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G. 1

The diagram shows a vacuum tube circuit. A power source P is connected to a filament L and a resistor R . A vacuum tube with a movable contact MS is connected to R and L . The tube's internal structure shows a grid G and a plate V , with an arrow indicating electron flow towards the plate.

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FIRING TRAINING SIMULATORS FOR REMOTELY - CONTROLLED GUIDED MISSILES

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3 Claims

ABSTRACT OF THE DISCLOSURE

The combination with a simulator reproducing optically the apparent displacements of a guided missile through a landscape from a firing point towards a target. The simulator comprises a sight and a semi-transparent mirror through which a firer may observe the landscape and the target. A projecting system includes a source of light and is capable of superimposing on the landscape by reflection on said semi-transparent mirror a luminous virtual image representing the guided missile. Manually operable control means are connected to a movable member of the projecting system to impart to the virtual image, from an initial position corresponding to the firing point, azimuth and elevational displacements relative to a line of sight defined by an optical axis of said sight, of a system for simulating automatic guidance control comprising a radiation detector linked to the sight, and radiation emitting means linked to the projecting system so that said detector detects the position of the radiation emitting means and thereby the position of the virtual image relative to the line of sight. The detector means for measuring the deviations of the radiation emitting means due to deviations of the virtual image relative to the line of sight. Means are provided for converting the measured deviations to correction signals, and means for transmitting the correction signals to the virtual image in line of sight.

This invention relates to firing training simulators for remotely-controlled guided missiles and more particularly firing trainers for missiles guided by remotely-controlled guiding on the target.

Missiles remotely guided by aligning on the target are at present in most cases guided by a manual control means. However, in some particular weapon systems of more recent development, the control is made automatic. The operator is no longer required to programme the guidance orders for the missile but still while concentrating on aiming at the target, has to watch events which may occur during firing in order to be able to intervene immediately.

The training and instruction of operators requires, as in the case of manually-guided missiles, the firing of a number of simulated shots in order to avoid the undue consumption of practice missiles.

When firing under manual control, the operator must combine suitable directional and elevational orders for ensuring and maintaining the alignment of the missile on the target. The spotting of the location of the missile by the operator as well as the observation of the target are most usually performed visually, the missile being frequently fitted with a luminous tracer easily held in view by the operator (firer).

Simulator equipment for firing with manual guidance control comprises an optical system presenting the firer with a view of a light spot simulating the tracer on an actual mission (or any other representation thereof). The

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guiding of the spot by the firer by means of the manual controls produces angular displacements of the spot with the same responses as would occur in the case of an actual missile.

For training in the drill hall (indoor range), the fixed or moving target with possibly a landscape background is represented by a reproduction, a mock-up, or a light projection, presented to the view of the pilot with a superposed image of the spot to be guided.

Training in the field and even at combat stations is performed with outdoor simulators comprising a semi-reflecting mirror presenting the firer, on the principle of the camera lucida, with a view of the target to be aimed at situated in a real environment (landscape) superposed on the view of a light spot or a guidable visual image simulating the missile. One of the views is observed directly through the transparent parts of the mirror, while the other view appears reflected in the mirror.

Such a simulator also comprises electronic devices, in particular, for computing the motion (flight) data of the simulated missile, the servocontrols evaluating these data for the purpose of operating the optical guidance system of the missile image, programming the firing sequence, simulating the trajectory of the missile, and events during firing.

Such simulators are often equipped with a second optical outlet to be used by an observer—human or robot—sighting the same view as the firer, and controlling or recording the progress of the shoot.

A simulator of this kind is described in the French patent specification No. 1,255,923.

When a simulator is installed in a mobile firing point the spot-emitting device should be stabilised with reference to the ground coordinates by means counteracting the real motions of the missile image caused by angular displacements of the optical part of the appliance during simulated firing.

A gyroscopic stabilising device is described in the French patent specification No. 1,489,865.

In the actual firing of remote-controlled missiles guided in alignment with the target by automatic means, the firer aims a sighting device at the selected target, whether stationary or moving, and maintains the sighting line and the ideal firing axis passing through the target in line. The sighting device is hinged on its support with two degrees of freedom, allowing the tracking of a moving target.

In the case of firing over open sights, the sighting device is a usually magnifying optical system, having a grid or graticule defining the optical line of sight.

The line of sight may alternatively be defined by different means such as the detection of electromagnetic radiations of any wavelength (e.g. ultraviolet rays, radio waves, visible light or infrared radiation) emitted by or reflected from the target, detection by radar, laser or maser beams, detection of the magnetic field of the target, or, finally, the detection of acoustic or ultrasonic waves.

In such case, the means of determining the line of sight are combined with a viewing device furnishing the firer with the requisite reference points for bringing a reference axis of the sighting arrangement into coincidence with the ideal line of fire.

The missile is remotely-controlled by guidance signals generated by a servo-system which data are fed from an RDF. The latter tracks the angular position of the missile, or, more particularly, the angular displacements between the firer's line of sight and the position of the missile. The guidance orders are computed in such manner that their action on the trajectory of the missile is to cancel the detected deflection. During the firing period, the missile is thus practically held, up to the instant of impact, on the line of sight, ending at the target.

The RDF instrument receives by known, optical or electronic means, the radiations emanating from the missile. These variations (deflections) may be emitted by a missile-linked device such as an emitter, a tracking unit, an infrared source, or by reflection from the missile, such as radiations from a radar, laser or maser source. In the general case, the firer controls the missile position with reference to the target visually, either directly or by means of an optical system.

The weapon system, i.e. the combination of sighting gear, radiation receivers, detectors, electronic firing control equipment or equipment for trajectory correction, whether manual or automatic, responding to signals from the detector, the missile remote controls and the auxiliaries, thus forms a complete servo-system with a feedback loop, controlling the positions of the missile on the line of sight.

The firer, however, retains an important share in firing under automatic control: the firer (gunner) must precisely align the sighting telescope on the target and follows the progress of the operation. He must further be alert for incidents which may occur during firing. Atmospheric conditions, the tracking of a highly-mobile target, the maneuvering of the vehicle carrying the firing point, combat environment, enemy counteraction or other fortuitous events are capable of causing trouble, often transiently, during the course of firing. Thus, the missile may move out of detection range, or even out of the field of view, visual observation may become impeded, or even impossible, in particular through fog, the detection and guidance signals of the missile may be blurred, or the missile, the sighting and/or detection means may become uncontrollable.

In certain cases, the firer may be able to cope with a critical situation by taking immediate action, some of the appliances even allowing of overriding by manual control.

The human factor should thus not be neglected in firing with automatic guidance control and the proper instruction of gunners remains important. This instruction must include the execution of numerous practice shoots, usually with a suitable simulator, the use of practice missiles being very expensive.

The object of the present invention is an improvement in simulators for manual guidance control allowing them to be used also for automatic control.

The present invention is a simulator for firing training with missiles guided by alignment on the target by automatic remote control comprising at least one optical sighting device presenting the fire with a view of the image of a light spot simulating the tracer element of a missile superposed on a target background, the said optical device being coupled with means for detecting the position or location of the said spot with reference to the line of sight of the said optical system and means for emitting the said spot and simulating its receding motion in accordance with a preset programme controllable by signals originated in an automatic guidance device responding to data received and transmitted by the said detecting means.

The optical system of such a simulator may include an optical outlet for the gunner with a further such output for observing and controlling the firing by the gunner.

The detector system may be incorporated with the optical system, using the same input.

The spot emitter can be gyroscopically stabilised when mounted on a movable (travelling) base.

The detector system may form a part of the weapon system of an actual missile launcher, responding to radiation from sources including visible light, infrared, and ultraviolet radiation, radar waves, acoustic waves, ultrasonic waves, laser and maser radiation as well as other magnetic or electromagnetic radiation.

The guidance system may be controlled by a signal transducer linked with a remote-control system for missiles of a weapon system with a real (unsimulated) launcher of such missiles.

A radiation source linked with the spot emitter can be used to simulate the detector emission after firing. The spot emitter can be assimilated with the radiation source for the detector.

The invention likewise proposes in the capacity of novel industrial products apparatus for controlling weapon systems on real missile launchers, consisting of a simulator in accordance with the present invention comprising adapting means for elements or element assemblies of the guidance systems of such weapon systems.

A simulator according to this invention may be arranged to use, either the complete weapon system, or, for reasons of economy, a simplified or only partially simulated weapon system. It may comprise particular known devices already used in simulators for firing training with manual control of the missiles guided by aligning on the target such as means for visualising the simulated or real target and background environment or landscape, simulation of the missile, guidance of the simulated missile, and the different means used for such simulation, i.e. computers, servo-mechanisms for guiding the simulated missile, programming for simulating the missile course and firing events, fire control and stabilisation.

If the actual weapon system is used, a simulator according to this invention must comprise a device simulating the radiation beam from a missile in actual firing, in order to allow the RDF unit to supply the data on the position of the missile. Such an arrangement will consist of a radiation source emitting radiation of the same kind as that to be detected in actual firing, in the form of a beam, such beam being then guided by a servo system locating it positionally in space.

Such a radiation source simulator may for particular purposes be linked or combined, at least partially, with the simulator device presenting the firer with the simulated view of a guided missile.

If an RDF-instrument is not used for the simulation, an equivalent system is used by which the motions of the simulated missile are detected in the simulator and supply the data for locating the missile.

When the weapon system is being used, a servo-control system for guidance control of the simulated missile evaluates the guidance orders transmitted from the weapon system to the missile in actual firing; in order to evaluate the guidance signals for the control system, to obtain from the simulated missile the same response as from a real missile. The guidance action thus extends equally to the image of the missile system as to the image of the radiation beam, thus providing means of detection.

An equivalent result can be obtained by direct evaluation of the missile-locating data in the servo-controls of the guidance system if the simulator does not employ the weapon system which evaluates the guidance signals transmitted to the missile on the basis of the data.

The conditions of real firing are thus simulated, both for the gunner and the automatic guidance system. Control with a closed feedback loop, as used in real systems, is obtained in a simulator using the complete weapon system. A simulator in accordance with the present invention, consequently constitutes an excellent device for controlling the automatic guidance of a weapon system and its functioning in general. In the case of a simulator for outdoor training, the optical head and spot emitter may be light and compact so as to be interchangeably connectable with the sighting and tracking means of the weapon system.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of the sighting and de-

tection arrangements of a simulator in accordance with the invention;

FIG. 2 is a similar view to FIG. 1 of a variant form of embodiment;

FIG. 3 is the diagram of a simulator according to the invention fitted with another variant of the sighting and detecting (tracking) means.

In the arrangement according to FIG. 1 a sighting telescope V is linked with a detecting device D. The spot projected by a light-source L is reflected in a semi-transparent mirror MS and passes through the telescope V to reach the gunner's eye O, while the target background or landscape P is observed directly through the semi-transparent mirror MS.

The detector (tracking) radiation is emitted by an independent source R. The sources L and R are, of course, dependent to follow the motions of the simulated missile.

In the variant form of embodiment according to FIG. 2, the sources L and R are combined but while the light beam L reaches the gunner's eye O by reflection in the mirror MS, the radiation beams pass through that mirror and are reflected in the normal mirror to fall on the detector D.

In the variant according to FIG. 3, the detector or tracking device D and the sighting device V have the same optical input. The gunner's eye O views the landscape (terrain) P directly through the semi-transparent mirror MS, by reflection in the mirror M_1S_1 , and reflection in the semi-transparent mirror M_2S_2 . The gunner simultaneously views the superposed image of the (light) spot coming from the source LR after reflection in a first optical reflecting device M_1 stabilised by a gyroscopic element S, further reflection in the mirror M_2 controlled by a guidance system P, another reflection in the semi-transparent mirrors M_1S_1 and M_2S_2 . The radiations emitted by the source R are likewise reflected in M_1 , M_2 and MS but pass through the semi-transparent mirror M_1S_1 and reach the sensing elements of the detector D. These sensing elements transmit their data to an automatic guidance device PA in a weapon system for firing real missiles. The signals emitted by this automatic guidance device PA are transmitted to the spot-guidance system PB by a signal transducer TO.

The operation of firing by the gunner is controlled by a monitoring device the scanner whereof C scans the same images of the landscape and the light spot as are viewed by the gunner O directly through the semi-reflecting mirror M_2S_2 , and by reflection in the mirror M.

The missile is equipped at the rear with a luminous tracer, the light emitted by which is utilised by the optical part of the weapon system and the infra-red radiation by the detector of the radio direction finder.

The optical device of the weapon system consists of a monocular telescope which the gunner aims at the target, the optical axis being accurately set by appropriate crosshairs. The RDF detector is incorporated in the telescope in such a manner as directly to detect the deviation of the missile position from the optical axis.

The radiation emitted by the missile enters the apparatus described above in the form of a single beam, through a common intake. A selector device inside the apparatus projects the beam in such a manner that the light rays enter the telescope while the infrared radiation passes to the detector of the radio direction finder.

The data supplied by the detector are evaluated by a servo-controlled electronic device which computes the guidance signals to be transmitted to the missile, in such a manner that this action on the trajectory of the latter tends to correct the detected deviation. For this purpose, a remote control system transmits the results to the missile for the purpose of initiating the appropriate action of the control means. Thus, within particular operation limits, the missile is practically servo-controlled to maintain its course, up to the instant of impact, along the optical axis of the (sighting) telescope.

The simulator for outdoor use is linked with the weapon system as a whole. Its optical and emitting system is suit-

ably located interchangeably during the simulated firing in front of the common entry of the light rays and infrared radiation of the said weapon system.

The said scanning head comprises a radiation source of small dimensions, emitting visible light and infrared radiation, located in the focus of a concave mirror or a convergent lens. It further incorporates an arrangement of gyroscopically stabilised mirrors reflecting the collimated beam emitted by the source, in a direction linked with the terrestrial axis (ground coordinates). Finally, it comprises an arrangement of two mirrors in the form of an apidiascope, successively reflecting the beam into the common entry of the weapon system. One of the mirrors has two angular degrees of freedom, and guides the beam, for which purpose it is actuated by a servo-mechanism controlled by an electronic device. The other, semi-reflecting mirror displays the (target) landscape in its transparent part and projects the target image into the telescope objective lens. It also reflects into the common entry of the light rays and the infrared radiation for which provision is made in the weapon system, a collimated beam simulating the radiation emitted by the missile. The optical device in the scanning head of the simulator, by the nature of its radiation source, the quality of the glasses (lenses) through which the beam is projected, and the reflecting power of the mirrors, ensures a sufficient emission and transmission of radiation to furnish the gunner, in both the visible light and the infrared radiation bands, with a visible image of the simulated missile and furthermore to operate the detecting means.

The weapon system incorporating a servo-controlled electronic device computing the guidance signals from the data supplied by the detection system, is also used for simulation. In such case, the guidance signals are transmitted, not to the missile itself, but to the computer device in the simulator device which computes from the signals received, the signals producing the corresponding response of the missile in actual firing and the characteristics of motion of the missile, the signals for the servo-mechanisms acting on the guidance mirror to deflect the collimated radiation beam in the same manner as an actual missile.

The utilisation of such a simulator in devices for missile firing (launching) equipped with a single source of radiation to ensure their guidance and visualisation allows for simulation, the provision of a single, common optical path to the entry of the weapons system. This allows the equipment to be substantially simplified.

The semi-transparent mirror allows a part of the light beam simulating the missile to pass through the transparent part towards a second optical outlet at the same time as the image of the target or the background landscape. The two images are identically superposed on the images viewed by the gunner. Firing control can consequently be exercised either by an instructor, directly or with the help of an optical system, or by a robot recorder, the one and the other both making use of the second optical outlet.

The use of the weapon system in simulation is optional. It can be partly or wholly replaced by simpler means which can allow equivalent results to be obtained with simulated firing.

The facility with which the complete weapon system can be used in conjunction with a simulator according to the present invention allows complete check and testing of the servo-controls with the feedback loop in regard to the position of the missile on the line of sight. The loop is closed, in the case of simulated firing, by the computer in the simulator, with its servo-controls, further by the deflection of the detector beam responding to these controls.

The deflection of the detector beam is easily controlled by optical means, this beam being combined with the beam of visible light. The response of the missile is

determined by the computer of the simulator, in accordance with the guidance signals received.

The computer will require regulating if the missile types to be simulated differ in their guidance characteristics.

A simulator in accordance with the present invention can be incorporated in a simulation apparatus for training on a complete mission or task, including, for instance, observation, warning, detection of the objective, spotting the target and firing the missile.

Such a simulator can equally be applied to an automatic guidance system, suitably by means of an electromagnetic field directed from the firing point to direct the missile by alignment on the target.

Thus such a simulator for firing training by automatic remote control of the guided missile by alignment on the target according to the present invention can be applied to both indoor and outdoor trainers, whether (gyro-)stabilised or not. It can be used with known means for detecting the position of the missile, according to the nature of the ray to be detected and the character and origin of the radiation reflected from or emitted by the missile. It can be used with known means for target spotting by open sights or by an optical system, by detection of electromagnetic radiation of all wavelengths, detection by radar or laser or maser radiation, by detecting the magnetic field of the target, as well as detection by audio or ultrasonic waves. It can be used, partially or as a whole, with weapon systems for simulation. It allows control of the functioning of the weapon system. It can be used for training on special missions or particular tasks; and it can be applied to guidance systems using a field directed on the target.

We claim:

1. The combination with a simulator reproducing optically the apparent displacements of a guided missile through a landscape from a firing point toward a target, said simulator comprising a sight and a semi-transparent mirror through which a firer may observe said landscape and said target, a projecting system including a source of light and capable of superimposing on said landscape by reflection on said semi-transparent mirror a luminous virtual image representing the guided missile, and manually operable control means connected to a movable member of the projecting system to impart to said virtual image, from an initial position corresponding to said firing point,

azimuth and elevational displacements relative to a line of sight defined by an optical axis of said sight, of a system for simulating automatic guidance control comprising a radiation detector linked to said sight and radiation emitting means linked to the projecting system so that said detector detects the position of said radiation emitting means and thereby the position of said virtual image relative to said line of sight, said detector having means for measuring the deviations of said radiation emitting means due to deviations of said virtual image relative to said line of sight, means for converting the measured deviations to correction signals, and means for transmitting said correction signals to said control means whereby to automatically maintain said virtual image in said line of sight.

2. A simulator as claimed in claim 1, wherein the spot-emitting device is gyroscopically stabilised when the said simulator is carried on a movable base.

3. A simulator as claimed in claim 1, wherein the detecting means are an element of the weapon system of an actual firing or launching device for guided missiles responding to radiations of the kind including visible light, infrared and ultraviolet radiation, radio waves, radar waves, acoustic waves, ultrasonic waves, laser and maser beams and other magnetic and electromagnetic radiation.

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