Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2366526 C 2004/10/05

(11)(21) 2 366 526

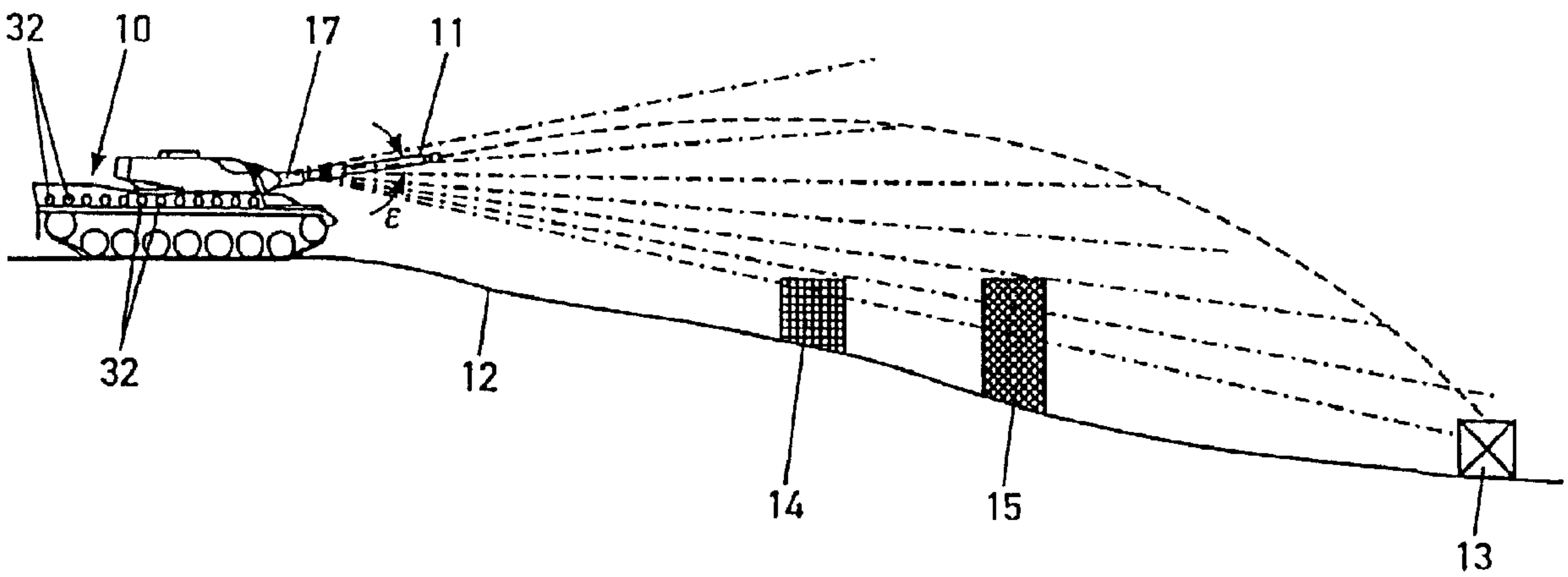
(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2000/02/26
(87) Date publication PCT/PCT Publication Date: 2000/09/28
(45) Date de délivrance/Issue Date: 2004/10/05
(85) Entrée phase nationale/National Entry: 2001/09/17
(86) N° demande PCT/PCT Application No.: EP 2000/001620
(87) N° publication PCT/PCT Publication No.: 2000/057123
(30) Priorité/Priority: 1999/03/18 (199 12 093.5) DE

(51) Cl.Int.^{7}/Int.Cl.^{7} F41G 3/26
(72) Inventeur/Inventor:
JUTTNER, HERMANN, DE
(73) Propriétaire/Owner:
STN ATLAS ELEKTRONIK GMBH, DE
(74) Agent: FETHERSTONHAUGH & CO.

(54) Titre : PROCEDE DE SIMULATION DE TIR
(54) Title: SHOOTING SIMULATION METHOD



(57) Abrégé/Abstract:
The invention relate to a shooting simulation method, comprising barrelled weapons which fire ballistic projectiles. When a shot is simulated, the barrelled weapon (11) illuminates the target (13) using an optical transmitter (20) and a virtual impact of the projectile is determined, in order to establish a hit on target. The inventive method aims to reduce the production costs of the shooting simulation system and to ensure sufficient accuracy for the use thereof on the combat training range. To this end, the transmitter light is tightly concentrated optically and is pivoted successively on one plane. Information relating to the current position and vertical alignment (elevation) of the barrelled weapon (11) and the type of weapon and projectile is modulated on the transmitter light. In the target (13) which is equipped with an optical receiver device, the virtual projectile impact and the distance between the target (13) and the barrelled weapon (11) are determined from the weapon information that has been transmitted to the target (13) and from the known target position and are compared with one another, in order to establish a hit on target. If the information matches, a hit is displayed.

(57) Abstract

The invention relates to a shooting simulation method, comprising barrelled weapons which fire ballistic projectiles. When a shot is simulated, the barrelled weapon (11) illuminates the target (13) using an optical transmitter (20) and a virtual impact of the projectile is determined, in order to establish a hit on target. The inventive method aims to reduce the production costs of the shooting simulation system and to ensure sufficient accuracy for the use thereof on the combat training range. To this end, the transmitter light is tightly concentrated optically and is pivoted successively on one plane. Information relating to the current position and vertical alignment (elevation) of the barrelled weapon (11) and the type of weapon and projectile is modulated on the transmitter light. In the target (13) which is equipped with an optical receiver device, the virtual projectile impact and the distance between the target (13) and the barrelled weapon (11) are determined from the weapon information that has been transmitted to the target (13) and from the known target position and are compared with one another, in order to establish a hit on target. If the information matches, a hit is displayed.

Shooting Simulation Method

The present invention relates to a method for simulating shooting with barrelled weapons that fire ballistic projectiles, of the type defined in the preamble to Claim 1.

A known method for simulating shots or shooting (DE 37 20 595 A1) is based on a so-called two-way simulation, in which the range to the target is first measured by using a sight that is aimed at the target, after which the target, which is fitted with a return reflector, is painted by a laser and the light that is returned from the return reflector is imaged on an electro optical locating device that is mounted on the barrel of the weapon. The location of the return reflector, which is determined from the image, is compared with the point of impact of the simulated shot, which is computed on the basis of the measured range, the weapon and the type of ammunition that is fired, and the elevation of the barrel, which forms the hypothetical trajectory with the line of sight. If the location of the return reflector coincides with the point of impact, a hit report is triggered from the barrelled weapon; it they do not coincide, an miss report is generated.

In the case of a similarly known shooting simulation method for ballistic munitions and moving targets (DE 31 14 000 A1), which is based on a two-way simulation method, before the simulated shot is fired, the target is constantly surveyed by laser measurement pulses that are transmitted from the weapon, and the range to the target and the target deviation from a reference line are determined; the data derived from these are then stored. When the shot is fired, the stored data are transmitted to the target by coded laser signals, and surveying of the target is terminated. After the shot has been fired, the movement of the target relative to the direction from which the laser pulses are received is measured during a simulated flight time for the projectile, and a hit indication is controlled by comparing the data transmitted from the barrelled weapon and the position of the target at the end of the projectile flight time.

The technical costs for such two-way simulation methods are very high, and they increase exponentially as the demand for ever-greater target ranges increases. Highly sensitive measurement electronics have to be used for surveying the target, and this makes the shooting simulator even more costly. The optical level of the laser light decreases by $1/r^4$ as the range r increases, so that the results of measurement become increasingly unreliable. It is not possible to increase the power output of the lasers, since the output classification of the lasers is prescribed and limited to amounts that will not damage the eyes of those taking part in the gunnery exercise.

It is the objective of the present invention to describe a shooting simulation method of the type described in the introduction hereto, which entails much lower production costs for the shot simulator that is used for this method, and at the same time ensures sufficient accuracy for use in a battle-training area..

This objective has been achieved by the features set out in Patent Claim 1.

The method according to the present invention entails the advantage that only a single optical transmission path from the weapon that is firing to the target is required, so that the simulator manages with lower laser output at a greater level of sensitivity. The checking that is done to determine whether or not the operator has aimed his weapon so that a target, which is located at an estimated range, has been hit or not, is done in the target, using the data from the weapon that has been laid on it; this is not a problem since weapon and target measure their positions constantly and the position of the weapon is transmitted to the target with the firing of the shot. The method makes it possible to handle the weapon realistically; the amount by which the weapon is tilted, the type of ammunition, the type of weapon, and the angles of elevation and traverse that have been set up when determining the hypothetical or virtual point of impact, all being taken into consideration.

Differences between the elevation of the target and of the weapon are corrected with the method according to the present invention. A hit indication from several targets that are all located on the same line of fire is avoided, since each target determines for itself whether or not the hypothetical or virtual point of impact coincides with its position or not, based on its range from the weapon that is firing.

The method according to the present invention can be used with barrelled weapons, such as tank guns, when applying the angle of elevation to the weapon is to be practised, and by barrelled weapons such as anti-tank rocket launchers, when estimating target lead is important. To this end, all that has to be done is that the direction of traverse of the transmitted light has to be shifted from the vertical to the horizontal plane, and matched to the maximal angle of traverse.

Functional embodiments of the method according to the present invention, with advantageous developments and configurations of the present invention, are set out in the secondary Claims.

According to one preferred embodiment of the present invention, the transmitted light is generated in the form of a series of laser pulses, and information about the weapon is modulated onto each laser pulse. Laser pulses entail the advantage that despite a high pulse level, they have a low energy density, so that–given the mandatory optical safety of the laser–they transmit sufficient power to the target to permit simulation of shooting. In addition, the laser pulses can be modulated with very little interference, so that information about the weapon can be transmitted to the target with a high level of reliability.

The present invention will be described in greater detail below on the basis of embodiments shown in the drawings appended hereto. These drawings show the following:

Figure 1, 2: in each instance, a battle tank armed with a barrelled weapon, in a training area, when a shot is fired at a target, as viewed from the side (Figure 1) and from above (Figure 2);

Figure 3: a block circuit diagram of the weapon-mounted components of a shooting simulator;

Figure 4: a block circuit diagram of the target-mounted components of the shooting simulator;

Figure 5: a perspective view of an antitank rocket launcher in the firing position, aimed at a target tank moving in a training area.

Figure 1 and Figure 2 show an exercise scenario in a battle-training area, as viewed from the side and from above, when a battle tank (10) that is armed with a barrelled weapon (tank gun) 11 is engaging one of several targets 13, 14, 15 that are located in the terrain 12. The target 13 that has been selected by the tank 10 is shown diagramatically, and can be an enemy tank, for example; the direction in which this target is moving is indicated by the arrow 16. The targets 14 and 15 are stationary, and can be buildings or natural obstacles.

A so-called shooting simulator is used to practice firing; this simulator system comprises a component 17 that is associated with the barrelled weapon 11 and a component 18 that is associated with the target 13. The weapon-mounted component 17 that is shown in the block circuit diagram at Figure 3 is installed in a housing 19 that is mounted on the barrel of the weapon 11, so that it follows the alignment of the tank gun 11 in azimuth and elevation, and tilts to the same degree as the tank hull, and thus the weapon 11, when the vehicle is moving cross country. An optical transmitter is installed within the housing 19 so that it can pivot in the vertical direction, and this transmitter emits a narrow beam of laser light as a series of laser pulses that are emitted as time pulses at a constant time interval. A pivoting movement of the optical transmitter 20 is effected by means of a stepper motor 21, which–like the optical transmitter–is controlled from a central control unit 22. On the input side, the central control unit 22 is connected to a tilt sensor 23 that measures the amount by which the hull of the battle tank 10 and thus the weapon 11 are tilted, to an inclination sensor 24 that measures the angle of elevation ϵ of the weapon 11 and the elevation of the weapon relative to the horizontal; it is also connected to an interface 25, through which information with respect to the type of ammunition, the type of weapon, the current position of the battle tank 10 in the terrain, and the firing of the simulated shot is passed to the central control unit 22. To this end, the interface 25 is connected through an input 27 to a satellite supported positioning system 26, for example, a GPS (global position system) (GPS) or DGPS (differential global position system); it receives appropriate additional information about type of weapon and type of ammunition, as well as a trigger pulse when the simulated shot is fired by the gunner, through additional inputs 28, 29, 30. Within the optical sender 20, there is also an optical modulator that is controlled from the central control unit 22 and this modulates the information about the type of weapon and type of ammunition received by way of the interface 25 , as well as the measured values from the tilt sensor 23 and the inclination sensor 26, onto each laser pulse transmitted from the optical sender 20.

The target-mounted component 18 of the shooting simulator, shown in the block circuit diagram at Figure 4, has an optical receiver 31 with a plurality of optical sensors 32, e.g., laser diodes;

these convert laser pulse hits into electrical signals. If, as assumed, the target 13 is also a battle tank, the light detectors or optical sensors 32 form a belt that encircles the hull of the tank, as shown in Figure 1 for the battle tank 10 that is shooting. All of the optical transmitters 32 are connected to a signal-processing unit 31 that incorporates a demodulator; it eliminates the weapon information (weapon position, type of weapon, type of projectile, elevation applied to the barrel of the weapon) from the laser pulses that are received, and passes it to a microprocessor 34. The micro-processor 34 also receives the current position of the target 13 from a satellite-supported positioning system (GPS or DGPS) that is installed on the target. On the basis of the information about the weapon and the position of the target, the microprocessor 34 determines a virtual hit by the projectile after it has travelled over a hypothetical projectile trajectory that results from the alignment of the weapon and the distance between the weapon 11 and the target 13. The microprocessor 34 compares the impact of the projectile and the range to the target and if they agree it triggers a hit indicator 36 that emits a visual, acoustic, or electromagnetic hit signal. In order to determine the virtual projectile impact, stored in the microprocessor there are, for example, a number of projectile trajectories with a parametrization of the elevation of the weapon (angle of elevation ϵ), as well as the type of weapon and the type of projectile. The appropriate trajectory is sought out with the received and demodulated information about the weapon, and the virtual projectile impact is read out.

Using such a shot simulator, the simulation of shots from barrelled weapons that fire ballistic projectiles is effected as follows:

The gunner aims the weapon 11 at the target 13, using a conventional sight that is mounted on the weapon 11, and elevates the barrel of the weapon by a specific amount (angle of elevation ϵ) on the basis of the range to the target that he has estimated. If the target 13 is a moving target, the gunner will also have to apply a certain amount of target lead (as is shown in Figure 2), and set the weapon 11 at an azimuth angle ϕ relative to the direct line of sight to the target 13.

When the shot is fired by the gunner, a trigger pulse is sent to the interface 25 by way of input 30, and this causes the control unit 22 to activate the optical transmitter 20. The optical transmitter emits a series of laser pulses, and these are pivoted successively downwards in the vertical plane. The first laser pulses are transmitted in a direction that is parallel to the axis of the barrel. Information regarding the current position and alignment of the weapon–in the present case relative to the angle of elevation ϵ provided by the inclination sensor 24 and the angle of tilt from the tilt sensor 23, as well as about the type of weapon and the type of projectile–is modulated onto each laser pulse. At some point in time during the vertical movement of the laser transmitter 20, at least one laser pulse will strike one of the light detectors or optical sensors 32 on the target 13. This laser pulse is received by the optical receiver 31 and processed in the units described heretofore. In the target 13, the virtual impact of the shot is now determined from the information about the weapon (angle of elevation ϵ, angle of tilt, type of weapon, ammunition) that was transmitted with the laser pulse; the range from the target 13 to the weapon 11 is also determined from the position of the weapon 11 and the known target position that has been transmitted by the laser pulse. If the fall of the shot and the range to the target agree, a hit is indicated.

In the scenario shown in Figures 1 and 2, were a simulated shot to be fired , the target 14 would also be hit by laser pulses at some time or another. If it is a training target, the target 14 is also fitted with the target-mounted component 18 of the shooting simulator, as is shown in Figure 2. At the target 14, the same computations are completed as they were for target 13. In this case, however, the range from the target 14 to the weapon 11 is significantly shorter than the range of the virtual shot impact from the weapon 11, so that no hit indication is given.

In order to reduce the number of optical sensors 32 that have to be installed at the receiving end, the laser light from the optical transmitter 20 can be spread horizontally, so that the optical sensors 32 mounted on the target 13 can be arranged at a greater distance from each other. In order to ensure identical sensitivity for all of the optical sensors 32, however, the power of the laser would have to be increased in order to paint the area at the target 13, which is now greater, at the same energy density.

Under certain circumstances, reception of signals from satellites can be made difficult or even impossible in a large training area because of the structure of the terrain or because of buildings or vegetation, so that the position of the weapon and/or the target is not available as information that can be evaluated when determining whether or not a hit has been made. For such cases, information about the time of transmission of each laser pulse is modulated onto the laser pulses that are transmitted from the optical transmitter 20. The information that indicates the time of transmission is the time between the simulated shot being fired and the transmission of the particular laser pulse. This information is acquired from a counter that is integrated into the central control unit 22, started when the shot is fired, and run at a constant cyclic frequency. Now the distance between the target and the weapon 11 can be determined in the target 13 from the information about its time of transmission and the weapon information that was transmitted with the received laser pulse. The positions of hits can thus be determined even if GPS reception has been made difficult or impossible, and the gunnery exercise can be continued. In the event of satisfactory GPS reception, specific target range can be monitored on the basis of the known positions of the target 13 and the weapon 11.

Figure 5 shows an exercise scenario when firing an antitank rocket launcher at a moving tank target 38 is to be practised. The antitank rocket launcher represents the barrelled weapon 11, and the target tank 38 represents the target 13, which is moving in the direction indicated by the arrow 16 in Figure 5. In this exercise, what is important is the correct application of target lead to the weapon 11, i.e., a suitable angle of traverse ϕ so that, once the antitank rocket launcher 37 has been fired, the moving target 13 (the target tank 38) will be hit at the correct time; the armour-defeating ammunition that is fired by the antitank rocket launcher 37 requires a specific flight time to cover the distance to the target 13 and during this time the target will have advanced from the position it occupied at the time the shot was fired by a distance that corresponds to its speed.

The method used to simulate shooting, described heretofore, has been modified in that the transmitted light that is tightly concentrated optically, i.e., the series of laser pulses, is now traversed in a horizontal plane (in azimuth) at a constant speed, and in addition, in each traversed position, information about the current angle of traverse ϕ_i relative to the axis 39 of the weapon 11 is modulated onto every laser pulse. When this is done, the laser pulses are transmitted at a constant cyclic rate (transmission frequency). In addition to the information about the weapon, described heretofore, information regarding the current azimuth angle of traverse ϕ_i relative to the axis 39 of the barrelled weapon is modulated onto every laser pulse in every traversed position of the optical transmitter 20. The angles of traverse ϕ_1 to ϕ_4 are shown diagrammatically in Figure 5. The transmitter 20 is once again integrated into the weapon-mounted component 17 of the shooting simulator, and is mounted rigidly on the barrelled weapon 11, in this instance on the sight of the antitank rocket launcher 37, so as to form one structural unit. Since the optical axis of the transmitter 20 is somewhat offset vertically relative to the axis 39 of the weapon because it is attached to the weapon-mounted component 17, the reference line 39' for the angle of traverse lead is offset by the same amount above the axis 39 of the weapon 39. Thus, the reference line 39' for the angle of traverse lead always runs through the centre of the barrel, parallel to the axis 39 of the weapon. The traversing range of the optical transmitter 20 is restricted to an identical azimuth range to the right and to the left of the centre line of the weapon, which is to say the axis 39 of the gun, which is at least as great as the lead angle ϕ that is required to engage a target 13 that is moving transversely to the axis 39 of the gun and takes into account the flight time of the projectile that is fired from the weapon11 at the moving target 13. The traversing movement of the optical transmitter 20 is always made from one of the limiting edges of the range of traverse when the simulated shot is fired; in the example shown in Figure 5, this is from the left-hand, outermost limiting edge of the range of traverse.

The moving target 13 that is formed by the target tank 38 that is moving in the direction indicated by the arrow 16 is fitted with the identical target-mounted component 18 of the shooting simulator as is shown in the block circuit diagram at Figure 4; the number of optical sensors 32 of the optical receiver 31 is limited to two to three per long side of the target 13, and the optical sensors 32 are arranged in the turret area of the target tank 38. In order to ensure that the light pulses are received dependably by the optical sensors 32, the laser pulses can be spread vertically, so that with every laser pulse the target tank 38 is painted to its maximal height , as far as the upper edge of the turret. Now, the same evaluation of the information transmitted in the laser pulses is carried out in the target-mounted component, as has been described heretofore, with the sole difference that the range to target previously used for establish a hit is now corrected by using the information regarding the angle of traverse and the known movement of the target 13. When this is done, this correction in carried out in such a manner that the range to target is computed for a target position that the target 13 moving at target speed will be in after covering a path that results for the angle of traverse information and the current range to target, within the flight time of the projectile, which is in its turn calculated on the basis of the weapon information. This angle of traverse information corresponds to the lead ϕ set up for the weapon in azimuth, and given the correct adjustment of the lead ϕ, the projectile impact calculated from the weapon information will correspond to the corrected target range, and a hit will be indicated.

If, as described heretofore, additional information regarding the time they were transmitted is modulated onto the laser pulses emitted from the optical transmitter 20, in the case of the shot simulator shown in Figure 5 it will be possible to dispense with the transmission of additional angle information ϕ_1 about the direction of transmission to the target 13, since angle information regarding the direction of transmission can be derived from the time of transmission of the laser pulses.

Patent Claims

1. Method for simulating shooting, with barrelled weapons that shoot ballistic projectiles, in which, when a simulated shot is fired, a target (13) is painted from the weapon (11) by an optical transmitter (20) that emits a narrowly concentrated transmitted light, by successively pivoting the transmitted light in a plane; in which information that is specific to the weapon is modulated onto the transmitted light; and in which, within the target that is equipped with an optical receiver (31), a virtual fall of shot is determined on the basis of information that is specific to the target and the weapon, and a hit is established, characterized in that the information specific to the weapon specifies the current position and vertical alignment, the so-called elevation, of the weapon (11), as well as the type of weapon and the type of ammunition; in that within the target (13), on the one hand, the position of the target is determined as target-specific information, and, on the other hand, distance between the target (13) and the weapon is computed from the positions of the target (13) and the weapon (11); and in that a hit is identified by comparing the distances between the target (13) and the gun (11) on the one hand, and between the virtual fall of shot and the weapon (11) on the other.

2. Method as defined in Claim 1, characterized in that the amount by which the weapon (11) is tilted relative to a vertical and/or horizontal reference line is measured, and the measured value so obtained is modulated onto the transmitted light; and in that the

information relative to the tilt of the gun is used in the target (13) when determining the virtual fall of shot.

3. Method as defined in Claim 1 or Claim 2, characterized in that trajectories of projectiles with a parametrization of the elevation (ϵ) as well as the type of weapon and type of projectile are stored within the target (13); and in that the relevant trajectory is retrieved with the weapon-specific information that has been received and demodulated, and the virtual fall of shot is read out.

4. Method as defined in one of the Claims 1 to 3, characterized in that the transmitted light is pivoted downward in a vertical plane from a direction that is parallel to the weapon (11).

5. Method as defined in Claim 4, characterized in that the optical receiver (31) of the target (13), which is preferably mobile, is provided with a horizontally encircling belt made up of a plurality of light detectors (32) that are spaced apart, said belt being secured to the target (13).

6. Method as defined in Claim 4 or Claim 5, characterized in that the transmitted light is optically spread in a horizontal direction.

7. Method as defined in one of the Claims 1 to 3, characterized in that the transmitted light is pivoted in a horizontal plane at a constant speed, and in every pivoted position information relative to the current angle of traverse as it applies to the gun (11) is modulated onto the transmitted light; and in that the range to target used previously when determining a hit in the target is corrected using the angle of traverse information and the known movement of the target (13) itself.

8. Method as defined in Claim 7, characterized in that the correction is made in such a way that the range to target is calculated for a target position in which the target (13) moving at target speed will occupy after covering a distance–that is derived from the angle of traverse information and the current range to target–during the flight time that is calculated on the basis of information about the weapon.

9. Method as defined in Claim 7 or Claim 8, characterized in that the traverse range of the transmitted light is restricted to an equal azimuth angle to the right and to the left of the centre of the weapon, which corresponds to at least a maximal lead angle (ϵ) applied to the weapon (11) in azimuth, which takes into account the maximal flight time of the projectile that was fired, when engaging a target that is moving at maximal speed transversely to the direction of fire; and in that, when the simulated shot is fired, the pivoting of the transmitter direction is effected from one of the limiting edges of the range of traverse.

10. Method as defined in one of the Claims 1 to 9, characterized in that the transmitted light is generated as a series of laser pulses and the weapon-specific information is modulated onto each laser pulse.

11. Method as defined in Claim 10, characterized in that the laser pulses are emitted at a constant cyclic rate.

12. Method as defined in one of the Claims 7 to 11, characterized in that information about its time of transmission is modulated onto each laser pulse; and in that the angle of traverse information can be derived in the target (13) from the information about the time of transmission, while dispensing with the transmission of the angle of traverse information.

13. Method as defined in Claim 12, characterized in that the time between the firing of the simulated shot and the transmission of the particular laser pulses is used as information about the time of transmission.

14. Method as defined in Claim 13, characterized in that the information about the time of transmission is taken from the output of a counter that is run at a constant frequency.

15. Method as defined in one of the Claims 1 to 14, characterized in that the positions of the weapon (11) and the target (13) are in each instance registered by means of a satellite-supported positioning system, e.g., GPS or DGPS, that is mounted on these.

Fetherstonhaugh & Co.
Ottawa, Canada
Patent Agents

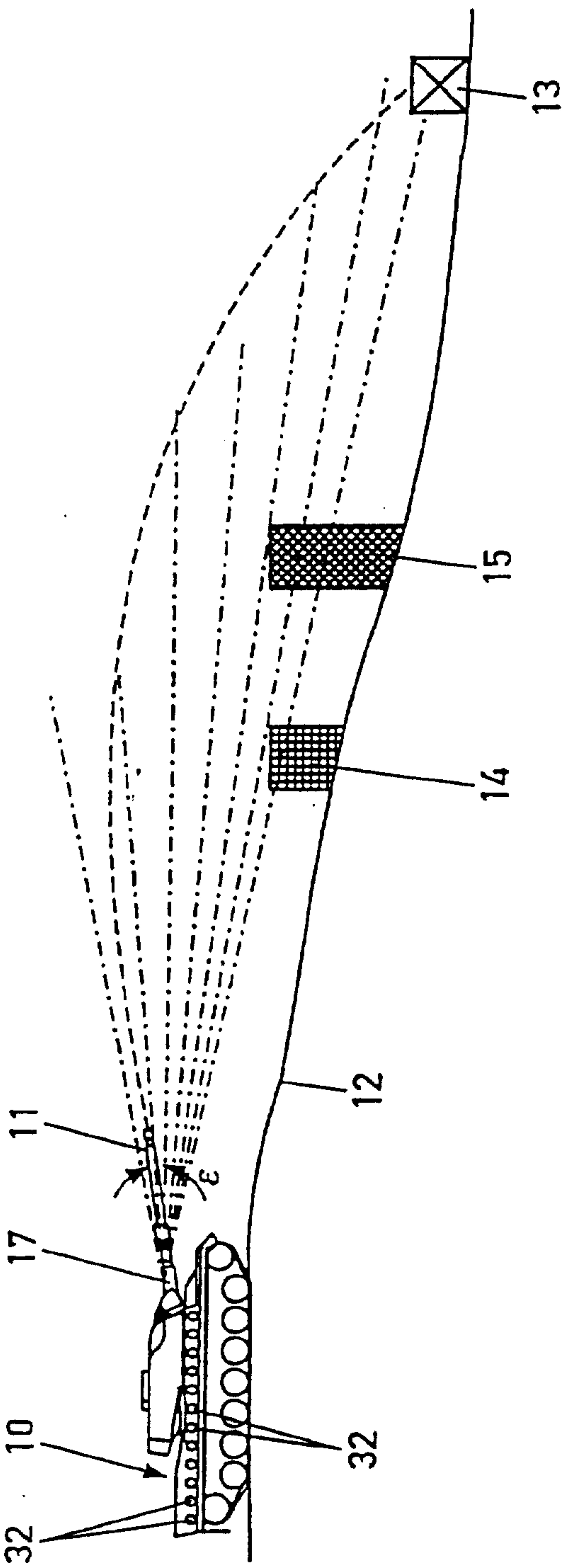


Fig. 1

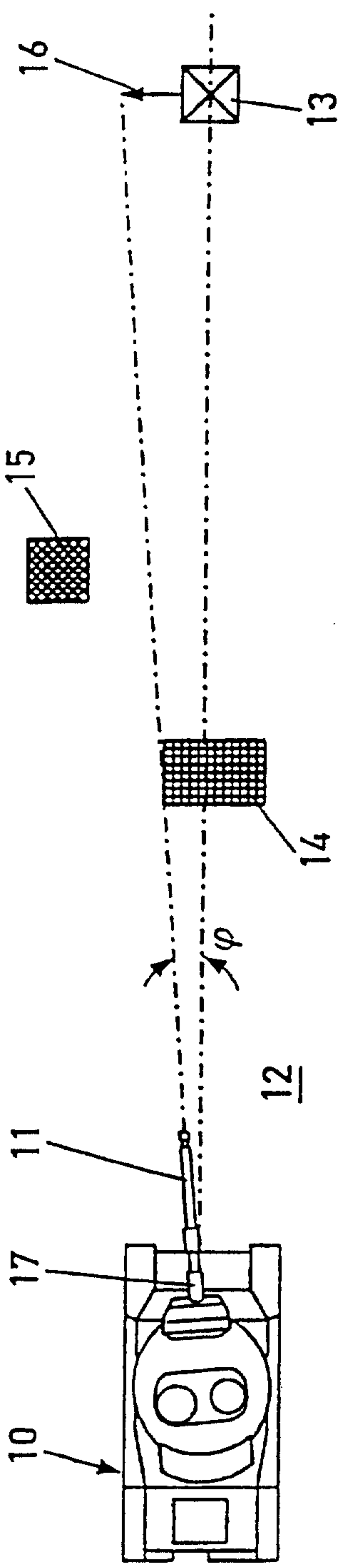


Fig. 2

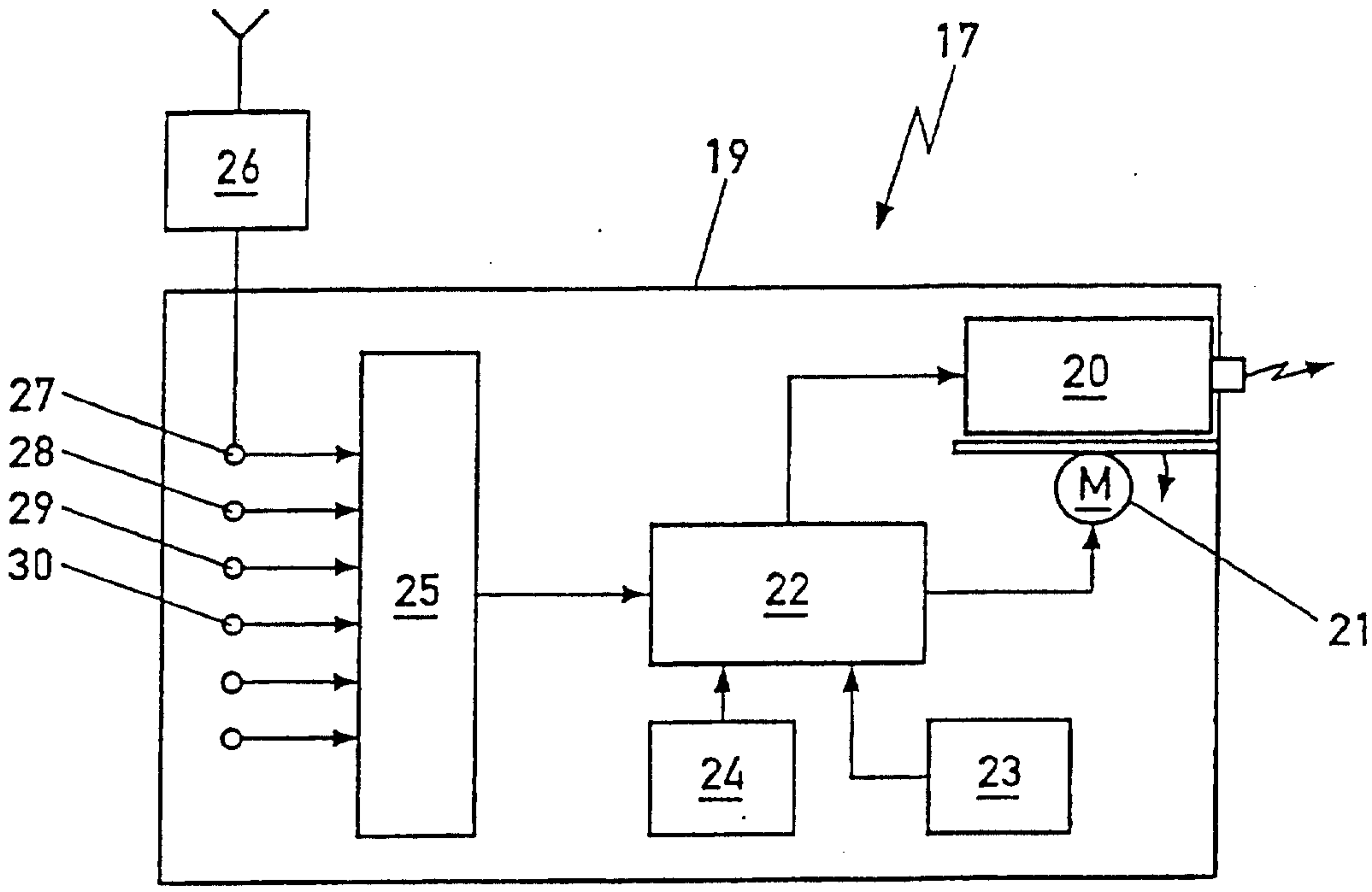


Fig. 3

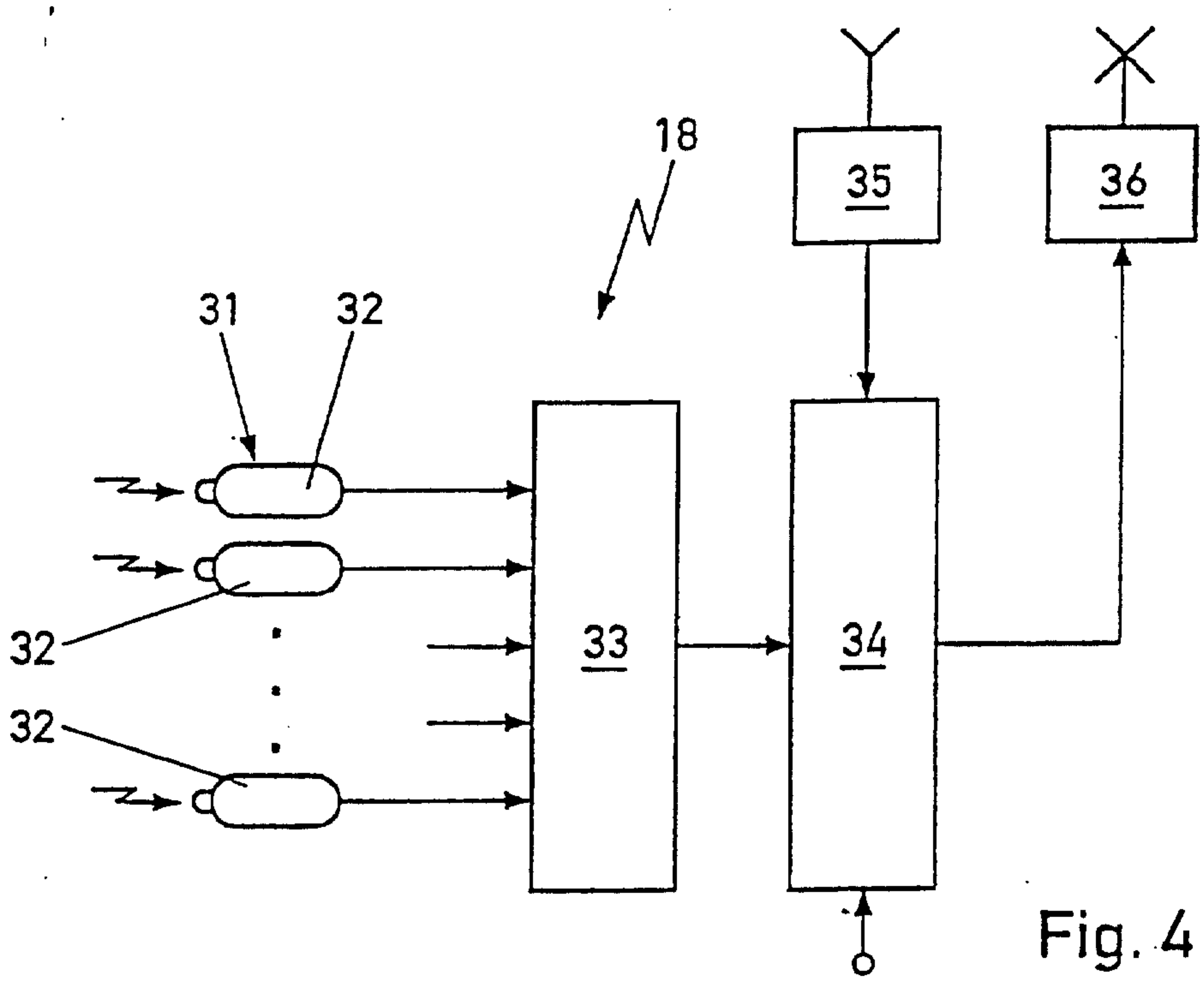


Fig. 4

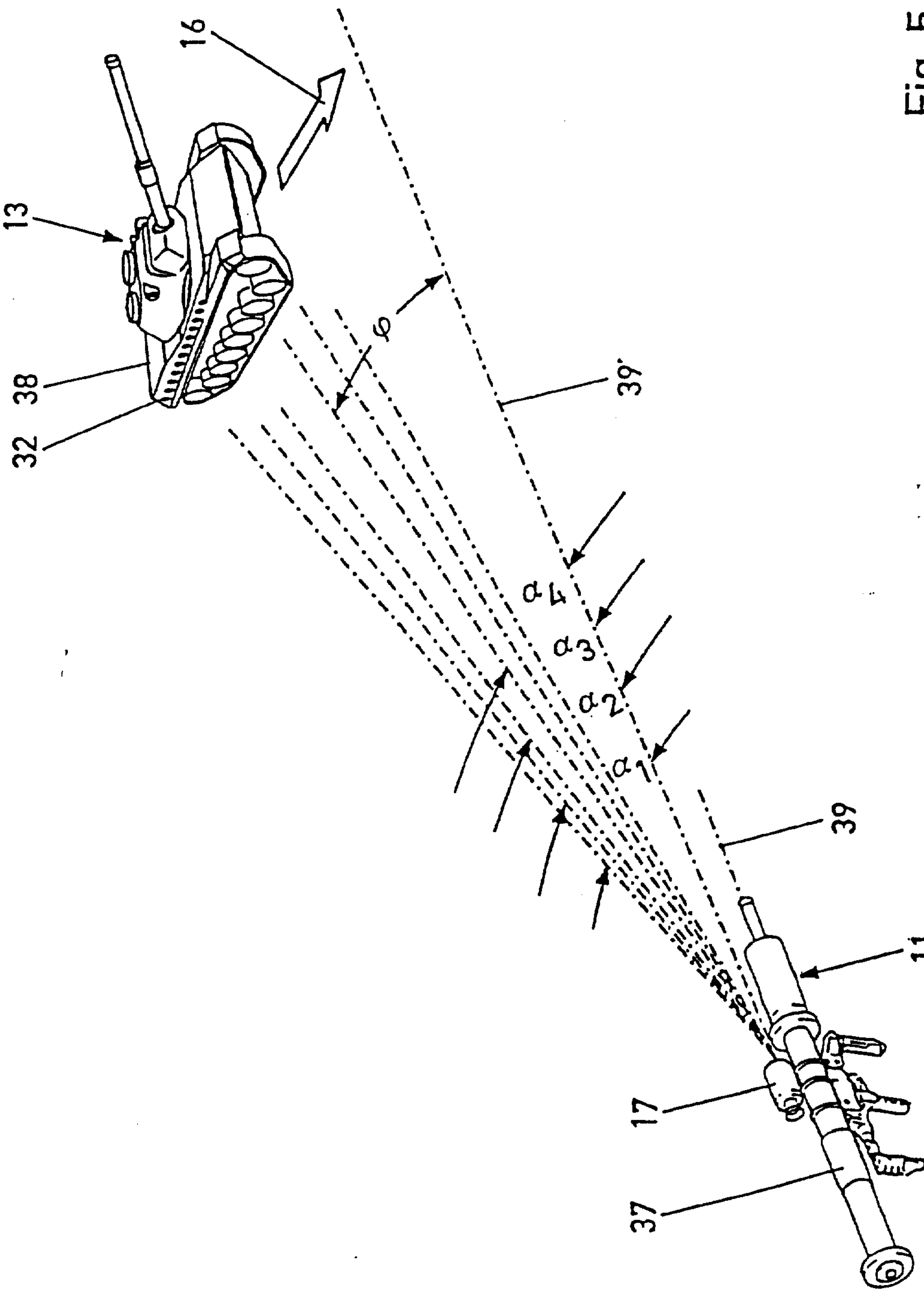
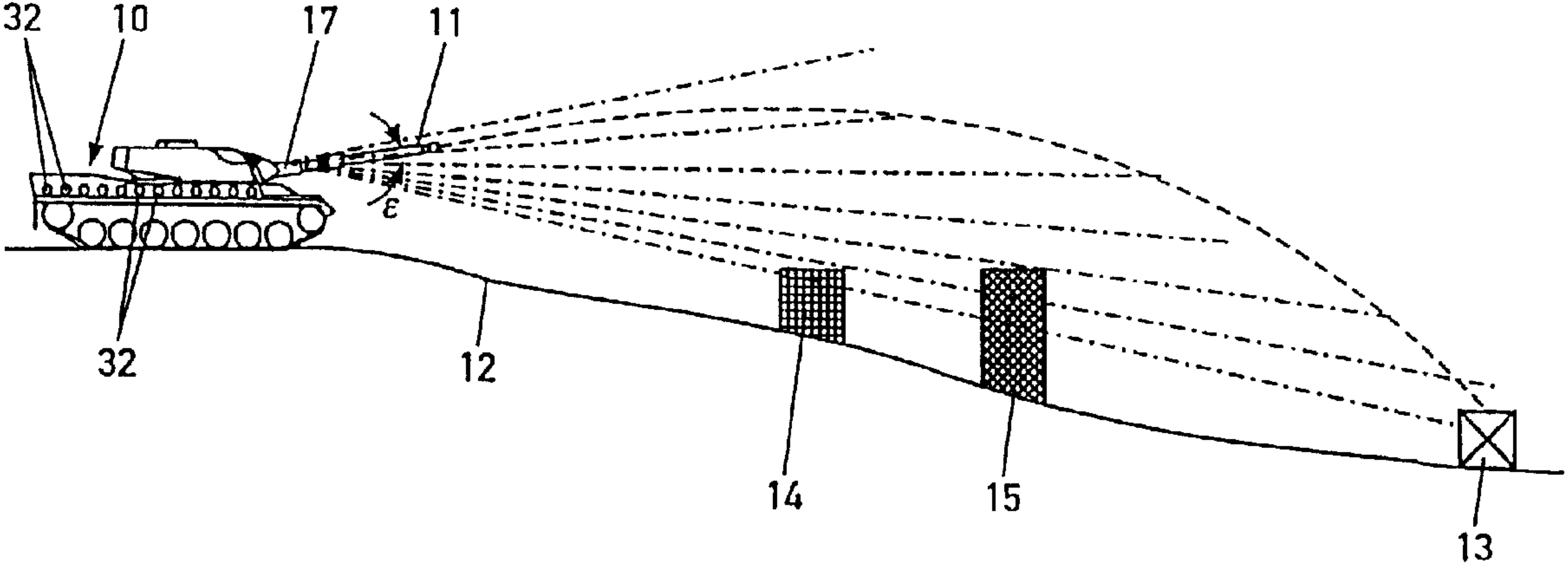


Fig. 5



32
10
17
11
ε
32
12
14
15
13