

Sept. 13, 1960

J. E. HENDERSON

2,952,778

FUZE

Original Filed Dec. 30, 1944

3 Sheets-Sheet 1

FIG. 1

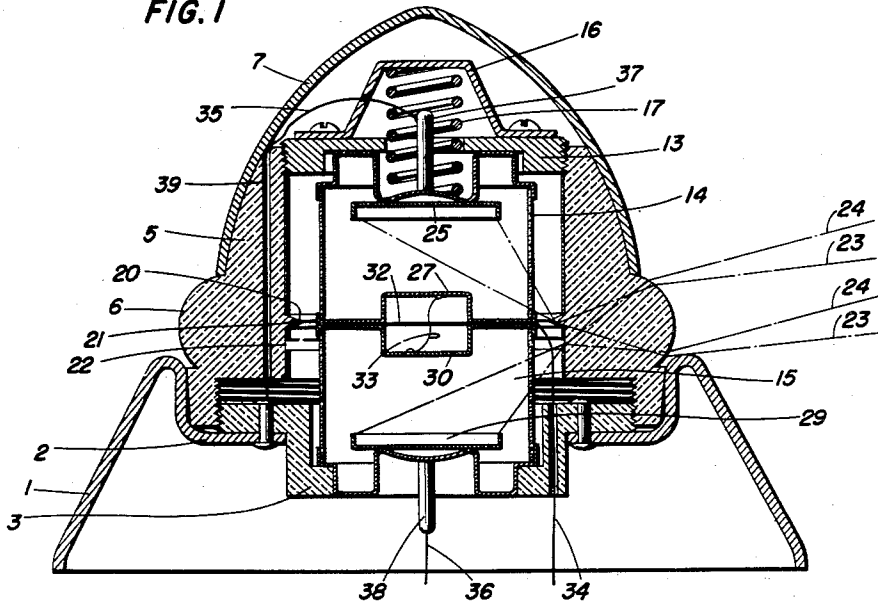
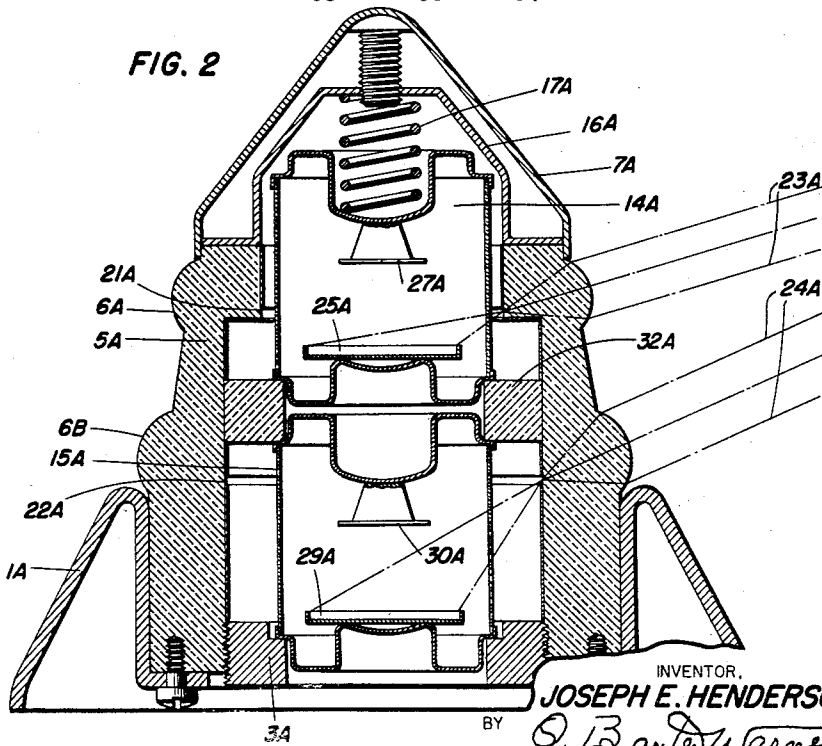


FIG. 2



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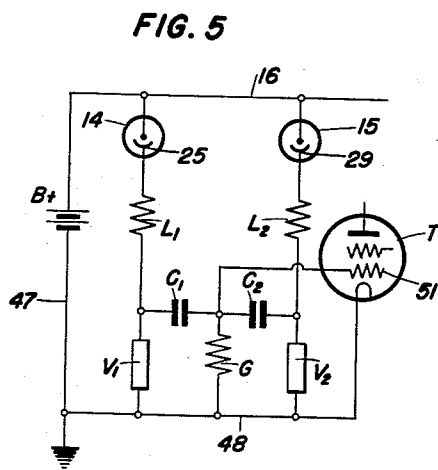
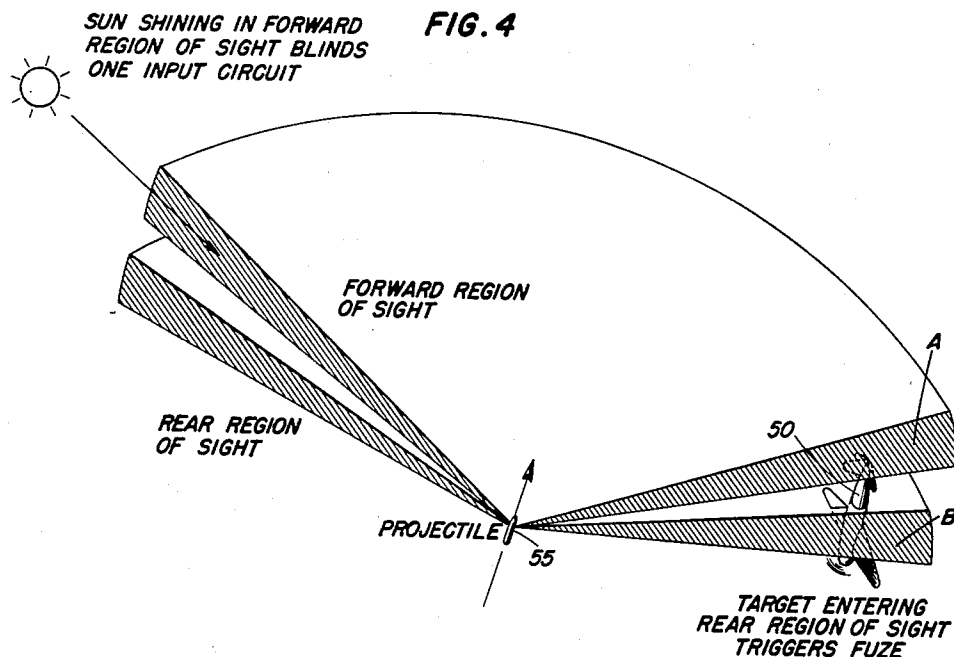
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FIG. 6

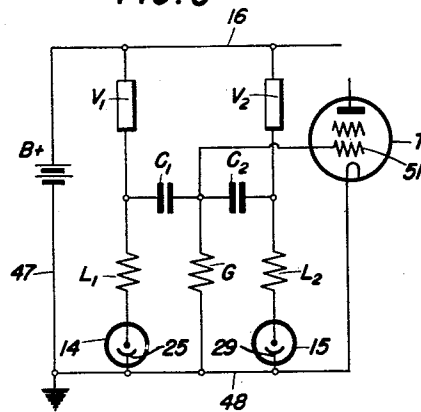
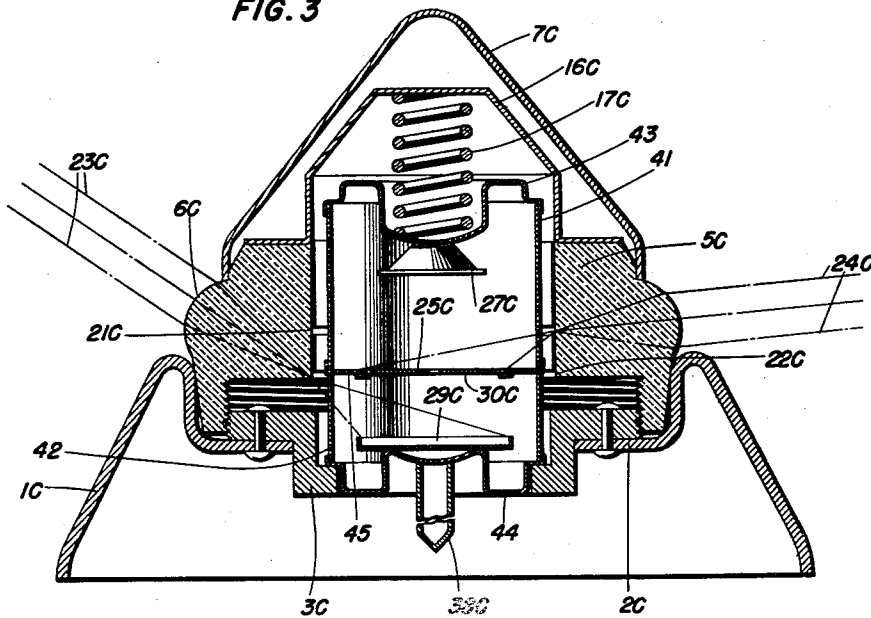


FIG. 3



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1

2,952,778

FUZE

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Original application Dec. 30, 1944, Ser. No. 570,689, now Patent No. 2,892,093, dated June 23, 1959. Divided and this application Mar. 16, 1954, Ser. No. 417,529

7 Claims. (Cl. 250—208)

This is a division of application of Joseph E. Henderson, Serial No. 570,689, filed December 30, 1944, now Patent No. 2,892,093, and entitled "Fuze."

This invention relates to photoelectric devices and more particularly light sensitive devices as they are used in light-responsive proximity fuzes, and constitutes a further development of the invention disclosed in copending application filed by me jointly with Laurence R. Hafstad and Richard B. Roberts, Serial No. 568,020, filed December 13, 1944, entitled "Fuze."

An important object of the invention is to provide an improved photoelectric device for use with a proximity fuze construction whose effectiveness is not destroyed when it is subjected to the direct rays of the sun or other intense illumination, and which will, even though (and while) subjected to such intense illumination, remain responsive to the relatively small light differences which occur when the fuze approaches a target.

Another object is to provide a photoelectric device with two photocells, each of which receives light from the same lens but at a different angle.

A further object is to provide a photoelectric device employing two lenses and two photocells, the "look forward" angle of each lens being different.

An additional object is to provide a novel photoelectric device for a light responsive proximity fuze having a double field of view, and to incorporate in the fuze operating characteristics such that the fuze will be fired when a target is viewed in either field, even though the other field may be temporarily inoperative.

Other objects will appear in the course of the following description, taken in conjunction with the drawings forming a part hereof, in which

Fig. 1 is a longitudinal part section of a photoelectric device constructed in accordance with the principles of the present invention;

Fig. 2 is a longitudinal part section of a somewhat modified construction of the device of Fig. 1 incorporating two lenses and two photocells;

Fig. 3 is a similar part sectional view of another modified construction;

Fig. 4 is a diagrammatic perspective representation of the look-forward zones of the double field-of-view of a fuze constructed in accordance with the present invention, illustrating the operative relationship of such fields with respect to the sun and a target (shown as an airplane);

Fig. 5 is a circuit diagram suitable for use with the device of the present invention showing a parallel input circuit for two photocells, as used in a fuze of the indicated character, the input circuit being arranged in such fashion as to be adapted to feed a one stage amplifier; and

Fig. 6 is a schematic diagram equivalent to Fig. 5, but showing the present invention in connection with an input circuit arranged to feed a two stage amplifier.

Referring now to the drawings, the mechanical arrangement of the parts shown in Fig. 1 will be seen to

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be essentially similar to that disclosed in the aforementioned copending application. The fuze casing 1, formed of sheet metal, is inwardly flanged at 2 at its forward end to carry the optical and related portions of the fuze mechanism with which the present invention is concerned. A supporting ring 3 is riveted to the flange. Threadedly attached to the ring 3 and projecting forwardly therefrom is a tubular extension 5 formed of transparent plastic and having a partly toroidal lens surface 6. Extension 5 constitutes a housing for the photocells 14, 15 and related parts. In the respects thus far outlined the parts will be recognized as corresponding to those disclosed in said copending application.

The extension 5 serves as a structural element as well as an optical element. The nose cap 7 is cemented or otherwise exteriorly mounted upon its forward extremity in a rigid manner to complete the fuze enclosure. Female threads are formed in the forward end of the extension to receive the cap ring 13 which retains the photocells 14, 15, housed therein. A crowned cap 16 of sheet metal is mounted over the opening in the cap ring, these parts being united by screws (undesigned). The crowned cap serves as a nose shield and as an abutment and retainer for spring 17, which prevents vibration of the photocells and takes up any clearance therebetween. Formed integrally with the plastic extension 5 and positioned to receive light rays entering the lens from any angle within a predetermined angular range is an inwardly projecting portion 20 of annular form and wedge-shaped cross section whose lower surface is adapted to serve as a reflector, portion 20 thus constituting an annular prism.

The interior surface of the plastic extension is masked with opaque paint or the like except in the slit-like unpainted areas 21, 22, the former positioned to admit light from the reflecting surface of the prism section 20 when such light enters from any angle within the limits indicated by the lines 23—23. Light rays thus admitted are totally reflected upwardly (by inward reflection from the bottom surface of annular prism 20) through the sidewall of forward photocell 14, to impinge the plane cathode 25 of that cell. The light is refracted in passing through the upper surface of the wedge-shaped reflector portion 20. The rear of such reflector portion will be seen to comprise the slit-forming unpainted area 21. The anode of photocell 14 is indicated at 27.

The similar photocell 15 also has a plane cathode 29, which may be of disc or other suitable shape, its anode 30 being similar to anode 27. Cells 14 and 15 are of the special rugged design disclosed in copending application Serial No. 570,691 filed by me jointly with Charles C. Lauritsen and Laurence R. Hafstad, under date of December 30, 1944, and now abandoned, entitled "Rugged Phototube," but are shortened to be even more rugged, as well as to facilitate placing the cathodes relatively close together so that light passing through a single lens can be readily directed upon the two cathodes.

Light rays striking lens 6 at any angle between the limits indicated by lines 24—24, are directed by the lens and slit 22 upon the surface of cathode 29. A metal disc 32 separates the cells to act as a light screen. This ensures separation of the two beams of light so that light from only one beam will strike the cathode of a given photocell. Anodes 27, 30 are connected in parallel, either through the common metal plate 32 or by means of a wire as 33. A suitable lead 34, connected to disc 32 and thereby to both anodes, is brought out for connection in a suitable circuit, and leads 35, 36 are connected to the metal exhaust tubes 37, 38 to provide connections to the cathodes 25, 29, respectively, lead 35 being brought to the rear through a bore 39 in the extension 5.

An alternative construction, using two lenses instead

of one, is shown in Fig. 2. The top assembly of this photoelectric device, including spring 17A, nose shield 16A and nose cap 7A is substantially the same as that shown and described in the previously filed application first above-mentioned, and will be seen to be functionally equivalent to the corresponding parts of the embodiment of Fig. 1 hereof. In this case, however, two integrally molded toroidal lens portions 6A, 6B are formed upon the transparent extension 5A, of "Lucite" or similar material, and two photocells 14a, 15a are arranged in the fuze in a tandem arrangement as shown. These photocells are also of the rugged cartridge type, having metal end caps serving as supports for and as connectors to the anodes 27A and 30A respectively and the cathodes 25A and 29A respectively. Insulating ring 32A is axially slidable in the cylindrical interior of the lens body and serves as a spacer between the two photocells, which are retained and urged thereagainst by spring 17A and threaded ring 3A, the latter screwed into the extension body 5A. Suitable connections or leads are similarly provided. The lens extension, as shown, is fastened to the fuze casing 1A by means of screws (undesignated).

The inner surface of the double lens extension sleeve 5A is opaque except for circular transparent slits 21A and 22A through which light rays within zones 23A—23A and 24A—24A are respectively directed by the portions 6A, 6B. As shown, the look-forward angle of the leading lens-slit combination may be about 15°, and that of the rear lens-slit combination about 23°, although this may of course be varied at will, the angles chosen being determined by the velocity and the fragment velocity characteristics of the particular projectile.

In the further modification illustrated in Fig. 3, a double field of view is attained with a single lens and two slits, analogously to the arrangement of the embodiment first described, but a single special phototube is used having two cathodes, 25C, 29C, and two anodes, 27C, 30C, within a single envelope. The envelope is defined by two coaxial glass tube sections 41, 42, forming a single enclosure whose ends are defined by sheet metal caps, 43, 44. A cathode 29C is carried by the rear cap 44 and an anode 27C by the forward cap, also in similar fashion, but these elements do not cooperate with one another. A centrally perforate web or partition 45 extends across the interior of the cell, being held between and serving to align the abutting ends of the tubing sections 41, 42. A light-sensitive cathode surface 25C is formed on the forward or upper surface of the web to cooperate with anode 27C, while the lower surface of the web acts as an anode for cooperation with cathode 29C. In order to permit using a circuit such as disclosed herein, the web 45 must be formed of insulating material, with separately applied anode and cathode surfaces. Alternatively, a circuit such as one of those disclosed in the copending application of Thomas M. Marion and John F. Streib, Serial No. 575,108, filed January 29, 1945, now Patent No. 2,927,213, may be used, in which event, the photocells being in series, a simple metallic web may be used, which thus furnishes electrical connection between the anode and cathode portions carried by its opposite sides. Other parts analogous to those already described are designated by like reference characters, distinguished by the addition of the letter "C" to each, and require no detailed redescription.

In operation, with either the single lens of Figures 1 and 3 or the double lens of Fig. 2, if the sun or other bright source directs strong light upon one photocell cathode, to "blind" it, i.e., more or less to short circuit it, then due to the difference of the look-forward angles and the narrow zones of light transmission, the other photocell will still be effective to make the fuze sensitive to small light changes.

The separation of the two zones of light transmission or "sight" is clearly shown in Fig. 4, which illustrates

a projectile traveling somewhere between the sun and an airplane target. If the forward zone of sight, A, receives direct rays of the sun, the rear zone of sight B is still effective in responding to a change of light produced by airplane 50 when projectile 55 passes near it.

The circuits shown in Figs. 5 and 6 illustrate suitable methods of connecting the photoelectric elements with respect to the input circuit of a thermionic amplifier, whose electron tube T is adapted to feed additional elements forming no part of the present invention and by means of which the explosive contents of the projectile are adapted to be detonated when a pulsation or current variation of greater than a predetermined magnitude is created by actuation of one of the photocells. For the purpose of detonating the charge, the output of the photocell circuit may of course be amplified in any suitable manner, and the circuits of Figs. 5 and 6 accordingly show only the first stage of an amplifier arrangement corresponding to that disclosed in the copending application first above-mentioned.

In Fig. 5, photocells 14 and 15 have their anodes connected in parallel by conductor 16, which is connected to the positive terminal of battery or other potential source B, the negative terminal of which is grounded through conductor 47 to which one terminal of nonlinear impedance V1 is connected. The other terminal of this impedance is connected to cathode 25 of photocell 14, through resistance or impedance L1 connected in series. Similarly, cathode 29 of photocell 15 is connected to one terminal of nonlinear resistor or impedance, V2, through series-connected resistance or impedance L2. The other terminal of nonlinear resistor V2 is connected to resistor V1 and ground, by means of conductor 48, the photocells thus being connected in parallel.

Potential fluctuations across resistance V1 are impressed upon grid 51 of tube T by means of condenser C1 connected as shown. Similarly, potential fluctuations across resistor V2 are impressed upon grid 51 by means of condenser C2, one terminal of which is connected to a terminal of condenser C1, the other terminals of the two condensers being connected to the respective resistors as indicated. Grid leak G is provided in the usual manner.

In operation, the photocells 14 and 15 will usually be approximately equally illuminated so that a sudden fluctuation of light intensity impressed upon either cell will result in a voltage pulse across the corresponding resistor which is coupled to the grid of tube T by the associated condenser. If, however, one photocell is subjected to very strong light, so that it is effectively short circuited due to copious electron emission, and if the other photocell is normally illuminated, then the latter photocell can still produce a pulse in the grid circuit due to a fluctuation of light intensity. This is possible since the limiting resistance or impedance (L1 or L2) in series with the flooded photocell prevents the signal from being short circuited through the connected cell. These impedances, by limiting the steady current flowing through the nonlinear resistors, also serve to maintain the differential impedance of the nonlinear resistors at a high value, thus preventing the signal from being short circuited through the nonlinear resistor connected with the flooded photocell.

Analysis and experiment indicate that with the two photocells equally illuminated the sensitivity of the circuit is about one-half that of the corresponding input circuit using a single cell as disclosed in the prior application first above referred to. If one photocell is flooded the sensitivity of the operative part of the circuit is still slightly lower. This loss of sensitivity can be compensated for, if desired, by the use of a two stage amplifier. In this case, as shown in Fig. 6, the nonlinear resistors V1 and V2 and photocells 14 and 15 are reversed in position with respect to grid 51 to compensate for the 180° phase shift of the additional amplifier

stage. This is to ensure that the device will operate on a pulse caused by a decrease of light, since it has been found that greater sensitivity is obtainable in this way.

While it will be apparent that the preferred embodiments of my invention herein described are well calculated adequately to fulfill the objects and advantages first above-stated, it will be apparent that the invention is susceptible to variation, modification and change within the spirit and scope of the subjoined claims.

I claim:

1. A double photocell construction for controlling the action of a photoelectric fuze or the like, comprising a pair of substantially cylindrical envelopes, each having metallic caps at its opposite ends, photoelectric elements carried by said caps, said cells being arranged in substantial axial alignment and abutting relationship with the abutting end caps thereof electrically connected to one another.

2. A double photocell construction comprising an envelope having a transverse partition, a light-sensitive cathode portion carried by one side of said partition, an anode portion carried by the other side of said partition, and additional anode and cathode portions within said envelope on opposite sides of said partition and spaced from said first-mentioned cathode and anode portions respectively.

3. A double photocell construction as set forth in claim 2 in which said envelope comprises a substantially cylindrical open-ended translucent tube, metallic end caps sealed to said tube and closing the ends of the envelopes, the second-mentioned, spaced anode and cathode portions being carried by said end caps.

4. A double photocell construction for controlling the action of a photoelectric fuze or the like, comprising a pair of envelopes, a pair of photoelectric elements sealed within said envelopes, sealing means on the opposite end of each of said envelopes, said cells being in substantial axial alignment and abutting relationship with the abutting end sealing means thereof electrically connected to one another, and toroidal light directing means for said cells.

5. A double photocell construction for controlling the action of a fuze projectile comprising a pair of envelopes, each having caps composed of metallic material disposed at the opposite ends thereof, a plurality of photoelectric elements carried by said caps, said cells being arranged in substantial axial alignment and abutting relationship with the abutting end caps thereof electrically connected to one another, means for directing light from a given direction against one of said photoelectric elements thereby to effect operation thereof, and additional means for directing light from another direction against another of said photoelectric elements thereby to effect operation thereof.

6. A double photocell construction for controlling the action of a photoelectric fuze projectile comprising a casing, a pair of envelopes disposed within and carried by said casing, photosensitive means sealed within said envelopes comprising a plurality of photocathodes and anode means associated with the cathodes, first means carried by said casing and including a lens for directing light from a predetermined angular direction with respect to the longitudinal axis of the projectile on one of said photocathodes, second means carried by the casing and including a second lens for directing light from a different angular direction with respect to the longitudinal axis of the projectile on another of the photocathodes.

7. A double photocell construction comprising an envelope, a transverse partition in said envelope, a light sensitive cathode element carried by one side of said partition, an anode element carried by the other of said partition, additional anode and cathode elements within said envelope on opposite sides of said partition and spaced from said first named cathode and anode elements respectively, means including an annular transparent element for directing light from a given direction against one of said cathode elements, and means including a second annular transparent element for directing light from another direction against said additional cathode.

No references cited.