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Willey

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[54] **GUNNERY TRAINER**

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[52] **U.S. Cl.** **35/25,** 273/101

[51] **Int. Cl.** **F41g 3/26**

[58] **Field of Search** 35/25, 10.2; 350/16; 273/101.1, 101.2

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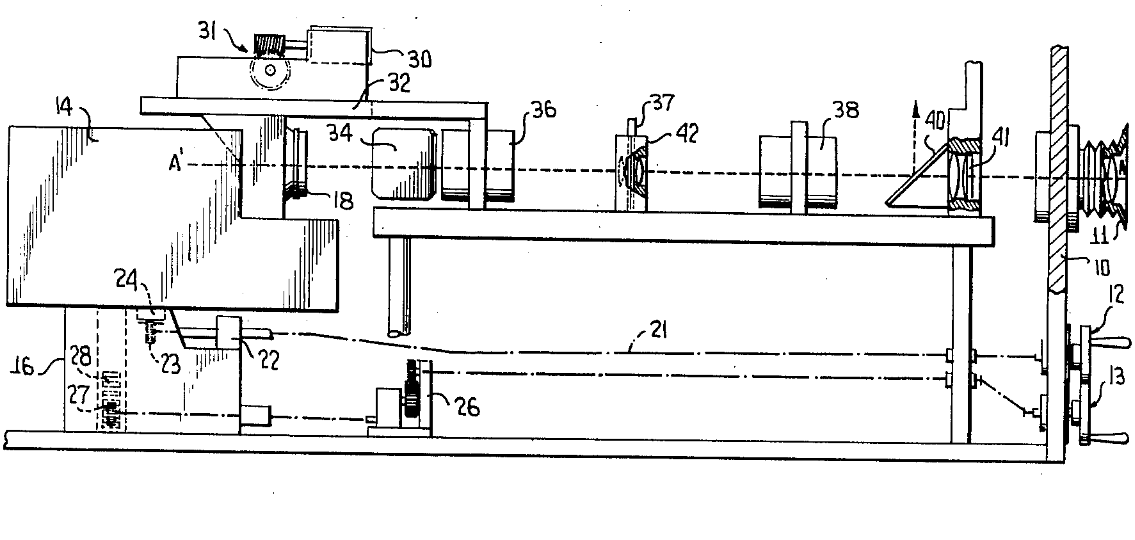
[57] **ABSTRACT**

A burst-on-target gunnery simulator, particularly suitable for training tank gunners, includes a slide projector for projecting realistic target scene images through a reticle slide to an eyepiece for a gunner-trainee. The projector is movable under trainee control to permit movement of the target scene relative to the reticle, thereby giving the trainee the feeling of gun movement. A laser beam is momentarily combined with the target image in response to operator actuation of a firing mechanism, thereby optically simulating a gun burst on the viewed target scene. By noting where the burst falls the trainee can re-aim the gun, i.e., reposition the projector, as needed to hit the target with the next round. The target scene and burst is also viewable on an instructor's screen. Instructor-operated controls permit the laser mount to be moved relative to the target to simulate various firing trajectories and wind conditions. The instructor is provided with a control which permits the laser burst to be blocked from the trainee's view without impairing the burst image on the instructor's screen.

14 Claims, 9 Drawing Figures



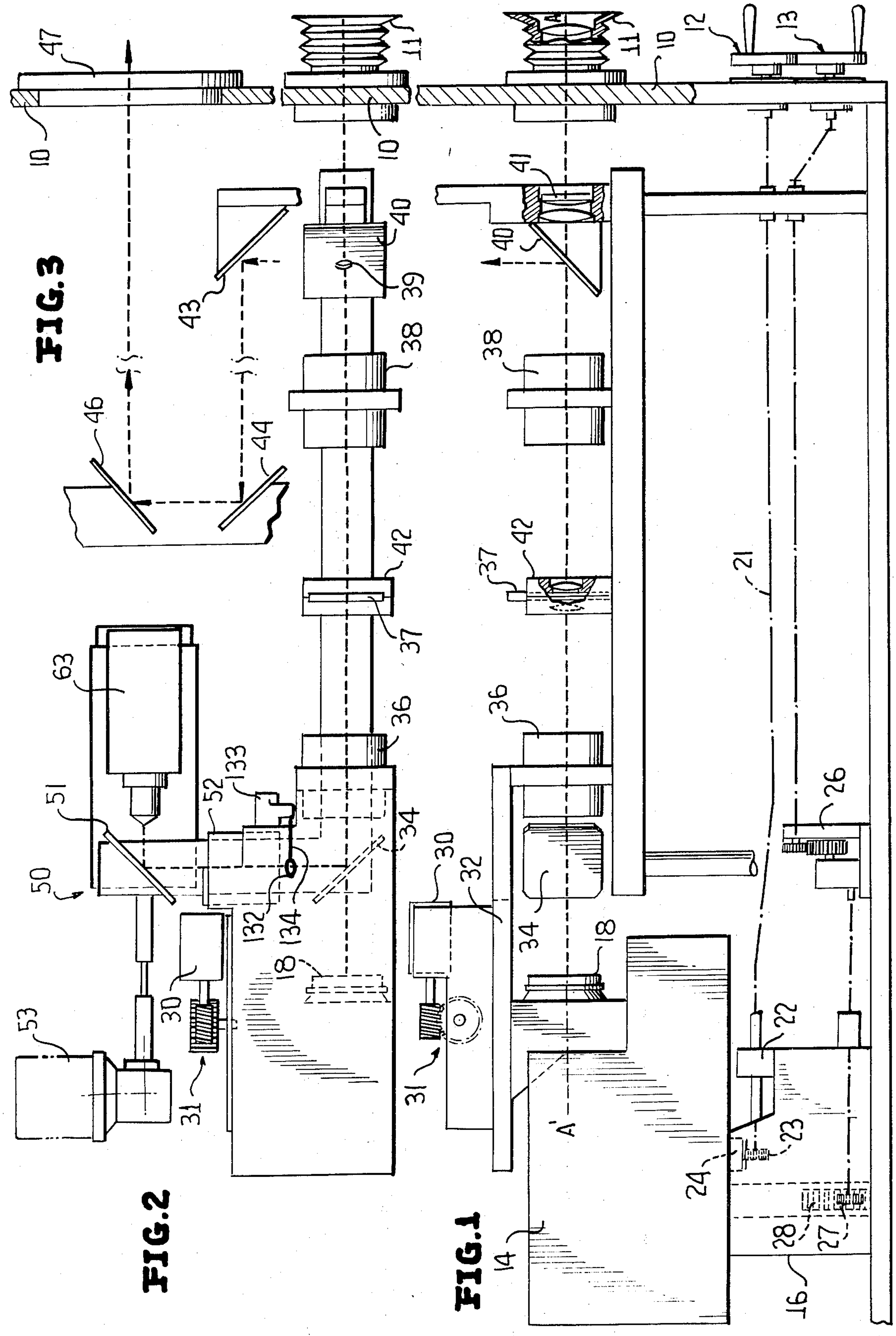


FIG.1

FIG.2

FIG.3

FIG. 8

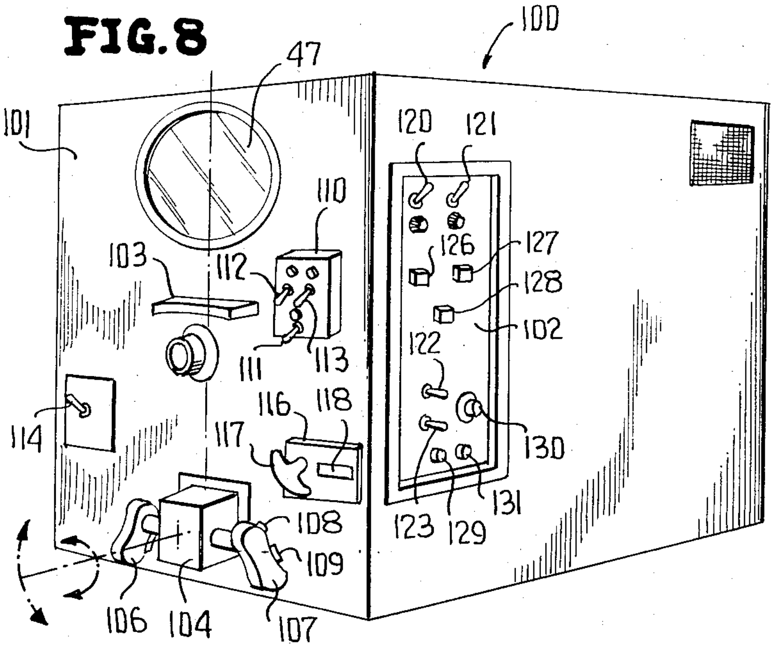


FIG. 5

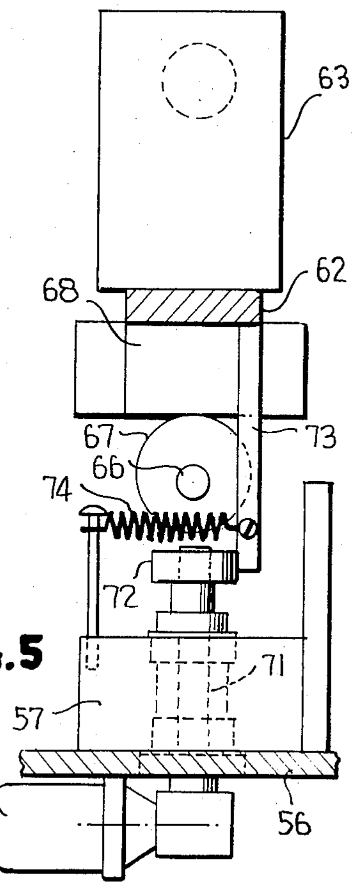


FIG. 4

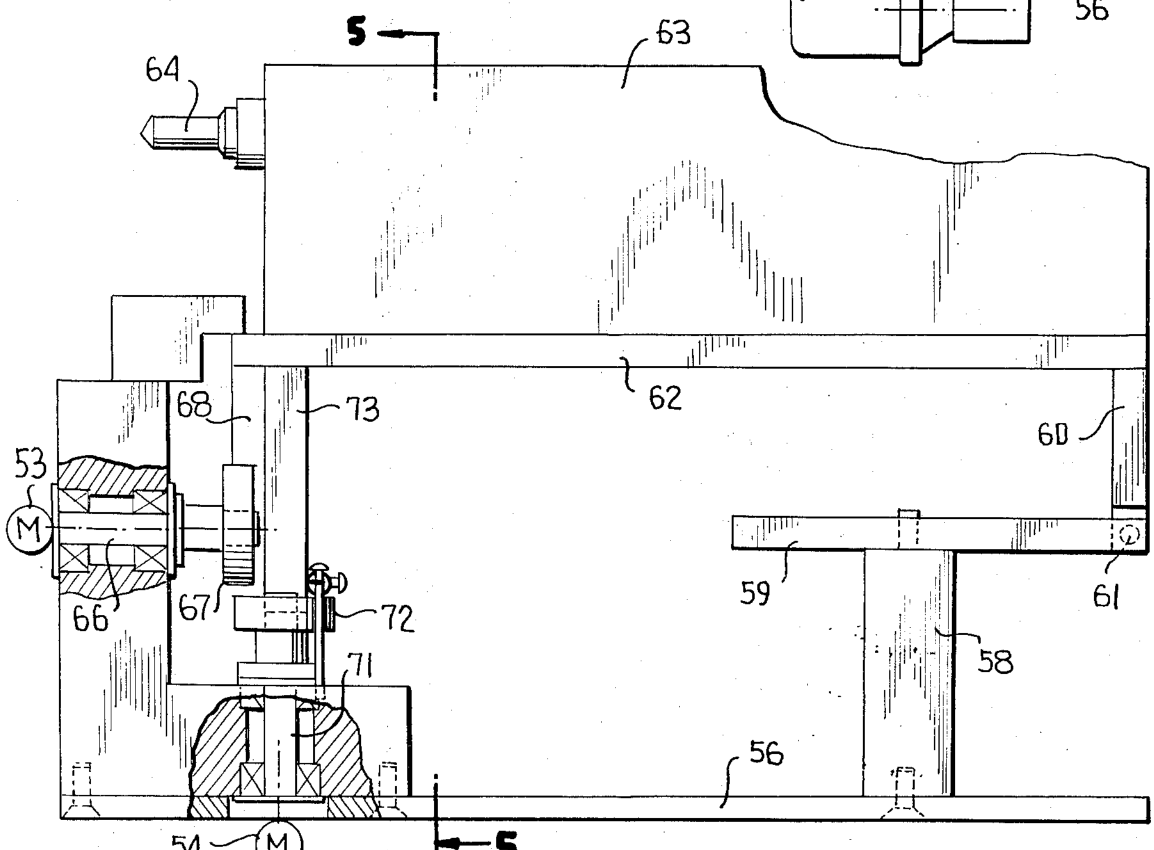


FIG. 9

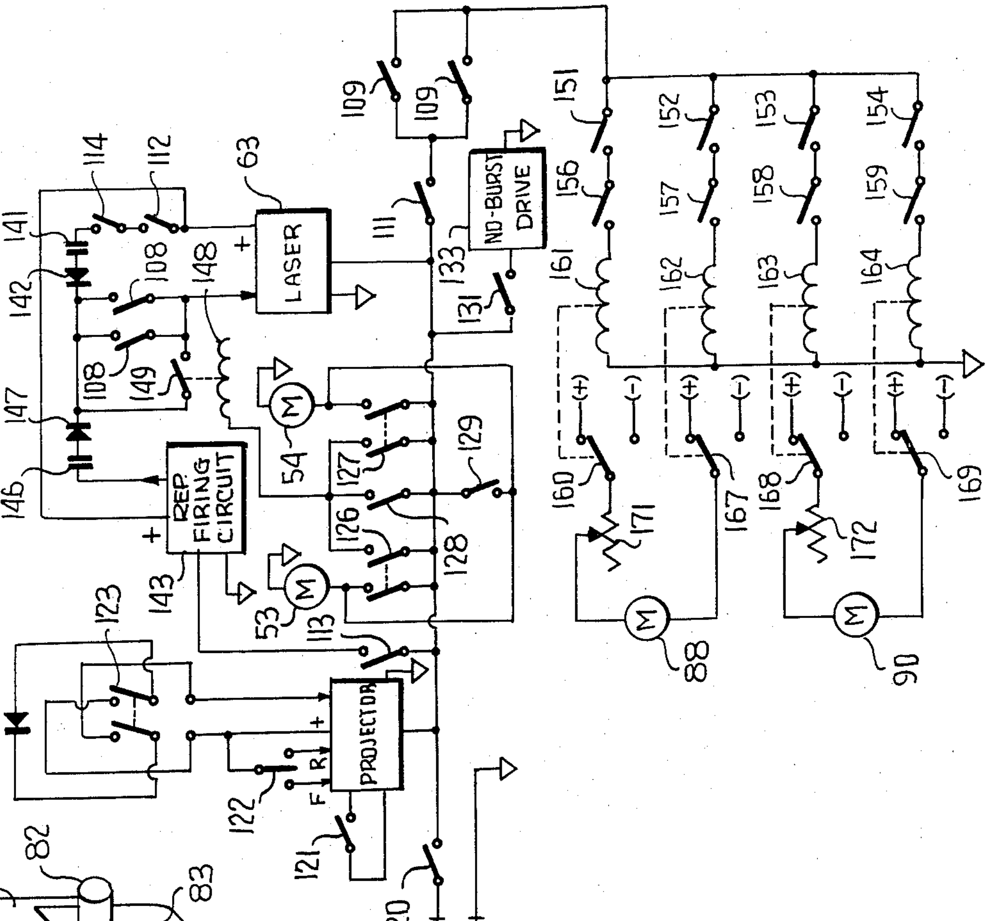


FIG. 6

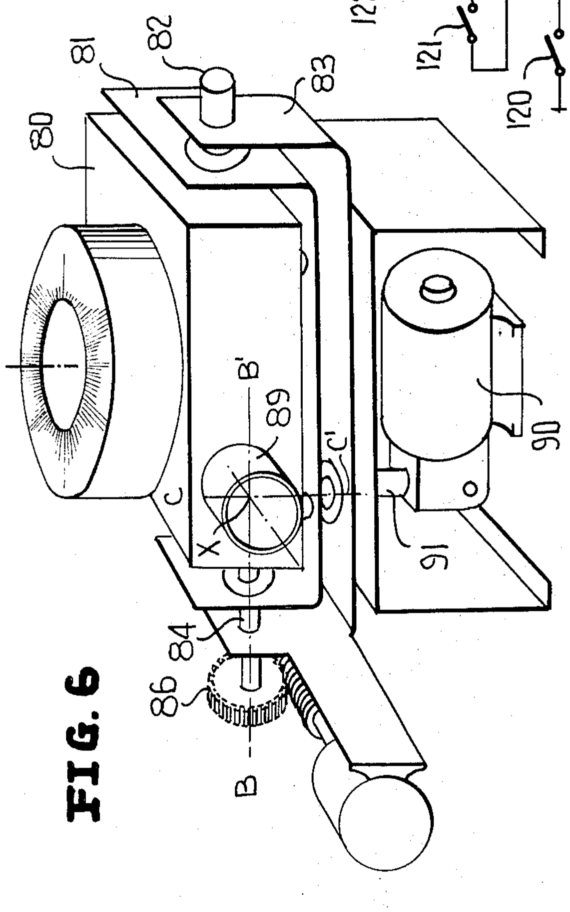
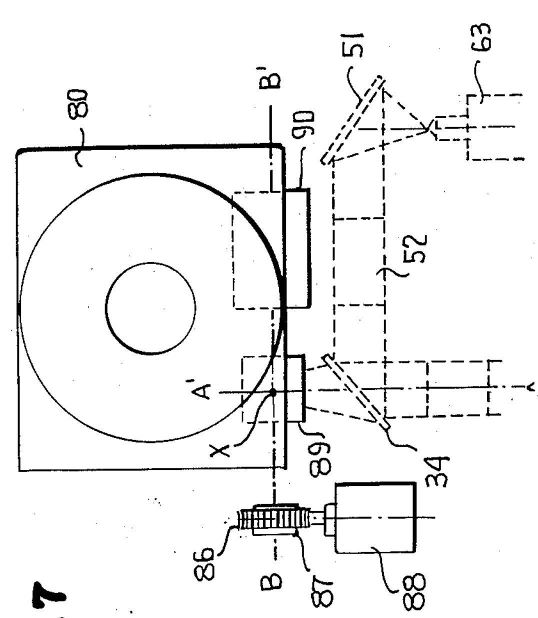


FIG. 7



GUNNERY TRAINER

BACKGROUND OF THE INVENTION

The present invention relates generally to optical image combining techniques and, more particularly, to simulators for use in a classroom type environment for training gunners and the like. While the present invention is described in terms of tank gunnery training it will be appreciated that the principles disclosed herein are suitable for gunnery training in other environments where the operator is located in an enclosure and views a target scene through a limited field of view, such as a periscope arrangement. Moreover, the optical arrangement disclosed herein has utilization apart from gunnery training, in such fields as amusement devices and the like.

Effective tank gunnery training has heretofore been limited to field training. The reason for this is the absence in the prior art of a gunnery simulator of sufficient realism to give the trainee the feeling of aiming and firing a gun at a realistic target.

A truly effective tank gunnery training simulator should permit the trainee to practice the gunner's primary method of adjusting firing direction, namely: the burst-on-target method. By this method, the gunner observes where a burst passes, falls short of, or strikes a target. Upon making such observation the gunner then adjusts the gun laying controls by the shortest route and fires again, attempting with this burst to hit the target directly. The accuracy of this gun-laying method depends upon the gunner's ability to correctly interpret his observation and make precise corrections. Considerable training is necessary to perfect this ability.

A gunnery simulator, to be useful in burst-on-target training, must provide a realistic target scene viewable through a gunnery eyepiece. The view must also include a reticle with respect to which the target must be movable. In addition, means must be provided to simulate a burst in the target scene at a position which can be coordinated to trainee-operated azimuth and elevation controls.

A more sophisticated version of the burst-on-target technique occurs when a burst of fire is seen by the tank commander as it passes the target but, for some reason, is not seen by the gunner. The tank commander must then estimate the correction and verbally direct the gunner to change the line of sight to the appropriate extent. It is desirable, in the case of a versatile tank gunnery training device to permit this technique to be realistically practiced.

It is therefore an object of the present invention to provide a realistic simulator for gunnery training.

It is another object of the present invention to provide a simulator capable of use in training tank gunners in the burst-on-target firing method.

It is still another object of the present invention to permit realistic gunnery training to beconducted in a classroom type of environment.

SUMMARY OF THE INVENTION

According to the present invention a realistic target scene is projected from a slide, through a reticle, to the eyepiece of the trainee. The slide is movable both vertically and horizontally in response to trainee-actuated elevation and azimuth controls, respectively, giving the appearance of reticle motion relative to the target

scene. A laser beam is momentarily optically combined with the target scene to simulate a burst from a fired round. By adjusting the elevation and azimuth controls the trainee can re-position the slide to give the appearance of gun movement and thereby change the location at which the next laser burst appears on the target scene.

A viewing screen is provided whereby the instructor may observe the target scene and burst. The instructor also has under his control means for adjusting the position of the laser mount, thereby permitting variation of the location of the projected burst on the viewed target scene. With this capability the instructor is able to simulate various desired trajectories or wind conditions. The instructor is also able to selectively block a portion of the projected laser burst so that the burst is not visible at the trainee's eyepiece but is visible at the viewing screen. The instructor, therefore, is able to observe a burst not seen by the trainee and then direct the trainee to adjust the "gun position" in the proper direction and by a proper amount in order to cause the next burst to strike the target.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a partially schematic side view in elevation of the optical system of a simulator according to the present invention;

FIG. **2** is a partially schematic top view of the simulator of FIG. **1**;

FIG. **3** is a schematic representation of a continuation of the optical path depicted in FIG. **1**;

FIG. **4** is a side view in elevation of a laser mount assembly employed in the simulator;

FIG. **5** is a sectional view taken along lines **5**—**5** of FIG. **4**;

FIG. **6** is a view in perspective of another form of slide projector and its displacement drive arrangement for use in a simulator of the present invention;

FIG. **7** is a diagrammatic illustration of the projector of FIG. **6** and its positional alignment with the optical components in FIGS. **1** and **2**;

FIG. **8** is a view in perspective of front and side control panels of a simulator constructed in accordance with the principles of the present invention; and

FIG. **9** is an electrical schematic diagram illustrating the circuitry utilized to effect various control functions initiated at the panels of FIG. **8**.

DESCRIPTION OF PREFERRED EMBODIMENTS

In order to facilitate an understanding of the simulator of the present invention and its operating principles, initial reference will be made to the optical components and their functional interrelation, as best illustrated in FIGS. **1** through **5**. Thereafter the various controls and their operation will be described.

Referring specifically to FIGS. **1**, **2** and **3** of the accompanying drawings, an eyepiece **11** for use by a gunner-trainee is mounted on a control panel **10** for viewing along an axis A–A'. Also mounted on panel **10** are a pair of hand-operated control members **12** and **13** which function in a manner described below.

A slide projector **14** is mounted atop a projector drive assembly **16** with the projector lens **18** in axial alignment with eyepiece **11** on axis A–A'. Projector **14** is a typical 35mm slide projector, (for example Model 150 Ti-Matic manufactured by Airequipt, Inc., New Rochelle, New York) modified so that the main body of the projector is movable relative to projector lens **18.** Horizontal movement of the projector, i.e., into and out of the plane of the drawing in FIG. **1,** is effected by control member **12,** which serves as an azimuth control at front panel **10.** A flexible cable **21** is rotated along with azimuth control **12** and drives speed reduction gear box **22.** The latter, in turn, drives pinion **23** to translate rack **24** secured to the body of projector **14.** Vertical movement of the projector is controlled by an elevation wheel in the form of control member **13,** rotation of which drives a speed reduction gear assembly **26.** The reduced angular rotation is in turn transmitted to pinion **27** which raises and lowers the projector by driving a rack **28** secured to the projector.

Alternatively, projector movement can be effected by electrical control in the manner described below in reference to FIGS. **6** and **7.**

Target slides (not shown) depict typical target scenes and are individually positioned in projector **14** for projection through lens **18** toward eyepiece **11.** Slides may be changed automatically by conventional techniques simply by actuating a slide changer switch at the control panel. Focus of the slide at eyepiece **11** can also be effected from the control panel. Specifically, operation of a switch (to be described below) actuates a motor **30** which drives a set of gears **31** to in turn translate the mount **32** for projection lens **18** along projection axis A–A'.

The target scene image projected by lens **18** is passed through a beam splitter **34,** a relay lens **36,** a reticle slide **37,** another relay lens **38,** a small hole **39** in a mirror **40,** and an achromatic transfer lens assembly **41** to eyepiece **11.** Beam splitter **34** may, for example, comprise a semi-silvered mirror oriented at a 45° angle relative to the projection axis. This permits the target scene image to be optically combined with a light burst directed perpendicular to projection axis A–A' for reflection along that axis by the beam splitter, as described below.

Reticle slide **37** is mounted in slide holder **42** which includes a slide access slot open at its top. Reticle slides are interchangeable to simulate the different sighting references required for varying ballistic properties in different types of ammunition being fired. Reticle slide changing may be effected manually or preferably, automatically from the control panel. If automatic reticle slide changing is employed, the reticle slides may be arranged on a selectively rotatable detented motor-driven wheel, whereby the desired reticle slides may be positioned along axis A–A' by operation of a simple rotary switch or the like. Preferably, the reticle is designed to occupy no more than onefourth of the field of view through eyepiece **11.**

Mirror **40** is oriented at 45° to the optic axis A–A'. The small hole **39** at the center of mirror **40** is elliptical on the mirror surface so that it appears circular on axis A–A'. Hole **39** permits some of the light from the image to pass through lens assembly **41** to eyepiece **11.** The remainder of the light from the image is reflected by mirror **40** upwardly to a mirror reversing assembly illustrated in FIG. **3.** Specifically, the image reflected by mirror **40** is reflected toward the rear of the cabinet by mirror **43.** This image is then re-directed upwardly by mirror **44** and then forwardly by mirror **46** to a projection screen **47** at the front panel **10** where the image is displayed for the benefit of the instructor and other trainees. The re-direction of the image by the mirror assembly is accompanied by an image expansion to the proper size for viewing at screen **47.**

The light burst, which simulates a gun burst to be combined with the target scene, is generated at a laser assembly generally designated at **50** in FIG. **2.** The laser is maintained in a standby state and is selectively actuated to provide short coherent light bursts in the manner described below in relation to FIGS. **8** and **9.** Each momentary laser burst is reflected by a mirror **51** through a lens **52** toward beam splitter **34** along an axis perpendicular to the projection axis A–A' of projector **14.** The light burst is thus optically combined with the target image at a point in the target scene determined by both the position of the projector **14** and the position of the light burst in the plane of lens **52.**

Laser assembly **50** is itself movable by the instructor by means of controls described in relation to FIGS. **8** and **9.** These controls operate motors **53** and **54** (FIGS. **4** and **5**) to effect laser assembly movement.

Referring specifically to FIGS. **4** and **5,** laser assembly **50** includes a base **56** on which is mounted a drive frame **57** and an upstanding azimuth pivot base **58.** A pivot member **59** is pivotally mounted atop base **58** for rotation in a horizontal plane. An upstanding support plate **60** is mounted on one end of member **59** for pivotal motion in a vertical plane about pin **61.** Plate **60** supports a laser mount **62** which in turn supports a laser **63.**

The momentary laser bursts pass through a microscope objective **64** to mirror **51** (FIG. **2**). The microscope objective **64** is provided to cause the essentially parallel laser beam to come to a focus slightly forward of the objective. The resulting laser burst passed by the objective appears as a point in the focal plane of lens **52** (FIG. **2**).

A drive shaft **66** of motor **53** extends horizontally through drive frame **57.** Secured to shaft **66** interiorly of the frame is a cam **67** mounted for slightly eccentric rotation about the axis of shaft **66.** Cam **67** actuates an elevation cam follower **68** secured to the bottom of laser mount **62.** Rotation of cam **67** moves follower **68** up and down, thereby pivoting laser **63** about pivot pin **61.**

A drive shaft **71** for motor **54** extends vertically into drive frame **57** and carries a cam **72.** The latter is mounted for slightly eccentric rotation about the axis of shaft **71** and, upon rotation, drive azimuth follower **73** which is secured to the bottom of laser mount **62.** Rotation of cam **72** translates follower **73** horizontally causing laser **63** to pivot about base **58.** A return spring **74,** fixedly referenced to drive frame **57,** urges follower **73** into engagement with cam **72** to assure smooth motion of both cam followers as their cams rotate. Specifically, since both cam followers are secured to support **62,** spring **74** biases the support toward drive assembly **57** at all times.

Motion of the laser burst image in the plane of lens **52** is controlled by the selective displacements of the two cams **67, 72.** The cams are sized and scaled to cause the image of the burst to fall within aregion near the boresight center of reticle **42,** typical of the effect produced by such factors as wind drift, projectile ballistics, etc. By properly shaping the cam profiles and choosing the ratio between the cams, it is possible to form a "probability of lay" profile about the boresight axis to match a gun's typical field performance. The target image and the image of the burst (when it appears) are optically combined on the beam splitter **34.**

Laser **63** is a low power laser of the helium-neon type. A typical unit is Model 310, manufactured by the Metrologic Corporation. The burst duration is preferably on the order of 1/25 second.

Referring specifically to FIG. **6** an alternative target slide projector **80** is illustrated. The projector may be an unmodified Kodak Carousel model projector, such as the Ektographic B-2. The basic difference between the projectors of FIGS. **1** and **6** lies in the fact that electrically operated drive motors are provided to pivot projector **80,** thereby eliminating the need to modify the projector as required in the FIG. **1** arrangement.

The underside of projector **80** is secured by screws or the like to bottom wall of an upstanding U-bracket **81.** One leg of bracket **81** has a short horizontally-extending shaft **82** rigidly secured thereto and projecting away from projector **80.** Shaft **82** is journaled in a vertically-extending wall of a support frame **83.** The opposite leg of bracket **81** has another short horizontally extending shaft **84** rigidly secured thereto and projecting away from projector **80.** Shaft **84** projects through and is journaled in another vertically-extending wall of frame **83.** The end of shaft **84** is terminated by a gear wheel **86** which mates with a worm gear **87** driven by an elevation motor **88.**

Shafts **82** and **84** are coaxially disposed along a horizontal axis B–B' which passes through point X, the exit pupil of the projection lens **89** of projector **80.** Motor **88** is operable to rotate shafts **82** and **84** about axis B–B', thereby pivoting bracket **81** and projector **80** up or down relative to frame **83.**

An azimuth motor **90** has a vertical drive shaft **91** extending along a further axis C–C'. The latter intersects axis B–B' at point X, the exit pupil of projection lens **89.** Shaft **81** is arranged to rotate frame **83** about axis C–C' when motor **90** is actuated, thereby rotating projector **80** about axis C–C'.

The portion of projector **80** relative to the optical paths of FIGS. **1** and **2** is illustrated schematically in FIG. **7.** Specifically, point X, the exit pupil of projection lens **89,** is positioned on optical axis A–A', whereby axes A–A', B–B' and C–C' intersect at point X. The target slide image is thus projected onto the beam splitter **34** where it is optically combined with light bursts from laser **63.** The combined image is then projected through the reticle to the eyepiece and viewing screen as described in relation to FIGS. **1–3.** The target image, therefore, can be moved in elevation and/or azimuth by means of actuator controls (to be described) for motors **88** and **90.**

Controls for the simulator employing the projector of FIG. **6** are illustrated in FIG. **8.** Specifically, a cabinet **100** includes a front control panel **101** and a side control panel **102.** Front panel **101** includes all of the gunner-trainee controls and realistically simulates an actual gunner's control arrangement in a tank. Specifically, eyepiece **11** is mounted on front panel **101** just below a head rest **103.** Below eyepiece **11** there is mounted a power control module **104** which is similar in size and appearance to the gunner's power control assembly in an M-60 tank. Module **104** includes a pair of hand grips **106, 107** for the gunner-trainee. Each hand grip includes normally open brake switch **109** which is closed when the hand grip is squeezed. By rotating the hand grips in a vertical plane about a horizontal axis D–D' and sueezing either hand grip to close the brake switch, the gunnertrainee actuates the azimuth motor **90** of FIG. **6** in a manner described in detail below in relation to FIG. **9.** By rotating the hand grips in respective vertical planes parallel to axis D–D' and squeezing either hand grip to close the brake switch, the gunner-trainee actuates the elevation motor **88** of FIG. **6** in a manner described below in relation to FIG. **9.** Hand grips **106** and **107** are therefore movable to control the motion of the field of view through eyepiece **11.** Additional switches and control for motor **88** and **90** and actuated by hand grips **106** and **107** are described below in relation to FIG. **9.**

Each of hand grips **106** and **107** is provided with an index finger trigger which the gunner-trainee squeezes when it is desired to fire the tank gun, i.e., to actuate the laser. This trigger actuates a microswitch to complete a relay circuit and thereby permit high voltage to be applied to the laser.

A switch box **110** is mounted on front panel **101** and includes three switches and respective indicator lamps to indicate the status of the switches. A turret power switch **111** prevents power from being applied to the projector drive motor **88** and **90** unless this switch is in its ON position. A main gun switch **112** and a machine gun switch **113** each having ON and OFF positions and determine whether a single laser burst (main gun) or repetitive laser bursts (machine gun) are effected when the trigger **108** in hand grips **106, 107** is actuated. Apart from switch box **110,** a separate fire-safe switch **114** is mounted on panel **101** and prevents actuation of the laser unless it is in its FIRE position.

The viewing screen **47** of FIG. **3** is mounted near the top of panel **101** to provide an instructor and other trainees with a clear view of target scene and burst as viewed through eyepiece **11.** A dummy ammunition selector **116** is also mounted on panel **101.** Selector **116** includes a handle **117** and a window **118.** By actuating handle **117** the designated ammunition type, as indicated at window **118,** can be changed. This selector is a mock-up control only and performs no operational function in the simulator.

The instructor control panel **102** is recessed in the side of cabinet **100.** It includes a main power switch **120** which selectively applies or removes primary power from the simulator. A lamp switch **121** is also provided to permit the lamp in projector **80** to be selectively actuated by the instructor. A focus control switch **123,** when actuated, permits the instructor to vary the focusing of projector **80.** Likewise a slide changer switch **122** permits the instructor to change the target scene slide automatically.

Also mounted on panel **102** are Vertical push button **126,** Horizontal push button **127** and Burst on push button **128.** The Vertical and Horizontal push buttons actuate respective switches which in turn control motors **53** and **54** (FIG. **4**), respectively, to re-position the laser. As is described in detail below with reference to FIG. **9,** these push buttons also actuate the laser in a repetitive burst mode to enable the position of the laser burst relative to the target scene to be viewed while the laser is being re-positioned. The Burst on push button 128 merely actuates the laser in its repetitive mode without re-positioning the laser.

A Random Burst push button 129 is also mounted on the instructor's panel 102. When depressed it actuates both laser drive motors 53 and 54 simultaneously, thereby imparting both vertical and horizontal motion to the laser.

A Reticle control switch 130 is also mounted on panel 1. This is a rotary switch having as many positions as there are different reticles and is provided where an automatic reticle changing capability is desired. As described above in relation to FIG. 1, this switch controls the position of a wheel on which the various reticle slides are mounted and which is rotatable to position any of the reticle slides in the optical path along axis A–A'.

One additional push button 131 is mounted on panel 102 and is designated a No-Burst control button. The purpose and function of this button are described in the following paragraphs.

A situation can occur in combat that requires training in a more sophisticated application of the Burst on Target technique. If the first burst passes by the target and is not seen by the gunner but is observed by the tank commander, the tank commander can estimate the correction and direct the gunner verbally to shift his line of sight, such as so many angular mills down and to the left, etc. To accomplish this kind of training effectively it is necessary for the instructor to be able to introduce a "no burst" mode to the gunner-trainee while permitting the tank commander to observe the burst. The tank commander is watching screen 47 while the gunner-trainee is observing through eyepiece 11 and manipulating the controls.

The light from the burst image is formed by objective lens 64 in such a way as to fill the aperture of burst lens 52. Only a narrow cone near the axis of the burst lens carries that portion of the burst light that progresses on through the system and reaches the gunner's eyepiece. To explain this more fully: All of the burst light is collimated by lens 52 and reflected from beam splitter 34 while still collimated and containing both the burst light going to screen 47 and the burst light going to eyepiece 11. When it is reimaged by lens 36 and brought to a focus at reticle 37, it may be visualized as emanating from this point in the form of two concentrically arranged cones, one surrounding the other and both cones having a common apex. The inner cone is limited at its base by the diameter of hole 39 in mirror 41, whereas the outer hollow cone extends from the outside of the inner cone and fills the aperture of lens 38. Therefore only a portion of the light (separated geometrically) reaches eyepiece 11; the rest is directed up and onto the screen 47.

If the image of the hole 39 is traced back to lens 52 it is found that the portion of the burst light that would fill hole 39 and reach eyepiece 11 via lens 41 can be stopped by interposing an opaque disc close to the exit pupil of lens 52. This disc is designated by the numeral 132 in FIG. 2 and is of a size slightly larger than the image of hole 39 at this point. The burst image light that passes around opaque disc 132 is unobstructed from following its normal path to screen 47. Also illustrated in FIG. 2 is a pivot arm 134 which carries disc 132 and a motor 133 which is actuable to pivot arm 134. When button 131 is actuated, motor 133 positions the disc in the optical path; otherwise the disc is positioned out of the optical path.

"No burst" condition is thus accomplished by the temporary insertion of opaque disc 132 by the instructor between lens 52 and beam splitter 34. This insertion has no detrimental effect on the burst appearing on screen 47 at the same position relative to the reticle that it would have had the image been permitted to appear in the eyepiece.

Referring to FIG. 9 and the electrical schematic diagram for the simulator, primary power, in the form of 115 volts, 60 Hz, is applied to the unit through the instructor's power control switch 120. The following discussion assumes that switch 120 is closed and that the unit is energized.

The A.C. voltage is brought out of projector 80 to lamp switch 121 to permit control over the projector lamp at panel 102. One side of the A.C. voltage at the projector is applied to the arm of the three-position slide changer switch 122. When switch 122 is placed on its forward position, the next target scene slide in the projector slide cartridge is placed in projection position. Likewise, placing switch 122 in its reverse position causes the previous slide in the cartridge to be inserted for projection. The A.C. voltage at the projector is also passed through the double-pole double-throw focus control switch 123 at panel 102 to actuate the focusing control motor in projector 80.

Laser 63 receives primary power which automatically places the laser in standby by applying appropriate low voltages thereto. The high voltage circuit for the laser can be actuated only by external control circuitry. A portion of this circuit includes the trainee's main gun switch 112 and fire-safe switch 114. When the main gun switch is on and the fire-safe switch is in its fire position, high voltage is applied to series-connected charging capacitor 141 and diode 142. Upon closure of the trainee's trigger 108 in either handgrip, a high voltage pulse is applied to the laser to produce a light burst. Capacitor 141 quickly charges, however, removing the high voltage from the laser and cutting off the light beam. An appropriate discharge circuit is provided for capacitor 141 to permit subsequent single burst operation of the laser. For present purposes this discharge circuit is considered to be included in the laser block.

The laser high voltage is also applied to a selectively actuable repetitive firing circuit 143. The latter, for example, may include a relay having a normally open pair of contacts through which the high voltage may be passed when the relay is actuated. Actuation of the repetitive firing circuit is effected with primary power through the Machine Gun switch 113 at the trainee's switch box 110. The repetitive firing circuit 143 additionally includes means such as an oscillator for pulsedly closing the high voltage line, such as with the aforementioned relay. The period of such an oscillator is about two seconds. With circuit 143 thus armed, actuation of either trigger permits the pulsating high voltage to be applied through a charging circuit including capacitor 146 and diode 147 to a laser 63. Depending upon the charging time constant for capacitor 146, the laser is pulsed on for a short time interval every 2 seconds for as long as a trigger 108 is actuated. The pulse duration for both charging circuits is preferably such that each laser burst is on the order of 1/25 second.

The laser may also be actuated repetitively by the instructor with actuation of triggers **108.** Specifically, by actuating burst on switch **128,** the instructor is able to arm the repetitive firing circuit **143.** In addition, switch **128** actuates a relay **148** having a pair of normally open contacts **149** connected in parallel with triggers **108.** The 1/25 second high voltage pulses, appearing at a two second repetition rate, are thus applied through contacts **149** to the laser.

Vertical movement of the laser mount is controlled by the instructor's vertical switch **126.** This double-pole double-throw switch utilizes one pole to apply primary power to the vertical drive motor **53** for this laser. The other pole of switch **126** arms the repetitive firing circuit **143** and actuates relay **148** so that repetitive laser bursts appear with the target image as long as switch **126** is closed. This permits the instructor to view the laser burst location as the laser is repositioned. A similar arrangement is provided for the horizontal drive motor **54** which is actuated by one pole of the instructor's horizontal switch **127.** The other pole of this switch acts as described above to repetitively actuate the laser.

Random movement of the laser without producing laser bursts is effected by closing the instructor's random burst switch. Closure of this switch actuates both motors **53** and **54** to produce random re-positioning of the laser burst image relative to the target scene.

The projector drive motors **88** and **90** cannot be energized unless the turret power switch **111** is turned on at panel **101.** If switch **111** is on, primary power can pass through either of brake switches **109** if one of hand grips **106, 107** is squeezed. The primary power thus passed can be applied to drive motors **88** and **90** in the manner described in the following paragraphs.

Inside the trainee's power control module **104** there are the following four normally open switches: the up elevation cam switch **151,** which is closed when the hand grips are rotated such that the tops of the grips move toward panel **101**; the down elevation cam switch **152,** which is closed when the hand grips are rotated such that the tops of the grips move away from panel **101**; the right cam switch **153,** which is closed when the hand grips are rotated counterclockwise by the gunner-trainee; and left cam switch **154,** which is closed when the gunner-trainee rotates the hand grips clockwise. Each of switches **151–154** is connected to selectively pass primary power received through either of grip-squeeze switches **109.**

Switch **151** is connected in series with the up elevation limit switch **156** and a relay coil **161.** Switch **156** is normally closed and only opens when projector **80** has been rotated to a maximum upward position which is selected to prevent the bottom edge of a target slide from appearing in the field of view at eyepiece **11.** Similarly, a normally closed down elevation limit switch **157** is provided and connected in series with switch **152** and relay coil **162**; a normally closed right limit switch **158** is provided and connected in series with switch **153** and relay coil **164**; and a normally closed left limit switch **159** is provided and connected in series with relay coil **164.** All limit switches are positioned to open to prevent a respective edge of the target scene slide from appearing in the trainee's field of view.

Relay coils **161, 162, 163** and **164** are actuable to switch respective single-pole contacts **166, 167, 168** and **169.** Each of these contacts is at a positive voltage in its normally open position; each contact, when switched, is connected to a negative voltage. The arm of contact **166** is connected to a potentiometer **171** whose resistance is varied as a function of the elevation position of hand grips **106, 107.** Actually, potentiometer **171** is illustrated in schematic form; it may additionally comprise a conventional switching arrangement to enable a single potentiometer to be utilized for both up and down elevation control. The wiper arm of potentiometer **171** is connected to one side of elevation drive motor **88.** The other side of motor **88** is connected to the arm of contact **167.**

The arm of contact **168** is connected to a potentiometer **172** whose resistance varies with the azimuth control position of handgrips **106, 107.** As is the case for potentiometer **171,** potentiometer **172** is illustrated schematically only and would include additional switching components to permit it to be used for both right and left azimuth control. The wiper arm of potentiometer **172** is connected to one side of azimuth drive motor **90.** The other side of motor **90** is connected to the arm of contact **169.**

If the trainee desires to elevate his field of view, he squeezes hand grips **106, 107** to close either or both grip switches **109.** While continuing to squeeze one or both hand grips, he then rotates the hand grips such that the top of the grips move toward him and away from panel **101.** This closes the down elevation cam switch **152** to permit energization of relay coil **162** through the normally closed down elevation limit switch **157.** Contact **167** is switched thereby to provide a positive potential (from top to bottom in FIG. 9) across elevation motor **88.** The magnitude of this potential is determined by the resistance of potentiometer **171** which in turn is determined by the extent of which the trainee rotates the hand grips. Specifically, the greater the angle of rotation of the hand grips from their spring-loaded neutral position, the greater is the voltage applied across motor **88.** Motor **88** thus pivots projector **80** downward, at a speed determined by voltage applied across the motor, to thereby change the trainee's field of view of the target in an upward direction.

In a similar manner, the trainee may rotate the hand grips in the opposite direction from their spring-loaded neutral position. Assuming the squeeze switches **109** to be closed, relay coil **161** now becomes energized instead of relay coil **162.** Consequently, contact **166** becomes negative while contact **167** remains positive, thereby reversing the polarity of the voltage applied across motor **88.** This polarity reversal results in the projector being pivoted upward to provide a downward displacement of the trainee's field of view. Again, the speed at which the projector is pivoted depends upon the extent to which the squeezed hand grips are rotated, since the rotational position of the handgrips determines the setting of potentiometer **171.**

Azimuth drive motor **90** is controlled by switches **153** and **154** is precisely the same manner as motor **88** is controlled by switches **151** and **152.** The polarity of the voltage applied across the motor is determined by which switch is actuated, i.e., which direction the hand grips are rotated, and the rate of projector movement is determined by the setting of potentiometer **172,** i.e., the extent to which the hand grips are rotated.

As mentioned above, several gun-laying techniques can be taught with the aid of the present invention. The primary technique (burst-on-target) is readily taught in realistic fashion. Specifically, the trainee-operator views the target scene through eyepiece **11.** If necessary he may move the slide projector to view different portions of the scene, giving the appearance of gun movement at the eyepiece. Upon firing a round, the trainee sees the burst on the target scene and is then required to squeeze and rotate hand grips **106** and **107** which results in the visual effect of the gun movement of the eyepiece. Actually, the target scene slide is moving relative to the reticle and to the point on beam splitter **34** at which the laser burst strikes. If the trainee's judgment as to the previous round was correct, the next round will be on target. Otherwise, new adjustments of the field of view must be made before firing again. All the while the instructor is able to view the trainee's performance on screen **47.**

If first firing by the trainee produces a "hit," the burst sill be on target and the instructor might then reposition the burst. He may do this by the exercise of the horizontal and/or vertical motion controls (switches **126, 127**) which permit him to place the burst at a desired position within the burst range. The instructor or the trainee himself may position the burst in a random manner by turning on both motors for a time with switch **129.** The location of the burst under this latter condition is unknown until the trigger is fired and the burst appears. If the first firing is not a hit, the trainee moves the target scene to accomplish moving the burst to the target, and it appears to those viewing the effects that the gun is being repositioned. The essence of training is thereby accomplished.

The target slides are made to represent a field of view of approximately 14° × 20°; the total field of view through eyepiece **11** is about 8°. The azimuth and elevation controls are geared to change the scene by approximately ± 2.5° in elevation and ± 5.5° in azimuth. Stop switches **161–164** are provided to prevent the edge of the slide from appearing at eyepiece **11** and thereby destroy the realism of the target scene. The apparent movement of the reticle on the target scene is thus scaled to realistically simulate actual control motion on a tank.

The target slides are preferably 35mm color transparencies taken from the vantage point of a gunner. Various target types, positions and ranges can be used.

While I have described and illustrated specific embodiments of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A gunnery trainer or the like comprising:

an enclosure including a front panel;

viewing means, including a lens having an optical axis, for providing a limited field of view of the interior of said enclosure in a first direction along an optical path defined at least in part by said optical axis;

a transparency projector mounted inside said enclosure and including: means for projecting a realistic target scene image via said optical path in a direction opposite said first direction and onto said viewing means; means for focusing the projected target scene image at said viewing means such that only a portion of said target scene image lies within said limited field of view; selectively actuable means for providing selectively controlled movement of said projector, and thereby said target scene, in two directions transverse to said optical path;

support means for mounting a reticle along said optical path between said projection means and said eyepiece in fixed position relative to said viewing means;

operator controlled means for selectively generating and optically projecting a momentary light burst; and

beam splitter means for optically combining said projected light burst with said projected target scene image as viewed at said viewing means, such that the location of said light burst as viewed relative to said target scene from said viewing means is determined by the position of said projection means and the resulting position of said target scene image relative to said optical path.

2. The trainer according to claim **1** further comprising means for selectively redirecting said light burst to reposition said light burst within the field of view of said eyepiece independently of the position of said projector.

3. The system according to claim **1** wherein said source is a laser normally maintained in standby condition during system operation, said means for providing a beam of light further comprising manually actuable means for momentarily applying high voltage to said source to provide a corresponding momentary burst of light from said laser.

4. The trainer according to claim **1** wherein said operator-controlled means comprises:

actuable source means for generating a light beam when actuated; and

manually operable means for momentarily actuating said source means to generate said light beam, said light beam being directed along a second axis perpendicular to and intersecting said optical axis; and

wherein said beam splitter means is disposed at the intersection of said optical and second axes so that it passes said projected target scene image and reflects said light beam toward said viewing means along said optical path.

5. The trainer according to claim **4** further comprising:

a viewing screen mounted on said front panel of said enclosure; and

further means for projecting said target scene image and said light beam onto said viewing screen.

6. The trainer according to claim **5** wherein said operator controlled means includes means for automatically producing a series of momentary actuations of said source at a predetermined frequency.

7. The trainer according to claim **5** wherein said further means comprises:

a first mirror disposed along said optical axis between said projection means and said eyepiece for reflecting said projected target scene image and light beam out of said optical path, said mirror including a small hole positioned on said axis to permit a portion of the projected target scene image and light beam to reach said viewing means; and additional mirror means for projecting the target scene images reflected by said first mirror onto said viewing screen.

8. The trainer according to claim 7 further comprising selectively actuable means for at will blocking the portion of said projected light beam passing through said small hole while permitting the projected target scene and light beam to be viewed at said viewing screen.

9. The trainer according to claim 7 wherein said source means comprises a low power laser and further including means for selectively positioning said laser to vary the point at which said light beam is incident on said beam splitter means.

10. The trainer according to claim 9 further comprising selectively actuable means for selectively blocking the portion of said light burst viewable at said viewing means while permitting said light burst to be viewed on said viewing screen.

11. The trainer according to claim 1 further comprising:

a viewing screen mounted on said enclosure; and means for projecting said target scene and said light burst into said viewing screen.

12. The gunnery trainer according to claim 1 further comprising actuable interlock means for preventing generation of said light burst unless said interlock means are actuated.

13. The trainer according to claim 1 further comprising means for optically combining a reticle with said target scene as viewed from said operator's eyepiece, said reticle being disposed on a slide positioned along said optical axis between said eyepiece and said projector.

14. The combination according to claim 1 wherein said projector includes a projection lens having an exit pupil via which said target scene image is projected, and wherein said selectively actuable means comprises means for selectively pivoting said projector about said exit pupil, whereby said controlled movement of said projector is constituted by said pivoting, and thereby enhances the realism of the projected target scene image at said viewing means during movement of said projector.

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