March 27, 1962 P. C. AUBERT 3,026,615

GUIDED MISSILE SIMULATOR

Filed Nov. 13, 1958 5 Sheets-Sheet 1

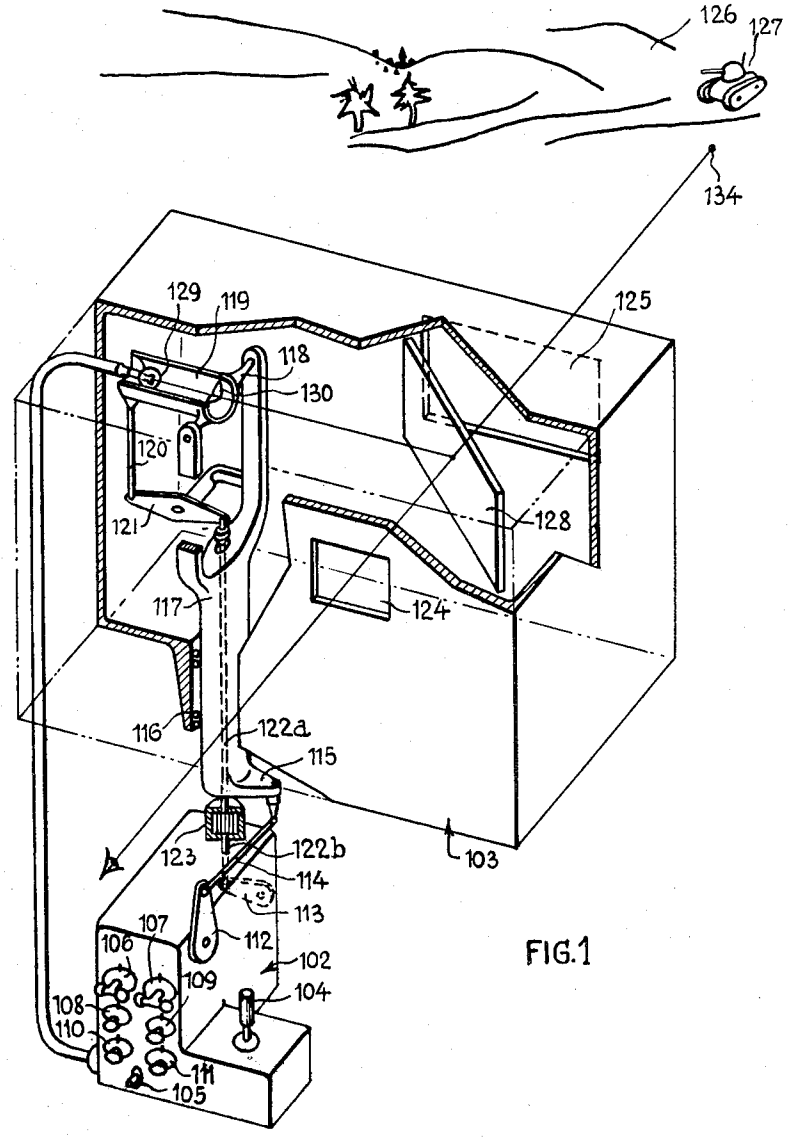


FIG. 1

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GUIDED MISSILE SIMULATOR

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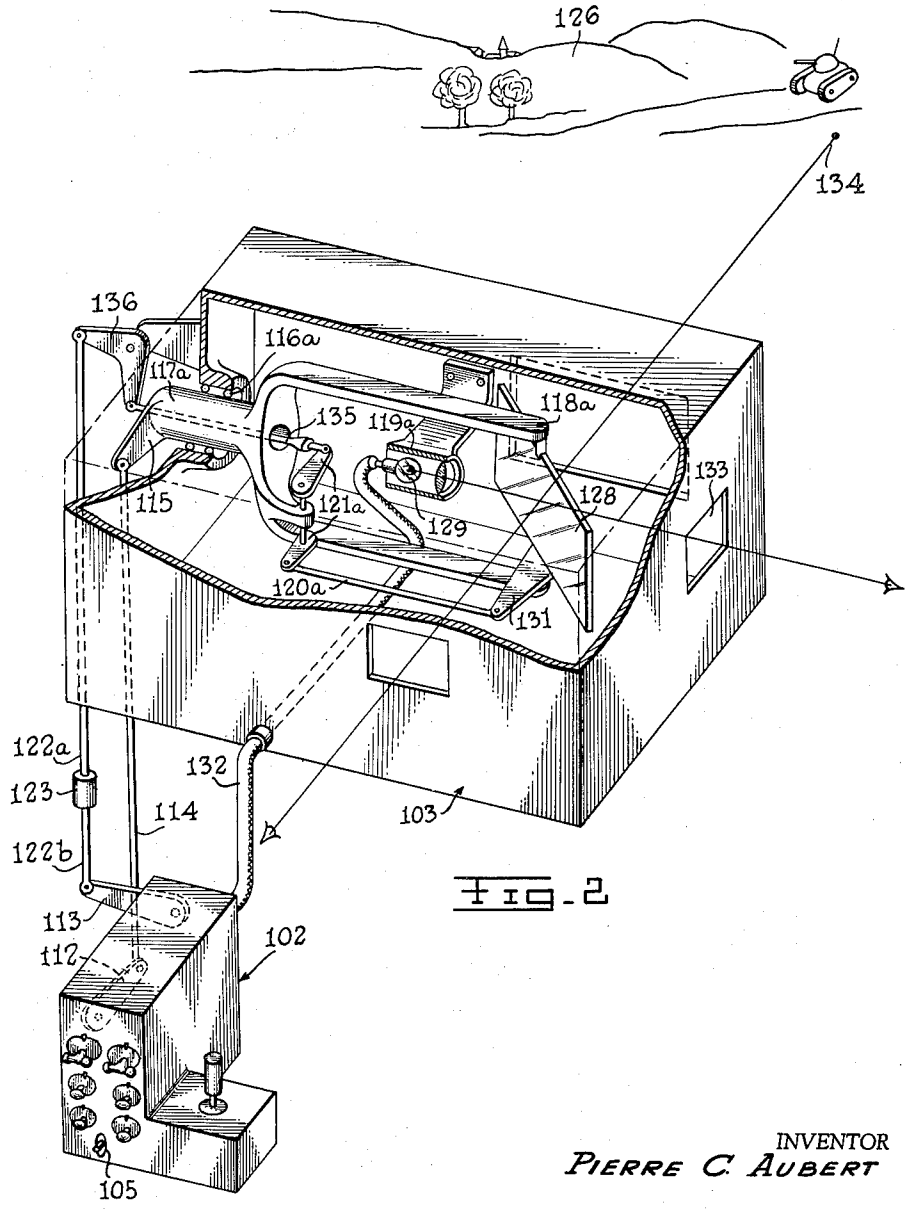


Fig. 2

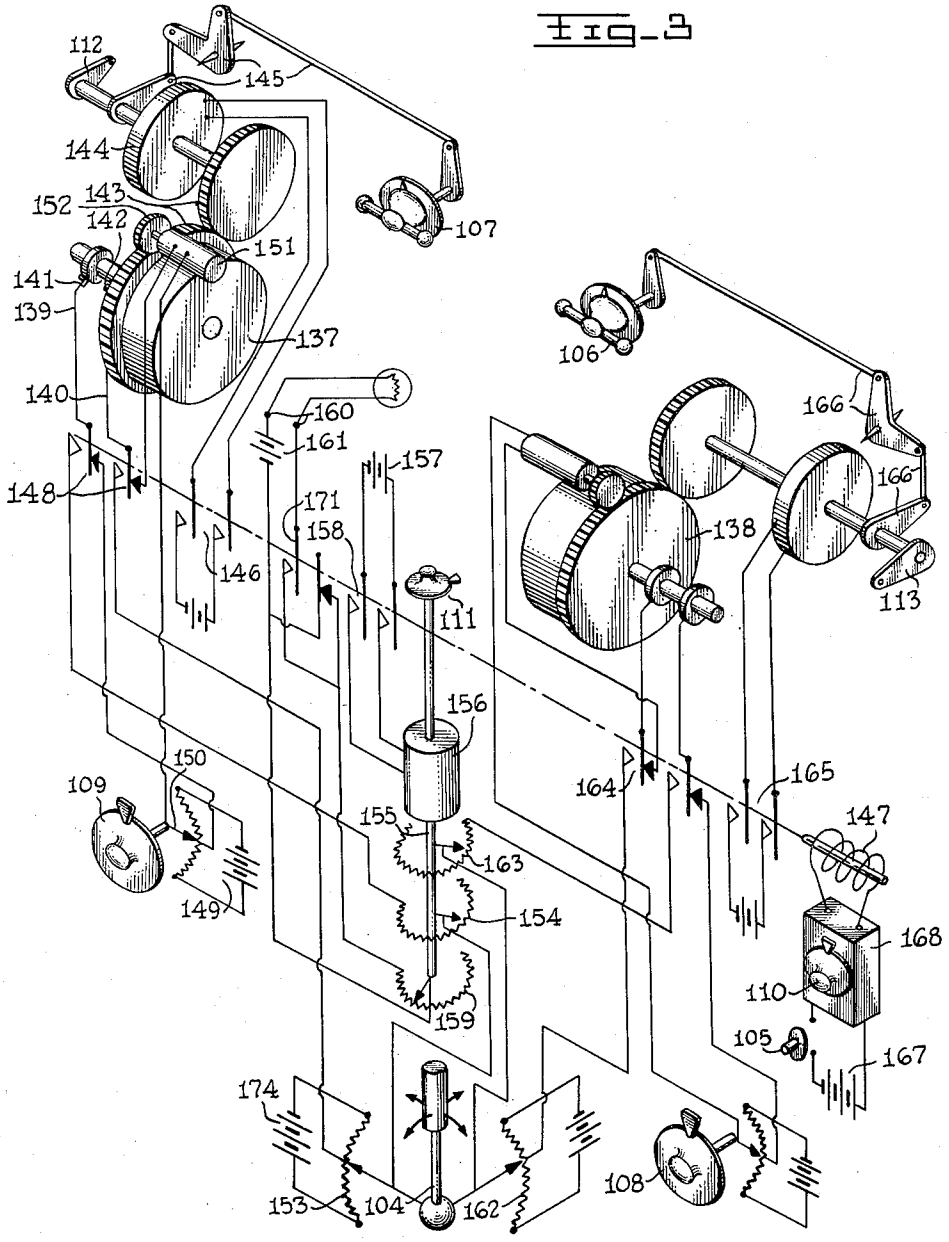
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Fig. 3



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FIG. 4

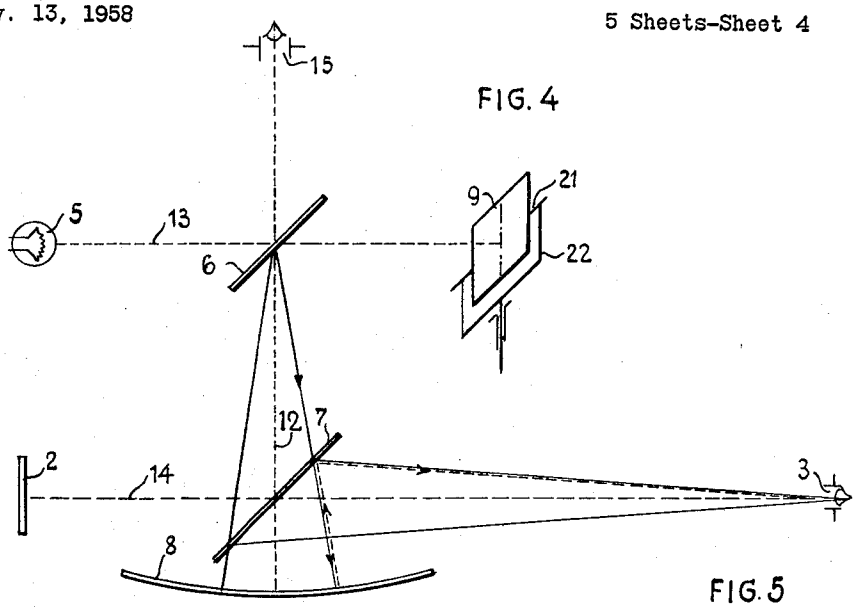


FIG. 5

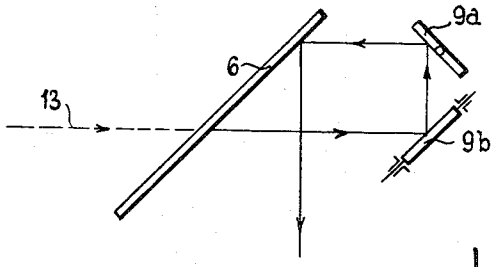


FIG. 6

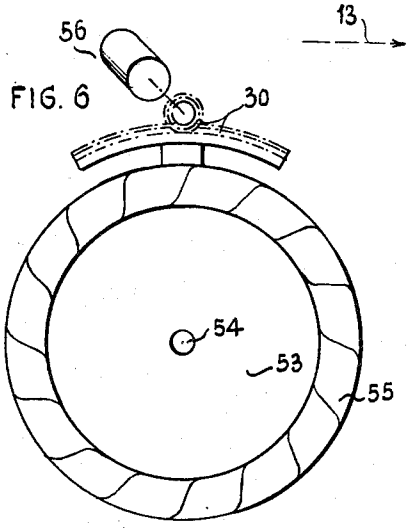
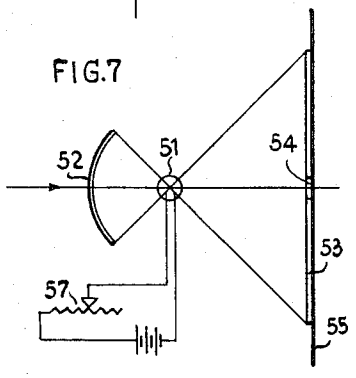


FIG. 7



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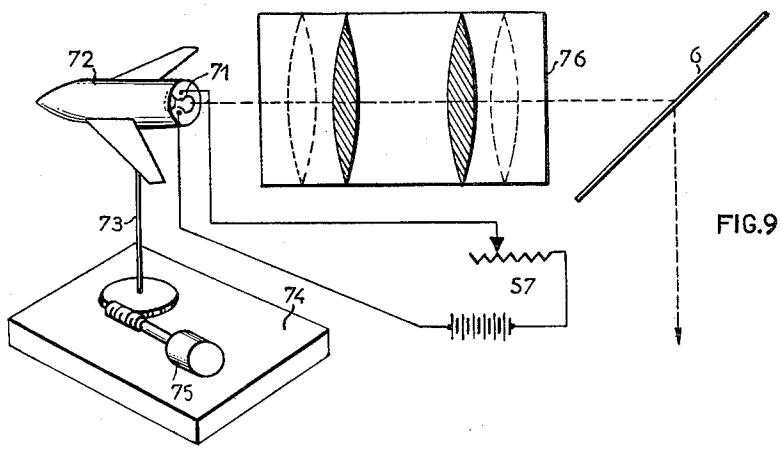


FIG.9

FIG.8

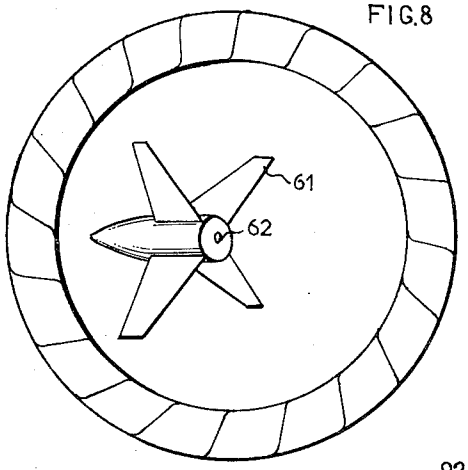


FIG.11

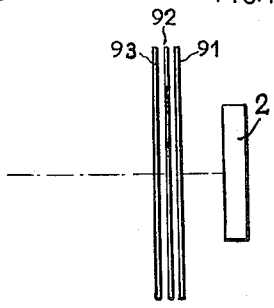
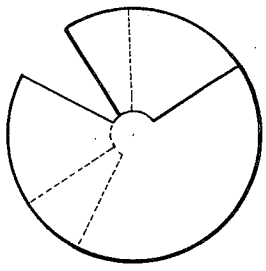


FIG.10



United States Patent Office 3,026,615 Patented Mar. 27, 1962

3,026,615

GUIDED MISSILE SIMULATOR

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Filed Nov. 13, 1958, Ser. No. 773,719
Claims priority, application France Nov. 15, 1957
15 Claims. (Cl. 35—25)

This invention relates to a guided missile simulator especially, but not exclusively, intended to be used for training guided missile firers.

The guided missiles to be simulated are fired in the manner of rocket projectiles, i.e. in a direction which may be defined by two conventional firing angles, viz. azimuth and elevation, and are then remotely guided along their entire trajectory by the firer. The guiding, for certain missiles, tends to hold the projectile aligned with the target at least during the last fraction of the trajectory.

For this purpose, the firer employs suitable hand controls such as, for example, a joy-stick. This guiding of the missile is similar to the remote piloting of aerodynes.

An object of the invention is to provide a guided missile simulator reproducing, on the one hand, the conditions of firing, including the initial position of the missile in elevation and azimuth and the initial vertical and lateral speed imparted to the missile when fired and, on the other hand, the apparent trajectory of the missile with azimuth and elevation corrections resulting from the action of the firer on the joy-stick or any other hand-control.

Heretofore, the training of guided missile firers has been effected almost exclusively in specially equipped projecting rooms in which indoor simulators provided with suitable hand controls project, on a screen, a movable picture optically reproducing the apparent displacements of a guided missile towards the image of a target. The firer may thus study his own reactions. However, in spite of elaborate cinematographic processes, this method remains insufficient and fails to create the illusion of actual firing so that it must be followed by a long on the spot training period with dummy missiles having inert noses. The cost of such dummy missiles is unfortunately hardly less than that of the actual missiles.

Another object of the invention is to provide a training apparatus of the above-defined type suitable for use outdoors and capable of super-imposing on a direct view of a real landscape a virtual image permanently controlled by the firer's joy-stick through a suitable computing unit and giving to the firer the same general optical impressions that he would have from firing and guiding an actual missile through the same landscape.

The invention further aims at improving the said general optical impressions by separately reproducing the apparent variations that an actual guided missile would undergo subsequently to firing and up to impact.

It is therefore another object of the invention to provide an open-air guided missile simulator of the type described, wherein the virtual image of a luminous body simulating a guided missile becomes visible to the firer as soon as he presses a push-button, thus simulating "firing" of the missile.

It is a further object of the invention to simulate the explosion of the missile with a sudden flashing of the virtual image immediately followed, if desired, by the disappearance of the same.

A further object of the invention is to provide the apparatus with a timing control system which is automatically triggered as the firer presses the aforesaid push-button and which automatically causes the above-mentioned flashing and disappearance of the image after a

predetermined adjustable time corresponding to the duration of flight of a real guided missile before it strikes.

The firer has to adjust the said timing in such a manner that the simulated "explosion" coincides with the "impact" of the virtual image of the target.

A further object of the invention is to give to the firer an improved illusion that the "missile" flies away, by progressively reducing the brilliancy and even, if desired, the size of the virtual image.

Yet another object of the invention is to equip the computing unit with a mechanism capable of progressively reducing, as the missile flies away, the amplitude of the azimuth and elevation displacements of the image, in response to actuation of the joy-stick.

While, in its simplest shape, the virtual image of the missile may be constituted by a simple luminous spot, e.g., by the very image of the source of projecting light proper, it is a more specific object of the invention to still improve the optical impressions of the firer to be trained by substituting for said spot a more realistic virtual image, for example, obtained by projecting an accurate scale reduction of the actual guided missile.

In order to render the illusion still more perfect, it is another object of the invention to project the virtual image from a movable reduced model, so as to also reproduce the changes in the apparent attitude of the real missile along its trajectory. This permits, for example, giving to the firer the illusion that he sees the missile slowly turning as he changes its direction of flight.

Still another object of the invention is to provide the simulator with a plurality of various dimming screens adapted to be interposed selectively before the eyes of the firer so as to artificially reproduce special conditions of visibility (bad weather, night firing, and so on).

While self-training with an apparatus according to the invention is in itself highly efficient, it will be understood that a permanent control of the results obtained by the firer under supervision may still accelerate the instruction of the firer.

Another object of the invention is therefore to provide a simulating apparatus of the type described offering to a second observer the facility of permanently supervising the work of the firer by observing, together with the firer and under the same optical conditions, both the firing field and the image of the missile.

An alternative object of the invention is to use the above-mentioned second observing facility for registering or transmitting the firing sequences by means of a cinematographic or television camera.

It has been mentioned that the guided missile simulator according to the invention is not exclusively adapted to the training of the firers. It is noteworthy that the said simulator finds another important application in the design and development of guided missiles. It is clear that if suitable automatic correcting systems are interposed between the controls of the firer and the computing unit of the apparatus, it will become possible to study the responses of guided missiles of various types to the real orders received from the real controls.

It is therefore yet another object of the invention to provide the apparatus with a plurality of additional controls for introducing into the computing unit what may be called constructive parameters, whereby the apparatus may be used either for studying or training purposes with a wide range of variegated missiles.

Other objects and advantages of the invention will be apparent from the following detailed description as illustrated in the accompanying drawing.

In the drawings:

FIG. 1 is a diagrammatical perspective view showing a simulator according to the invention;

FIG. 2 shows, also diagrammatically, an alternative, slightly more developed, embodiment;

FIG. 3 is a wiring diagram of the computing unit used in the devices of FIGS. 1 and 2;

FIG. 4 shows the path of the light rays in a more elaborate optical system which may be used instead of that shown in FIG. 2;

FIG. 5 shows an alternative mirror system for deflecting the virtual image of the missile;

FIG. 6 is a plan view of a device which may be used for simulating the size and lighting reduction of a missile as it flies away.

FIG. 7 is a side view of the device shown in FIG. 6;

FIG. 8 shows an alternative embodiment comprising a cutoff illuminated plate simulating the outline of the guided missile;

FIG. 9 shows another embodiment in which the image projected is that of a reduced model exactly reproducing the missile and rotating about its yaw axis to simulate turning;

FIG. 10 is a plan view of a device which may be associated with the apparatus for artificially reproducing conditions of firing with bad visibility (night firing, fog, bad weather and so on), and

FIG. 11 is a side view corresponding to FIG. 10.

FIG. 1 broadly illustrates the principle of the guided missile simulator according to the invention. This apparatus essentially comprises a computing unit generally shown at **102** and an optical unit generally shown at **103**. The details of the computing unit **102** will be thoroughly described hereunder with reference to FIG. 3.

The firer employs a plurality of hand controls of which only the main ones have been diagrammatically shown in FIG. 1. These controls include a joy-stick **104** which may be used by the firer to control the "missile" along its trajectory or, more precisely, to displace in elevation and azimuth the virtual image of the missile, so as to simulate the apparent behaviour of the actual missile in response to real guiding controls. The firing proper is triggered by means of a push-button **105**. Two control knobs **106**, **107** respectively determine the initial position of the image in elevation and azimuth, while two other control knobs **108**, **109** respectively define its vertical and lateral initial speed. These four control knobs together reproduce the conditions of firing proper. Another control knob **110** is provided for adjusting the time during which the image will be observed, which corresponds to the timing of the "explosion" of the real missile as measured from the instant of actual firing. Finally, another control knob **111** is provided to reset to the initial conditions the mechanism provided for progressively reducing the effect of the joy-stick on the image and for simulating the variations of the missile aspect as it flies away. The computing unit is provided with two mechanical output members diagrammatically shown in the shape of crank-arms **112**, **113** for respectively transmitting to the optical unit **103** the aximuth and elevation corrections to be imparted to the virtual image.

For this purpose, the crank arm **112** acts through a connecting rod **114** on a crank-arm **115** pivoted around a vertical axis through a bearing **116** on the casing of the optical unit **103**. The crank-arm **113** is integral with a yoke **117** carrying a horizontal axle **118** on which is tiltably supported a projecting apparatus **119**. The latter is linked with the crank-arm **113** through a connecting rod **120**, a rocking lever **121** pivoted on the yoke **117** and two aligned connecting rods **122***a*, **122***b* between which is interposed a rotary connector **123**. The upper connecting rod **122***a* is freely accommodated through the horizontal crank-arm **115** and its bearing **116** and the yoke **117** to permit slight inclination of said rod when the crank-arm **113** and rocking lever **121** oscillate. This linkage permits displacing the projecting apparatus **119** independently in elevation and azimuth. For example, when the crank-arm **112** is rotated clockwise from the position shown in FIG. 1, the crank-arm **115**, together with the yoke **117**, is rotated counter-clockwise and the beam projected by the apparatus **119** is shifted in azimuth towards the left. Now, if the crank-arm **113** is, for example, rotated counter-clockwise, the rocking lever **121** is rotated clockwise together with the projecting apparatus **119**, so that the projecting beam is shifted vertically and downwardly.

The optical system **103** comprises, further to the already mentioned projecting apparatus, an eye-piece diagrammatically shown in the shape of a rectangular opening **124** in the casing of the optical system by means of which the firer may observe, through a window **125**, the real landscape **126** which contains the target **127**. A semi-transparent mirror **128** is fixedly secured to the casing of the optical system **103** between the eye-piece **124** and the window **125** and substantially at an angle of 45° with the axis of the field of vision of the firer as well as with the axis of the beam projected by the projecting apparatus **119** in zero azimuth position of the latter. The projecting apparatus **119** essentially comprises a strongly illuminated object **129** to be projected, which may be merely constituted by the projecting lamp and an objective **130**. The object **129** is preferably located in the focal plane of the objective **130**, so as to project the virtual image **134** ad infinitum. In the simplest embodiment just mentioned, wherein the object is constituted by the projecting lamp, the said virtual image is a mere luminous spot.

It will be easily understood that the semi-transparent mirror **128** both insures the reflection of the image projected by the projecting apparatus **119** and the direct vision of the landscape through the window **125**.

This apparatus is used for training a firer as follows:

The firer first selects the conditions of firing proper by setting the four knobs **106** to **109** in accordance with the firing data he wishes to choose. This operation determines the initial point at which the firer will first see the virtual image of the missile and the initial vertical and lateral speed which will be assumed to be imparted thereto. The firer then resets the mechanism provided for reducing the action of the joy-stick on the image. Finally, he adjusts the knob **110** controlling the timing device to determine the instant at which his "missile" will explode. Then, while holding the joy-stick **104**, the firer presses the push-button **105** down exactly at the instant chosen for firing. The push-button **105** causes:

(*a*) The switching on of the source of light and hence the illumination of the object **129** (these two elements being the same in the example shown) and the sudden appearance of the virtual image **134** before the eyes of the firer amidst the real landscape **126**. This first vision of the image takes place at the position determined by the above-mentioned setting of the knobs **106**, **107**.

(*b*) The clutching of the mechanical output members **112**, **113** with parts of the computing unit which will be described in detail hereunder and to which the above-mentioned setting of the knobs **108**, **109** has imparted a rotational speed corresponding to the initial speed to be simulated both vertically and laterally. The two components of motion thus imparted to the virtual image as described above under (*a*) result in a displacement of the said image before the eye of the firer exactly simulating the apparent trajectory which the real projectile would describe under the same conditions of firing towards the target **127**.

(*c*) The immediate suppression of the action controlled by the initial speed knobs **108**, **109** on the above-mentioned parts of the computing unit, which become at the same time subjected to the correcting action of the joy-stick **104**, while however keeping the initial speed which has been imparted to them owing to inertia effect. This will be more clearly explained hereunder with reference to FIG. 3.

(*d*) The starting of the above-mentioned efficiency reducing mechanism.

(*e*) The triggering of the timing device which will cause "explosion" after the elapsing of the length of time selected by the above-mentioned setting of the knob **110**.

From this moment, the firer may correct at will the "trajectory" of the simulated missile in elevation as well as in azimuth in order to try to bring into and maintain the spot in alignment with the target, by judiciously acting on the joy-stick **104**. This operation will be also described in detail hereunder with reference to FIG. 3.

Finally, the timing device causes a sudden flashing of the virtual image to simulate the explosion, so that the firer may see directly if said explosion happens at the right place when virtual image **134** coincides with the target **127**.

In the alternative embodiment shown in FIG. 2, numerous parts shown in FIG. 1 are again employed. Only those parts which are differently arranged are provided with different reference numerals, the suffix *a* being employed where the function is similar.

In this embodiment, the deflection of the virtual image, instead of being obtained by a suitable orientation in elevation and azimuth of the projecting apparatus as in FIG. 1, is produced by an adjustment of the semi-transparent mirror **128** in azimuth and elevation. For this purpose, the mirror **128** is pivoted around an axle **118***a* mounted between the arms of the yoke **117***a* which is in turn pivoted around a horizontal pivot in the casing of the optical system **103** and provided by a bearing **116***a*. Furthermore, the mirror **128** is integral with a crank-arm **131** which is actuated through the connecting rod **120***a* from a two-arm rocking lever **121***a*, pivoted on the yoke **117***a*. The latter is connected with the mechanical output member **113** of the computing unit through a connecting rod **135**, a bell-crank lever **136** and the connecting rods **122***a*, **122***b*, between which the rotating connection **123** is interposed. These two connections respectively insure elevation and azimuth control of the mirror **128**. In this embodiment, the projecting apparatus **119***a* is fixedly secured on the casing of the optical system **103** with its axis coinciding with that of the yoke **117***a*. In both embodiments of FIGS. 1 and 2, the source of light contained in the projecting apparatus **119***a*, such as the lamp **129**, is fed with electric current from the computing unit **102** through a flexible cable **132** under the control of the push-button **105** as previously described.

Otherwise, the apparatus shown in FIG. 2 operates exactly in the same manner as that of FIG. 1, except that the deflections imparted to the virtual image by the mirror **128** as in FIG. 2 have an angular amplitude which is the double of that obtained by orienting the projecting apparatus **119***a* as in FIG. 1.

Moreover, in the embodiment of FIG. 2, the apparatus is provided with a second eye-piece diagrammatically shown in the shape of a rectangular opening **133** through which another observer may observe both the landscape **126** and the virtual image **134** in the same conditions as the firer except that the second observer sees a movable virtual image of the landscape reflected by the semi-transparent mirror **128** and a direct real stationary image of the spot projected by the apparatus **119***a*. The relative displacements have the same absolute values but the directions of displacement are all reversed. This is not objectionable since the second observer is usually an instructor well trained in firing techniques. Moreover, in practice, as will be described hereunder, other arrangements can be provided so as to give to both observers exactly the same visual impression.

A computer **102** is shown in detail in FIG. 3. In this figure, those parts which have been already described with reference to FIGS. 1 and 2 have been designated by the same references. The computer comprises two electromechanical double time integrating units **137**—**138** of any suitable type such as for example those described in U.S. Patent 2,911,151 respectively related to azimuth and elevation computation.

These double time integrating units have the property of transforming a voltage input representing an angular acceleration into an angular displacement of a mechanical output member, i.e. into the integral of second order of said angular acceleration. Both units operate in the same manner and are associated with the same devices. Only one of them will be described hereunder:

The unit **137** is fed with a suitable input voltage on two conductors **139**, **140** and this voltage acts through brushes **141**, **142** on the input computing element (a galvanometer moving coil assembly in the above-cited U.S. Patent). The mechanical output member, which in the example shown is constituted by the crank-arm **112** of FIGS. 1 and 2, is driven from output gears **143** of the unit **137** under the control of a magnetic clutch **144**. Moreover, the initial angular position of the crank-arm **112** may be adjusted from the knob **107** through a linkage **145**. The magnetic clutch **144** may be actuated by two make contacts **146** of a relay **147** which controls both units **137** and **138**. In this regard it is to be noted that the arrangement of relay **147** and contacts **146** is diagrammatically shown and that relay **147** controls the operation of contacts **146** as well as of contacts **148**, **158**, **164**, **165** and **171**. This relay comprises two make-and-break contacts **148** acting as a two-way reversing switch to control the feeding of the input conductors **139**, **140** of the unit **137**. In one position of the contacts **148**, viz. when the relay **147** is not energized, the said input conductors are fed from a current source **149** under the control of a potentiometer **150** through a generator **151**. This generator progressively reduces the input voltage by generating a voltage of opposed polarity, the value of which increases as a function of the angular velocity of the gears **143** with which the shaft of said generator meshes through a pinion **152**. Under these conditions, if the potentiometer **150** is set to a given position by means of the knob **109**, the output gears **143** of the double integrator **137** will be initially accelerated and then the acceleration will be progressively reduced until the initial lateral speed corresponding to the setting of the knob **109** will be reached. Thereafter, the gear **143** will continue to move at the same speed, due to the equilibrium between the voltage fed through the potentiometer **150** and the counteracting voltage supplied by the generator **151**.

When the make-and-break contacts **148** are brought to their other position in response to energizing of the relay **147**, the generator **151** as well as the source **149** are switched off, but the gears **143** will continue to rotate for a certain time under the effect of inertia and they will drive the virtual image laterally through the clutch **144** which is then operated, the crank-arm **112** and the linkage described with reference to FIGS. 1 and 2. At the same time, the input conductors **139**—**140** are connected with a potentiometer **153** through a variable resistor **154**. The rotating arm of the potentiometer **153** is controlled by the lateral motion of the joy-stick **104**. On the other hand, the rotating arm of the variable resistor **154** is continuously rotated by the driving shaft **155** of a motor **156** separately fed from a source **157** under the control of two other make contacts **158** of the relay **147**. In the example shown, it has been assumed that the rotating arm of the variable resistor **154** continuously rotates counter-clockwise, so that it progressively increases the variable value of the said resistor. The potentiometer **153** controls a source of current **174** so as to apply to the input conductors **139**, **140** a voltage varying as a function of the lateral position of the joy-stick **104**. Moreover, due to the above-described permanent increase of the variable value of the resistor **154**, this input voltage is progressively reduced, for a given lateral position of the joy-stick **104**, as time elapses, to simulate the flying away of the "missile." The driving shaft of the

motor 155 and, hence, the rotating arm of the variable resistor 154 may be reset in an initial condition corresponding to the zero value of the resistor 154 by means of the knob 111. In the example shown, the driving shaft 155 of the motor 156 further drives the rotating arm of another variable resistor 159 which controls the illumination of the source of projecting light 129 which is connected to two terminals 160 fed from a source of current 161. The switching on of the source 129 is controlled by make contacts 171 of the relay 147.

As already mentioned, the double integrator 138 related to elevation control is designed and operates in the same manner as the double-integrator 137. In particular, a potentiometer 162 controlled by the fore-and-aft motion of the joy-stick 104, associated with a variable resistor 163 actuated by the driving shaft 155 of the motor 156 supplies the said double integrator 138 with input voltages under the control of make-and-break contacts 164 when the relay 147 is energized. As for azimuth control, a magnetic clutch controlled by make contacts 165 of the relay 147 is interposed between the output gears of the double-integrator 138 and the mechanical output member constituted by the crank-arm 113 of FIGS. 1 and 2. The initial position of the latter is adjustable through a linkage 166 from the knob 106, while the knob 108 permits selecting the initial vertical speed of the image according to the process described above with reference to knob 109. The energizing of the relay 147 is insured by a source of current 167 under the control of the push-button 105 and a timing device 168 of any suitable conventional type, which may be adjusted by means of the knob 110, is triggered as soon as the relay 147 is excited and automatically cuts off the energizing current of said relay after the elapsing of the selected time.

The optical system shown in FIG. 4 which may be used instead of the optical system 103 of FIGS. 1 and 2 comprises essentially luminous means generally indicated as at 5, a first semi-transparent mirror 6, a second partially reflecting mirror 7, a concave spherical mirror 8, and a movable deflection mirror 9. The mirrors 6, 7 and 8 are positioned on a common optical axis 12. The luminous means 5 and the mirrors 6 and 9 are positioned on a common optical axis 13 extending at right angles to the optical axis 12. The aperture 2 corresponding to the window 125 of FIGS. 1 and 2, the mirror 7 and the firer's eye-piece 3 also are positioned on an optical axis 14 also extending at right angles to the optical axis 12. In the embodiment illustrated, the casing of the optical system carries a further eye-piece 15 located on an extension of the optical axis 12 beyond the mirror 6. This eye-piece is intended for a second observer such as a training officer and will be hereinafter called the instructor's eye-piece.

The deflection mirror 9 is mounted for pivotal movement on a horizontal spindle 21 journalled in the branches of a yoke 22 which is rotatably mounted about a vertical axis. The mirror 9 may be pivoted about the two axes 21 and 22 as described with reference to FIG. 2 for the semi-transparent mirror 128. As the mirror is pivoted about the horizontal axis, the image of the missile is shifted vertically, while pivotal movement of the mirror about the vertical axis causes the missile image to be shifted laterally. Of course, any combination of both pivotal movements of the mirror causes a corresponding oblique shifting of the missile image.

In this optical system, the firer sees the landscape through the aperture 2 and the semi-transparent mirror 7 directly and he also sees the virtual image of the luminous body 5 super-imposed on the landscape, the light beam emitted by the luminous body 5 traveling along the following path: luminous body 5, semi-transparent mirror 6 (through), adjustable reflecting mirror 9, semi-transparent mirror 6 (reflection), semi-transparent mirror 7 (through), concave mirror 8, semi-transparent mirror 7 (reflection), eye-piece 3.

The second observer sees the landscape by reflection on the semi-transparent mirror 7 through the aperture 2 and the virtual image of the luminous body 5 according to the following optical path: luminous body 5, semi-transparent mirror 6 (through), adjustable mirror 9, semi-transparent mirror 6 (reflection), semi-transparent mirror 7 (through), concave mirror 8, semi-transparent mirror 7 (through), semi-transparent mirror 6 (through), eye-piece 15. It will be noted that with this improved optical system, both observers have exactly the same optical impression. In particular, the displacements imparted to the virtual image by the adjustable mirror 9 are in the same direction for both observers.

In the alternative embodiment shown in FIG. 5, the single mirror 9, adjustable both in azimuth and elevation, has been replaced by two separate mirrors *9a* and *9b* respectively adjustable in elevation and azimuth, the said mirrors being suitably disposed with respect to each other and the semi-transparent mirror 6 so as to cause successive deflections in azimuth and elevation of the light rays traveling through said semi-transparent mirror 6 before their reflection by the same towards the semi-transparent mirror 7 of FIG. 4.

It has been mentioned hereinbefore that the apparatus may be provided with means to progressively reduce the illumination and, if desired, the size of the virtual image.

In one embodiment of the said means illustrated in FIGS. 6 and 7, a powerful electric bulb 51 the luminous beams of which are concentrated by a suitable concave mirror 52 brightly illuminates a green glass disc 53 centrally apertured as at 54. An annular diaphragm 55 similar to the diaphragms incorporated in photographic cameras determines a boundary for the glass disc. This diaphragm is actuated through a rack and pinion mechanism 30 by a motor 56 which may be the motor 156 of the computer described with reference to FIG. 3.

At the instant the missile is supposed to be fired the diaphragm 55 is wide open and the rheostat 57 which may be constituted by the variable resistor 159 of FIG. 3 is adjusted to its minimum value corresponding to maximum brilliance of the bulb, whereby the missile image appears as a green circle strongly illuminated and therefore clearer than the surrounding landscape while the center of the circle appears as a highly luminous point simulating the jet of the missile. In the course of the first seconds of flight, the electromechanical device 56 progressively reduces the inner diameter of the diaphragm 55 which results in the luminous circle becoming smaller and smaller, while the effective resistance of the rheostat 57 is progressively increased and the luminosity of the image progressively reduces accordingly. By suitably adjusting the original values of the diaphragm opening and of the bulb intensity, as well as the speed of decrease in the values thereof, the image simulates quite satisfactorily a missile flying away from the observer.

In the modification illustrated in FIG. 8, a plate 61 cut-out to the outline of a true missile is substituted for the glass disc 53 of the embodiment of FIGS. 6 and 7. The plate 61 is apertured as at 62 at the aft portion of the missile outline.

In a further modification shown in FIG. 9, the source of light 71 is incorporated in a model 72 of a missile carried by a column 73 rotatable about its own axis on a support 74 under the action of an electric motor 75 which may be, if desired, controlled from the computer 102 of FIGS. 1 and 2. An optical device 76 with adjustable focal distance, of any conventional suitable type is inserted between the model 72 and the semitransparent mirror 6 of FIG. 4. This optical device may be also controlled from the computing unit 102.

The original adjustments of the angular position of the model 72, the rheostat 57, and the focal distance of the optical device 76, as well as the rotational speed of

the model supporting column 73, the progressive increase of the effective resistance of the rheostat 57, and the progressive modification of the focal distance of the optical device 76, are such that, at the moment the missile is being fired, the image of the model appears in the field of vision through the aperture 2 (FIG. 4) as if the missile were coming from one side thereof and progressively moves away from the firer while turning around its yaw axis to finally become visible only from the rear whereupon it progressively decreases as described hereinbefore.

FIGS. 10 and 11 show a device intended to reproduce in daylight and even under clear weather, atmospheric conditions which prevail in the night, in the moonlight, at dawn, in mist, and so on. For this purpose, a set of three discs 91, 92, 93 each having a segmental portion cut-out and having a radius at least as large as the aperture 2 of the casing of the optical system are pivotally mounted near said aperture in order to alter the conditions of visibility of the landscape being observed through the eye-pieces. The discs 91 and 92 are made of so-called "polaroid glasses" while the disc 93 is made of white glass with a dimmed segment and a ground segment in order to create special effects such as fog and temporary blinding due to smoke. The pivotal axis of the discs is at right angles to the plane of the aperture 2 of the casing. By manually setting the discs with respect to the aperture and the two polaroid discs with respect to each other, it becomes possible to reproduce any degree of brightness of the landscape being observed through the eye-pieces, as well as other atmospheric conditions as hereinabove indicated.

While the invention has been described with particular reference to preferred embodiments, it is not intended to limit the scope of the invention to the embodiments illustrated, nor otherwise than the terms of the subjoined claims.

What is claimed is:

1. A guided missile simulator for reproducing optically the apparent displacements of a guided missile through a landscape from a firing station towards a target, comprising an eye-piece and a window through which a firer may directly observe said landscape and said target, a semi-transparent mirror interposed between said eye-piece and said window, a projecting system operatively associated with said mirror and capable of superimposing on said landscape before the eyes of said fiber, by reflection on said semi-transparent mirror, a luminous virtual image representing said guided missile, said mirror and projecting system including a movable element angularly movable in two perpendicular planes to shift said virtual image in azimuth and elevation respectively, pre-adjustable means to generate electrical voltages corresponding to initial conditions of firing, hand-controlled means to generate electrical voltages corresponding to guiding correction orders and a computing unit coupled to said hand-controlled means and including two mechanical output members each operatively connected with said movable element to displace the same separately in each of said planes in response to said electrical voltages, to thereby impart to said virtual image, from an initial position corresponding to said firing station, azimuth and elevation displacements exactly simulating, for the firer, the apparent behaviour of the missile being simulated.

2. A guided missile simulator according to claim 1, further comprising a second eye-piece operatively disposed with respect to said semi-transparent mirror and through which a second observer can see said virtual image superimposed on said landscape.

3. A guided missile simulator for reproducing optically the apparent displacements of a guided missile through a landscape from a firing station towards a target, comprising a first fixed casing including an eye-piece and means provided with a window through which a firer may directly observe said landscape and said target, a semi-transparent mirror interposed between said eye-piece and said window, a projecting apparatus capable of superimposing on said landscape before the eyes of said firer, by reflection on said semi-transparent mirror, a luminous virtual image representing said guided missile, bracketing means to pivot said projecting apparatus in said casing around a vertical and a horizontal axis, first and second linkages passing through said casing, and a second fixed casing containing externally pre-adjustable means to generate electrical voltages corresponding to initial conditions of firing, externally hand-controlled means to generate electrical voltages corresponding to guiding correction orders and a computing unit including two mechanical output members mounted outside said second casing and each operatively connected, through one of said first and second linkages, with said projecting apparatus to displace the same angularly and separately about said horizontal and vertical axis in response to said electrical voltages to thereby impart to said virtual image from an initial position corresponding to said firing station, azimuth and elevation displacements exactly corresponding, for the firer, to the apparent behaviour of the missile being simulated.

4. A guided missile simulator for reproducing optically the apparent displacements of a guided missile through a landscape from a firing station towards a target, comprising a first fixed casing including an eye-piece and means provided with a window through which the firer may directly observe said landscape and said target, a semi-transparent mirror interposed between said eye-piece and said window, supporting means to pivot said mirror in said casing around two perpendicular axes, first and second linkages passing through said casing, a projecting apparatus fixedly mounted in said casing with its axis associated with one of the first said axes, said projecting apparatus being adapted for superimposing on said landscape before the eyes of said firer, by reflection on said semi-transparent mirror, a luminous virtual image representing said guided missile and a second fixed casing containing externally pre-adjustable means to generate electrical voltages corresponding to initial conditions of firing, externally hand-controlled means to generate electrical voltages corresponding to guiding correction orders, and a computing unit including two mechanical output members located outside said second casing and each separately connected, through one of said first and second linkages, with said semi-transparent mirror to displace the same angularly and separately about said perpendicular axes in response to said electrical voltages, to thereby impart to said virtual image from an initial position corresponding to said firing station, azimuth and elevation displacements exactly corresponding, for the firer, to the apparent behaviour of the missile being simulated.

5. A guided missile simulator according to claim 1, wherein said hand-controlled means including a joy-stick and are adapted to separately generate electrical voltages corresponding to guiding correction orders, respectively in azimuth and elevation, in response to actuation by the firer of said joy-stick in a lateral and fore-and-aft direction, respectively.

6. A guided missile simulator according to claim 1, wherein said computing unit comprises two double integrators coupled to said hand-controlled means and each connected to and adapted to impart to one of said mechanical output members a defined angular displacement in response to said hand-controlled means.

7. A guided missile simulator according to claim 1, wherein said computing unit comprises, for each one of the azimuth and elevation controls to be imparted to the virtual image, a mechanical input member, a double-integrator, including and adapted to impart an angular displacement to an output gear in response to acceleration of said mechanical input member, an electro-magnetic relay including a set of contacts, a magnetic coupling adapted to clutch said output gear with one of said me-

chanical output members upon energizing of said relay, a rotary knob operatively connected with said mechanical output member to set the same to any desired initial angular position, reversing contacts having an automatic position when said relay is not energized and a hand-control position when said relay is energized, a first potentiometer to feed said mechanical output member with an adjustable direct current voltage in said automatic position of said reversing contacts, a direct current generator driven by said output gear and mounted in series with said potentiometer to feed to said mechanical input member a variable direct current of a polarity opposed to that of the current fed through said potentiometer, a second potentiometer to feed an adjustable direct current voltage to said mechanical input member in said hand-control position of said reversing contacts, a rotary variable resistor mounted in series with said second potentiometer, and driving means to continuously rotate said variable resistor to thereby progressively decrease the voltage fed, through said second potentiometer, to said mechanical input member.

8. A guided missile simulator according to claim 7, comprising an electric motor and wherein the rotary variable resistors respectively associated with each one of said double-integrators are both controlled by said electric motor, said simulator further comprising a rotary knob to reset said variable resistors to zero value.

9. A guided missile simulator according to claim 7, comprising a push-button controlling the energizing of said electromagnetic relay, and a holding circuit maintaining the energizing of said relay, and an adjustable timing device in said holding circuit to cut-off the same after a predetermined time.

10. A guided missile simulator according to claim 1, wherein said projecting system comprises a source of light, a disc of translucent material operatively disposed with respect to and illuminated by said source of light and provided with a central hole, a retractable diaphragm surrounding said disc and adapted for restricting the visible area of said disc, power means coupled to and adapted for constricting said diaphragm, dimming means coupled to and adapted for dimming said source of light, said computing unit including timing means and means connected to said diaphragm power means and to said dimming means to control the same so that as missile flight is simulated, the luminous intensity of the light source and the visible area of the disc are progressively reduced by said dimming means and said diaphragm respectively in order to simulate the movement of the missile away from the firer from the moment the missile is fired until the moment it explodes after a predetermined length of time, whereupon the initial intensity of the light source is reinstated for a short duration of time for simulating explosion of the missile.

11. A guided missile simulator according to claim 10, wherein said disc includes a plate having an opening corresponding to the outline of a guided missile the jet of which is simulated by said central hole of said disc.

12. A guide missile simulator according to claim 1, wherein said projecting system includes a missile model, a source of light in said model, a vertical spindle pivotally supporting said model, means for rotating said model about said spindle, an adjustable focal distance unit located in the path of travel of light emitted by said source of light for adjusting the size of the missile image, said computing unit including timing means and means connected to said means for rotating said model and to said adjustable focal distance unit, for insuring the formation of an image which, from the moment the missile is fired, simulates a missile one side of which is visible and which is progressively reduced in apparent size as the missile flies away from the firer and finally shows only the rear end thereof.

13. A guided missile simulator according to claim 1, further comprising adjustable screen means for simulating particular atmospheric conditions.

14. A guided missile simulator according to claim 1, wherein said projecting system comprises a projecting apparatus adapted for projecting a beam, another semi-transparent mirror parallel to said semi-transparent mirror and located above the same at an angle of 45° with the beam projected by said apparatus, a flat mirror member substantially perpendicular to said beam axis and symmetrically disposed within said apparatus with respect to said second semi-transparent mirror, a second eye-piece for a second observer disposed above said second semi-transparent mirror and a concave mirror disposed under said first semi-transparent mirror, said flat mirror member constituting said element angularly movable in two perpendicular planes.

15. A guided missile simulator according to claim 1, wherein said projecting system comprises a projecting apparatus adapted for projecting a beam, another semi-transparent mirror parallel to said semi-transparent mirror and located above the same at an angle of 45° with the beam projected by said apparatus, a flat mirror member substantially perpendicular to said beam axis and symmetrically disposed within said apparatus with respect to said second semi-transparent mirror, a second eye-piece for a second observer disposed above said second semi-transparent mirror and a concave mirror disposed under said first semi-transparent mirror, said flat mirror member constituting said element angularly movable in two perpendicular planes, said flat mirror member including two separate flat mirror members, one of which is angularly movable in a first plane to cause displacement of the virtual image in azimuth, while the other one is separately movable in a second plane perpendicular to the first one, to cause displacement of said virtual image in elevation.

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