CONTROL SYSTEM (U)

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Int. Cl. F42c *13/02*

U.S. Cl. 102—70.2 2 Claims

## ABSTRACT OF THE DISCLOSURE

In a munition, such as a projectile, a forwardly-located annular pyrotechnic or high-intensity light source is placed behind an annular lens system for focusing and projecting a conical beam of light to a forward focus point that meets a target and reflects back high magnitude light energy. This is received in a centrally located diode-type detector which operates to fire the munition in response thereto, through a firing circuit which includes a diode gating means for discharging a firing capacitor therein.

The present invention relates to fire-control systems for munitions which may be fixed or movable in use, such as land and marine mines or projectiles and ballistic missiles.

More particularly, the present invention relates to fire-control systems of the above type which provide for functioning of the explosive trains of such munitions in predetermined spaced or standoff relation to the objectives or target areas therefor.

In the firing of different munitions in relation to different objectives or target areas it has been found that for best effects in each case, different standoff distances are required. Thus, it is desirable to provide for a wide range of standoff distances for such munitions which may vary, for example, between 15 and 40 feet or between a few inches or even less, to distances measurable in hundreds of feet.

It is, therefore an object of the present invention to provide an improved standoff fire-control system for various munitions of the type referred to, which not only permits a wide range of standoff distances to be set up, but which may be set at precise distances for improved functioning with each objective or target area.

It is also an object of the present invention to provide an improved standoff fire-control system of the above type which is adapted to use focused reflected radiant energy and which includes an optical system having focal points for said radiant energy which are readily selectable over a wide range of distances forward of the munition.

Thus a standoff fire-control system in accordance with the invention may have an optical system similar to the present day "Zoom" cameras which have an infinite number of focal points selectable over a relatively wide range, as is desirable in use with different munitions and objectives for best standoff distance in each case.

It is a still further object of this invention to provide an improved standoff fire-control system for use with ballistic vehicles or carriers of a plurality of ejectable loads of the explosive munition type to effect precise individual standoff adjustment thereof and functioning by forward and reflected radiant energy or light.

In accordance with the invention, the standoff functioning system provides radiant energy or light from single or multiple sources of various geometric shapes focused for a precise selected distance of the munition or missile from the target area or objective. The munition is fired when the focal point of the transmitted radiation reaches the said target area or objective, thereby reflecting back



to the missile or munition enough radiant energy to be detected and amplified to trigger or close a firing circuit.

The invention will further be understood from the following description of certain embodiments thereof, with reference to the accompanying drawings, and its scope is pointed out in the appended claims.

In the drawings, FIG. 1 (comprising FIGS. 1A and 1B) is a longitudinal view in cross-section, of a projectile embodying the standoff control system of the present invention,

FIGS. 2 and 3 are views of the projectile of FIG. 1 in flight toward a target with focused control beams of radiant energy in accordance with the invention,

FIGS. 4 and 5 are schematic diagrams of energy detectors and firing circuits adapted to operate or fire the projectile,

FIG. 6 is a schematic diagram showing an alternate source of radiant energy and means for focusing to effect standoff in accordance with the invention.

FIG. 7 is a diagrammatic representation of a space vehicle or carrier provided with a plurality of munitions to be dropped in timed sequence, each with standoff functioning in accordance with the invention,

FIG. 8 is a diagrammatic representation of the munitions of the space carrier of FIG. 7 in operation against different target objectives, and

FIGS. 9 and 10 are further diagrammatic representations of fixed munitions of the standoff type, in accordance with the invention, in operation against moving targets of different types.

Referring to the drawings, wherein like parts and elements are designated by like reference numerals and letters, and referring particularly to FIG. 1 (1A and 1B) the munition here is a projectile **32** or like space vehicle, showing the general construction and arrangement of major components. The radiant energy source used in the present example is pyrotechnic in nature as will be described. Therefore, to provide a central, forward, light receiving optical system on the central longitudinal axis of the projectile with the radiant energy source or generating means concentric therewith, was found to be a desirable arrangement for the radiant energy components. Thus the present optical system **11** is on the axis of the projectile in a central body extension **12** of the nose **13** of the projectile. A radiant energy detector or receiver **14** of the electronic type is located rearwardly of the optical system, as indicated, and connected with the internal electrical circuitry **19**.

The radially-outer radiant-energy transmitting means includes a suitable focusing lens **16** at the rear end of the nose cone, an initiating device **17** which may be mechanical, chemical or electrical, and a radiant-energy generator or transmitter **18**. In the present example, these are all annular in form. The forward nose assembly of FIG. 1A fits into the cylindrical rear or body portion **21** having an inner cone or wall for holding the explosive load **22**, an outer abdurator ring **23** and a base **24**. A tapered tail end or boom **26** is attached to the base **24** and carries the fin assembly **27** at the rear end of the projectile. Vent holes **31** are provided around the rear end of the nose cone **13** and a central fuze or detonator **25** is provided for firing the explosive charge **22**. Firing circuits for the fuze are considered hereinafter.

Referring now to FIGS. 2 and 3 along with FIG. 1, the projectile **32** approaching a target **33** projects radiation from the source **18** in a conical beam **28** which has a focal point **29** forward of the nose **13** by the desired standoff distance for the particular munition and target. Thus the distance between the projectile and the target is initially greater than the distance between the projectile and the focal point of transmitted radiation. It is to be

noted that in FIG. 2 the radiation is spread over a relatively large area and the energy reflected back toward the receiving lens of the projectile is of a low power per unit area. Therefore, the explosive train is not initiated.

When the projectile comes into the position shown in FIG. 1 and FIG. 3, the target **33** is at the focal point **29** of the transmitted energy or radiation. The energy **30** reflected back is then of relatively high power per unit area compared with that of FIG. 2 for example. The total power received by the receiving lens or optical system is dependent upon the power per unit area reflected by the target. Hence the receiver or detector **14** selected is one which is sensitive to the radiant power reflected by the target when the projectile is at the optimum standoff distance from the target.

While radiant energy in the infra-red region is at present considered and used, other suitable forms of radiant energy, such as light or a laser beam of high intensity or RF electrical energy, may be adapted and used in the present system.

Referring now to FIG. 4, the circuit **19** is one example of an electrical circuit adapted to be connected with the receiver or detector **14**. A low voltage source of direct current, such as a battery E, is connected through an inertial or set-back switch S and a series resistor R with a storage capacitor C which is connected with the source E through a grounded return conductor G. In parallel relation with the capacitor C is connected a series circuit comprising the fuze **25** and the detector **14**. The latter is a radiant-energy activated gate or rectifier connected in proper polarity relation to the capacitor to prevent current flow therefrom at low reflected energy levels.

Upon closing of the inertially-actuated switch S, on takeoff of the projectile, and arming of the fuze **25**, the supply voltage source E applies a trickle charge to the capacitor C through the resistor R. With insufficient radiant energy applied to the detector **14**, it is essentially an open circuit. When sufficient radiant energy is applied thereto, as in FIG. 3 for example, when the projectile reaches optimum standoff, the resistance drops to a low value and the charge on the capacitor C is discharged into the electric detonator or fuze **25** and initiates the explosive charge **22**. The resistor R reduces the rate of charge and also reduces the rate at which voltage is applied to the anode of the detector **14** when the switch S is closed suddenly, thereby preventing the detector from triggering prematurely.

Referring to FIG. 5, an alternative detector or receiver circuit is shown in a modification of the circuit of FIG. 4. Here the detector **14** is connected in series with the storage capacitor C so that when the switch S1 closes, a voltage Vo with respect to ground G builds up at the junction of the detector and capacitor. With an increase in the radiant energy received by the detector **14**, as when the optimum standoff distance is reached, the resistance of the detector deceases and the voltage Vo increases to a point where a second diode D2 in series with the detonator or fuze **25** conducts and the capacitor C discharges through the detonator and thereby functioning it. The second diode in the present example may be of the four-layer PNPN type.

Referring to FIG. 6 an alternative source of radiant energy such as an infra-red filament **34** on each side of the projectile or munition in place of the source **18**, is provided with a parabolic or like reflector or mirror **35** which projects the IR energy into two beams **36**. These are directed onto the focusing lenses **37** and thence into the focused beams **28** and onto the target **33** at the focal point **29** for reflection back at high energy levels as herein before described. The IR filament sources **34** may be a carbon or a tungsten filament or point heated to incandescence from any suitable current supply or battery (not shown). Although the elements **37** are multiple focusing lenses, the filament source **34** could be a simple geometric shape such as a circle, square, etc.

Thus the system of the present invention may be seen to have a new capability for achieving optimum effectiveness of a projectile of a given caliber with an external configuration which provides stability in flight and optimum cone angle and standoff distance when functioned. Optimum standoff is accomplished in the system of the present invention by proximity burst, instead of by physical contact as is commonly used.

In operation, when the projectile of FIG. 1 is fired, the following sequence of events takes place soon after it leaves the firing or launching means: (1) an electric primer or like device initiates the firing of the pyrotechnic source or generator **18**, (2) the focused radiation therefrom is continually projected into space ahead of the projectile (3) the fuze **25** is armed and (4) the switch S is closed to charge the firing capactor C. By the time the projectile has approached the target **32**, as shown in FIG. 2, it has been readied for functioning at maximum standoff as further indicated at **29**.

When the projectile reaches optimum standoff as shown in FIG. 3, that portion of the beam which is brought into focus at the surface **33** and reflected generally in the direction of the axis of the projectile and within the acceptance angle of the receiving lens **11** will be focused on the detector **14**. The detector **14** reacts to the radiation focused on it and triggers the circuit, spilling the charge stored in capacitor C into the load which is the electric detonator or fuze **25**. The fuze **25** functions, initiating the explosive charge **22** in the projectile. Approximately 50 microseconds pass between the time the projectile is at standoff distance **29** and functioning of explosive charge **22** takes place, without physical contact between projectile and target.

For the radiant energy sources **18** and **34**, a wide variety of known means are available, among which can be wires made incadescent by electric current, burning fuels such as coal powders, magnesium ribbons, or pyrotechnics as used in military operations. Mechanical, chemical and electrical sources are thus considered as hereinbefore explained.

For the detector **14**, innumerable detector devices can be used in combination with appropriate infra-red sources and optical systems. For example: if the IR source selected transmitted a 3.8 micron wavelength, a lead sulfide detector might be used at **14** in the electrical circuit shown in FIG. 4.

In addition to the foregoing uses of the standoff fire control system of the present invention it may be applied in FIG. 7, to a space vehicle or carrier **40** which has a plurality of payloads A, B, C, and D, a timer **41** and a dispatcher **42** for simultaneous or sequential dispatching of the payloads. The carrier **40** may be a plane of the fast moving bomber type in the present example.

Each of the payloads may thus be a warhead or the like carrying an explosive charge as in the case of the projectile of FIG. 1, and include standoff control means as in FIG. 1. These are ejected from the carrier as indicated and may be of different types, as shown in FIG. 8, where they are approaching selected target areas for functioning when the focal point **29** of the radiation beam **28** reaches these areas in each case and reflects back to the detector in each unit enough radiant energy to function the charge, as explained in the operation of the embodiment of FIG. 1. In the present case, target areas AA and DD are covered respectively by the warheads A and D as bombs, while the target areas BB and CC are covered by warheads B and C controlled by parachute devices **43** and **44** respectively.

The direction of fall of the four munitions A, B, C, and D are indicated by the dot and dash lines **45**, and show how the different units may disperse over a wide area to cover relatively widely-spaced target areas at different heights or levels in the terrain below.

In FIGS. 9 and 10 use is made of the system of the present invention to meet situations where the target or

objective moves and in which case the munition may be fixed in position to project the focal points out into the path of the said target or objective.

In FIG. 9 the target is a vehicle **48** moving along a roadway **49** approaching a concealed location of a munition **50** which is functioned as described hereinbefore when the vehicle reaches the focal point **29** and sends back reflected radiation along the path **30**.

In FIG. 10 emplaced marine mines **52** and **53** are anchored in a channel **55** below the maximum draft level of shipping **54** using the water way. Each mine is equipped with the standoff firing control system of the invention and provides the focal point **29** of the radiation beam at the above level.

The standoff fire control system of the present invention is thus adapted for many uses, such as those above pointed out. It is extremely useful for this because it is considered to be practically impossible to countermeasure by radiated energy. This is for the reason that a countermeasure, design to function the munition by radiated energy before it arrives at the target, would have to possess certain qualifications such as transmitted power level, wave length and optical alignment. Furthermore in order to trigger the circuit, as in FIG. 4, the countermeasure device must transmit an energy level which, when received by the munition would be at least equal to the energy level received thereby when normal transmitted energy is reflected back from the focal point **29**. Also, the countermeasuring device would have to possess the correct wavelength to which the detector **14** is sensitive, and it also would have to be practically aligned with both the focal point **29** and the receiving optics **11**.

Considering such a hypothetical case, let it be assumed that the wavelength the munition is transmitting has been discovered and that the counter-measuring device has infinite power because of unlimited size and that, therefore, it can qualify by transmitting sufficient radiant energy to trigger the detector. Having hurdled those two difficult obstacles an almost insurmountable third is the exact optical alignment, because the power plant of the counter-measure device would be relatively large and unwieldy, and the beam transmitted could be aligned only with an expected trajectory of the warhead. Therefore, the three qualifications which a counter measure device must meet are almost impossible to attain.

From the foregoing description of the present preferred embodiment of the invention and its adaptability to many uses, it will be seen that the system provides precise stand-off distances for functioning a munition with respect to an objective or target area by effective use of focused reflected radiant energy transmitted from and forward of the munition, in conjunction with self contained receiver means sensitive to the optimum value of the reflected energy, and electrical firing circuits connected therewith.

The operative elements are adapted to be housed in the relatively small space provided by the nose cone of a projectile or like munition and to direct the focused beam along the axis thereof. Optimum standoff is accomplished in the present system by proximity burst in place of physical contact which is presently used, and which requires a compromised standoff and cone angle.

I claim:

**1.** The combination with an explosive munition having a forward operating end, of a self-contained fire control system therefor comprising, light generating means adapted for optical control and in annular ring form in said forward operating end, means including an annular lens system forward of and adjacent to said generating means for directing and focusing light energy from said generating means forwardly from said munition in a central conical beam having a focus point spaced from said munition by a predetermined standoff distance in extension of the axis thereof, optical means in said operating end and on the central axis thereof for receiving reflected light energy from said focus point along said axis, light energy detector means of the diode rectifier type coupled to said optical means for conduction in response to said reflected light energy applied thereto at a relatively-high magnitude from said optical means in response to a target intercept with said focus point, means providing an explosive initiating train in said munition including an electric detonator, and a firing circuit for said detonator controlled by and connected with said detector means, said circuit including a firing capacitor and a parallel-connected leakage resistor therefor, charging means for said capacitor connected thereto serially through said detector means, and means including a series diode device providing a connection between said detonator and said capacitor for applying a charge from said capacitor through said detonator in response to activation of said detector means by received reflected light energy at said relatively-high magnitude from said focus point.

**2.** A standoff fire control system for an explosive munition, having a longitudinal axis comprising in combination, annular pyrotechnic light generating means adapted to be carried by said munition, means including an outer annular coaxial lens system for directing a conical light beam from said generating means to a focus point in extension of said axis forward of and in spaced relation to said munition, light receiving means including a receiving lens adapted to be carried by said munition and located centrally thereof in coaxial relation to said last named means for receiving light energy reflected generally in the direction of said axis and within the acceptance angle of the receiving lens from an intercepted objective at said focus point, said light generating and beam directing means being in close coupled relation for coaxial mounting with the light receiving means, an electrical detonator device for said munition, a diode-type detector in said light receiving means adapted to be activated by said reflected light energy and connected to control the firing of said detonator device, a firing capacitor connected to receive a charge through said detector during an interval before firing, and diode-type gating means completing a firing circuit through said detonator device from said charged capacitor and biased into conduction upon activation of the detector.

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