

April 8, 1941.

K. PETSCHENIG

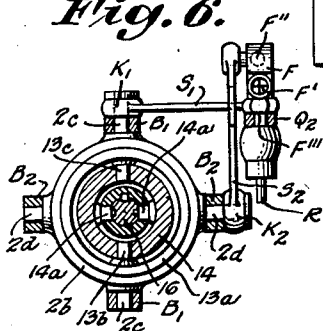
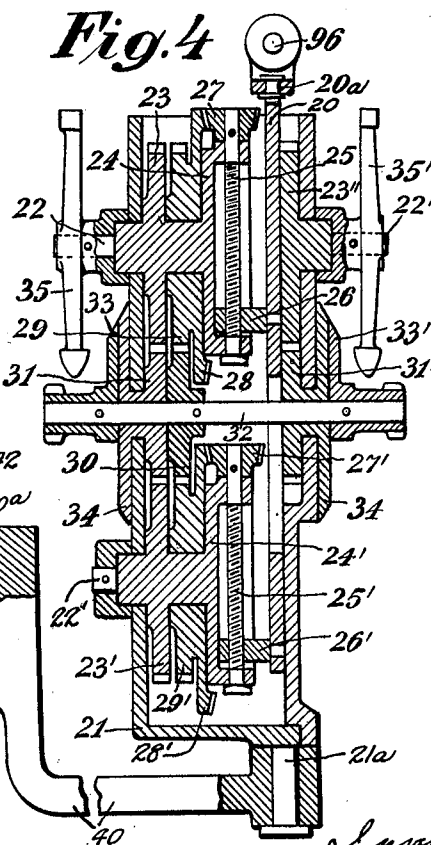
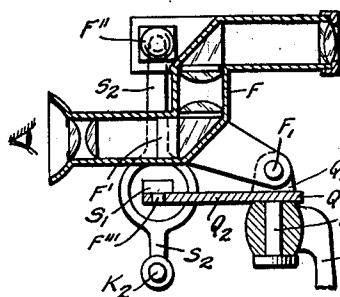
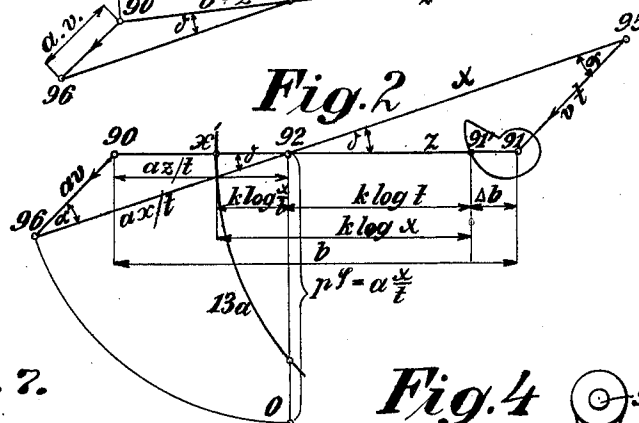
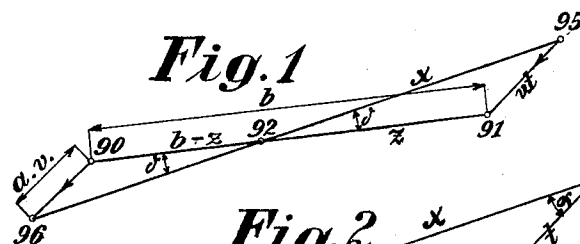
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12. **R. FETSCHENIG**
DEVICE FOR THE MECHANICAL DETERMINATION OF FIRING
DATA FOR FIRING AT MOVING TARGETS

DATA FOR FIRING AT MOVING TARGETS

Filed Nov. 9, 1937

2 Sheets-Sheet 1



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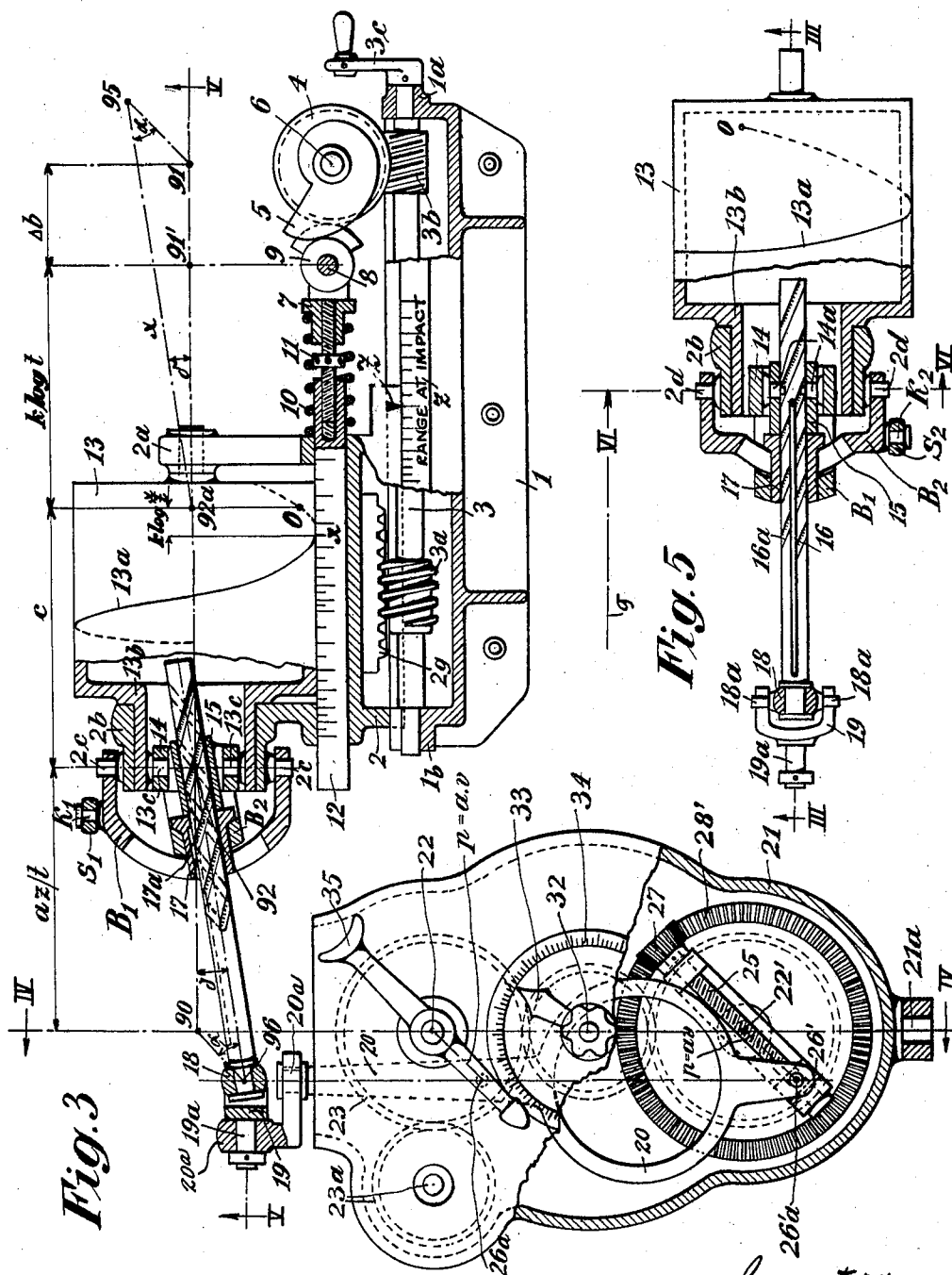
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R. PETERSCHENIG DEVICE FOR THE MECHANICAL DETERMINATION OF FIRING

DATA FOR FIRING AT MOVING TARGETS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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DEVICE FOR THE MECHANICAL DETERMINATION OF FIRING DATA FOR FIRING AT MOVING TARGETS

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6 Claims. (Cl. 33—49)

The invention relates to range finders for military ordnance use. More particularly, it concerns apparatus for the mechanical determination of the particular angle of lead, or target-velocity-allowance angle, for which the associated gun is to be set; together with the determination of the time of flight of the projectile, and the distance or range of the point of impact. All these data must be coordinated to facilitate proper launching of the projectile.

The present invention is based upon and constitutes an improvement over apparatus of the type such as shown in British Patent No. 343,011. This patent, perhaps referring more specifically to Figure 9 thereof, describes apparatus for the mechanical determination of essential shooting data based upon the solution of the equation $t = az/(b-z)$, wherein t is the time of flight of the projectile, z is the distance of the point of impact, and a and b are two fixed parameters. The equation $t = az/(b-z)$ is also employed as the fundamental equation, towards the accurate solution of which the present invention is directed.

Known devices, of which the apparatus according to the British patent aforesaid may be taken as typical, are defective in that, for one thing, the accuracy of transmission of the adjusting movements is diminished because of the variable extensibility of a cord which is employed as an adjusting member. Additionally, such known devices cannot be adjusted in any desired direction, nor can they be satisfactorily employed to determine the shooting triangle, when the angle δ thereof, later to be discussed, is quite acute.

This invention is directed towards overcoming these difficulties found in practice to exist in the known devices. I have found a satisfactory solution of the difficulty to exist in avoiding the use of the aforementioned equation, and to use in its stead the logarithmic form thereof.

The apparatus according to my invention provides a means for mechanically solving this logarithmic equation. Thus the shooting triangle can be mechanically reproduced, using for that purpose the individual values of the triangle determined by estimate or measurement.

My new apparatus makes it possible, for the first time, to solve the shooting triangle mechanically in simple manner by assistant gunners. Thus it is possible for the gunner who sights the target to do this independently of the adjustment of the shooting triangle, at the same time achieving a correct setting of the gun barrel. This is possible because the position of the gun barrel

relative to the sight line is correspondingly adjusted by my apparatus in accordance with shooting conditions. Thus my invention may be said to relate to an improved apparatus for mechanically carrying out the solution or reproduction of the shooting triangle on the basis of previously determined or estimated values of the shooting triangle.

It has been stated at an earlier point herein that the time of flight of the projectile is determined. This time of flight of such projectile can always be read off the shooting table of the corresponding projectile, when the distance of the point of impact has first been determined from the shooting triangle, since the shooting table includes two juxtaposed columns for point of impact distances and for the time of flight to the point of impact.

These constructions are improved according to the present invention by the provisions, between the mechanical target velocity vector to be manually adjusted according to both magnitude and direction, on the one hand, and the likewise manually operated device for the continuous adjustment of the successively measured target distances, on the other hand, of a two-part Cardan shaft of variable length, the forward part of which, connected by a universal joint to the control member of the target velocity vector, is constructed in the form of a screw-threaded spindle of large pitch, secured against rotation; while the rearward part, which is connected to the adjusting device for the target distance, is in the form of a nut mounted on the screw-threaded spindle and secured against axial movement, which nut is connected by a universal joint to the spindle of a cylindrical drum, said spindle being parallel to the axis of the barrel of the piece of ordnance. On the peripheral surface of said drum is marked a logarithmic helix, the point of contact of which with a logarithmically graduated target distance scale adapted to slide axially parallel to the axis of the drum serves as adjusting mark for the measured target distance, said distance scale being moved simultaneously with the drum in the axial direction by an amount dependent upon the time of flight of the projectile. The bodily axial displacement of the drum upon setting of the target distance is accompanied by the simultaneous positive rotation of said drum. In addition, the control device for adjusting the velocity vector is constructed so that the latter can be adjusted in any desired magnitude and direction as an air gap between a non-material point and the centre of the uni-

versal joint of the rearward part of the Cardan shaft. That is, by means of my new apparatus the target speed vector is reproduced in space in such manner that the rearward bearing point of the Cardan shaft is arranged in space opposite the starting point of the shooting triangle which is reproduced by the apparatus, in accordance with the direction and magnitude of the said target speed vector. The magnitude of this vector is adjusted by means of a suitable indicator, the position or direction of the vector being adjusted by a second indicator.

One construction of the invention is represented by way of example in the accompanying drawings, wherein:

Figure 1 shows the mechanical basic principle.

Figure 2 again shows the basic principle with correcting adjustment of the linear parameter (b) and with the scheme of the logarithmic target distance adjustment.

Figure 3 is an elevation partly in section along the line III—III of Fig. 5, showing the entire arrangement.

Figure 4 is a vertical cross-section, along line IV—IV of Fig. 3, of the device for adjusting the target velocity vector.

Figure 5 shows a longitudinal, approximately horizontal sectional view of the Cardan shaft, taken on line V—V of Fig. 3, parts being omitted for clarity.

Figure 6 is a cross-section through the front universal joint, along line VI—VI of Fig. 5, the drum 13 being omitted.

Figure 7 is a longitudinal vertical section through the sighting telescope.

In the mechanical basic principle according to Figure 1, the point 92 in the triangle 92—95—91 denotes the piece of ordnance (muzzle); point 95 is the target at the moment of firing; that is to say the distance 92—95 is the target distance last measured and adjusted on the instrument (measured distance). The target, during the time of flight of the projectile t , travels with the measured or estimated velocity v in the estimated direction 95—91 over said distance $=v \cdot t$ up to the point of impact 91, so that the distance 91—92 represents the range or distance z of the point of impact. If the counter-triangle 92—90—96, similar to this distance triangle, be constructed, the length 90, 91 being assumed as the linear parameter b and the side 96, 90 parallel to 91, 95 being denoted by av , we obtain from the similarity of these two triangles the proportion $vt:z=av:(b-z)$ and thence $t=az/(b-z)$ which is the approximate equation referred to previously. This equation, however, for constant parameters a and b , gives only approximate values of the time of flight of the projectile, as taken from a firing table and as referred to the range z of the point of impact; which time, however, may be corrected by automatic variation of the parameter b by the amounts Δb according to the values of t obtained from the firing table for the firing distances or ranges z . That the equation $t=az/(b-z)$ is only an approximation can be demonstrated as follows: The said equation is valid only for the theoretical solution of the shooting triangle, assuming rectilinearly extending projectile paths between the gun and the points of impact. Since, however, the true paths of the projectiles follow ballistic curves, the values obtained from the equation must be corrected by inserting the parameter b , not as a constant, but as a variable depending on the correction factor Δb . This increment Δb can be

taken into consideration in my new device by means of a cam disc, having a curved periphery, the contour of which is determined empirically, and the angular position of which cam disc is determined according to the distance of the point of impact. If in Figure 2, the triangle 90—92—96 is considered as a velocity triangle with the time a as a proportionality factor, the side 90, 92 $=az/t$ appears proportional to the mean velocity of the projectile along the chord z of the trajectory and the side 92, 96 $=ax/t$ appears proportional to the velocity of a fictitious projectile which would travel over the measured distance x in the time t . Now quite generally $k \log x = k \log x/t + k \log t$ where k is the longitudinal scale of the logarithmic graduation. This scale is now so selected that $k \log t + \Delta b = az/t = \text{distance } 91, 92$, whence $k \log t = b - az/t - \Delta b$, that is to say

$$k \log x = k \log x/t + b - az/t - \Delta b$$

If now, in accordance with the equation

$$k \log x = k \log x/t + k \log t$$

the target distance graduation is carried out logarithmically, the second term, Δb , of the sum may be formed by means of a cam disc rotatable about the point 91, and the radius vectors of which cam disc correspond to the variations $\Delta b = b - az/t - k \log t$ for angles of rotation proportional to z/t , where z and t are momentary values. If now the target distance scale (hereinafter shown at 12 in Fig. 3) is moved by these amounts Δb parallel to the distance 90—92 axially in the correct direction, the target distance x can be correctly adjusted if the point of intersection X' of the distance 90, 91 with a logarithmically divided line is employed as an adjusting mark. This logarithmically divided line is obtained by recording on the peripheral surface of a cylinder of radius r , adapted to rotate about the line 90, 91 as axis, a helix which, for angles of rotation $\phi = a/r \cdot x/t$ has abscissae values

$$92, X' = k \log x/t$$

This equation may be explained as follows: The rotation of drum 13 is effected by the engagement of the bolt 14a of the Cardan link, which is carried by drum 13, in the helical groove 16a of spindle 16. When the drum is moved along the axis 90—92—91, there is a simultaneous rotation of the drum as a result of the cooperation of bolt 14a with the helical groove 16a, since spindle 16 is secured against rotation by key 17a which engages in its longitudinal groove. Since the rotational angle of helical groove 16a is proportioned to the axial displacement along the spindle, the rotational angle of the drum 13 is also proportional to the linear extent of the spindle. The spindle length from point 96 to point 92 is given by the expression ax/t . Consequently, the rotational angle of the drum 13 is proportional to ax/t . That it is expressed by the term ax/rt , r representing the radius of drum 13, is merely a question of choice of scale. There is then obtained according to Figure 2 the relationship $k \log x = k \log x/t + k \log t$. By adjusting the target distance X on this logarithmic distance scale contacting the cylinder periphery along a generator by means of its point of intersection X' with the logarithmic helix, said point serving as adjusting mark, the angle δ between the line of the point of impact 90, 92 and the line of sight 96, 92 is automatically adjusted, so that by sighting the target in the direction 96, 92 by ele-

vating and traversing the piece of ordnance, the axis of the barrel thereof comes into position determining a hit if the axis of the barrel is also inclined upwards relatively to the direction 90, 92 by firing angle corresponding to the range and the angular position of the point of impact. By the term "adjusting the target distance," employed at the beginning of the preceding sentence is meant as follows: By adjusting the indicators 32 and 35, both the magnitude and direction of the vector 90, 96 of the target triangle are determined. Thereupon, it is necessary to adjust the target distance on the logarithmic scale 12 in such manner that the distance value x on scale 12, determined by estimate or measurement, coincides with the like value on the logarithmic spiral 13a of drum 13. This is effected by longitudinal displacement, on the one hand, of drum 13, and on the other hand, of scale 12, in connection with which it is to be noted that drum 13 is positively rotated upon a longitudinal displacement, since it is connected through its Cardan link with the helical groove 16a of spindle 16. The adjustment of the target distance is therefore effected through the longitudinal displacement of drum 13 and of scale 12, which are displaced relative to each other and simultaneously rotated until the value of the target distance on scale 12 and on the logarithmic spiral of drum 13 coincide. This adjustment of the target distance automatically moves point 92 into the position corresponding to the target distance, so that the range triangle 90—92—96 or 91—92a—95 is automatically determined by the successive setting of the indicators 32 and 35 (for the magnitude and direction of the target speed vector) and by the setting of the target distance by axial displacement of drum 13 and of scale 12. By suitably coupling the sight with the adjustment device, the magnitudes of the resultant range triangle are automatically carried over to the gun, so that the latter is ready to fire the projectile when the target is sighted after the apparatus is set in accordance with my invention.

By means of the aforescribed adjustment of the apparatus, the sight is brought, for each aiming operation, to such a position relative to the gun barrel that, upon correct sighting of the target, the gun barrel is so directed, in accordance with the magnitudes of the range triangle, that upon shooting the gun at the moment of correct sighting, a hit results. The sight operator therefore sets the gun each time, by means of vertically and laterally directing means, so that the target is accurately sighted. By simultaneously or preliminarily adjusting the apparatus according to my invention, there results a corresponding adjustment between the shooting direction of the gun and the sighting direction of the particular range triangle. This firing angle adjustment may in this case preferably be carried out according to the known method of height of fall of the projectile by vertical adjustment of the point 96 of the sighting line 96, 92 by an amount ah/t corresponding to the height of fall of the projectile during the time of flight t of the projectile.

The construction of the invention shown in Figures 3 to 6 is also applicable to pieces of ordnance which are trained by two attendants, one of whom has to follow the target in the field of view of his sighting telescope by means of the elevating mechanism and the other by means of the traversing mechanism.

A supporting plate 1 (Fig. 3) provided with a

carriage guide is fixed to the cradle g of the gun barrel of the piece of ordnance in such a manner that said guide is directed parallel to the axis of the gun barrel. A carriage 2 is adapted to slide in the supporting plate 1 and is provided between the two slide surfaces with a rack 2g having helical teeth engaged by the worm thread 3a of a spindle 3 arranged to rotate in the supporting plate 1, but secured against sliding. Said spindle is also provided with a second worm thread 3b engaging a worm wheel 4 fast, together with a cam disc 5, on a transverse shaft 6. A roller 9 mounted to rotate on the pin 8 in a fork 7, which latter is secured against rotation, is pressed by a helical spring 10 against the said cam disc. Said fork is adjustably connected to the logarithmically graduated distance scale 12 by means of the spindle 11 provided on one end with a right-handed thread and on the other end with a left-handed thread. The carriage 2 is provided with two bearing brackets 2a, 2b for mounting the cylindrical drum 13, on the periphery of which is marked a logarithmic helix 13a serving as adjusting mark. This helix 13a represents a rolling up of the logarithmic curve on the drum 13. The vertical line 92—0 of Figure 2 is also represented, in rolled up manner, on the periphery of the drum 13. By carrying over the length

$$92-96=ax/t=r\cdot\phi$$

on the rolled up peripheral line, the scale for the curve 13a is established. The tubular trunnion 13b of said drum is provided with a pair of inner pivots 13c—13c (see also Fig. 6), on which is pivoted the Cardan ring 14 provided with a pair of inner pivots 14a—14a extending at right-angles to 13c—13c (Figure 5). Adapted to swing about said pivots 14a—14a is a sleeve 15 in which a spindle 16, provided with two steep-pitched helical grooves, is adapted to slide. Engaging each of said two helical grooves according to Figure 5 is the recessed end of one of the two pivots 14a—14a passing transversely through the radial pivot holes of the sleeve 15. Bearing directly against said sleeve is the end face of a second sleeve 17 of square cross-section which is adapted to slide on the spindle and is secured against rotation by one of the two intersecting slots of two guide brackets B₁, B₂ which are journaled on two pairs of pivots 2c—2c (Fig. 3) and 2d—2d (Fig. 5) fixed diametrically and at right-angles to each other on the tubular extension of the drum bearing 2b, the last mentioned pair of pivots 2d—2d being horizontal. In addition to the two steep-pitched helical grooves, the spindle 16 carries an axial keyway 16a (Fig. 5), which in order to prevent any rotation of the spindle in the sleeve 17, is engaged by a parallel key 17a fixed in said sleeve. At its rearward end, said spindle is arranged to rotate in the spherical member 18 of a universal joint (Figure 5), which member in turn is mounted in the fork 19 of the universal joint by means of the pairs of pivots 18a—18a, said fork also being pivotally mounted by means of the horizontal pivot 19a in the bore of a bell crank 20a rotatably mounted on a vertically guided control rod 20. The point of intersection of the axis of the pivots 18a—18a with the axis of the horizontal pivot 19a of the fork embodies the point 96 of the velocity triangle 90—96—92, the apex 92 of which is embodied by the point of intersection of the axis of the pair of pivots 13c—13c with the axis extending at right-angles thereto of the pair of pivots 14a—14a. This means that the time of delay in the firing

is dependent upon the distance of the point of impact. This distance can be read on scale z when the apparatus of my invention is correctly set. The value of the distance to the point of impact, which is read on scale z , gives, on the shooting table, the time which the projectile takes to reach that point of impact. This time value is determinative for the timing, i. e. for the time delay in firing. The apex 92a of the triangle 92a—95—91 (Figure 3), which in Figure 1 coincides with the point 92, is here, for constructional reasons, provided at a suitably selected distance c (Figure 3) from its associated apex 92 of the triangle 92—95—96, the normal projection of the zero 0 of the logarithmic line 13a on the axis of rotation of drum 13, which coincides with the side 91—92 (Figure 2), embodying the apex 92a. Finally, if through the centre of the roller 9 a line is drawn at right-angles to said axis of rotation, the latter cuts off on the triangle side 91—92a the correction distance $\Delta b=91', 91$ which, as already mentioned by the axial movement of the target distance scale 12 through the amount Δb , corrects the merely approximately accurate result according to the equation $t=az/(b-z)$.

According to Figures 3 and 4, for adjusting the target velocity vector measured or estimated according to magnitude and direction, two forks 24, 24', each provided with a horizontal pivot 22, 22' and a spur wheel 23, 23' are rotatable in a casing 21 pivotally mounted on a vertical pivot 21a on the gun carriage. In each of said forks 24, 24' is journaled a screw-threaded spindle 25, 25', secured against sliding, and on each of said two spindles a nut 26, 26', secured against rotation, is mounted within the fork, and outside each fork a bevel wheel 27, 27', respectively, is secured to the spindle and engages suitable teeth 28, 28' on a double toothed wheel, the second set of teeth 29, 29' of which engages a toothed disc 30 fast on the shaft 32 adjacent a loose toothed disc 31 of the same size. Fixed on said shaft 32 is a pointer 33 provided with a finger-grip edge and serving for the adjustment of the target velocity v on the peripheral scale of a scale disc 34 rigidly secured to the toothed disc 31. A similar toothed disc 31' with a scale disc 34' and a pointer 33' is also mounted on the other end of shaft 32. The teeth of the disc 31', which is fast on said shaft, engage the spur wheel teeth of the toothed disc 23'', which is co-axial with the toothed disc 23 and is coupled to it by an intermediate gear 23a (Fig. 3). The discs 23 and 23'' are adapted to be rotated by means of the arrow-shaped handles 35, 35' secured to the pivots 22, 22''. Each of the two nuts 26', 26 carries a horizontal stud 26a, 26a' (Fig. 3) each engaging one of the two bores of the connecting rod 20 which is vertically guided by the two parallel crank arms r, r (Figure 3) and the head of which carries the aforesaid universal joint 18—18a—19—19a. This device is secured to the gun cradle in such a manner that, on adjusting the target velocity $v=0$ by means of the pointers 33, 33' on the scales 34, 34' and the distance of the point of impact $z=0$ on a height of fall attachment (not shown), the centre 96 of the universal joint lies in the trunnion axis of the gun. To secure the desired height of fall adjustment, the pin 21a by which the casing 21 is vertically mounted for rotation preferably is mounted in thoroughly conventional manner in an adjustable arm 40 (Figure 4) of a construction serving to compensate for the influence of gravitation on the shell during its flight. This construction, which per

se forms no part of my invention, is comprised of a device for adjusting the height of the arm 40 according to the set target distance. By known means, such as a hand crank 41, a spindle 42, carrying arm 40, is rotated. Arm 40, by a suitable extension 40a thereby moves along a scale 43 which is so graduated that, according to the target distance given on the scale z , a suitable adjustment in height of the arm 40 and consequently of the point 96 is brought about, suitable to compensate for the drop of the shell during its flight to the target. The adjustment in height of arm 40 along scale 43 takes place corresponding to the indications of the mark z on the target distance scale (see Figure 3). Then the target velocity allowance angle δ of the axis of the gun barrel relatively to the line of sight and applicable to a rectilinear trajectory of the projectile, as shown in Figures 1 and 2, is thereby corrected, the firing angle being taken into consideration. According to Figures 3, 5 and 6, this corrected target velocity allowance angle is now resolved by the two guide brackets B₁, B₂ into a horizontal angle component and a vertical angle component, of which the vertical angle component is transmitted by means of a crank pin K₂ (Fig. 5), parallel to 2d, mounted on the guide bracket B₂, and a pivoted connecting rod S₂, to a member controlling the line of sight of the sighting telescope F in a vertical direction, while the horizontal angle component of the target velocity allowance angle is transmitted to the sighting telescope F' possessing a wire cross F' by means of a crank pin K₁ (Fig. 3), parallel to 2c, mounted on the guide bracket B₁, and a connecting rod S₁. The telescope shown in Figs. 6 and 7 is controlled by the rods S₁ and S₂ in the following manner: Rod S₂ is connected by a universal joint F'' to the frame of telescope F. Rod S₁ is connected by a pivoted joint F''' to a carrier Q at the free end of an extension Q₂ thereof, the carrier Q being rotatable in a substantially horizontal plane around a pivot Q₁ which is held by a bracket R fixed at any desired point to the member 2. The frame of the telescope F is linked at F₁ to a bearing Q₃ arranged on the top of the carrier Q and allowing a dipping movement of the telescope in a substantially vertical plane. If, for instance, with reference to Figs. 6 and 7, rod S₁ is moved by a slight rotation of the axis 2c to the right, then the telescope F will be swung so as to become directed more to the left of the operator. If, on the other hand, rod S₂ is moved, having reference to Fig. 6, a slight rotative extent in a downward direction, about pivot 2d, then the telescope F will be swung so as to become directed upwardly with respect to the observation line. Mounted on the outer guide rail of the supporting plate 1 (Fig. 3) is a distance scale z on which by means of the index Z provided on the carriage 2, it is possible to read the distance of the point of impact necessary for the setting of the projectile and if desired, for the manual adjustment of the height of fall attachment.

This device is manipulated as follows: First, the measured or estimated velocity of the target is adjusted on the scale 34 (34') by turning the pointer 33 (33'). The bevel wheel mechanisms 28—27 and 28'—27' are thereby rotated through the spur wheels 30—29—29', hence also rotating diametrical screw-threaded spindles 25, 25', thus effecting a radial adjustment of the nuts 26. In consequence of this, the two studs 26' thereof are cranked with respect to the parallel axes of the pairs of wheels 28—29, 28'—29' by an amount

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which is proportional to the velocity of the target. The direction in space of this cranking or eccentricity, which is transmitted by the connecting rod 20 to the centre 96 of the universal joint, is with reference to the trunnion position or zero 90 located in the vertical axis of rotation of the casing 21, parallel to the arrow-indicated direction in space of the two handles 35, 35', the variation in the inclination of which is transmitted directly to the screw-threaded spindles 25, 25'; the velocity scales 34, 34' being bodily rotated to a corresponding extent, along with the pointers 33, 33', through the spur wheels 23'', 23a, 23, 31, 23'. By the adjustment of the direction arrows 35, 35' to the estimated or measured direction of flight of the target, therefore, the side 90-92 of the triangle (Figures 1, 2, 4) is so adjusted that the axis of the grooved spindle 16 must pass through the sighted target point 95 if the target is to be hit at the point 91.

The adjustment of the target velocity and of the direction of the arrows to the direction of flight of the target is the duty of the gun leader, while a second man, by turning the hand crank 3c, shifts the carriage 2 and independently thereof the measured distance scale 12, so that the latter is contacted by the rotating helix 13a at the graduation x' corresponding to the target distance x just measured. The rotation of the drum 13 is brought about as follows: A displacement of drum 13 in an axial direction results in a movement of pins 14a of the drum-connected Cardan link along the helical groove 16a of spindle 16. The pins 14a can follow the helical groove 16a only when the drum 13 describes a rotary movement simultaneously with the longitudinal movement. Thus rotation of drum 13 is ensured. A third man attends to the setting of the carriage in accordance with the range of the point of impact just read off by means of the pointer Z, while a fourth man adjusts the gun by means of the elevating and traversing mechanisms according to elevation and lateral aim in such a manner that the target often appears in the correct line of sight, in which case firing should be effected.

The allowance for the influence exerted by the muzzle velocity, which is dependent upon the particular physical conditions (daily relationship) and upon the wear of the barrel, on the range and time of flight of the projectile is here effected simply by adjusting the target distance scale x by rotating the double screw-threaded spindle 11 according to a scale of angles (not shown), thereby varying the length $k \log t$ (Figure 2) which corresponds to a multiplication of all the values for the time of flight of the projectile by the same factor.

What I claim is:

1. Apparatus adapted to be mounted on a gun for determining data for firing said gun at moving targets, having both means for determining a target-velocity-allowance vector, both in magnitude and direction, and providing a mechanical equivalent thereof, and means for providing a mechanical equivalent a previously determined target distance; the said apparatus a Cardan shaft, of extensible effective length, between said two means and comprising a spindle fixed against rotation and having a screw thread of large pitch and a sleeve about said spindle; a universal joint securing said spindle to said target-velocity-vector-determining means, whereby the spindle is oriented by said means in accordance with the target velocity vector; means whereby said sleeve is rotatable by the threads of said spindle; a ro-

tatable drum forming part of said target-distance-determining means and having its principal axis adapted to be disposed in the range of the projectile to be employed, and having a logarithmic spiral on its periphery for cooperating in determining the momentary range, for correction of elevation of the gun; and a universal joint interconnecting said drum and said sleeve, axial movement of said spindle causing rotation of said drum, and consequent variation in the calculated range.

2. As a part of apparatus adapted to be mounted on a gun for determining data for firing said gun at moving targets, means for providing a mechanical equivalent of a previously determined target distance, said means comprising a rotatable drum adapted to be rotated through the energization of target-velocity-vector-allowance determining means, said drum having its principal axis adapted to be disposed parallel with the axis of the barrel of the gun, and having a logarithmic spiral on its periphery, the abscissae of which spiral are proportional to the $\log x/t$ where x is the momentary distance and t is the time of flight of said projectile; a distance scale slidable along said drum in accordance with a logarithmic progression, the point of contact of said spiral with said scale determining an adjusting mark for the momentary target distance; means for sliding the distance scale a small increment of length according to such logarithmic progression, to ensure that the same is in proper coincidence with said spiral; and means for automatically indicating, as a result of such sliding of the distance scale, and dependent upon the time of flight of the projectile, the correct distance of the point of impact of the projectile.

3. As a part of apparatus adapted to be mounted on a gun for determining data for firing said gun at moving targets, means for determining the target-velocity-allowance vector, both in magnitude and direction, said means comprising a casing adapted to rotate about its vertical axis, and to move vertically; a connecting rod in said casing; a universal joint at the upper end of said rod; cranks for actuating said rod, and centering on the same vertical axis; means for varying the effective length of said cranks dependent upon the calculated velocity of the target; and means for varying the angular position of said cranks, about their centers, dependent upon the elevation of the target, the combination of these two adjustments determining the vertical adjustment of the connecting rod relative to said casing.

4. In apparatus adapted to be mounted on a gun for determining data for firing said gun at moving targets and comprising means for determining a target-velocity-allowance vector; a universal joint actuated by said means; a Cardan shaft, positioned by said universal joint; a sighting telescope mounted on said gun; a second universal joint associated with said telescope; a horizontally pivotal bearing parallel to the trunnion axis of the gun and rocked by said Cardan shaft; a vertically pivotal bearing at right angles to the trunnion axis of the gun and also rocked by said Cardan shaft; and linkages connecting said horizontally pivotal bearing and said vertically pivotal bearing with said second universal joint to impart to the telescope both the vertical and the horizontal components of the target-velocity-allowance angle; said Cardan shaft forming with the axis of the gun barrel the particular target-

velocity-allowance angle, so that the components imparted to the telescope give to the latter the desired angle of lag behind the gun.

5. As a part of apparatus adapted to be mounted on a gun for determining the data for firing said gun at moving targets, means for providing a mechanical equivalent of a previously determined target distance, said means comprising a carriage guide extending parallel to the axis of the gun barrel; a carriage movable along said guide; a drum rotatably mounted in said carriage and adapted to be rotated through the energization of target-velocity-allowance vector determining means, said drum having its principal axis parallel to that of said carriage and having a logarithmic spiral on its periphery, the abscissae of which spiral are proportional to the $\log x/t$ where x is the momentary target distance and t is the time of flight of said projectile; a distance scale slidable along said drum in accordance with a logarithmic progression, the point of contact of said spiral with said scale determining an adjusting mark for the momentary target distance; means for sliding the distance scale a small increment of length according to such logarithmic progression, to ensure that the distance scale is in proper coincidence with said spiral, the last-mentioned means simultaneously also moving said carriage and hence also the drum, along said carriage guide according to a linear progression; a scale on a selected one of said carriage guide and carriage serving as a measure of the time of

flight of the projectile; and a reading mark on the other one of said carriage guide and carriage and cooperating with said last-mentioned scale.

6. As a part of apparatus adapted to be mounted on a gun for providing a mechanical equivalent of a previously determined target distance, said means comprising a rotatable drum adapted to be rotated through the energization of target-velocity-allowance-vector determining means, said drum having its principal axis adapted to be disposed in the range of the projectile to be employed, and having a logarithmic spiral on its periphery, the abscissae of which spiral are proportional to the $\log x/t$ where x is the momentary target distance and t is the time of flight of said projectile; a distance scale slidable along said drum in accordance with a logarithmic progression, the point of contact of said spiral with said scale determining an adjusting mark for the momentary target distance; means for sliding the distance scale a small increment of length according to such logarithmic progression, to ensure that the same is in proper coincidence with said spiral; means between said distance scale-sliding means and the scale itself, for compensating for variations in the apparatus resulting from variations such as wear in the gun; and means for automatically indicating, as a result of such sliding of the distance scale, and dependent upon the time t of flight of the projectile, the correct distance of the point of impact of the projectile.

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