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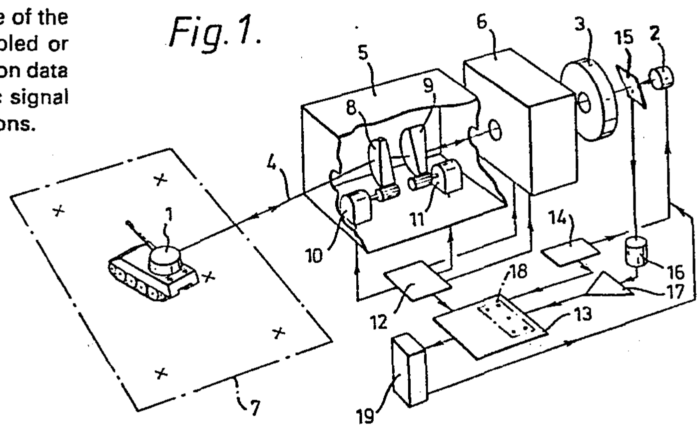
(54) **Area weapon simulation.**

(57) An area weapon simulation for simulating minefields, gun-batteries and the like in training exercises comprises means for scanning a narrow beam over a target field, means for detecting incidence of the beam on targets within the target field (which field is typically 300m by 1500m) and hit indicating means responsive to detected incidence of the beam on a target. The hit indicating means is enabled or disabled either in response to stored lethal area position data relating to the weapons or in response to a periodic signal representative of the stopping power of the weapons.

Fig. 1.



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Area Weapon Simulation.

The present invention relates to the simulation of "area" weapon systems, that is to say groups of co-operating weapons such as gun batteries or mine fields, which have effect over wide areas.

Optical weapon simulators are known in which a low-power laser projector is mounted on a gun barrel and aimed at a target, the target being provided with a suitable reflector. The laser projector is provided with a sensitive detector and beam splitter which enable laser light reflected from the target to be detected when the aim is correct and the target has been "hit" by a laser beam from the projector. This information is generally communicated to the target equipment by coded laser pulses.

Such weapon simulators are useful for simulating combat between armoured vehicles but can only simulate the effect of the gun on which they are mounted. Furthermore they scan over a very limited area and are not capable of simultaneously locating more than one target within the scanned area. According to the present invention, an area weapon simulator arrangement comprises beam-forming means for generating a narrow, sharply defined beam of radiation, controlled scanning means for scanning said beam, detector means arranged to detect incidence of said beam on a target, and hit indication means responsive to said detector means and arranged to indicate a "hit" when said beam is incident upon a said target, characterised in that said scanning means is arranged to scan said beam at least over an angle corresponding to the typical lethal regions of a group of two or more actual or hypothetical co-operating weapons and in that further means are provided for storing and/or entering data relating to the distribution of simulated lethal regions within the region scanned by said beam, said further means being arranged to enable or disable a "hit" indication according to said data.

The scanning means may incorporate a pulse coder for communicating "hit" signals to equipment on the relevant targets.

The scanning means may comprise a pair of superimposed rotating prisms. Preferably the scanning means is arranged to scan said beam in a two dimensional manner. However in any case the arrangement preferably includes range-finding means incorporated in or otherwise arranged to cooperate with the scanning means so as to accurately determine the two-dimensional position of the or each target.

The prisms may be rotated by controlled stepping motors which output digital position data.

The detector means is preferably arranged to detect retro-reflaction of the beam from the target but may alternatively be located on the target.

Preferably said further means comprises control means arranged to periodically enable and disable said "hit" indication in a predetermined time ratio, thereby simulating a uniform average distribution of said simulated lethal regions.

The memory means may be arranged to store the coordinates of mines in a simulated minefield within the scanned area and the hit indicating means will then indicate a "hit" when a target (typically a tank or other vehicle) crosses any point corresponding to the stored coordinates.

The memory means may be arranged to store fall-of-shot data of a plurality of ballistic weapons (for example the guns of a gun battery). In such a case the scanner is preferably provided with a sight for manual aiming so that target ranges may be determined by an artillery spotter. The spotter may then choose one of several stored fire pattern types and feed it into the memory before activating the scanner. The resulting "hits" indicated by the scanner will indicate to the spotter the accuracy of his spotting and calculation and the effectiveness of his chosen fire pattern.

The fall-of-shot data may be stored as point coordinates and the hit-indicating means may incorporate processing means for calculating the distance of the or each target from the nearest point represented by said point coordinates and generating a hit indication in accordance with said distance. In such a case, the scanner may include randomising means for determining whether or not a hit indication shall be given, in accordance with a probability function of said distance. The randomising means may suitably comprise an electronic random number generator linked to the hit-indicating means.

The processing means may calculate the distances of the or each target from a plurality of said points within a predetermined area and calculate the hit probability as a function of said distances.

The fall-of-shot data may be stored as areas within which there is a predetermined minimum hit probability, randomising means being provided for generating the appropriate probability of a hit indication. The fall-of-shot data may be stored as a plurality of hit-probability contours, appropriate weighting factors being provided in the randomising means to generate the appropriate probability of a hit indication.

The hit probability distribution of the area weapons may be simulated by providing an array of closely spaced independent detector elements which detect off-axis targets and the outputs of which are sampled with the appropriate time weighting to simulate the required probability distribution.

The hit probability distribution may be simulated by providing optical means for randomly or periodically diverting the retro-reflected target radiation from the detector.

According to another aspect of the invention, a method of simulating a plurality of ballistic weapons comprises the steps of manually scanning a target area for targets with a scanner remote from any such weapons to determine the target positions, determining an appropriate fire pattern for said target positions, determining the randomised fall of shot of such weapons corresponding to said fire pattern and electro-mechanically scanning said target area to determine the true target positions and thereby the probable number of "hits" against said targets.

The method is useful for the training of a forward observation officer (F.O.O.) who in actual warfare will be typically several miles in front of the ballistic weapons and will determine the target positions with a aser range-finder and radio these positions back to the ballistic weapons (typically a gun battery).

The method of the invention does not require the participation of an actual gun battery or other set of ballistic weapons since the randomised fall-of-shot may be determined by calculation with the aid of an appropriately weighted randomising function and a random number generator. However, in some cases it may be appropriate to involve actual ballistic weapons firing blank ammunition, in which case simulated fall-of-shot displayed by the equipment may be communicated back to the weapon personnel. The scanner used may suitably be in accordance with the other aspect of the invention.

Three embodiments of the invention will now be described by way of example with reference to Figures 1 to 3 of the accompanying drawings, of which:

Figure 1 is a diagrammatic illustration of a scanner arrangement in accordance with the invention for use in the simulation of minefield,

Figure 2 is a diagrammatic illustration of a similar scanner arrangement and method in accordance with the invention for use in the simulation of a gun battery, and

Figure 3 is a diagrammatic illustration of a simplified version of the scanner shown in Figure 1.

Figure 1 shows a tank 1 and a scanner comprising an I.R. laser diode 2 and collimator 3 (which constitute beam forming means and generate a narrow low-intensity beam 4 of I.R. radiation) and azimuth and elevation dual-prism scanners 5 and 6 respectively (which constitute controlled scanning means and scan beam 4 over area 7). Tank 1 is provided with an I.R. reflector (not shown) which reflects beam 4 back to the scanner. The scanning range corresponds to an angle of scan of approximately ± 10 degrees in azimuth and ± 10 degrees in elevation. Dual-prism scanner 5 is shown partially cut away to show two wedge prisms 8 and 9 which are mounted on a common axis for rotation by step-motors 10 and 11 respectively. Prisms 8 and 9 contra-rotate so as to linearly scan beam 4 in azimuth, in the well-known manner described for example on pages 10 to 12 of The Infrared Handbook by W.L. Wolfe and G.T. Zissis (Enviromental Res. Inst. Michigan). Step-motors 10 and 11 rotate the prisms in steps of 0.1125° and are controlled by control board 12, which also controls similar step-motors (not shown) in elevation scanner 6. The instantaneous position of beam 4 is calculated on control board 12 and fed to a correlator board 13. Laser diode 2 is pulsed by clock control 14 and pulses of retro-reflected radiation from tank 1 are diverted by beam splitter 15 to detector 16, which feeds an amplifier 17. Amplifier 17 incorporates a comparator (not shown) to block out input noise. A clock output from control 14 to correlator board 13 enables the latter to calculate the range of the tank 1 and hense monitor its exact position within area 7. Correlator 13 incorporates a programmable memory 18 which stores a set of positions within target area 7 at which mines are deemed to be laid. Correlator board 13 sends a signal to a pulse code generator 19 immediately the tank 1 or any other target provided with a suitable reflector strays onto one of the stored positions (which are shown as crosses in memory 18 and area 7). The code generator 19 causes the scanner to send coded laser pulses to the tank, which pulses cause the tank to emit smoke or give some other indication that it has been "disabled" by a mine.

Figure 2 shows a scanner similar to that shown in Figure 1 except that it is provided with sights 20 to enable it to be used manually as a low powered laser range-finder and a display 21 which displays fall-of-shot, including "hits" corresponding to the superposition of a fire pattern F stored in memory 18 with the instantaneous position of a target T as determined by the scanner. The scanner is made man-portable and is operated by a forward observation officer (F.O.O.) 22 in a typical spotting area in front of a range of hills between a gun battery B and an array of targets T. The gun battery B need not have a real existence - all that is necessary is that data on a realistic fire pattern liable to be produced by such a battery should be available to the F.O.O. or stored in memory 18.

The arrangement is used as follows:

1) The F.O.O. switches the dual-prism scanners 5 and 6 so that beam 4 remains parallel to sights 20, and determines target range. The range, azimuth and elevation of each target are fed into correlator board 13.

2) The F.O.O. selects one of five fire patterns, namely:

a) GUNS PARALLEL - all guns in the battery fire parallel - the fire pattern reproduces the guns' positions.

b) Converge - all guns laid to converge on one point.

c) Line - guns laid to fire along the line say a road.

d) Lozenge - fire pattern when firing for target range determination.

e) Spare.

Correlator 13 calculates the exact shape and position of the fire pattern, utilising an appropriate probability algorithm and random number facility and stores this pattern in memory 13.

3) The F.O.O. then activates scanners 5 and 6 which under the control of board 12 scan for targets T and feed the accurate positions of the targets into correlator board 13, after allowing an appropriate time to allow for the time of flight of the shells.

4) Correlator 13 correlates these positions with fire pattern F and generates the appropriate pattern of "hits" on display 21. This enables the F.O.O. to see which targets have been "hit" and to adjust the fire pattern accordingly and then repeat steps 3) and 4).

The "hits" information displayed on display 21 and stored in memory 13 is transmitted to the targets T in the form of coded laser pulses generated by coder 19 and transmitted by the projector. Detection equipment (not shown) on the targets then causes them to emit smoke and display flashing lights when "hit".

Figure 3 shows a simplified version of the minefield simulator arrangement of Figure 1, which may be preferable in some circumstances. As in Figure 1, the scanned area or target field 7 represents a simulated minefield, and is typically of dimensions 300m by 1500m. Targets such as tank 1 advance in direction D across the simulated minefield. A similar real minefield would on average disable a certain percentage of tanks or other targets crossing it in direction D at some stage before they reached its far side. This parameter, known as the percentage stopping power, is utilised in the apparatus of Figure 3 to characterise minefield 7, and there is thus no need to store the individual positions of simulated mines. Accordingly control board 12 of Figure 1 (which compared the target position with stored mine positions) is dispensed with in Figure 3 and beam 4 is scanned continuously by scanners 5 and 6, which may incorporate motors 23, 24 of any suitable type. A control computer 26 is programmed with an appropriate percentage stopping power via an input 27 and an internal signal generator 28 sends a periodic two state switching signal to code generator 19. Control computer 26 causes code generator 19 either to send, or to fail to send, a "hit" signal to tank 1 via laser diode 2, according to the instantaneous state of the switching signal generated by signal generator 28. Thus the mark-to-space ratio R of the switching signal corresponds to the probability that an instantaneously detected target will be deemed to be "hit".

The overall time ratio R of enabling to disabling a "hit" indication, the number of times N that an average target is struck by beam 4 before it crosses minefield 7 and the percentage stopping power S_D are simply related by the formula:

$$1 - \frac{S_D}{100\%} = (1-R)^N$$

Thus if the scanning rate of the beam 4 is know (so that N is known) the required value of R can be found for any required stopping power. Accordingly scanners 5, 6 are powered by constant speed motors 23 and 24 of any suitable type. It will be appreciated that the control 26 could be used to periodically enable and disable the detector 16 by blocking its light path, or to periodically enable and disable the amplifier 17, to achieve a similar result. Furthermore it is not absolutely necessary that control 28 should generate a regular periodic "blocking" signal with a controllable mark: space ratio - alternatively it could generate a random two-state signal with a probability distribution determined by the value of percentage stopping power employed, as will be apparent to those skilled in the art. All that is necessary is that the <u>overall</u> ratio of enabled time to disabled time should be controllable.

Claims.

1. An area weapon simulator arrangement, comprising beam-forming means(2,3)for generating a narrow, sharply defined beam(4)of radiation, controlled scanning means(5,6) for scanning said beam(4),detector means(16)arranged to detect incidence of said beam(4)on a target(1),and hit indication means(19,21)responsive to said detector means and arranged to indicate a "hit" when said beam is incident upon a said target, characterised in that said scanning means(5,6)is arranged to scan said beam(4)at least over an angle corresponding to the typical lethal regions of a group of two or more actual or hypothetical co-operating weapons(B) and in that further means(18)are provided for storing and/or entering data relating to the distribution of simulated lethal regions within the region scanned by said beam,said further means(18)being arranged to enable or disable a "hit"indication according to said data.

2. An arrangement according to Claim 1 wherein said further means(18)comprises control means arranged to periodically enable and disable said "hit" indication in a predetermined time ratio, thereby simulating a uniform average distribution of said simulated lethal regions.

3. An arrangement according to Claim 2 wherein said detector means(16)is periodically enabled and disabled in said time ratio by said control means.

4. An arrangement according to Claim 1, wherein said further means comprises memory means(18)for storing data representative of said simulated lethal regions, and correlating means(12,13,14)arranged to correlate the instantaneous orientation of said beam(4)with the output of said detector means(16)and thereby to generate target position data, said further means(12,13,14,18)being arranged to instantaneously compare said target position with said lethal regions and to enable or disable the generation of said "hit" indication accordingly,thereby simulating a discrete distribution of said simulated lethal regions.

5. An arrangement according to any preceding Claim further comprising means for communicating said "hit" signals to equipment on the or each relevant target.

6. An arrangement according to any preceding Claim wherein said scanning means(5,6)is arranged to scan said beam(4) over an angle of at least five degrees.

7. An arrangement according to Claim 3 wherein said scanning means(5,6)is arranged to scan said beam over an angle of ten degrees or more.

8. An arrangement according to any preceding Claim wherein said detector means(16)is arranged to detect retro-reflection of said beam(4)from said target(1).

9. An arrangement according to any preceding Claim wherein said scanning means(5,6)is arranged to scan said beam(4)two-dimensionally.

10. An arrangement according to Claim 8 wherein said scanning means(5,6)comprises first and second pairs of superimposed contro-rotating prisms(8,9)said prisms being rotated by controlled stepping motors(10,11),said stepping motors being arranged to generate digital position data.

11. An arrangement as claimed in any preceding Claim further comprising range-finding means(14)arranged to cooperate with said correlating means(12,13,14)to determine the two-dimensional position of said target(1)in relation to lethal areas of said weapons.

12. An arrangement according to any preceding Claim wherein randomising means are provided to control said hit indicating means(19).

13. An arrangement according to any preceding Claim wherein memory means(18)is arranged to store the coordinates of mines within a scanned area(7)corresponding to a simulated minefield,the hit indicating means(19)being arranged to indicate a "hit" whenever a target crosses any point (X) in said scanned area(7)corresponding to the stored coordinates.

14. An arrangement according to any of Claims 1 to 9 wherein said memory means(18)is arranged to store fall-of-shot data of a plurality of ballistic weapons (B).

15. An arrangement according to Claim 4 or Claim 13 wherein sighting means(20)are provided to enable the range and/or position of a target to be determined manually.

16. An arrangement according to Claim 14 or Claim 15 as dependent on Claim 4 wherein said fall-of-shot data is stored as point coordinates and said hit-indicating means(19) is provided with processing means for calculating the distance of the or each target from the nearest point represented by said point coordinates and generating a hit indication in accordance with said distance.

17. An arrangement according to Claim 14 or Claim 15 as dependent on Claim 4 wherein said fall-of-shot data is stored as areas within which there is a predetermined minimum hit probability.

18. A method of simulating a plurality of ballistic weapons (B) comprising the steps of manually scanning a target area(7)for one or more targets (T) with a scanner(5) remote from any such weapons to determine the or each target position, determining an appropriate fire pattern for the or each said target position, determining the randomised fall-of-shot of such weapons (B) corresponding to said fire pattern and electro-mechanically scanning said target area to determine the true number of "hits" against the or each said target.

19. An arrangement as claimed in Claim 2 or Claim 3 wherein said control means(26)includes means for generating a random variable and means for periodically enabling or disabling said hit indication according to the instantaneous value of said random variable.

Fig. 1.

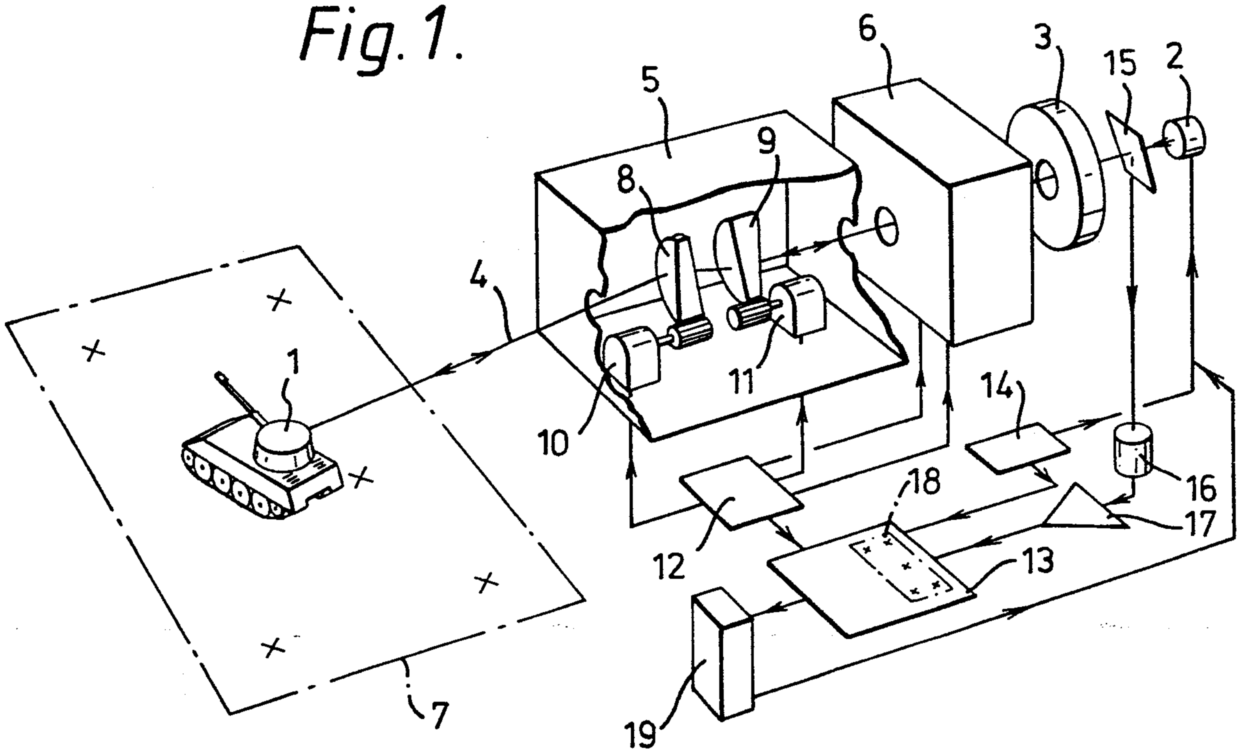
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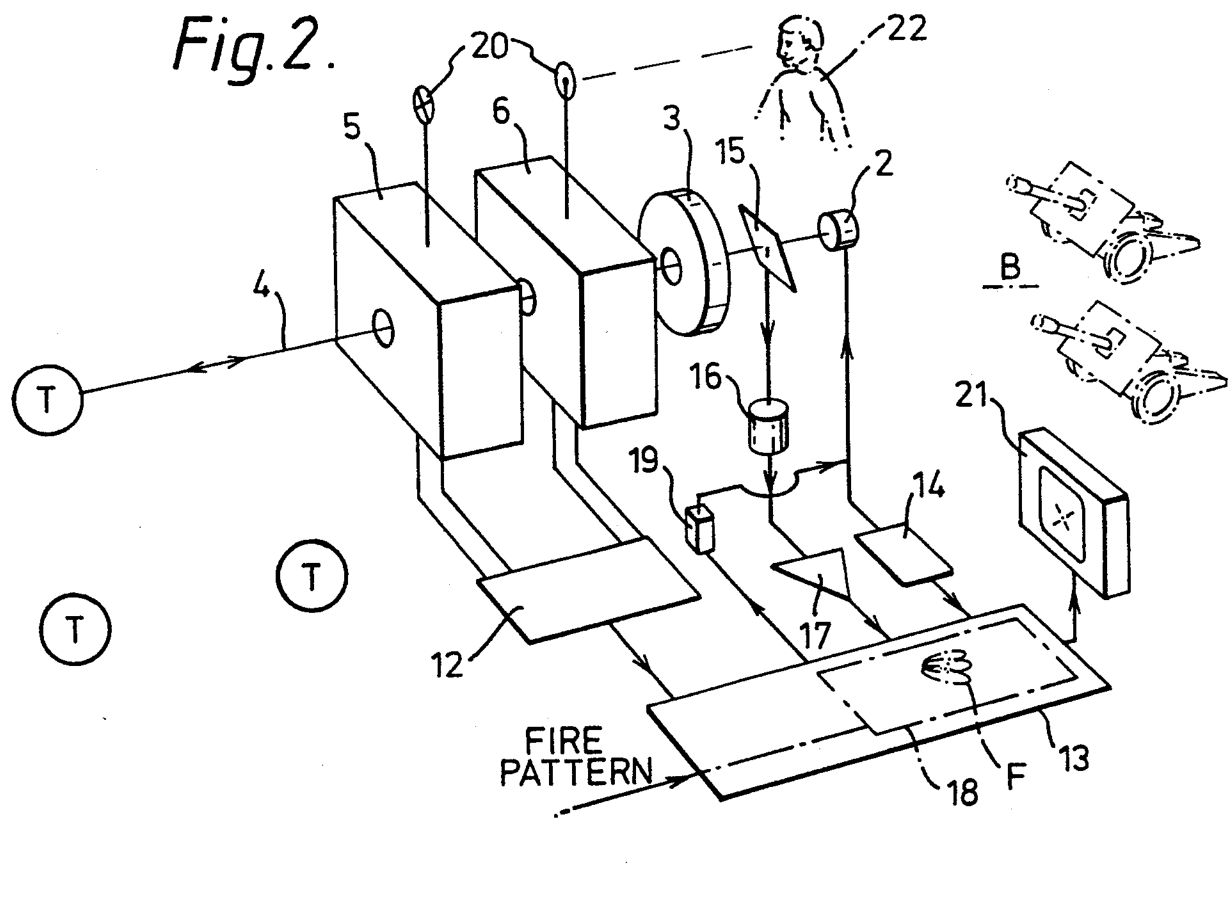
Fig. 2.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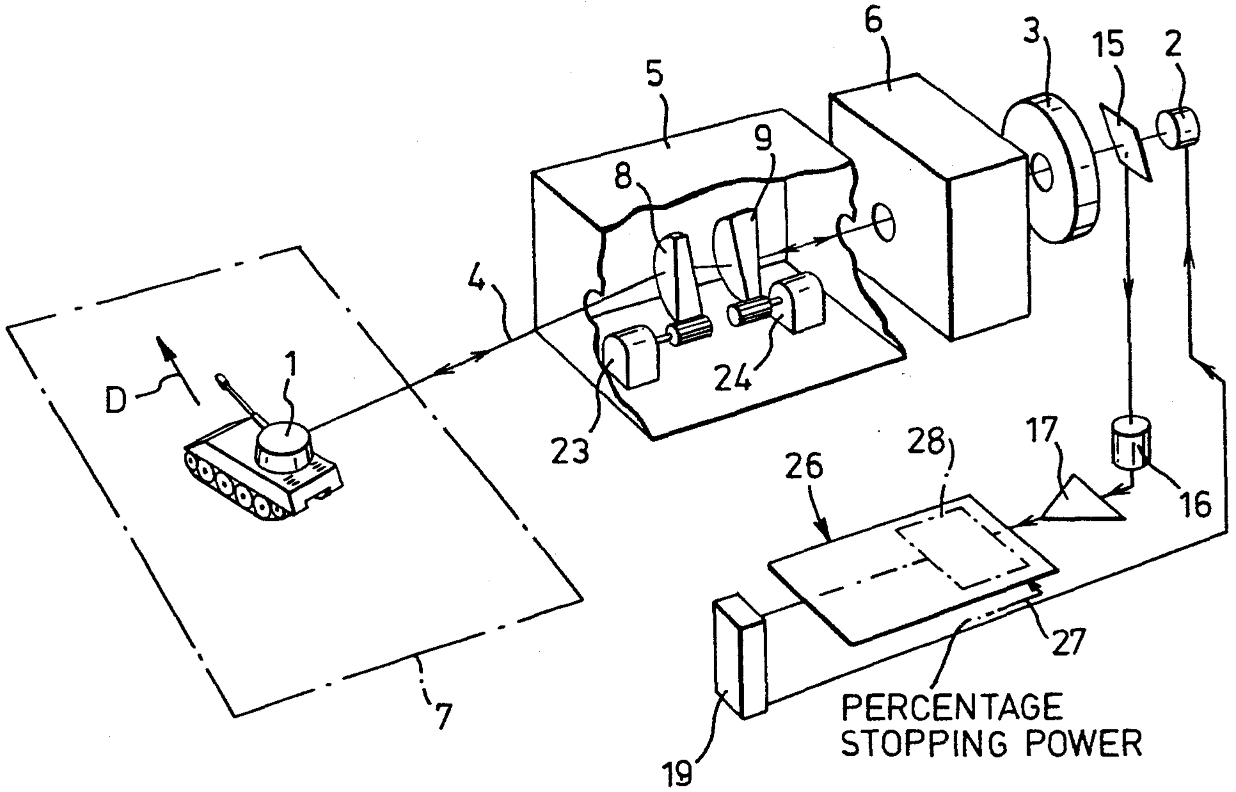
PATTERN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PERCENTAGE
STOPPING POWER
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7

Fig. 3.