April 8, 1930. H. C. FORD 1,753,781

PLOTTING APPARATUS

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Fig. 1.

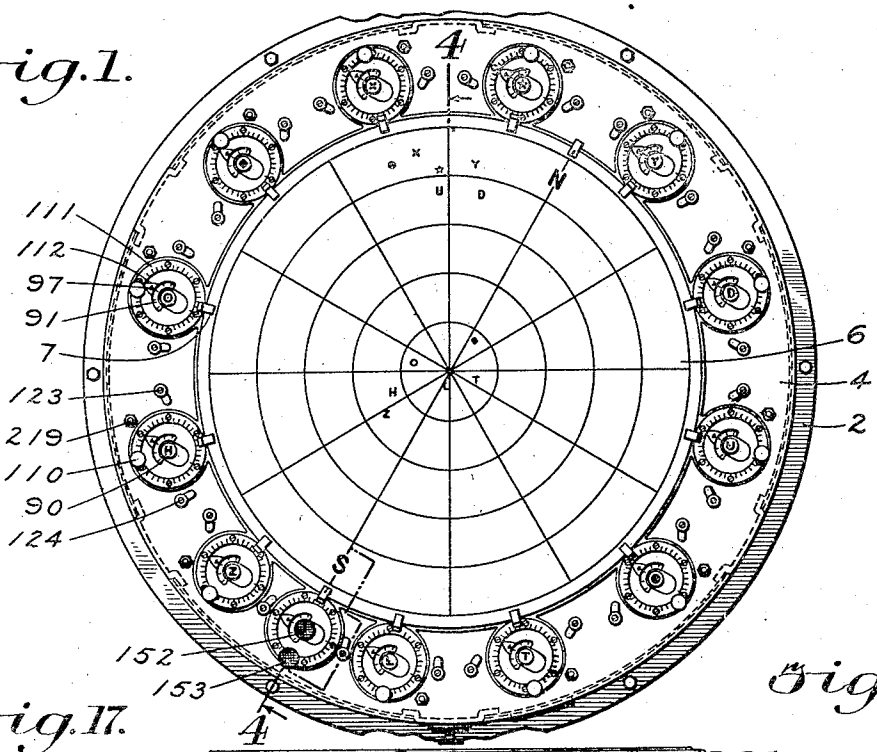
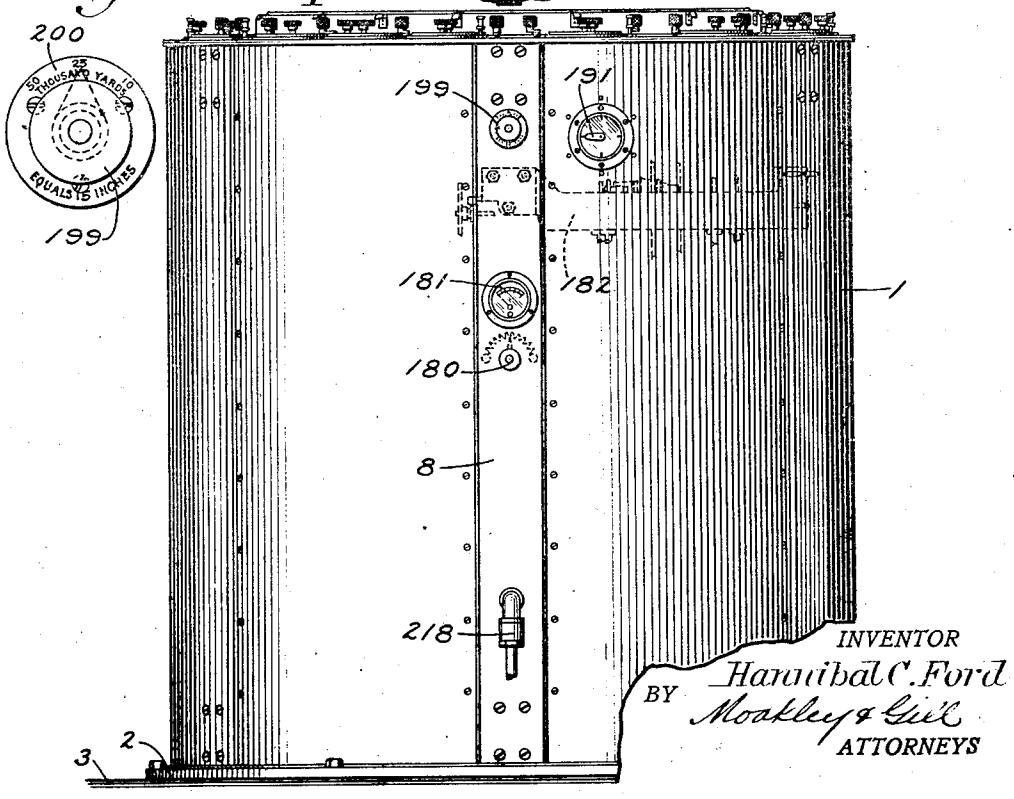


Fig. 2.

Fig. 17.



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Fig. 3.

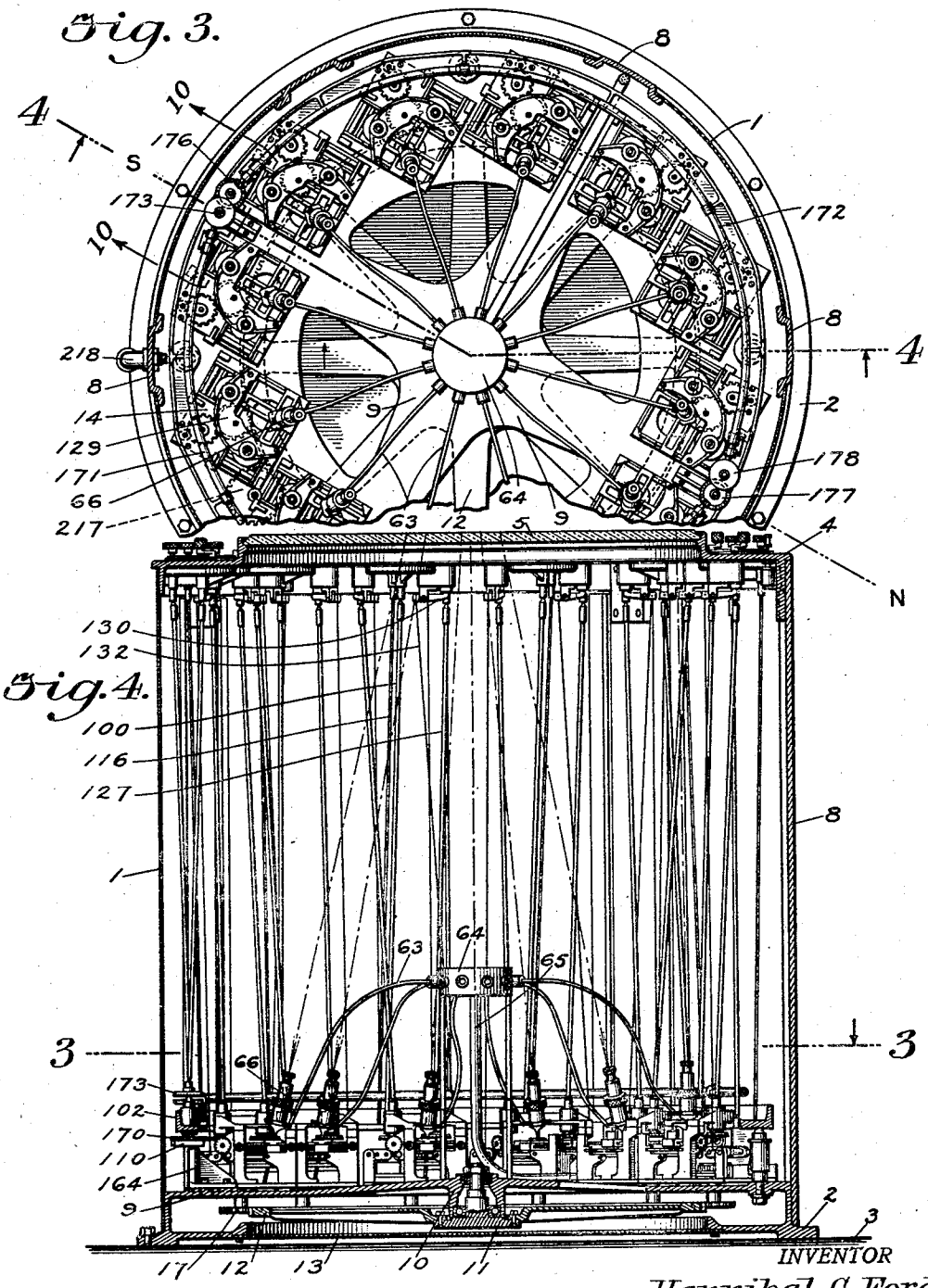


Fig. 4.

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Fig. 5.

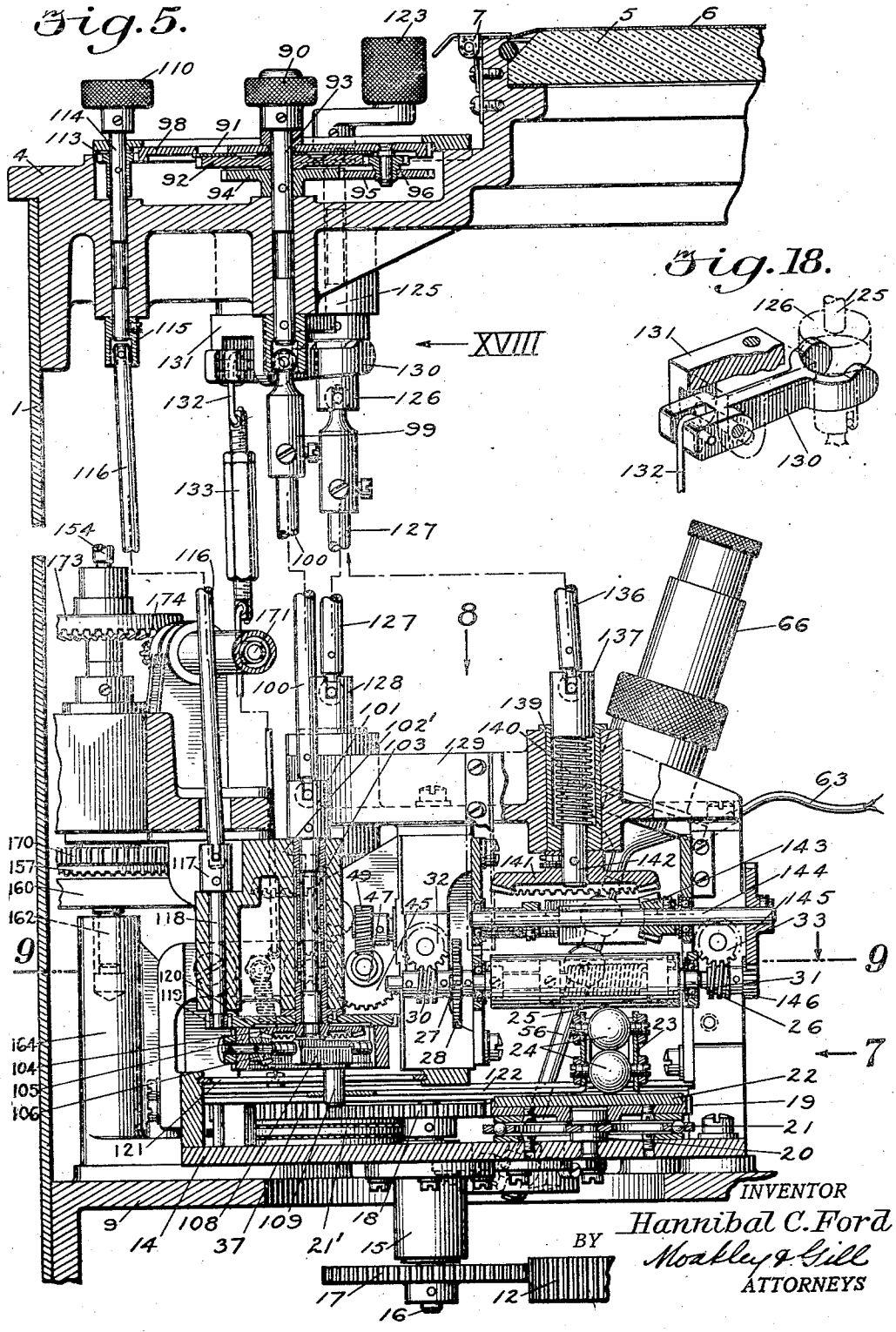


Fig. 18.

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Fig. 6.

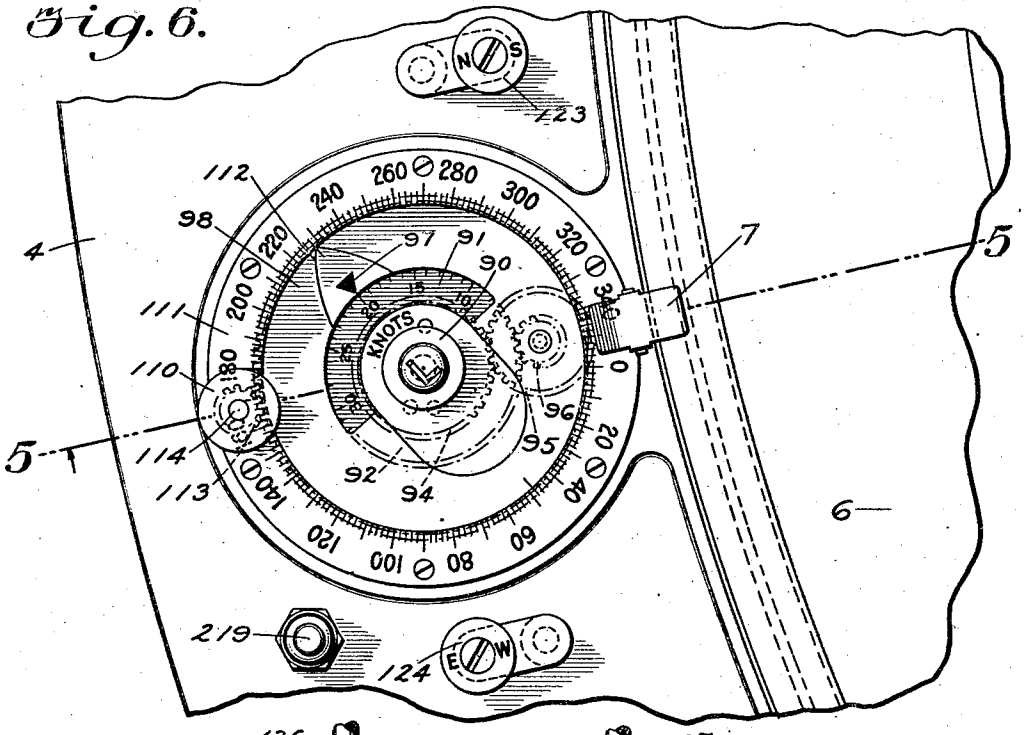
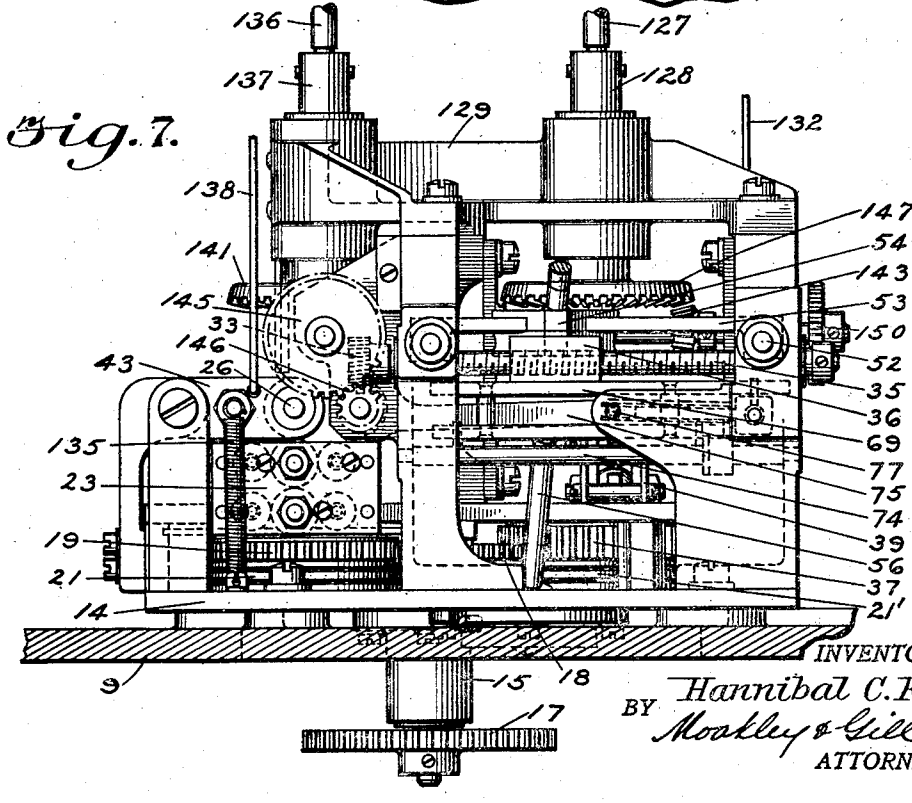


Fig. 7.



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Fig. 8.

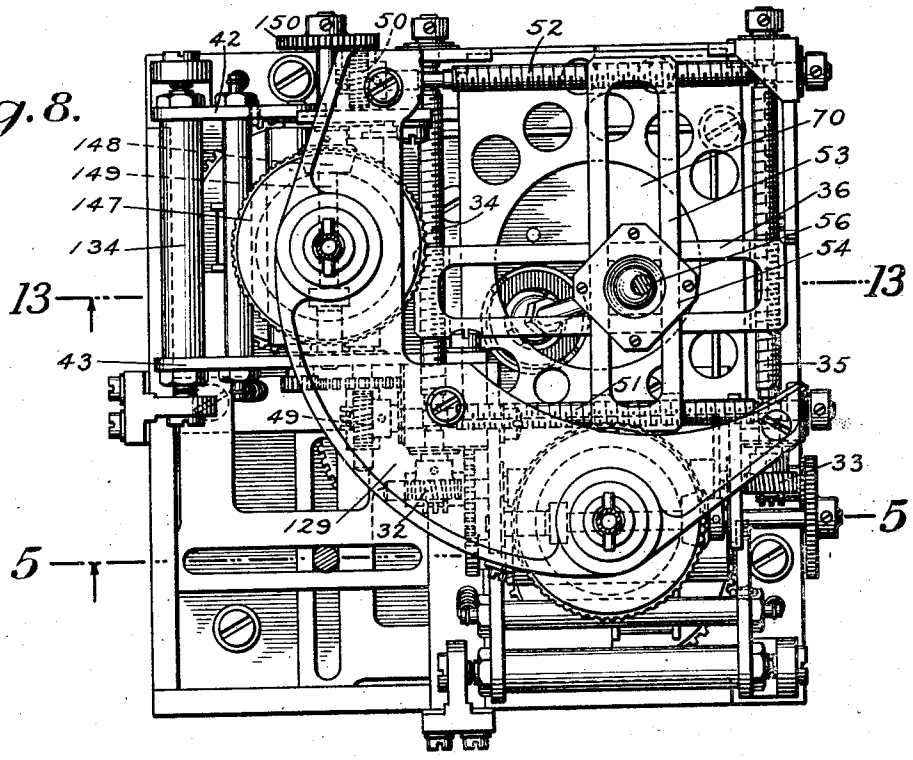
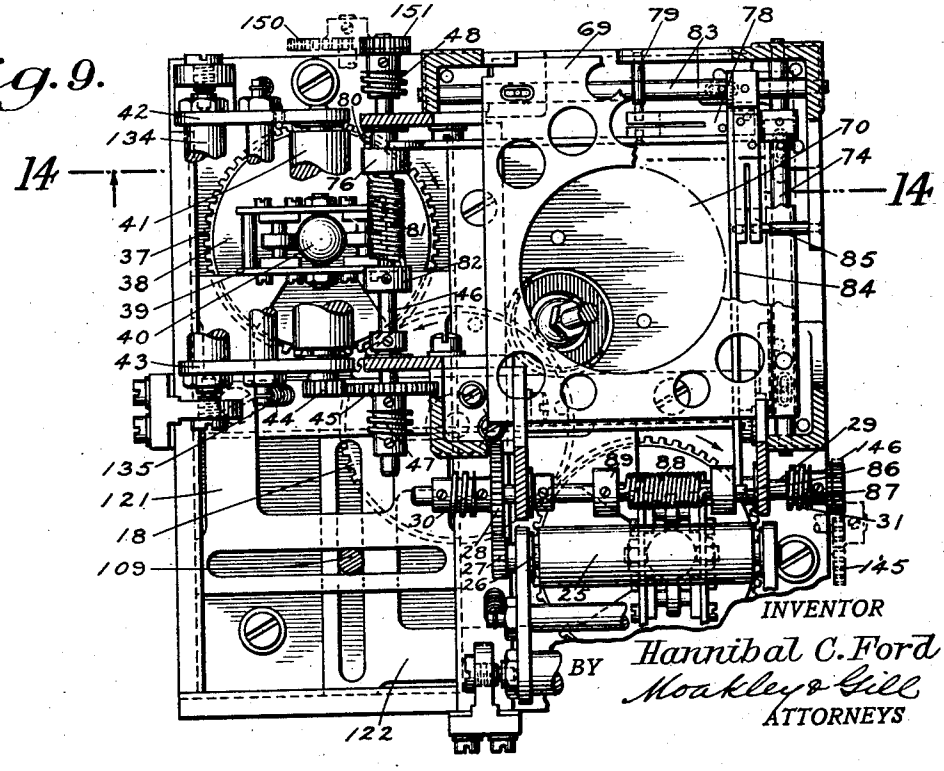


Fig. 9.



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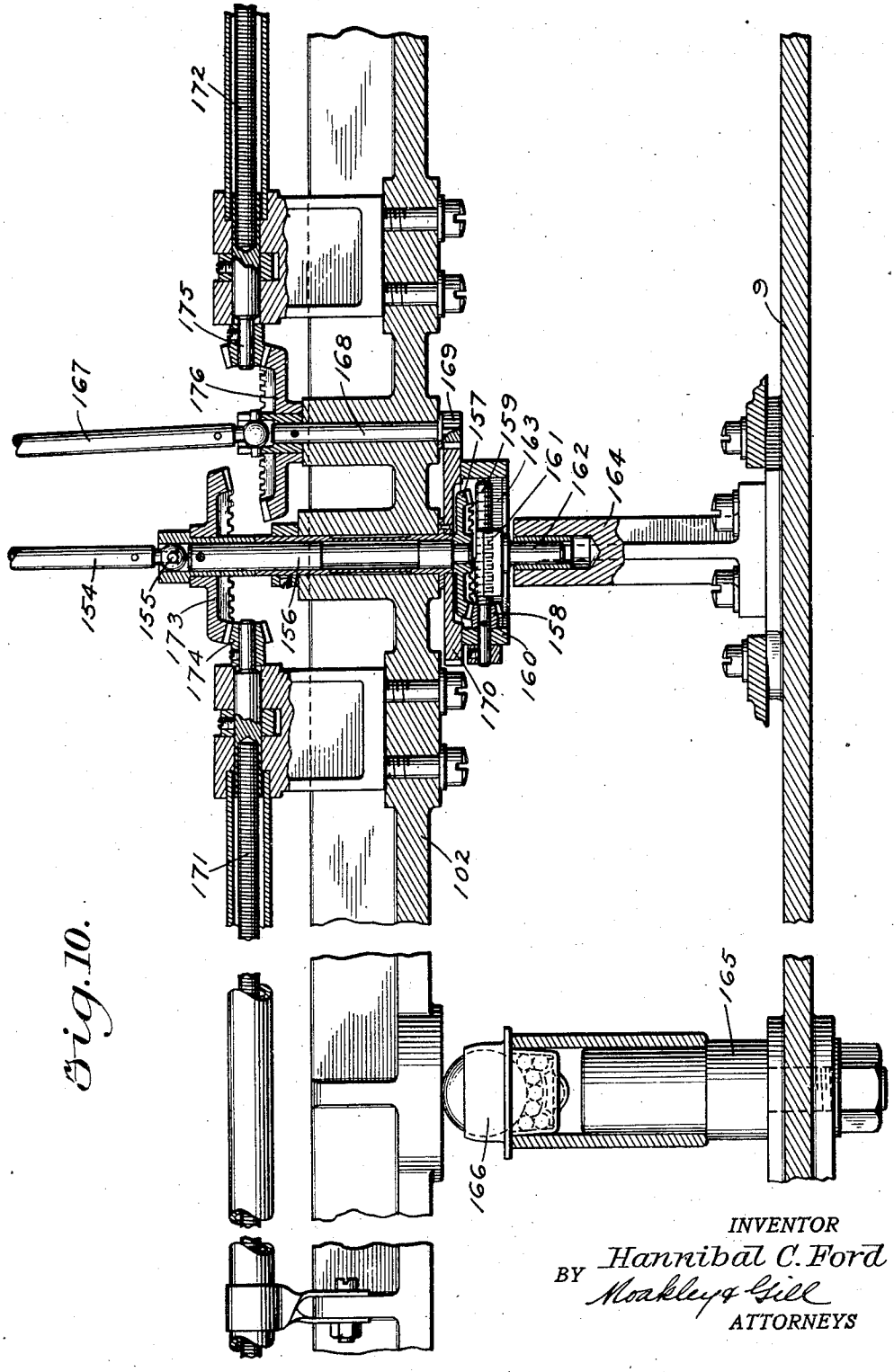


Fig. 10.

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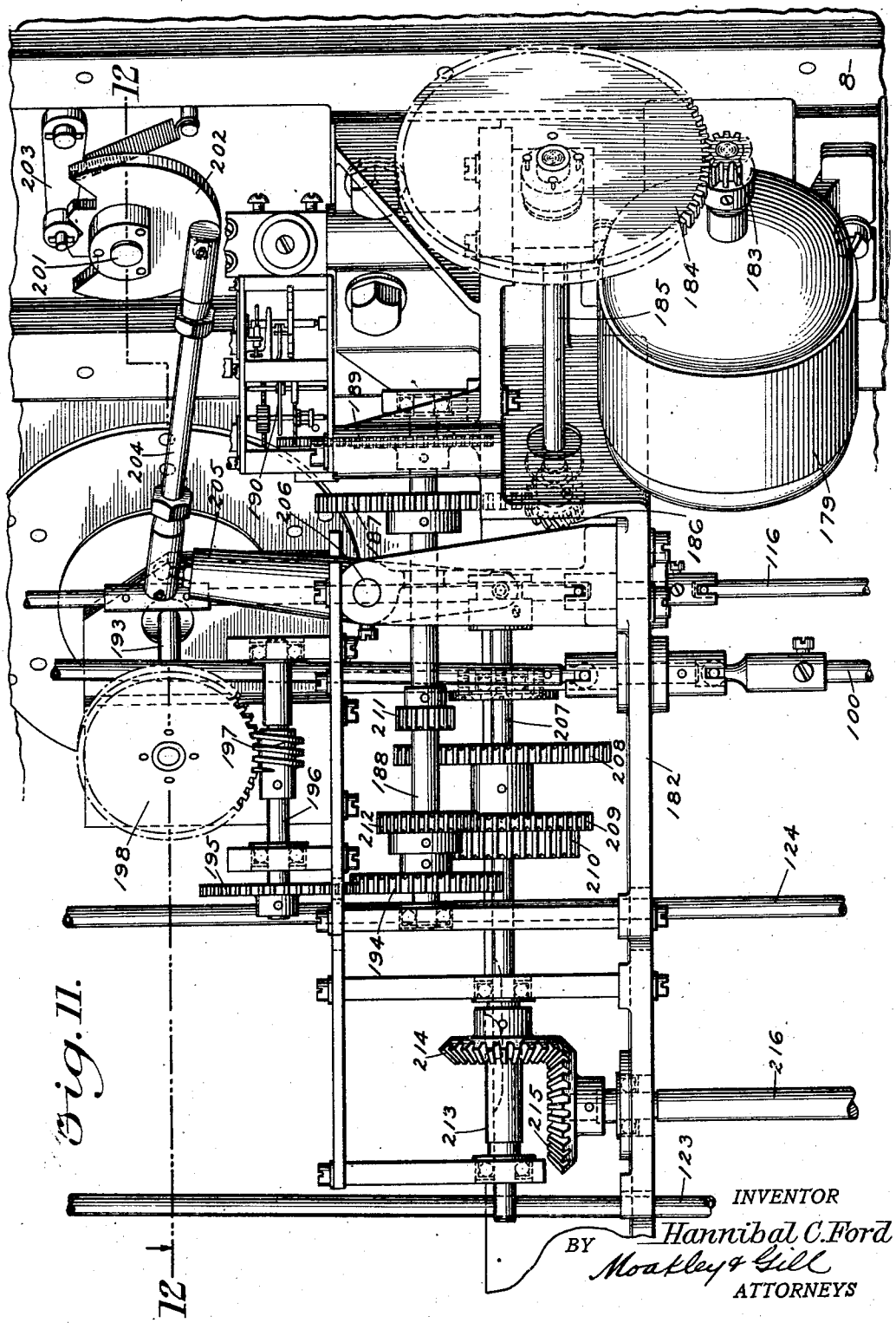


Fig. 11.

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Fig. 13.

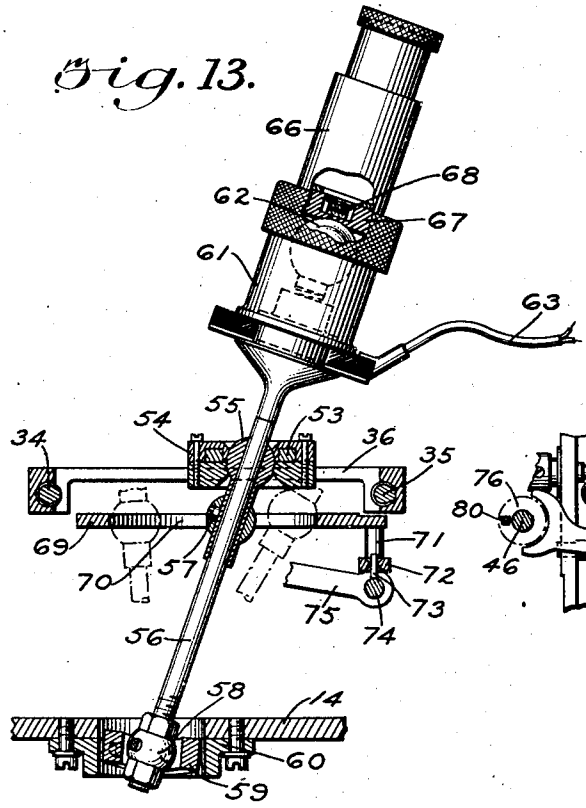


Fig. 14.

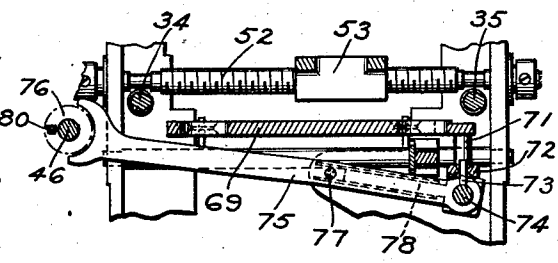


Fig. 15.

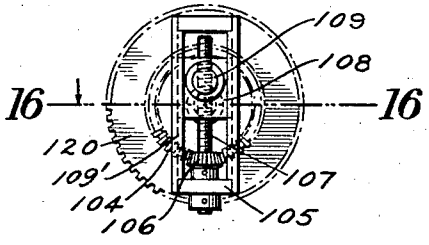
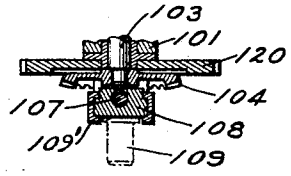


Fig. 16.



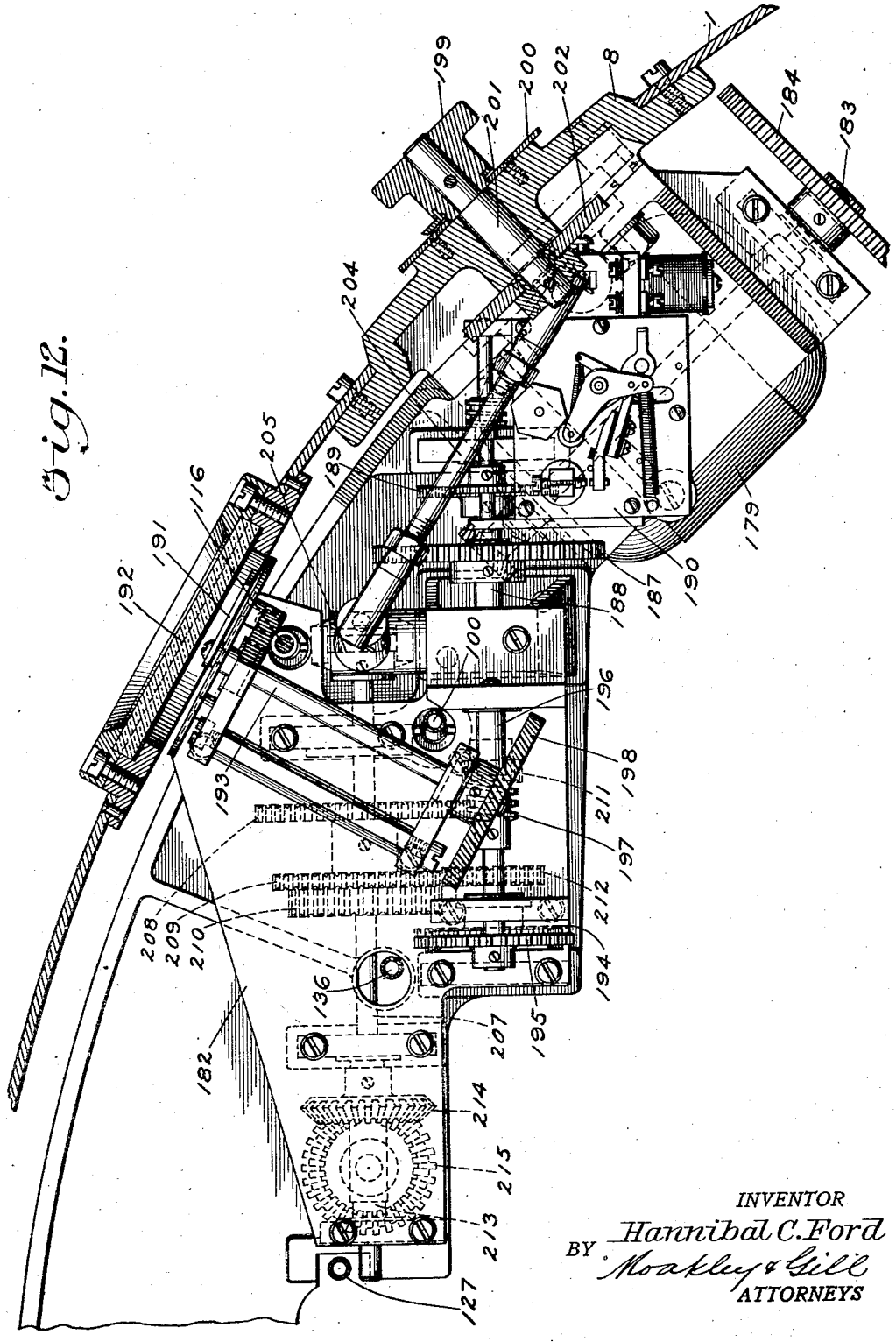
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Fig. 12.



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UNITED STATES PATENT OFFICE

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PLOTTING APPARATUS

Application filed May 4, 1928. Serial No. 275,195.

This invention relates to plotting apparatus, and has particular reference to apparatus for indicating the relative positions and movements of remote objects, and automatically changing such indications in accordance with the movements of the objects.

Heretofore, the plotting of ships at sea, such as the maneuvers of own and enemy fleets for example, necessitated the continuous observation and manual plotting of the locations of the several vessels upon a plotting board, which caused considerable labor and resulted in confused and inaccurate data, which were virtually useless during the confusion of battle.

The principal object of this invention is to provide an apparatus whereby it is possible to visualize accurately, from a remote station, the location and relation of any desired object or objects and to automatically follow the movement or movements thereof, assuming no change in course or speed of the object or objects.

The apparatus embodying this invention comprises a transparent plotting surface upon which may be laid translucent work sheets for locating the instantaneous positions of the desired objects, these sheets being preferably inscribed with concentric circles representing ranges, and radial lines representing compass bearings, the center of the sheet representing the position of own ship. Beneath the plotting surface are disposed suitable integrating mechanisms for each remote vessel or unit, each of which is provided with a light projecting means directed upon the under side of the translucent work sheet, whereby each vessel or unit appears represented by a distinctive symbol upon the plotting board. Setting means are provided for each integrating mechanism for introducing the compass courses and speeds of the several vessels or units, and for locating them initially as well as for correcting their relative positions in accordance with subsequent observations. In the foregoing description, own ship was assumed to remain fixed, but when own ship moves, the relative effect upon the other ships is compensated for by introducing own ship's course and speed whereby the proper relations between the several vessels and own ship is maintained.

Thus, by the apparatus of this invention, the officer commanding a number of vessels may not only be constantly advised of their positions and movements relatively to each other, but may also follow the relative movements and locations of the enemy vessels. By plotting the desired future movements of the several vessels of own fleet, it is possible, by means of a protractor and scale, to determine from the plotting board of the apparatus the course and speed which each vessel or unit must employ in order to carry out the desired maneuvers. This information can be taken directly from the plotting board and signalled to each vessel or to the flag-ship of the various units.

Other objects and advantages of this invention will become apparent from the following descriptions of a preferred embodiment thereof as illustrated by the accompanying drawings, in which like reference characters designate like parts in the several views. In the drawings:

Figure 1 is a plan view of the plotting surface of the apparatus embodying this invention;

Fig. 2 is an elevation thereof;

Fig. 3 is a horizontal cross-section of the apparatus taken along the line 3—3 of Fig. 4, showing the interior in plan;

Fig. 4 is a radial section taken along the line 4—4 of Figs. 1 and 3, showing the interior in elevation;

Fig. 5 is a magnified view of a portion of the section shown in Fig. 4 as taken along line 5—5 of Figs. 6 and 8, in which the integrator and associated mechanism is illustrated;

Fig. 6 is a magnified view of one of the remote ship relative position locating dials, showing setting knobs and compass ring;

Fig. 7 is another view of a portion of Fig. 5 looking in the direction of arrow 7;

Fig. 8 is a plan view of the integrating mechanism proper looking in the direction of arrow 8 of Fig. 5;

Fig. 9 is a horizontal cross-section of the

integrating mechanism proper, as taken along line 9—9 of Fig. 5;

Fig. 10 is an inside elevation of a portion of the own ship ring and adjusting mechanism, shown in partial section, as seen along line 10—10 of Fig. 3;

Fig. 11 is an inside elevation of the apparatus driving mechanism;

Fig. 12 is a horizontal section of the driving mechanism taken along line 12—12 of Fig. 11;

Fig. 13 is an elevation of the light-projecting means, showing the mounting therefor partially in section as seen along the line 13—13 of Fig. 8;

Fig. 14 is a view of the stop mechanism for the light-projecting means shown in Fig. 13 as taken along the line 14—14 of Fig. 9;

Fig. 15 is a bottom view of the ship course and speed vector;

Fig. 16 is a cross-section of the same taken along line 16—16 of Fig. 15;

Fig. 17 shows the range scale setting knob and dial; and

Fig. 18 is a perspective view of the integrator disconnecting clutch lever located as indicated by the arrow XVIII of Fig. 5.

Referring particularly to Figs. 1 and 2, numeral 1 designates the cylindrical housing or casing of the apparatus, which is attached to a base-plate 2 adapted to be bolted to the deck 3, or the like. The top plate 4 of the apparatus is provided with a large circular opening in which is disposed a plate of glass 5, as is shown most clearly in Fig. 5, upon which is adapted to be placed a translucent sheet of plotting paper 6, thus making a translucent screen. Sheets 6 are held in position by a number of peripheral clips 7 attached to the inner rim of top plate 4. The structure is reinforced and stiffened by several vertical columns 8, as shown in Figs. 2, 3 and 12, which, with the curved plates attached thereto forms casing 1.

Base plate 2 is provided with an integral web 9, upon the upper surface of which are mounted a plurality of integrating mechanisms, one of which is shown in detail in Fig. 5 and accompanying Figs. 7, 8 and 9. Web 9 is provided with a central hub 10 in which is journalled a shaft 11 carrying a large gear 12 driven at constant speed, the motive mechanism of which will be hereinafter described. A bottom cover plate 13 covers the opening in base plate 2 and provides for ready access to the driving gear above described.

Referring particularly to Fig. 5 in order to illustrate the description of the integrating mechanism, numeral 14 designates generally the frame thereof, which is mounted upon web 9 as shown. Frame 14 is fitted with a hub 15 in which is journalled a short shaft 16 provided at one end with a gear 17 meshing with the constant speed drive gear 12, and at the other end with gear 18 which engages with and drives a gear 19 which turns about stud 20 and upon ball thrust bearing 21 mounted upon frame 14. Attached to gear 19 is a circular disc 22 forming the driving element of a mechanical integrator of the type disclosed in U. S. Patent No. 1,317,915 issued October 7, 1919, to H. C. Ford, the remaining parts consisting of the shiftable carriage 23 containing balls 24, the upper one of which drives roller 25 at varying speeds depending upon the radial position of balls 24 upon disc 22. Roller 25 is journalled in the pivoted frame 14′ and one end of the shaft 26 thereof is provided with a pinion 27 which meshes with gear 28 attached to shaft 29, which is fitted with worms 30 and 31 adapted to drive worm wheels 32 and 33 of threaded rods 34 and 35, respectively, which are journalled in frame 14, as shown particularly in Figs. 5, 8 and 9. A slotted slide 36 moves along rods 34 and 35 as the latter are rotated.

An identical integrating mechanism is located in the diagonally opposite corner of frame 14, as seen in Figs. 8 and 9, of which the driven gear 37, corresponding to gear 19, is mounted upon thrust bearing 21′ and meshes with pinion 18, as shown in Fig. 5. Referring particularly to Fig. 9, integrator disc 38 is shown mounted upon gear 37, integrator carriage 39, balls 40 and roller 41 being arranged in the manner heretofore described, roller 41 being mounted between levers 42 and 43 attached to frame 14, the additional purpose of which will be hereinafter explained.

The rotation of roller 41 is transferred by gears 44 and 45 to shaft 46, the ends of which are provided with worms 47 and 48 which drive worm wheels 49 and 50 attached to threaded rods 51 and 52 upon which moves slotted slide 53. Slotted slides 36 and 53, being disposed in juxtaposition and at right angles jointly locate the position of rider 54 through which pass slides 53 and 36, as shown in Fig. 13, rider 54 being provided with a spherical socket in which is disposed ball 55 arranged slidably in rod 56 and being provided with another ball 57 spaced therefrom upon the sleeve thereof. The lower end of rod 56 is provided with a ball 58 which is universally journalled in a socket 59 disposed in a bracket 60 fixed to the lower web of frame 14, as shown in Fig. 13. The upper end of rod 56 is provided with a light projecting means comprising a tubular casing 61 containing a small electric light bulb 62 energized from wires 63 which terminate in a central junction box 64, which is mounted upon the end of a vertical conduit 65 containing the supply wires, as shown in Fig. 4. Referring again to Fig. 13, tube 61 carries a second tube 66 having a lens 66′ at its outer end and holding in position a screen 67, in the center of which is a graticule 68 of a pe-

culiar shape or symbol whereby the projected light rays assume the same symbol. Each one of the tubes 66 shown in Fig. 4 is provided with a different distinctive symbol representing a separate ship unit, or the like, when projected upon the under side of translucent plotting sheet 6 to be visible therethrough.

A stop mechanism is provided for each light projector 66 whereby its movement is limited to the area of its visibility upon plotting sheet 6. Beneath slides 36 and 55 a plate 69 is disposed so as to be slidable in both directions in grooves or slots provided therefor in the frame, as shown in Figs. 8, 9 and 13. Plate 69 is provided with a large central circular opening 70 through which passes projector rod 56, the stop ball 57 of which is adapted to engage the edges of opening 70 in the manner shown in phantom in Fig. 13, i. e., when the projector is at two extremes of its travel in one back-and-forth direction. One outer edge of plate 69 is provided with a depending pin 71 having a lug 72 in which is an aperture, countersunk on both sides for the reception of a small pin 73 fixed in rocking rod 74, which is journalled in the frame 14, as shown in Figs. 13 and 14. Mounted upon rocking rod 74 is a bar 75, which is bifurcated at its free end so as to substantially embrace but not engage collar 76 freely mounted upon shaft 46, as shown in Figs. 9 and 14. Fixed to rocking rod 74 is a double-leaf spring 78 which in connection with pin 77 mounted in the arm 75 and the pin 79 mounted in frame 14 is adapted to normally maintain bar 75 in a disengaged position and to return it to that position when displaced.

From the foregoing description it is evident that as the rider 54 moves upon, and is jointly moved by slides 36 and 53 to one of the extreme positions illustrated in phantom in Fig. 13, ball 57 will engage the inner edge of plate 69 and push it with it, thereby causing bar 75 to rock about the center of rod 74 as an axis and against the tension of leaf spring 78 until one of the prongs of bar 75 engages a pin 80 projecting from rotating collar 76. Collar 76 is freely mounted upon shaft 46, but is constrained to rotate with it through the agency of coil spring 81, the other end of which is fastened in collar 82 pinned to shaft 46. Accordingly when one of the prongs of bar 75 engages pin 80, the rotation of collar 76 is arrested, and subsequently the rotation of shaft 46 also, whereupon balls 40 of the integrating mechanism slip between disc 38 and roller 41, since the movement of roller 41 is also arrested. Thus the movement of projector 66 is stopped in that particular direction, and, obviously, if it moves to the limit in the opposite direction the reverse action will result, namely, plate 69 will be moved in the opposite direction causing the other prong of bar 75 to engage pin 80 in the same manner. As soon as projector 66 is moved away from its extreme position the lateral pressure upon plate 69 is released, whereupon spring 78 returns bar 75 to its normal disengaged position, as shown in Fig. 14, permitting the integrating mechanism to again function. Likewise, the back-and-forth movement of projector 66 in the direction at right-angles to that above described is arrested by another identical stop mechanism. Referring particularly to Fig. 9, rocking rod 83, corresponding to rocking rod 74, is journalled in the frame 14 and carries bar 84 and double leaf spring 85. The prongs at the end of bar 85 are adapted to engage pin 86 upon free collar 87 of shaft 29, whereupon, through spring 88, fixed collar 89 upon shaft 29, and gears 28 and 27, the rotation of roller 25 is arrested, causing balls 24 to slip in the manner above described.

The means for initially setting the projections so as to locate their symbols upon the plotting board according to observations as well as for correcting their locations from time to time in accordance with changes due to alteration of speed or course of the observed ship, are located upon annular top-plate 4, as shown in Figs. 1, 5 and 6. Numeral 90 designates the speed setting knob, by means of which the estimated or known speed of the observed ship is set upon dial 91 mounted upon gear 92, which is actuated from knob shaft 93 through attached gear 94 and pinions 95 and 96, the latter meshing with gear 92, until the proper speed numeral registers with speed index 97 inscribed upon gear 98. The knob is inscribed with the symbol representing that particular ship or unit, as for example the letter "L" illustrated in Fig. 6, which is the symbol projected upon plotting sheet 6. All symbols in all other projectors are different, so as to distinguish one from the other when projected upon the plotting sheet, as is illustrated by way of example upon the plotting sheet 6 of Fig. 1. Shaft 93 is journalled in top plate 4, and is provided with a flexible knuckle joint 99, the other element of which carries a long link 100 which passes into another flexible joint 101 disposed upon a large crank ring 102, which is to be hereinafter described, through a boss 102′ upon the under side of which passes connected shaft 103, as shown in Fig. 5. The lower end of shaft 103 is provided with a bevel gear 104 which is disposed in a housing 105 so as to engage a bevel pinion 106 secured upon a diametrical shaft 107 journalled in housing 105. As shown in Figs. 5, 15 and 16, shaft 107 is threaded and carries a nut 108 provided with a depending pin 109, and is slidable in guides 109′ arranged parallel to shaft 107. This arrangement permits of the radial positioning of pin 109 relatively to the center of gear 104 in accordance with the amount of rotation imparted to gear 104 by

the manipulation of observed ship speed setting knob 90.

The knob 110 is provided for setting up the compass direction of travel of the observed ship, the compass bearings being inscribed upon the fixed ring 111 with which pointer 112 inscribed on gear 98 is adapted to cooperate. Thus, as knob 110 is turned, pinion 113 attached to its shaft 114 rotates gear 98 to cause relative movement between pointer 112 and scale 111. The movements of knob 110 are transmitted by shaft 114, flexible joint 115, link 116, flexible joint 117 to shaft 118 journalled in a boss upon the under side of crank ring 102, the lower end of shaft 118 being provided with a pinion 119 which meshes with a gear 120 formed integrally with housing 105 so as to turn the same when knob 110 is manipulated. Thus, the vector establishing the speed and direction relation of an observed ship locates the resultant position of pin 109, which position is reduced to the components of the resultant speeds in rectangular directions, namely, the east-west and the north-south. These components are indicated and produced mechanically by slide 121 for the north-south direction, and by slide 122 for the east-west direction, being slotted for the reception of pin 109 so as to be positioned thereby, as shown in Fig. 9.

The slides 121 and 122 are slidably fitted in the frame 14 and carry and accordingly position integrator ball carriages 39 and 23, respectively, of the north-south and east-west integrator, as they may be called. Inasmuch as the radial position of the integrator balls on their respective driving discs determines the speed of the respective rollers, and as that position is determined by the observed ship's speed and course in the manner above described, the resultant speed of each integrator roller is proportional to and simulates the speed of the observed ship along the N—S and E—W components of its path. These movements are jointly impressed upon the rider 54 and the projector 66, so that the movement thereof assumes the direction and speed of the aforementioned components. This is done by the N—S integrator through its roller 41, which rotates gears 44 and 45, shaft 46, worms 47 and 48, worm wheels 49 and 50, which in turn rotate threaded shafts 51 and 52 to position slide 53, upon which is mounted projector rider 54. Likewise, the E—W integrator roller 25 rotates gears 27 and 28, shaft 29, worms 30 and 31, worm wheels 32 and 33, which in turn rotate threaded shafts 34 and 35 to position slide 36, upon which projector rider 54 is also mounted. By these two movements, projector 66 is located so that its luminous symbol appears in the same relative position upon the plotting sheet 6 with reference to the center thereof, representing own ship, as the actual observed ship appears with relation to actual own ship, and the symbol moves across the plotting sheet at the same relative speed and in the same relative direction as the observed ship, which it represents, moves.

Means are provided for initially setting each projector so that its symbol appears in the proper place on the plotting sheet, and the same means are used for resetting or correcting the position of the symbol. Referring to Fig. 6, numeral 123 designates the N—S integrator setting crank, and numeral 124 designates the E—W integrator setting crank. In order to place these cranks in operative condition, it is necessary to push down upon them so that the shafts thereof slide longitudinally in their bearings. Referring to Fig. 5, which illustrates the mechanism of the N—S crank 123, numeral 125 designates the shaft thereof, which is provided with a flexible joint 126 having a link 127 depending therefrom and attached to another flexible joint 128 disposed in a boss on plate 129 which spans the frame 14 of the integrating unit. Flexible joint 126 is provided with a collar which engages a bifurcated lever 130 pivoted in a bracket 131 secured to the under side of top plate 4, as shown in Fig. 5. Fig. 18 is a perspective view, partially in phantom, of this lever mechanism, the other end of lever 130 being provided with a depending wire 132, which is fitted with a tension adjusting turn-buckle 133, and terminates in lever 42 in which one end of N—S integrator roller 41 is journalled, the other end thereof being journalled in corresponding lever 43, as shown in Figs. 7, 8 and 9.

Levers 42 and 43 are mounted upon pivoted rod 134, the ends of which are mounted in extensions of frame 14, as shown in Figs. 8 and 9. Levers 42 and 43 are fitted with coil springs 135, attached to the bed of frame 14, which are adapted to exert tension upon wire 132 and restrain levers 42 and 43 in their normally horizontal position. The same form of mechanism is attached to E—W crank 124, having link 136, flexible joint 137 which is journalled in a boss on plate 129 and wire 138 which operates to lift E—W integrator roller in the manner above explained. Referring to Figs. 5, 6 and 7, it is evident that when crank 124 is pushed down, 137 slides in bushing 139 to compress coil spring 140 and cause bevel gear 141, fixed to shaft 142, to engage bevel pinion 143 attached to shaft 144, which is fitted with a spur gear 145 meshing with pinion 146 attached to shaft 29 of the E—W integrator, as shown in Fig. 9. The N—S crank 123 is provided with an identical mechanism, comprising bevel gear 147, which meshes with bevel pinion 148 upon shaft 149 having gear 150 engaging pinion 151 upon the end of shaft 46 of the N—S integrator.

The operation of the initial setting and

correcting mechanism may be illustrated by considering the N—S setting mechanism since the E—W setting is identical. As crank 123 is pushed downwardly, lever 130 pivots about its fulcrum and pulls upwardly upon wire 132, which accordingly raises lever 42 against the tension of spring 135 to lift integrator roller 41 away from the top integrator ball 40, thereby disconnecting the integrating mechanism. Then, by turning crank 123 in the proper direction, bevel gears 147 and 148 being engaged, shaft 149 is revolved and with it, and, through gears 150 and 151, shaft 46 is also rotated. By means of the worms and wheels 48, 50 and 47, 49, threaded shafts 52 and 51, respectively, are rotated to move slide 53 in a N—S direction. In the same manner, by pressing down upon and rotating crank 124, the E—W integrator may be adjusted. By manipulating both cranks 123 and 124 simultaneously, the operator may quickly adjust the luminous symbol of that particular unit to its intended position on the plotting sheet. Upon releasing the cranks, the compression and tension springs, such as springs 140 and 135, cause the disengagement of the bevel gears 147 and 148 and the lowering of integrator roller 41 into operative engagement with the upper one of integrator balls 40.

With the exception of one dial upon top plate 4, namely the own ship's dial located upon the N—S diameter of the plotting sheet, all of the dials and associated knobs and cranks operate a separate integrating and projecting mechanism, so that in the embodiment shown in Fig. 1, twelve separate ships, units, or groups may be portrayed graphically in any desired arrangement upon the surface of the plotting sheet. The own ship's dial is preferably the same in appearance as the remote ship dials, except for distinguishing markings, but the operation thereof is entirely different, there being no distinguishing luminous symbol therefor upon the plotting sheet other than the center mark of the sheet, nor an integrating mechanism therefor. However, since the symbols show the position of the remote ships relative to the own ships when own ship moves or changes speed or course, a compensation must be introduced in order to maintain the proper relation of the remote ships, but instead of moving the location of own ship, the graphic locations of all of the remote ships are altered accordingly, and for that purpose all of the remote ship mechanisms are connected together and all operated by a common adjusting means according to own ship's course and speed. The mechanism for accomplishing this is illustrated particularly in Fig. 10 in connection with Figs. 5 and 6.

In common with the several remote ship dials, own ship dial has a speed knob 152 corresponding to knob 90 of Fig. 5, and a course knob 153 corresponding to knob 110 of Fig. 5, as shown in Fig. 1, the remaining parts of own ship dial being identical with those of the remote ship dials, except for the omission of setting cranks such as 123 and 124 shown in Fig. 6. As heretofore explained in connection with the remote ship dial illustrated in Fig. 5, the shaft of own ship speed knob 152 is connected to a link 154 which is connected by a flexible joint 155 to shaft 156 journalled in crank ring 102, the lower end of which bears the same vector mechanism as is illustrated by Figs. 15 and 16, namely a bevel gear 157 fixed to shaft 156, which gear meshes with a bevel pinion 158 mounted upon a threaded shaft 159, which is diametrically disposed and journalled in housing 160. Moving upon threaded shaft 159 as it is rotated, is a nut 161 provided with a depending pin 162 and slidably confined by guides 163. Pin 162 is disposed in a bearing in vertical bracket 164 which is rigidly attached to the web of base plate 9, upon which are also mounted several posts 165, which carry a single ball caster 166 upon which crank ring 102 is movable, as illustrated by Fig. 10.

The bearing knob 153 and the other associated parts of own ship dial, are identical with those of the remote ship dial illustrated in Fig. 5, the shaft of which carries link 167 which is connected by a flexible joint to shaft 168, which is journalled in crank ring 102. The lower end of shaft 168 is provided with a pinion 169 which engages a gear 170 to which housing 160 and associated parts is attached. For structural reasons in the instance of strength, the opposite side of the apparatus is provided with the same mechanism shown in Fig. 10, in the manner illustrated by Fig. 3. Accordingly, the movements of shafts 154 and 167 are relayed respectively by flexible shafts 171 and 172 which are mounted along crank ring 102, the connection of shaft 154 with shaft 171 being by bevel gears 173 and 174, and the connection between shafts 167 and 172 being bevel gears 175 and 176, as shown in Fig. 10. Flexible shafts 171 and 172 terminate in gears 177 and 178 respectively, which correspond to gears 176 and 173, respectively, and the remainder of the mechanism also corresponds to that shown in Fig. 10. Thus, own ship's speed and course determine lateral position of crank ring 102, and inasmuch as the speed and course shafts 103 and 118, respectively, of all of the remote ship vector mechanisms are journalled in crank ring 102, the position of the vector pins 109 depend upon the position of crank ring 102, as well as upon the speed and course values introduced by remote ship knobs 90 and 110, respectively, whereby the speeds and course relations of all of the remote ships are varied. In this manner, the relation between own ship and

all of the remote ships may be maintained and corrected from time to time in accordance with observed changes in the relation between them.

The driving mechanism unit for the apparatus is illustrated particularly in Figs. 11 and 12. The motor 179 is mounted upon the inside surface of one of the vertical columns 8 and is started and stopped by means of rheostat 180, shown in Fig. 2, the voltmeter for which is designated 181. The remainder of the driving unit is mounted upon a curved bracket or shelf 182, which is attached to the inside surface of housing 1. Pinion 183 of motor 179 drives gear 184 of shaft 185, the other end of which carries a skew pinion 186 driving gear 187 and shaft 188. The end of shaft 188 is provided with a gear 189 which drives an escapement type of speed control mechanism 190 for motor 179, and which is preferably of the kind disclosed by Patent No. 1,577,618 issued March 23, 1926, to H. C. Ford. For a detailed description of this speed regulating mechanism, reference may be had to the patent, but for purposes of this invention a brief description thereof will suffice. Motor 179 is shunt wound with its field connected directly across a supply line, and a resistance is placed in series with the motor armature, the resistance being short-circuited by a pair of contacts. These contacts are actuated by a six-sided cam driven by the spider of a differential, one side of which is driven by motor 179, and the other side by a clock escapement mechanism. When the motor 179 is exceeding the required speed, the differential spider will rotate, since the escapement is constant, whereby the contacts are opened to introduce the resistance into the armature circuit, thus slowing motor 179 down. When the motor is going too slowly, the spider will rotate in the opposite direction and close the contacts, thus speeding up the motor.

In operation the contacts will be opened and closed rapidly, thus maintaining the motor 179 at a constant speed, which is shown by clock pointer 191 disposed behind a glass cover 192 in the side of casing 1, and attached to shaft 193, which is driven from shaft 188, through gears 194 and 195, shaft 196, worm 197 and gear 198. The pointer 191 is preferably regulated to make one revolution per minute.

A gear shift is provided whereby different speeds of all of the integrator discs may be obtained, since the speed of the several integrator discs governs the primary speed of the movement of the symbols across the plotting board. This is for the purpose of changing the distance scale of the plotting sheet 6, so that the outside circle, thereof, the radius of which has been chosen at say, fifteen inches, may represent either 50,000 yards, 25,000 yards, or 10,000 yards, there being preferably three selective speeds. Thus, if the observed ships are within a range of 10,000 yards, a larger scale may be used than when the ships are within a radius of 50,000 yards, and this selection may be done by shifting gears by means of knob 199, disposed on the outside of casing 1, the pointer of which coacts with range scale 200, as shown in Figs. 2 and 17. The inner end of shaft 201, to which knob 199 is attached, carries a notched disc 202, in the notches of which a spring-pressed detent 203 is adapted to lodge, so that the operator of knob 199 may position the gears readily and know when they are correctly positioned according to the range selected upon range scale 200. The movement of disc 202 is transmitted by link 204 to gear shift lever 205, which is pivoted at its center 206, and the other end of which engages slidable jack shaft 207 upon which are mounted spur gears 208, 209 and 210, of different diameters. Gear 208 is adapted to mesh with pinion 211 of drive shaft 188 to impart a low speed to shaft 207, gear 209 is adapted to mesh with gear 212 for the intermediate speed, and gear 210 is adapted to engage gear 194 for the high speed, representing respectively the 50,000, 25,000 and 10,000 yard ranges designated upon range scale 200. A sleeve 213, into which slidable shaft 207 is splined, is provided with a bevel gear 214 which meshes with another bevel gear 215 to and driving shaft 216. The lower end of shaft 216 is fitted with a pinion 217, shown in Fig. 3, which meshes with and drives large gear 12 at the desired regulated speed, which is transmitted to the several integrator discs through gears 17, 18, 19 and 37, as shown in Fig. 5.

The electrical supply line enters the apparatus by conduit 218 from which branch the motor 179 supply wires and the conduit 65 having junction box 64 from which the wires 63 emerge, which supply the current for energizing projector incandescent lamps 62 upon closure of the individual switches 219 disposed adjacent the several remote ship dials, as shown in Fig. 6. As many projectors may be illuminated at one time as there are vessels required to be plotted upon the plotting board.

In describing the operation of the apparatus, let it be assumed that there are two groups of ships, such as own and enemy fleets for example. By turning rheostat knob 180, the motor 192 is started and runs at a regulated speed indicated by one revolution of pointer 191 per minute. Assuming that the most remote ship of the enemy fleet is estimated as being at a range of 45,000 yards from own ship, then range knob 199 is set so that its pointer indicates 50,000 yards, whereupon the gears 209 and 212 are disengaged from the position shown in Fig. 11 and gears 208 and 211 engaged, so that all of the inte-

grator discs 22 and 38 are rotating at a constant relatively low speed. Meanwhile the locations, compass directions of travel, and speeds of each enemy ship and each ship of own fleet have been estimated by observers, and which are accordingly set up on the several dials, one for each ship, the luminous symbols of which appear upon plotting sheet 6, as illustrated in Fig. 1, when their several incandescent lights 62 are energized by operating switch buttons 219.

Referring to Figs. 5 and 6, the symbol of each ship is located in its proper position in the plotting sheet by pressing down on cranks 123 and 124 and rotating them simultaneously, the former moving the symbol in a north-south direction and the latter in an east-west direction. Then the estimated speeds of each ship is set up on dial 91 by rotating knob 90 until index 97 registers with the proper numeral indicating knots, and the compass direction of that ship is set up on compass ring 111 by rotating knob 110 until index 112 registers with the proper numeral. The several symbols then travel across the plotting sheets at speeds and directions simulating the speeds and directions of the ships they represent, assuming that own ship remains stationary, the movements of the ships and their symbols are relative to own ship, which is represented by the center of the plotting sheet 1.

This instance is usually only true when the apparatus is mounted in a land observation and plotting station, since a ship is usually moving. If the own ship is moving, the relative motion between it and the several remote ships is different than when own ship is stationary, and therefore, own ship's course and speed must be introduced. This is done by means of knobs 152 and 153, respectively, shown in Fig. 1, and ring 102 whereby the speed and direction of all of the remote ship symbols are altered accordingly, since their speeds and directions are governed by the position and movement of crank ring 102, which is controlled by knobs 152 and 153 in the manner hereinbefore described. Corrections in the speeds, positions and compass directions of the several symbols may be altered from time to time in accordance with subsequent observations, and permanent records of the paths of the several remote vessels may be had by marking the paths of their symbols upon plotting sheet 6. By laying out on the plotting sheet the desired future movements of own fleet vessels with a protractor and scale, it is possible to determine what course and speed each vessel must employ in order to carry out desired future maneuvers. Also, by means of a scale, the relative ranges of each own ship to each enemy ship may be readily determined from the plotting sheet. Thus, a complete visual plot of the entire array of both fleets is continually visible to the admiral of own fleet, and he can trace their movements and instantaneous positions and thus more readily determine future maneuvers and tactics.

While this specification describes and the accompanying drawings illustrate a preferred embodiment of this invention, it is to be understood that alterations in form and detail may be freely made without departing from the spirit of this invention within the scope of the appended claims.

What is claimed is:

1. In apparatus for indicating the relative position of an object, the combination of an indicator, independent mechanism for driving the indicator in mutually perpendicular directions, light-projecting means associated with the indicator, and a chart upon which said means projects light to represent the relative position of the object.

2. In apparatus for indicating the relative position of a moving object, the combination of a light-projecting indicator, elements movable in mutually perpendicular directions in accordance with the movements of said object, means for driving said indicator from said elements and a chart upon which the light from said indicator is adapted to be projected to represent the relative position of the object.

3. In apparatus for simulating the relative position of an object, the combination of a light projecting means, elements movable in mutually perpendicular directions in accordance with the movements of said object, means for driving said light-projecting means from said elements and a screen upon which said light-projecting means projects light.

4. In apparatus for simulating the relative position of an object, the combination of a light projecting means, mechanism for driving said means in directions in accordance with the movements of said object, means for controlling said mechanism, and a screen upon which said means projects light.

5. In apparatus for simulating the position of a moving object, the combination of a luminous symbol projector, mechanism for changing the angular position of said projector, means for controlling said mechanism in accordance with the course and speed of said object, and a screen upon which the luminous symbol is adapted to be projected.

6. In apparatus for indicating the position of a moving object, the combination of a luminous symbol projector, mechanism for controlling the movements of said projector in accordance with the movements of said object, and a chart upon which said luminous symbol is adapted to appear.

7. In apparatus for indicating the position of a moving object, the combination of a luminous symbol projector, variable speed mechanism for driving said projector, means

for controlling said mechanism in accordance with the movements of the object, and a screen upon which the symbol is adapted to be projected.

8. In apparatus for simulating the movements of a distant object, the combination of an indicator, mechanism for moving said indicator, means for adjusting said mechanism to move the indicator according to the course and speed of said object, and means for correcting the movements of said indicator in accordance with the movements of the object.

9. In apparatus for simulating the movements of a plurality of distant objects, the combination of an indicator for each of said objects, mechanism for actuating each of said indicators in accordance with the movements of said objects, and means for correcting the relative positions of said indicators according to the positions of said objects.

10. In apparatus for indicating the positions of a plurality of distant objects movable relative to a moving body, the combination of indicators for each of said objects, mechanism for positioning said indicators according to the relative locations of the moving objects, and means for maintaining the relative positions of said indicators according to the relative movements of said objects.

11. In apparatus for simulating the movements of a distant object, the combination of a translucent screen, a luminous symbol projector behind said screen and adapted to project said symbol thereupon, and mechanism for moving said projector in accordance with the movements of said distant object.

12. In apparatus for simulating the movements of a distant object, the combination of a screen, a luminous symbol projector adapted to project the symbol onto said screen, variable speed mechanisms for actuating said projector, means for controlling said mechanisms in accordance with the course and speed of said object, and selective speed driving means for said mechanism.

13. In apparatus for simulating the movements of a distant object, the combination of a screen, a luminous symbol projector directed upon said screen, independent mechanisms for driving said projector in component directions to reproduce the movement of said object, means for jointly setting said mechanism in accordance with components of the direction and velocity of movement of said object, and means for correcting the position of said projector.

14. In apparatus for indicating the relative positions of a plurality of movable objects, a plurality of luminous symbol projectors, a screen associated with the projectors, means for introducing the direction and velocity of movement of each of the movable objects, means for controlling the movement of said luminous symbol projectors from the aforesaid means to continuously direct said projectors so that the symbols projected upon the screen represent the relative position of the objects.

15. In apparatus for indicating the relative position of moving objects, a vector representing means adjustable in accordance with the direction and velocity of movement of an object, means for making said adjustment, a part located by said vector representing means, a second vector representing means mounted upon said part and adjustable in accordance with the direction and velocity of movement of a second object, means for making said adjustment, elements representing the combined components of said vectors and controlled directly from said second vector representing means, variable speed mechanisms controlled from said elements, an indicator driven by said variable speed mechanisms to indicate the relative position of said objects and means for initially setting the position of said indicator.

16. In apparatus for indicating the position of movable objects, relative to a movable point the combination of an adjustable crank representing the direction and velocity of movement of the point, means for adjusting said crank, a part located by said crank, vector representing means mounted upon said part and representing the directions and velocities of movement of the objects, means for separately adjusting each of said vector representing means, a pair of component slides operable from each of said vector representing means, variable speed mechanisms, the speed varying element of each being adjustable from one of said slides, a plurality of indicators each driven in two components of motion from two of said variable speed mechanisms, to indicate the relative position of each of said objects from said point.

17. In apparatus for indicating the relative position of movable objects, the combination of vector representing means adjustable in accordance with the direction and velocity of movement of said objects, variable speed mechanisms controlled by said vector representing means and having constant speed elements, indicators driven from said variable speed mechanisms, a source of fixed rotational velocity for driving the constant speed elements of the variable speed mechanisms and means for varying the constant speed of the elements relative to the fixed rotational velocity for changing the scale by which the indications of the relative positions of said objects are compared.

18. In apparatus for indicating the relative position of movable objects, indicators driven by variable speed mechanisms, said variable speed mechanisms having constant speed elements, a source of fixed rotational velocity for driving said constant speed ele-

ments and means for varying the speed of said elements relative to said source for altering the scale by which the positions of said indicators are compared.

19. In an indicating apparatus, the combination of an indicator located in an observing field by the intersection of two mechanically driven coordinates, a plate having an opening substantially the shape of the field and mounted for movement on the plane of the coordinates, means for centralizing the opening in the plate relative to the field, and means operable when the indicator approaches the edge of the field to move the plate in the direction of movement of the indicator, and means operable from the movement of the plate to stop the drive of the indicator by the co-ordinates toward the edge of the field.

In testimony whereof I affix my signature.

HANNIBAL C. FORD.