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R. V. MORSE.

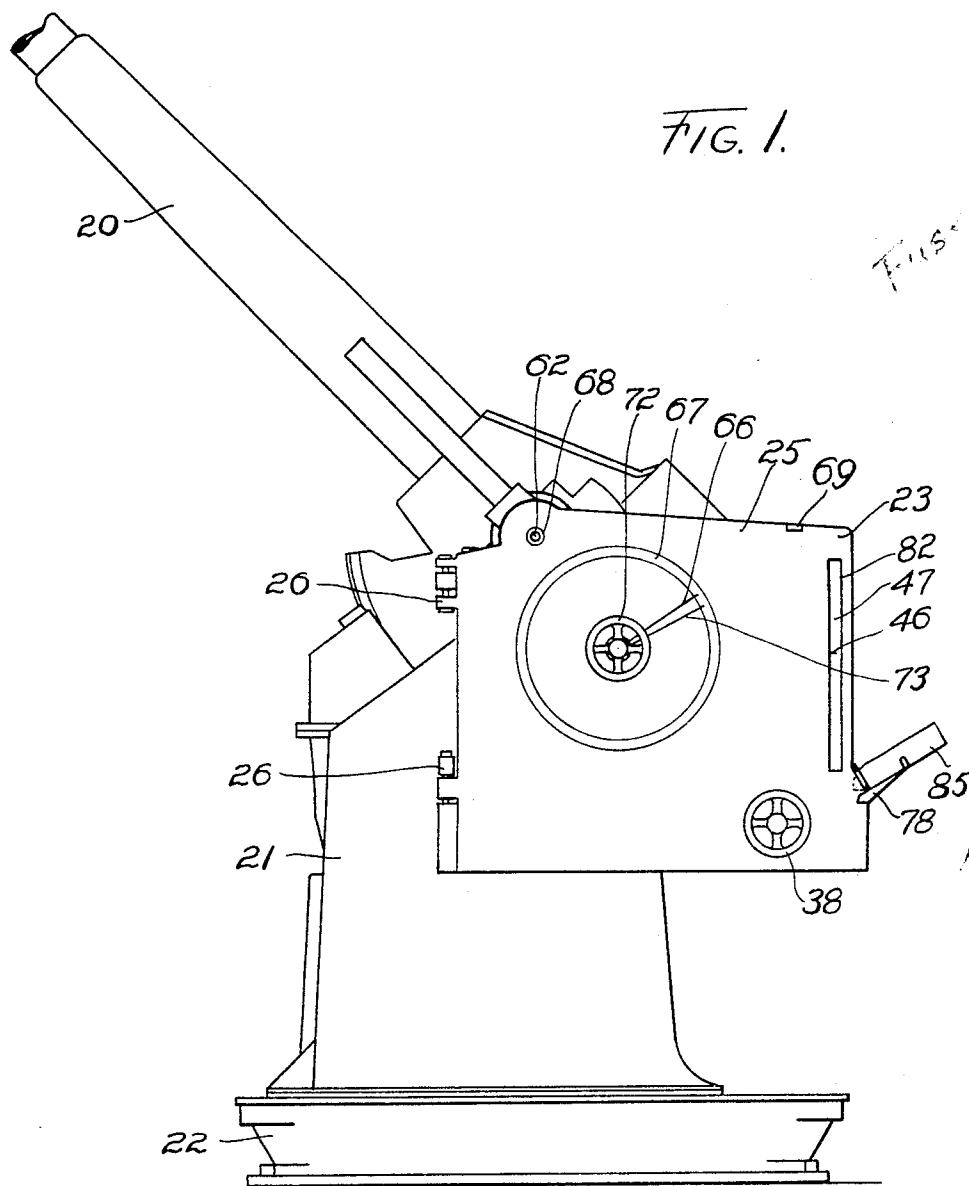
AUTOMATIC FUSE SETTER FOR ANTI-AIRCRAFT ARTILLERY.

APPLICATION FILED OCT. 10, 1919.

1,349,220.

Patented Aug. 10, 1920.

3 SHEETS—SHEET 1.

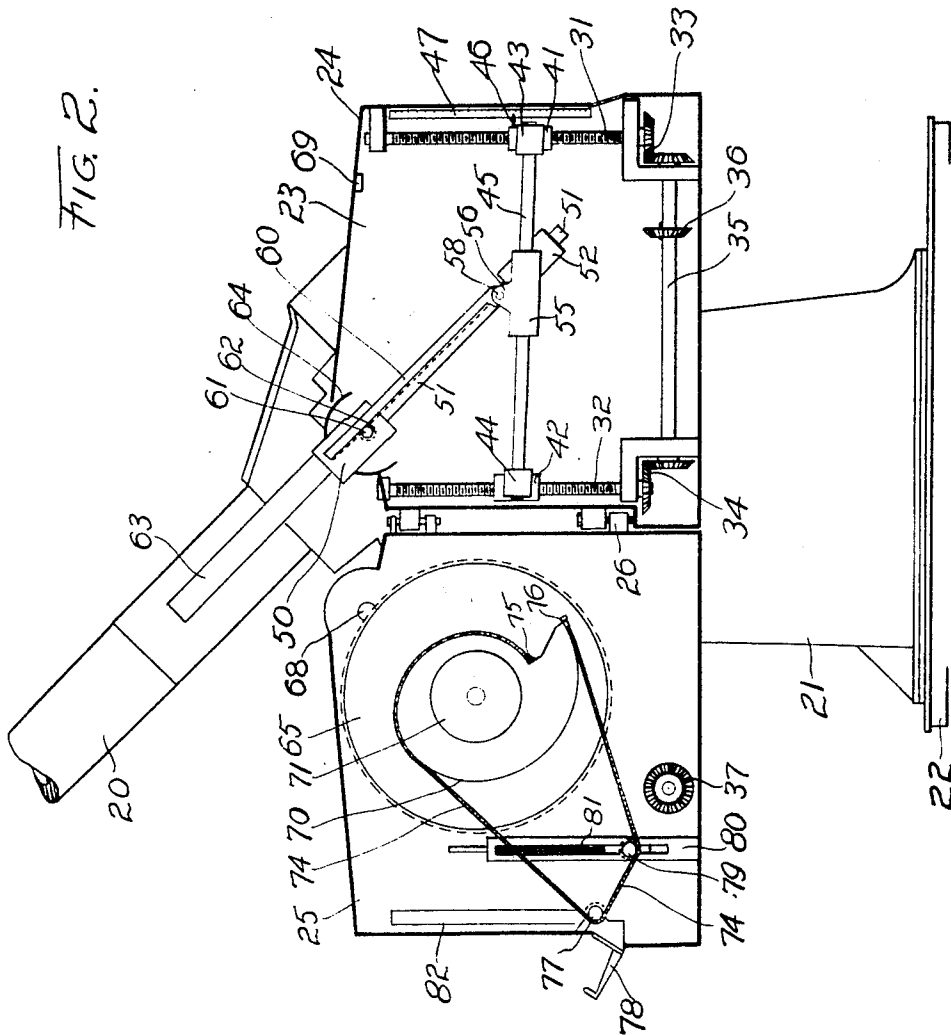
**INVENTOR**

Robert V. Morse

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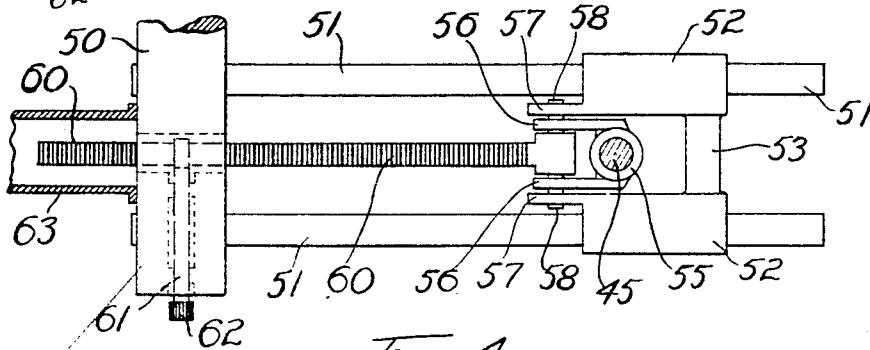
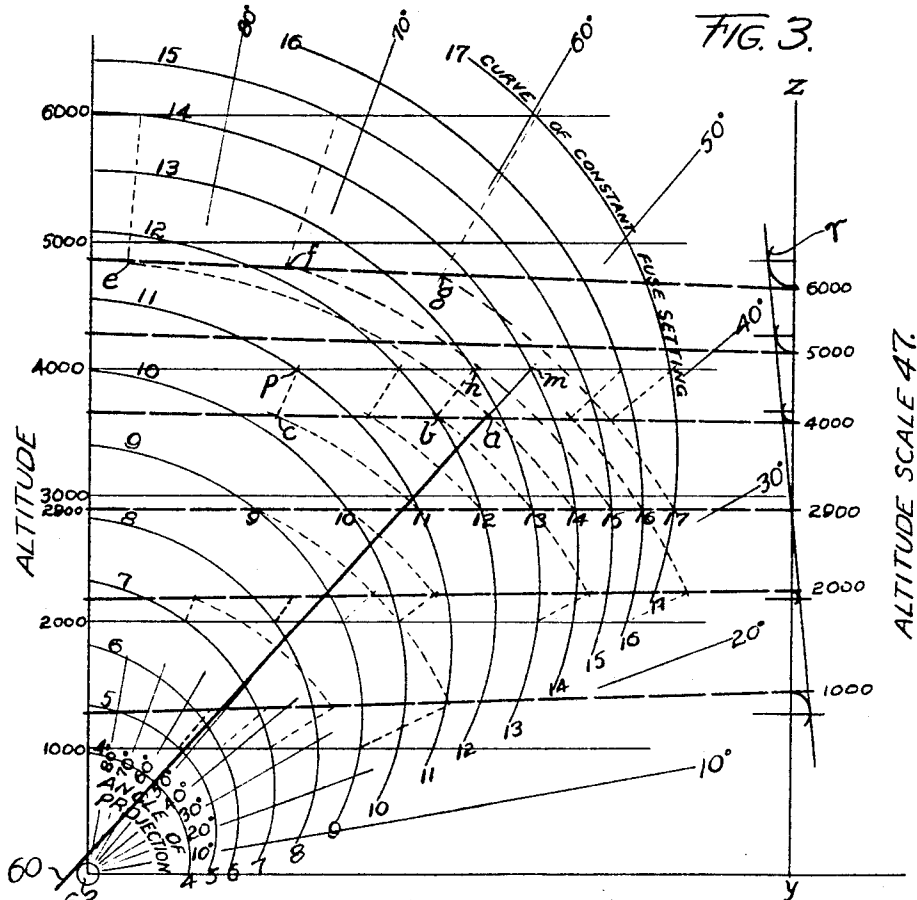
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3 SHEETS—SHEET 3.



*made by
 electric gun*

INVENTOR
 Robert V. Morse

UNITED STATES PATENT OFFICE.

ROBERT V. MORSE, OF ITHACA, NEW YORK, ASSIGNOR TO MORSE INSTRUMENT COMPANY, INC., OF ITHACA, NEW YORK, A CORPORATION OF NEW YORK.

AUTOMATIC FUSE-SETTER FOR ANTI-AIRCRAFT ARTILLERY.

1,349,220.

Specification of Letters Patent.

Patented Aug. 10, 1920.

Application filed October 10, 1919. Serial No. 329,697.

To all whom it may concern:

Be it known that I, ROBERT V. MORSE, a citizen of the United States, residing at Ithaca, in the county of Tompkins and State of New York, have invented new and useful Automatic Fuse-Setters for Anti-Aircraft Artillery, of which the following, taken with the accompanying drawings, is a specification.

This invention relates in general to artillery employed against aircraft, and in particular to the control of the fuse setter, by which the time fuse of the projectile is set, and which accordingly determines the point in the trajectory at which the shell shall burst. Fuse setters have heretofore been set by hand, but in anti-aircraft fire the target moves so fast that any delay creates such uncertainty regarding the future position of the target, (that is, the proper point of aim), as to seriously impair the accuracy of fire. One object of this invention is to operate the fuse setter continuously by automatic mechanical means so that accurate settings are obtained without any delay. This, combined with a compensating device, permits the lead of the point of aim to be reduced to the smallest possible amount,—that is, to equal merely the travel of the target during the time of flight of the projectile. The dead time formerly allowed for fuse-setting and loading is thus eliminated, so far as the lead or deflection of the point of aim is concerned.

Another object is to prevent the personal errors which necessarily are present when rapidly changing values are continuously read and set by hand. Another object is to eliminate elements sensitive to shock or wear such as cams of double curvature and point contacts, in order to make an instrument capable of withstanding the shocks and jars of service. Other objects will be apparent as the description proceeds.

In the drawings, Figure 1 is a side elevation view of the automatic fuse setter attached to an anti-aircraft gun, as it appears when ready for service. Fig. 2 is a similar view, with the door of the automatic fuse setter thrown open so as to expose the mechanism to view. Fig. 3 is a diagram

illustrating the determination of certain variable factors in the design. Fig. 4 is a detail showing one method of connecting the slide blocks and the angle and altitude bars.

In Fig. 1 and Fig. 2 the anti-aircraft gun 20 is shown carried in the mount 21, which is supported on the rotatable base 22 in the usual manner. Secured to the side of the mount 21 is the case or housing of the automatic fuse setter 23. This housing consists of a back portion or case 24 in which is placed some of the mechanism, and a swinging door 25 on which is mounted the remainder of the mechanism. The door 25 is connected to the case 24 by adjustable hinges 26, which permit the door 25 to be slightly adjusted vertically relative to the case 24. The purpose of this vertical adjustment will be explained later.

The mechanism in the case 24, as shown in Fig. 2, consists of two screws, 31 and 32, generally of slightly different pitch, which are rotated by bevel gearing 33 and 34 respectively. Both of these bevel gearings 33 and 34 are driven by the shaft 35, which has also keyed to it the bevel gear 36. This gear 36 receives its power from the bevel gear 37 when the door 25 is closed so as to bring the two gears 36, 37 into mesh. The gear 37 is operated by the hand wheel 38, (shown in Fig. 1,) so that when the hand wheel 38 is turned the screws 31 and 32 are both rotated through the medium of the gearing described.

Each screw, 31 and 32, operates a traveling nut, 41 and 42 respectively; and each of these nuts, 41 and 42, carries a pivoted socket, 43 and 44 respectively. Through these sockets 43 and 44 extends a rigid rod or bar 45. This bar 45 can be elevated or lowered by operating the hand wheel 38,—through the medium of the screws and connecting gearing as described. The position of the bar 45 is indicated by a pointer 46 which plays over an arbitrary scale 47, which is calibrated in terms of altitude, as will be explained. For this reason, the bar 45 is sometimes called the altitude bar.

The trunnion block 50 is moved in accord with the angle of elevation of the gun. It

is immaterial whether the block 50 is made integral with the gun trunnion, or has a separate trunnion operated by the gearing that operates the gun trunnions,—so long as the angular position of the trunnion block 50 continuously corresponds to the angle of elevation of the gun. Securely mounted in the trunnion block 50 is a rigid rod or bar 51, whose angular motion accordingly corresponds to the elevation of the gun. This bar 51 is sometimes termed the angle bar. A pair of these bars 51 is generally provided, as shown more in detail in Fig. 4, in order to balance twisting stresses, but only one of the bars 51 is shown in Fig. 2, in order that the mechanism may be clearly exposed to view. Movable slides 52 surround and are arranged to traverse the bars 51; these slides 52, as shown in Fig. 4, are integrally connected by a cross-piece 53, to eliminate twisting. On the altitude bar 45 is a somewhat similar sliding member 55, which is provided with a pair of ears 56. The slides 52 also are provided with ears 57, and a pivot pin 58 extends through the ears 56 and 57, thus pivotally connecting the slide 52 with the slide 55. The end of the rack bar 60 is also pivoted around the pin 58. The teeth of the rack bar 60 engage a pinion on the shaft 61, which is rotatably mounted in the trunnion block 50. At the other end of the shaft 61 is the pinion 62. As the rack bar 60 in its motion might often extend beyond the main casing 24, a tubular extension or casing 63 is provided, up which the rack 60 may move. The upper end of the casing 63 is closed, so that the rack 60 is protected from the weather. A curved shield 64 attached to the trunnion block 50 closes the opening in the main casing 24, while permitting the free rotation of the trunnion block and attached parts.

The remainder of the mechanism is mounted on the door 25, for the sake of convenience in construction and inspection. The gear wheel 65 is arranged to mesh with the pinion 62 when the door 25 is closed. The motion imparted to the gear 65 by the pinion 62 is indicated by the pointer 66, which is attached to the shaft of the gear 65 and plays over a circular scale 67 on the outside of the door 25, as shown in Fig. 1. A peep-hole 68 is provided in the door 25 through which the pinion 62 can be seen when the door 25 is closed. A stop 69 is arranged on the casing 24, which prevents the door being closed until it has been slightly lowered by adjusting the hinges 26. After the door has been closed in this slightly lowered position, it is elevated by operating the adjustable hinges 26 until the gear 65 and pinion 62 are seen to be properly in mesh, seen through the peep-hole 68. This arrangement prevents the gear 65 and pinion 62 being damaged by the

door 25 being carelessly slammed shut, and also permits an accurate adjustment of the gear 65 and pinion 62.

A smooth faced cam 70 is mounted on the same shaft as the gear 65, and this cam is connected to the gear 65 by a clutch 71. The handwheel 72 and pointer 73, (which also plays over the scale 67,—see Fig. 1), are attached to the cam 70. When the handwheel 72 is pressed inward, the clutch 71 is disengaged, so that the cam 70 can then be freely rotated relative to the gear 65, by merely turning the handwheel 72. When the pressure is released the clutch 71 engages, clamping the gear 65 and cam 70 in whatever new position they may have been set, and the cam 70 and gear 65 then continue to rotate as a unit.

A power transmission chain, preferably of the type known as the "silent chain", is wrapped around the smooth faced cam 70. One end of this chain 74 is attached to the cam 70 at the point 75, and the other end is attached at the point 76,—the connections being of the turnbuckle type so as to permit a small adjustment. The chain 74 runs over a toothed sprocket 77, which is keyed on the worm shaft of a standard bracket type fuse setter 78. The mechanism of the fuse setter can be found described in the *Handbook of 3-inch Gun Matériel* published by the Government Printing Office, Washington, D. C. The chain 74 also passes around a spring-pressed idler 79, attached to a block which slides in a groove in the frame 80, and is forced downward by the spring 81, so as to keep the chain 74 always taut, regardless of the position of the irregular cam 70.

There is also provided a window 82 in the door 25, through which the scale 47 can be seen when the door is closed. As has been stated, the gear 37 is operated by the handwheel 38, and meshes with the gear 36 when the door 25 is closed.

The operation is as follows: The pointer 46 on the scale 47 is set at the altitude at which the fire is desired, by operating the handwheel 38. The altitude is generally telephoned to the gun by the central fire control officer in charge of the fire of all the guns. The use of altitude in place of range as the linear factor permits any number of guns to be controlled as a unit, since the same altitude settings may be used for them all, regardless of their various locations. The gun is pointed in the usual manner, and its vertical angular motion about its trunnions causes the rod 51 to swing in a corresponding manner, which operating through the slide 52 and pivot pin 58 causes the slide 55 to move along the altitude bar 45. This causes the rack 60 to be pushed in or drawn out over the pinion on the shaft 61, thus rotating the pinion 62. Assuming

for the moment that the operator has placed the pointer 73 in coincidence with the pointer 66, so that the gear 65 and cam 70 rotate as a unit while locked together in that relative position. The rotation of the pinion 62 turns the gear 65 and cam 70; and this motion, somewhat modified by the configuration of the cam 70, is transmitted through the chain 74 to the pinion sprocket 77, which operates the fuse setter proper, 78. The shell 85 is inserted into the fuse setter 78, set, loaded in the gun, and fired, all in the usual manner.

The foregoing description of the operation applies when the target is stationary, such as a captive balloon; but it will be obvious that when the target is rapidly moving, and the setting at the fuse setter is constantly changing, a setting which was correct at the instant the shell was withdrawn from the fuse setter would not be correct at the instant when it was discharged from the gun. In order to compensate for the interval of time which might cause such an error, the cam 70 is arranged so that it may be given a lead relative to the gear 65, the cam 70 being set forward slightly in the direction in which the gear 65 is moving so as to give a setting at the fuse setter 78 a little in advance of that which would be given by the operation as above described. Thus the fuse is set so as to be correct by the instant it is discharged from the gun.

Taking up this loading lead compensation more in detail, it will be recalled that the pointer 66 is connected to the gear wheel 65, while the pointer 73 is connected to the cam 70, that is, to the fuse setter 78. The operator watches the motion of the pointers as they travel slowly over the scale 67, and sets the pointer 73 ahead of the pointer 66 so that the reading which comes under the pointer 73 at the instant when a shell is withdrawn from the fuse setter 78 will come under the pointer 66 at the instant of discharge of the gun. Since the motion of the pointers is slow, and the loading speed of a well drilled gun crew fairly regular, the adjustment is not difficult to make. Each time a shell is withdrawn from the fuse setter 78 the operator observes the reading under the pointer 73, and watches it until he hears the discharge of the gun. If, at the instant of discharge, the pointer 66 has not reached the observed reading, the operator decreases the lead; if the pointer 66 has passed the observed reading, he increases the lead. The accuracy of the settings is thus observed and checked at each shot, so that a very close compensation is not difficult to attain.

Though the actual operation, from the operator's standpoint, is simple and easy to understand, the principles of operation from the standpoint of a designer are not so read-

ily comprehended. The difficulty arises from the fact that at first sight it does not appear possible to obtain fuse settings correct for all altitudes from a mechanism employing a single simple cam element, since the shape of such an element would depend on the altitude for which it was designed, and when designed for one particular altitude would be incorrect for any other altitude; (by a single simple cam is meant one whose curvature can be expressed by a single plane curve, as distinguished from cams of double curvature, such as irregular surfaces having curvature in more than one plane). It is possible, however, by properly proportioning other elements of the mechanism, to bring the errors within such small limits as to be negligible at all altitudes. The most important of these elements whose proportions must be determined are the screws 31 and 32, and the scale 47. The difference in pitch between the screws 31 and 32 causes the altitude bar 45 to assume various inclinations at various altitudes, which bring the bursts into horizontal planes; and the scale 47 is then calibrated according to the actual altitudes at which the bursts occur, that is, according to empirical data, and not according to any fixed theory inherent in the mechanical relations. In other words, the calibration of the scale 47 is not uniform, though the pitch of the screw 32 is uniform. Other elements through which the designer can mold the operating characteristics are the pinion 62, whose diameter can be selected to introduce a correction varying with the angle of fire, as will be explained; and the selection of the position of the altitude bar 45 which is to be the primary position for which the shape of the cam 70 is to be determined. These and other modifiable points will become apparent as the steps incident to an actual design are briefly followed through.

The first step is to draw a family of curves showing the various fuse settings for various altitudes and various angles of projection, (that is, angles of fire). Referring now to Fig. 3, there are shown by way of illustration curves of constant fuse setting, running from 4 to 17 inclusive, and plotted in terms of altitude and angle of projection. These curves are plotted from data obtained from firing under normal conditions, and they may be readily obtained from an ordinary trajectory sheet having curves of constant fuse setting, in the following manner. A table of altitude of bursts is compiled by reading from the trajectory sheet the altitudes at which the various trajectories intersect the various curves of constant fuse setting. The trajectories are identified by their angles of projection,—that is, their original firing angles. The following illus-

trates the manner of arranging such a table,—the body of the table reading in meters altitude.

Table of altitude of bursts.

F u s e s e t t i n g		Angle of projection.								
		90°	85°	80°	75°	70°	65°	60°	55°	50°, etc.
5	3.....	1068	1063	1048	1025	997	960	915	860	805
	4.....	1433	1420	1401	1365	1323	1267	1202	1135	1060
	5.....	1760	1740	1718	1679	1630	1565	1492	1407	1313
	6.....	2100	2085	2053	2010	1948	1870	1777	1673	1556
	7.....	2425	2409	2373	2318	2247	2155	2047	1921	1782
10	8.....	2752	2732	2692	2632	2550	2447	2323	2178	2013
	9.....	3100	3067	3015	2945	2847, etc.				
	etc.									

From such a table curves of constant fuse setting, such as shown in Fig. 3, are readily plotted, using altitude as the linear ordinate, and angle of projection as the angular coördinate.

We next select some primary position for the altitude bar 45, taking for example the horizontal broken line marked 2900 in Fig. 3; (strictly speaking this is the locus of the pivot move 58, as the sliding member 55 moves along the altitude bar 45). It will be obvious that for this altitude there is a certain fuse setting corresponding to each angular position of the gun. Thus there is obtained the series of fuse settings which will produce bursts in a horizontal plane at the altitude of 2900 for the various angles of fire. The vertical angular motion of the gun moves the mechanism which operates the fuse setter 78, and the curvature of the cam 70 is so designed as to give the desired series of fuse settings for this particular altitude of 2900. The configuration of the cam 70 is now fixed, and though we have a mechanism which will maintain the bursts in the desired horizontal plane at the 2900 altitude, the problem arises as to how we are to obtain bursts in horizontal planes at other altitudes, using the same cam 70.

If we assume that the small gear 62 is a mere point, without finite diameter, it will be obvious that no motion will be imparted to the fuse setter 78 if the point 58 is moved along circular arcs having the point 62 as a center. After making due allowance for the finite diameter of the gear 62, (whose angular motion through 60° can be compensated by a movement of the point 58 radially through a distance equal to the radius of the gear 62, for example), the locus of the point 58 for a constant fuse setting is substantially a circular arc, such as shown by the dotted line running from the point 14, at the intersection with the 2900 altitude, for example.

We will now see how we may obtain a horizontal string of bursts at the altitude of 4000 meters. It will be seen that the actual curve of constant fuse setting 14 crosses the altitude 4000 at a point *m*; yet, for that angle of projection the point 58 would have to have traveled to the point *a*

in order to have maintained the fuse setting 14. Therefore, if we wish to have the burst at the altitude 4000 corresponding to the point *m*, we must have the altitude bar 45 so located as to bring the point 58 at the point *a*. Going through the same steps with the fuse setting 13, we find that in order to have the burst occur at the 4000 altitude at the point *n*, we must have the altitude bar 45 so arranged as to bring the pivot 58 to the point *b*. Similarly, for the fuse setting 11, in order to get a burst at the 4000 altitude at the point *p*, we must arrange the altitude bar 45 so as to bring the pivot 58 to the point *c*. Thus there is obtained a string of points, *a*, *b*, *c*, etc., through which the altitude bar 45 must make the pivot 58 pass. Since the altitude bar is straight, a straight line is drawn as nearly as can be through these points, as shown by the heavy broken line labeled 4000 at the right hand side of the diagram.

The same operations are then carried through for the 5000 and 6000 meter altitudes. It will be found that straight lines will run very closely through the points thus determined, as shown by the heavy broken lines in the diagram, (Fig. 3). The amount that the points diverge from the straight line is the inherent error of the mechanism; for example, on the 6000 line, the point *e* is about 8 meters below the line, the point *f* about 10 meters above, and the point *g* about 2 meters below the line. Such errors are of course negligible. The manner in which the arbitrary calibration of the scale 47, (as shown on the right of Fig. 3) and the inclination of the altitude bar 45 operate to reduce the range of error in the mechanism can be seen from Fig. 3. For example, if the altitude bar was set according to the regular graphical scale at the left of the diagram, and the altitude bar was maintained constantly horizontal, the apparatus when set for an altitude of about 4800 meters and an angle of about 87°, (that is, for the point *e*), would actually give a burst at an altitude of 6000 meters, (since the fuse would be set at 14), which would mean an error of 1200 meters. This is the error which would naturally result from using at 4800 meters a cam which was designed on the basis of 2900 meters. The error for the point *g*, fuse setting 17, would be about 1400 meters. But by arbitrarily calling this particular setting of the altitude bar 6000, in place of its real graphical value of 4800, the maximum range of error is reduced from 1200 or 1400 meters to about 200 meters; and when we apply the further correction obtained by inclining the altitude bar, the range of error is reduced so as to average merely nominal values, such as 5 or 10 meters. It has been mentioned that the finite diameter of the pinion 62 has some effect on

the fuse settings, due to the fact that even if the rack bar 60 did not move either in or out over the pinion, a purely angular swing would still rotate the pinion 62 an equal angular amount. The amount of this effect on the fuse setting is proportional to the diameter of the pinion 62, and its quality, whether positive or negative, depends on whether the rack bar 60 extends above or below the pinion. These facts can be utilized to some extent by the designer in correcting slight curvatures in the string of bursts.

There has been shown the derivation of the various broken lines which indicate the inclination of the altitude bar 45 for various altitude settings. There remains to be determined how closely the two screws, 31 and 32, can give these various inclinations. Here it will be noted that since the two screws are of uniform, though slightly different pitch, the difference in elevation between one end of the bar and the other is a linear function, being directly proportional to the distance the bar is moved from its primary horizontal position. In order to determine the accuracy with which such a linear function will suffice, the difference between the right and left hand ends of the altitude bar for the 6000 position is measured, and an arc r is struck, having its center in the vertical line $y-z$, and passing through the intersection of that vertical line $y-z$ with the broken line marked 6000. Similar arcs are struck for the 5000, 4000, 2000, and 1000 positions, and short horizontal lines are drawn passing through the centers of the arcs. Since the radius of these arcs depend on the difference in elevation between the two ends of the altitude bar, a straight slanting line must be drawn through the points located by the intersection of these arcs with the short horizontal lines, if these elevations are to result from the operation of the two screws 31 and 32. There is sometimes a little difficulty in getting a straight line to run through these points. Slight alterations can be made in the originally selected inclinations of the altitude bar, and the points brought into a right line. It will be recalled that the entire design is based on a fundamental or primary position of the altitude bar, taken at 2900 in the illustrative example. Since this primary position is arbitrarily selected by the designer with no guide other than his experience resulting from trial, it is advisable to try out different primary positions, unless the first lay-out is so perfectly satisfactory as to admit of no appreciable improvement. In this connection it may be stated that the primary position need not be strictly horizontal, neither need it coincide with the graphical scale of the diagram. For example, an inclined line may be run along at

the altitude of about 2000 and yet have the cam so designed as to give horizontal bursts at an altitude of 2500 meters, just as in the diagram the bar when placed graphically at 4800 gave bursts at 6000; the only difference being that whereas there were certain residual errors in the 6000 altitude, owing to the use of a 2900 cam, there would, in the case where 2500 meter bursts are decided on as the primary line, be no errors because the cam would be primarily designed to eliminate all errors at that altitude. Variations in the location of the primary line will be found to modify the general results to a considerable extent, and this should be borne in mind as an expedient in cases which do not readily yield the desired solution. The essence of the method is the successive reduction of the residual error until the final residual error is negligible.

Similar apparatus and a similar method can be used when the original angular motion follows the angle of position of the point of aim, instead of the angle of projection of the gun,—that is, follows the inclination of the line of sight instead of the line of fire. In fact practically any angular motion that is simultaneous with the elevation of the gun,—whether the law connecting that motion to the gun be simple or complex,—may be used to impart the motion to the block 50 of the automatic fuse setter described. The only difference being that, for example when the angle of position is used, the curves of constant fuse setting of Fig. 3 would be laid out according to altitude and angle of position instead of altitude and angle of projection; or if some other angular motion was used, such for example as one having twice the motion of the angle of projection, or some other multiple thereof, then the values of that angle would be used in the diagram in place of the angle of projection, in determining the location of the original curves of constant fuse settings.

In the mechanism which has been described it need hardly be pointed out that there is no particular virtue in having the bar 51 parallel to the gun 20, since the angular motion of the bar 51 would equal the angular motion of the gun 20 if the two were maintained in any fixed angular relation relative to each other. Similarly, the screws 31 and 32 need not necessarily be vertical,—in fact the whole mechanism can be arranged at any convenient angle, if desired, and yet operate in the same manner so long as the same arrangement of its elements relative to each other is preserved. The screws 31 and 32 have been described as having slightly different pitch, in order to give the altitude bar 45 various inclinations, yet it will be obvious to those skilled in the art that a mechanical equivalent of

that arrangement would be to make the gear ratio of the bevel gearing 33 slightly different from the ratio of the bevel gearing 34, while making the screws 31 and 32 of the same pitch.

The design has been described as based on firings under normal conditions, yet it is well known that variations in barometric pressure and humidity affect the fuse settings to a considerable extent. Such variations however can be considered a function of the altitude only,—that is, they change the absolute altitude of a string of bursts without seriously impairing its horizontal character. Such variations therefore need not be considered in the design of the mechanical features of the mechanism; they do not impair the accurate coördination of the various guns, and they can either be compensated at the altitude scale 47 or be considered and corrected in the original designations of altitude settings which are sent out by the central fire control officer. When the fire is being controlled through observation of the behavior of the horizontal barrage,—on the principle that the fire of a number of spaced guns will automatically focus at the correct altitude but become diffused in proportion to the error in altitude,—the absolute altitude becomes of course immaterial.

In the foregoing there has been described a particular installation for the purpose of illustration, but it will be apparent to those skilled in the art that the mechanism is capable of various modifications and adaptations without departing from the scope of the invention as outlined in the following claims:

1. In a fire control mechanism, the combination of a member having an angular movement, an adjustable member which can be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, a cam shaped element, gearing connecting the movable connecting means to the cam shaped element, a fuse setter, a toothed wheel for operating the fuse setter, a chain connecting the cam shaped element to the toothed wheel, and means for keeping the chain taut.

2. In a fire control mechanism, the combination of a member having an angular movement, an adjustable member which can be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, a rack operated by said movable connecting means, a pinion shaft rotated by said rack, a cam shaped element, gearing connecting the pinion shaft and the cam shaped element, a fuse setter, and mechanical means through which the fuse setter is operated by the cam shaped element.

3. In a fire control mechanism, the com-

bination of a member having an angular movement, an adjustable member which can be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, a movable indicator, gearing connecting the said movable connecting means to the indicator, a second movable indicator, a fuse setter, mechanical means connecting the second indicator to the fuse setter, and means for adjusting the second indicator relative to the first mentioned indicator.

4. In a fire control mechanism, the combination of a member having an angular movement, a non-uniform scale, an adjustable member which can be set for various altitudes according to said scale, means for giving the adjustable member different inclinations at various altitude settings, a movable connecting means whose motion is determined by the aforesaid members, a cam shaped element, mechanical means operatively connecting the said movable connecting means to the cam shaped element, a mechanism to be controlled, and mechanical means operatively connecting the cam shaped element to the mechanism to be controlled.

5. In a fire control mechanism, the combination of a member having an angular movement, an adjustable member which can be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, a rack operated by said movable connecting means, a pinion shaft rotated by said rack, a gear operated by said pinion shaft, a cam shaped element driven by said gear, a mechanism to be controlled, and mechanical means operatively connecting the cam shaped element to the mechanism to be controlled.

6. In a fire control mechanism, the combination of a member having an angular movement, an adjustable member which can be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, a rack operated by said movable connecting means, a pinion shaft rotated by said rack, a gear operated by said pinion shaft, an indicator connected to said gear, a cam shaped element, an indicator connected to the cam shaped element, an adjustable mechanical connection between the gear and the cam shaped element whereby the cam shaped element can be driven by the gear with various degrees of lead, a fuse setter, a toothed wheel for driving the fuse setter, a chain connecting the cam shaped element to the toothed wheel, and means for keeping the chain taut.

7. In a fire control mechanism, the combination of a member having an angular movement, a non-uniform scale, an adjustable member which can be set for various altitudes according to said scale, means for giving the adjustable member different in-

clinations at various altitude settings, a movable connecting means whose motion is determined by the aforesaid members, a rack operated by said movable connecting
5 means, a pinion shaft rotated by said rack, a gear operated by said pinion shaft, an indicator connected to said gear, a cam shaped element, an indicator connected to the cam shaped element, an adjustable mechanical
10 connection between the gear and the cam shaped element whereby the cam shaped element can be driven by the gear with various degrees of lead, a fuse setter, and mechanical means through which the fuse setter is oper-
15 erated by the cam shaped element.

8. In an automatic mechanism, the combination of a case, mechanical means within said case, a pinion operated by said mechanical means, a door for said case, a gear on the
20 door arranged to mesh with the pinion when the door is properly closed, a stop arranged to prevent the door from being directly closed to its final position, and adjustable means for bringing the door to its final po-
25 sition with the gear and pinion properly in mesh, whereby the gearing is protected from being damaged by the slamming of the door.

9. In a fire control mechanism, the com-

bination of an automatic determining mechanism, a scale, a movable indicator moving
30 over said scale in accord with the determinations of the automatic mechanism, a fuse setter, a second movable indicator mechanically
35 connected to the fuse setter so that it moves over the scale in accord with the fuse settings, and an adjustable connection between the first indicator and the second indicator whereby the second indicator may be moved
40 simultaneously with the first indicator but with various degrees of lead.

10. In a fire control mechanism, the combination of a member having an angular movement, an adjustable member which can
45 be set for various altitudes, a movable connecting means whose motion is determined by the aforesaid members, said movable connecting means comprising a slide on one of
50 said members, a pair of slides arranged on the other of said members, whereby the applied forces are balanced, and a pin pivotally connecting the first mentioned slide with the second mentioned slides.

In witness whereof I have hereunto set my hand this 7th day of October, 1919.

ROBERT V. MORSE.