United States Patent [19]

Eglin

[11] **3,892,352**

[45] **July 1, 1975**

[54] **TARGET SIMULATOR FOR A SIGHTING APPARATUS**

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Feb. 24, 1973 Germany 2309344

[52] **U.S. Cl.** ..... **235/61.5 S;** 35/12 N; 35/25

[51] **Int. Cl.** **F41g 3/26**

[58] **Field of Search** ..... 35/25, 12 N, 10.2; 235/61.5 S

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Primary Examiner—Felix D. Gruber

Attorney, Agent, or Firm—Werner W. Kleeman

[57] **ABSTRACT**

A target simulator for a sighting device of a gun, comprising

a light source for transmitting a light beam,

a first movable mirror arranged in the path of said light beam for portraying by a first light mark the apparent movement of a target which is to be attached at a ground glass-plate,

a second movable mirror also arranged in the path of said light beam for generating a second light mark which is effective for indicating an aiming error arising during adjustment of the sighting device,

five synchronous drives for moving said two mirrors

a. according to a programmable distance from the gun to a crossing point of the linear flight path of the target,

b. according to a programmable inclination angle of the flight plane within which there is located the target to be simulated,

c. according to a programmable target velocity for generating the apparent target movement,

d. according to a flight inclination angle,

e. according to an azimuth angle at the moment when the target appears.

11 Claims, 11 Drawing Figures

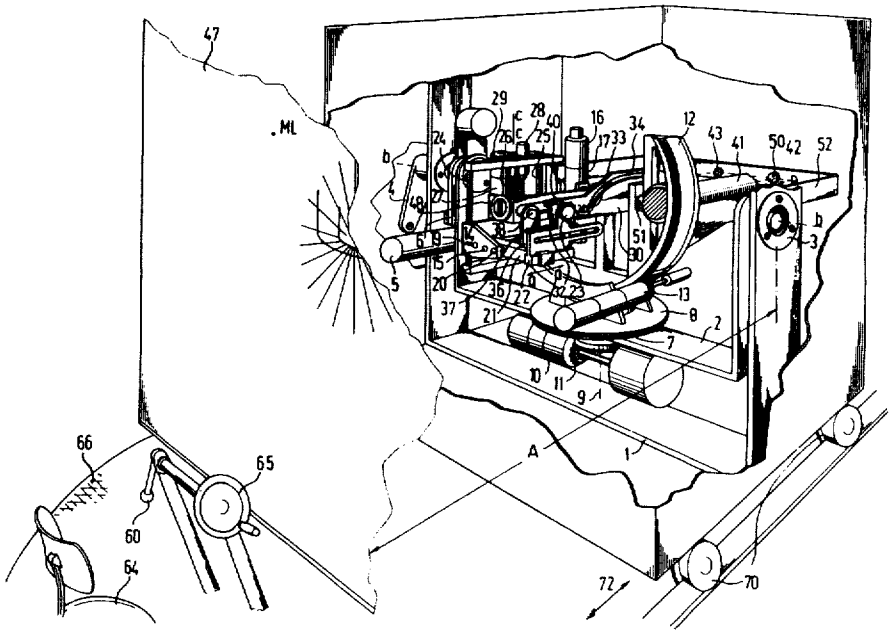


Fig.1

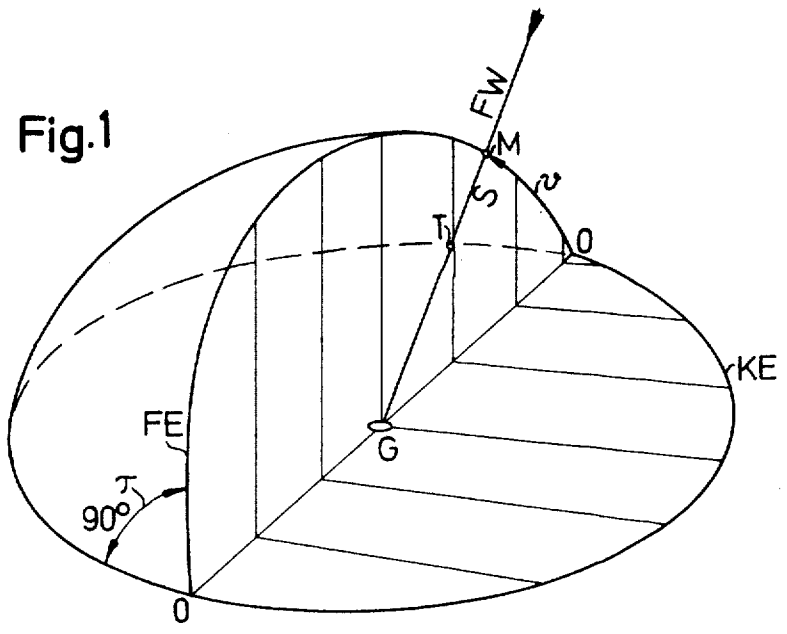


Fig.2

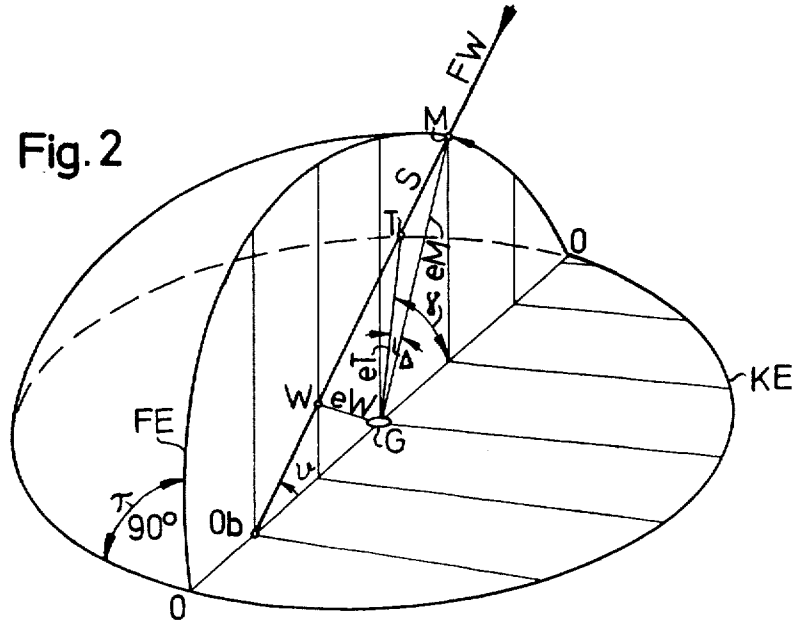


Fig.3

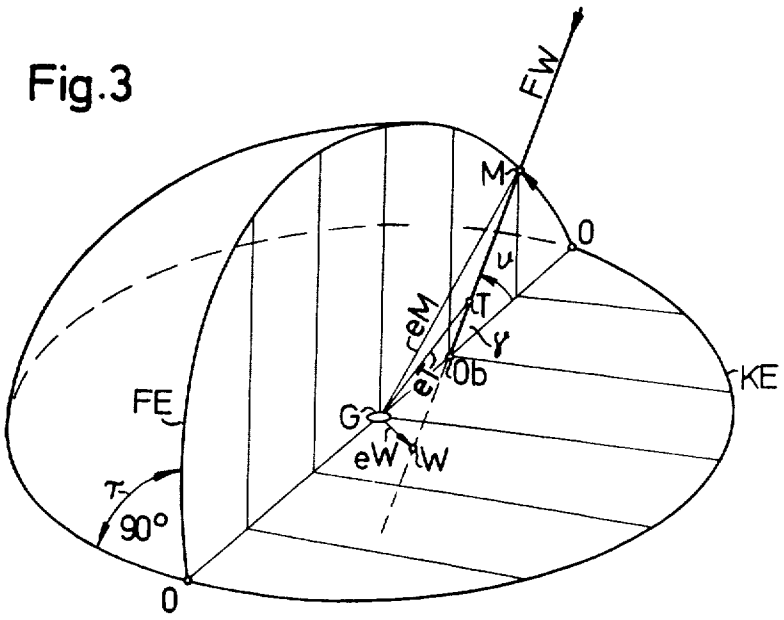
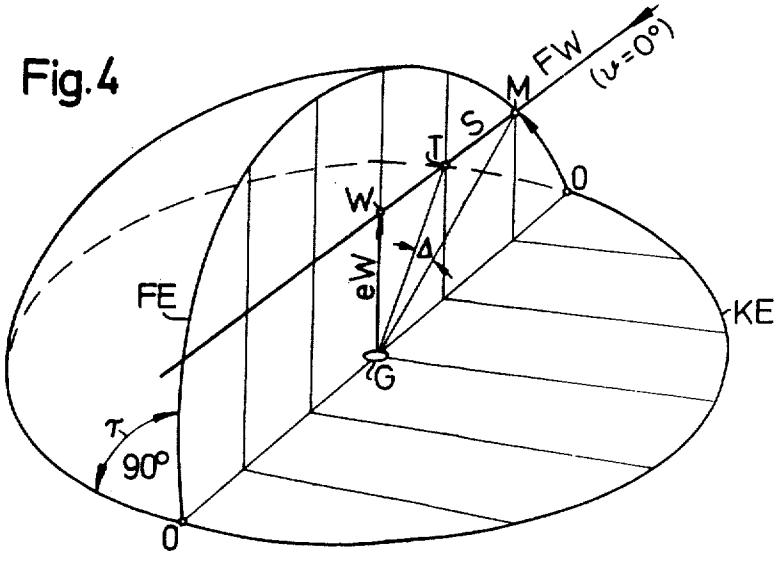


Fig.4



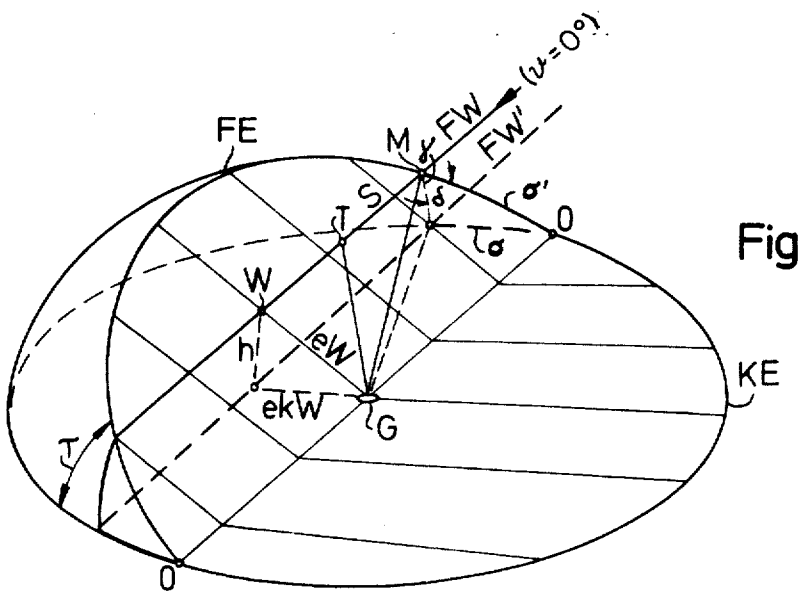

FE
M
FW
FW'
(ψ=0°)
S
δ
σ'
T
τσ
0
W
h
eW
ekW
G
KE
T
0

Fig.5

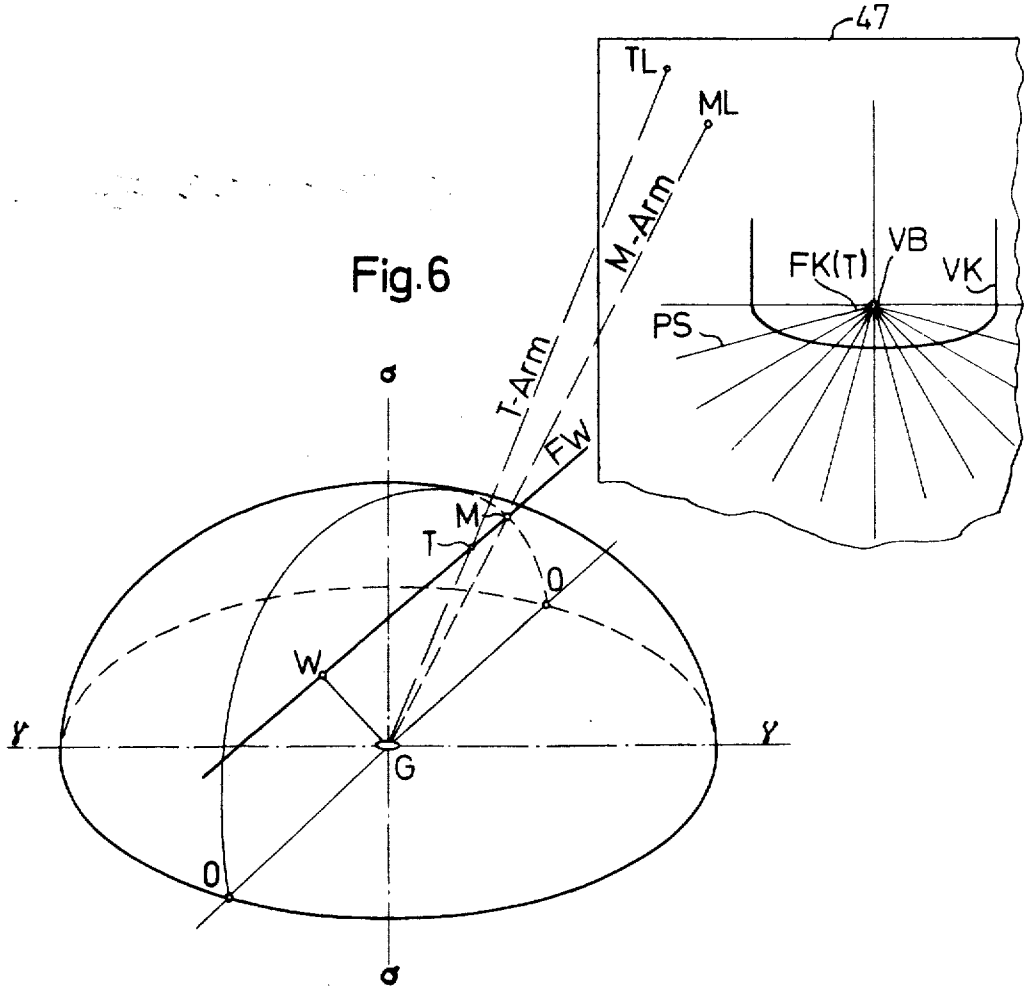

47
TL
ML
M-Arm
T-Arm
FW
FK(T)
VB
VK
PS
σ
M
T
0
W
γ
γ
G
0
σ

Fig.6

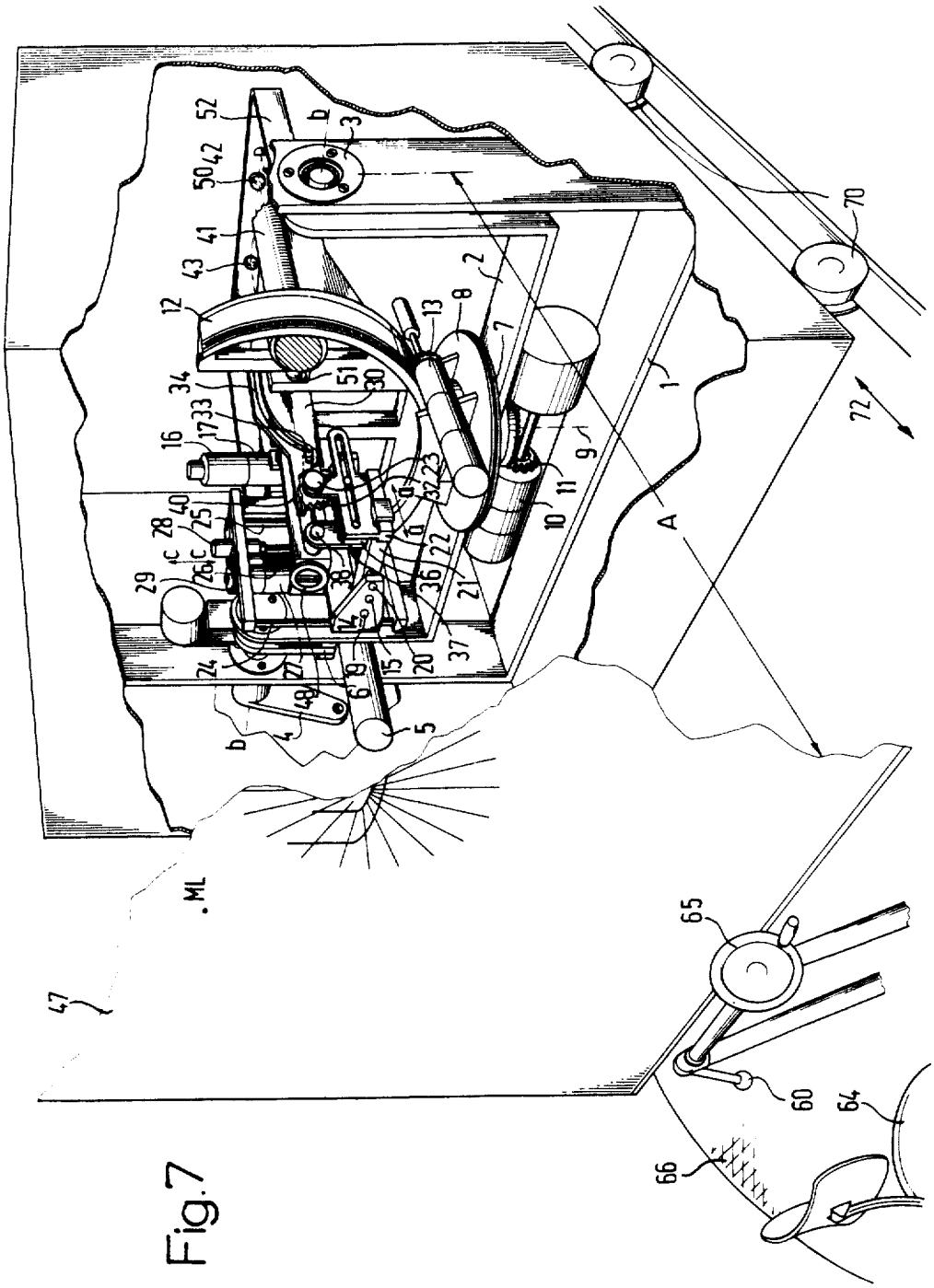

52
50
42
41
43
12
34
16
17
33
40
28
25
29
26
24
27
48
6
4
5
b
3
2
8
13
7
51
30
1
9
11
10
23
22
21
36
37
20
15
A
70
72
47
ML
65
60
64
66

Fig.7

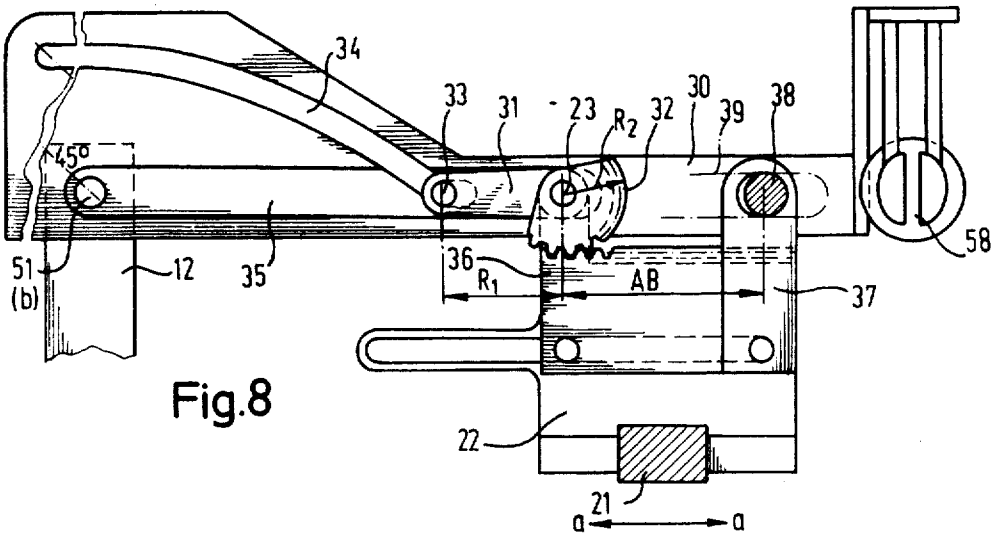
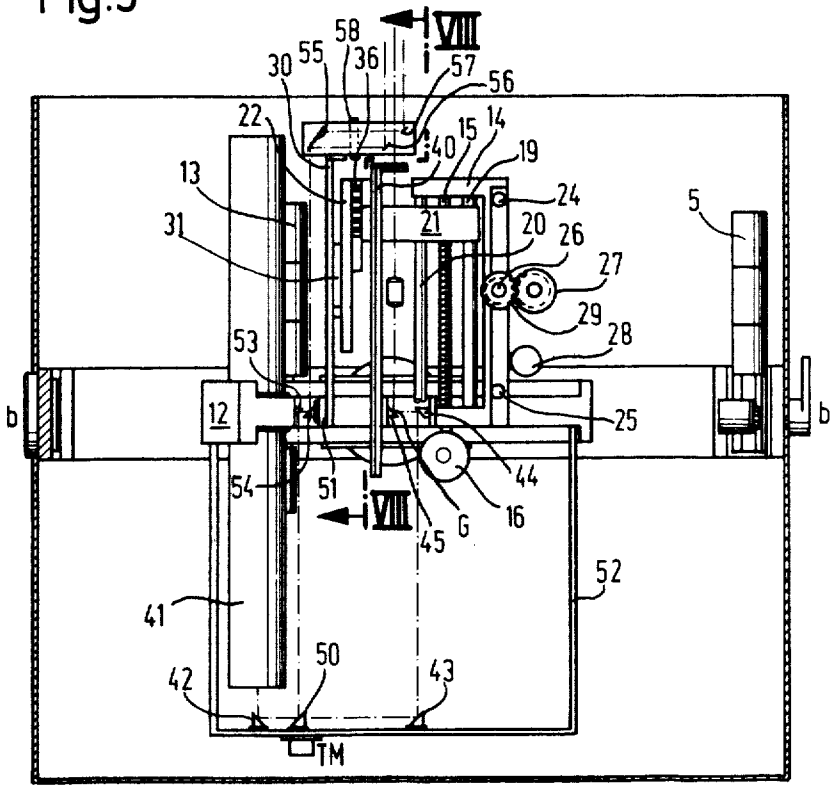

34
33
31
23
R_2
32
30
39
38
45°
58
51
(b)
12
35
36
R_1
AB
37
22
21
a
a

Fig.8

Fig.9


VIII
58
30
55
36
57
56
22
15
14
40
19
13
24
5
21
20
26
31
27
29
28
53
12
25
b
b
54
51
44
VIII
G
16
45
52
41
50
43
42
TM

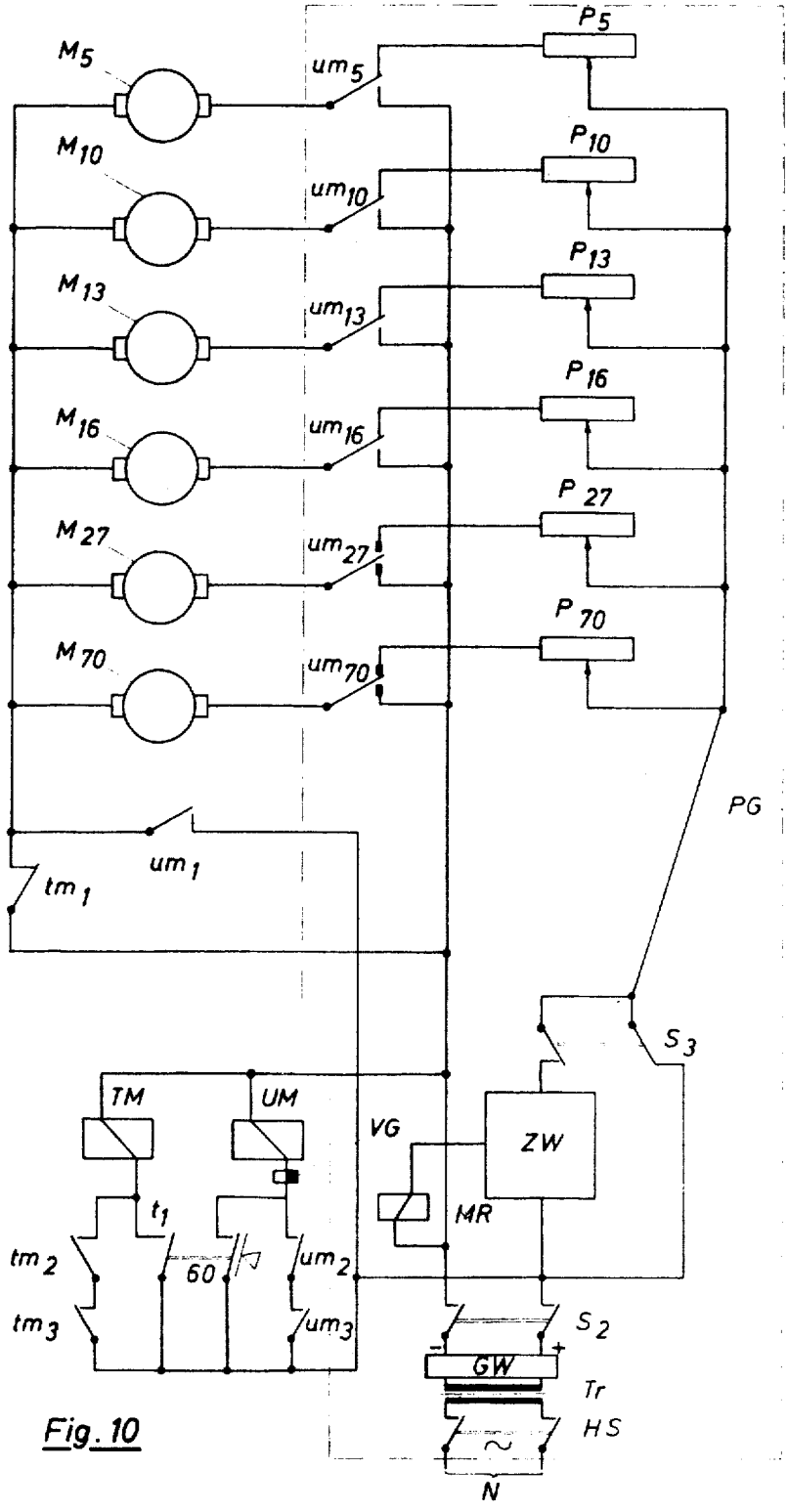

M5
M10
M13
M16
M27
M70
um5
um10
um13
um16
um27
um70
P5
P10
P13
P16
P27
P70
PG
um1
tm1
S3
TM
UM
VG
ZW
MR
t1
tm2
60
um2
tm3
um3
S2
GW
Tr
HS
N

Fig. 10

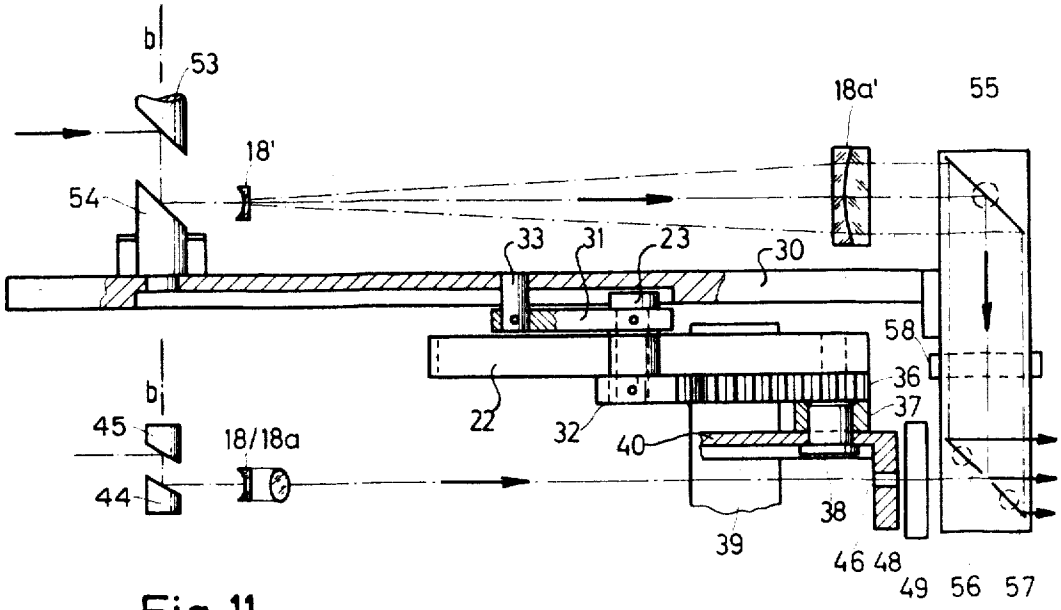

b
53
18'
54
18a'
55
33
31
23
30
58
36
37
22
32
40
b
45
18/18a
44
38
39
46
48
49
56
57

Fig. 11

TARGET SIMULATOR FOR A SIGHTING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a new and improved construction of target simulator for a sighting apparatus equipped with a movable mirror for optically portraying apparent movements of a target to be attacked at a ground-glass plate or the like and with a second mirror for generating a light mark which is effective for a period of time to indicate any existing aiming or directional errors arising during repositioning of the sighting apparatus.

Such target simulators are required for training the aiming gunners of manually aimed weapons, typically anit-aircraft guns.

With a known target simulator of this type a respective projector is secured to a respective stub shaft, these shafts being coaxially arranged and the confronting ends thereof are connected with a respective control cam support in the manner of a single-arm lever which can be pivoted under the action of guide pins at a carriage which is linearly displaced at constant speed by a motor. The light rays which are transmitted by the projectors onto the target disk or plate coupled with the simulator portray both the target movement and also the movement of the aiming-off or lead point in the form of light spots. In this regard attention is invited to German patent publication 1,198,249.

With such construction of target simulator, when changing the speed of the target disks must be exchanged and when changing the flight altitude of the target to be simulated there must be exchanged the saddle carrying the guide pins. Not only is such cumbersome and expensive but also constitutes a drawback for training the gunners. Furthermore, it is only essentially possible to simulate overhead flights. Although it is basically possible to simulate an inclined or slant incoming flight path of the target, still owing to the constructional features of the control apparatus and the target disk such only can be carried out within very narrow limits and even within these limits only then with distortion. The aiming-off value which is important for training a gunner is not automatically determined, rather must be calculated from case to case. The instructor therefore can only check the hit accuracy, not however the alignment or aiming accuracy.

However, the fighting efficiency of an anit-aircraft weapon which is to be manually aligned is dependent to a very great extend upon the speed and accuracy with which the aiming gunner can find and track the target which is to be attacked. Therefore, any training program must include exercises in spotting a target and tracking such target.

These exercises must be however as realistic as possible, i.e., the target to be simulated must be able to carry out all movements which correspond as closely as possible to those movements which are to be expected in actual battle. The target paths to be portrayed must be capable of simulation in virtually unlimited numbers, in order to preclude the possibility that the gunner to be trained can memorize the portrayed target flight paths. If this were to happen then there would be falsified the training results.

Moreover, such target simulator must be simple in construction and directly usable at the relevant anti-aircraft weapons or at so-called direction or aiming simulators, in order to thus especially simplify the basic training of the aiming gunners at such anti-aircraft weaponry and at the sighting devices associated with such weapons, without having to employ for this purpose actual aircraft targets, something which would be associated with high costs.

SUMMARY OF THE INVENTION

Hence, it is a primary object of the present invention to provide an improved construction of target simulator for a sighting apparatus or device which is not associated with the aforementioned drawbacks and limitations of the prior art proposals.

Another and more specific object of the present invention aims at the provision of a relatively simple and operationally reliable target simulator which essentially is composed of mechanical components, with the aid of which, apart from portraying the target, there can also be simulated the aiming-off value, which presupposes its calculation and portrayal according to magnitude and direction.

Another object of the invention aims at providing an improved construction of target simulator allowing for as intensive as possible training of a gunner and which training also encompasses the important aspects of target spotting, permits simulating interrupted target flights, individual- and group flights, the in-flight direction of the aircraft target at the range of the weapon, and finally also the shape and size of the aircraft target as a function of a programmed target flight and the distances resulting therefrom.

Starting from the considerations which have become known to the art from German patent publication 956,025 as concerns portraying the flight plane extending through a linear flight path FW of the target and intersects the horizontal, designated as the map plane (i.e. the horizontal extending through the base of the trajectory) KE, in a straight line which extends through the site of the weapon G, wherein the flight plane, assuming a random inclination angle, intersects an imaginary sphere circumscribed about the site of the gunner at a major circle, at which there are located the measurement points of the flight path, and the recognition that incoming target flights and their characteristics only can be judged from the site of the gunner, and specifically on the basis of the directional or aiming movements which occur during target tracking and not during spotting of the target, the objectives of the invention are realized in that the movable mirror is movably mounted about three axes which are perpendicular to one another, of which axes two coincide with the azimuth axis and the elevational axis of a weapon which is to be aligned. The element can be motor driven about each such axis by an amount corresponding to a programmable distance eW from the gun to a crossing point, an inclination angle of the flight plane within which there is located the target to be simulated, a flight inclination angle and target speed for generating the apparent target movement. Further, manually adjustable means are provided which are associated with the azimuth angle and the elevation angle by means of which there can be forced upon the movable mirror a motion directed opposite to the apparent movement of the target, and that for generating the light mark indicating the aiming or directional error there is provided a mechanism serving to simulate the aiming-off value as a function of predeterminable weapon ballistics, the

light mark of such mechanism being located at the cross hairs of the sighting device when there has been successfully carried out the aiming operation.

In this way there is generated a first light mark which portrays the aircraft target and is visible to the aiming gunner at the ground-glass plate or the like which is erected in front of the sighting device, and which light mark, with the exception of simulated direct incoming flights continuously changes its position as a function of the programmed distance eW from the gun to crossing point, the inclination angle of the flight plane, the flight inclination angle and the target speed and the angular speed or velocity resulting therefrom. The aiming gunner must align the weapon or an aiming simulator as a function of the portrayed target movements such that the first light mark which corresponds to the programmed target flight appearing at the ground-glass disk is brought into coincidence with a sighting mark, when the aiming-off value and the aiming-off direction of both mechanisms coincide. The directional or aiming movements resulting from such target tracking thus require at the target simulator a corresponding return of the first light mark.

For the purpose of controlling the aiming accuracy, there appears a second light mark, upon actuating an actuation element, at the ground-glass plate or disk of the target simulator as a function of the impact or hit point position calculated by the target simulator. When the aiming gunner has aimed correctly and the sighting device has correctly determined the aiming-off value and has pre-controlled such aiming-off value, then the second light mark appears at the center of the crosshairs of the sighting device, i.e. the ground-glass disk and which crosshairs are identical with the impact or hit point. Under the expression aiming-off value there is to be understood the value through which the gun barrel, compared to the aircraft target, must migrate from or lead such target, so that the projectile and the aircraft target impact along the flight path. The aiming-off direction in turn determines the course of such flight path through which the gun barrel must travel or migrate.

According to a further feature of the invention the movable mirror or element for generating the first light mark is arranged at the end of a lever arm which is pivotably mounted in a traverse or guide arm which can be moved to-and-fro along axes which are perpendicular to one another, and with which there is movably connected a second laver arm, at the end of which there is arranged a further mirror or element for generating the second light mark. Both lever arms are coupled with one another through the agency of a drive chain or equivalent structure, the transmission ratio of which is determined by a curve embodying the ballistics of the weapon. The traverse is preferably arranged upon a longitudinally movable carriage which is elevationally movable mounted in a ring movable about two axes which are perpendicular to one another, the bearing location thereof rendering possible movement about the vertical axis is pivotable about a transverse axis intersecting the null position of the movable element.

The bearing locations of the ring are carried by a frame which is movably mounted in a further frame, the spacing of which with regard to the ground-glass plate or disk is adjustable.

The drive of the components which are movable relative to one another occurs through the agency of servomotors which can be controlled via a programming device, whereas the components or parts simulating the speed of the target to be displayed are controlled via a tachogenerator.

In order to provide for as intensive training as possible, the invention is further predicted upon the features that particularly for the basic training the simulated target flights can be interrupted, so that the aiming errors can be immediately brought to the attention of the aiming gunner and not first upon expiration of the target flight.

According to a further feature of the invention, for the purpose of portraying two- or group-aircraft flights, the drive means of the movable element can be intermittently switched- or turned- on according to a prescribed timing program, wherein during the intervals between the switching operations there can be carried out an automatic change of the parameters characterizing the flight altitude, the flight direction or the flight inclination angle.

During the portrayal of the flight of two or more aircraft, i.e. the group aircraft flights, there do not appear at the same time on the ground-glass plate all of the light marks of the aircraft constituting the group flight, rather in each case only one light mark, which again disappears after the first fire surge, i.e. directly after releasing the trigger and non-visibly returns to a starting position in accordance with a programmed time-delay. As soon as such time-delay has expired the light mark again lights up and there begins a new target flight. By means of an easy adjustment of the programmed flight characteristics, such as for instance the flight altitude, the flying or approach direction or the flight inclination angle, during the time the light mark returns back into its starting position, the light mark again appears as previously, but under other starting conditions, so that the aiming gunner experiences the feeling that there actually appears another aircraft target. Judgment of the aiming accuracy, in other words, interruption of the progress of the simulation operation, is also insured for during the flight of two or more aircraft. In this manner the aiming gunner can practice rapid target changes. This affords the possibility that for light and intermediate anti-aircraft defenses, there can be practiced the very important target spotting operations under approximately actual battle conditions. Finally, precautions are to be undertaken to ensure that the size and shape of the aircraft target changes as a function of the distance and the programmed target flight; in this way the aiming gunner who is to be trained has the feeling that the target actually is approaching the position of the gun.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 to 5 geometrically illustrate target incoming or approach flights to be simulated and the aiming-off values associated with such target incoming flights;

FIG. 6 is a geometric illustration of the return of the first light mark during simulation of the target flight;

FIG. 7 is a perspective view of a target simulator designed according to the teachings of the present invention;

FIG. 8 is a side view portraying individual components of the target simulator;

FIG. 9 is a top plan view of the target simulator;

FIG. 10 is an electrical circuit diagram; and

FIG. 11 is a plan view showing individual components of the system depicted in FIG. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to facilitate the understanding of the concepts of the invention, there will be more particularly explained on the basis of FIGS. 1 to 5 the target incoming or approach flights which are to be simulated.

The target flights which are to be simulated can be subdivided into three primary groups, namely direct incoming or approach flights, overhead or overflights, and fly-by flights. In this regard, if there are not considered the so-called underflights which, with the exception of the target incoming flight according to FIG. 3, only occurs very seldom and then generally only can occur in mountainous terrain, one is basically dealing with horizontal or inclined or slant flights.

During horizontal flights the flight inclination angle ν is equal to 0°, during inclined or slant flights it can theoretically reach 90°. Inclined flights also can be distinguished from horizontal flights by their incipient greater flight altitude, i.e. by the greater elevational angle γ, which can be ascertained during spotting of the target. During underflights, the elevation angle γ always decreases during target tracking.

FIG. 1 illustrates a direct incoming or approaching flight flying towards the weapon or gun located at the center point G of map plane KE. The aircraft target, located at the measurement point M of the flight plane FE, which encloses an angle $\tau = 90°$ with the map plane, moves along the flight path FW, which is characterized by the flight inclination angle ν, in the direction of the gun G. Since the weapon located at point G is being directly flown towards by the aircraft, there neither results directional movements of the weapon or gun nor angular speeds which can be derived therefrom towards the side and elevationally. The aiming- off path S plotted along the flight path FW can be derived from the elevation V.t, wherein V represents the target speed and t the projectile flight time from location G until the impact or hit point T. The aiming-off path S therefore corresponds to the previously mentioned aiming-off value. It therefore must be directly aligned with the crosshairs.

FIG. 2 illustrates an inclined or slant overflight, i.e. the aircraft target located at the measurement point M moves along the flight path FW characterized by the flight inclination angle ν and the distance eW from the gun G to crossing point W, the aircraft target moving along such flight path FW in the direction of the crossing point W and the object Ob. Since the flight path FW possesses a distance eW from the gun G to crossing point W, and since the inclination angle $\tau = 90°$, the weapon is only to be elevationally aligned or directed; from the elevational alignment movement there results a corresponding elevational or vertical angular velocity. Consequently, the triangle formed by the lines G–%, G–M, and M–T encloses between the lines G–T, and G–M the aiming-off or lead angle, the value of which is determined by the distance eW from the gun G to crossing point W and the aiming-off path S. The aiming-off direction is given by the inclination angle τ, i.e. with a value of τ of 90° it always amounts to 0°.

For sighting during the aiming operation as the aiming-off or lead mark, there thus comes into consideration the point of intersection between the lower vertical polar line PS (cf FIG. 6) and the aiming-off curve VK associated with an inclined or slant overflight of the aircraft. With increasing elevational movements aiming always must be carried out with the lower range of the sighting image.

FIG. 3 illustrates an inclined underflight, that is to say, the flight path FW, characterized by the flight inclination angle ν and the distance eW from the gun G to the crossing point W, extends beneath the weapon G, i.e., the distance eW from the gun G to the crossing point W, compared to the distance eW from the gun G to the crossing point W which has been explained in conjunction with FIG. 2, has a decreasing elevational movement.

The aiming-off or lead conditions, notwithstanding a certain similarity with those of FIG. 2 as concerns the aiming-off direction, in this instance are completely different, since owing to the decreasing elevational movements in the case of underflights it is necessary to aim with the upper portion of the sighting image. Since also with this type of flight the value $\tau = 90°$, it is necessary to aim with the vertical yet upper polar line PS of the sighting image.

With the flight path FW which has been depicted in FIG. 4, characterized by the distance eW from the gun G to the crossing point W and towards which the aircraft target located at location M flies in the direction W, one is dealing with a horizontal overflight, i.e. the flight path FW extends parallel to the track OO. With horizontal overflights and underflights, the distance eW from the gun G to the crossing point W corresponds to the flight altitude h.

As was the case for all of the previously discussed flight paths, here also the inclination angle τ amounts to 90°. Accordingly, also with this flight the angle of the apparent flight direction, i.e. the aiming-off direction, always remains at null, so that the aiming gunner also for such flight must aim with the vertical lower polar line PS of the sighting image.

Since with horizontal flights the starting aiming-off angle is always somewhat greater than for inclined or slant flights, the aiming gunner, during aiming of the gun or weapon, must select a correspondingly larger aiming-off value or lead.

FIG. 5 portrays a horizontal fly-by of the aircraft, at an angle $\tau < 90°$, in which the flight path FW, which is characterized by the distance eW from the gun G to the crossing point W, extends from location M to location W and forms at the map plane KE, owing to the inclined flight plane FE, the flight path FW which extends parallel to the track OO. The distance eW from the gun G to the crossing poing W no longer corresponds to the flight altitude h, as was the case for overflights and underflights or depressed flights. Additionally, there appears at the map plane KE a map slant range to crossing point ekW.

By virtue of the inclined flight plane FE, during target tracking, apart from the elevation angle γ there also results a lateral or azimuth angle σ. From both angles γ and σ there appears at the flight plane FE the aiming angle σ'. These three angles form a spherical triangle in which there is contained the angle σ designating the apparent flight direction, i.e., the aiming-off or lead direction, which now no longer remains constant, rather assumes an ever increasing value and at the reference

point W, compared to the vertical, always reaches the value 90°.

The aiming gunner now no longer must carry out aiming of the weapon with the vertical polar line, rather with a polar line PS which is located between the vertical and the horizontal, wherein the angle of the apparent flight direction δ, considered from the vertical polar line, always becomes greater. As concerns the aiming-off or lead magnitude in this instance, the conditions are the same as for a horizontal overflight.

The previously mentioned straight lines G–T, G–M, and M–T, wherein G–T represents the impact or hit distance, G–M the measurement distance and M–T the aiming-off or lead path S, constitutes the starting position for the aiming simulator which will be described shortly hereinafter in conjunction with FIGS. **7** to **10**. In FIG. **6** the straight line G–M has been designated by the M-arm and carries the light mark ML which simulates the aircraft target at the measurement point, and which light mark disappears upon actuation of the weapon trigger, whereas the straight line G–T designated by the T-arm, and which carries the light mark TL which simulates the aircraft target at the hit or impact point, illuminates upon actuation of the weapon trigger. By rotating the weapon through the value γ (elevation angle) and σ (azimuth angle), the light mark ML is adjusted as a function of the aiming-off value according to magnitude and direction such that it appears at the aiming-off or lead curve. When the aiming gunner has properly considered the aiming-off value, then the impact or hit light mark TL, upon actuation of the weapon trigger, must appear at the crosshairs FK of the sighting image VB.

Turning attention now to the system disclosed in FIG. **7**, it is to be understood that a bracket **2** is rotatably supported by means of bearings **3** for rotation about the axis *b—b* in a housing frame **1**. By means of a not particularly illustrated parallelogram and through the agency of a lever arm **4** the aiming movements carried out by an aiming gunner who is to be instructed is transmitted to the bracket **2** for the purpose of returning the light mark ML which will be still considered more fully hereinafter, as a function of the elevation angle γ.

With the aid of a synchronous drive **5**, which is secured to a carrier **6** connected with the lever arm **4**, it is possible to undertake an adjustment corresponding to the flight inclination angle ν, wherein the bracket **2** is adjusted with respect to the lever arm **4** and thus with regard to the elevation angle γ by the value ν.

A disk **7** and a bearing element **8** are rotatably mounted about an axis **9** at the bracket **2** and are adjusted through the agency of a synchronous drive **10** and a gearing arrangement **11** as a function of the lateral or azimuth angle δ of the movement of the weapon G, which likewise results in a return, in a manner also more fully described hereinafter, of the light mark ML. With the aid of the synchronous drive **10** and the gearing arrangement **11**, it is possible to also transmit a programmed flying-in direction of the aircraft target to the disk **7** and the bearing element **8**.

Now at the bearing or support element **8** a toothed segment **12** which is constructed as the primary support, is mounted in such a way that it can be rotated through the agency of a synchronous drive **13** (see also FIG. **9**) as a function of the inclination angle τ of the flight plane FE about the imaginary point G of the map plane KE, and specifically about the track OO forming an axis.

A carriage **21** guided by bolts **19** and **20**, as best seen by referring to FIG. **9**, is displaced by a threaded spindle **15** in the direction of the point G which appears at the axis *b—b*, and which threaded spindle **15** is moved by a motor tachogenerator **16** via miter gearing **17** as a function of a programmed target speed V along the horizontal *a—a*, which corresponds to the track OO in FIGS. **1** to **5**. The bolts **19** and **20** as well as the threaded spindle **15** are mounted at a substantially U-shaped support or carrier **14**, which also can be displaced in a manner to be explained more fully hereinafter.

Due to this displacement of the carriage **21**, there is also displaced, likewise along the horizontal *a—a*, a traverse **22** connected with the carriage as well as a bolt **23** which marks the hit or impact point T, (compare FIGS. **1–5**).

The carrier **14** is guided by the bolts **24** and **25**, which likewise are secured at the toothed segment **12** and can be adjusted, starting from the horizontal *a—a*, in the vertical plane *c—c* with the aid of threaded spindle **26**, a synchronous drive **27**, a transmitter **28** and a gearing **29** (FIG. **9**), wherein the bolt **23** mounted at the traverse **22** can be raised or lowered as a function of a programmed distance *e*W from the gun G to the crossing point W.

The bolt **23** engages with a T-arm **30** which is pivotably mounted at the toothed segment **12** with the aid of the bearing bolt **51** at the axis *b—b*, at which there is likewise located the imaginary point G (weapon site).

As best seen by referring to FIG. **8**, there is secured on the one hand to the bolt **23** a lever arm **31** and on the other hand a toothed segment **32**. A pin **33** connected with the lever arm **31** engages into a ballistic curve **34** located at the T-arm **30**. Due to displacement of the bolt **23** along the horizontal *a—a* in the direction of the axis *b—b* and owing to the fact that such is guided in a groove or track **35** of the T-arm **30**, thus during displacement of the carriage **21** the lever arm **31**, the bolt **23** and the toothed segment **32** carry out a rotational movement, whereby a toothed rack **36** engaging with the toothed segment **32** and a M-carrier or support **37** connected with rack **36** and displaceably mounted at the traverse **22** carry out an additional movement which likewise extends along the horizontal *a—a*.

A bolt **38** mounted at the M-carrier **37** (FIG. **7**) engages into a groove **39** of an M-arm **40** which is likewise mounted to be rotatably movable and is located at the toothed segment ring **12** at the axis *b—b*. Since the carrier **37** is fixedly connected with the toothed rack **36**, the bolt **38** is likewise displaced along the horizontal *a—a*, wherein the distance AB (FIG. **8**) corresponding to the aiming-off path S and which separates the bolt **38** from the bolt **23** is decreased as a function of the ballistic curve **34** (cf. FIG. **1**).

The ballistic curve **34** as well as the radius R_1 (cf. FIG. **8**) of the lever arm **31** satisfy a multiplicity of target speeds V, provided that for each target speed there is calculated a different radius R_2 of the toothed segment **32** and such is exchanged as a function of the desired target speed V and at each instance the aiming-off path S is properly adjusted as a function of the maximum impact or hit distance.

In order to avoid exchange of the toothed segment **32** and in order to be able to infinitely program the aiming-off path S and the target speed or velocity V, the spacing A between the ground-glass plate or disk **47** or equivalent structure and the axis *b—b* is adjustably arranged. The spacing A is proportional to the speed or velocity V. The projection S' of the aiming-off path S appearing at the ground-glass plate **47** corresponds to the tangent function of the aiming-off angle Δ which can be calculated according to the following equation.

$$S' = A \times \tan \Delta = A \times \frac{S \cdot \sin \delta'}{eT + S \cos \delta'},$$

and wherein S' is the aiming-off path on the ground-glass plate **47**.

In order to change the distance A (FIG. 7) between the ground-glass plate **47** and the axis *b—b* in the housing the housing frame **1** is displaceably mounted in the direction **72** and can be accordingly displaced by electric motors **70**.

In order to render discernible to the aiming gunner the aircraft target M determined by the bolt **38**, a laser light source **41** secured to the toothed segment **12** projects a light beam via mirrors **42** and **43** secured to the bracket **52** and via the mirror **44** secured at the axis *b—b* of the toothed segment **12** upon a mirror **45** which is rotatably secured to the M-arm **40** for rotation about the axis *b—b*. This mirror **45** deflects the light beam via the lenses **18** and **18***a* through slot **46** provided at end surface **48** so as to impinge upon the ground-glass plate **47**, where it appears in the form of the ML-light mark. The lenses **18** and **18***a* serve to enlarge the diameter of the laser beam and to maintain the path of the light rays parallel, so that the ML-light mark appears the same size at the ground-glass plate or disk for each spacing A.

The diaphragm **49** which is mounted in front of the slot **46** of the end surface or face **48** of the M-arm **40** is adjusted as a function of the bolt **38** which is movable in the direction *b—b*, such that the ML-light mark with maximum distance to the target, appears at the ground-glass plate **47** in the form of a spot or point and with decreasing distance, in conjunction with the slot **46** and the lenses **18** and **18***a* takes the form of an enlarging line, with the result that there is rendered discernible to the aiming gunner the lengthwise axis of the aircraft and thus also the apparent flight direction. Stated in another way, according to the showing of FIG. **11** a diaphragm **49** is arranged in front of the slot **46** in the end face **48** of the M-arm **40**, this diaphragm being adjustable by the movement of the arm **40**, so that the light mark ML becomes larger or smaller. A large light mark ML is intended to indicate that the target is close, a small light mark ML signifies a target which is at a great distance. With increasing light mark ML the target comes closer to the gunner, with the light mark becoming smaller the targer moves away from the gun or weapon G. With the aid of the slot **46** and the lenses **18** and **18***a* the enlarging mark ML is converted into a line-shaped mark.

On the basis of the just-described light mark ML, it is possible for the instructor to check the progress or course of the aiming operation, not however the aiming accuracy. In order to also provide this possibility, there is rendered discernible at the ground-glass plate or disk **47** a light mark TL in the following manner:

Upon actuation of the weapon trigger **60** (FIGS. **7, 9** and **10**), a mirror **50** is moved by the switching magnet TM into the path of the light rays of the laser light source **41**. Consequently, on the one hand the light beam between the mirrors **42** and **43** is interrupted, and the ML-light mark disappears and, on the other hand, the light beam is deflected to a mirror **53** which is located at the axis *b—b*. From this location the light beam is transmitted via a mirror **54** connected with the T-arm **30**, through the agency of the optical lenses **18'** and **18***a'* to a mirror **55**. This mirror **55** conducts the light beam to the semi-reflectors **56** and **57** and finally upon the ground-glass disk **47**. The semi-reflectors **56** and **57** are arranged such that the light beam which impinges through the slot **46** is not interrupted. An iris diaphragm **58** is located between the mirror **55** and the semi-reflectors **56** and **57**, and controlled in the same manner as that of the M-arm, enlarges the TL-light marks which appear at the ground-glass disk **47** in such a way that the instructor can judge the aiming accuracy as a function of the impact or hit distance.

The correlation of the points portrayed in FIGS. **1** to **6** and the switching elements of FIGS. **7** to **9** is as follows: In the null position of the target simulator, the weapon is located at the intersection point of the axes *a—a* and likewise at the axes *b—b* the horizontal *a—a* corresponds to the track OO, the T-arm to the line G-T, the M-arm to the line G-M, the bolt **23** to the impact or hit point T, the bolt **38** to the measurement point M, the spacing between the bolts **23** and **38** to the aiming-off or lead path S, the spacing between the horizontal *a—a* and the line defined by the bolts **23** and **38** to the distance *e*W from the gun G to the crossing point W, the displacement of the bolt **38** to the target movement along the flight path FW, and the rotation of the toothed segment **12** to the adjustment of the inclination angle τ of the flight plane FE.

If, for instance, there is not adjusted any distance *e*W from the gun G to the crossing point W, then the bolts **23** and **38** move along the horizontal *a—a*, corresponding to a direct incoming flight without angular velocities, i.e. that end of the M-arm **40** confronting the ground-glass disk **47** does not move and remains in the horizontal *a—a*. If with the same conditions there is adjusted a flight inclination angle ν then the entire mechanism mounted upon the bracket **2** is rotated through the value ν, corresponding to a programming of the direct incoming flight discussed in conjunction with FIG. **1**.

During adjustment of the distance *e*W from the gun G to the crossing point W, the bolts **23** and **38** move away from the horizontal *a—a*. Due to the movement of the bolt **38** in the groove **39** of the M-arm **40** in the direction of the axis *b—b*, the M-arm **40** rotates about axis *b—b* and together with the horizontal *a—a* forms an angle. The smaller the spacing between the axis *b—b* and the bolt **38**, that much greater is the size of this angle. To the same degree there is also increased the speed or rate of increase of the angle, with the result that the angular speed of the aircraft target is simulated. Because of the aiming-off or lead path S, the bolt **23** is situated closer to the axis *b—b* than the bolt **38** there is formed the aiming-off angle Δ between the T-arm and the M-arm.

In FIG. **10** there are illustrated six motors M_5, M_{10}, M_{13}, M_{16}, M_{27} and M_{70} which correspond to the motors (synchronous drives) **5, 10, 13, 16, 27** and **70** in FIG. 7, i.e.

with the motor M_5 the bracket **2** (FIG. 7) can be pivoted about the axis *b—b* in accordance with the elevation angle γ,

with the motor M_{10} the toothed segment **12** can be pivoted about the axis *c—c* (FIG. **9**) in accordance with the azimuth angle δ,

with the motor M_{13} (FIGS. 7 and **9**) the toothed segment **12** can be pivoted about the axis *a—a* in accordance with the inclination of flight plane τ,

with the motor M_{16} (FIGS. 7 and **9**) (tachogenerator **16**) the carriage **21** can be displaced on the bolts **19** and **20** along the axis *a—a* in accordance with the target speed V,

with the motor M_{27} the carriage **14** can be displaced on the bolts **24, 25** along the axis *c—c* corresponding to the distance *e*W of the gun G from the crossing point W of the liner flight path FW of the target M,

with the motor M_{70} it is finally possible to displace the housing frame **1** relative to the ground-glass plate **47** and to change the distance A.

Each motor M_5, M_{10}, M_{13}, M_{16}, M_{27} and M_{70} has associated therewith a potentiometer P_5, P_{10}, P_{13}, P_{16}, P_{27} and P_{70} respectively, by means of which there can be selected the elevational angle γ (P_5), the azimuth angle δ (P_{10}), the inclination of flight plane τ (P_{13}), the target speed V (P_{16}), the distance *e*W from the gun to the crossing point W (P_{27}) and the distance A (P_{70}). By means of the switches um_5, um_{10}, um_{13}, um_{16}, um_{27}, and um_{70} it is possible to reverse the direction of rotation of the motors M_5, M_{10}, M_{13}, M_{16}, M_{27} and M_{70} respectively, in order to again pivot back all of the components (**1**, 2, 6, 12, 14, 21, 22) into their starting position.

In FIG. **10** there is further illustrated a contact t_1 which can be actuated by the weapon trigger **60** for actuating a switching magnet TM by means of which the mirror **50** illustrated in FIG. **9** can be pivoted into the light beam.

Furthermore, by means of the trigger **60** it is possible to actuate the holding contact um_2 which, through the agency of a time-delay element VG and a switching magnet UM, switches over or reverses the switches um_5, um_{10}, um_{13}, um_{16}, um_{27} and um_{70}. In the event that a number of flight targets are to be simultaneously taken into account (group flights), then by means of a hand switch S_3 it is possible to switch-in a timing mechanism ZW for actuating the contacts tm_3 and um_3 through the agency of a switching magnet MR.

In order to generate a direct-current voltage there is connected to an alternating-current network N a direct-current voltage transformer GW by means of a main switch HS. In order to switch-in the electrical system there is provided a trigger switch S_2.

A simulation operation now occurs in the following manner: After the instructor has adjusted at the programming device PG (FIG. **10**) provided for such instructor the magnitudes necessary for simulation of a target flight with the aid of the potentiometers P **5**, P **10**, P **13**, P **16** and P **27** possessing a not particularly illustrated switch, then upon actuation of the main switch HS, the target simulator is connected with the current supply network, and upon actuation of the trigger switch S_2 said target simulator is switched-on. A not particularly illustrated direct-current voltage transformer provides the necessary direct-current voltage. The motors which have been turned-on now, in the manner described above, move the therewith associated switching elements out of the rest position, so that the light beam which is produced via the laser light source **41** and which is deflected via the reflectors or mirrors **42** and **43** and departs throught the diaphragm **46** of the M-arm **40** produces a light mark ML which migrates across the ground-glass disk **47** in accordance with the simulated target flight. The aiming gunner trainee who occupies the seat **64** by actuating the elevation wheel **65**, which is connected via an electrical or mechanical drive with the lever **4**, must move the bracket **2** as a function of the elevational angle γ about the axis *b—b*. In completely analogous manner by actuating the foot plate or pedal **66**, which is connected via an electrical or mechanical drive with the housing frame **1**, it is possible to pivot the bracket **2** about the axis *c—c* as a function of the azimuth angle δ. The bracket **2** thus on the one hand is pivoted by the synchronous drive **5** about the elevation axis *b—b* and by the synchronous drive **10** about the azimuth *c—c* (**9**) and, on the other hand, the bracket **2** is pivoted in the opposite direction by means of the elevation wheel **65** likewise about the elevation axis *b—b* and by means of the foot plate or pedal **66** likewise about the azimuth axis *c—c*. Both manual adjustment means are to be actuated in such a way that the migrating light mark ML arrives at the crosshairs FK, i.e. at the aiming-off curve VK along one of the radius vectors or polar lines PS of the sighting image which has been portrayed at the ground-glass plate **47**. If this is the case then the aiming gunner, by actuating the trigger **60**, by means of which the contact t_1 is actuated, can interrupt the aiming operation. By closing the contact t_1, the switching magnet TM is energized, i.e. responds, so that the contact tm_1 is opened and thus the current supply circuit of the aforementioned electric motors is interrupted. As a result, the deflecting mirror **50***a* is simultaneously brought into the path of the light rays of the laser light source **41** (FIG. **9**), so that the light beam now is deflected via the T-arm **30** and via the mirrors **55, 56** and **57** carried by such T-arm **30** onto the ground-glass plate **47**. If the aiming gunner has carried out a correct sighting operation, then the thus-generated light spot TL appears at the impact or hit point T, that is to say, at the central point of the crosshairs FK. By means of the holding contact tm_2 it is possible to hold the magnet TM.

With the response of the switching magnet TM, there is also energized with a time-delay, via a time-delay element VG, the switching magnet UM which closes the holding contact um_2 and moves the contacts um_5 to um_{70} into their work position. Consequently, the polarity of all of the motors is reversed and the extended or displaced switching elements again move back into the rest position. As soon as they reach this position, they open the contacts tm_3 and um_3, so that the magnets TM and UM no longer have current supplied thereto and the electrical starting position is again reached.

Also upon release of the trigger **60** the aforementioned switching magnets are without current. Upon actuation of the release or trigger switch S_2 there can occur a new simulation operation.

In order to be able to simulate a flight by a plurality of aircraft, there is provided at the programming device

a timing mechanism or timer ZW which can be switched-on via a switch S_3. In this way the operation of the trigger **60** is changed in the manner that when it is actuated, directly after the illumination of the light mark TM, there is triggered reversal of the switching means via a briefly effective switching magnet MR, which actuates the contacts tm_3 and um_3. Therefore, to the gunner there appears that from the same flight direction there again arrives a target which is portrayed by the light mark ML, so that he must repeat his aiming procedure. If fly-by modes are to be simulated, then the main carrier **12** must be rotated with the aid of the motor **13** shown in FIG. **7**. With increasing adjustment of the main carrier **12** the flight plane τ becomes smaller and with an adjustment of 90° reaches the smallest value, that is to say, 0°.

The light mark ML which is generated during the simulation operation then moves, with regard to FIG. **7**, transverse to the ground-glass plate **47**.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims. Accordingly,

What is claimed is:

1. A target simulator for a sighting device of a gun comprising;

a light source (**41**) for transmitting a light beam;

a ground-glass plate (**47**);

a first movable mirror (**45**) arranged in the path of said light beam for portraying at said ground-glass-plage (**47**) by means of a first light mark (ML) the apparent movement of a target (M) which is to be attacked;

a scond movable mirror (**54**) arranged in the path of said light beam for generating a second light mark (TL) which is effective for indicating an aiming error arising during adjustment of the sighting device;

a first lever arm (**40**), the first mirror (**45**) being arranged at an end of said first lever arm (**40**);

a second lever arm (**30**), the second mirror (**54**) being arranged at an end of said second lever arm (**30**);

drive means (**23, 31, 32, 33, 36, 37, 38**) for operatively interconnecting both lever arms with one another;

means for mounting said two lever arms (**30, 40**) so as to be movable about three axes (*a—a*, *b—b*, *c—c*) which are perpendicular to one another;

means for motor driving (**5, 10, 13, 16, 27**) said movable lever arms (**30, 40**) about each such axes (*a—a*, *b—b*, *c—c*) by an amount corresponding to:

a. a programmable distance (eW) from the gun (G) to a crossing point (W) of the linear flight path (FW) of the target,

b. a programmable inclination angle (τ) of the flight plane (FE) within which there is located the target to be simulated,

c. a programmable target velocity for generating the apparent target movement; and

manual adjustment means (**65, 66**) provided for the azimuth angle (δ) and the elevation angle (γ).

2. The target simulator as defined in claim **1**, said mounting means including a traverse (**22**) mounted for to-and-fro movement along axes (*a—a*) (*c—c*) which are perpendicular to one another, said first lever arm (**40**) being pivotably mounted at said transverse (**22**), said second lever arm (**30**) being movably connected with said traverse (**22**).

3. The target simulator as defined in claim **2**, said drive means further including a curve (**34**) embodying the ballistics of the weapon and determining a transmission ratio for said interconnected lever arms (**30, 40**).

4. The target simulator as defined in claim **3**, further including a lengthwise displaceable carriage (**21**), said traverse (**22**) being arranged at said lengthwise displaceable carriage (**21**), a ring member (**12**) movable about two axis (*b—b*) (*c—c*) which are perpendicular to one another, said carriage (**21**) being arranged on a carrier (**14**) which is elevationally displaceably movable at said ring member (**12**), bearing means (**8**) for the ring member (**12**) for rendering possible movement of the ring member (**12**) about a vertical axis (*c—c*), said bearing means (**8**) being pivotable about a transverse axis (*b—b*) which intersects a null position of the first mirror (**45**).

5. The target simulator as defined in claim **4**, further including bracket means (**2**) for supporting the bearing means (**7, 8**) of the ring member (**12**), a frame (**1**), said bracket means (**2**) being pivotably mounted at said frame (**1**) which is adjustable in its spacing (A) from the ground-glass plate (**47**).

6. The target simulator as defined in claim **5**, wherein the drive means of components (**2, 6, 12, 14 21**) which are movable relative to one another comprises servomotor means (M_5, M_{10}, M_{13}, M_{27}, M_{70}), programming means (PG) for controlling said servomotor means, and a servo-motor (M_{18}) equipped with a tachogenerator for controlling components (**21, 22**) simulating the velocity of the target (M) to be portrayed.

7. The target simulator as defined in claim **6**, further including means (**70**) for adjusting the spacing (A) between the ground-glass plate (**47**) and a null point (G) of the target simulator.

8. The target simulator as defined in claim **4**, further including a toothed rack (**36**) fixedly connected with the carriage (**21**) driven by a drive motor with tachogenerator (M_{16}), said traverse (**22**) being secured to said toothed rack (**36**), a toothed segment (**32**) rotatably mounted at a bolt (**23**) and meshing with said toothed rack (**36**), said toothed segment (**32**) being provided with a lever arm (**31**) engaging by means of a pin (**33**) at the curve (**34**) embodying the ballistics of the weapon of a T-arm defining said second lever arm (**30**) pivotably mounted at the ring member (**12**), a support (**37**) rigidly connected with the toothed rack (**36**), said support (**37**) engaging by means of a bolt (**38**) in a groove (**39**) of an M-arm defining said first lever arm (**40**) pivotably mounted at the ring-member (**12**), wherein during substantially linear movement of the carriage (**21**) there occurs a curve-controlled pivotal movement of the first lever arm (**40**) and the second lever arm (**30**).

9. The target simulator as defined in claim **1**, wherein the drive means of the first movable mirror (**45**), for the purpose of portraying a flight of a plurality of aircrafts, is provided with a timing mechanism (ZW) which can be intermittently turned-on for portraying the flight of a plurality of aircrafts according to a predetermined timing program, wherein at the intervals between the switching operations of the timing mechanism (ZW) there can be carried out an automatic change of the parameters characterizing the flight alti-

tude (h), the flight direction (δ) or the flight inclination angle (γ).

10. The target simulator as defined in claim **1**, further including diaphragm means (**49, 58**) arranged at the path of the light beam, the opening of said diaphragm means (**49, 58**) being variable as a function of the simulated flight time of the simulated target.

11. The target simulator as defined in claim **1**, further including a laser light source constituting said light source (**41**), optical means (**18, 18***a*) including reflector means (**42, 43, 44, 45, 50, 53, 54, 55, 56, 57**) and variable diaphragm means (**49, 58**) for spreading out the laser light beam in its cross-section such that there appears upon the ground-glass plate (**47**) a target image which increases in size in proportion to a reduction in the target distance.

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