O. RITTER VON EBERHARD.

SIGHTING DEVICE FOR GUNS.

APPLICATION FILED JAN. 12, 1909.

988,760.

Patented Apr. 4, 1911.

3 SHEETS—SHEET 1.

Fig. 1.

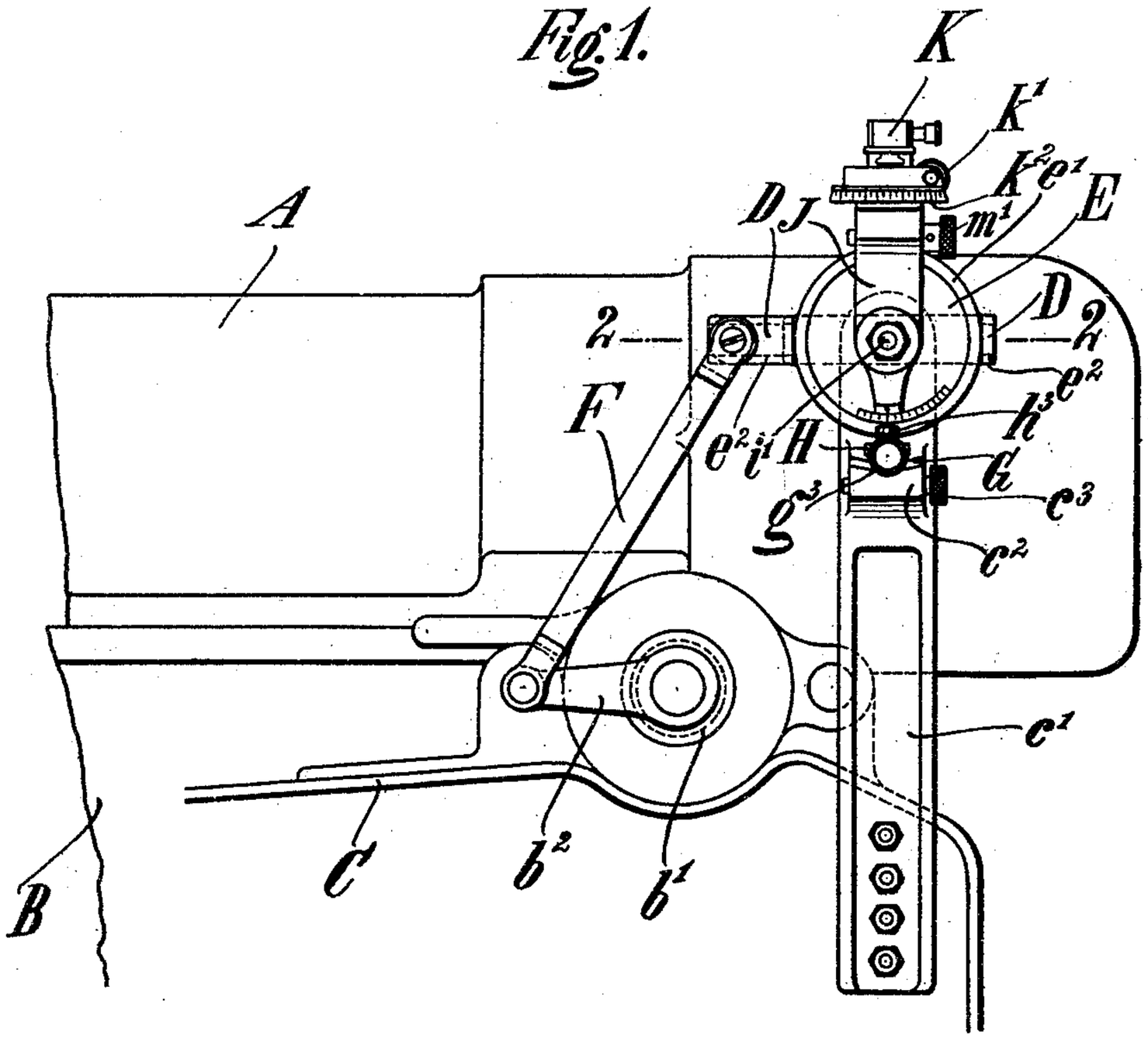
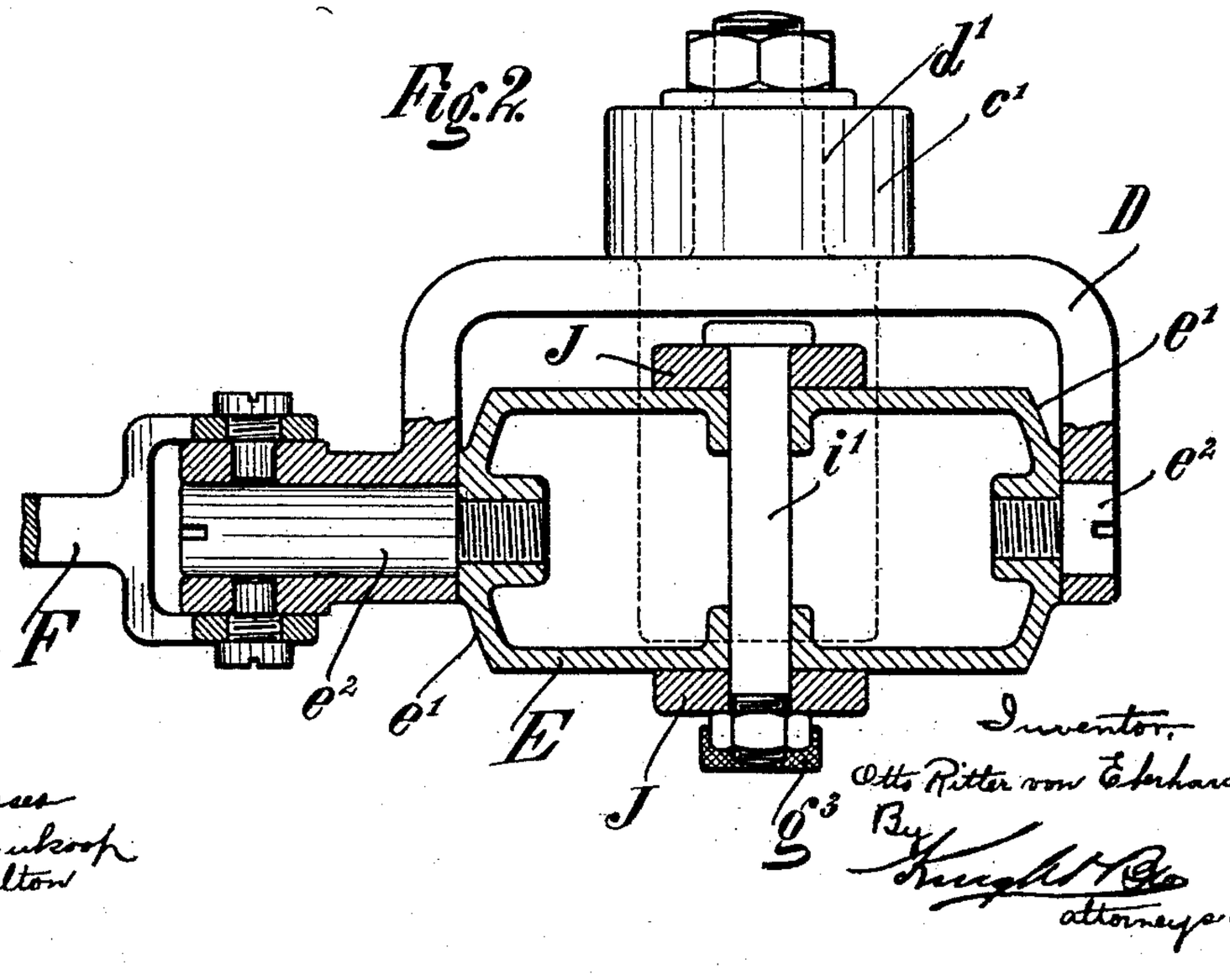


Fig. 2.



Witnesses
J. M. Hyslop
C. B. Melton

Inventor.
Otto Ritter von Eberhard
By Knight Bros
attorneys.

49

O. RITTER VON EBERHARD.

SIGHTING DEVICE FOR GUNS.

APPLICATION FILED JAN. 12, 1909.

988,760. Patented Apr. 4, 1911.

3 SHEETS—SHEET 2.

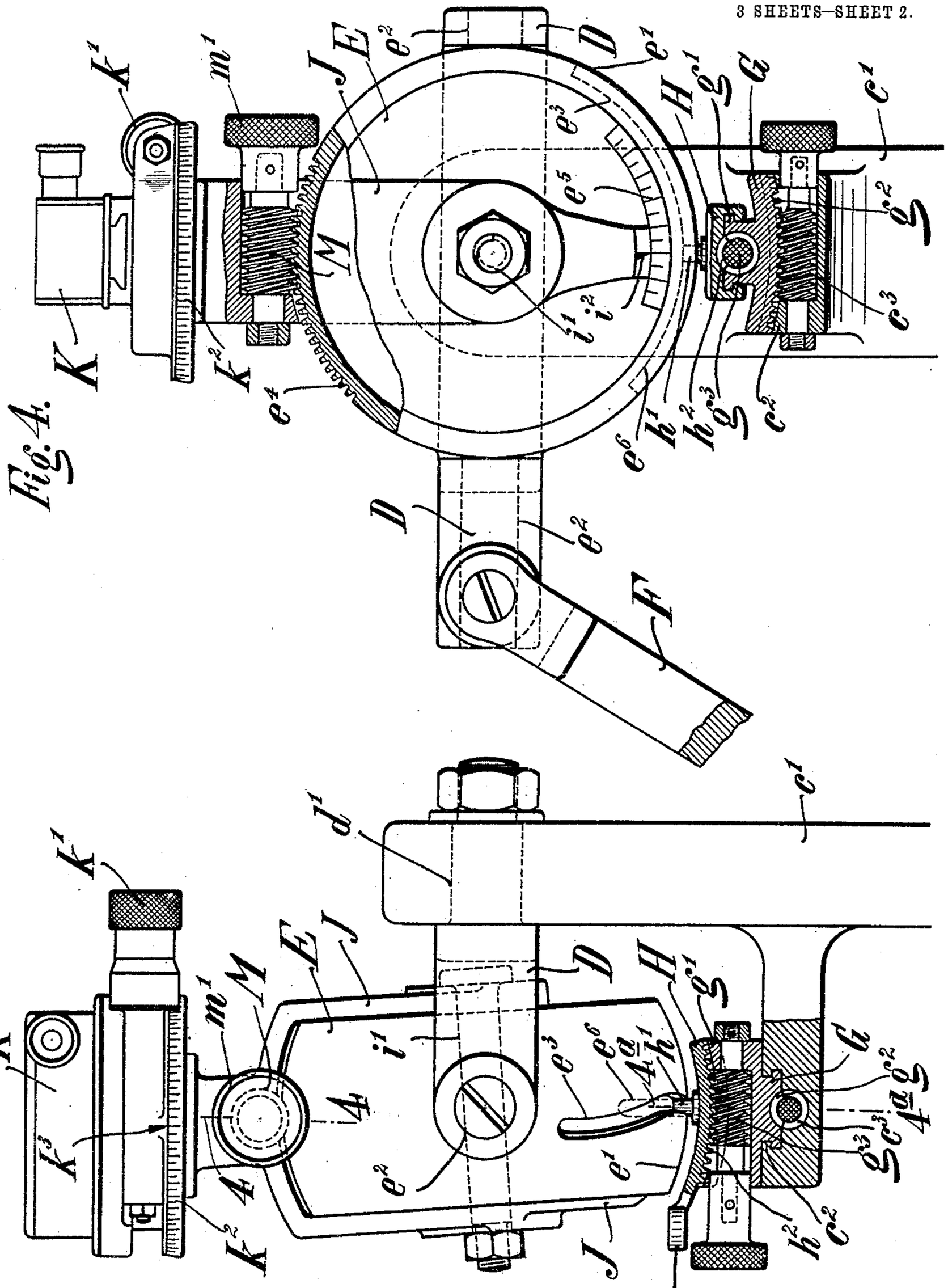


Fig. 4.

Fig. 3.

Witnesses
J. W. Wyckoff,
C. B. Shelton.

Inventor
Otto Ritter von Eberhard
By Knight Bros
attorneys.

49

O. RITTER VON EBERHARD.

SIGHTING DEVICE FOR GUNS.

APPLICATION FILED JAN. 12, 1909.

988,760.

Patented Apr. 4, 1911.

3 SHEETS—SHEET 3.

Fig. 6.

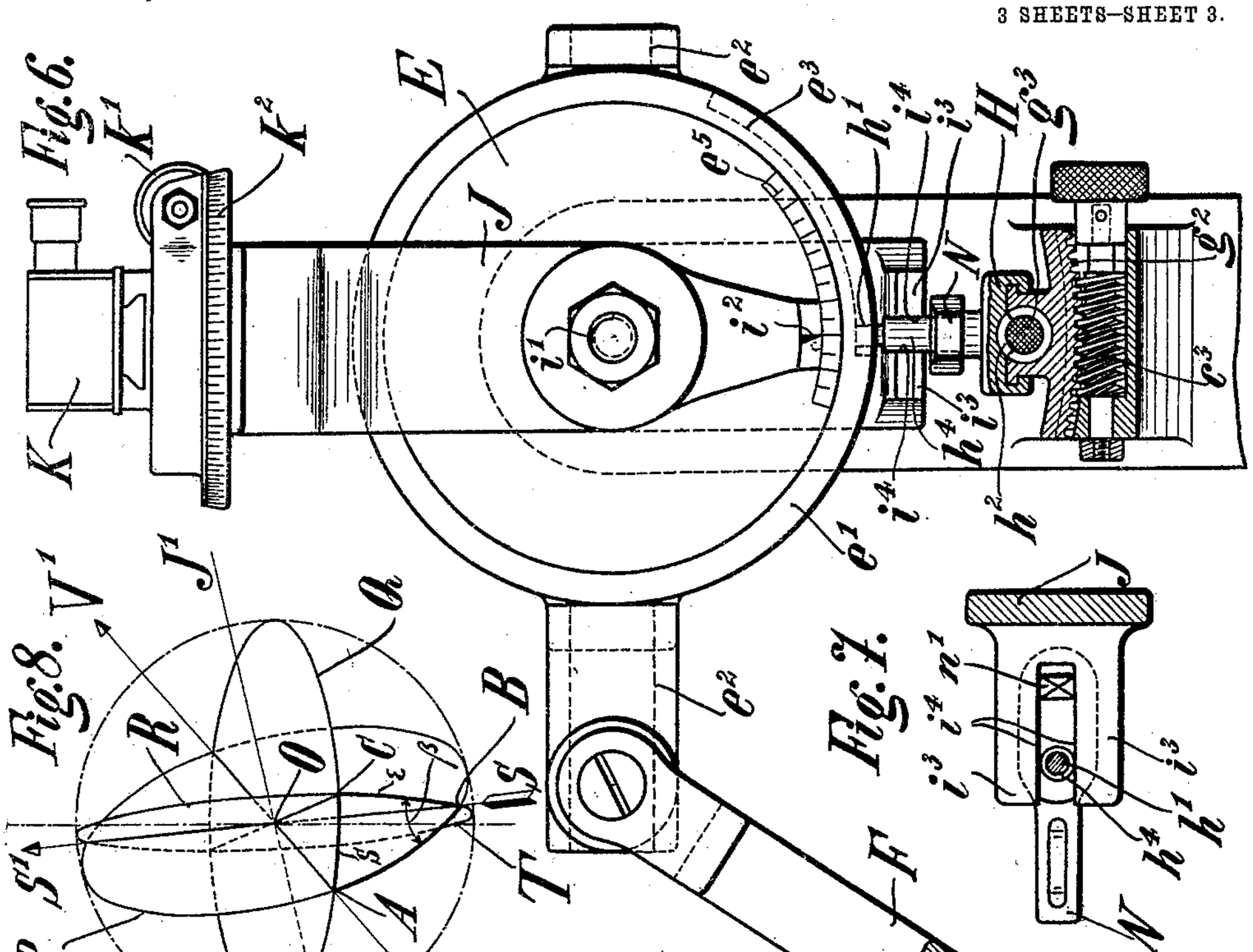
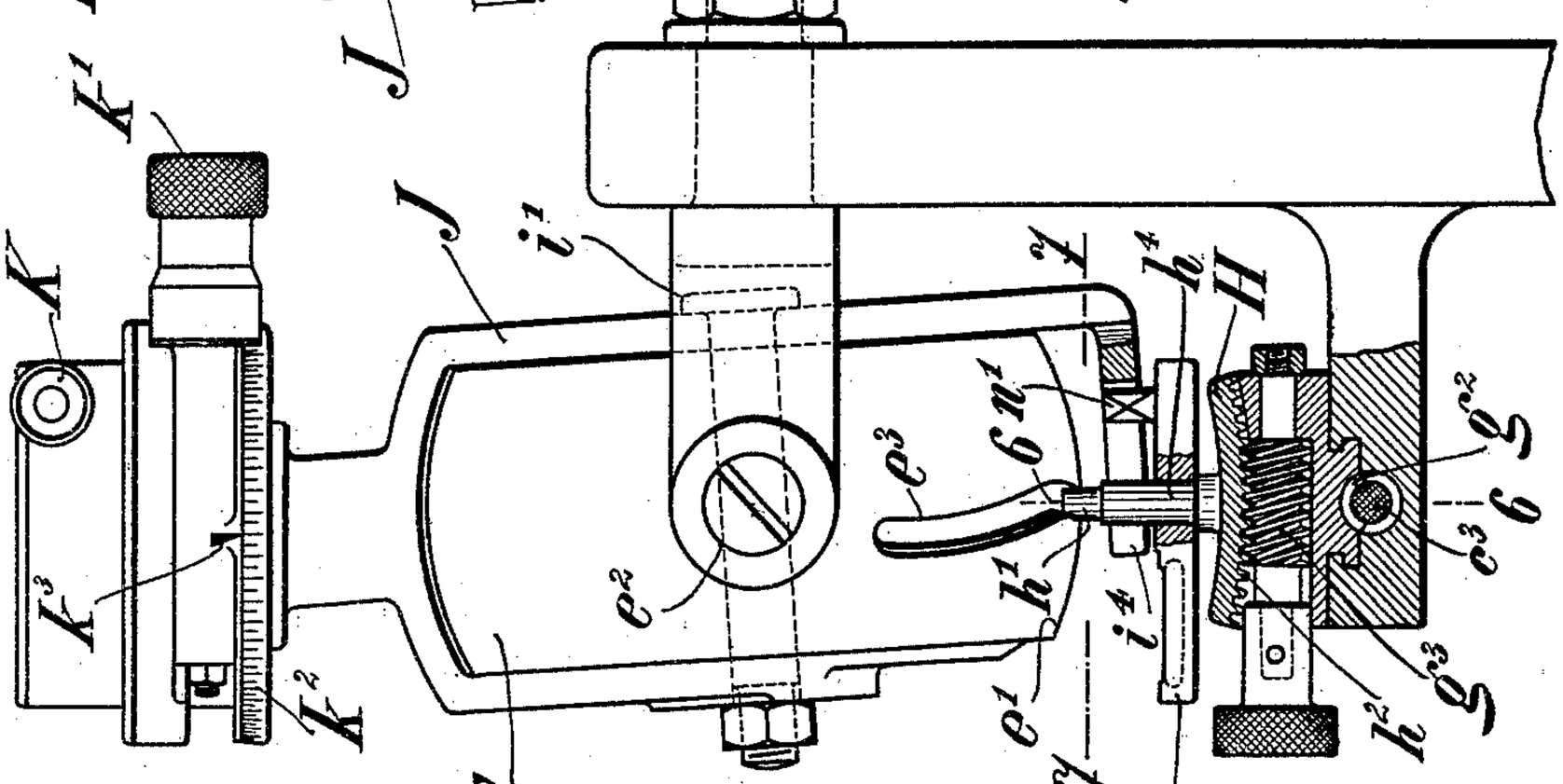


Fig. 8.

Fig. 7.

Fig. 5.



Witnesses
J. W. Wynkoop.
C. B. Melton

Inventor
Otto Ritter von Eberhard.
By Knight Bros
attorneys

49

UNITED STATES PATENT OFFICE.

OTTO RITTER VON EBERHARD, OF BREDENEY-ON-THE-RUHR, GERMANY, ASSIGNOR TO FRIED. KRUPP AKTIENGESELLSCHAFT, OF ESSEN-ON-THE-RUHR, GERMANY.

SIGHTING DEVICE FOR GUNS.

988,760. Specification of Letters Patent. Patented Apr. 4, 1911.

Application filed January 12, 1909. Serial No. 471,990.

To all whom it may concern:

Be it known that I, OTTO RITTER VON EBERHARD, a subject of the Emperor of Germany, and a resident of 23 Alfredstrasse, Bredeney-on-the-Ruhr, Germany, have invented certain new and useful Improvements in Sighting Devices for Guns, of which the following is a specification.

The present invention relates to sighting devices for guns and the object of the invention is to provide a sighting device which makes allowance for the angle which corresponds to the lateral deviation of the projectile caused by the twist of the gun barrel and which for the sake of brevity will be referred to as the "lateral deviation" and this is done in such a manner that, at any elevation of the gun barrel, an exact elimination of the lateral deviation takes place automatically, at least for all targets located in the muzzle-horizon.

In the accompanying drawings Figure 1 is a side view of one embodiment of the sighting device and the parts of the gun to which the invention relates. The sighting device *per se* is shown on an enlarged scale in Figs. 2 to 4. Fig. 2 being a section on line 2—2, Fig. 1, looking from above, Fig. 3 being a rear view of the sighting device, partly in section, and Fig. 4 being a side view of Fig. 3, partly in section on lines 4—4 and 4^a—4^a, Fig. 3; Fig. 5 shows another embodiment of the sighting device in a view corresponding to that shown in Fig. 3, Fig. 6 is a side view of Fig. 5, partly in section on line 6—6, Fig. 5, and Fig. 7 is a section on line 7—7, Fig. 5. Fig. 8 is a mathematic figure serving to explain the invention.

Reference will first be had to the embodiment shown in Figs. 1 to 4.

The gun-barrel A (Fig. 1) is in the known manner mounted to slide on the track-carrier B which is swingingly mounted in the mount C through the medium of the horizontal trunnions b^1. An elevating mechanism (not shown), which may be of any suitable known construction, is inserted between the track-carrier B and the mount C. To the mount C is rigidly secured an upwardly extending arm c^1 in which a fork-shaped member D (see especially Fig. 2) is rotatably mounted through the medium of a trunnion d^1 which has its axis extending parallel to the axis of the horizontal trunnions. A hollow member E having a spherical zone e^1 is swingingly connected to the fork-shaped member D through the medium of two coaxial trunnions e^2 (see especially Fig. 2). The arrangement is selected in such a manner that the axis of the trunnions e^2 intersects the axis of the trunnion d^1 at a right angle in the center of the sphere of which the zone e^1 forms a part. By means of a coupling rod F, which has one end jointed to the member D and has its other end jointed to an arm b^2 on the track-carrier which arm is rigidly connected to the adjacent trunnion b^1, the member D is positively connected with the track-carrier in such a manner that the axis of the trunnions e^2 always remains parallel to the axis of the bore of the gun barrel.

On the arm c^1 is provided an arcuate guide c^2 for a slide G and on the slide is provided an arcuate guide g^1 for a slide H which is provided with a pin h^1. The arrangement is selected in such a manner that the axis of curvature of the guide c^2 coincides with the axis of the trunnion d^1 and intersects the axis of curvature of the guide g^1 at a right angle in the center of the sphere of which the zone e^1 forms a part. The axis of the pin h^1 intersects the axis of curvature of the guide g^1 at a right angle in the center of the spherical surface e^1. The slide G can be adjusted in the guide c^2 by means of a worm c^3 which engages with teeth g^2 on the guide G. The slide H is also adjustable in its guide g^1 by means of a worm g^3 which engages with teeth h^2 on the slide. On the slide H is located an air-level h^3 the air-bubble of which can be caused to register through adjustment of the slides G and H. The level h^3 is disposed in such a manner that the axis of the pin h^1 is vertical when the bubble of the level registers. In the spherical wall e^1 of the hollow member E is provided a curved groove e^3 by means of which the hollow member E is guided on the pin h^1 when the axis of the trunnions e^2 turns about the axis of the trunnion d^1. A bifurcated arm J which straddles the hollow member E is rotatably mounted on the hollow member by means of a bolt i^1 the axis of which intersects the axis of the trunnions e^2 at a right angle in the center of the spherical surface e^1. On its upper end the arm J car-

ries a sight-telescope K the sighting line of which can be swung in a lateral direction in the known manner by means of a gear operated by a hand-wheel k^1. A scale k^2 and a mark k^3 serve for reading the adjustments which can be imparted to the sighting line by the gear. In the arm J is journaled a worm M which is provided with a hand-wheel m^1 and engages with teeth e^4 (Fig. 4) on the hollow member E. The worm gear M e^4, by means of which the arm J can be swung relatively to the hollow member E about the axis of the pin i^1, serves for imparting to the sighting line the inclination relatively to the axis of the trunnions e^2 which corresponds to the distance of the target. A distance scale e^5, which is provided on one of the end walls of the hollow member E, and a mark i^2 on the arm J (see especially Fig. 4) serve for reading the adjustment which is imparted to the sighting line by means of the worm gear M e^4.

When the fork-shaped member D turns about the axis of the trunnion d^1 the engagement of the pin h^1 in the groove e^3 will cause the hollow member E to swing about the axis of the trunnions e^2, which is parallel to the axis of the bore of the gun-barrel so that the axis of the bolt i^1, about which the sighting line turns upon adjustment of the firing angle corresponding to the distance of the target, obtains an inclined position which varies with the elevation of the gun barrel. The shape of the curved groove e^3 is selected in such a manner that, for targets located in the muzzle-horizon, an exact elimination of the lateral deviation of the projectile caused by the twist of the gun-barrel is obtained by the inclined position imparted to the axis of the bolt i^1. It will be explained later on how the shape of the curved groove e^3 can be determined. The curved groove e^3 is of such length that any suitable elevation or depression within sufficiently wide limits can be imparted to the gun barrel.

The mode of aiming by means of the improved sighting device is as follows: By turning the hand-wheel k^1 the operator first imparts to the sighting line the lateral direction which corresponds to the conditions of the weather and other conditions to be taken in consideration and which can be read on the scale k^2 by means of the mark k^3. Thereupon the sighting line is adjusted to the firing angle corresponding to the distance of the target, this being done by swinging the arm J about the axis of the bolt i^1 through the medium of the worm-gear M e^4, the scale e^5 and the mark i^2 being employed in connection with this operation. Thereupon the sighting line is directed against the target, this being done by swinging the track-carrier B and the gun barrel A about the axis of the horizontal trunnions by means of the elevating mechanism and, if necessary, by imparting the required lateral direction to the gun. While this takes place the turning movement of the gun barrel A and the track-carrier B is transmitted to the fork-shaped member D by means of the coupling-rod F in such a manner that the axis of the trunnions e^2 always remains parallel to the axis of the bore of the gun barrel. The hollow member E is thereby moved in such a manner that the sighting line is directed against the target. Simultaneously herewith the curve-gear h^1 c^3 causes the hollow member E to swing about the axis of the trunnions e^2 so that the inclined position of the axis of the bolt i^1 is continuously changed. When the hollow member E finally reaches the position in which the sighting line points at the target the gun is directed, if at the same time the bubble of the level h^3 registers. If the bubble does not register the position of the level must be corrected accordingly through adjustment of the slides G and H relatively to their guides c^2 and g^1 by means of the worm gears c^3 g^2 and g^3 h^2. If the sighting line thereby loses its direction against the target the proceeding just described must be repeated until at the same time the sighting line points at the target and the bubble of the level h^3 registers. Due to the shape of the curved groove e^3 the axis of the bolt i^1 then assumes such an inclined position that, for targets located in the muzzle-horizon, the lateral deviation of the projectile caused by the twist of the gun barrel is exactly eliminated.

In Figs. 5 to 7 is shown the second embodiment of the invention which is a sighting device with so-called independent sighting line. The main points of difference between the second embodiment and the first embodiment are merely as follows: The worm-gear M e^4 is dispensed with. The arm J is provided with two flaps i^3 which straddle a pin h^4 which is co-axial with the pin h^1. The surfaces i^4 with which the flaps i^3 contact with the pin h^4 form planes which are disposed perpendicularly to the direction which the sighting line assumes when it is adjusted so as to be parallel to the plane through the center of the spherical surface e^1 and perpendicular to the axis of the bolt i^1. The result of this arrangement is that the common axis of the pins h^4 and h^1 forms a right angle with the sighting line when the latter assumes the position just mentioned. The air-level h^3 is replaced by a level N having an oblong air bubble. The housing of the level N is rotatable on the pin h^4 and is provided with a projection n^1 which engages between the flaps i^3 of the arm J and is guided by the surfaces i^4. The arrangement is selected in such a manner that the longitudinal axis of the level inter-

sects the common axis of the pins h^4 and h^1 at a right angle and is parallel to the guide-surfaces i^4.

When using the sighting device of the second embodiment the sighting line is directed, as regards height, against the target through the medium of the worm-gear c^3 g^2. For the purpose of adjusting the inclination between the sighting line and the axis of the bore of the gun barrel which corresponds to the distance of the target the gun barrel is swung by means of the elevating mechanism about the axis of the horizontal trunnions until the division-line on the scale e^5 which corresponds to the desired distance of the target registers with the mark i^2. If, at the same time, the bubble of the level N registers the gun is directed. If this is not the case the position of the level must be correspondingly corrected through adjustment of the slide H by means of the worm-gear g^3 h^2. If the sighting line thereby loses its direction against the target or the position of the mark i^2 is changed relatively to the scale e^5 the aforesaid proceeding must be repeated until, at the same time, the sighting line points at the target, the division-line of the scale e^5 corresponding to the distance of the target registers with the mark i^2 and the air-bubble of the level N registers.

It will now be explained, by means of Fig. 8, how the shape of the curved groove e^3 can be determined. In doing so it will be assumed that the gun is directed against a target located in the muzzle-horizon. The firing angle corresponding to the distance of the target will be designated ϵ and the appurtenant lateral deviation of the projectile will be designated s. Furthermore it will be assumed that the sight-telescope K by means of the hand-wheel k^1 is adjusted in such a manner that the sighting line is parallel to the plane which passes through the center of the spherical surface e^1 and is perpendicular to the axis of the bolt i^1.

The proposition of determining the shape of the curved groove e^3 can be considered solved when the middle-line of the curved groove is determined, that is the geometrical location of the points in which the axis of the pin h^1 intersects the spherical surface e^1 when the axis of the bore of the gun barrel has a predetermined elevation and the axis of the bolt i^1 has the inclined position required for the exact elimination of the lateral deviation corresponding to such elevation. It is the object of the following examination to determine this geometrical location and the examination is applicable both to the first and to the second embodiment of the invention.

In Fig. 8 O designates the center of the spherical surface e^1 which is indicated by the meridian E in dotted lines. S S^1 indicates the position of the axis of the trunnions e^2 which is parallel to the axis of the bore of the gun barrel, J J^1 indicates the position of the axis of the bolt i^1 and P indicates the plane which passes through the center O of the sphere and is perpendicular to the axis of the bolt i^1. As the axis of the trunnions point e^2 intersects the axis of the bolt i^1 at a right angle in the O the straight line S S^1 must fall in the plane P. V V^1 indicates the straight line which passes through O and is parallel to the sighting line. As it was assumed that the sighting line is parallel to the plane P the straight line V V^1 must also fall in the plane P. A indicates one of the two points in which the straight line V V^1 intersects the spherical surface and B indicates the point adjacent to A in which the straight line S S^1 intersects the spherical surface.

The linear dimensions of the gun can be left out of consideration during the following examination as they are very small as compared with the distance of the target and as furthermore their effect on the position of the target is without importance compared with the spreading effect of the projectiles. The gun may therefore be considered being a point which is assumed to coincide with the point O. It may therefore be assumed that the straight lines S S^1, which is parallel to the axis of the bore of the gun barrel, really indicates the axis of the bore and that the straight line V V^1, which is parallel to the sighting line, really indicates the sighting line. As it was assumed that the gun is directed against a target located in the muzzle-horizon the sighting line V V^1 must extend horizontally. Q indicates the horizontal plane through V V^1. R indicates the vertical plane through S S^1 and C indicates the point adjacent to the points A and B in which the line of intersection of the planes Q and R intersects the surface of the sphere.

The lateral deviation s of the projectile with relation to the muzzle-horizon is measured by the angle between the vertical plane through the axis of the bore and the vertical plane through the connecting line between the target and the center of the muzzle of the gun barrel or, as the entire gun can be considered as a point coinciding with the point O, through the connecting line between the target and the point O. If this lateral deviation is to be regarded as eliminated by the inclined position of the axis J J^1 the vertical plane through the axis S S^1 of the bore must deviate from the vertical plane through the sighting line V V^1 in the direction opposite to the direction of deviation of the projectile and the angle between the two vertical planes must be equal to s. Consequently if the lateral deviation of the projectile is to the right, which is generally the case and is here assumed to be so, the vertical plane R

through the axis S S^1 of the bore must deviate from the vertical plane through the sighting line V V^1 toward the left in the direction of firing, as shown in Fig. 8. The angle between these two vertical planes is equal to the angle A O C and must, in accordance with the above explanation, be equal to s. As it is assumed that the gun is directed against a target located in the muzzle-horizon the elevation of the gun barrel, which is measured by the angle B O C, is equal to the firing angle ϵ.

The points A B C determine a rectangular triangle of a sphere, the right angle of the triangle being located at C. In this triangle one cathetus A C is $= \sphericalangle$ A O C $= s$ and the other cathetus B C is $= \sphericalangle$ B O C $= \varepsilon$. From this we get for the angle between the planes P and R:

$$\text{tang. } \beta = \frac{\text{tang. } s}{\text{sin. } \varepsilon}$$

from which β can be calculated.

When the gun is directed the axis of the pin h^1 is vertical in both the embodiments of the sighting device. In the first embodiment this is directly the result of the fact that the air-bubble of the level h^3 registers. In the second embodiment it is due to the fact that, on the one hand, the air-bubble of the level N registers and that, on the other hand, the sighting line is assumed to be horizontal and is in a position in which the axis of the pin h^1 is perpendicular to the sighting line. As the axis of the pin h^1 is vertical it must be perpendicular to the horizontal plane Q and as it passes through the point O, it must fall in the vertical plane P. The lower point of intersection between the axis of the pin h^1 and the spherical surface is designated T. This point belongs to the middle line of the curved groove e^3 which it is desired to determine. As the straight line O T is perpendicular to the plane Q, $\sphericalangle$ T O C is $= 90°$; furthermore $\sphericalangle$ B O T is $= 90° - \sphericalangle$ B O C $= 90° - \epsilon$.

The location of the point T on the spherical zone e^1 can be determined by means of the two relations

$$\text{tang. } \beta = \frac{\text{tang. } s}{\text{sin. } \varepsilon} \text{ and } \sphericalangle \text{ B O T} = 90° - \varepsilon.$$

The plane P, that is the central plane of the spherical zone e^1 which is perpendicular to the axis of the bolt i^1, is ascertained on the hollow member E of which the spherical zone e^1 forms a part, and the axis S S^1, that is the axis of the pins e^2, is ascertained in the plane P. With this as basis the point T is determined by placing through the axis S S^1 a plane R which intersects the plane P at an angle β and by applying to the axis S S^1 in the plane R an angle $90° - \epsilon$ the free side of which intersects the spherical zone e^1 in the point T. By repeating this construction for a suitable number of values of ϵ and s the middle line of the curved groove e^3 can be determined with any desired accuracy.

As will readily be seen from Fig. 8 a lateral deviation of $s = O°$ can only be eliminated by the inclined position of the axis J J^1 at an elevation of $\epsilon = O°$. However it often happens, especially in high-elevation guns, that the lateral deviation at an elevation of $\epsilon = O°$ has a value s_o which is different from O, this being due to changes in direction to which the axis of the bore is subjected on firing and which are called discharge-errors. In such case the scale k^2 must be disposed in such a manner that the sighting line, when the mark k^3 points at zero on the scale k^2, forms an angle of s_o with the direction which it assumes when it is adjusted to become parallel with the plane P, and by subsequently determining the shape of curved groove e^3 in such a manner that the lateral deviations $s - s_o$ are eliminated by the inclined position of the axis J J^1.

The foregoing examination is carried out on the assumption that the target is located in the muzzle-horizon. If this is not the case small errors will occur in the first embodiment of the sighting device but these errors can generally be left out of consideration. As to the second embodiment of the sighting device a simple reflection will show that, provided the firing angle is the same, the lateral deviations of the projectile which are eliminated by the sighting device are the same when a target located outside of the muzzle-horizon is fired at as if the target were located in the muzzle-horizon. By using the second embodiment of the invention the lateral deflections which occur on firing at targets located outside of the muzzle-horizon, are therefore eliminated with the same accuracy, provided the firing angle is the same, as are the corresponding lateral deviations for targets located in the muzzle-horizon.

If the gun barrel is lowered the pin h^1 in the first embodiment of the sighting device reaches the part of the curved groove e^3 which is designated e^6. As the target in this instance can never be located in the muzzle-horizon the shape of the part e^6 of the curved groove e^3 cannot be determined according to the before-mentioned proceeding. As shown in the drawing it is simplest to determine the shape of the part e^6 in such a manner that the axis J J^1 retains the inclined position which it has for an elevation $\epsilon = O°$. The lateral deviations are then eliminated with at least approximate exactness.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. A sighting device for guns having its sighting line swingable about an axis adjust-

able parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis perpendicular to said axis of swinging movement for adjustment of the firing angle corresponding to the distance of the target, and a drive having a curved guide for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel.

2. A sighting device for guns having its sighting line swingable about an axis adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis perpendicular to said axis of swinging movement, and a drive having a curved guide and adapted to be operated through the elevation of the gun barrel for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel.

3. A sighting device for guns having its sighting line swingable about an axis adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis perpendicular to said axis of swinging movement for adjustment of the firing angle corresponding to the distance of the target, and a drive having a curved guide for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel; the curved guide of said drive being of a shape permitting the lateral deviation of the projectile to become exactly eliminated for targets located in the muzzle-horizon.

4. A sighting device for guns having its sighting line swingable about an axis adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis perpendicular to said axis of swinging movement for adjustment of the firing angle corresponding to the distance of the target, a curved drive for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel, and a member on which the axis of said swinging movement and the axis of said turning movement are fixed; one part of said curved drive being adjustable relatively to the mount and the other part thereof being provided on said member.

5. A sighting device for guns having its sighting line swingable about an axis adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis intersecting said axis of swinging movement at a right angle for adjustment of the firing angle corresponding to the distance of the target, a curved drive for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel, and a spherical member on which the axis of said swinging movement and the axis of said turning movement are fixed the point of intersection of said axes coinciding with the center of said spherical member, one part of said curved drive being adjustable relatively to the mount and the other part thereof being formed on said spherical member, said adjustable part of the curved drive consisting of a pin having its axis passing through said point of intersection, and the other part of the curved drive consisting of a curved groove formed within said spherical member and having its center-line located on the surface thereof.

6. A sighting device for guns having its sighting line swingable about an axis, adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis intersecting said axis of swinging movement at a right angle for adjustment of the firing angle corresponding to the distance of the target, a curved drive for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel, and a spherical member on which the axis of said swinging movement and the axis of said turning movement are fixed the point of intersection of said axes coinciding with the center of said spherical member, one part of said curved drive being adjustable relatively to the mount and the other part thereof being formed on said spherical member, said adjustable part of the curved drive consisting of a pin having its axis passing through said point of intersection, and the

other part of the curved drive consisting of a curved groove formed within said spherical member and having its center-line located on the surface thereof and a level connected to said pin and adapted to register when the axis of the pin is vertical.

7. A sighting device for guns having its sighting line swingable about an axis adjustable parallel to the direction to be imparted to the axis of the bore of the gun barrel, means permitting the sighting line and its axis of swinging movement to turn relatively to each other on an axis intersecting said axis of swinging movement at a right angle for adjustment of the firing angle corresponding to the distance of the target, a curved drive for automatically imparting to said axis of turning movement an inclination varying with the elevation of the gun barrel to effect elimination of the lateral deviation of the projectile caused by the rifling of the gun barrel, and a spherical member on which the axis of said swinging movement and the axis of said turning movement are fixed the point of intersection of said axes coinciding with the center of said spherical member, one part of said curved drive being adjustable relatively to the mount and the other part thereof being formed on said spherical member, said adjustable part of the curved drive consisting of a pin having its axis passing through said point of intersection, and the other part of the curved drive consisting of a curved groove formed within said spherical member and having its center-line located on the surface thereof; and a level having an elongated air-bubble and rotatably connected to said pin; said level having its axis of rotation coinciding with the axis of the pin and its longitudinal axis intersecting the axis of the pin at a right angle, the level and the pin being conected with the carrier of the sight device proper in such a manner that the plane through the axis of the pin and the longitudinal axis of the level is always perpendicular to the direction which the sighting line assumes when it is adjusted to be parallel to a plane perpendicular to said axis of turning movement.

The foregoing specification signed at Barmen, Germany, this 23rd day of December, 1908.

OTTO RITTER VON EBERHARD. [L. S.]

In presence of—

OTTO KÖNIG,

WALTER EZKELHAM, Jr.