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[54] INDICATING THE PASSING OF A PROJECTILE THROUGH AN AN AREA IN SPACE

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[30] **Foreign Application Priority Data**
Jan. 21, 1971 Australia.................................. 3775

[52] **U.S. Cl.**...................... **356/141,** 356/4, 350/190, 250/222
[51] **Int. Cl.** **G01b 11/26**
[58] **Field of Search** 340/258 B; 356/4, 5, 141, 152, 356/158; 350/190, 191, 198; 250/222

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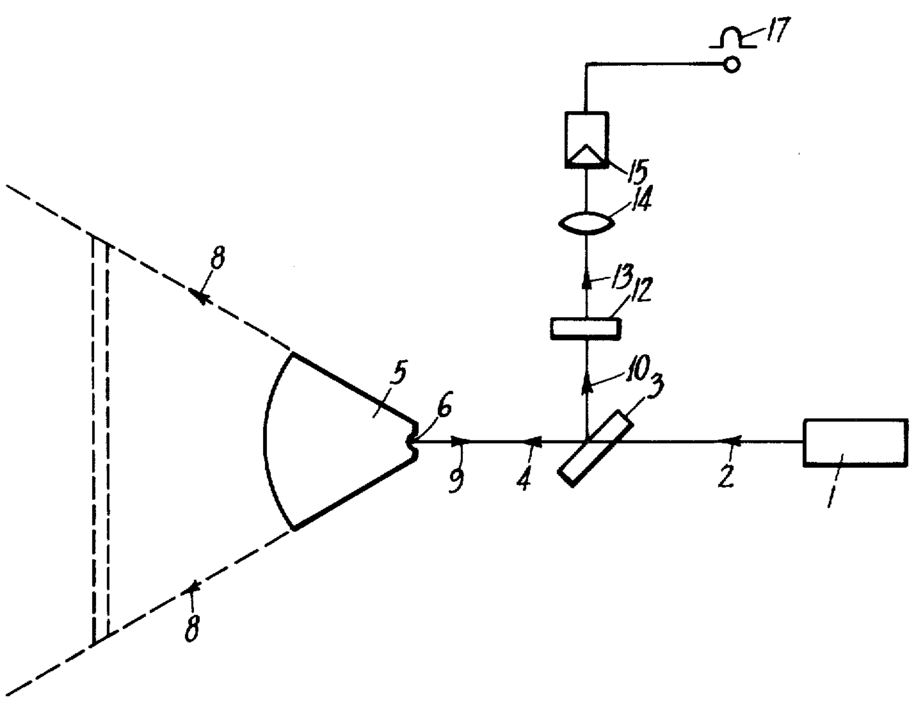
Attorney, Agent, or Firm—Oberlin, Maky, Donnelly & Renner

[57] **ABSTRACT**

A method of and apparatus for indicating the passing of a projectile through an area in space comprising inciding the whole of said area with a projectile light beam and detecting a reflection of said beam off a projectile passing through said area resulting from incidence of said beam thereon thereby determining that said projectile passed through said area.

29 Claims, 10 Drawing Figures



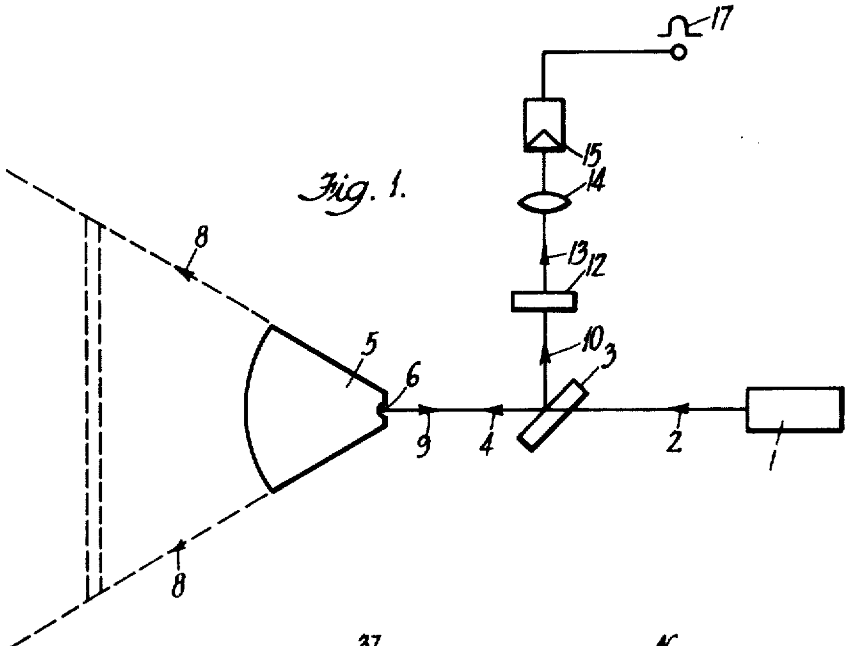


Fig. 1.

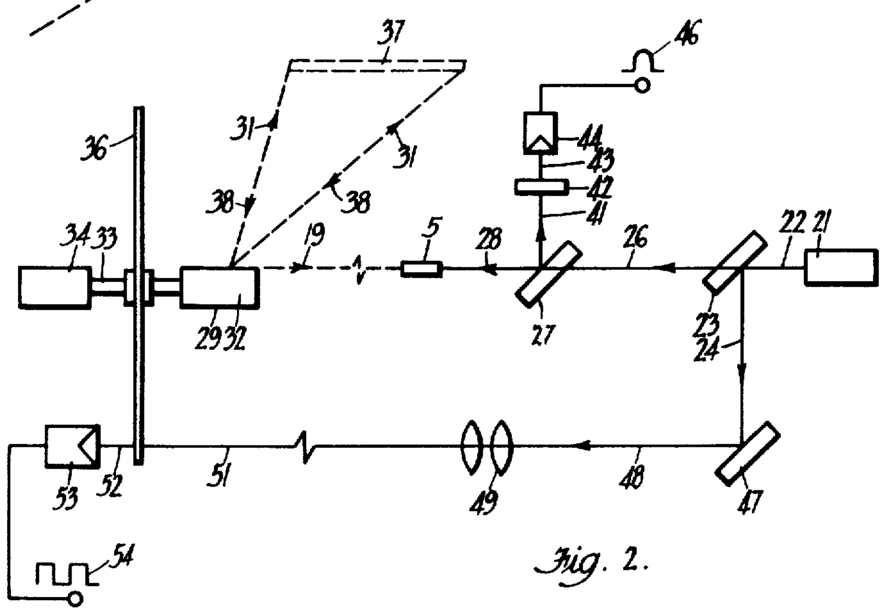


Fig. 2.

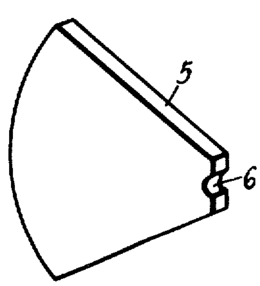


Fig. 3.

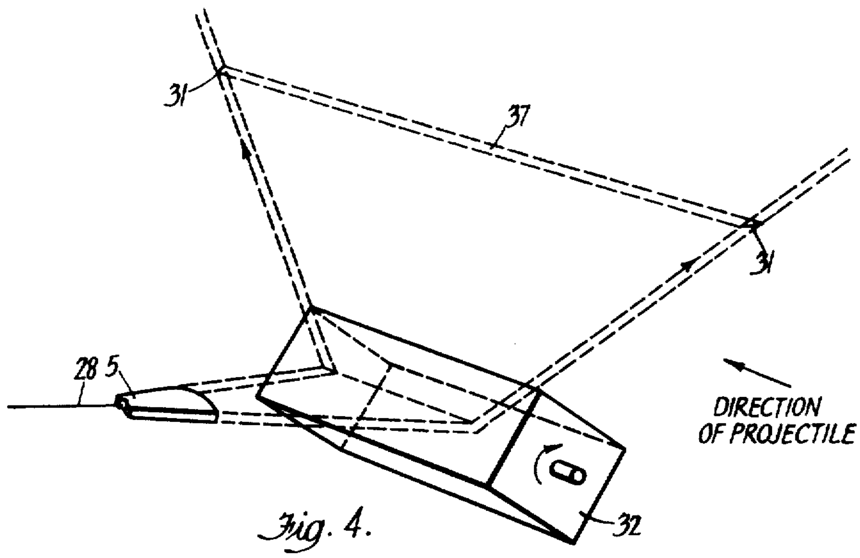


Fig. 4.

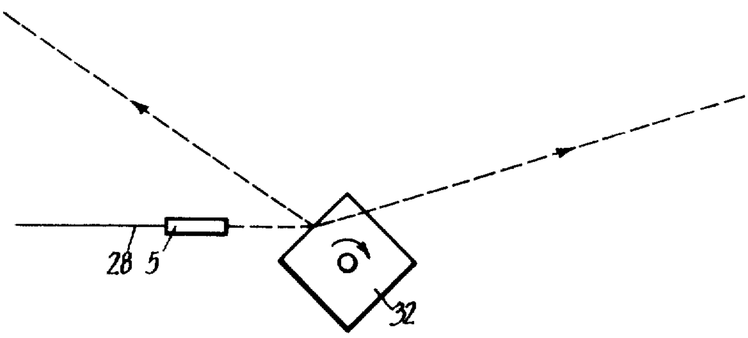


Fig. 5.

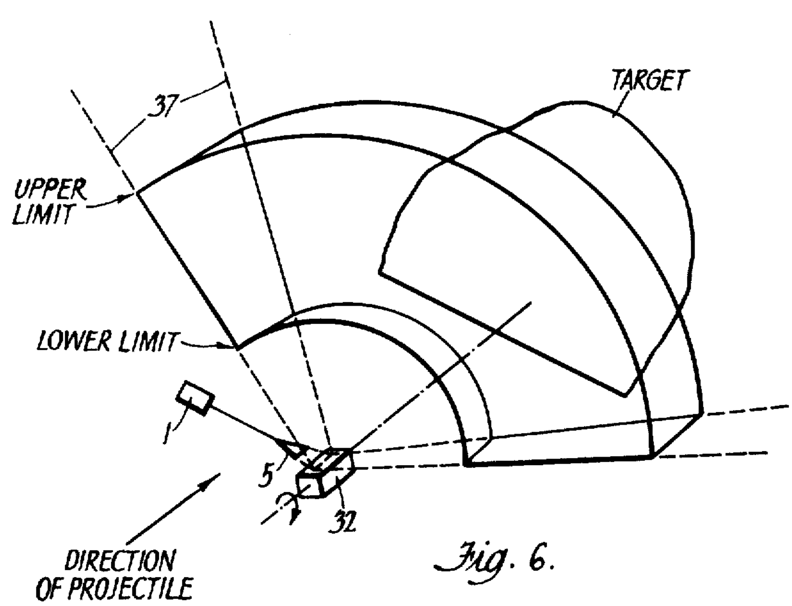


Fig. 6.

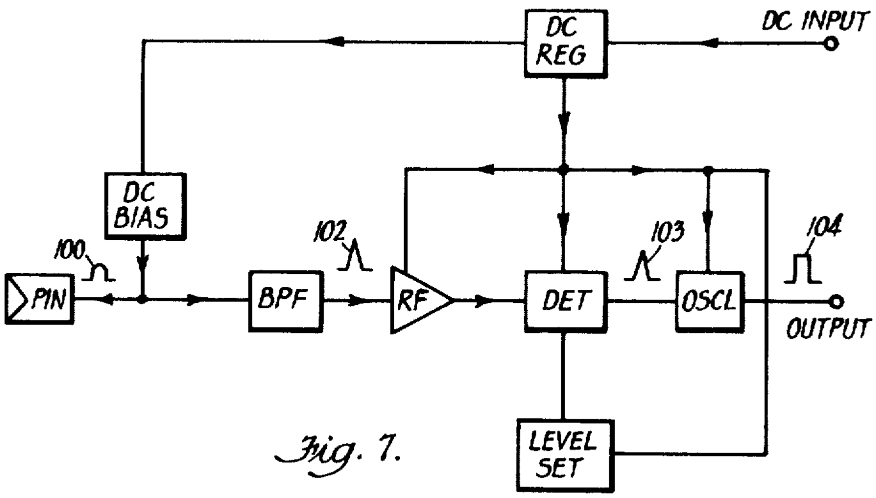

DC INPUT
DC REG
DC BIAS
100
PIN
BPF
102
RF
DET
103
OSCL
104
OUTPUT
LEVEL SET

Fig. 7.

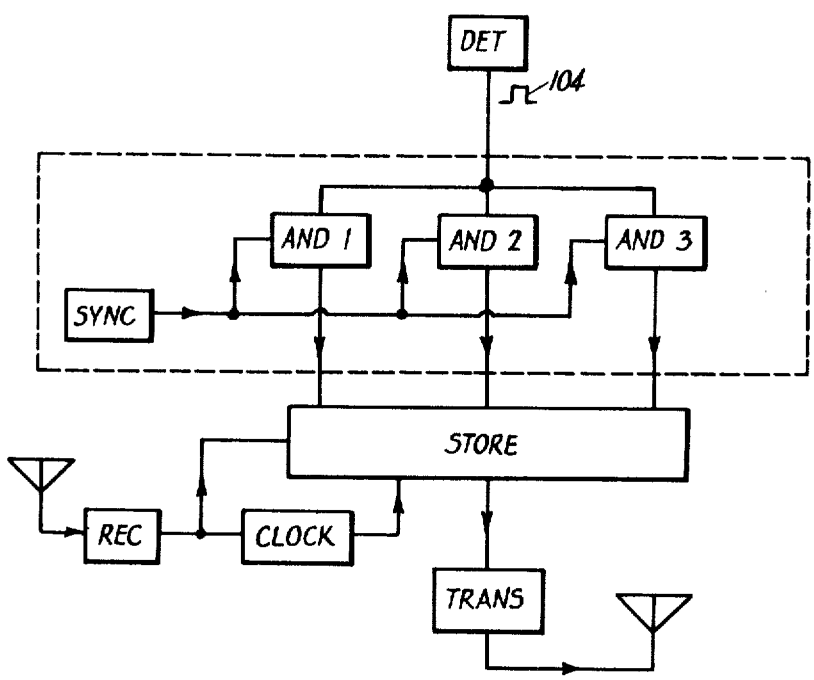

DET
104
AND 1
AND 2
AND 3
SYNC
STORE
REC
CLOCK
TRANS

Fig. 8.

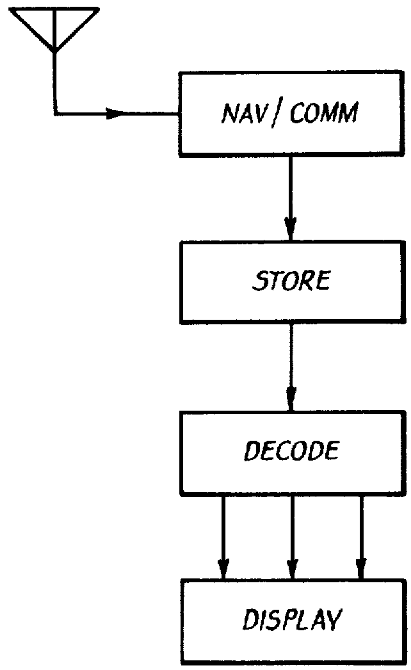

NAV/COMM
STORE
DECODE
DISPLAY

Fig. 9.

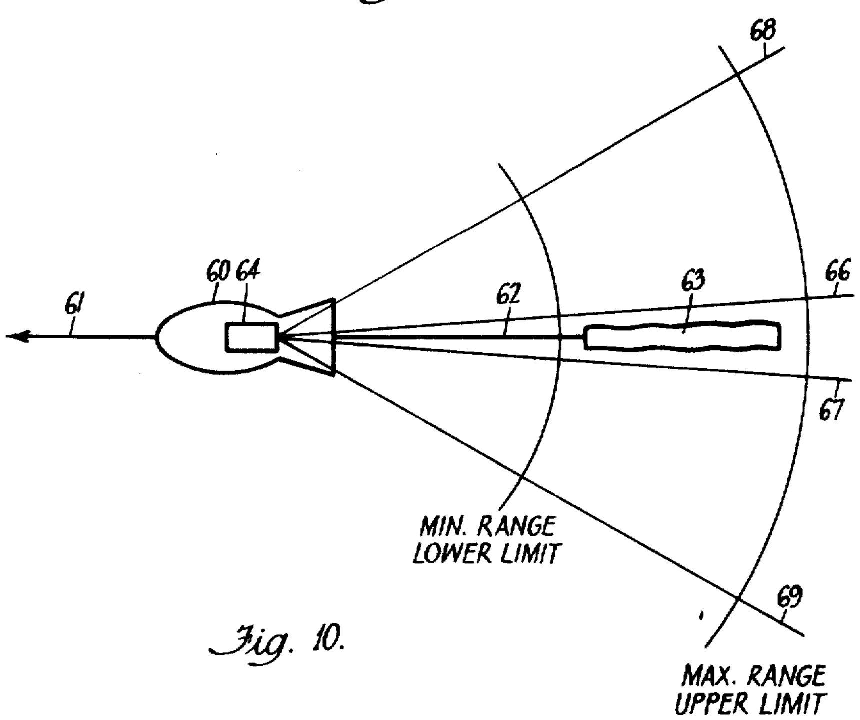

68
60 64
61
62
63
66
67
MIN. RANGE
LOWER LIMIT
69
MAX. RANGE
UPPER LIMIT

Fig. 10.

INDICATING THE PASSING OF A PROJECTILE THROUGH AN AREA IN SPACE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to indicating the passing of a projectile through an area in space.

The invention has particular application in determining accuracy of aim of bullets, cannon shells, missiles and the like at a target and has particular application in air-to-air and air-to-ground gunnery.

2. Description of Prior Art

Hitherto it has been necessary to visually inspect towed drogue targets after shooting thereat by an attacking aircraft. The count of hits determined by that inspection can then be radioed to the attacking aircraft. The time taken for the visual inspection is considerable and as we are here considering military aircraft which are expensive to keep in the air the cost of the visual inspection is considerable.

The object of this invention is to provide a method of, and apparatus for, indicating the passing of a projectile through a target area in space which can be applied to gunnery generally and specifically, but not exclusively, to air-to-air and air-to-ground gunnery.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a method of indicating the passing of a gunnery projectile through an area in space comprising inciding the whole of said area with a projected light beam and detecting a reflection of said beam off a gunnery projectile passing through said area resulting from incidence of said beam thereon thereby determining that said projectile passed through said area. The term "gunnery projectile" as used herein is intended to include all projectiles fired or projected from military or civilian firing or projecting equipment such as guns, pistols, rifles, rocket launchers, and missle launchers, and wherein the projectiles have a relatively high velocity as compared to projectiles such as stones thrown or fired by slingshots or arrows fired by bows or like type weapons.

This invention also provides gunnery apparatus for use in gunnery comprising a light beam projector adapted to incide the whole of an area in space with a projected light beam produced by said projector and a detector adapted to detect a reflection of said beam off a gunnery projectile passing through said area resulting from incidence of said beam thereon thereby to determine that said projectile passed through said area.

This invention further provides a method of indicating the passing of a gunnery projectile through one of a number of areas in space comprising scanning said areas with one or more projected light beams such that one of said one or more beams will incide on a projectile passing through one of said areas and detecting a reflection of said one of said one or more beams off said projectile resulting from such incidence and determining from which of said areas said reflection originated thereby determining that said projectile passed through said one of said areas from which said reflection originated.

This invention further provides gunnery apparatus for indicating the passing of a projectile through one of a number of areas in space comprising scanning means adapted to scan said areas with one or more projected light beams such that one of said one or more beams will incide on a projectile passing through one of said areas, and a detector adapted to detect a reflection of said one of said one or more beams off said projectile resulting from such incidence and to determine from which of said areas said reflection originated thereby to determine that said projectile passed through the one of said areas from which said reflection originated.

According to a still further aspect of this invention there is provided a lens comprising a slab of light transmitting material having two substantially straight edges which converge and having a part, adjacent the apex defined by said edges, adapted to diverge light entering the lens thereat and wherein said edges are reflective to light within the slab whereby, when in use, said lens is adapted to produce a fan shaped beam of angle equal to the angle included by said edges.

According to a further aspect of the invention there is provided a reflector comprising a body, a number of reflecting surfaces on a surface of the body around a central axis thereof, said reflecting surfaces being disposed so that when a beam of light is directed at one of the surfaces and the body is rotated about the central axis, the beam of light will be reflected successively by each reflector surface to scan an area in space, the reflecting surfaces being so shaped and arranged so that at the instant of completion of scan from one reflecting surface the beam is caused to again start scanning the area in space.

Preferred aspects and details of the present invention will now be described with the aid of the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of an optical part of an apparatus in accordance with the present invention.

FIG. **2** is a schematic representation of a different version of the optical part of the apparatus shown in FIG. **1.**

FIG. **3** is a perspective view of a lens used in the apparatus shown in FIG. **1.**

FIG. **4** is a perspective view of a reflector used in the apparatus shown in FIG. **2.**

FIG. **5** is an end view of the reflector shown in FIG. **4.**

FIG. **6** is a representation of an area incided with light by the apparatus shown in FIGS. **1** and **2.**

FIGS. **7, 8** and **9** are block circuit diagrams of apparatus forming an electronic part of the present invention.

FIG. **10** is a cross sectional view of a bird and drogue in which bird the apparatus shown in FIG. **1** and **2** may be fitted and towed behind an aeroplane.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. **1** the optical part of the apparatus has a continuous wave helium-neon laser **1.**

A beam **2** generated by the laser **1** is directed onto an inclined quartz mirror **3** which has a mirror coating on the second surface, relative to beam **2,** such that between approximately of beam **2** is transmitted therethrough to be beam **4.** Beam **4** is passed into a lens **5.** The lens **5** is shaped as a segment of a circle cut from a sheet of perspex (see FIG. **3**) and beam **4** is directed to bisect the angle of the segment and passes centrally thereinto at a circular cut-out portion **6.** Cut-out portion **6** causes beam **4** to project as beam **8** which can for convenience be called "the incident beam" which is of substantially rectangular cross section as shown by dotted line without substantial transverse divergence.

The lens **5** comprises a generally triangular slab of light transmitting material having two substantially straight edges which converge, and having a part in the form of a part cylindrical notch **6** adjacent to apex defined by the converging edges, which is adapted to diverge light entering the lens at the apex. The two straight edges of the lens, not being the edge opposite the apex at which light is to enter the lens, are reflective to light within the lens. For example, the edges may be mirrored. Such a lens is adapted to produce a fan shaped beam of light having an angle which is equal to the angle included by the edges of the slab adjacent the apex at which light is to enter the slab.

If a projectile such as a bullet or cannon shell should pass through beam **8** it will be incided by beam **8.** Since the projectile cannot be a perfect black body, a portion of the beam will be reflected thereby, and a portion of that reflection, conveniently known as "the reflected beam", will return to lens **5** where it will be collected and directed at mirror **3** as beam **9.** Beam **9** will be reflected by mirror **3** which is first surface coated, with respect thereto, as beam **10.** The coating of mirror **3** is such that beam **10** will be approximately 50 percent of beam **9.** Beam **10** passes through an optical band pass filter **12** which prevents light of frequency substantially different to that of laser **1** from passing — so as to reduce errors which may arise from stray light such as sunlight. Beam **10** emerges as beam **13** which then passes through lens **14** which focuses beam **13** onto the centre of PIN diode **15.** PIN diode **15** thus emits an electrical signal represented as **17.** Signal **17** will be hereinafter referred to as the reflected signal. The optical part of the apparatus described with respect to FIG. **1** provides an indication of a projectile passing through beam **8** and can be used, as to be described later, to give an indication of accuracy of shooting at a target.

As lens **5** is shaped primarily for projecting beam **4** as beam **8** and not for receiving the reflected beam off a projectile and causing that beam to be beam **9** a further lens shaped primarily for receiving the reflected beam may be provided and placed at a suitable location adjacent lens **5** to receive a reflected beam when it reflects along an axis to one side of the axis of projecting beam **8.**

Referring now to FIG. **2,** which shows a different version of an optical part of the apparatus, there is provided a helium-neon laser **21** which generates a continuous wave laser beam **22.** The beam **22** generated by the laser is directed onto an inclined quartz mirror **23** first surface coated, relative to beam **22,** which has a mirror coating such that between 1 and 5 percent of the beam **22** is reflected thereby to be beam **24** and between 95 percent and 99 percent of the beam **2** passes therethrough to be beam **26.**

Beam **26** is directed onto an inclined quartz mirror **27** second surface coated, relative to beam **26,** and approximately 50 percent of beam **26** passes therethrough to be beam **28.**

Beam **28** then passes to a faceted reflector **29** and is reflected thereby to be beam **31.**

The reflector **29** comprises a rectangular body **32** which is rotated about a face centred axis on shaft **33** by motor **34.** Also fixed to the shaft is a disc **36.** On the body **32,** see FIGS. **4** and **5,** are four planar mirror surfaces. The mirrors are disposed at 90° relative to one another on the sides of the body **32.**

It is to be noted that said axis is at right angles to beam **28** but for convenience of depiction is shown in line therewith in FIG. **2.**

Prior to passing to body **32** beam **28** is passed through a lens **5** similar to that described in respect of FIG. **1** – see FIGS. **4** and **5.**

As a result of rotation of the body **32** the beam **28** is reflected, in turn, by each of the mirrors to be, as stated before, beam **31.** Beam **31** as a result of rotation of the body **32** scans an area, hereinafter called "the scanned area." The scanned area has the shape shown in FIG. **6.**

As a result of lens **5** the beam **31** has an elongated section **37** as shown in FIG. **2** and FIG. **6.**

The shape of the scanned area is as shown in FIG. **6** and the reflector causes beam **31** to be of elongated section **37** as aforesaid and outwardly diverging as shown and scanning a segment. A lower limit as far as operation of the apparatus is concerned is arbitrarily set and an upper limit as far as operation of the apparatus is concerned is arbitrarily set in an electronic part of the invention. The depth of the beam to a projectile at the lower limit of scan is conveniently **27** inches for one particular embodiment, although it will be understood that the lower limit may be considerably greater in particular applications, for example, air to air targets.

The angular velocity of the body **32** and the width of the beam **31** (measured along the long and short axes of said elongated section **37**) are chosen so that a projectile such as a bullet passing through the scanned area will be incided by beam **31.**

For a projectile speed of 4,000 ft/sec. the time to travel through the beam, for the depth of the beam to the projectile of 27 inches at the lower limit of intended scan. = (27/48) m.sec. = 0.564 m.sec.

Thus for a 4 sided body **32** the speed of rotation of the body **32** is desirably not less than (1000/0.564 × 4) = 443 Revs/sec = 26580 RPM. In practise we have found it best for these dimensions to be in excess of that required so as to be applicable to a wide range of projectile velocities.

If a projectile such as a bullet or cannon shell should pass through the scanned area it will be incided by the beam **31.** Beam **31** is conveniently called "the incident beam." Since the projectile cannot be a perfect black body, perfect **31** will be reflected thereby and a portion of the reflection will travel back along the path of beam **31** at the instant of incidence. That portion will be known as beam **38** and it is convenient to refer to it as "the reflected beam" and it will be realised that the beam **38** will have the nature of a pulse and not be continuous.

Beam **38** is reflected by the mirrors on body **32** and will travel along the path of beam **28,** except that it will travel in the opposite direction, as beam **19.**

Beam **19** meets mirror **27** which, to beam **39** is first surface coated, and approximately 50 percent reflected thereby as beam **41.**

Beam **41** then passes to optical band pass filter **42** which prevents light of frequency substantially different to that of the laser from passing — so as to reduce errors which may arise from stray light such as sunlight.

From filter **42** beams **43** emerges and passes to a PIN diode **44.** The beam **43** causes the diode **44** to emit an electrical signal which is represented as **46.** That signal will be hereinafter called "the reflected signal,"

Beam **24** is passed to inclined mirror **47** and is substantially entirely reflected thereby to be beam **48.** Beam **48** passes through lens system **49** and emerges as beam **51.**

The disc **36** has a large number of optical holes of apertures adjacent its periphery with their centres at the same radial distance from the centre of rotation of the disc. The holes are arranged in four groups and the groups are angularly disposed relative to one another in the same manner as the four mirrors on body **32** are angularly disposed relative to one another. Each group corresponds to one of the four mirrors so that whilst one mirror is reflecting beam **38** the group corresponding to that mirror is disposed so that beam **51** is passing through the holes in that group to emerge from the disc as pulse beams **52.**

Pulse beams **52** pass to PIN diode **53** and cause the diode **53** to emit a pulsed electric signal which is represented as **54.** That signal will be hereinafter called "the reference pulse signal."

In use the apparatus is set up so that the scanned area will be generally along the sides of a target or other convenient objects to aim at. The invention, of course, has particular application in air-to-air and air-to-ground gunnery and in which case the scanned area will be in front of a towed drogue as shown in FIG. **10,** or in front of or behind a ground target.

Referring now to FIG. **10,** when the apparatus is to be used in air-to-air gunnery a bird **60** is connected at one end by a tow line **61** to an aircraft and connected at the other end by a tow line **62** to a drogue **63.** The optical part of the invention is shown as a block **64** and is arranged such that the incident beam produced by it is in a vertical plane adjacent drogue **63.**

If the optical part of the apparatus as described with respect to FIG. **1** is used in the bird **60** then the lens **5** thereof is arranged so that the incident beam thereof is as shown by lines **66–67.**

If the optical part of the apparatus as shown in FIG. **2** is used in the bird **60** the mirror surfaces can be arranged to cause the angle of scan of the beam to be as shown by lines **66–67** but preferably they are arranged to cause the scan to be as shown between lines **68–69** and with a minimum and maximum ranges as shown with respect to the drogue **63.**

At the end of a days shooting the drogue **60** can be hauled in to the aircraft or the tow line **61** can be released from the aircraft and a parachute in the bird **60** made operable as a consequence of releasing towline **61** so that the bird can be safely landed.

It will be realised that the optical part of the apparatus can be mounted in the aircraft instead of in the bird for air-to-air gunnery but because the drogue is towed a considerable distance behind the aircraft so as to avoid the towing aircraft from being hit by projectiles and for economy of laser constructions and efficiency of operation of the apparatus we prefer the optical part of the apparatus to be as close as possible to the target so the magnitude of reflection of the laser beam will be as large as possible.

In air-to-ground gunnery the optical part of the apparatus is arranged to produce the incident beam in front of the target as is shown in FIG. **6.**

Manners in which the reflected signal and the reference pulse signal can be used will now be generally described and thereafter circuitry used to derive information from those signals will be described in detail.

Since the reflected signal is a pulsed signal the number of projectiles passing through the scanned area is determined merely by counting the pulses. By this means a crude estimation of aim accuracy is obtainable.

Further, since the reflected signal will have a magnitude related to the magnitude of the reflected beam and, since the magnitude of the reflected beam is related to the distance of the projectile on which the incident beam incided, it is possible, by rejecting signals of below or above predetermined magnitudes, to put an upper limit and a lower limit on the range at which projectiles will be detected. These ranges are shown in FIGS. **6** and **10.** It will be realised that this provides a better estimation of aim accuracy. Further increase in quality of estimation can be obtained by determining the relation of the magnitude of the reflected signal to range of projectiles but it will be realised that such a relation is likely to vary substantially dependent on whether the reflected signal is obtained from relatively large or relatively small calibre projectiles.

By the use of the optical part of the apparatus as shown in FIG. **2** with the aid of other means it is possible to determine the angular position, relative to an imaginary baseline, of a detected projectile in the scanned area. This is done by providing a certain aperture in said disc larger than the other apertures. Said certain aperture will produce a pulse in the reference pulse signal larger and longer than the pulse produced by the other apertures. Said certain aperture is also positioned so that the pulse produced thereby is produced at the instant that one of the mirrors commences to scan the scanned area. By knowing the number of pulses produced during the time that said one of the mirrors is scanning the scanned area and by dividing that number by another number — conveniently, three — it is possible, by counting pulses and relating the reflected signal to the count at the time that the reflected signal is received to determine the angular position, relative to an imaginary base line, of a projectile in the scanned area in three segments of the scanned area. Thus an even more accurate estimation of aim accuracy is obtained.

The above is a general description of manners of using the pulse reference signal and the reflected signal. More specific details and circuitry used in a preferred instance is given below.

The circuit used for obtaining signals corresponding to a projectile passing within a certain range of the origin of the incident beam is shown in FIG. 7 and includes a PIN diode (previously referred to by number as **15** and **44**). When a reflected light beam off a projectile strikes PIN diode a signal is generated which is now indicated by 100. The signal 100 is fed to a band pass filter B.P.F. arranged with circuit constants to only allow a signal falling within a predetermined range of frequencies to pass. The signal passed from the band pass filter is shown generally as **102.** The signal **102** is amplified by a radio frequency amplifier R.F. and clamped by a level set and detected between preset levels to generate an output shape shown generally as **103.** The signal **103** is used to trigger an oscillator to generate a signal, shown generally as **104** of known duration and amplitude. A D.C. regulator is used for supplying constant voltage to the above circuit integers.

When using the optical part of the apparatus as shown in FIG. 1 the signal **104** can be fed directly into a store. This is shown basically in FIG. **8** except that additional circuitry outlined with dotted lines is shown. The additional circuitry will be explained later. On the receiver REC receiving a command signal or after a fixed small time delay after the first detected hit in a burst the STORE is made operative to feed information stored therein in binary code on signals from CLOCK concerning hits to a transmitter TRANS which in turn transmits the information to be received by an aircraft firing at the drogue or ground target. The transmitter TRANS operates at a frequency such that the usual NAV/COMM equipment in the aeroplane can receive the information. This is basically shown in FIG. **9** except that further additional circuitry is shown. The further additional circuitry will be explained later. Connected to the NAV/COMM equipment is a decoder DECODE which decodes the information received and feeds it to a display unit DISPLAY which has a series of digital reading display tubes for giving an indication of the number of projectiles which passed through the incident beam and hence the number of target hits.

The receiver REC in the circuitry shown in FIG. **8** is made operative on receipt of a command signal from the transmitter in the NAV/COMM equipment of the aircraft which is shooting at the target. The command signal can be initiated by the pilot or gunner in the aircraft. Alternatively, the transmission of hit data may be made automatic after a small time delay (5 seconds).

When the optical apparatus shown in FIG. **2** is used the signal **104** is preferably fed to three electronic gates, AND **1**, AND **2** and AND **3**, (see FIG. **8**) which gates are individually openable for a period corresponding to a number of selected reference pulse signals. The selected reference pulse signals are obtained by providing suitable dividing means for dividing the pulse signals generated by the number of apertures in the disc **36** into groups of signals and using those signals to operate further circuit means to generate a signal to open a gate for the duration of each group of signals. The disc **36** has 1,199 equally spaced circumferential apertures and one larger circumferential aperture, totalling 1,200 apertures. The larger aperture is aligned to correspond to the start of scan of the beam across the scanned area by one of the mirrors. Because there are four mirrors there are (1,200/4) = 300 apertures corresponding to each mirror. By providing dividing means for counting 300/3 = 100 pulses and means for generating a signal to be fed to one of the three gates for the duration of 100 pulses and, to a second of the three gates for the duration of the next 100 pulses and, to a third of the three gates for the next 100 pulses, from the SYNC and back to the said one of the gates for the next 100 pulses, etc., we can open each of the gates for a third of the sector of scan of the beam. In the present case the area of scan is divided into three sectors. As the signal **104** is fed to all three gates, it passes only through the gate which is opened. Hence we can obtain a signal representative of which sector a projectile passed through, and hence we can obtain a more accurate determination of the accuracy of the air of the projectile. The three gates may correspond to "Left of target," "Hit target," and "Right of target" respectively. The hit information from the gates is fed into the STORE and transmitted as described for the optical construction shown in FIG. **1.**

The hit information transmitted by TRANS is received by the NAV/COMM equipment shown in FIG. **9** and fed into a STORE from the STORE the information is fed to a decode which decodes the information which is in binary form into a suitable form for operating a display unit. The decoded information is fed to a display unit DISPLAY where it can be read by an observer.

It will be appreciated that by using the apparatus as described above it is possible for a number of aircraft to fire at a target, one at a time, and for an indication of the accuracy of shooting at the target to be given almost instantaneously to each aircraft in turn. Hence the cost of keeping several aircraft in flight whilst manually counting the hits of the target is reduced.

In order to eliminate the effect of sunlight or effects of other light beams or effects of slow moving objects passing through the incident beam from being registered as hits the circuitry used for registering a hit resulting from a projectile passing through the incident beam may be arranged to operate when a projectile leaves the scanned area, by providing a blanking signal to a reflected signal which occurs for, say every three scans of light beam.

In order to reduce the diameter of disc **36** having regard to the problems involved in producing a required number of apertures at the periphery thereof as the disc becomes smaller and smaller in diameter the disc can be provided with magnetic signals of differing frequency and having a relation to the number of apertures which would otherwise be used. A tape recording replay head can be arranged to read the recorded signals as the disc **36** rotates so that signal **54** can be generated and used as previously described.

To ensure that a hit is not registered in two sectors of scan if a projectile passes through the transition position of two adjacent sectors of scan, the reflected signal can be used to inhibit the next count until after a set time.

Throughout the specification the term light beam has been used and this is to be understood to include light which is visible and light which is not visible. The term "light beam" is to include light which is in the I.R. spectrum and light which is in the U.V. spectrum.

We claim:

1. A method of indicating the passing of a gunnery projectile through an area in space comprising inciding the whole of said area with a projected light beam which passes through a lens element so as to provide a fan shaped beam which at least partially defines said area in space, and detecting a reflection of said beam off a projectile passing through said area resulting from incidence of said beam thereon thereby determining that said projectile passed through said area, said reflected beam passing through said lens element prior to said detection.

2. A method as claimed in claim **1**, wherein said beam is of a size, in use, such as to incide the whole of said area and is stationary.

3. A method as claimed in claim **1**, wherein said beam is of a length in the direction of intended movement of a gunnery projectile insufficient to incide the whole of said area and is scanned such that said beam incides the whole of said area and such that said beam will incide a projectile passing through said area.

4. A method as claimed in claim 3, further including the step of relating said reflection to the angular position of said beam at the time of detecting said reflection whereby to derive information on the angular position of said projectile.

5. The method of claim 4, further including the step of disregarding reflections of said beam off a projectile above and below predetermined magnitudes whereby to define boundaries of said area.

6. A method as claimed in claim 1 wherein said beam is fan shaped.

7. A method as claimed in claim 1 wherein said beam is generated by a laser.

8. Gunnery apparatus for indicating the passing of a gunnery projectile travelling at a relatively high speed originating from a weapon comprising a light beam projector adapted to incide the whole of an area in space with a projected light beam produced by said projector, a lens element in the path of said projected beam to produce a fan shaped beam at least partially defining said area in space, and a detector adapted to detect a reflection of said beam off said gunnery projectile travelling at a high speed through said area, whereby said reflection results from incidence of said beam thereon thereby to determine that said projectile passed through said area, and said reflected beam passes through said lens element to said detector.

9. Gunnery apparatus as claimed in claim 8 wherein said projector is such that said beam is of a size, in use, such as to incide the whole of said area and is stationary.

10. Gunnery apparatus as claimed in claim 9 wherein said projector is such that said beam is of a size and of a length in the direction of intended movement of a gunnery projectile insufficient to incide the whole of said area, and further comprising scanning means adapted to scan said beam such that said beam incides the whole of said area and such that said beam will incide a gunnery projectile passing through said area.

11. The gunnery apparatus of claim 10, further including a reflective surface mounted for movement whereby to scan said area with a light beam reflected therefrom such as to incide a gunnery projectile passing through said area.

12. The gunnery apparatus of claim 11, further including means adapted, in use, to produce an indicia of the angle said beam makes with respect to a reference line at any one time.

13. Gunnery apparatus as claimed in claim 8, further including means adapted to produce a visual or audible signal consequent on detection of said reflection by said detector.

14. Gunnery apparatus as claimed in claim 8, further including means adapted to relate said reflection to the angular position of said beam at the time of detecting said reflection by said detection whereby to provide information on the angular position of said projectile.

15. Gunnery apparatus as claimed in claim 8, further including means adapted to disregard reflection of said beam off a gunnery projectile above and below predetermined magnitudes whereby to define boundaries of said area.

16. A method of indicating the passing of a gunnery projectile through one of a number of areas in space comprising scanning said areas with a projected light beam such that said beam will incide on said projectile passing through one of said areas, and detecting a reflection of said beam off said projectile and determining from which of said areas said reflection originated thereby determining that said projectile passed through said one of said areas from which said reflection originated.

17. A method as claimed in claim 16, wherein said beam is caused to scan said areas by reflecting off a reflector moving with respect to said beam before it is projected.

18. A method as claimed in claim 16 wherein an electrical signal is generated when said reflection is detected and wherein an electrical reference signal is generated representative of the one of said areas being scanned by said beam at any one time and wherein the first mentioned electrical signal is related with the electrical reference signal to provide an indication of which of said areas the projectile passed through.

19. A method as claimed in claim 18, wherein information related to the first mentioned electrical signal and the electrical reference signal is transmitted to a display unit and displayed as an indication of a projectile which passed through the respective area.

20. Gunnery apparatus for indicating the passing of a projectile travelling at a relatively high speed originating from a weapon and indicating the passing of a projectile through one of a number of areas in space, comprising scanning means adapted to scan said areas with a projected light beam such that said beam will incide on a projectile travelling at high speed through one of said areas, and a detector adapted to detect a reflection of said beam off said projectile resulting from such incidence and to determine from which of said areas said reflection orignated thereby to determine that said projectile passed through the one of said areas from which said reflection originated.

21. Gunnery apparatus as claimed in claim 20 further including means adapted to produce an electrical signal consequent on detection of said reflection, means adapted to produce an electrical reference signal representative of the one of said areas being scanned by said beam at any one time and including means adapted to relate the first mentioned signal to the electrical reference signal to provide an indication of which of said areas said projectile passed through.

22. Gunnery apparatus as claimed in claim 21, further including a number of electronic gates selectively operable by the electrical reference signal whereby each of said gates represents one of said areas and is open when said beam is scannning the respective one of said areas and wherein circuitry is provided adapted to feed the first mentioned electrical signal to said gates whereby passage of the first mentioned electrical signal through one of said gates indicates which of said areas said projectile passed through.

23. A lens comprising a slab of light transmitting material having two substantially straight edges which converge and having a part, adjacent the apex defined by said edges, adapted to diverge light entering the lens thereat and wherein said edges are reflective to light within the slab whereby, in use, said lens is adapted to

produce a fan-shaped beam of angle equal to the angle included by said edges.

24. A lens comprising a generally triangular slab of light transmitting material having a part adjacent one of apexes thereof adapted to diverge light entering the lens thereat and wherein the edges of the lens other than the edge opposite said part are reflective to light within the slab whereby, in use, said lens is adapted to produce a fan-shaped beam having an angle equal to the angle included by the edges adjacent said part.

25. A lens as claimed in claim **24** wherein said part comprises a part cylindrical notch.

26. Apparatus for indicating the presence of a gunnery projectile travelling at a relatively high speed originating from a weapon in an area in space, comprising a light beam projector for projecting a continuous beam of light, a lens element in the path of said continuous projected beam, said lens element having a concavity in the end thereof receiving said projected beam, said concavity serving to convert said continuous beam into an incident beam having a width proportional to said concavity, thereby to define said area in space, a reflector for receiving a reflected beam off a projectile in said area resulting from incidence of said projected beam thereon, and a detector adapted to detect said reflected beam thereby to determine the presence of said projectile.

27. Apparatus for indicating the presence of a gunnery projectile in an area in space, comprising light beam projector, said projector including a reflector element for reflecting a beam of light so as to incide the whole of said area in space with a projected light beam produced by said projector, said reflector element being movably mounted and further including a lens element in the path of the projected light beam and positioned between said beam projector and said reflector element, said lens element having a concavity in the end thereof receiving said projected beam, said concavity serving to convert said continuous beam into an incicent beam having a width proportional to said concavity, said incident beam being reflected by said movable reflector element to scan the whole of said area in space, and a detector adapted to detect a reflection of said beam off a projectile in said area resulting from incidence of said beam thereon, the energy reflected by the projectile being directed to said detector by said reflector element thereby to determine the presence of said projectile.

28. The apparatus of claim **27** wherein said reflector element comprises a four-sided member having planar reflecting surfaces at each side, means for mounting said reflector element on an axis perpendicular to the axis of said lens element, and means for rotating said reflector element at a sufficiently high speed so as to substantially continuously incide said area in space so as to detect the presence of a projectile travelling at a predeterminedly known speed.

29. Gunnery apparatus for indicating the passing of a projectile travelling at a relatively high speed originating from a weapon, comprising means for projecting a light beam, scanning means adapted to scan a defined area in space with said projected light beam such that said beam will incide on a projectile travelling at such high speed passing through said area, and a detector adapted to detect a reflection of said beam off said projectile resulting from such incidence and to determine that said projectile passed through said area.

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