

No. 865,247.

PATENTED SEPT. 3, 1907.

E. W. HUBBARD.

AUTOMATIC GUNNERY CORRECTING DEVICE.

APPLICATION FILED AUG. 18, 1906.

3 SHEETS—SHEET 1.

Fig. 1.

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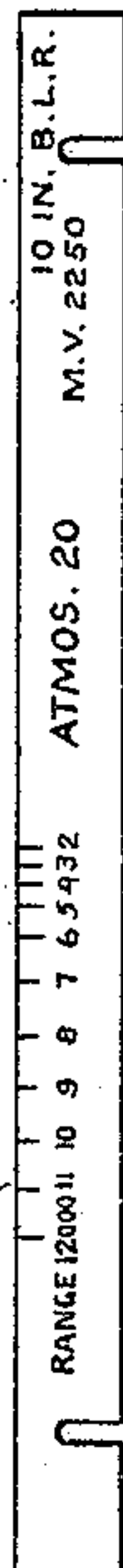


Fig. 2.

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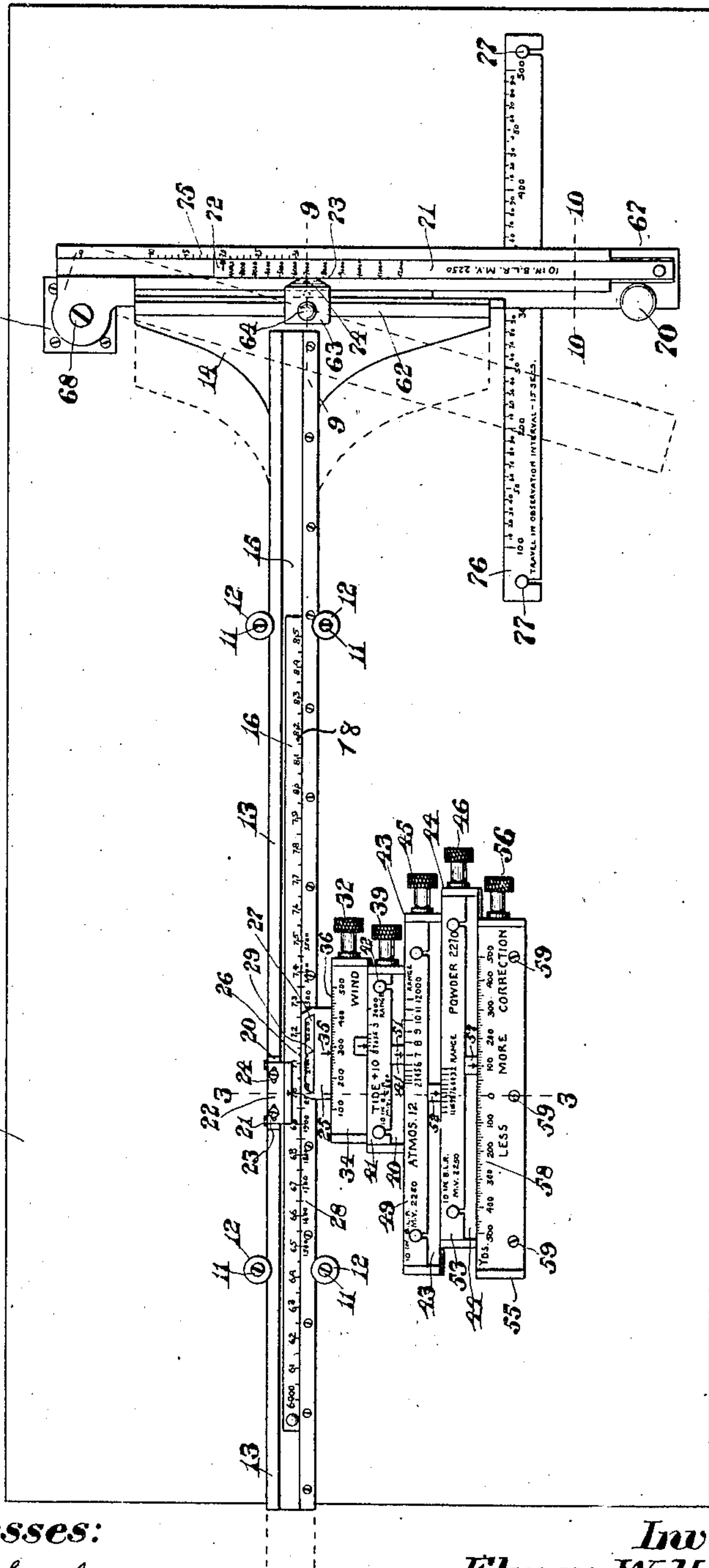
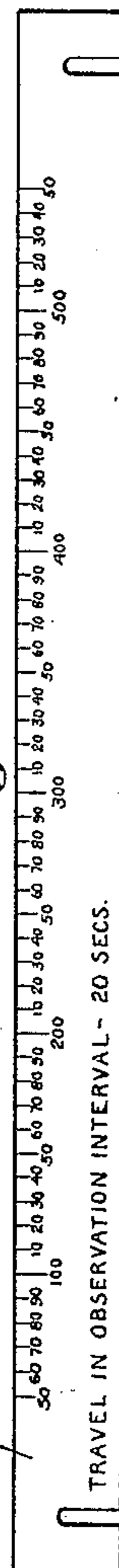


Fig. 3.

78



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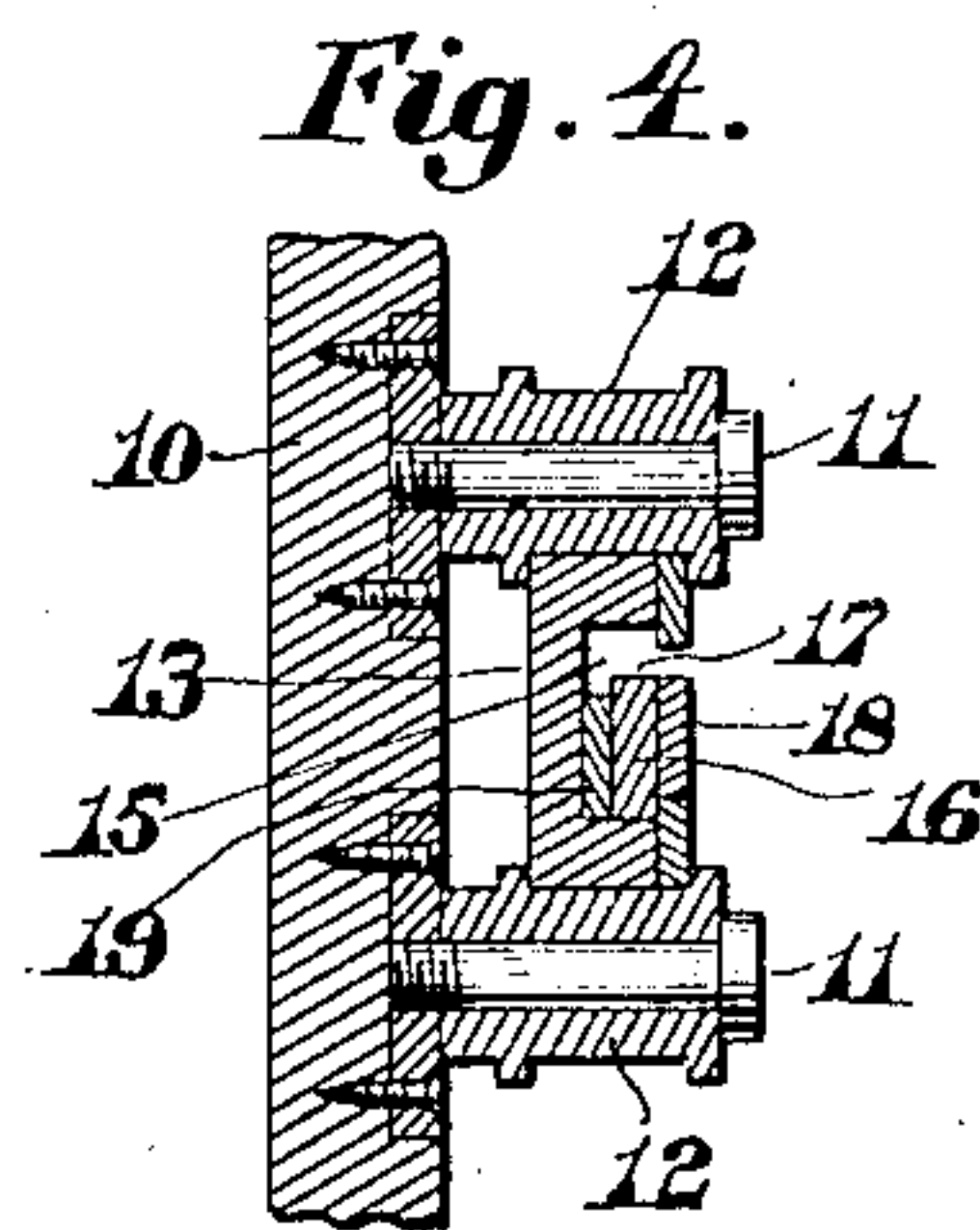
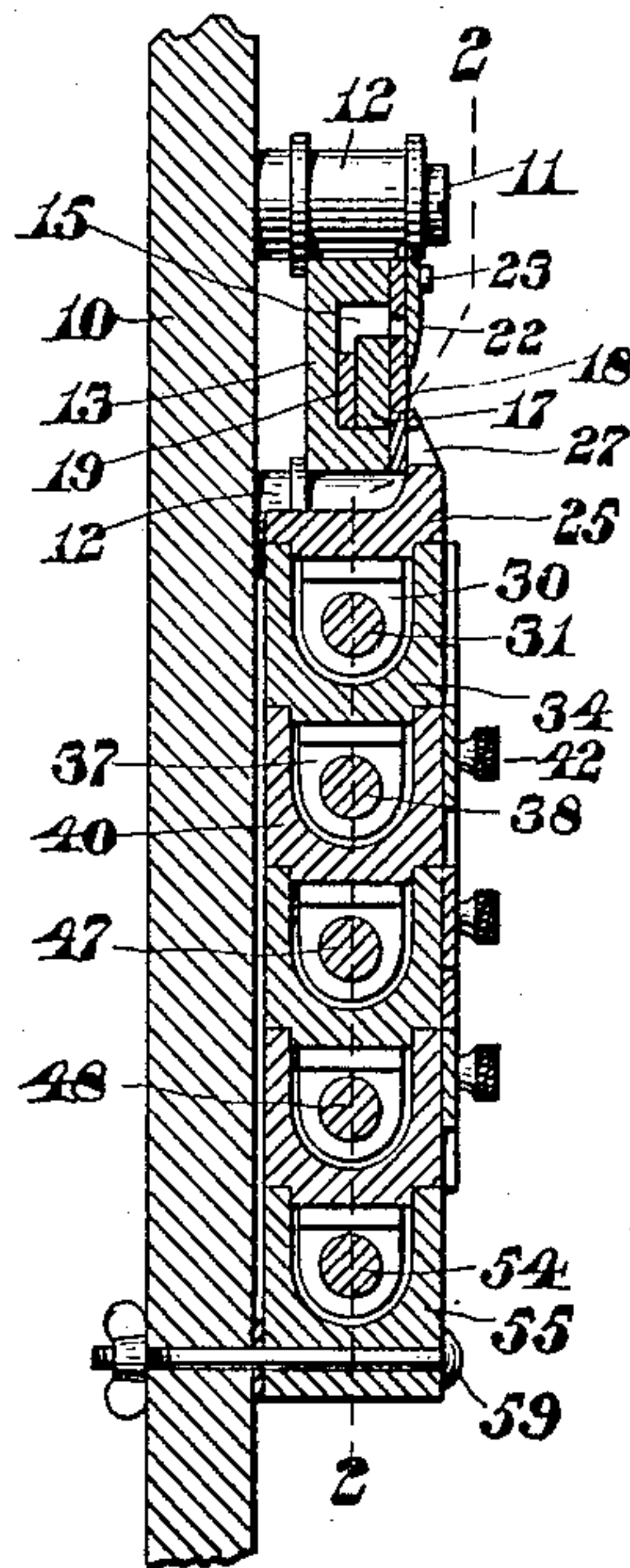
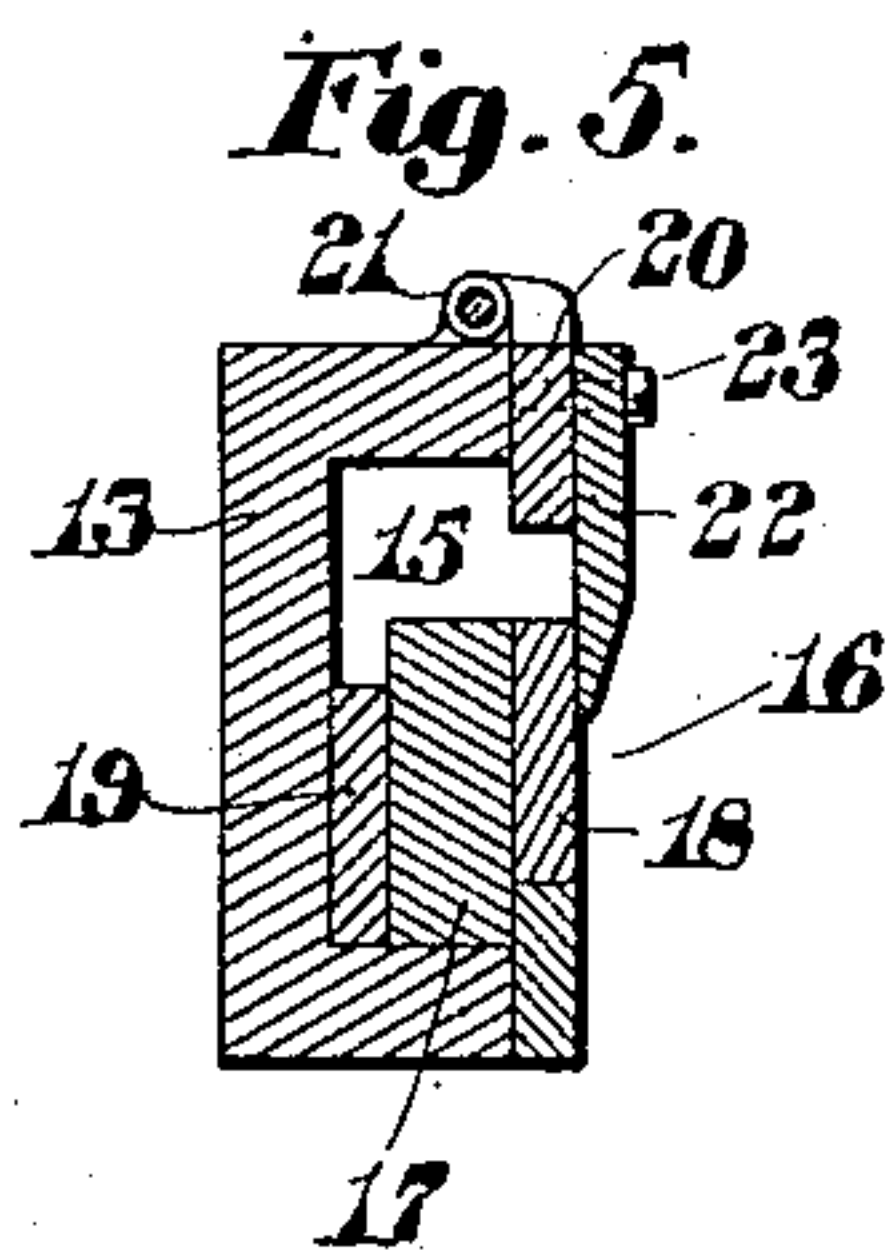
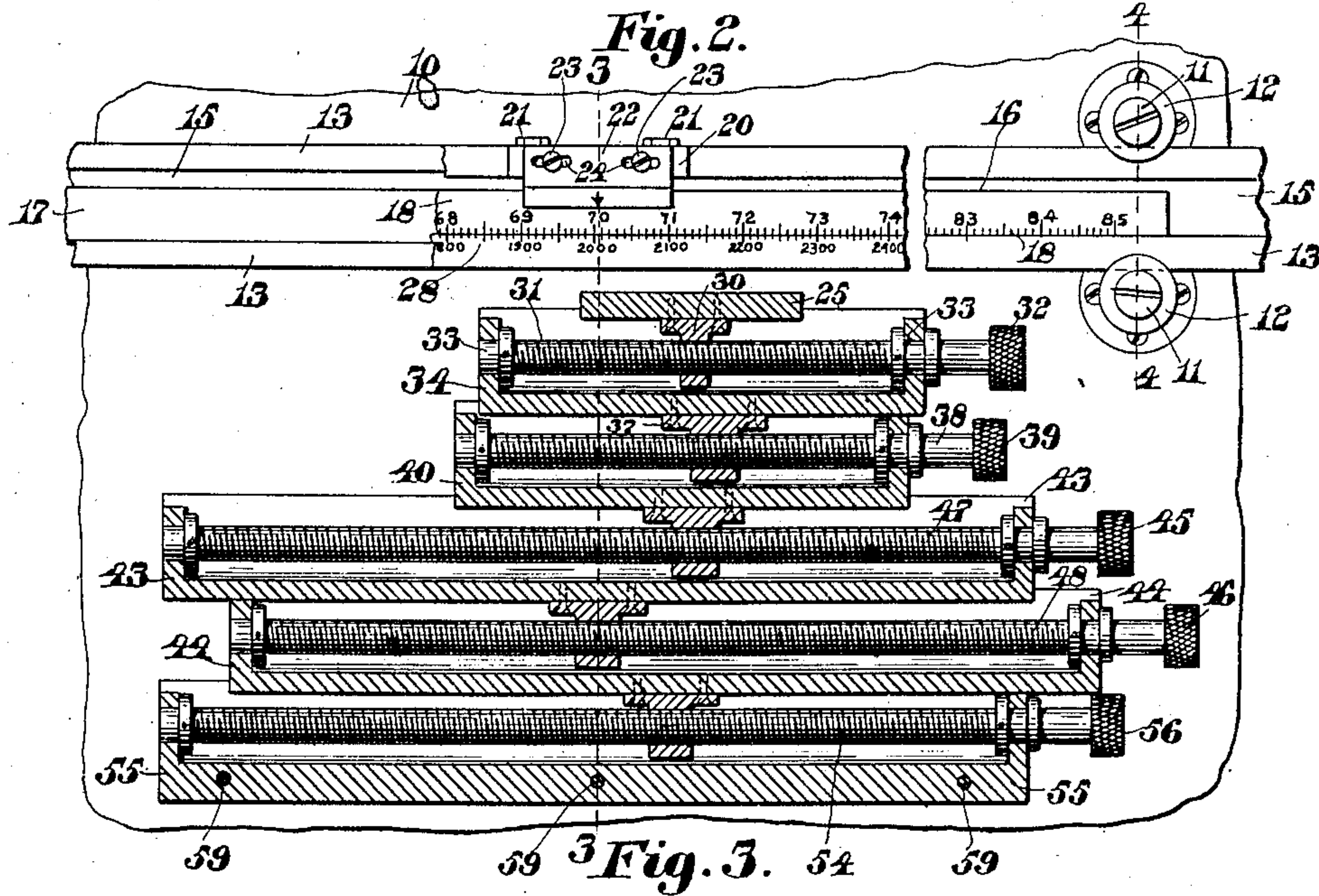
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3 SHEETS—SHEET 2.



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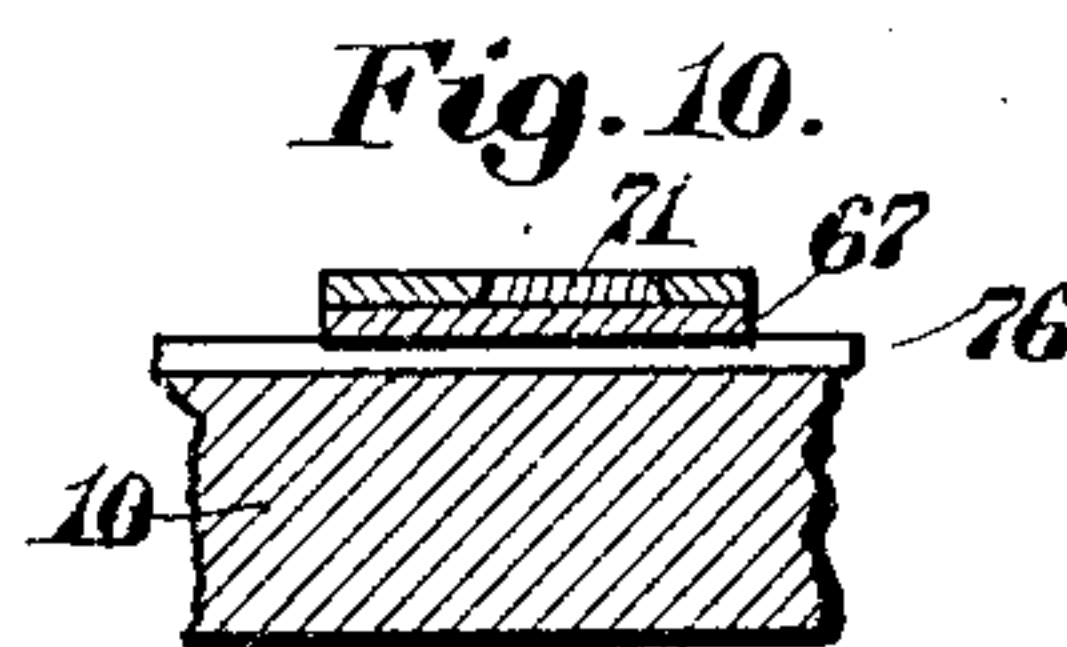
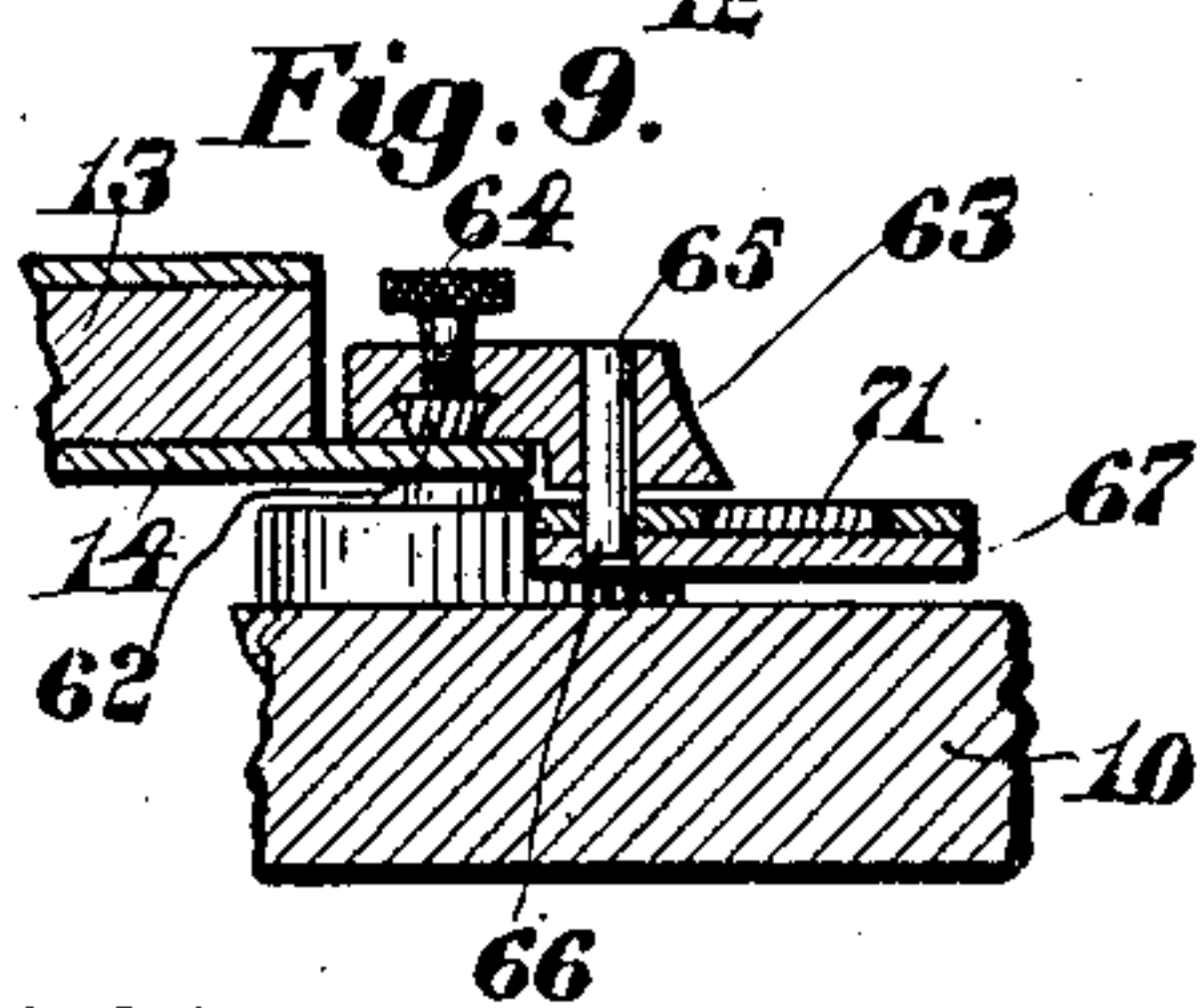
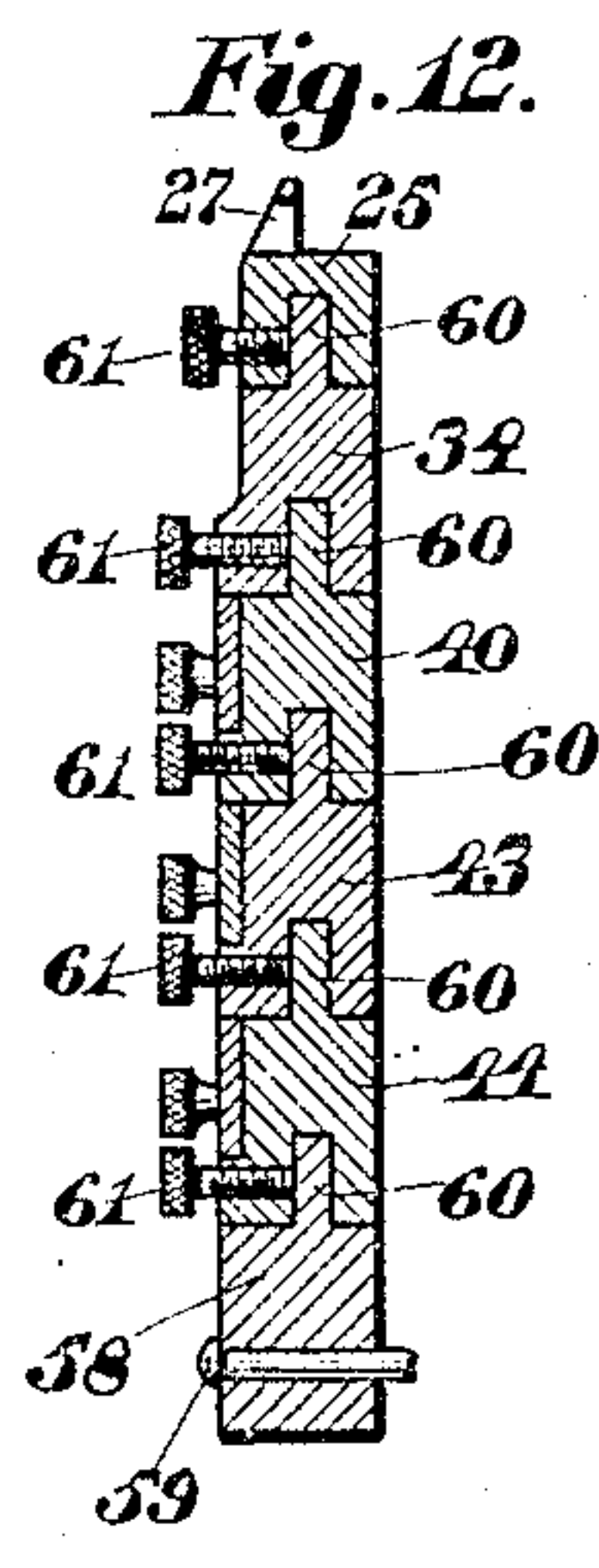
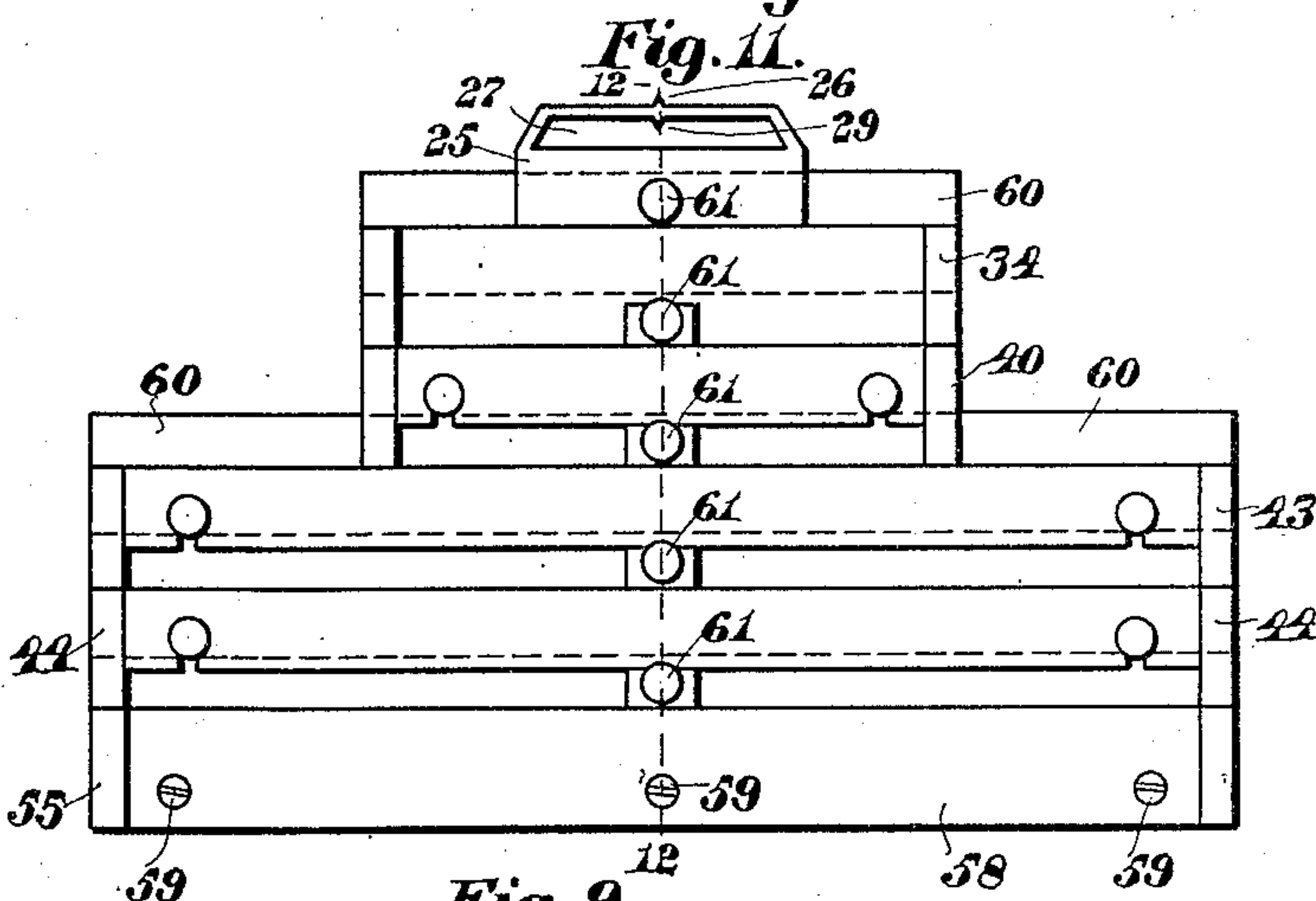
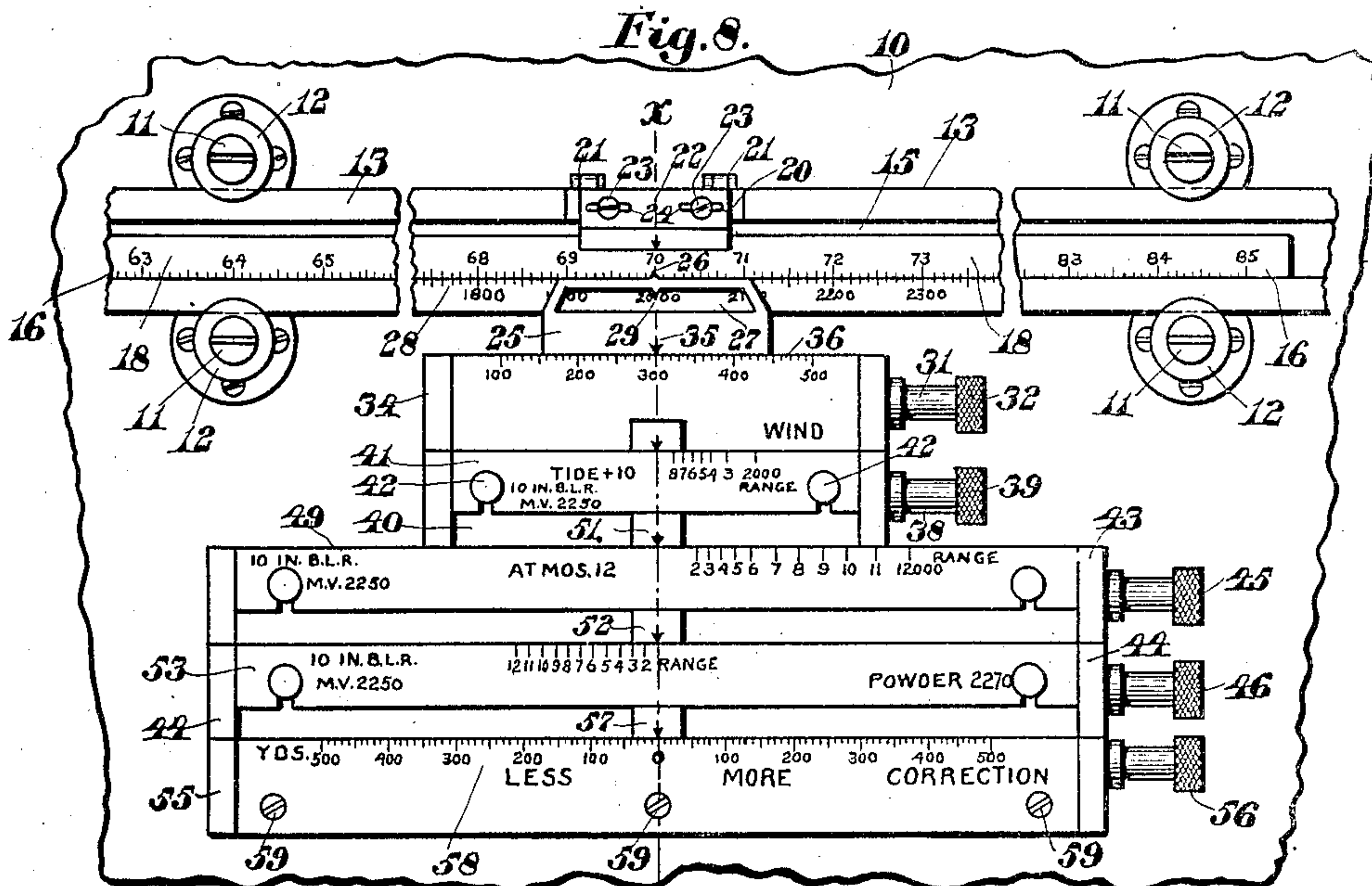
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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

ELMER W. HUBBARD, OF THE UNITED STATES ARMY.

AUTOMATIC GUNNERY-CORRECTING DEVICE.

No. 865,247.

Specification of Letters Patent.

Patented Sept. 3, 1907.

Application filed August 18, 1906. Serial No. 331,124.

To all whom it may concern:

Be it known that I, ELMER W. HUBBARD, a citizen of the United States of America, and a captain in the Artillery Corps of the United States Army, stationed at Fort Revere, Hull, in the county of Plymouth and State of Massachusetts, have invented certain new and useful Improvements in Automatic Gunnery-Correcting Devices, of which the following is a specification.

This invention relates to improvements in devices for giving the necessary corrections in artillery firing; and the object of the invention is to provide a device of the class described which shall give with greater speed and facility and with less liability to error the necessary gunnery corrections for use in artillery firing (especially with heavy seacoast guns) than any device heretofore known and which shall interfere in no way with the usual operations of plotting at the plotting board or with working of the gun itself.

In heavy artillery firing, as is well known, the range tables used are computed on the basis that atmospheric conditions, muzzle velocity of powder, charge, weight and form of projectile, etc., are all normal or standard. As a majority of these conditions are seldom fulfilled it follows that various corrections must be applied in elevating and sighting the gun. In addition the motion of the ship or target must be allowed for.

In the United States Coast Artillery Service the range or actual distance from gun to target at any instant is usually corrected for the following conditions or causes, viz:

1. Wind, or effect of the wind in shortening or increasing the range attained by the projectile in its flight.
2. Powder velocity or rather the variations of the initial velocity given the projectile by the powder charge used from the normal or standard.
3. Tide, or height of tide at the time, usually reckoned above the plane of mean low water. The effect of the variation of the tide, as is well known, is to change the height of the gun about the plane of the target and hence in turn affects the elevation to be given to the gun for a given horizontal range.
4. Atmospheric density as determined by readings of the barometer and thermometer. This in turn affects the range attained by the projectile.
5. Motion of the target or the increase or decrease of range during the time elapsing from the instant the range is determined until the projectile strikes. That is, one must aim to hit a point in the track of the ship and ahead of her at which she will arrive at the time the projectile strikes. The time elapsing from the instant the range is determined to the instant the shot strikes and is evidently made up of two periods: (a) The prediction interval, or interval from the instant the range is determined to the instant the gun is discharged. This interval is usually a constant one and covers the

time consumed in plotting and determination of the various corrections, time of transmission of intelligence, setting of gun, etc.; (b) the time of flight of the projectile, a well known interval, which for any particular gun, powder charge, etc., varies with the range. Based on a known change of range for any particular interval, say twenty seconds, it is obvious that the range corrections to be applied would be found by solving a simple proportion for a number of seconds equal to sum of prediction interval and time of flight.

6. An arbitrary correction may be applied dependent on the range attained by the previous shot or shots.

While the above are the usual corrections applied in heavy artillery firing, my devices can be readily adapted to make any other range corrections or a less number, as may be desired.

The various range effects described above could be allowed or corrected for by making suitable changes or corrections in the elevation of the gun as given in range tables for the particular range considered. It is customary, however, to estimate the effect on the range of the shot of a certain cause and apply the correction to the range. Thus if at 5000 yards the effect of a certain wind is to shorten the range by 50 yards the practical method is to add 50 yards to the actual distance of 5000 yards, thus giving a working range of 5050 on which the elevation is based. Similarly with the other causes noted above. Thus if a certain cause tends to shorten the range attained by the projectile the correction is an additional one and vice versa. These effects may be either positive or negative, positive when an increase of range results and negative in case of a decrease. The corrections to be applied obviously are of the opposite sign. Supposing in case of a given range, all the various range corrections, each taken with its proper sign, are applied to the distance of the target or range. The result is a fictitious or working range on which the angular elevation of the gun is based and is commonly called the "corrected range."

The object of this device is to give quickly and mechanically the corrected range. It may also, as will appear hereafter, be used with equal facility to attain the "correction" to be applied, i. e. the algebraic sum of the various corrections. This is a matter of detail and depends on the particular system of fire adopted.

The device for making range corrections is independent of the particular system of fire adopted and may be used with a plotting board or any device or devices which give at regular intervals, say every fifteen, twenty, or thirty seconds, (called the "observation interval") the following data, viz: 1. Range or distance of target from gun at any particular instant. 2. Change of range during the previous observation interval. These data are found by well known means which need not be described here. When arranged to give the total cor-

rected range this range would obviously be communicated direct to the gun. When arranged to give the correction only such correction would be applied to the range by well known methods.

5 This device can similarly be applied to finding the sight setting or azimuth setting to be given the gun. The corrections usually applied in a horizontal plane, due to the errors of deviation are those due to the following causes, viz: 1. Wind, or effect of the wind in
10 causing the projectile to depart to the right or left of the plane of fire. 2. Drift, or the well known effect of the rifling in causing the projectile to depart from the plane of fire. 3. Travel, or the effect of the motion of the target considered as an angular change of position as
15 viewed from the gun. 4. Angular error of last shot as determined by observation. It is to be noted, however, that in Case II, so-called, of the *U. S. Artillery Corps Position Finding System* in which direction is given by the sight and elevation by an elevation scale
20 attached to the gun carriage and where the sight is provided with an horizontal scale, allowance must be made for the motion of the target, or ship, for the time of flight only. This since a condition of aiming requires the index or vertical wire of the sight to be on
25 the target at the instant of firing. The setting of said index would include the allowance for travel. But in Case III, so-called, of the *U. S. Artillery Corps Position Finding System* where the direction of pointing is set on an azimuth circle on the gun carriage, and the elevation by an elevation scale attached to said carriage
30 it is obvious that the correction must include a correction for the motion of the ship during the "prediction interval" plus the time of flight precisely as in the case of the range device previously described.

35 As shown later this device is adapted either to Case II or Case III. It is obvious that to secure the corrected range for the various heavy coast defense guns under any and all conditions by computation it must necessarily lead to great liability to costly errors especially when this work must be performed by enlisted
40 men of no technical education as is generally the case. Evidently therefore it is desirable that some device should be provided by which the corrected range may be secured without this liability of error and by which
45 a non-technical man or one with little education may mechanically make the various corrections necessary to insure the accuracy of each shot fired from the gun.

To provide such a device is the purpose of the present invention which is fully illustrated in the accompanying drawings in which
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Figure 1 represents one embodiment of the invention adapted primarily for use in obtaining corrected ranges. Fig. 2 represents a partial elevation of the same drawn to an enlarged scale with the adding or
55 computing device shown in section. Fig. 3 represents a transverse section of same on line 3—3 on Fig. 2. Fig. 4 represents a transverse section of the same on line 4—4 on Fig. 2. Fig. 5 represents a transverse section through the reading scale, its grooved supporting member, and index plate, on line 3—3 on Fig. 2, drawn to a yet larger scale. Fig. 6 represents the reverse of an atmosphere scale showing a subtractive graduation thereon, drawn to an enlarged scale. Fig. 7 represents a twenty-second observation interval scale, enlarged.
60 Fig. 8 represents an enlarged elevation of the reading

scale and the adding or computing device therefor, the various members of which are in their normal or central position. Figs. 9 and 10 represent respectively enlarged sections on lines 9—9 and 10—10, on Fig. 1, and Figs. 11 and 12 represent respectively an elevation
70 and section of a modified form of adding or computing device.

Similar characters designate like parts throughout the several figures of the drawings.

In the drawings, 10 represents a suitable backboard 75 in which is secured a plurality of studs 11 on each of which is mounted a revoluble grooved roller 12. The rollers 12 support a tongue 13 forming with a head 14 a suitable T square which is adapted for movement longitudinally of said tongue between the rollers 12. The
80 tongue 13 is provided with a groove 15 longitudinally thereof in which is mounted a slidable member 16. The member 16 consists of a bar 17 having secured to either face thereof a scale 18 or 19 the scale 18 on one side being graduated in yards of range to a certain
85 point while the graduations are continued upon the other scale 19 together with a suitable overlap of the ranges. It is obvious from an inspection of Fig. 4 that this member 16 may be readily withdrawn from the groove 15 and be returned therein in reversed position
90 with the scale 19 facing outwardly or it may be removed entirely and another member with different range graduations thereon substituted for it. This construction of the reversible scale dispenses with the necessity of having too long a tongue 13 which would
95 otherwise be required. A plate 20 is hinged at 21 to the upper portion of the tongue 13 and to the front face of this plate 20 is secured an index plate 22 by means of the screw 23 extending through slots 24 therein, these slots providing a ready means for securing accu-
100 rate adjustment of said index plate longitudinally of the tongue 13.

Below the tongue 13 is mounted a member 25 provided with an index 26 adapted to register with the graduations on the reading range scale 18 and having
105 therein a window 27 through which the operator may read the scale 28 formed upon the lower outer face of the tongue 13. The member 25 is provided with a second index pointer 29 adapted to register with the graduations of the scale 28 as it is moved longitudi-
110 nally thereof. The origin of this scale is 2000 and reads in either direction for 500 yards and is adapted for use in connection with the gun arm of any suitable plotting device.

The member 25 is provided on its under face with a
115 suitable nut 30 to which is threaded a screw 31 provided with an operating head 32 and having bearings 33 in a member 34. It is obvious that by turning the head 32 the screw 31 will operate upon the nut 30 to move the member 25 longitudinally of the member 34
120 in either direction thereby causing the index 35 thereon to register with the graduations formed upon the adjacent edge of the front face of the rectangular box member 34.

The graduations 36 on the member 34 are for the
125 purpose of correcting for wind and are spaced in any predetermined manner adapted for use in any desired system whereby a movement of the index 35 to any given graduation on the wind scale 36 would make the desired correction for wind on the reading range scale
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18. For convenience the origin of the graduations of the wire scale is given as 300 but any other number might as well be assumed provided it agreed with other systems with which the device might be used.

5 To the bottom of the member 34 is secured a nut 37 to which is threaded a screw 38 provided with an operating head 39 and mounted in bearings in a similar rectangular box member 40. To the front face of the member 40 is detachably secured a scale 41 provided
10 with arbitrary markings thereon adapted to correct for a given tide for the various ranges.

The scale 41 is provided with suitable slots engaged by clamping screws 42 which retain said scale in position and which may be operated to release the scale
15 and allow it to be reversed or another scale inserted in its place. It is obvious that various scales must be used each having its predetermined arbitrary markings thereon for making corrections for tides of different heights and for different types of guns. In the
20 same manner other rectangular box members 43—44 are located beneath the members 34—40 and are similarly moved lengthwise of one another by means of the operating heads 45—46 of the screws 47—48 threaded to nuts extending downwardly from the bottom of the
25 members 40 and 43. The member 43 is provided with means of attaching thereto an atmosphere correction scale, said scale being provided with suitable arbitrary graduations which have been predetermined and are adapted to make corrections for a given atmosphere,
30 the scale shown in Fig. 1 being adapted to make corrections for a 12 atmosphere which is an additive correction.

The atmospheric origin is 16 and all corrections for atmospheres above 16 are subtractive corrections and
35 in this case the arbitrary markings will be upon the opposite side of the center as indicated on the scale 50 shown in Fig. 6. The index 51 on the member 40 registers with the arbitrary markings on the atmosphere scale and the member 43 to which the atmosphere scale is secured is provided with an index 52
40 which registers with the arbitrary markings for the powder scale 53, detachably secured to the member 44. It is obvious that for different muzzle velocities and different types of guns various scales must be used
45 and for this reason the scales are made readily detachable so that a new scale for a new muzzle velocity may be attached conveniently.

The member 44 is operated by means of the screw 54 having bearings in the lower rectangular box member
50 55 and provided with an operating head 56 by which the member 44 may be adjusted longitudinally thereof so that the index 57 upon said member 44 may be moved lengthwise of the correction scale 58 by the screw 54 to add or subtract any arbitrary number of
55 yards to the previous range given. This scale 58 is permanently secured to the backboard 10 by means of bolts 59, with the zero of said scale in the axis $x. y.$, see Fig. 8, while the indexes of the various movable members 25—34—40—43, and 44 are all in this axis when in
60 their normal positions.

It is obvious from an inspection of the drawings that each of the rectangular box members 25—34—40—43—44 may be moved independently longitudinally of the member beneath to make any subtractive or additive
65 correction while the movement of any member will

carry with it all the members mounted thereon without disturbing any other settings and the sum of the various corrections thus made will be indicated by means of the index 26 upon the reading range scale 18 thereby automatically and mechanically giving
70 the corrected range to be used at the gun. It is also obvious that where the conditions of either one of these causes is constant it is unnecessary to make any changes in that particular member, the only operation necessary being a change for any cause which has varied since the last reading. It is also evident that this device at all times shows clearly what correction has
75 been made and whether any correction has or has not been made, this varying from other devices for similar purposes in use in which one or more corrections may
80 be made and no indication be shown as to whether this has been accomplished or not. This uncertainty often requires that the entire operation should be recommenced, while when the failure to make any desired correction is not discovered in time, costly errors
85 creep into the calculations which are entirely obviated by the present device. Again it is entirely immaterial which correction is made first, or in what order the various corrections are made. As the changes for tide, atmosphere, and muzzle velocity usually remain practically the same for a considerable period
90 for any particular day the proper scales to be used for the particular tide, atmosphere, and powder, will be placed in position at the commencement of operations and these only will be exposed to view thus preventing the operator from being confused on mistaking
95 other scales for different conditions of tide, atmosphere, and powder as in the case of other devices now in use. A great advantage accrues from having these detachable scales graduated in ranges rather than yards as
100 all that is necessary to secure the proper corrections for these various causes is to set the proper index to the mark designating the range given by the observer or otherwise obtained.

While the box members 25—34—40—43—44 are
105 shown as adjustable longitudinally by means of screws mounted in bearings and threaded to units on the members immediately above said screws, it is perfectly obvious that any other suitable means may be used which will permit one member being moved longitudinally of the other and then clamped in said adjusted position. One such modification is shown in
110 Figs. 11 and 12 in which each member has an upwardly extending rib 60 entering a groove in the member next above, which member is adapted to be moved on
115 said rib and clamped in adjusted position by the set screw 61.

The arbitrary correction scale 58 is only used after a shot has been fired from the gun and found upon plotting to have fallen over or short, as for instance,
120 if it fell 100 yards short, to correct for the last shot, 100 yards would be added, this being accomplished by a movement of the index 57 along the scale 58 until it reads 100 yards "more." If the shot plotted 200 yards over, then a correction of 200 yards less would be
125 required and the index 57 moved to the 200 on the left of zero, thereby making the proper correction.

It is obvious from the foregoing and from an inspection of the drawings that whatever corrections are made by means of this arbitrary correction scale or
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any of the movable scales superimposed thereon for the purpose of making corrections of powder, atmosphere, tide, or wind, the algebraic sum of the corrections will be indicated upon the range scale 18 by the index 26 where it may be readily used and transmitted to the guns as the corrected range to be used, this range scale previously having been moved in the groove 15 until the given range, say 7000, registers with the index 22.

With 7000 as a given range the proper indexes on the movable box members must register with the 7 mark on the tide, atmosphere, and powder scales. A glance by the range officer at the device would immediately disclose to such officer whether or not these different members were properly set. As shown in Fig. 1 the corrected range for the corrections made from the various causes provided for is 7,130, this reading being obtained from the scale 18 which shows the index a little beyond the number 71 which indicates 7,100 and the part of a graduation is equal to 30 making the total of 7,130. This would be the correct range for a fixed target but as the targets are usually movable targets, in active service being the vessels of the enemy moving in various directions to confuse the gunners, and in practice being targets towed by means of tugs, it is necessary to take into consideration the travel of the targets during the time of flight and the prediction interval. It must be assumed that the automatic computing device has corrected for the various causes heretofore mentioned and that the corrected range which for these causes, is, as for instance, in this particular case 7,130, is now fixed. Hence, if we know by any means the travel correction of the target during the prediction interval and time of flight would be plus 200 yards, *i. e.* the target would move 200 yards further away from the gun before the projectile struck, it is obvious that the actual corrected range for the target moving at this speed away from the guns must necessarily be 7,130 plus 200 yards, making a total corrected range of 7,330, which should be the range sent to the gunners. In order to provide for this and secure corrected data for the travel of a target during this prediction interval and time of flight the head 14 of the T square is provided with a guide 62 at right angles to the tongue 13. On this guide 62 is mounted a trammel 63 having a clamp screw 64 by which said trammel may be clamped in any adjusted position. The trammel is provided with a downwardly projecting pin 65 (see Fig. 9) entering a slot 66 in an arm 67 pivoted at 68 to a plate 69 secured to the front of the range board 10. The arm 67 is adapted to be moved about the pivot 68 by means of a handle 70. In a suitable groove on said arm 67 is slidably mounted a time of flight scale 71 provided with an index 72 and a plurality of range graduations 73 with which the index 74 on said trammel is adapted to register. The index 72 is adapted to register with graduations forming a prediction interval scale 75 extending lengthwise of said pivoted arm 67. Detachably secured to the front of the backboard 10 is a travel in observation interval scale 76 held in position by means of suitable set screws 77. Several of these scales are provided for various observation intervals and any one of these scales may be selected for use as, for instance, 10, 15, 20, or 30 seconds.

The scale shown in Fig. 1 is for an observation inter-

val of fifteen seconds while the scale 78 shown enlarged in Fig. 7 is for an observation interval of twenty seconds. Each includes only so much of the scale as would correspond to a speed of twenty-five miles per hour for a target moving directly to or from the gun. Thus on fifteen seconds scale an extreme travel of 200 yards is shown inasmuch as a vessel going at the extreme speed of twenty-five miles an hour would practically go over 12 yards in one second and in fifteen seconds fifteen times that, or only 180 yards, showing conclusively that with the extreme speed of the vessel for a fifteen-seconds interval only 200 yards are needed in extreme cases. The other travel and observation interval scales are similarly proportioned. It is obvious that if the arm 67 is moved about its pivot to the 200-yard mark upon the travel and observation interval scale the tongue 13 of the T square being constrained to move in a direct line upon the rollers 12 will be moved into the position shown in dotted lines upon Fig. 1 and cause a new reading upon the range scale, this being the total corrected range to be sent to the gun. Before the arm 67 is swung into this position the index 72 must register with the prediction interval used and the trammel 63 moved so that its index 74 registers with the given range, *i. e.* 7000. The time of flight scales are interchangeable and other similar scales for different muzzle velocities or different types of guns may be inserted in lieu of the one shown in the drawings. The travel in observation interval scale is entirely independent from the prediction interval scale so that the observations may be continued at stated intervals irrespective of the time of firing of the gun. This is a great advantage as observations may be taken at different and shorter intervals than the prediction intervals and as a consequence the variations of speed and travel of the target may be observed and used more nearly at the time of firing of the gun. By this means changes in speed can be more accurately ascertained at the time of firing than in the case where the last observation has to be taken. It is obvious that this same board may be used for different calibers of guns by changing the time of flight scale and the various detachable scales on the automatic computing device for others prepared for another type of gun as for instance a 12" B. L. R.

In the operation of the device the range officer or chief plotter at the beginning of practice determines the condition for the day—powder, atmosphere, tide, etc., and places on the box members 40—43—44 the corresponding scales. The time of flight scale 67 is now set to the predetermined prediction interval and the proper observation interval scale attached to the backboard. The observer at the range finder observes the position of the target and transmits the range and the range from the gun to the target is found by the plotting detail which in the present example will be assumed to be 7000 yards. Proper tide, atmosphere, and powder scales having been placed in position upon their respective box members the operator manipulates the screw heads 39—45—46 to adjust the tide, atmosphere and powder indexes to the arbitrary markings for 7000-yard range. The index 74 is set at 7000-yard range and the wind index is set for any reading which may be given by any suitable wind device.

On the next observation fifteen seconds later in the present example the target is first plotted as usual and travel is then called off. Supposing the travel equaled 100 yards, or 200 yards on the scale, take hold of the knob 70 and throw the arm 67 to 200 on the scale 76. At once the total corrected range is read at the index 26 on the range scale 18. This corrected range goes direct to the gun. The distance to last plotted position of the target is now called off and all operations continue as before, everything now being ready for travel on the next observation. One throw of the arm 67 thus solves the proportional travel and at the same time adds it into the range as previously corrected giving total corrected range. By this means the corrected range is held and travel determined by last observation interval is quickly added in to give the total.

It is believed that from the foregoing the operation will be fully understood without any further description. The construction and operation of the device is so simple that enlisted men of ordinary intelligence may be readily taught the principles of the device and operate it effectively as to operate this device requires no knowledge of gunnery.

In many other devices utilized for this purpose the computations are so many and the operations are so complicated that only trained men are capable of operating the same and as these trained men are often scarce it is a great advantage to have a device which may be readily operated by the majority of the members of a coast artillery organization. Moreover, another advantage of the present device is the absence of curves, strings, and charts, which are liable to easily get out of order and be affected by the changes in the weather conditions. The present device is free from all of these objections, all of the parts being mechanically constructed and united in such a manner as to make each action positive and accurate.

Where the wind, tide, atmosphere, and powder and other arbitrary corrections remain constant as is often the case all the corrections for these conditions including the travel may be made by one motion of the lever 67 which obviously is a great advantage. Another great advantage in this device is that the travel is determined on the observed travel in the last observation interval instead of as usual in the one preceding. Any changes of speed are therefore more closely followed. It is only necessary in the use of the present device for an expert, that is the range officer or chief plotter, to determine the conditions at the beginning of practice and adjust the scales. In this device only actual conditions are exposed thereby minimizing errors by the elimination of all scales not in actual use.

The provision of a device of this nature whereby the prediction interval may be changed at will and in which any desired interval may be used is a great advantage and this is also true of the ability to freely change the device so that any observation interval may be used. Moreover, another advantage in this connection is the entire independence of the observation interval from the prediction interval whereby there is no necessity of the intervals being the same and an opportunity is afforded of changing either of these intervals according to the degree of efficiency of the personnel operating the different devices. For

instance with rapid trained plotters it might be possible to take two observations during one prediction interval.

The apparatus has been more particularly described to make various corrections for different causes and register the same upon the range scale 18 from which may be read the total corrected range to be sent to the gun for use in aiming or laying. The apparatus is equally well adapted to indicate by means of the scale 28 upon the tongue 13 the algebraic sum of the total corrections to be made, the index 29 registering with said scale 28 to indicate thereon the exact algebraic sum of the total corrections to be applied on the gun arm of a plotting board or to be used in any other computations in connection with other systems which may be in use.

It is obviously an advantage to have provision made in a single apparatus whereby the total corrected range may be indicated to be sent directly to the gun or the total sum of the various corrections indicated which may be used in connection with other systems for aiming and laying.

While the device herein shown is adapted primarily for use as a range board for the purpose of securing either the algebraic sum of the total corrections to be used or the total corrected range to be sent to the gun it is obvious that by slight changes of some of the scales the device is equally applicable to be used for a deflection board to make corrections in deviation to the right or left of the target, i.e. giving the total sight setting in any adopted system which may be used or to give the total corrected azimuth setting by which the gun is to be laid.

Claims.

1. The combination of an arm adapted to be moved about a center; means by which the movement of said arm may be regulated to any predetermined point; a movable scale pivoted to said arm and slidable in a fixed path at right angles to the normal position of said arm; and an automatic computing device independent of said scale but coöperating therewith to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

2. The combination of an arm adapted to be moved about a center; a scale pivoted thereto and movable thereby in a fixed path at right angles to the normal position of said arm; and an automatic computing device independent of but coöperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

3. The combination of an arm adapted to be moved about a center; a fixed scale by which the movement of said arm may be regulated; a scale pivoted to said arm movable in a fixed path at right angles to the normal position of said arm; and an automatic computing device independent of but coöperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

4. The combination of an arm adapted to be moved about a center; a scale movable in a fixed path at right angles to the normal position of said arm; means interposed between said scale and arm for varying the movement of the scale by the movement of said arm; and an automatic computing device independent of but coöperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

5. The combination of an arm adapted to be moved about a center; a scale movable in a fixed path at right angles to the normal position of said arm; a connector

between said scale and arm; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

- 5 6. The combination of an arm adapted to be moved about a center; a scale movable in a fixed path at right angles to the normal position of said arm; an adjustable connector between said scale and arm adapted to vary the movement of said scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 10 7. The combination of an arm adapted to be moved about a center; a scale movable in a fixed path at right angles to the normal position of said arm; means by which the movement of said arm may be regulated to any predetermined point; an adjustable connector between said scale and arm adapted to vary the amount of movement of said scale by the movement of said arm; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 15 8. The combination of an arm adapted to be moved about a center; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm; means for moving said connector to and from said center to vary the movement of said scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 20 9. The combination of an arm adapted to be moved about a center; means by which the movement of said arm may be regulated to any predetermined point; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm; means for moving said connector to and from said center to vary the movement of said scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 25 10. The combination of an arm adapted to be moved about a center; a plurality of graduations thereon; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any predetermined graduation on said arm; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 30 11. The combination of an arm adapted to be moved about a center; an interchangeable member thereon provided with a plurality of graduations; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any predetermined graduation on said member; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 35 12. The combination of an arm adapted to be moved about a center and provided with a longitudinal groove; an interchangeable scale slidable in said groove; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register any predetermined graduations on said scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
- 40 13. The combination of an arm adapted to be moved about a center; a graduated member slidable thereon; a fixed scale adapted to locate the position of said graduated member; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any
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predetermined graduations on said slidable member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

14. The combination of an arm adapted to be moved about a center; a time of flight scale thereon; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any given range on said time of flight scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

15. The combination of an arm adapted to be moved about a center; an interchangeable time of flight scale thereon; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any given range on said time of flight scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

16. The combination of an arm adapted to be moved about a center; an interchangeable time of flight scale slidable thereon; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register any given range on said time of flight scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

17. The combination of an arm adapted to be moved about a center; a time of flight scale slidable thereon; a prediction interval scale registering therewith; a scale movable in a fixed path at right angles to the normal position of said arm; a connector between said scale and arm adapted to be adjusted to register with any given range on said time of flight scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

18. The combination of an arm adapted to be moved about a center; a member pivotally connected thereto and movable thereby in a fixed path at right angles to the normal position of said arm; a scale movably mounted upon said member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

19. The combination of an arm adapted to be moved about a center; a member pivotally connected thereto and movable thereby in a fixed path at right angles to the normal position of said arm; a reversible scale movably mounted upon said member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

20. The combination of an arm adapted to be moved about a center; a member movable in a fixed path at right angles to the normal position of said arm; a scale slidably mounted thereon; an adjustable connector between said arm and movable member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

21. The combination of an arm adapted to be moved about a center; a member movable in a fixed path at right angles to the normal position of said arm; a scale slidably mounted thereon; a time of flight scale on said arm; a connector between said movable member and said arm movable to register with any given range on said time of flight scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

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22. The combination of an arm adapted to be moved about a center; means for regulating the movement of said arm to any predetermined point; a member pivotally connected to said arm and movable thereby in a fixed path at right angles to the normal position of said arm; a scale movably mounted upon said member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

23. The combination of an arm adapted to be moved about a center; a member pivotally connected thereto and movable thereby in a fixed path at right angles to the normal position of said arm; a scale movably mounted upon said member; an index on said member registering with said scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

24. The combination of an arm adapted to be moved about a center; a member movable in a fixed path at right angles to the normal position of said arm; a scale slidably mounted thereon; an index adjustably secured to said member and registering with said scale; an adjustable connector between said arm and movable member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

25. The combination of an arm adapted to be moved about a center; a laterally movable member; a scale slidably mounted thereon; a slidable graduated member on said arm; a fixed scale on said arm to register the position of said slidable member; a connector between said movable member and said arm movable to register with any predetermined graduation on said slidable graduated member; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

26. The combination of an arm adapted to be moved about a center; a member movable in a fixed path at right angles to the normal position of said arm; a scale slidably mounted thereon; a slidable graduated member on said arm; a connector between said movable member and said arm movable to register with any predetermined range on said range scale; and an automatic computing device cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

27. The combination of an arm adapted to be moved about a center; a member movable in a fixed path at right angles to the normal position of said arm; a scale slidably mounted thereon; a slidable time of flight scale on said arm; a connector between said movable member and said arm movable to register with any given graduation on said graduated member; and an automatic computing device cooperating with said scale to make gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

28. The combination of an arm adapted to be moved about a center; a laterally movable member; a head thereto provided with a guide at right angles to said movable member; a trammel movable upon said guide provided with an index; a graduated member upon said arm with which said index is adapted to register; a pin upon said trammel extending into a groove in said arm; a scale slidably upon said movable member; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

29. The combination of an arm adapted to be moved about a center; a laterally movable member; a head thereto provided with a guide at right angles to said movable member; a trammel movable upon said guide provided with an index; a time of flight scale upon said arm with which said index is adapted to register; a pin upon said trammel extending into a groove in said arm; a scale slidably upon said movable member; and an automatic com-

puting device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

30. The combination with a scale, and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying; of a fixed graduated member; and a screw mounted in bearings in said member and threaded to a nut on said computing device adapted to move the latter lengthwise of said graduated member.

31. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; an index plate hinged to said member and registering with said scale; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

32. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; a plate hinged to said member; an index adjustably mounted thereon and registering with said scale; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

33. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; an index fixed relative to said grooved member and registering with said scale; another index movable relative to said grooved member registering with said scale; and an automatic computing device cooperating with said movable index adapted to make various gunnery corrections and cause said index to indicate on said scale the actual corrected data to be used in aiming and laying.

34. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; an index fixed relative to said grooved member and registering with said scale; a plate movable relative to said grooved member and provided with two indexes adapted to register respectively with said scale, and a plurality of graduations on said movable member; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale and graduations the actual corrected data to be used in aiming and laying.

35. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; an index movable relative to said grooved member adapted to register with said scale; and a plurality of interlocked slidable members adapted to be moved together or independently of each other, each of said members being provided with a plurality of graduations adapted to register with an index on an adjacent member to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.

36. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; a member movable relative to said grooved member provided with two indexes one of which is adapted to register with said scale; a nut secured to said index member; a member provided with a plurality of graduations with which the other index is adapted to register; and a screw revoluble in said member and threaded to said nut whereby a gunnery correction may be made on said graduated member and the corrected data to be used in aiming and laying indicated upon said slidable scale.

37. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; a member movable relative to said grooved member provided with two indexes one of which is adapted to register with said scale; a member parallel thereto provided with a plurality of graduations with which the other index is adapted to register; and means interposed between said members whereby one of said members may be adjusted relative to the other and secured in adjusted position to cause a gunnery correction to be made and the actual corrected data to be used in aiming or laying to be indicated on said slidable scale.

38. The combination with a movable member provided with a longitudinal groove; a scale slidable in said groove; a member movable relative to said grooved member provided with two indexes one of which is adapted to register with said scale; a member parallel thereto provided with a plurality of graduations with which the other index is adapted to register and also with another index; means for adjusting one of said members lengthwise of the other; a third member parallel to the others; a correction scale; and means for removably attaching said scale to said third member whereby the index on the second member may register therewith; means for adjusting one of the last-mentioned members relative to the other whereby various gunnery corrections may be made and indicate upon said slidable scale the actual corrected data to be used in aiming and laying.
39. The combination of an arm adapted to be moved about a center; a scale indicating intervals of travel by which the movement of said arm may be regulated; a movable scale pivoted to said arm movable in a fixed path at right angles to the normal position of said arm; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
40. The combination of an arm adapted to be moved about a center; a time of flight scale thereon; a prediction interval scale by which to set said time of flight scale; a movable scale; a connector between said scale and arm adapted to be adjusted to register with any given range on said time of flight scale; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
41. The combination of an arm adapted to be moved about a center; a time of flight scale thereon; a prediction interval scale on said arm to set said time of flight scale; a travel interval scale by which to set said arm; a movable scale; a connector between said scale and arm adapted to be adjusted to register with any given range on said time of flight scale; and an automatic computing device cooperating with said scale and adapted to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying.
42. The combination of an arm adapted to be moved about a center; a member carrying two scales adapted for longitudinal movement pivotally connected to said arm and movable at right angles to the normal position of said arm; and an automatic computing device independent of but cooperating with scales to indicate on one the cor-

rected range to be used at the gun and on the other the sum of all the corrections to be applied for various causes.

43. The combination of a pendent swinging arm; a handle secured thereto for moving said arm; a scale pivoted to said arm and movable between guides in a horizontal path; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying said device, consisting of a plurality of scaled members parallel with said scale and adapted for longitudinal movement relative to each other.

44. The combination of a pendent swinging arm; a handle secured thereto for moving said arm; a scale pivoted to said arm and movable between guides; another scale slidable longitudinally of said first mentioned scale; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying said device, consisting of a plurality of scaled members parallel with said scale and adapted for longitudinal movement relative to each other.

45. The combination of a pendent swinging arm; a handle secured thereto for moving said arm; a member pivoted to said arm and movable between guides; a scale slidable longitudinally of said member; and an automatic computing device independent of but cooperating with said scale to make various gunnery corrections and indicate upon said scale the actual corrected data to be used in aiming and laying said device, consisting of a plurality of scaled members parallel with said scale and adapted for longitudinal movement relative to each other.

46. The combination of a frame; a scale normally fixed thereon; a computing device consisting of a plurality of scales parallel to each other and to said fixed scale, adjustable relative to each other to secure various readings and relative to said fixed scale for correcting for too great or too short a range; and a slidable scale mounted upon said frame cooperating with the side of said computing device furthest removed from said fixed scale and adapted to indicate thereon the actual corrected data to be used in aiming and laying the gun.

Signed by me at Boston, Massachusetts, this 13th day of August 1906.

ELMER W. HUBBARD.

Witnesses:

HAROLD H. BROWN,
WALTER E. LOMBARD.