FLASHBLINDNESS PROTECTIVE APPARATUS

Original Filed Jan. 15, 1962 8 Sheets-Sheet 1

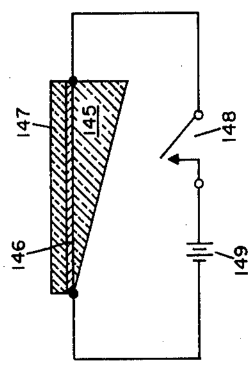

FIG. 16

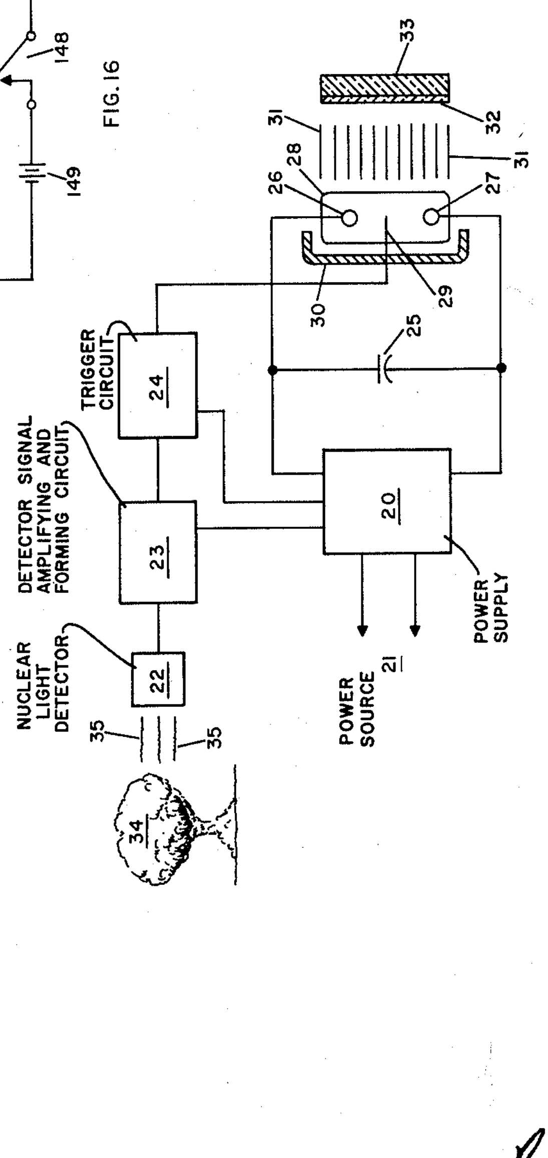

FIG. 1

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FLASHBLINDNESS PROTECTIVE APPARATUS

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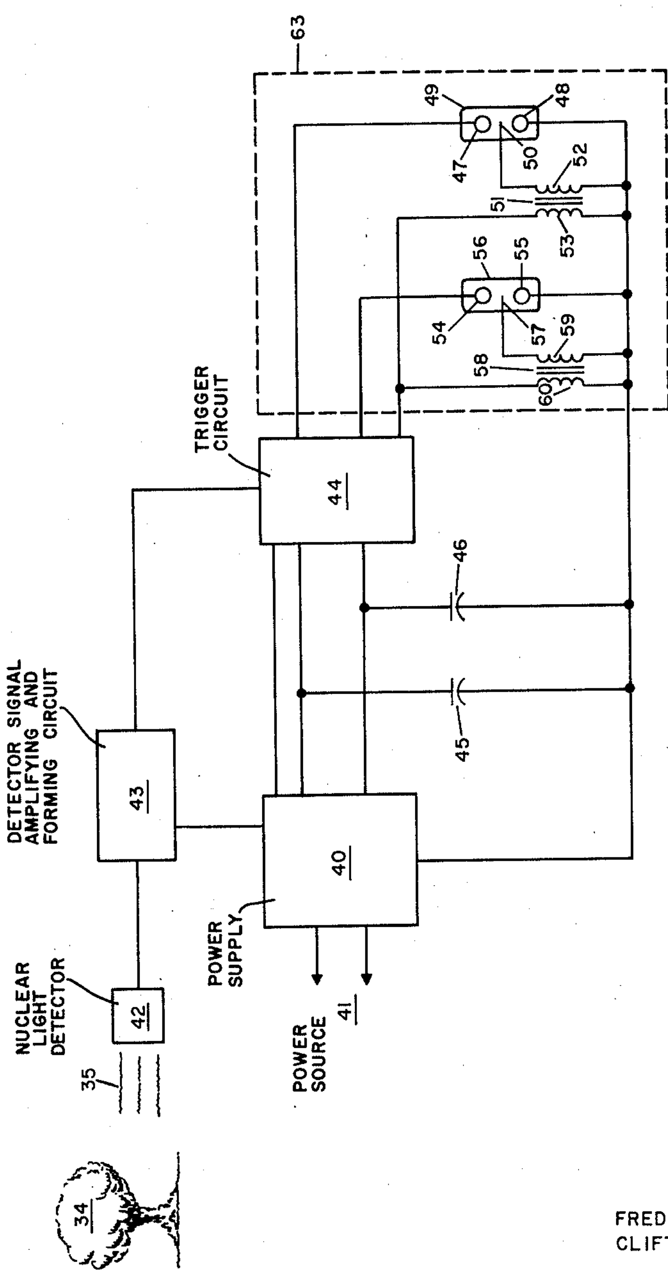

FIG. 2

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Oct. 6, 1964 F. E. BARSTOW ETAL 3,152,215

FLASHBLINDNESS PROTECTIVE APPARATUS

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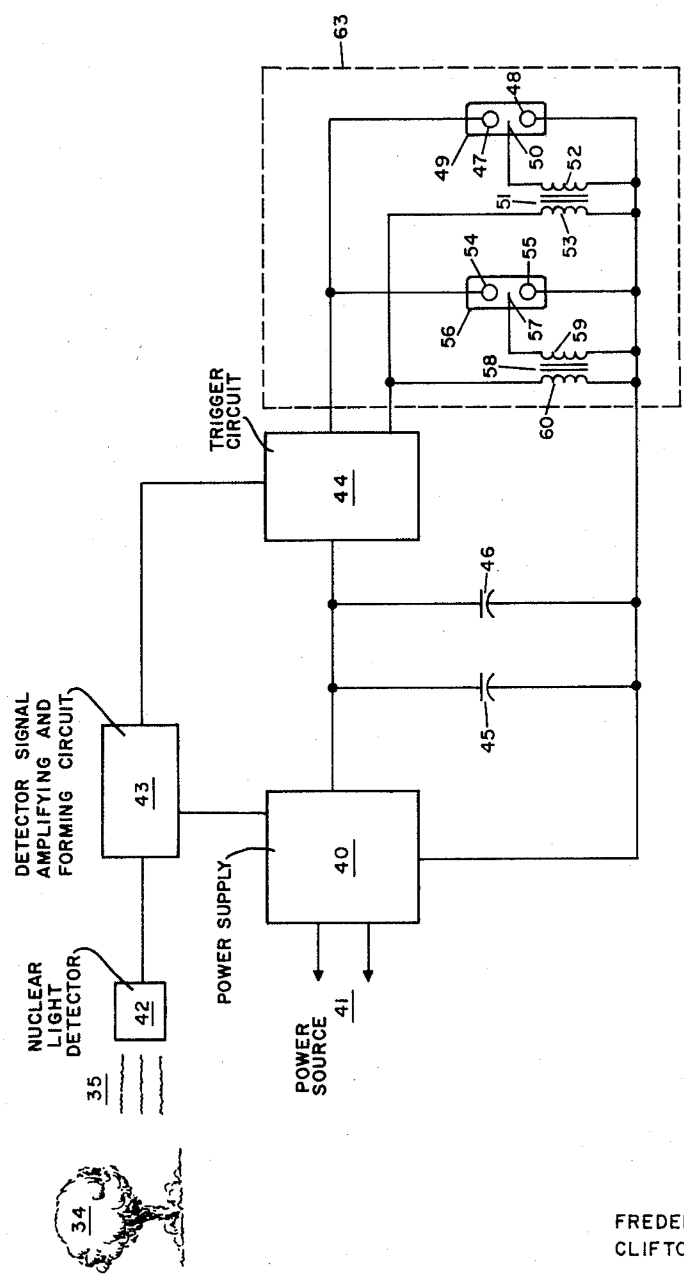

FIG. 3

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FLASHBLINDNESS PROTECTIVE APPARATUS

Original Filed Jan. 15, 1962 8 Sheets-Sheet 4

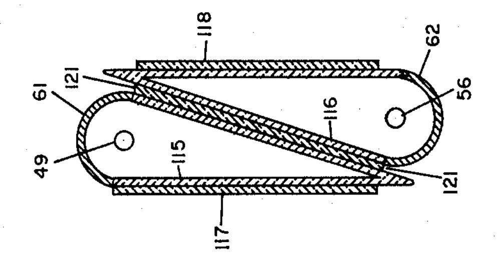

FIG. 6

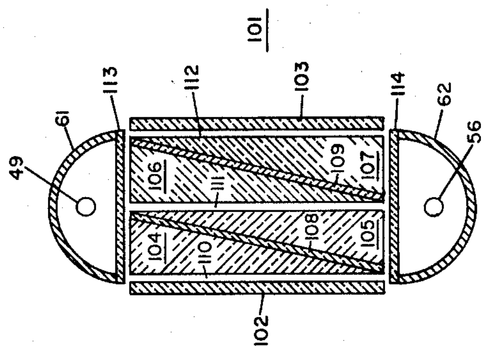

FIG. 5

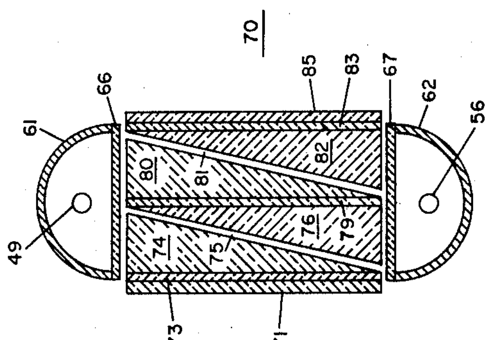

FIG. 4

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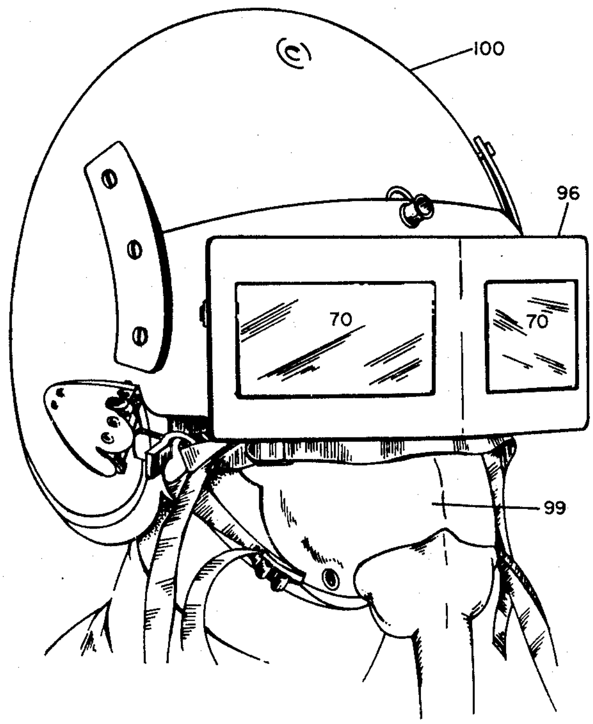

FIG. 7

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FLASHBLINDNESS PROTECTIVE APPARATUS

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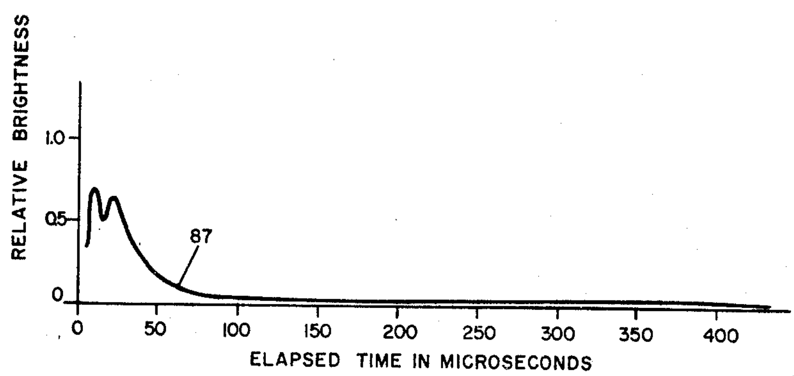

FIG. 9

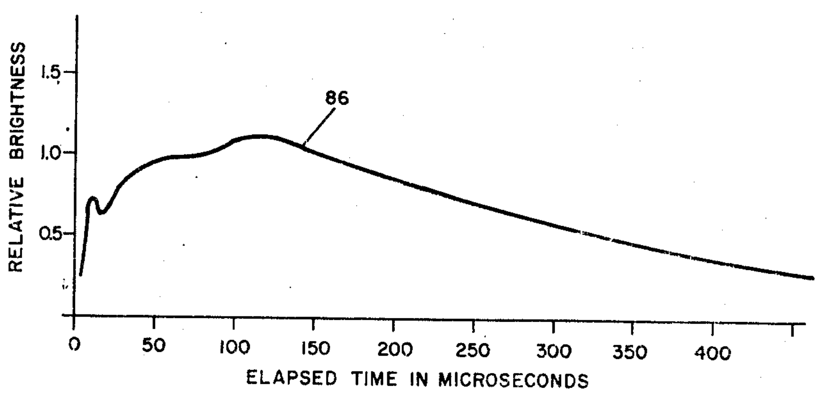

FIG. 8

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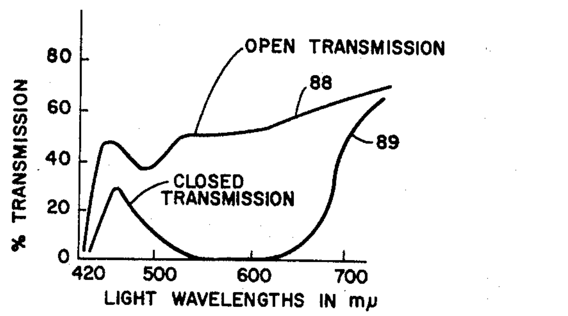
FIG.10



SIDEBAND FILTERS 71 AND 85 REMOVED FROM LENS SYSTEM 70 OF FIG.4

FIG.11

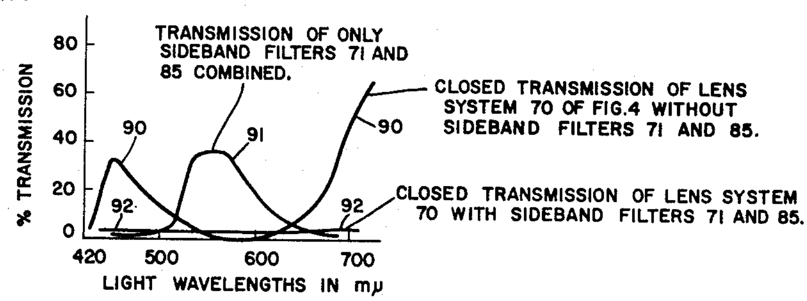
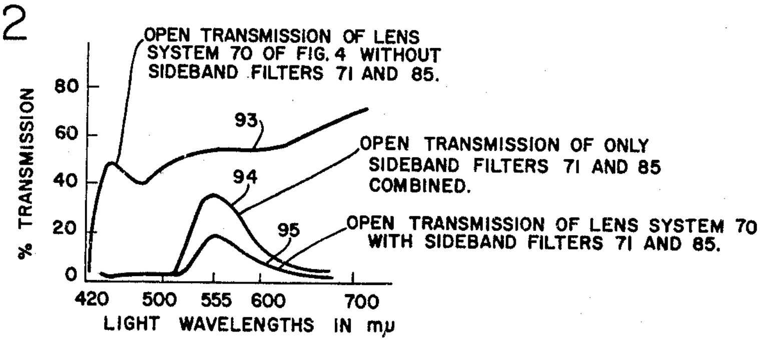


FIG.12



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FLASHBLINDNESS PROTECTIVE APPARATUS

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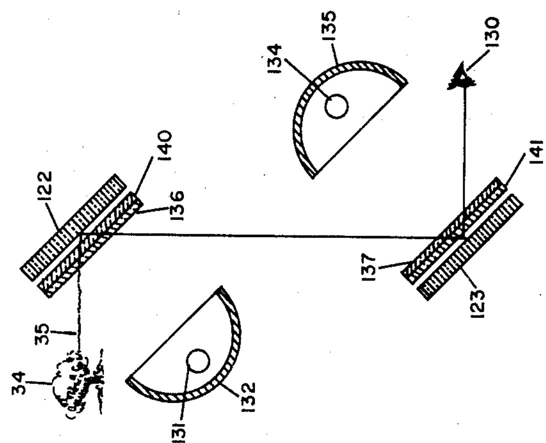

FIG. 15

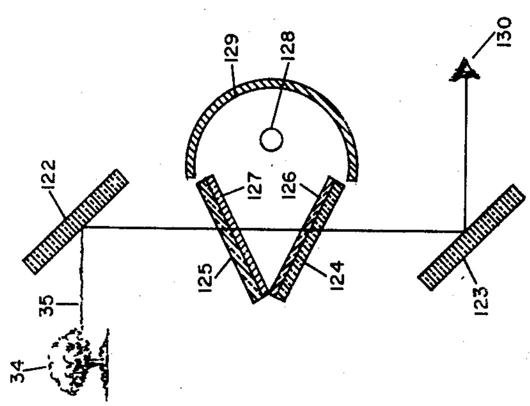

FIG. 14

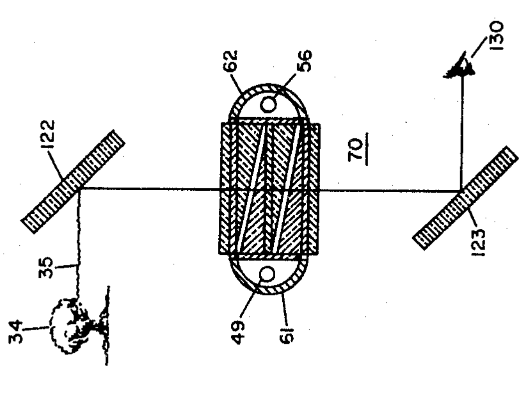

FIG. 13

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United States Patent Office

3,152,215
Patented Oct. 6, 1964

3,152,215

FLASHBLINDNESS PROTECTIVE APPARATUS

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Continuation of application Ser. No. 166,195, Jan. 15, 1962. This application Oct. 3, 1963, Ser. No. 318,773
30 Claims. (Cl. 88—61)

Our invention relates to apparatus for preventing flashblindness and more particularly to automatically operating apparatus designed to protect the eye from the light of a nuclear detonation.

This application is a continuation of application Serial No. 166,195 which we filed on January 15, 1962 and expressly abandoned on December 13, 1963.

A nuclear detonation creates a burst of light of such great magnitude that it can easily burn the human retina, or cause flashblindness—a condition that temporarily impairs human vision. These effects are considerably more severe for the dark-adapted eye at nighttime than for the light-adapted eye under full daylight conditions. In daylight, the pupil automatically contracts to a diameter of about two millimeters, thus limiting the light that can enter the eye. In addition, recovery from flashblindness in daylight is faster due to the high ambient illumination levels. At nighttime, however, the pupil dilates to a diameter of about eight millimeters and even a small amount of light will destroy the dark-adaption of the eye. Should a pilot be flashblinded, he may lose control of his aircraft and be unable to complete his flight safely. Likewise, a submarine commander, or a tank crew member, observing a nuclear flash through a periscope will be temporarily incapacitated. Similarly, deck and bridge personnel of ships at sea will be flashblinded and unable to perform their duties.

In practice, flashblindness can occur at distances much greater than the distances at which either personnel or equipment would sustain damage from either the shock or radiation of a nuclear detonation. Therefore, some means of eye protection is vital.

A satisfactory protective device must not unduly limit vision for normal tasks, but must prevent the light from a nuclear detonation from reaching the eye. If it is to be effective, the device must operate during the very early phase of the detonation. Many types of devices have been proposed and some have been investigated. Mechanical devices in general are too slow-acting. Devices utilizing polarized light in general have "open" transmissions that are too low; that is, when not operating, they unduly restrict vision for normal tasks. A number of other devices require explosives. Other devices require too much time to change from the optically dense state to the transparent state.

It is therefore a major object of our invention to provide eye protective apparatus that has a relatively high open transmission, a high closed density, and a rapid operating time.

A furher object is to provide apparatus of this type that has a reasonable "clearing" time; that is, that changes from an optically dense state to a transparent state within a reasonable time.

Other and further objects will be explained hereinafter and will be more particularly pointed out in connection with the appended claims.

Our invention will now be described in connection with the accompanying drawings, FIG. 1 of which is a simplified schematic and block diagram illustrating the basic principles of the invention;

FIG. 2 is a simplified schematic and block diagram of apparatus designed for use in aircraft;

FIG. 3 is a modification of FIG. 2;

FIGS. 4, 5, and 6 are cross-sectional views in part of different embodiments of a lens system that may be used in the apparatus illustrated in FIGS. 2 and 3;

FIG. 7 is a perspective view of a pilot's helmet in which the system of the present invention has been installed;

FIG. 8 is a graph of the light versus time of a simulated nuclear flash passing through a nonoperating lens system of the type illustrated in FIG.4;

FIG. 9 is a graph of the light versus time of a simulated nuclear flash passing through an operating lens system of the type illustrated in FIG. 4;

FIG. 10 is a graph illustrating the open and closed transmission of the lens system illustrated in FIG. 4 without sideband filters;

FIG. 11 is a graph illustrating the closed transmission of the lens system illustrated in FIG. 4 with and without sideband filters;

FIG. 12 is a graph illustrating the open transmission of the lens system illustrated in FIG. 4 with and without sideband filters;

FIGS. 13, 14 and 15 illustrate alternative embodiments of periscope systems utilizing the principles of the present invention; and

FIG. 16 illustrates a simple means for clearing the darkened photochromic material.

In summary our invention utilizes materials sensitive in a particular way to ultraviolet light. Such materials must change from a colorless or transparent state to a colored or optically dense state when properly energized with ultraviolet light. Photochromic materials are one class of materials that do this. However, it is to be understood that we are not claiming such materials as our invention. Rather, the apparatus herein generically disclosed constitutes our invention. Since the maximum distance at which the ultraviolet component of the light of a nuclear detonation will properly energize such materials is much less than the distance at which flashblindness can occur, it is necessary that another source of ultraviolet light be used. Accordingly, our invention utilizes a nuclear light detection system to trigger an electronic flashtube system which produces the ultraviolet light needed to energize these materials. Different embodiments utilizing the basic principles of our invention for different applications are disclosed.

As stated above, photochromic materials are one class of materials that change from the colorless or transparent state to the colored or optically dense state when subjected to ultraviolet radiation. Others have synthesized a great many phototropic compounds, each of which has its own particular characteristics. Thus, the wavelength of maximum absorption, the efficiency, the ultimate maximum density, and the stability depend upon the particular compound. In general, stability also depends greatly upon temperature. Some photochromic materials can be reconverted to the clear state by applying heat, or radiation of longer wavelength, such as infrared.

In the unactivated state, the idealized protective system would not restrict vision in any respect, but upon direct irradiation by the earliest bomb light, it would automatically form a light-absorbing shield whose density would be proportional to the intensity of the light being viewed. In the following discussion, it is shown that currently available photo-sensitive materials that also possess the other necessary characteristics fall several orders of magnitude short of adequate sensitivity to perform in this manner under practical operating conditions. In field experiments, for example, samples of photochromic materials have been activated by the energy from atomic detonations, so that there is no question but that, under certain conditions, the total energy from the bomb is adequate to produce color. The question is whether the ultraviolet radiation received in the first 100-microseconds is sufficient to cause the necessary density change.

Let us assume that an effective ND–3 filter is desired; that is, a filter that absorbs 99.9 percent of the light. Clearly, the filter must be activated by the first 0.1 percent of the incident light if it is to absorb the remaining 99.9 percent. Actually, the first 0.1 percent of the light is concentrated at the central part of the image and therefore represents more than 0.1 percent for this central area. Thus, activation by the first 0.1 percent of the total incident light does not produce a fully effective ND–3 filter.

Next, consider a twenty kiloton bomb at a distance of ten miles. One finds ("Effects of Nuclear Weapons," U.S. Department of Defense, June, 1957) that approximately 0.006 calorie per square centimeter is deposited by a one kiloton bomb at a slant range of ten miles. A twenty kiloton bomb, therefore, will deposit 0.12 calorie per square centimeter at ten miles. As stated above, the material is to be activated by the first 0.1 percent of the light, or 0.00012 calorie per square centimeter. Sensitivity figures quoted for photochromic materials, as an example, lie in the range of 0.01 to 0.02 calorie per square centimeter, or one hundred times greater than the value of 0.00012 calorie per square centimeter. Actually, since only ultra-violet enrgy will activate the materials, considerably less than 0.00012 calorie per square centimeter of energy is effective. This, combined with the fact that less energy is available at greater distances, and that a fully effective density of ND–3 is not realized, leads to the realistic conclusion that materials would have to be at least a thousand times more sensitive to meet the general protective-goggle requirements. And, this still does not take into account intervening absorption of some of the ultraviolet energy.

There may be special applications where the distances would be very much less and self-activation might conceivably be possible, but this is not true for the average eye-protection conditions. Even if future developments produce a material of the needed sensitivity, it will be difficult to use, because its high sensitivity will cause it to darken in normal daylight use.

Obviously, ultraviolet energy other than that from the nuclear bomb must be used to energize these materials. A xenon-filled electronic flashtube that produces a large amount of ultraviolet energy can be positioned relatively close to the material to be energized. A short pulse of radiation (less than 100 microseconds) produced by the flashtube prior to the time of the first light maximum of the nuclear bomb will cause the photochromic material to darken before the intense nuclear flash reaches its peak.

However, when photochromic materials are activated, they not only absorb energy in a band in the visible, but also absorb energy in the ultraviolet. Thus, as such material is being activated, an ultraviolet filter is also being formed which begins to filter out the ultraviolet energy that is added. The more ultraviolet energy that is added, the lower the efficiency of the process. This effect is such as to limit the depth of penetration of the colored or darkened material to one or two thousandths of an inch, regardless of coating thickness, depending on the concentration. Increasing the coating thickness in this case does not increase the density.

The darkening process is generally reversible by heat or infrared energy. When the material is exposed to a low intensity direct current ultraviolet source, very high densities can eventually be built up, while any heating due to wavelengths other than ultraviolet is dissipated over the relatively long period of time. However, in the case of a flashtube, which activates the material in times measured in microseconds, the thermal energy absorbed in the material cannot be dissipated at a corresponding rate. Therefore, while the ultraviolet energy is converting photochromic material to the colored or dense state,

the thermal energy tends to reverse it. In general, a lower maximum density of photochromic materials is achieved with flashtubes than with low-power direct current sources.

The basic principles of our invention will now be explained with reference to FIG. 1. A power supply 20 is connected to a suitable electric power source 21. Power supply 20 provides the necessary direct current voltages for nuclear light detector 22, detector signal amplifying and forming circuit 23 and trigger circuit 24. Power supply 20 also charges discharge capacitor 25 which is connected across the main electrodes 26 and 27 of flashtube 28. The output of trigger circuit 24 is shown connected to trigger electrode 29 of flashtube 28. Schematically illustrated adjacent to flashtube 28 is a reflector 30. Reflector 30 reflects the light rays, here represented as straight lines 31, produced when flashtube 28 flashes, into layer 32 of photochromic material. A transparent support 33, such as glass, is illustrated as coated with layer 32 of photochromic material.

In operation, when the light 35 from a nuclear detonation 34 impinges upon detector 22, a signal is generated in detector 22. This signal is transmitted from detector 22 to detector signal amplifying and forming circuit 23. Circuit 23 amplifies the detector signal, forms and shapes it, and if it is too strong, clips it. The details of circuit 23 are not shown because circuits to perform such functions are well known in the art and because the specific details thereof form no part of this invention.

The output of circuit 23 is fed to trigger circuit 24. Trigger circuit 24 may be any one of the well-known thyratron discharge circuits in which a thyratron is made to fire by a signal applied to its control grid. Upon firing, a capacitor discharges therethrough and through the primary of a pulse transformer (not shown). The output of the pulse transformer may be a voltage in the kilovolt range which is here applied to trigger electrode 29 of flashtube 28. The high voltage existing between trigger electrode 29 and one of the main electrodes 26 or 27, causes ionization of the gas to occur within flashtube 28. This is sufficient for breakdown to occur between main electrodes 26 and 27, whereupon discharge capacitor 25 discharges through flashtube 28 creating a brilliant flash of light.

The light produced is reflected by reflector 30 into layer 32 of photochromic material, as illustrated. The ultraviolet energy in the flash of light will cause coloring or darkening in layer 32 of photochromic material. In general, a system utilizing one such layer 32 of presently available photochromic material will not provide sufficient density to protect the eye from the light of a nuclear detonation.

It is to be understood that any other photosensitive material may be substituted for photochromic materials, if it darkens when activated by the light output of a flashtube.

The more complex system illustrated in FIGS. 2 and 4 was devised to provide greater density. Referring first to FIG. 2, power supply 40 is connected to a suitable electric power source 41. Power supply 40 provides the necessary direct current voltages for nuclear light detector 42, detector signal amplifying and forming circuit 43, and trigger circuit 44. Power supply 40 also charges discharge capacitors 45 and 46. Discharge capacitor 45 is connected through a triggered spark gap (not shown) contained in trigger circuit 44 across main electrodes 47 and 48 of flashtube 49. Discharge capacitor 46 is connected through another triggered spark gap (not shown) contained in trigger circuit 44 across main electrodes 54 and 55 of flashtube 56.

Trigger circuit 44 may also contain a thyratron or silicon controlled rectifier capacitor discharge circuit (not shown) for discharging a capacitor (not shown) through the primary windings 60 and 53 of pulse transformers 58 and 51 respectively which are connected in parallel, as illustrated. The secondary windings 59 and 52 of pulse transformers 58 and 51 are connected to trigger electrodes 57 and 50 of flashtubes 56 and 49, respectively.

The only difference between the arrangement illustrated in FIG. 2 and that of FIG. 3 is that discharge capacitors 45 and 46 are connected in parallel in FIG. 3 through a single triggered spark gap (not shown) in trigger circuit 44. The output of said spark gap is shown parallel connected to flashtubes 49 and 56. Both arrangements work equally well.

Referring now to FIG. 4 reflectors 61 and 62 reflect the light produced by flashtubes 49 and 56 respectively into the lens system generically designated by reference character 70. Lens system 70 comprises, from left to right, sideband filter 71 which may be made of gelatin, wedge 74 coated with layer 73 of photochromic material, air space 75, wedge 76, wedge 80, layer 79 of photochromic material sandwiched between wedges 76 and 80, air space 81, wedge 82 coated with layer 83 of photochromic material, and sideband filter 85, which may be made of gelatin. Sideband filters 71 and 85 are placed in surface to surface contact with layers 73 and 83 of photochromic material. Air spaces 75 and 81 are necessary so that total reflection at one surface of each wedge is provided, reflecting the ultraviolet component of the light produced by flashtubes 49 and 56 uniformly into layers 73, 79 and 83 of photochromic material. Wedges 74, 76, 80 and 82 may be made of quartz, high silica glass, or plastic. Such materials must have a high transmission to light both in the visible and the ultraviolet. Disposed between reflectors 61 and 62 and lens system 70 are band pass filters 66 and 67 respectively which pass only the ultraviolet light produced by flashtubes 49 and 56. It will be appreciated that these components are all mounted on a common support which is not shown so as to avoid confusion.

The effectiveness of lens system 70 is illustrated in FIGS. 8 and 9. The light produced by a nuclear detonation was simulated by using a high power flashtube. The light passed by lens system 70 was viewed with a phototube. The signal produced was then impressed upon the plates of an oscilloscope and the curves illustrated in FIGS. 8 and 9 were obtained. In FIG. 8 curve 86 represents the light passed by lens system 70 when the system of FIG. 2 was not operated. In FIG. 9 curve 87 represents the light that was passed by lens system 70 when the system of FIG. 2 was operated. Note that the operating time of the whole system including all component circuits was very rapid, being considerably less than 100 microseconds. The effective closed density of system 70 is approximately 3 as seen by the human eye. Therefore, protection against flash blindness would be effective. Note that four wedges 74, 76, 80 and 82 are used. Total reflection of the ultraviolet energy from the inclined but uncoated surfaces of the wedges distributes the energy such that two individual wedges of each set complement each other to produce relatively uniform density. Two sets of two each are used in series to produce a sufficiently high density.

Activated photochromic materials presently available do not exhibit a neutral or uniform density throughout the visible region. If, for example, sideband filters 71 and 85 are removed from lens system 70, the open transmission of the combination of photochromic layers 73, 79 and 83 is illustrated by curve 88 of FIG. 10 in which the ordinate represents percentage transmission and in which the abscissa represents light wavelengths of the visible spectrum in millimicrons. Note that this representation is common to the axes of FIGS. 11 and 12. By "open transmission" is meant, light transmission before the circuit of FIG. 2 is operated. "Closed transmission" means the transmission of light when the circuit of FIG. 2 is operated. The closed transmission of lens system 70 without sideband filters 71 and 85 is illustrated by curve 89 of FIG. 10. It is clear from curve 89 that light leaks exist in both the blue and red regions; that is, that there are some light components not uniformly absorbed by the photochromic material.

To produce a high closed density, it is therefore necessary to add sideband filters 71 and 85 which absorb such light components. In FIG. 11 curve 90 shows the closed transmission of lens system 70 without sideband filters 71 and 85. Note that it is the same as curve 89 of FIG. 10. Curve 91 represents the transmission of the combination of sideband filters 71 and 85 alone. Curve 92 represents the closed transmission of lens system 70 with sideband filters 71 and 85. Note that the light leaks are blocked.

As stated heretofore, one of the objects of our invention is to provide eye protective apparatus that has a relatively high open transmission. In FIG. 12 curve 93 represents the open transmission of lens system 70 without sideband filters 71 and 85. Curve 94 represents the open transmission of sideband filters 71 and 85 alone. Curve 95 represents the open transmission of lens system 70 with sideband filters 71 and 85. The peak transmission at about 555 millicrons illustrated in curve 95 coincides with the sensitivity peak of the eye. Hence the limitation placed on visibility is not as severe as it might be.

A perspective view of a pilot's helmet 100 in which lens system 70, flashtubes 49 and 56, and pulse transformers 51 and 58 have been installed, is illustrated in FIG. 7. Only lens system 70 is visible, the remaining components being enclosed within assembly 96. Provision is made for lens system 70 to be raised up out of the way. Thus the pilot can clear the filter at his convenience by moving it out of his line of vision. The pilot's oxygen mask and oxygen supply tube are illustrated at 99.

Referring back to FIGS. 2 and 4, the operation of the system will now be explained. When the light 35 from a nuclear detonation 34 impinges upon nuclear light detector 42, a signal is generated. This signal is transmitted from nuclear light detector 42 to detector signal amplifying and forming circuit 43. Circuit 43 amplifies the signal, forms and shapes it, and if it is too strong, clips it. Like circuit 23, the details of circuit 43 are now shown because circuits to perform such functions are well known in the art and because the specific details thereof form no part of this invention.

The output of circuit 43 is fed to trigger circuit 44. Trigger circuit 44 in FIG. 2 performs one additional function not performed by trigger circuit 24 of FIG. 1. Since the pulse transformers 51 and 58, and the flashtubes 49 and 56 (here shown within dashed line 63) are mounted within helmet 100 which is worn by a pilot, it is desirable that the high voltages of discharge capacitors 45 and 46 and the trigger pulse transformer voltages not be present in close proximity to the pilot's head, except when needed to darken lens system 70. Accordingly, triggered spark gaps (not shown) are provided within trigger circuit 44. The basic trigger circuitry, when activated by the signal delivered by detector circuit 43, delivers high voltages to the trigger electrodes of said spark gaps causing them to ionize and to discharge thereby completing the discharge circuit for discharge capacitors 45 and 46 to flashtubes 49 and 56 respectively. Concurrently, trigger circuit 44 delivers pulse voltages to the primary windings 60 and 53 of pulse transformers 58 and 51 respectively. The high voltages generated in the secondary windings 59 and 52 of pulse transformers 58 and 51 appear on trigger electrodes 57 and 50 respectively of flashtubes 56 and 49. Ionization of the gas occurs within each flashtube and immediately breakdown occurs whereupon capacitors 45 and 46 discharge through flashtubes 56 and 49 producing brilliant flashes of light.

The operation of the circuitry illustrated in FIG. 3 is somewhat similar, the differences being that discharge capacitors 45 and 46 are charged in parallel and discharge through a single triggered spark gap (not shown) in trigger circuit 44 into flashtubes 49 and 56 which are connected in parallel.

These flashes of light are reflected by reflectors 61 and 62 through band pass filters 66 and 67 where all the light except the ultraviolet component is effectively absorbed. The ultraviolet light then passes into wedges 74, 76, 80 and 82 and is reflected from the inclined uncoated surfaces of said wedges into the photochromic layers 73, 79 and 83. Darkening occurs which together with sideband filters 71 and 85 provides an effective density of 3. This is sufficient to protect the eye from the light of a nuclear detonation.

A different lens systems 101 is illustrated in FIG. 5. In this embodiment sideband filters 102 and 103 are again used as in FIG. 4. Four wedges 104, 105, 106 and 107 are used as illustrated. However, layer 108 of photochromic material is placed between wedges 104 and 105. Similarly, layer 109 of photochromic material is placed between wedges 106 and 107. Air spaces are provided at 110, 111, and 112 to assure total reflection from the uncoated surfaces of said wedges. Likewise, band pass filters 113 and 114 having the same function as band pass filters 66 and 67 are utilized. The ultraviolet light passing through band pass filters 113 and 114 is reflected from the uncoated surfaces of wedges 104, 105, 106 and 107 into photochromic layers 108 and 109. Note that both surfaces of each photochromic layer is darkened. Again, a lens system having an effective density of 3 is attained.

The embodiment illustrated in FIG. 6 is somewhat different. Two V-shaped troughs 115 and 116 of transparent plastic material each have a surface coated with layers 117 and 118 respectively of photochromic material. Said plastic material must have a high transmission in the ultraviolet. V-shaped troughs 115 and 116 are then fastened to reflectors 61 and 62 containing flashtubes 49 and 56 respectively. Mounting means are not shown. A layer 121 of photochromic material is then sandwiched between the two assemblies, as illustrated. In this embodiment, band pass filters and sideband filters are not shown. They may be utilized, if desired. When flashtubes 49 and 56 are flashed, the ultraviolet light impinging upon photochromic surfaces 117, 118 and 121 cause these materials to darken, thereby providing an effective filter.

It is to be understood that sideband filters 71 and 85, and 102 and 103 of FIGS. 4 and 5 may be eliminated when photochromic materials having different light transmission curves are available.

The system of the present invention may be utilized in periscopes as illustrated in FIGS. 13, 14 and 15. In FIG. 13 lens system 70 of FIG. 4 is illustrated as interposed between mirrors 122 and 123 at right angles to the light path therebetween. When lens system 70 is darkened in response to the light from a nuclear detonation as herein disclosed, a filter having an effective density of 3 is obtained, which is sufficient to protect eye 130 from flashblindness.

In FIG. 14 a somewhat different embodiment for a periscope is illustrated. Interposed between mirrors 122 and 123 are two glass plates 124 and 125. Glass plates 124 and 125 have layers 126 and 127 respectively of photochromic materials coated thereon. Coated glass plates 124 and 125 are disposed in the shape of a V opposing reflector 129 and flashtube 128, as illustrated. When flashtube 128 flashes, the ultraviolet light produced darkens photochromic layers 126 and 127, thereby creating a filter that is effective to block the nuclear light 35 from eye 130.

A preferred embodiment for a periscope system is illustrated in FIG. 15. Here, transparent supports 140 and 141, having layers 136 and 137 respectively of photochromic material coated thereon, mask mirrors 122 and 123 respectively. Note that layers 136 and 137 may be coated directly on mirrors 122 and 123 if desired, instead of supports 140 and 141. Flashtube 131 and its reflector 132 are disposed opposite mirror 122 and photochromic layer 136, so that light produced by flashtube 131 will fall perpendicularly on layer 136. Flashtube 134 and reflector 135 are similarly placed with respect to mirror 123 and photochromic layer 137. Flashtubes 132 and 134 may be connected to the circuit of FIG. 2. When flashtubes 131 and 134 are flashed by the circuit of FIG. 2, the ultraviolet light impinging upon photochromic layers 136 and 137 causes darkening thereof. Nuclear light 35 from detonation 34 must, however, traverse darkened layer 136 twice and darkened layer 137 twice, as illustrated. Thus, a two layer system is equivalent to a four layer system.

It is to be understood that mirrors 122 and 123 above disclosed and discussed may be replaced by any system of totally reflecting surfaces arranged as a periscope, such as a system of total reflecting prisms.

Heretofore, methods of "clearing," or changing the photochromic material from an optically dense state to a transparent state, have not been discussed. Means to accomplish clearing have not been illustrated in FIGS. 1 through 15 because this would unduly complicate the figures. Clearing can be readily accomplished by using photochromic materials that rapidly "self-clear" after darkening, when these are available.

Other means for clearing are illustrated in FIG. 16. Wedge 145 is shown having a layer 146 of tin oxide and a layer 147 of photochromic material coated on it. Layer 146 of tin oxide is shown connected through switch 148 to battery 149.

In operation after layer 147 of photochromic material has darkened, switch 148 may be closed completing the circuit for direct current to flow through layer 146 of tin oxide. Layer 146 of tin oxide acts as a heater and heat energy is radiated to layer 147 of photochromic material. This causes the darkening process to reverse.

It will be apparent that tin oxide layers may be coated on the wedges of system 70. Moreover, power supply 40 can supply necessary voltages for the clearing system. In addition, delay circuits and other automatically operating circuits may be incorporated into trigger circuit 44 to make the clearing system fully automatic, operable within a predetermined time after darkening occurs.

It is to be understood that photochromic materials may be applied in the dry state, in a jellied state, or in a liquid state, and be maintained in such states. The sensitivity of such materials in the jellied and liquid states is much greater than in the dry state.

Therefore, it will be obvious that various omissions and substitutions and changes in the form and details of the embodiments illustrated and in their operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A system for rapidly reducing the light transmission of a light path extending from the light of a nuclear detonation to the eye that comprises:

(*a*) a power supply;

(*b*) a detector system connected to said power supply, and disposed to see and adapted to detect said light of said nuclear detonation and to produce in response thereto a predetermined electrical signal;

(*c*) an electronic flash circuit comprising a discharge capacitor connected so as to be charged by said power supply, and an electronic flashtube;

(*d*) a trigger circuit connected to said power supply and adapted to respond to said predetermined electrical signal by ionizing the gas in said flashtube and causing said capacitor to discharge therethrough, thereby producing a brilliant flash of light of short duration, having an ultraviolet component; and

(*e*) a lens system disposed between the eye and said light of said nuclear detonation comprising

(1) a surface of a first material having a high transmission to light both in the visible and the ultraviolet, and

(2) a layer of a transparent photosensitive material, which changes from said transparent state to an optically dense state when subjected to ultraviolet radiation, coated on said surface, said surface being so disposed that said ultraviolet component of said flash of light impinges on said photosensitive material causing it to become optically dense, thereupon effectively reducing the light transmission of said light path.

2. A system as in claim 1 in which

(a) said discharge capacitor is normally connected to said flashtube; and

(b) said trigger circuit ionizes the gas in said flashtube thereby permitting said discharge capacitor to discharge therethrough.

3. A system in claim 1 in which

(a) said discharge capacitor is normally disconnected from said flashtube; and

(b) said trigger circuit ionizes the gas in said flashtube and simultaneously connects said flashtube to said discharge capacitor permitting it to discharge therethrough.

4. A system as in claim 3 in which said trigger circuit comprises a triggered spark gap adapted to be fired by said predetermined electrical signal thereby connecting said flashtube to said discharge capacitor.

5. A system as in claim 1 in which said photosensitive material is photochromic material.

6. A system as in claim 1 in which said photosensitive material also changes from the optically dense state to the transparent state when subjected to heat.

7. A system as in claim 1 in which said photosensitive material also changes from the optically dense state to the transparent state when subjected to infrared radiation.

8. A system as in claim 5 in which said photochromic material also self clears.

9. A system as in claim 1 in which said first material is a wedge made of quartz.

10. A system as in claim 1 in which said first material is a wedge made of high silica glass.

11. A system as in claim 1 in which said first material is a wedge made of plastic material.

12. A system for rapidly reducing the light transmission of a light path extending from the light of a nuclear detonation to the eye that comprises:

(a) a power supply;

(b) a detector system connected to said power supply, and disposed to see and adapted to detect said light of said nuclear detonation and to produce in response thereto a predetermined electrical signal;

(c) an electronic flash circuit comprising a discharge capacitor connected so as to be charged by said power supply and an electronic flashtube, with its associated pulse transformer connected to its trigger electrode;

(d) a trigger circuit connected to said power supply and adapted to respond to said predetermined signal by energizing said pulse transformer to ionize the gas in said flashtube and causing said capacitor to discharge therethrough, thereby producing a brilliant flash of light of short duration, having an ultraviolet component; and

(e) a lens system disposed between the eye and said light of said nuclear detonation comprising

(1) a V-shaped trough of a material having a high transmission to light both in the visible and the ultraviolet;

(2) a layer of a transparent photosensitive material, which changes from said transparent state to an optically dense state when subjected to ultraviolet radiation, coated on a surface of said V-shaped trough, and

(3) a reflector disposed about said flashtube and adapted to reflect said flash of light and its ultraviolet component into said V-shaped trough thereby causing said layer of photosensitive material to become optically dense, thereupon effectively reducing the light transmission of said light path.

13. A system for rapidly protecting the eye from the light of a nuclear detonation that comprises:

(a) a power supply;

(b) a detector system connected to said power supply, and disposed to see and adapted to detect the light of said nuclear detonation and to produce in response thereto a predetermined electrical signal;

(c) an electronic flash circuit comprising a plurality of discharge capacitors connected so as to be charged by said power supply and a plurality of electronic flashtubes, each with its associated pulse transformer connected to its trigger electrode;

(d) a trigger circuit connected to said power supply and adapted to respond to said predetermined electrical signal by energizing each pulse transformer to ionize the gas in each flashtube and causing said capacitors to discharge therethrough, thereby producing a plurality of brilliant flashes of light of short duration, each having an ultraviolet component; and

(e) a lens system disposed between the eye and said light of said nuclear detonation comprising a plurality of layers of a transparent photosensitive material, which changes from said transparent state to an optically dense state when subjected to ultraviolet radiation, said layers being arranged optically in series and disposed in the light path between said nuclear detonation and the eye, and means for channeling said ultraviolet components of said plurality of flashes of light to said plurality of layers of photosensitive material to cause each to become optically dense, said series arrangement of optically dense layers of photosensitive material constituting an effective filter to protect the eye from said light of said nuclear detonation.

14. A system as in claim 13 in which

(a) said discharge capacitors are normally connected to said flashtubes; and

(b) said trigger circuit ionizes the gas in said flashtubes thereby permitting said discharge capacitors to discharge therethrough.

15. A system as in claim 13 in which

(a) said discharge capacitors are normally disconnected from said flashtubes; and

(b) said trigger circuit ionizes the gas in said flashtubes and simultaneously connects said flashtubes to said discharge capacitors permitting them to discharge therethrough.

16. A system as in claim 15 in which said trigger circuit also has a plurality of triggered spark gaps adapted to be fired by said predetermined signal thereby connecting each of said plurality of flashtubes to a corresponding one of each of said plurality of discharge capacitors.

17. A system as in claim 15 in which:

(a) said plurality of flashtubes are connected in parallel;

(b) said plurality of discharge capacitors are connected in parallel; and

(c) said trigger circuit has one triggered spark gap adapted to be fired by said predetermined electrical signal thereby connecting said plurality of flashtubes to said plurality of discharge capacitors.

18. A system as in claim 13 in which said photosensitive material comprises photochromic material.

19. A system as in claim 13 in which said channeling means comprises:

(a) a reflector disposed about each flashtube to reflect said flashes of light toward said layers of photosensitive material;

(*b*) a band-pass optical filter disposed adjacent to each flashtube and opposing each reflector to pass the ultraviolet component of each flash of light and to absorb the remaining components thereof; and

(*c*) a plurality of wedges, each wedge being of a material having a high transmission to light both in the visible and the ultraviolet, and having a surface thereof in surface-to-surface contact with a surface of one of said plurality of layers of photosensitive material, said plurality of wedges being disposed adjacent to said band-pass optical filters to receive said ultraviolet components.

20. A system as in claim 19 in which said lens system has a side-band optical filter disposed adjacent to one of said wedges, in said line of sight, and adapted to absorb those components not normally absorbed by the photosensitive material.

21. A system as in claim 19 in which said wedges are made of quartz.

22. A system as in claim 19 in which said wedges are made of high silica glass.

23. A system as in claim 19 in which said wedges are made of plastic material.

24. A system as in claim 13 in which said means for channeling said ultraviolet components of said flashes of light comprises:

(*a*) a plurality of V-shaped troughs, each of a material having a high transmission to light both in the visible and the ultraviolet, each having a surface thereof in surface-to-surface contact with a surface of one of said plurality of layers of photosensitive material, and each disposed adjacent to a corresponding flashtube of each of said plurality of flashtubes; and

(*b*) a plurality of reflectors, each disposed about a corresponding flashtube of each of said plurality of flashtubes, and adapted to reflect the flash of light produced by said flashtube and its ultraviolet component into the V-shaped trough disposed adjacent to said flashtube.

25. A system as in claim 18 also comprising means connected to said power supply, disposed adjacent to said layers of photochromic material, and adapted to clear said layers of photochromic material.

26. A system as in claim 18 also comprising:

(*a*) a plurality of layers of tin oxide, each disposed in surface-to-surface contact with a surface of a layer of photochromic material; and

(*b*) means connected to said power supply and to each of said layers of tin oxide, adapted to pass an electric current through said layers of tin oxide at a predetermined time after said layers of photochromic material have darkened, thereby creating heat to heat said layers of photochromic material causing them to clear.

27. A system as in claim 13 in which said lens system further comprises a plurality of totally reflecting surfaces disposed as a periscope and each of said plurality of layers of photosensitive material is disposed parallel to a corresponding one of each of said reflecting surfaces.

28. Apparatus for rapidly reducing the light transmission of an optical system subject to sudden impingement by light energy of great intensity relative to the light energy impinging upon said system immediately prior to said sudden impingement, said apparatus comprising:

(*a*) first means disposed in the path of said light energy of great intensity for producing an electrical signal when the first of said light waves strike thereupon;

(*b*) a normally ineffective electronic flash system having a flashtube, said system being adapted to become effective in response to said electrical signal to produce a brilliant flash of ultraviolet illumination, said flashtube being disposed adjacent to said optical system; and

(*c*) second means comprising a transparent photosensitive material which changes from said transparent state to an optically dense state when subjected to ultraviolet radiation, said second means being disposed in said optical system adjacent to and within the scope of the ultraviolet illumination produced by said flashtube, providing a normally transparent path to light energy when not subject to ultraviolet illumination and providing an attenuating filter to light energy when subjected to ultraviolet illumination.

29. Apparatus for substantially instantaneously reducing the light transmission of an optical system subject to sudden impingement by light energy of great intensity relative to the light energy impinging upon said system immediately prior to said sudden impingement, said apparatus comprising:

(*a*) first means disposed in the path of said light energy of great intensity for producing an electrical signal when the first of said light waves strike thereupon;

(*b*) a normally ineffective electronic flash system having a plurality of flashtubes, said system being adapted to become effective in response to said electrical signal to produce a plurality of brilliant flashes of ultraviolet illumination, said flashtubes being disposed adjacent to said optical system; and

(*c*) second means comprising a plurality of wedges of a material having a high transmission to light both in the visible and the ultraviolet, each of said wedges having a surface coated with a layer of a transparent photosensitive material which changes from said transparent state to an optically dense state when subjected to ultraviolet radiation, said second means being disposed in said optical system adjacent to and within the scope of said flashes of ultraviolet illumination produced by said flashtubes, providing a normally transparent path to light energy when not subject to ultraviolet illumination and providing an attenuating filter to light energy when subjected to ultraviolet illumination.

30. Apparatus in claim 28 further comprising third means disposed adjacent to said transparent photosensitive material and adapted to clear said material after the same has been changed to an optically dense state.

No references cited.