United States Patent [19]

Robertsson

[11] **3,927,480**

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[54] **GUNNERY TRAINING SCORING SYSTEM WITH LASER PULSES**

[75] Inventor: **Hans R. Robertsson,** Molndal, Sweden

[73] Assignee: **Saab-Scania Aktiebolag,** Linkoping, Sweden

[*] Notice: The portion of the term of this patent subsequent to Sept. 3, 1991, has been disclaimed.

[22] Filed: **Mar. 26, 1974**

[21] Appl. No.: **454,941**

Related U.S. Application Data

[63] Continuation of Ser. No. 318,008, Dec. 26, 1972, Pat. No. 3,832,791.

[52] **U.S. Cl.** **35/25**
[51] **Int. Cl.²** **F41G 3/26**
[58] **Field of Search** 35/25; 273/101.1

[56] **References Cited**

UNITED STATES PATENTS

3,257,741	6/1966	Cameron et al.	35/25
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1,115,141	12/1965	United Kingdom	35/25

Primary Examiner—John H. Wolff

[57] **ABSTRACT**

In apparatus for gunnery practice by which firing towards a target comprising a reflector is simulated by laser emissions, a first radiation emission at firing is used for ranging, to ascertain a time interval following firing at which a round of a selected type of ammunition will arrive at the target. After that interval following firing, a second emission is used to obtain a fix on the target. The second emission comprises pulses encoding information about ammunition type and relation of point of impact of the simulated round to target location, to be decoded at the target and used for evaluating hit effect.

3 Claims, 5 Drawing Figures

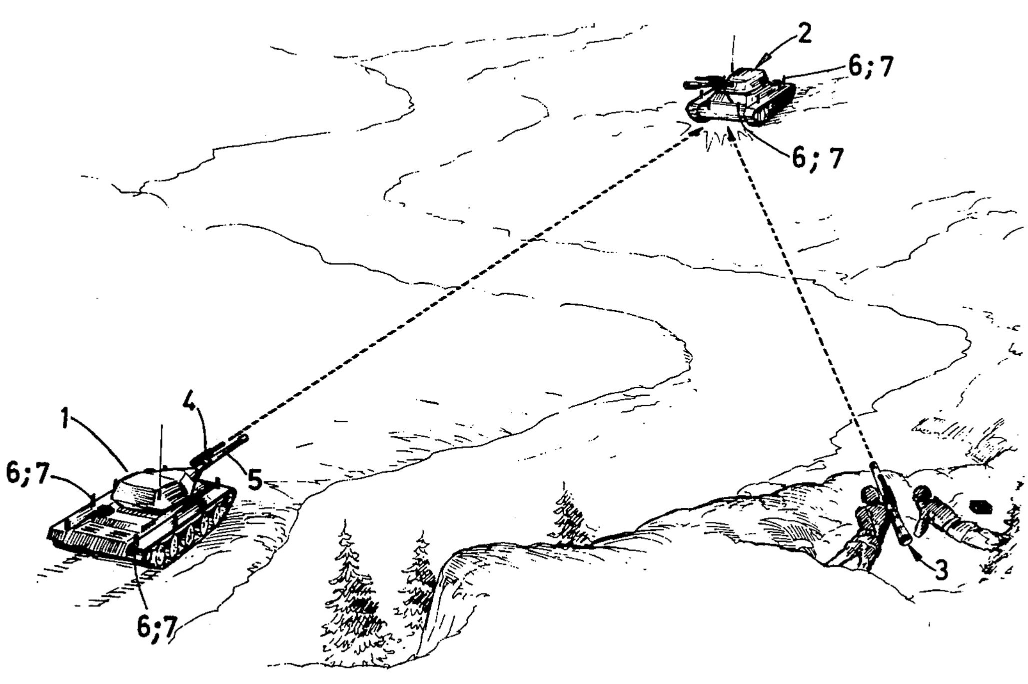


FIG 1

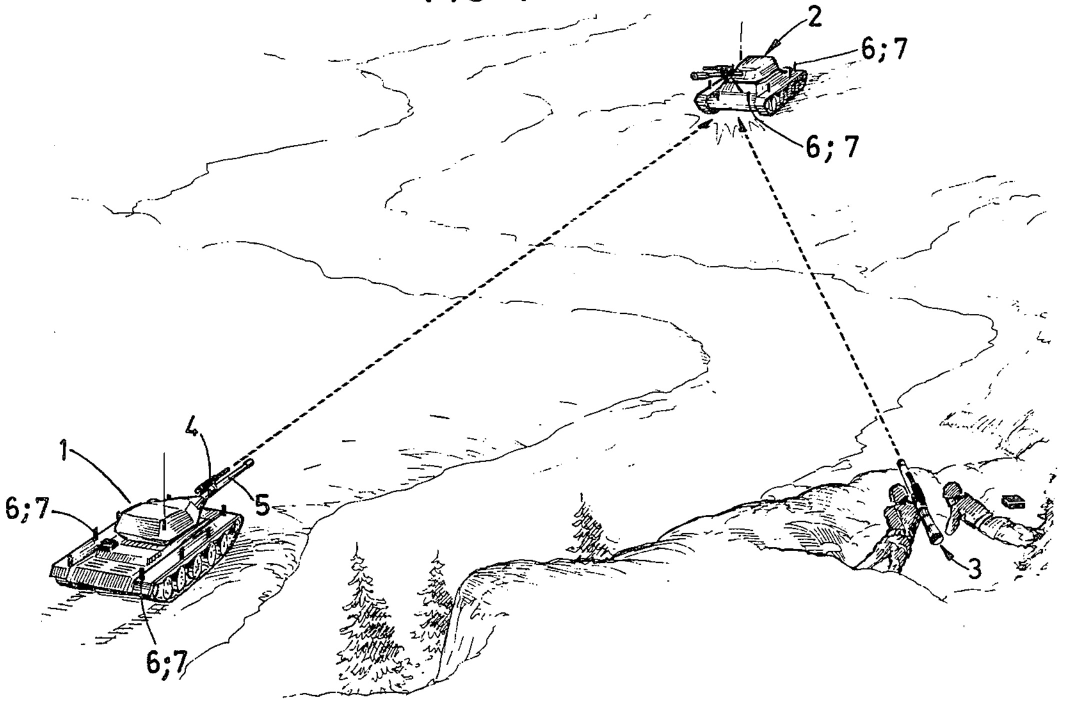


FIG 2

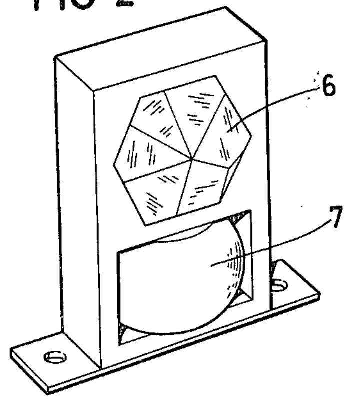


FIG. 3

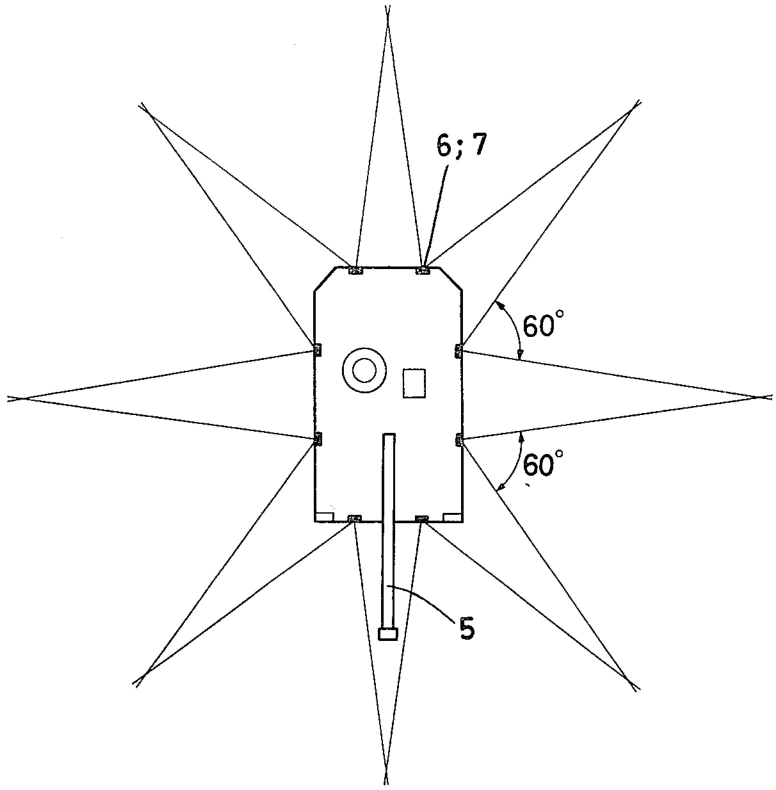


FIG. 4

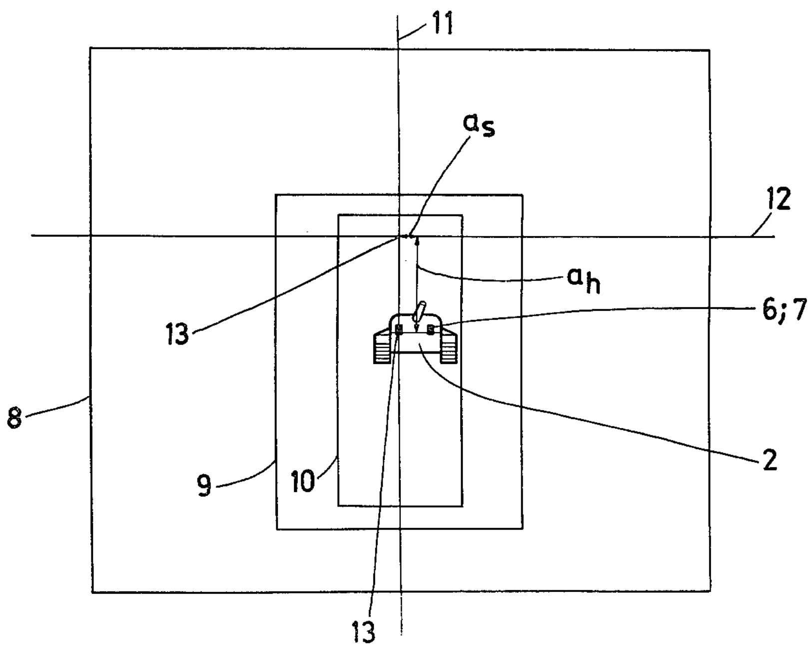
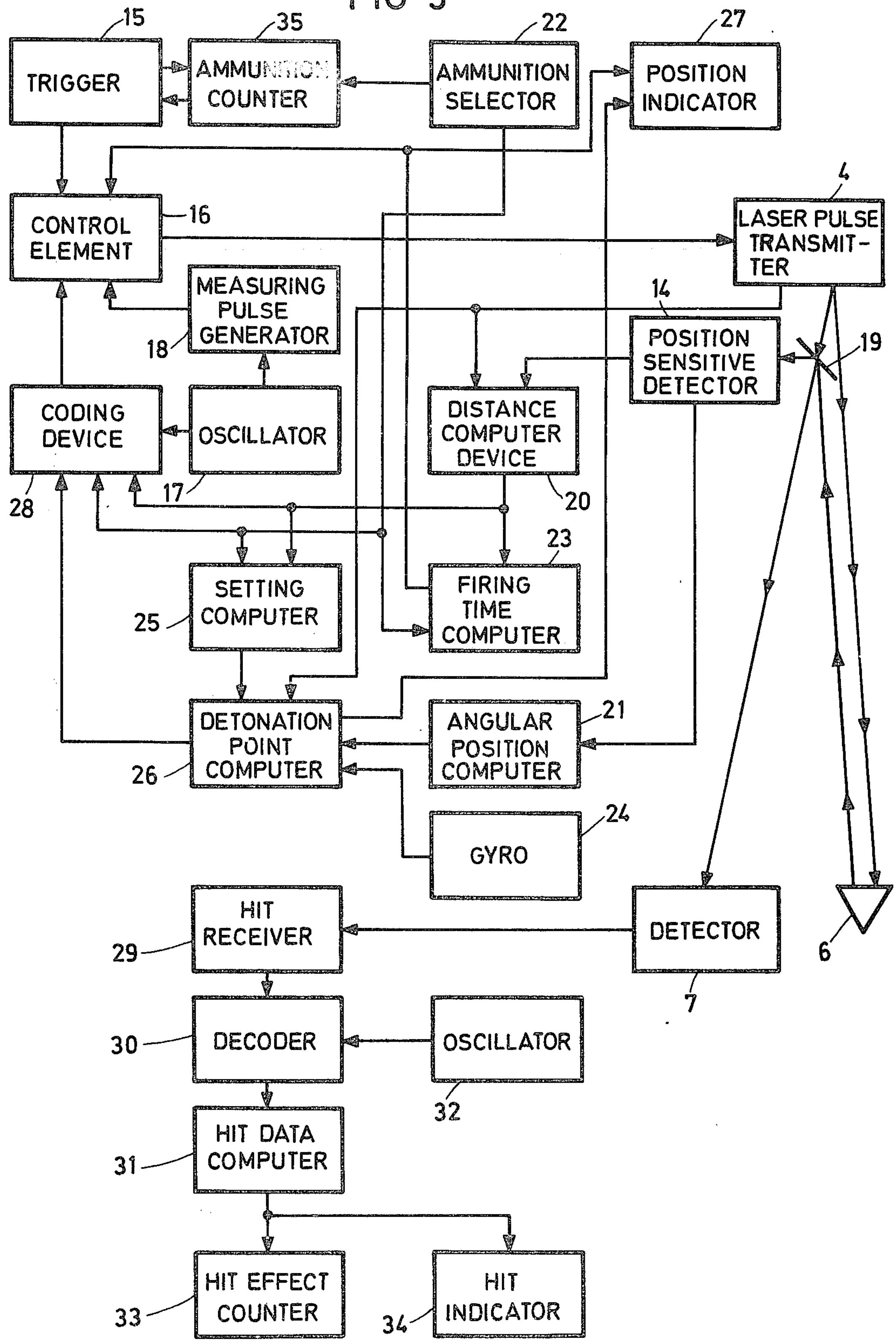


FIG 5


15
TRIGGER
35
COUNTER
22
AMMUNITION SELECTOR
27
POSITION INDICATOR
CONTROL ELEMENT
16
4
LASER PULSE TRANSMIT-TER
MEASURING PULSE GENERATOR
18
14
POSITION SENSITIVE DETECTOR
19
CODING DEVICE
OSCILLATOR
DISTANCE COMPUTER DEVICE
28
17
20
23
SETTING COMPUTER
25
FIRING TIME COMPUTER
DETONATION POINT COMPUTER
26
ANGULAR POSITION COMPUTER
21
GYRO
24
HIT RECEIVER
29
DETECTOR
6
7
DECODER
30
OSCILLATOR
32
HIT DATA COMPUTER
31
HIT EFFECT COUNTER
33
HIT INDICATOR
34

GUNNERY TRAINING SCORING SYSTEM WITH LASER PULSES

This application is a continuation of my copending application Ser. No. 318,008, filed Dec. 26, 1972, now U.S. Pat. No. 3,832,791, and is filed as a voluntary division of that earlier application.

The present invention relates to a gunnery target scoring system with laser pulses.

The purpose of practice firings is, in the first place, to give soldiers the ability to handle their weapon in the correct manner, especially with regard to the sighting of the weapon towards a target, and to train the soldiers in the tactically correct performance. This implies among other things that they should use the arms against a target against which fire from the weapon has a chance of being effective.

In order to simplify such practice firings it has already been proposed to use simulator devices in which actual firing is replaced by a radiation pulse within the optical radiation range, e.g. from a laser. The radiation is transmitted in the direction which the weapon is aimed and if this aiming is correct at the firing instant a hit is indicated in a suitable way. Simulator devices based upon this generally described principle are more fully disclosed in e.g. U.S. Pat. Nos. 3,257,471 and 3,104,448. These earlier known simultator devices, however, are constructed in such a way that the possiblity of carrying out an actual realistic practice firing is reduced due to the complexity of the device. As an example of this it can be observed that these known simulator devices, in addition to optical radition, use infared and/or radiofrequency radiation for hit determination and signaling.

It is the object of the present invention to achieve a device of the said type by means of which sighting and firing towards a target can be practiced under realistic conditions without any hazard to participants in the exercise.

It is a further object of the invention to create the pre-conditions for practicing the tactics of individual soldiers as well as of a whole armed unit with different kinds of weapons under combat conditions and with realistic simulation of the factors which affect the result of firing from weapons towards different kinds of targets. By means of the invention it is also made possible to record a training routine for later tactical review.

Further advantages and characteristics of the invention will become obvious from the following description of the accompanying drawings in which:

FIG. 1 is a position picture which shows a terrain sector with a tactical situation during an exercise in which a tank is being fired at by laser pulses from a second tank and an antitank weapon.

FIG. 2 shows a reflector device which is built in conjunction with a receiver sensitive to laser radiation.

FIG. 3 shows how the reflector device and the laser receivers are located on a tank so that the sensitivity sectors of the laser receivers together cover the perimeter of the tank.

FIG. 4 shows schematically the position of a target in a plane perpendicular to the centre-line of a barrel of a weapon, the range of vision for laser receiver and sight, and a radiation beam of the laser emitter.

FIG. 5 is a block diagram which shows in general outline the step-up of a device in accordance with the invention.

In the following description a device in accordance with the invention will be described in connection with a special application, namely the so-called duel firing of tanks. The invention should not be considered, however, to be restricted to such an application, but can be applied to exercises which, on the whole, embrace all directly aimed weapons. The number of weapons included in an exercise may be varied within wide limits. It is also obvious that every weapon in operation in a combat practice may be considered to represent a target when it is being fired at. The designations weapons/targets for two units in combat with one another are therefore interchangeable according to whether the one or the other unit gives off fire.

In FIG. 1 a tank designated **1** can be considered a weapon owing to the fact that it gives off simulated fire towards another tank **2** at the moment shown in the figure. The second tank **2**, which is being fired at and should therefore be considered the target at the moment, is also subject to simulated fire from an anti-tank weapon **3**.

The simulated fire consists of laser radiation, which originates from a laser pulse transmitter **4.** This is fixed to the barrel **5** of the gun of tank **1,** in accordance with the invention, so that the optical axis of the laser pulse transmitter **4** substantially coincides with the centre-line of the barrel. The target **2** has a reflector device **6** whose task it is to reflect laser radiation back to the weapon from which it emanates. The reflector device consists in a preferred embodiment of so-called corner-reflecting prisms, which are capable, irrespective of the angle of incidence of incident radiation, of reflecting such radiation in a direction which is parallel with the direction from which it arrives.

In accordance with the invention, the weapon has an element that is sensitive to laser radiation and which consists of a position-sensitive detector **14** directly connected to the transmitter **4,** and circuits for the determination of the distance to the target and the position of an expected detonation point of a real projectile in relation to the target. The position-sensitive detector is build as a unit combined with the laser pulse transmitter **4** and is therefore not discernible in FIG. **1.** This and the circuits just mentioned will instead be described in connection with FIG. **5.**

The laser radiation originating from the laser pulse transmitter **4,** as can be seen from FIG. **1,** is of two kinds. The one kind is a laser pulse train with substantially fixed frequency intended for the measuring of the position of the target. In a manner known in itself the distance between the weapon **1** and the target **2** is calculated by measurement of the transit time for laser pulses emitted by the laser pulse transmitter **4,** reflected in the reflector element **6** of the target and detected in the position-sensitive detector. From the center of intensity of laser pulses reflected from different reflector elements **6** on the target **2** the position of the target **2** in relation to the center-line of the barrel **5** is also measured out by the position-sensitive detector. The second type of laser radiation is laser pulse signal which constitutes the simulated fire itself and which in coded form contains on the one hand information regarding the precalculated detonation point in relation to the target with regard to the position of the target, the movement during the firing time and the type of ammunition, on the other hand the firing distance, kind of arms, type of ammunition and possibly further information. The invention is not restricted to any particular kind of coding. All types of coding which give high probability of correct transmission and which require relatively small numbers of pulses are useable. For the control of the laser pulse transmitter in order for it to transmit pulse signals there is an element capable of being programmed, which will be described in detail in connection with FIG. 5.

For the reeption and exploitation of the laser pulse signal the target 2 has elements sensitive to laser radiation consisting of a number of detectors 7 and calculating and indicating elements. As can be seen from FIG. 3, the detectors 7 are so arranged that their sensitivity sectors, which are each approximately 60°, together cover the perimeter of the weapon. The detectors 7 are adapted so that they receive the laser pulse signal, and determination is made from the coded information as to whether the firing weapon is effective against the target and the effect of the firing with regard to type of ammunition, firing distance and calculated position of the target in relation to the position of the expected detonation point.

It is evident from what has been said earlier, regarding the relationship weapon/target, that the weapon 1 as well as the target 2 and the anti-tank weapon 3 are identically equipped with regard to laser pulse transmitter 4, reflector element 6 and the other devices mentioned. In FIG. 2 is shown how a reflector 6 and a detector 7 can practically be build together as a unit which can be attached by means of screws or strong permanent magnets.

As stated above, FIG. 4 is taken at the plane of the tank 2 in FIG. 1, considering it as the target and the tank 1 of that figure as comprising the weapon. In FIG. 4 numerals 8, 9 and 10 designate rectangular shaped areas which in the order given represent: the range of vision of the sight of the tank 1, the range of vision of the position-sensitive detector placed in connection to the laser pulse transmitter 4, and the surface in the plane of the figure illuminated by the radiation beam of the laser transmitter. 11 and 12 are two lines which constitute projections of a vertical plane and a plane perpendicular to this, the line of intersection of which planes constitutes the extension of the center-line of the barrel 5. The point of intersection between the lines 11, and 12 is designated in the figure by 13 and this is the point, therefore, where the extension of the center-line of the barrel intersects the plane of the figure. The point 13 is at the same time the origin of coordinates of the range of vision of the position-sensitive detector 14, that is to say, its optical axis coincides with the extension of the center-line of the barrel 5. The origin of coordinates of the detector is the point to which is related the position of the target in elevation and in lateral direction. In the figure the deviation of the target in elevation is designated a_h and the deviation in lateral direction a_s. The object is of course to require that the weapon should be so aimed that a_h and a_s correspond at the moment of firing to the correct elevation and lateral setting, respectively, having regard to the type of ammunition, firing distance and any target displacement during the firing time, the demand for correctness being conditioned by the extension of the target and by the effective range of the projectile.

The radiation beam of the laser transmitter 4 has such an extension that in elevation it is at least greater than what corresponds to the elevational setting angle of the barrel 5 at the greatest firing distance, and that in lateral direction it covers at least the distance between

two detectors 7 at the smallest firing distance. This means, in other words, that the cross-section of the radiation beam has such a height that no compensation is required for the elevation setting of the gun barrel and such a width that if the weapon 1 is aimed substantially correctly at the target 2, at least some of the detectors 7 will be attained by the laser radiation even at the shortest firing distance, without it being necessary to aim the radiation beam towards a special detector.

The block diagram in FIG. 5 will now be described by its function. It is assumed that the weapon 1 is aimed at the target 2, which may be in movement or be at a standstill. In the figure will be found again the laser pulse transmitter 4, the reflector 6, the detector 7 and the aforementioned position-sensitive detector, which is here designated 14. In tracking, the gun barrel is made to point towards the target 2 and consequently the laser pulse transmitter 4 and the position-sensitive detector 14 are also aimed towards the target. As in real combat, the weapon is fired when the aiming is considered to be correct. The firing is effected by means of the trigger 15 of the weapon and thereby an automatic procedure is started which, in accordance with the invention, is initiated by a command to the laser transmitter from a control element 16 to emit a laser pulse train of a duration of a few thousandths of a second and comprising a number of laser pulses. The frequency of the laser pulse train is substantially constant and is controlled by an oscillator 17 which is connected via a measuring pulse generator 18 to the control element 16. It is the task of the generator 18 to convert the output signal of the oscillator 17 to a form such that the laser pulses emitted under its control cannot be mistaken for the earlier mentioned laser pulse signal that carries information. If the aiming of the weapon is sufficiently accurate, the laser pulses will encounter the reflector 6, from which they are reflected towards the position-sensitive detector 14. From the transit time of the laser pulses, measured by the time from the instant when they leave the laser pulse transmitter 4 until they are reflected by means of the reflector 6 and, via a semitransparent mirror 19, are detected in the detector 14, the distance between the weapon 1 and the target 2 can be calculated by means of a computer device 20 connected to the detector 14. At the same time, the angular deflection at the instant of firing between the center-line of the barrel 5 and the center of intensity of the reflected laser radiation is calculated by means of an angular position computer device 21.

Since the target is assumed to be moving, although the movement may temporarily be zero, an essential part of the training will be concerned with correct sighting. On the basis of the movement of the target, the angular position of the target at the firing instant as well as the end of the firing time will be of interest. The firing time — that is, the time required for a supposed missile to traverse its trajectory — depends upon the type of ammunition used, and therefore a manually adjustable ammunition selector 22 is provided, to enable simulation of shooting with any of a variety of types of ammunition. Once the distance to the target 2 and the type of ammunition are known, the firing time can be calculated in a computer device 23. At the end of the firing time another laser pulse train is emitted and the agnular position of the target in relation to the center-line of the gun barrel is calculated anew in the device 21. owing to tracking, the center-line of the gun barrel has been turned about a certain angle in space during the firing time. By means of a two-axis gyro 24 the lateral as well as the elevational magnitude of the angle of such rotation of the gun barrel is determined.

The ammunition selector 22 is connected to a computer device 25 which also has an input connection from the distance computing element 20 and which is adapted to calculate, with regard for the type of ammunition selected, the correct setting for the firing distance. Once data are obtained concerning the correct setting, the angular position of the target in elevation at the start and end of the firing time, the angle of gun barrel rotation in the elevational direction furing the firing time, and the firing distance, it is possible to calculate the position in elevation of the detonation point; and this is done in computer device 26. In an analogous manner that device calculates the position of the detonation point in the lateral direction from the lateral angular position of the target at the start and finish of the firing time, the lateral angle of rotation of the barrel during the firing time and the firing distance. The position of detonation is calculated on the one hand as the elevational and lateral distance in relation to the target, on the other hand as the angular deflections in relation to the center-line of the barrel. In accordance with a special characteristic of the invention, these latter quantities can be made apparent by means of a detonation position indicator 27 belonging to the computer device 26 and adapted to generate a luminous spot which is reflected into the sight of the weapon and the position of which corresponds to the detonation point of a real projectile discharged according to the above.

The device 26 for computing the position of the detonation point is connected to a coding device 28 which is also connected to the ammunition selector 22 and the distance computer device 20. According to the invention, the coding device 28 can be programmed in accordance with the type of weapon and the type of ammunition and is adapted to command the laser pulse transmitter to emit a coded laser pulse signal that interrupts the laser pulse train and contains in coded form, in addition to the data just mentioned, also the calculated distance and the lateral as well as elevational distance of the detonation point in relation to the target. The laser pulse signal is produced in response to a coded signal generated by the coding device 28, on the basis of an output signal from the oscillator 17 and acting via the control element upon the laser pulse transmitter 4.

The laser pulse signal is perceived by the target 2 as if it were the actual firing and is received by means of detector 7 which is adapted to convert the laser pulse signal to an electric pulse signal. This passes via a hit receiver 29 and a decoder 30 to a hit data computer 31. The hit receiver 29 has the tank of amplifying the detector signal and filtering out disturbances in the same. The decoder 30 is connected to an oscillator 32 with the same frequency as the oscillator 17 and is adapted to produce the original information from the coded signal. The hit computer 31 is adapted on the one hand to determine from the information transmitted whether the weapon is effective against the target with regard to the type of ammunition used, and on the other hand, through comparison between the extension of the target in the firing direction and the divergence of the detonation point in the lateral and elevational direction, to calculate the effect of the detonation. It has to be borne in mind that a projectile which in itself has the capacity of completely knocking out the target by a direct hit from a certain direction, brings about only moderate damage with a similar hit from another direction or when its detonation takes place to one side of the target. To this end the signals from different detectors 7 and different types of ammunition are allotted different weight. The effect of the detonations is considered as a number, the "hit effect number," the magnitude of which thus depends on the susceptibility of the target in the firing direction to the type of ammunition in question. When a hit is made, a visual hit indicator is released, for example a rotating spotlight which is made to rotate a number of turns corresponding to the "hit effect number," so as to give the firing tank 1 an idea of the effect of the simulated firing. Connected to the hit data computer is a hit effect counter 33 which at the start of the practice is pre-set to a number which corresponds to the total effect of the firing that is required to knock out the target. The counter is adapted to be counted down by each "hit effect number" from the hit data computer 31, and when the position of the counter is zero, the counter gives a signal to a hit indicator 34 which has the task of indicating when the target has been knocked out. At the same time the electric supply to the target is cut so that it stops and loses the capacity of giving off fire that it has previously possessed during the whole time. As a sign that the target has been knocked out, light and smoke signals may be released.

According to a special characteristic of the invention, an ammunition counter 35 in the weapon is coupled to the trigger 15 and to the ammunition selector 22 and is adapted to be preset to a number corresponding to the number of projectiles of the respective type of ammunition which the weapon normally carries. The counter 35 is counted down for each firing, and it stops when the count down has reached zero, preventing any further firing of the particular type of ammunition the exhaustion of which is thus simulated.

It is obvious that if it is intended only to practice dual firing against stationary targets, the device in accordance with the invention can be substantially simplified. Since in the base of stationary target its angular position is the same at the beginning and at the end of the firing time, this need not be calculated so that the computer device 23 can be omitted. Consequently no gyro 24 is required and it is sufficient to measure the distance and the angular deflection of the target only once, that is to say only one laser pulse train is required, which implies a simpler set-up of the computer device 26 for the position of the detonation point.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

The invention is defined by the following claims:

I claim:

1. A method of evaluating the results of target practice with a weapon which has a barrel and which is located at a weapon position, firing at a target at a target position which is remote from the weapon position and which may be changing due to target motion, wherein firing from the weapon of a round of a selected type of ammunition is simulated by emitting radiation substantially coaxially with the weapon barrel from a directional radiation emitter such as a laser at the instant when the weapon is fired, and wherein a relation-

ship between target location and the point of impact of said simulated round is calculated at the weapon position on the basis of detected radiation returned to the weapon position from reflector means at the target, said method being characterized by:

A. after a delay interval following said instant of simulated firing, which interval substantially corresponds to the time required for a real round of said ammunition to arrive at its point of impact, producing a further radiation emission from said radiation emitter that comprises a train of pulses in which is encoded information concerning selected ammunition type and relationship of said point of impact to target position, the directionality of the emitter ensuring that said information is delivered substantially only to a target at which the weapon is effectively aimed; and

B. at the target, combining said information with other information which relates to the vulnerability of the target, to produce an output signifying the hit effectiveness against that target of the simulated round as fired.

2. A method of evaluating the results of practice firing with a weapon which has a barrel and which is located at a weapon position, against a target at a target position which is remote from the weapon position and which may be changing due to target motion, wherein firing of the weapon is simulated by emitting radition substantially coaxially with the weapon barrel from a directional radiation emitter such as a laser, wherein the point of impact of a simulated round of a selected type of ammunition is calculated at the weapon position on the basis of barrel axis orientation at an instant when the weapon is fired and detected radiation returned to the weapon position from reflector means at the target position, said method being characterized by:

A. producing a first radiation emission from the radiation emitter that comprises at least one pulse and is emitted substantially at said instant when the weapon is fired;

B. utilizing the reflected return radiation of said first radiation emission to determine a time interval that substantially corresponds to the time required for a round of said selected type of ammunition to traverse the distance between the weapon and the target;

C. after said time interval following the beginning of said first radiation emission, producing a second radiation emission from the radiation emitter that comprises a train of pulses in which is encoded information concerning selected ammunition tupe and relationship of said point of impact to target position, the directionality of the emitter ensuring that said information is delivered substantially only to a target at which the weapon is effectively aimed; and

D. at the target, combining said information with other information which relates to the vulnerability of the target and which is stored at the target, to produce an output signifying the hit effectiveness against that target of the simulated round as fired.

3. The method of claim **2,** further characterized by:

D. preserving information about the orientation of the weapon barrel axis at the beginning of said first radiation emission; and

E. utilizing

  1. said preserved information and

  2. reflected return radiation from said second radiation emission to calculate the point of impact of said simulated round of ammunition in relation to the position of the target at the beginning of said second radiation emission.

* * * * *