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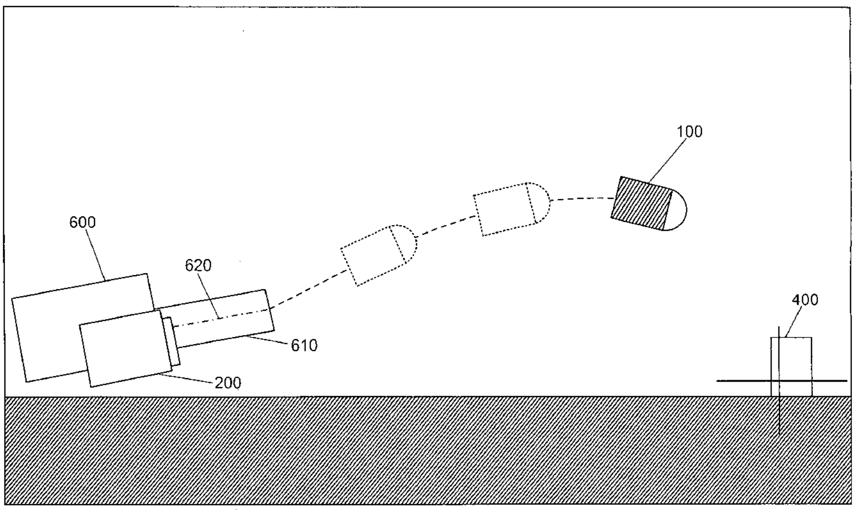

FIG. 1

(57) Abstract: A method and system for improving precision and accuracy of weaponry according to which angular position information of the fire control device and optical location information of the optical signals emitted during the flight of a projectile are processed in a computer using software to calculate and provide a precise aim point for firing one or more subsequent projectiles.

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METHODOLOGY FOR BORE SIGHT ALIGNMENT AND CORRECTING BALLISTIC AIMING POINTS USING AN OPTICAL (STROBE) TRACER

FIELD OF THE INVENTION

The present invention relates to weaponry systems, more specifically, it relates to a method and arrangement for improving precision and accuracy of weaponry and their fire control devices.

BACKGROUND OF THE INVENTION

There are several real time factors that influence the accuracy of weaponry and their fire control devices.

Existing fire control devices use ballistic tables and metrological sensors to calculate a predicted hit point (gunner aiming point), further, some fire control devices allow for users to input manual drift and elevation offsets, but these offsets are generally linear offsets. Further, fire control devices often provide inaccurate aim points because a limited number of inputs are taken into consideration while calculating the aim points.

Further, existing wind sensing methodologies such as LIDAR and Doppler radar are too expensive to be incorporated into existing ground combat systems. Also, during the flight of the projectile, different wind conditions exist at different elevations, thus it is not effective to use a wind sensor at the fire control device as the wind conditions at the firing location are different from wind conditions on the in-flight projectile. Further, the trajectory of some projectiles makes it problematic to use wind sensors.

Chemical tracers have been used in ammunition for many years, but use of chemical tracers induces drag that negatively affects projectile ballistics. Further, chemical tracers do not allow precise measurement of the projectile time-location.

The US Patent 4,152,969 discloses a wind and target motion correction method for an airborne fire control system; however, the patent does not describe any method for correcting wind errors in ground combat systems.

The patent number GB 2,107,835 relates to a method and a device for correcting subsequent firing of a projectile from a weapon. However, the disclosed system is limited to the firing of the projectiles having a flat trajectory only, excluding its use for long range firing, and it does not take into account certain factors such as errors due to gun jump or the like.

The US Patent 7,239,377 relates to a method and a device for determining a second range to a target based on data observed from a first range to the target. The method uses computer programs to calculate second range to the target using sensors such as laser range sensor and tilt sensor; however, practical considerations, such as atmospheric conditions, limit the accuracy of calculated solutions. Thus, there is a need to take into account the real time observed data to improve the precision and accuracy of a fire control device.

In light of the foregoing discussion, there is a need for using real time data in weaponry systems to provide an improved ballistic control.

SUMMARY OF THE INVENTION

The purpose of the present invention is to improve the precision and accuracy of weaponry systems by taking into account all the factors that affect the actual flight of a projectile fired from a fire control device.

It is an object of the present invention to use a projectile with an optical emitter that emits short and intense optical signals at pre-determined time intervals to trace the path followed by the projectile. These optical emissions include but may not be restricted to light in ultraviolet, infra red and visual wavelengths.

It is another object of the present invention to improve fire control device of the weaponry system to observe the angular position information of ammunition at known time points.

It is still another object of this invention to improve fire control solutions and allow for fire control computers to observe and calculate precise aim points and further to solve the errors due to (a) bore sight misalignment, (b) lot-to-lot errors, (c) occasion-to-occasion errors, (d) wind action on the projectile, and (e) several other local factors that contribute to error in fire control devices.

It is still another object of the present invention is to use real time observed data to calculate new and improved fire control solutions for subsequent firing of projectiles.

It is still another object of the present invention to transmit optical signals in short form, thereby minimizing power consumption of reserve batteries and field generators used in the projectile fuzes.

It is still another object of the present invention to transmit optical signals in discrete bursts, thereby avoiding continuous processing of sensor inputs by processors of the computer disposed in the fire control device.

In the present invention, the weapon's ammunition tracer strobe, which is normally located with the fuze in the projectile ogive, provides time-location data and the fire control device observes the angular position of the projectile.

These objects, as well as still further objects which will become apparent from the discussion that follows, are achieved, in accordance with the present invention, by a method including the following steps:

(a) measuring angular position information between the weapon's barrel centerline and a fire control device;

(b) use of one or more sensors to identify possible parameters affecting the flight of the projectile;

(c) generating optical signals at predetermined time intervals using an optical emitter disposed in housing of a projectile;

(d) receiving the optical signals generated in step (b) using an optical detector attached to the fire control device and measuring angular shift of the fire control device using sensors to detect gun jump or other post firing movement;

(e) processing the optical signals in a video processor for identifying optical location information of the flight of the projectile;

(f) using the angular position information, the aforesaid parameters, the angular shift and the optical location information to calculate a precise aim point, wherein the said calculation is carried out using software in a computer; and

(g) identifying the precise aim point to a user for firing one or more subsequent projectiles.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates a weaponry system for firing a projectile.

FIG. 2 illustrates different components of a fire control device.

FIG. 3(a) illustrates the projectile and an exploded view of its nose.

FIG. 3(b) illustrates the transmission of optical signals.

FIG. 4(a) illustrates an induced yaw in the projectile in a flat trajectory.

FIG. 4(b) illustrates the axis of rotation of the projectile for ballistic trajectory.

FIG. 4(c) illustrates a ballistic profile of an in-flight projectile.

FIG. 5 illustrates an optical strobe images of the projectile at pre-determined time intervals (viewed from the fire control or position of the fire control).

FIG. 6 illustrates an actual hit point of the projectile fired without any correction.

FIG. 7 illustrates a lateral drift and vertical drop of the fired projectile.

FIG. 8 illustrates a lateral camera shift and vertical camera shift caused by gun jump at pre-determined time intervals.

FIG. 9 illustrates a lateral correction factor and vertical correction factor.

FIG. 10 illustrates a subsequently fired projectile hitting the intended target.

FIG. 11 shows a table for a sequence of measurements at different points of time to calculate an improved fire control solution.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention provide a method and arrangement for bore sight alignment and correcting ballistic aiming points using an optical strobe tracer. In the description of the present invention, numerous specific details are provided, such as examples of components and/or mechanisms, to provide a thorough understanding of the various embodiments of the present invention. One skilled in the relevant art will recognize, however, that an embodiment of the present invention can be practiced without one or more of the specific details, or with other apparatus, systems, assemblies, methods, components, materials, parts, and/or the like. In other instances, well-known structures, materials, or operations are not specifically shown or described in detail to avoid obscuring aspects of embodiments of the present invention.

FIG. 1 illustrates a weaponry system comprising one or more projectiles 100, a weapon 600 and a fire control device 200. The weapon 600 can be a gun, launcher, firearms, cannons, rocket pods, aircraft and the like.

The projectile 100 aimed at a target 400 is fired through a barrel 610 of the weapon 600 in response to a shoot command generated manually by a user. The shoot command can also be generated automatically by the fire control device 200 of the weaponry.

FIG. 2 illustrates the weapon 600 and the fire control device 200 comprising one or more sensors 220, one or more optical detectors 230, one or more video processors 240 and a computer 250 having a software 260.

The sensors 220 are used in the present invention for identifying signals or any other parameters. Such sensors can be of various types, for example, position sensors, sensors for gun elevation, optical sensors and the like.

The optical detector 230 can be a camera or any image capturing device, for example video camera, infrared camera or the like.

The fire control device 200 measures angular position information of the weapon 600, when the weapon 600 fires the projectile 100 aimed at the target 400. The angular position information includes radial azimuth/elevation barrel centerline 620 and elevation of barrel/fire control elevation, wherein the angular position information is measured by using the sensors 220 and the information is recorded by the computer 250.

FIG. 3(a) illustrates the projectile 100 and exploded view of nose 130 of the projectile 100. The projectile 100 comprises an optical strobe emitter 110, wherein the optical emitter 110 is disposed in a translucent housing 120 of the projectile 100. Optical emitter 110 of the projectile 100 is a light generating source which can be a light emitting diode, laser or the like.

In one embodiment of the present invention, an electronic fuze 150 is disposed in the projectile 100. The fuze 150 is programmed to relay precise position information of the projectile 100 to the fire control device 200.

FIG. 3(b) illustrates the transmission of optical signals 140 generated from the optical emitter 110 of the projectile 100, wherein the optical signals 140 are generated at pre-determined time intervals during flight of the projectile 100. A 360 degree refractive lens (not shown in the figure) disposed in the translucent housing 120 of the projectile 100. The lens allows optimized transmission of optical signals 140 from the emitter 110 in the direction of the fire control device 200.

The optical emitter 110 emits optical signals 140 of high intensity and for very short period of time during the flight of the projectile 100. Various types of optical emissions such as emissions in ultraviolet, infra red and visual spectrum of various frequencies and intensities can also be used without altering the scope of the invention.

In another embodiment of the present invention, it is possible to code the emissions of the optical signal 140 with a time code pulse.

In still another embodiment of the present invention, the optical emission (signal) 140 may include embedded signals corresponding to the precise time function.

FIG. 4(a) and FIG. 4(b) illustrate an arrangement for effectively transmitting the optical signal 140 generated from the optical emitter 110 towards the fire control device 200 during the flight of the projectile 100.

In still another embodiment of the present invention, FIG. 4(a) illustrates firing of the projectile 100 aiming a short range target (not shown in the figure). The path followed by the projectile 100 is relatively flat 300. Yaw enables the projectile 100 to rotate about its vertical axis so as to optimally position the projectile 100 to emit optical signals 140 more effectively in the direction of the fire control device 200, wherein the yaw can be induced on projectiles 100 through a number of well known mechanical factors.

In still another embodiment of the present invention, as shown in FIG. 4(b), the projectile 100 is fired at an angle for long range targets (not shown in the figure). The axis of the in-flight projectile 100 changes relative to the position of the fire control device 200; thereby allowing the emitter 110 to transmit optical signals 140 in the direction of the fire control device 200. The path followed by the projectile 100 is ballistic 302 as shown in FIG. 4(c) (the figure shows the ballistic profile of 40mm X 53 HV grenade by using PRODAS (PROjectile Design and Analysis System) cross plot).

The optical signals 140 generated by the optical emitter 110 of the projectile 100 are detected by the fire control device 200 using the optical detector 230. The optical detector 230 of the fire control device 200 collects the optical emissions (signals) 140 at pre-determined time intervals after firing. The optical signals 140 emitted by the optical emitter 110 of the projectile 100 at discrete time intervals (t1, t2, t3, t4 and t5) are received by the optical detector 230 and digitally recorded as strobe images 145, as illustrated in FIG. 5.

FIG. 6 illustrates actual hit point 500 of the fired projectile 100 and intended target 400. The projectile 100 misses the intended target 400 because of some real time errors such as, for example, occasion to occasion errors, lot-to-lot errors, bore sight misalignment and errors resulting from varying environmental conditions such as wind direction, wind speed and the like. The present invention facilitates in correcting these errors for firing subsequent projectiles 100 to hit the intended target 400 by processing real time observed data.

The digitally recorded strobe images 145 are processed by the video (or image) processor 240 of the fire control device 200 to identify actual drift and drop of fired projectile 100 as observed from the fire control device 200.

The video processor 240 of the fire control device 200 detects the strobe images 145 at pre-determined time intervals (t1, t2, t3, t4 and t5) after firing of the projectile 100. Video processing software of the video processor 240 distinguishes optical signal 140 from the collected strobe image 145 and measures angular changes that are used to calculate optical location information, wherein the optical location information comprises lateral drift (i.e. x1, x2, x3, x4 and x5) and vertical drop (i.e. y1, y2, y3, y4 and y5) of the projectile at predetermined time intervals (i.e. t1, t2, t3, t4 and t5) as illustrated in FIG. 7.

At each pre-determined time interval (t1, t2, t3, t4 and t5), the fire control device 200 also records angular shift in the optical detector 230 using one or more sensors 220 disposed in the fire control device 200. This angular shift is determined by measuring shift in the horizontal (x) direction (i.e. xx1, xx2, xx3, xx4 and xx5) and shift in the vertical (y) direction (i.e. yy1, yy2, yy3, yy4 and yy5) of the optical detector 230 at pre-determined time intervals (t1, t2, t3, t4 and t5), as illustrated in FIG. 8, wherein the angular shift occurs due to gun jump or other post firing movements. Gun jump refers to the movement of the fire control device 200 or weapon 600 at the time of firing the projectile 100. Errors due to gun jump can be solved in a number of ways such as, but not restricted to using software algorithms that detect the image shift or by using sensitive accelerometers or measuring equipments that detect relative change in position of sensors.

The angular shift information along with the observed actual lateral drift and vertical drop data is provided to the computer 250 of the fire control device 200. The computer 250 uses this information and the angular position information of the weapon 600 recorded at the time of firing the projectile 100 with software 260 to calculate lateral correction 252 and vertical correction 254 as illustrated in FIG. 9. The lateral correction 252 is a function of total observed lateral drift in the x coordinate (i.e. sum observed lateral drift x1, x2, x3, x4 and x5) and vertical correction 254 is a function of total observed vertical drop in the y coordinate (i.e. sum observed lateral drift y1, y2, y3, y4 and y5) of the initially fired projectile 100 that misses the target 400. These corrections are used to calculate a new and improved fire control solution for subsequent firing. The solution takes into account the errors resulting from factors such as wind speed, wind direction or the like.

In one embodiment of the present invention, the fire control device 200 resets subsequent fire control solutions by using actual observed drift and drop of the improved fire control solution; thereby providing a precise aim point for firing the subsequent projectiles 100.

In another embodiment of the present invention, the fire control device 200 establishes a correction factor to modify the calculated fire control solution; thereby providing a more precise aim point for firing a subsequent projectile 100.

The fire control device 200 uses the new and improved fire control solution to adjust the azimuth and elevation of aim point of the weapon 600 for firing subsequent projectiles 100 to hit the intended target 400 as illustrated in FIG. 10. Adjustment in azimuth corresponds to angle adjustment of the weapon 600 in horizontal (left or right) direction to hit the intended target 400. Adjustment in elevation corresponds to angle adjustment of the weapon 600 in vertical (up and down) direction to hit the intended target 400. These adjustments provide a precise aim point wherein said precise aim point is identified to the user for firing subsequent projectiles 100.

Further, when subsequent projectiles 100 are fired, the fire control device 200 repeatedly measures the adjustments in the azimuth and elevation of the aim point and use commonly known mathematical algorithms to improve the precision and accuracy of the corrected aim point by repositioning the weapon 600.

FIG. 11 illustrates measurement of various parameters at different points of time during the flight of the projectile. Further, the measurements allow for optional measurement of muzzle velocity variation if needed.

The variables that may be used for calculating the improved fire control solution are described below.

T0-o	:	Time duration that fire control solutions are displayed and the weapon is physically positioned (aimed)
T0-n	:	Time when operator initiates firing.
T0	:	Moment ammunition is fired (set-back)
z1	:	Position of 1st time measurement (Position A barrel mouth)
z2	:	Position at 2nd time measurement (Position B Tz2-Tz1= Time/known distance =Muzzle Velocity)
x	:	Horizontal position
y	:	Vertical Position

Thus, the weaponry of the invention uses real time data and observations to calculate precise aim point solutions that help in removing errors: for example, errors resulting from varying environmental conditions such as wind direction, wind speed and the like, occasion-to-occasion errors, lot-to-lot errors, bore sight misalignment and the like.

While embodiments of the present invention have been illustrated and described, it will be clear that the present invention is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions and equivalents will be apparent to those skilled in the art, without departing from the spirit and scope of the present invention, as described in the claims.

CLAIMS

What is claimed is:

1. A method for improving precision and accuracy of weaponry, said weaponry comprising a weapon, a fire control device and one or more projectiles, said method comprising the steps of:

(a) measuring angular position information of said fire control device to barrel centerline of said weapon;

(b) using one or more sensors to identify parameters affecting the flight of said projectile;

(c) generating optical signals at predetermined time intervals using an optical emitter disposed in a housing of said projectile;

(d) receiving said optical signals using an optical detector attached to said fire control device and measuring angular shift of said fire control device to detect post firing movement;

(e) processing said optical signals in a video processor for identifying optical location information of the flight of said projectile;

(f) using said angular position information, said parameters, said angular shift and said optical location information to calculate a precise aim point; wherein said calculation is carried out using software in a computer; and

(g) identifying said precise aim point to a user for firing one or more subsequent projectiles.

2. The method according to claim 1, wherein said projectile further comprises a fuze.

3. The method according to claim 2, wherein said fuze is an electronic time fuze.

4. The method according to claim 1, wherein said angular position information comprises radial azimuth or elevation barrel centerline.

5. The method according to claim 1, wherein said angular position information comprises elevation of barrel or fire control elevation.

6. The method according to claim 1, wherein said optical emitter is a light emitting diode.

7. The method according to claim 1, wherein said optical emitter emits said optical signals at discrete frequencies in the UV, visual or IR spectrums.

8. The method according to claim 1, wherein generation of said optical signal can be coded with a time code pulse.

9. The method according to claim 1, wherein said optical signals are collected by said optical detector in the form of strobe image data.

10. The method according to claim 9, wherein said optical detector is a camera.

11. A method for improving precision and accuracy of weaponry, said weaponry comprising a weapon, a fire control device and one or more projectiles having a translucent housing, said method comprising the steps of:

(a) measuring angular position information of said fire control device to barrel centerline of said weapon;

(b) using one or more sensors to identify parameters affecting the flight of said projectile;

(c) generating optical signals at predetermined time intervals using an optical emitter disposed in said housing of said projectile;

(d) receiving said optical signals using an optical detector attached to said fire control device and simultaneously measuring angular shift of said fire control device using sensors to detect gun jump or other post firing movement;

(e) processing said optical signals in a video processor for identifying optical location information of the flight of said projectile, said optical location information comprising:

i. lateral drift; and

ii. vertical drop;

(f) using said angular position information, said parameters, said angular shift and said optical location information to calculate a precise aim point; wherein said calculation is carried out using a software in a computer; and

(g) identifying said precise aim point to a user for firing one or more subsequent projectiles.

12. The method according to claim 11, wherein said projectile further comprises a fuze.

13. The method according to claim 12, wherein said fuze is an electronic time fuze.

14. The method according to claim 11, wherein said angular position information comprises radial azimuth or elevation barrel centerline.

15. The method according to claim 11, wherein said angular position information comprises elevation of barrel or fire control elevation.

16. The method according to claim 11, wherein said optical emitter is light emitting diode.

17. The method according to claim 11, wherein said optical emitter emits said optical signals at discrete frequencies in the UV, visual or IR spectrums.

18. The method according to claim 11, wherein generation of said optical signal can be coded with a time code pulse.

19. The method according to claim 11, wherein said optical signals are collected by said optical detector in the form of strobe image data.

20. The method according to claim 19, wherein said optical detector is a camera.

21. A method for improving precision and accuracy of weaponry, said weaponry comprising a fire control device and one or more projectiles having a translucent housing, said method comprising the steps of:

(a) measuring angular position information of said fire control device to barrel centerline of said weapon;

(b) using one or more sensors to identify parameters affecting the flight of said projectile;

(c) generating optical signals at pre-determined time intervals using an optical emitter disposed in said housing of said projectile;

(d) receiving said optical signals using an optical detector attached to said fire control device and simultaneously measuring angular shift of said fire control device using sensors to detect gun jump or other post firing movement;

(e) processing said optical signals in a video processor for identifying optical location information of the flight of said projectile, said optical location information comprising:

i. lateral drift; and

ii. vertical drop;

(f) using said angular position information, said parameters, said angular shift and said optical location information to calculate a precise aim point by providing lateral correction factor and vertical correction factor to subsequent firing of projectiles, wherein said calculation is carried out using software in a computer; and

(g) identifying said precise aim point to a user for firing one or more subsequent projectiles.

22. The method according to claim 21, wherein said projectile further comprises a fuze.

23. The method according to claim 22, wherein said fuze is an electronic time fuze.

24. The method according to claim 21, wherein said angular position information comprises radial azimuth or elevation barrel centerline.

25. The method according to claim 21, wherein said angular position information comprises elevation of barrel or fire control elevation.

26. The method according to claim 21, wherein said optical emitter is light emitting diode.

27. The method according to claim 21, wherein said optical emitter emits said optical signals at discrete frequencies in the UV, visual or IR spectrums.

28. The method according to claim 21, wherein generation of said optical signal can be coded with a time code pulse.

29. The method according to claim 21, wherein said optical signals are collected by said optical detector in the form of strobe image data.

30. The method according to claim 29, wherein said optical detector is a camera.

31. An improved weaponry system comprising:

(a) one or more projectiles having a translucent housing and an optical emitter for emitting optical signals at pre-determined time intervals;

(b) a weapon for firing said projectiles;

(c) a fire control device comprising:

i. one or more sensors for measuring angular shift caused by gun jump;

ii. one or more sensors for measuring angular position information; and

iii. an optical detector for receiving said optical signals;

(d) a video processor for processing said optical signals to identify optical location information; and

(e) a computer having software which identifies a precise aim point for firing subsequent projectiles by processing parameters, said parameters comprising:

i. said angular shift;

ii. said angular position information; and

iii. said optical location information.

32. The system according to claim 31, wherein said projectile further comprises a fuze.

33. The system according to claim 32, wherein said fuze is an electronic time fuze.

34. The system according to claim 31, wherein said optical emitter is light emitting diode.

35. The system according to claim 31, wherein said optical emitter emits said optical signals at discrete frequencies in the UV, visual or IR spectrums.

36. The system according to claim 31, wherein said video processor is attached to said fire control device.

37. The system according to claim 31, wherein said video processor processes strobe image data collected by said optical detector.

38. The system according to claim 37, wherein said optical detector is a camera.

39. The system according to claim 31, wherein said computer is attached to said fire control device.

40. The system according to claim 31, wherein said optical location information comprises lateral drift and vertical drop of the projectile.

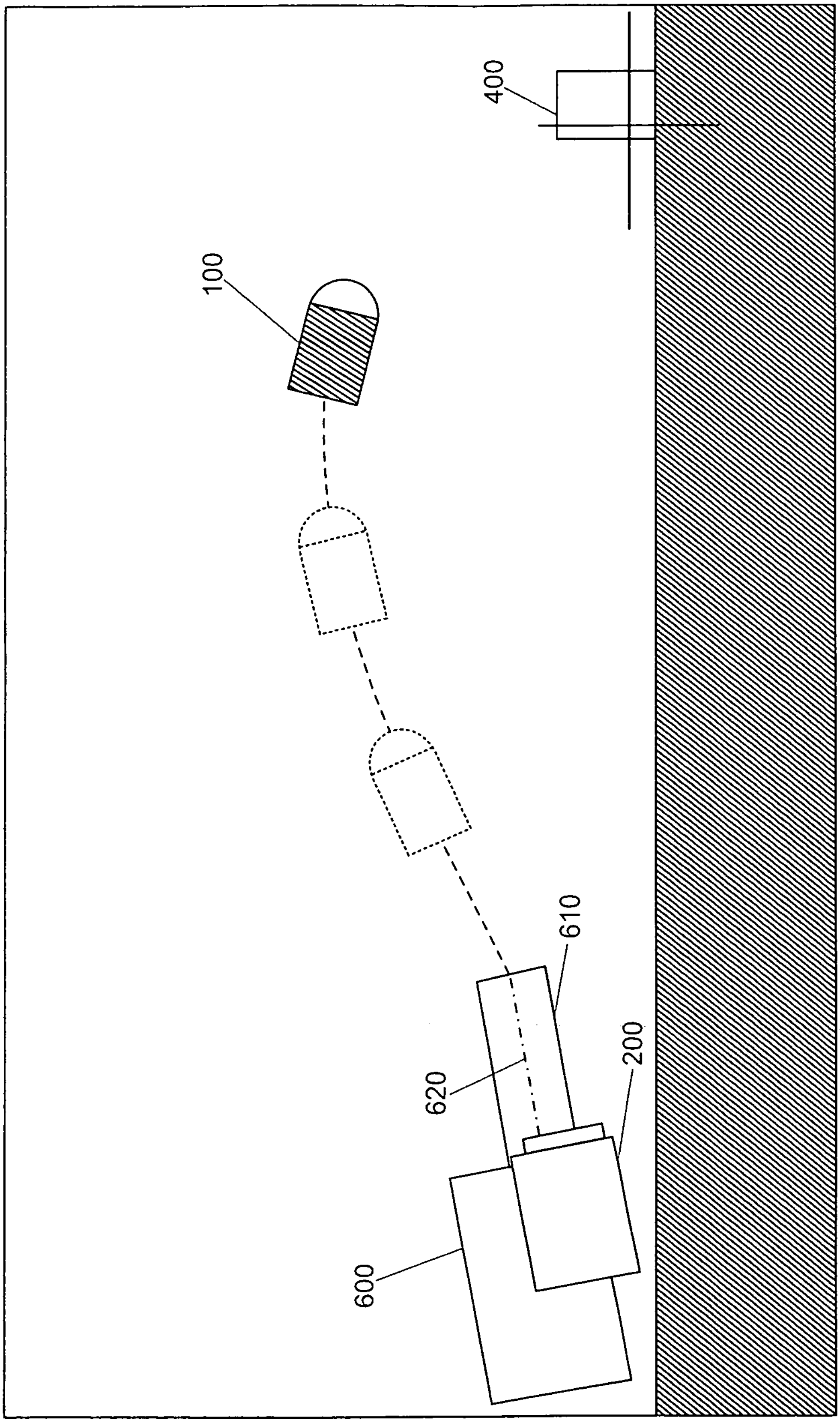


FIG. 1

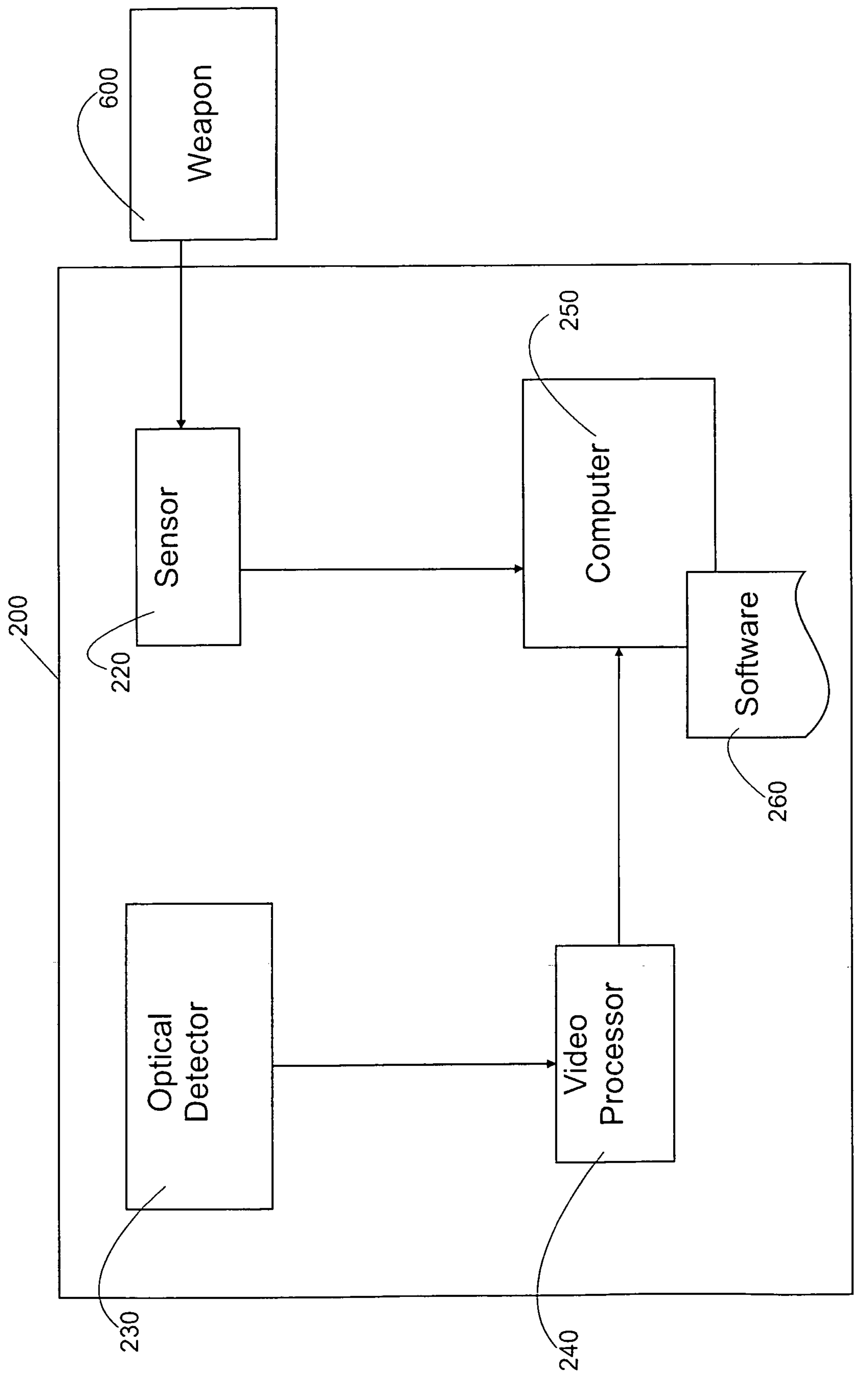

Weapon
600
200
Sensor
220
Computer
250
Software
260
Optical Detector
230
Video Processor
240

FIG. 2

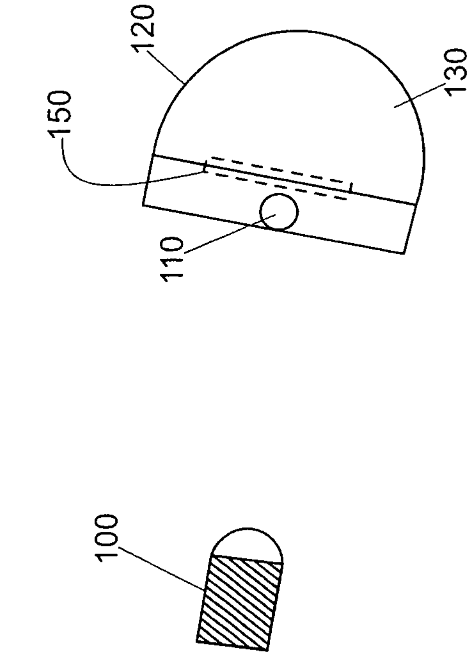


FIG. 3a

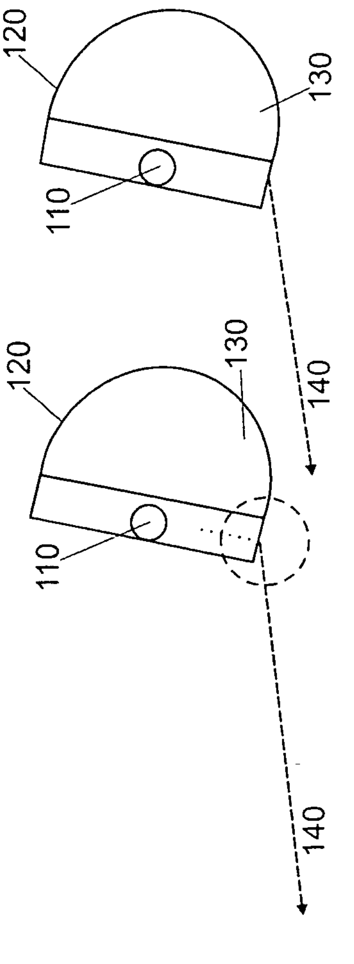


FIG. 3b

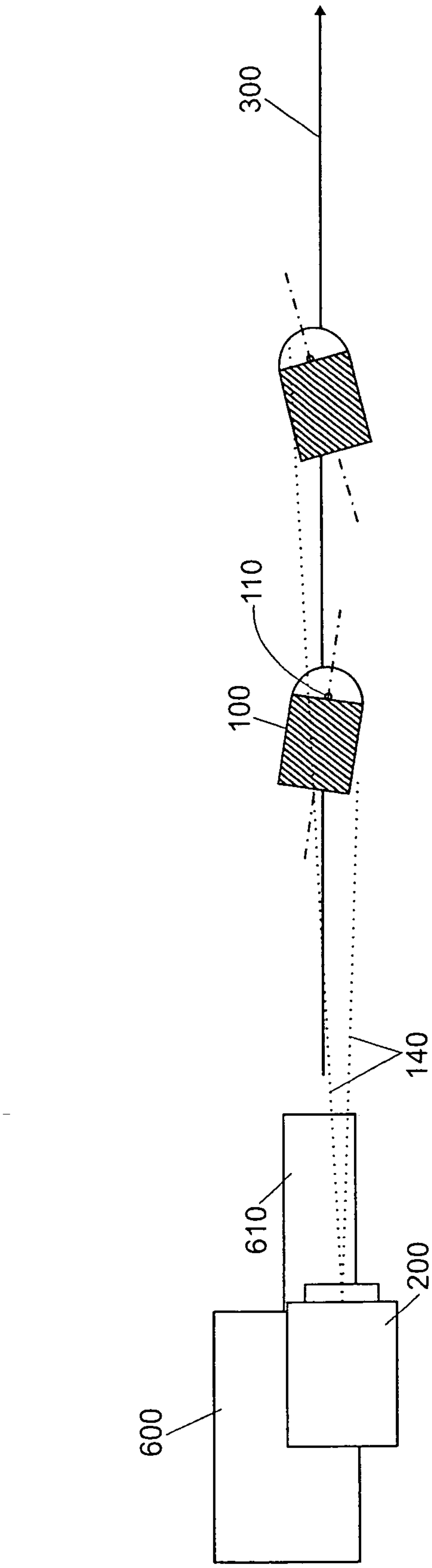


FIG. 4a

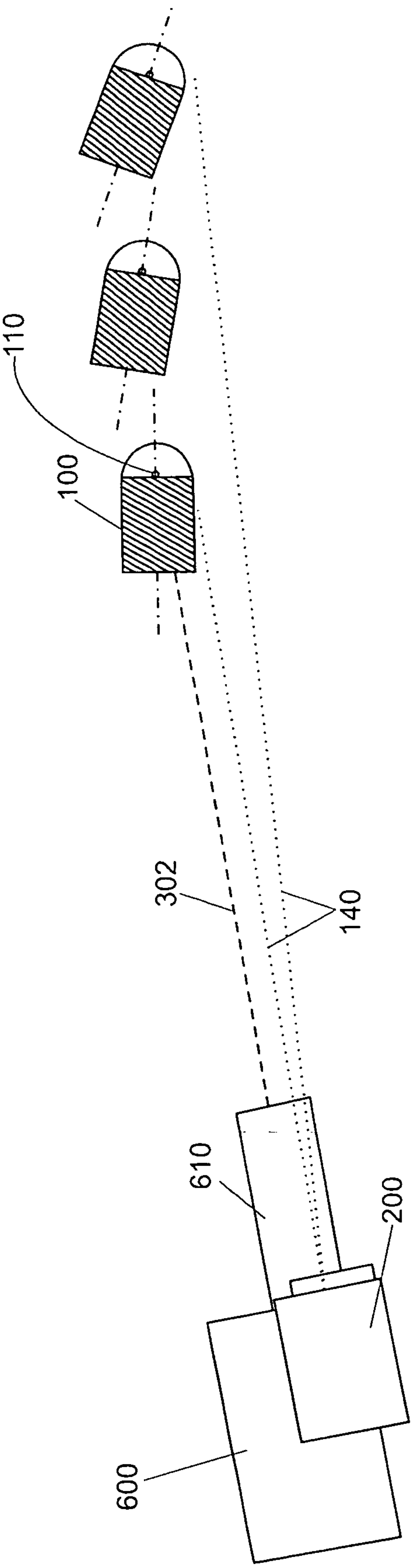
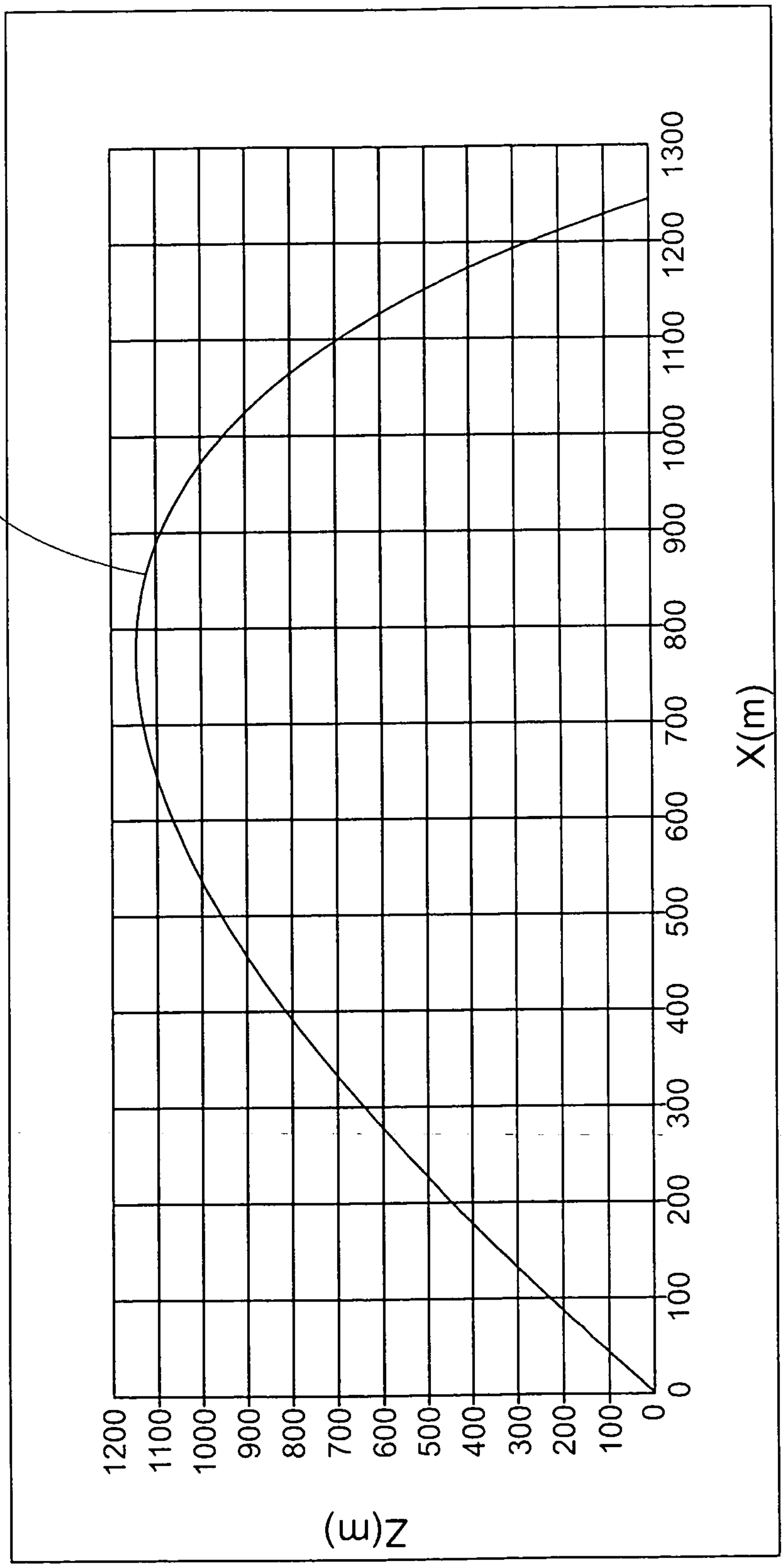


FIG. 4b


302
X(m)
Z(m)
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100
200
300
400
500
600
700
800
900
1000
1100
1200
1300

FIG. 4c

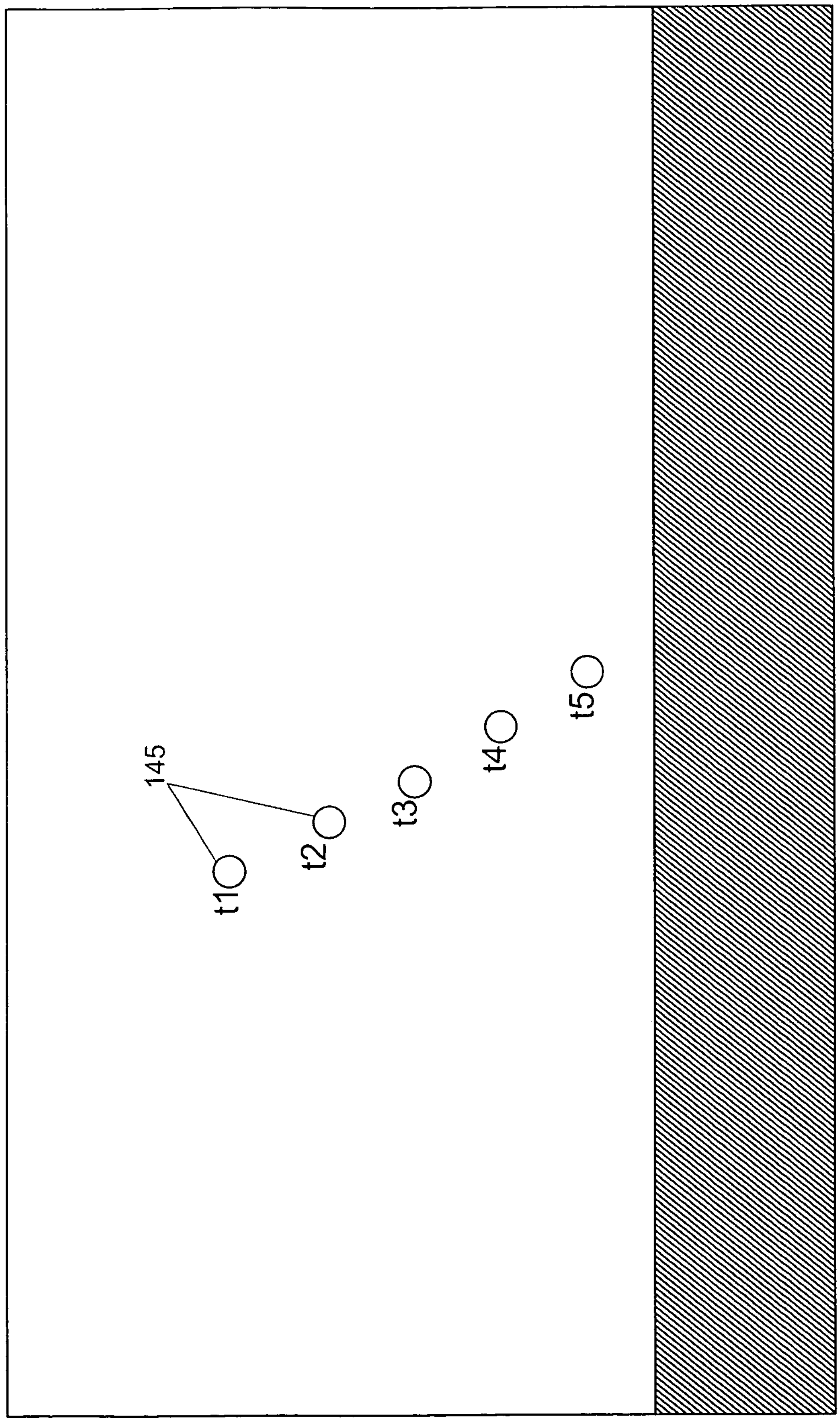

FIG. 5

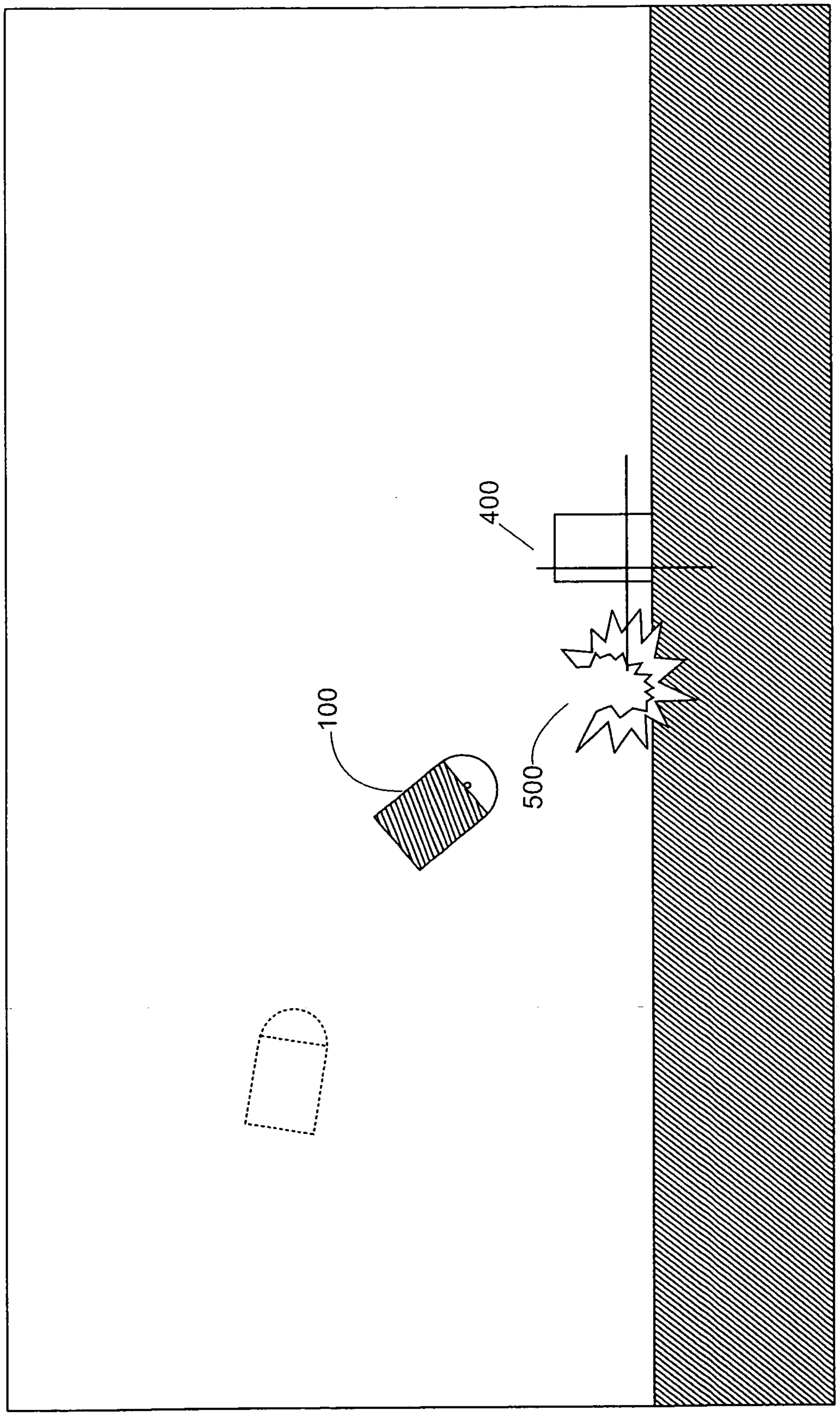

FIG. 6

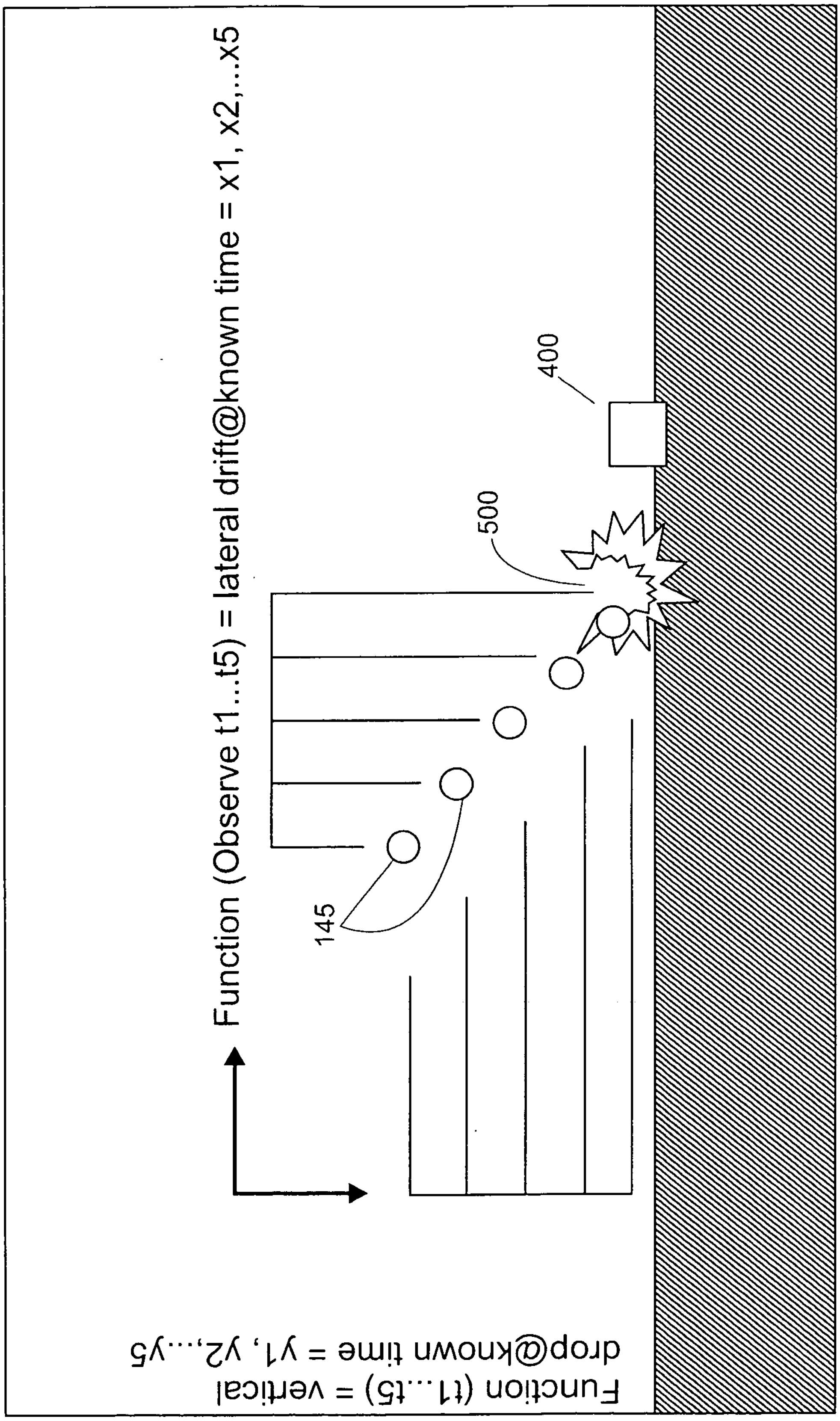
Function (Observe t1...t5) = lateral drift@known time = x1, x2,...x5
Function (t1...t5) = vertical drop@known time = y1, y2,...y5
400
500
145

FIG. 7

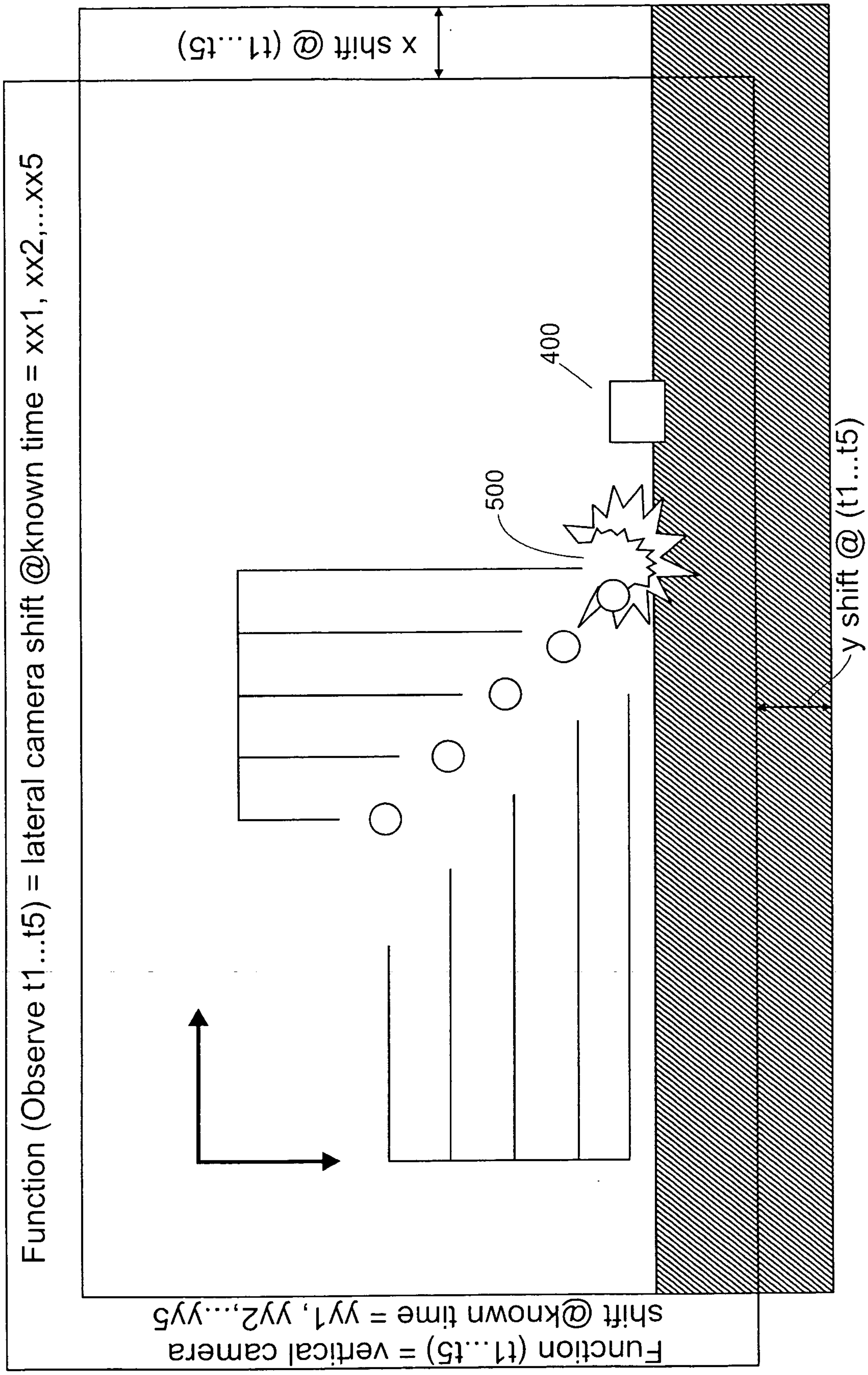
Function (Observe t1...t5) = lateral camera shift @known time = xx1, xx2,...xx5
x shift @ (t1...t5)
400
500
y shift @ (t1...t5)
Function (t1...t5) = vertical camera shift @known time = yy1, yy2,...yy5

FIG. 8

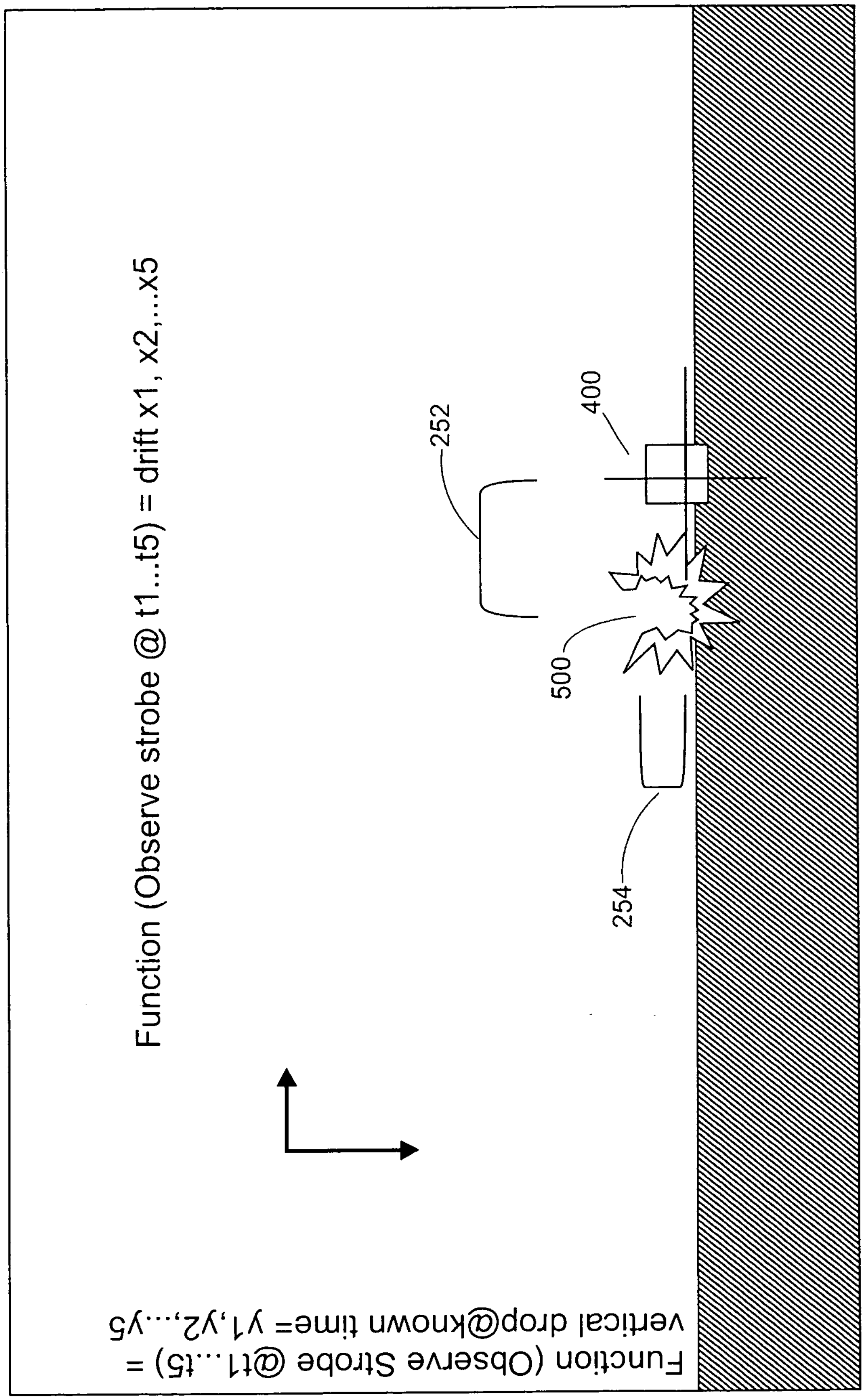
Function (Observe strobe @ t1...t5) = drift x1, x2,...x5
252
400
500
254
Function (Observe Strobe @t1...t5) =
vertical drop@known time= y1,y2,...y5

FIG. 9

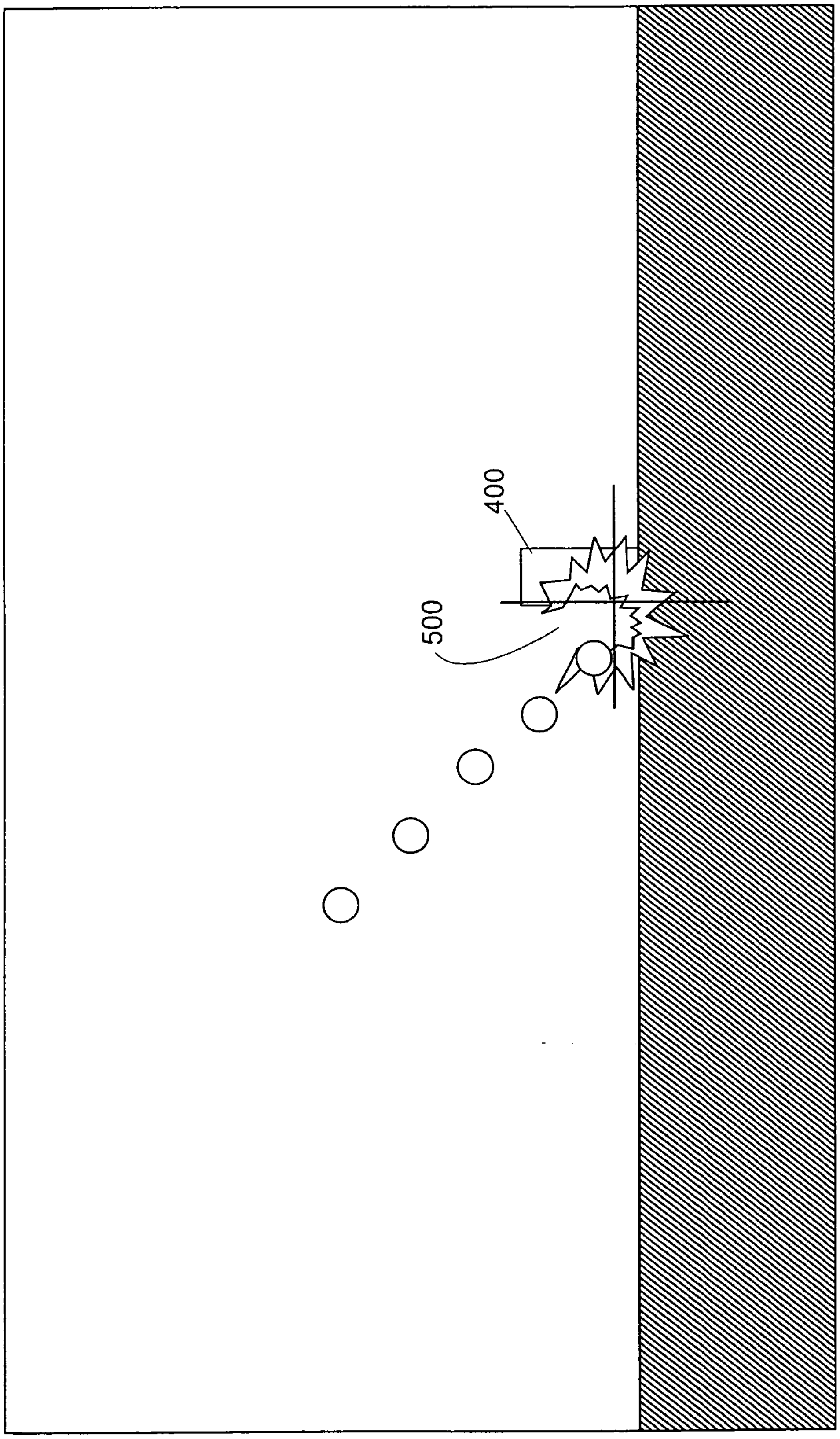

FIG. 10

Time	Item
T0-o	Fire Control Displays Solution based on solution derived from algorithm (based on previous video measurement)
	Information recorded/measured for processing by computer algorithms.
T0-n	Measurement of (a) radial Azimuth/Elevation Barrel centerline and (b) elevation of barrel/fire control elevation)if not aligned)
T0-n	Firing Pin Trigger pull (or hammer fall sensor)
T0	Set Back/Cartridge Launch
Tz1	Measurement of projectile at Position A
Tz2	Measurement of projectile at Position B
T1	Video Image(x1, y1) of strobe 1 and video position (xx1,yy1)
T2	Video Image(x2, y2) of strobe 2 and video position (xx1,yy1)
T3	Video Image(x3, y3) of strobe 3 and video position (xx1,yy1)
Tx	Video Image(x4, y4) of strobe x and video position (xx1,yy1)
Txn	Video Image(x5, y5) of strobe xn (last strobe prior to impact) and video position (xx1,yy1)

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/11122

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F42B 8/00 (2009.01)
USPC - 102/513
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): F42B 8/00 (2009.01)
USPC: 102/513

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): F42B 8/00 (2009.01) - see search terms below
USPC: 102/211, 213, 501, 513; 244/3.1, 3.13-3.16 - see search terms below

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(USPT,PGPB,EPAB,JPAB); DialogPRO(Engineering); GoogleScholar
Search Terms: Flight, angular, optical, guidance, missile, correction, optical, emitter, ballistic, rocket, electronic, time, fuze, radial, azimuth, barrel, elevation, light, diode, measure, gun, jump, detect, movement

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,710,028 A (GRENIER et al.) 01 December 1987 (01.12.1987), entire document especially Fig 1, col 3, ln 34-35, col 3, ln 38-41, col 3, ln 66 - col 4, ln 4, col 4, ln 31-39	1-40
Y	US 7,210,392 B2 (GREENE et al.) 01 May 2007 (01.05.2007), col 11, ln 12-39	1-40
Y	US 5,042,743 A (CARNEY) 27 August 1991 (27.08.1991), col 9, ln 2-4	1-40
Y	US 5,647,559 A (ROMER et al.) 15 July 1997 (15.07.1997), Fig 4, col 4, ln 24	1-30
Y	US 4,885,977 A (KIRSON et al.) 12 December 1989 (12.12.1989), col 2, ln 45-48	4-5, 14-15, and 24-25
Y	US 2005/0034627 A1 (MANOLE et al.) 17 February 2005 (17.02.2005), Fig 1-7, para [0064]	6, 9-30, and 31-40
Y	US 4,577,561 A (PERRY) 25 March 1986 (25.03.1986), Fig 1	2-3, 12-13, 22-23, and 32 -33
Y	US 2005/0262993 A1 (NURSE) 01 December 2005 (01.12.2005), claim 1	21-30
A	US 5,988,645 A (DOWNING) 23 November 1999 (23.22.1999), entire document	1-40
A	US 6,298,841 B1 (CHENG et al.) 09 October 2001 (09.10.2001), entire document	1-40

☐ Further documents are listed in the continuation of Box C. ☐

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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 June 2009 (09.06.2009)	17 JUN 2009

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774