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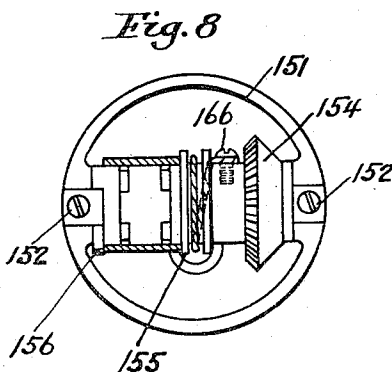
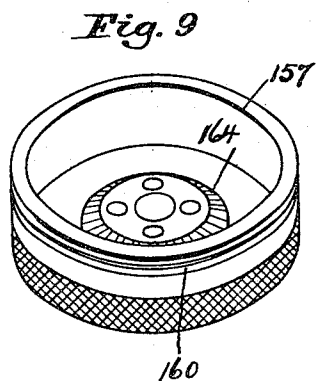
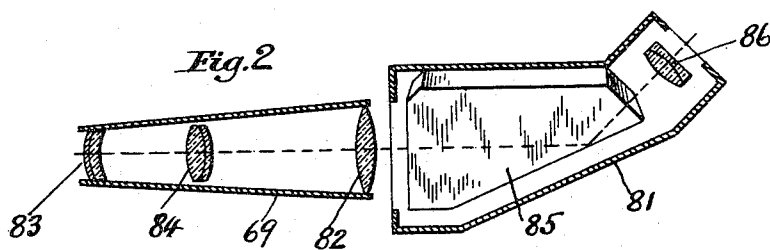
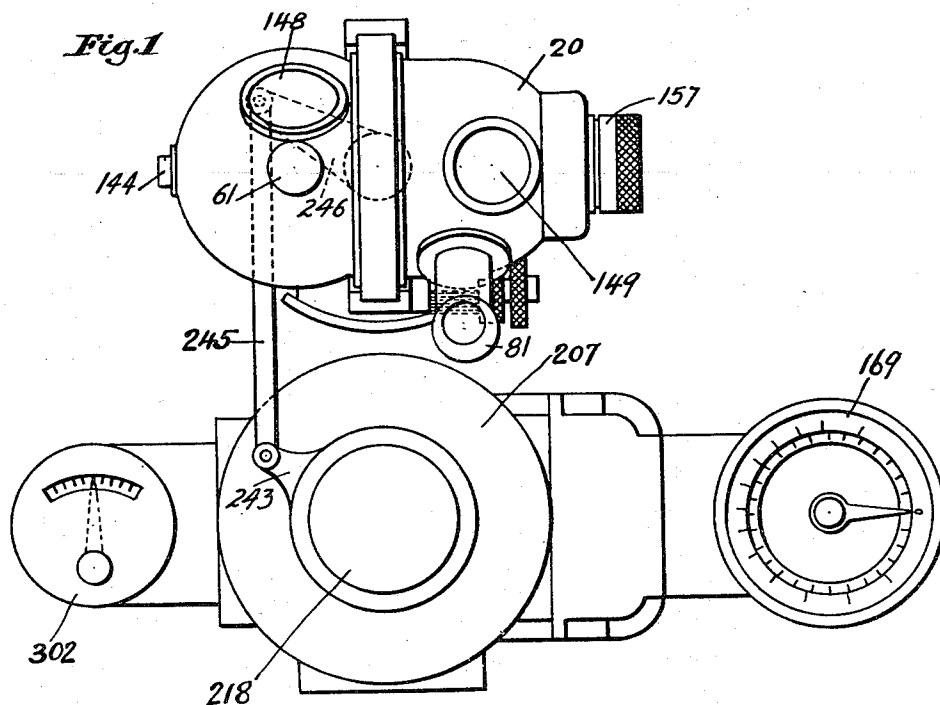
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BOMB SIGHT

Filed May 27, 1930

11 Sheets-Sheet 1



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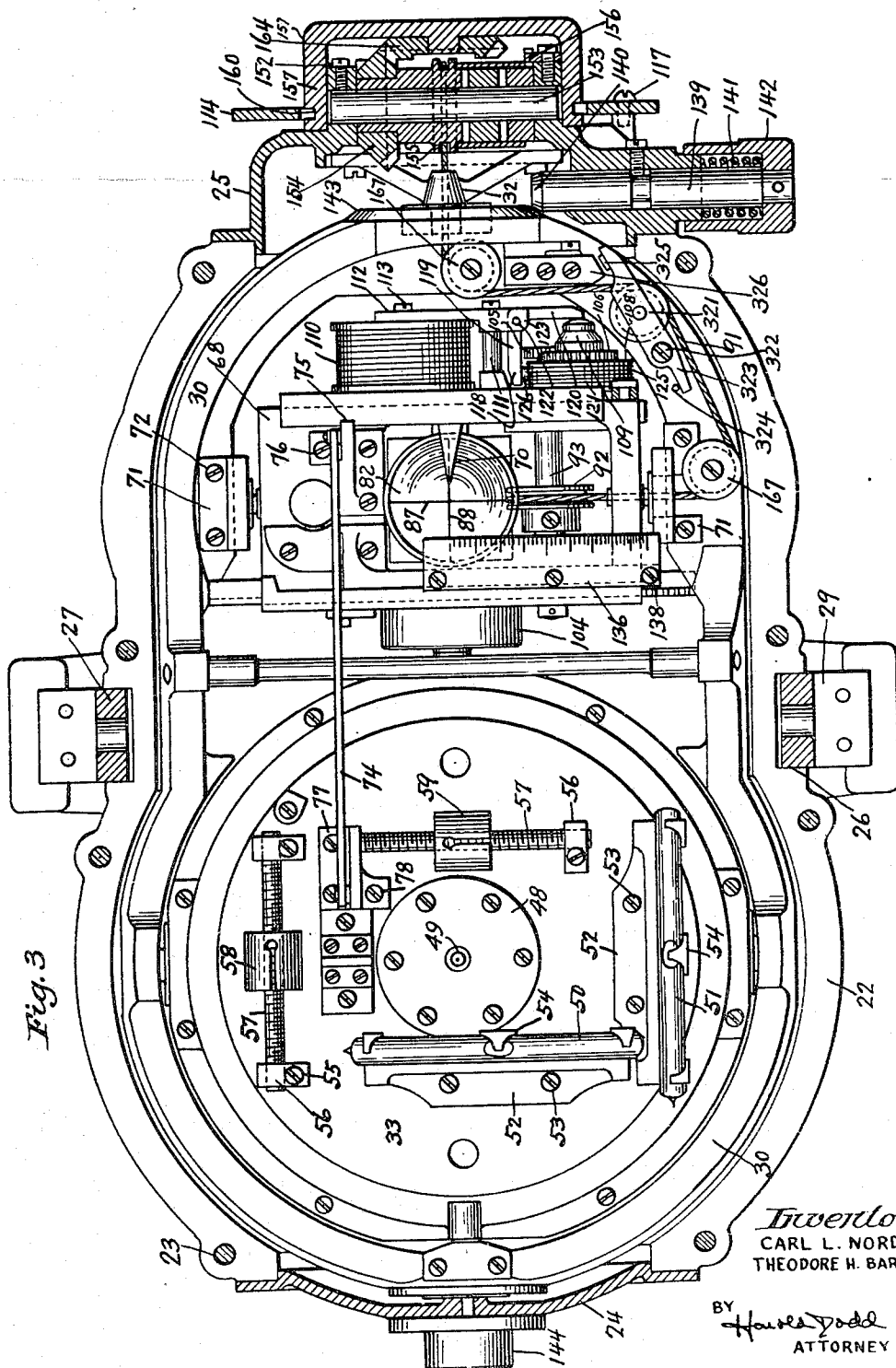
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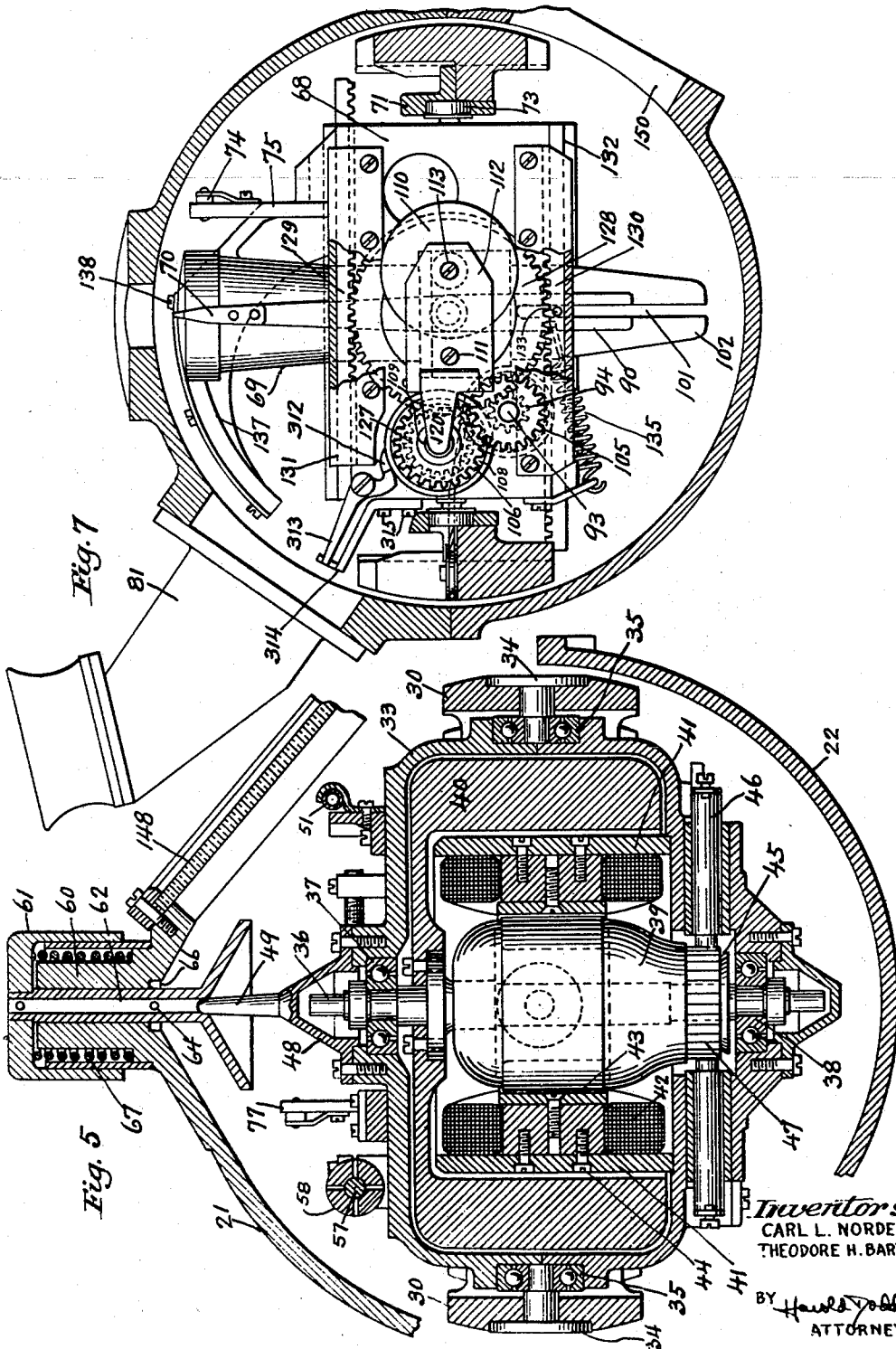
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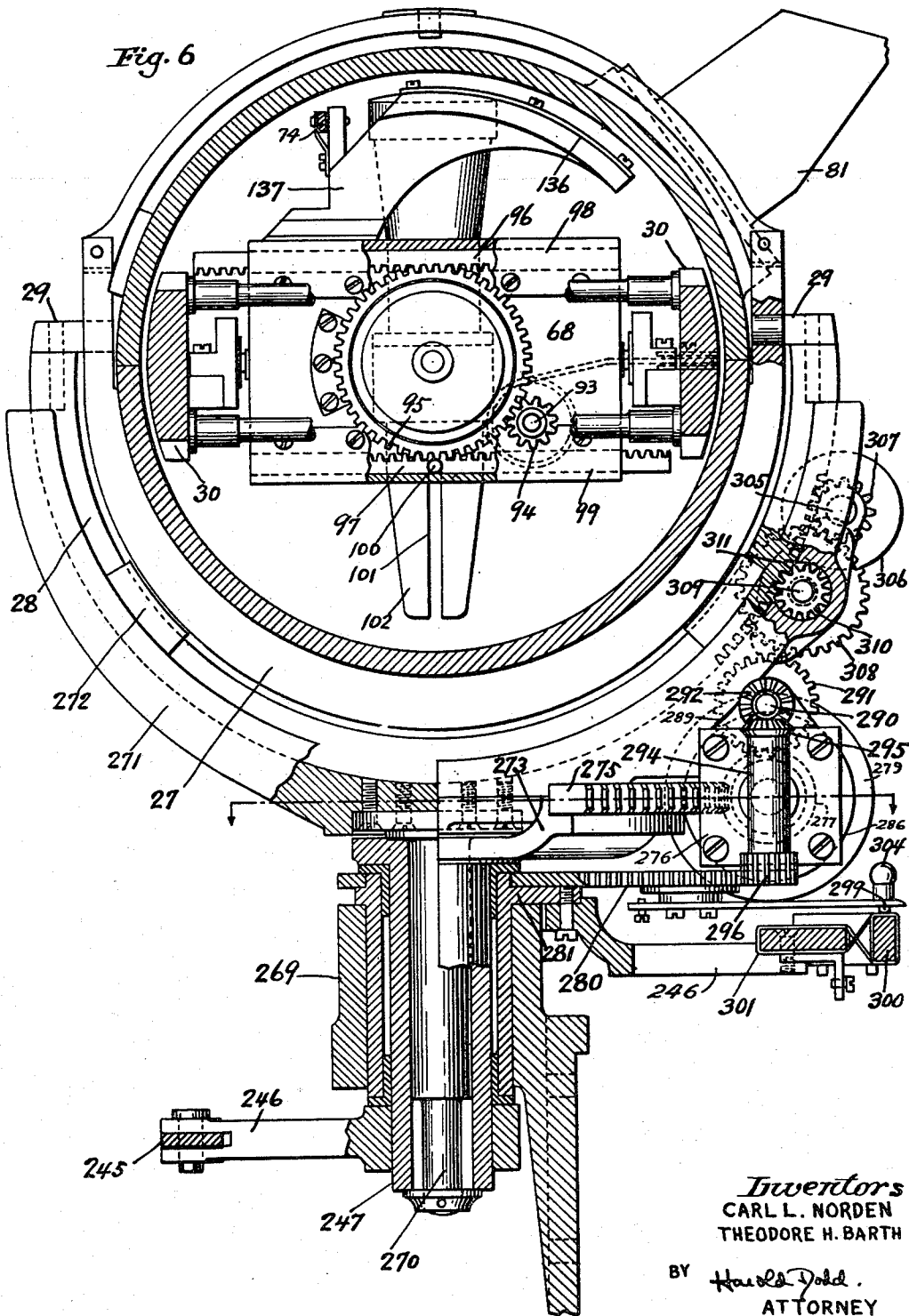
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Fig. 10

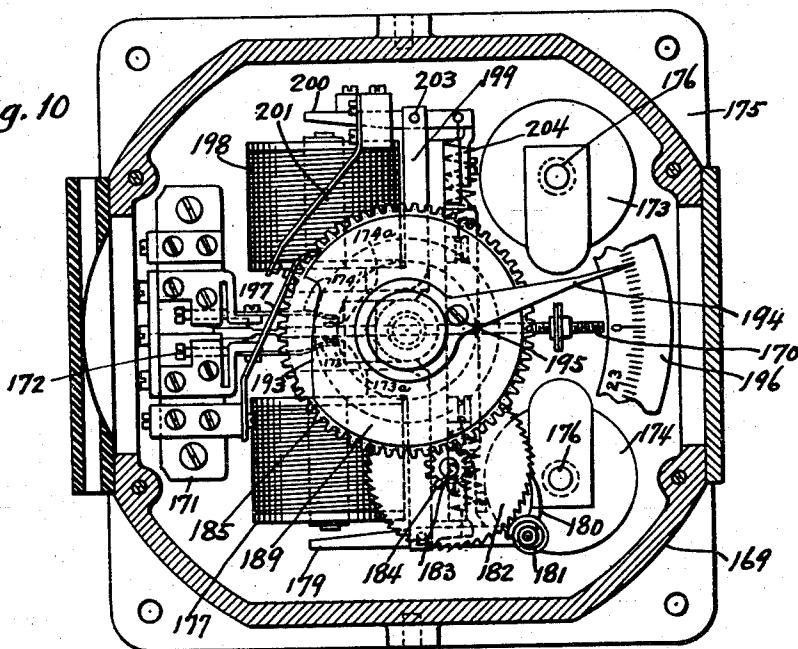


Fig. 11

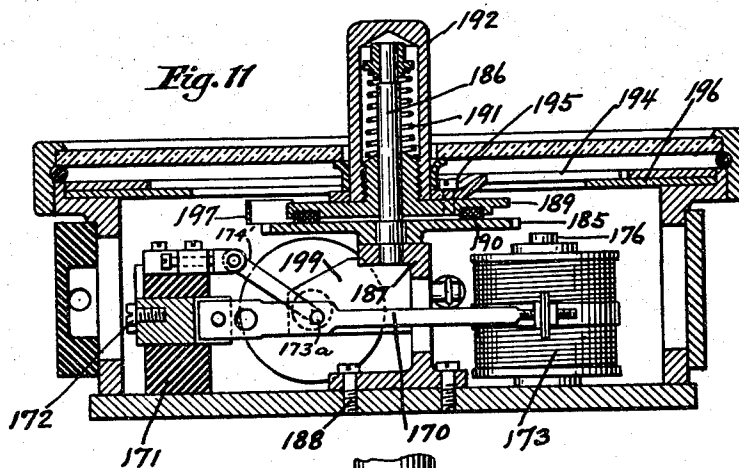
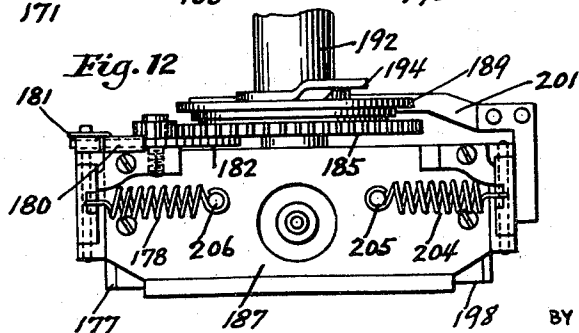


Fig. 12



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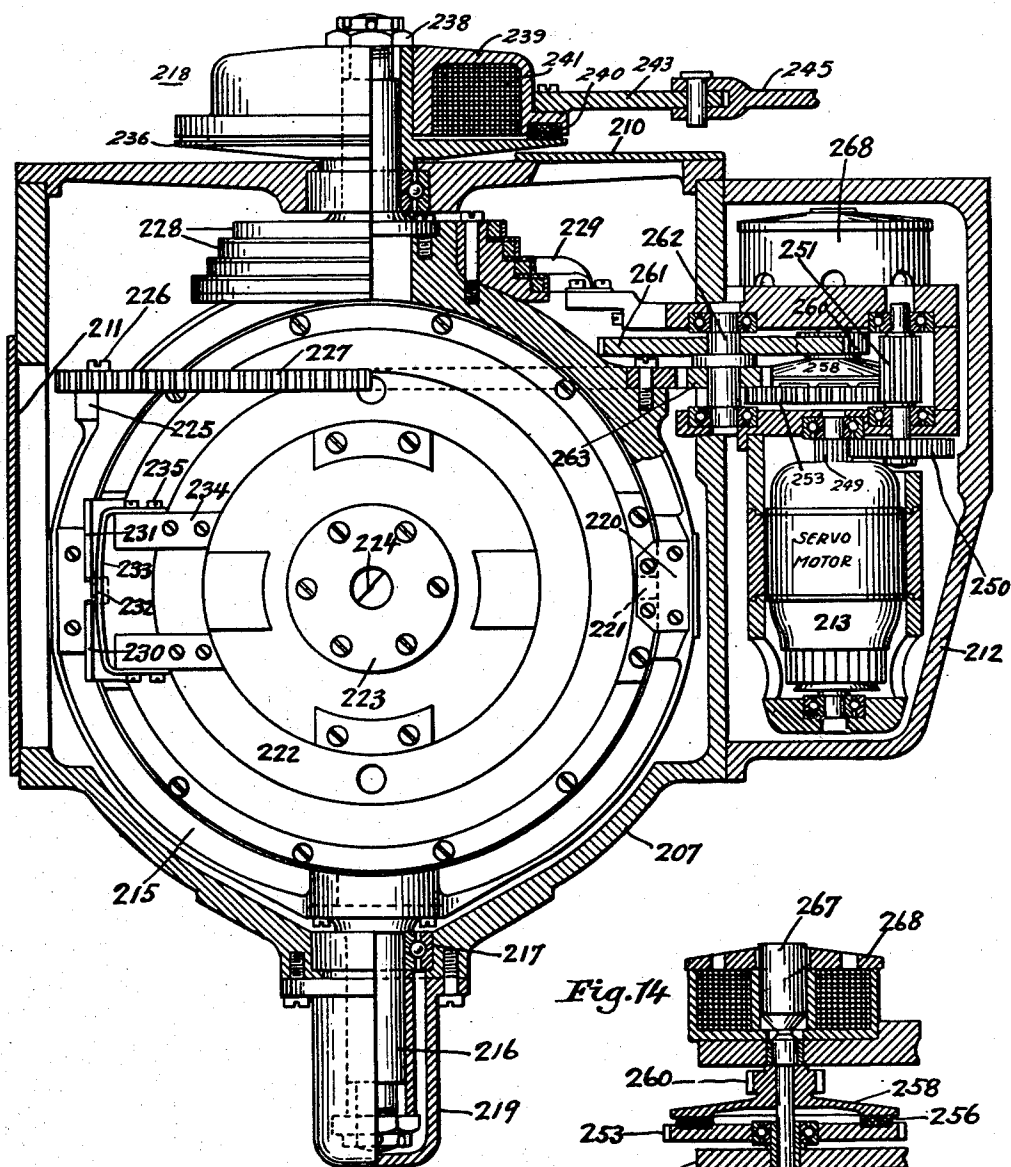
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Fig: 13



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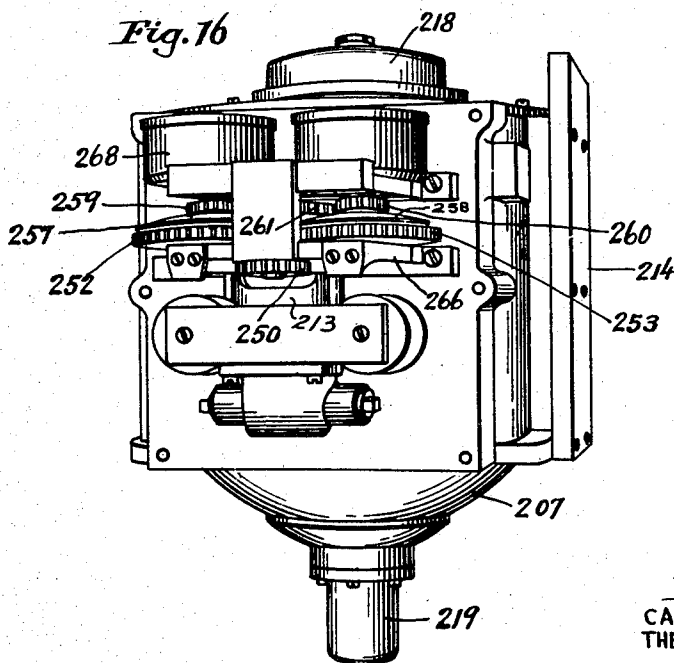
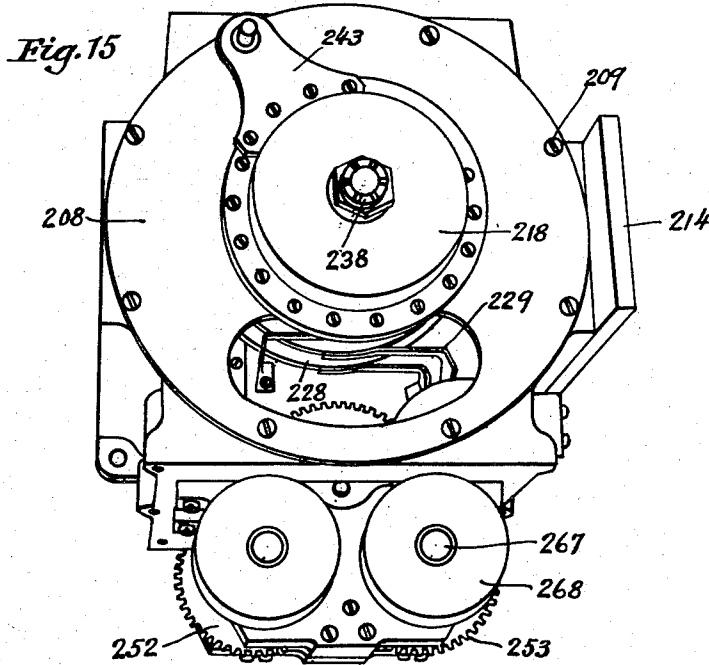
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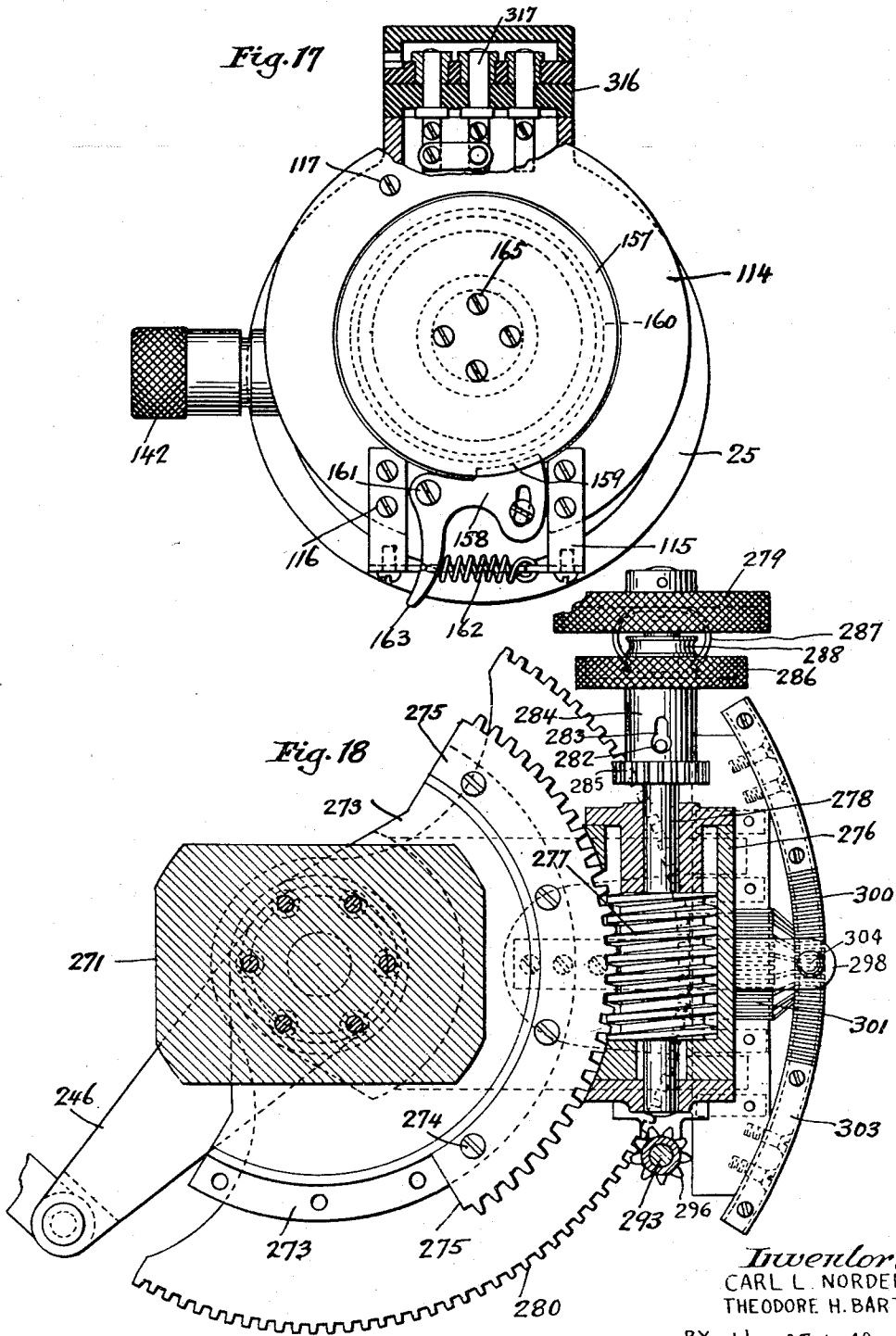
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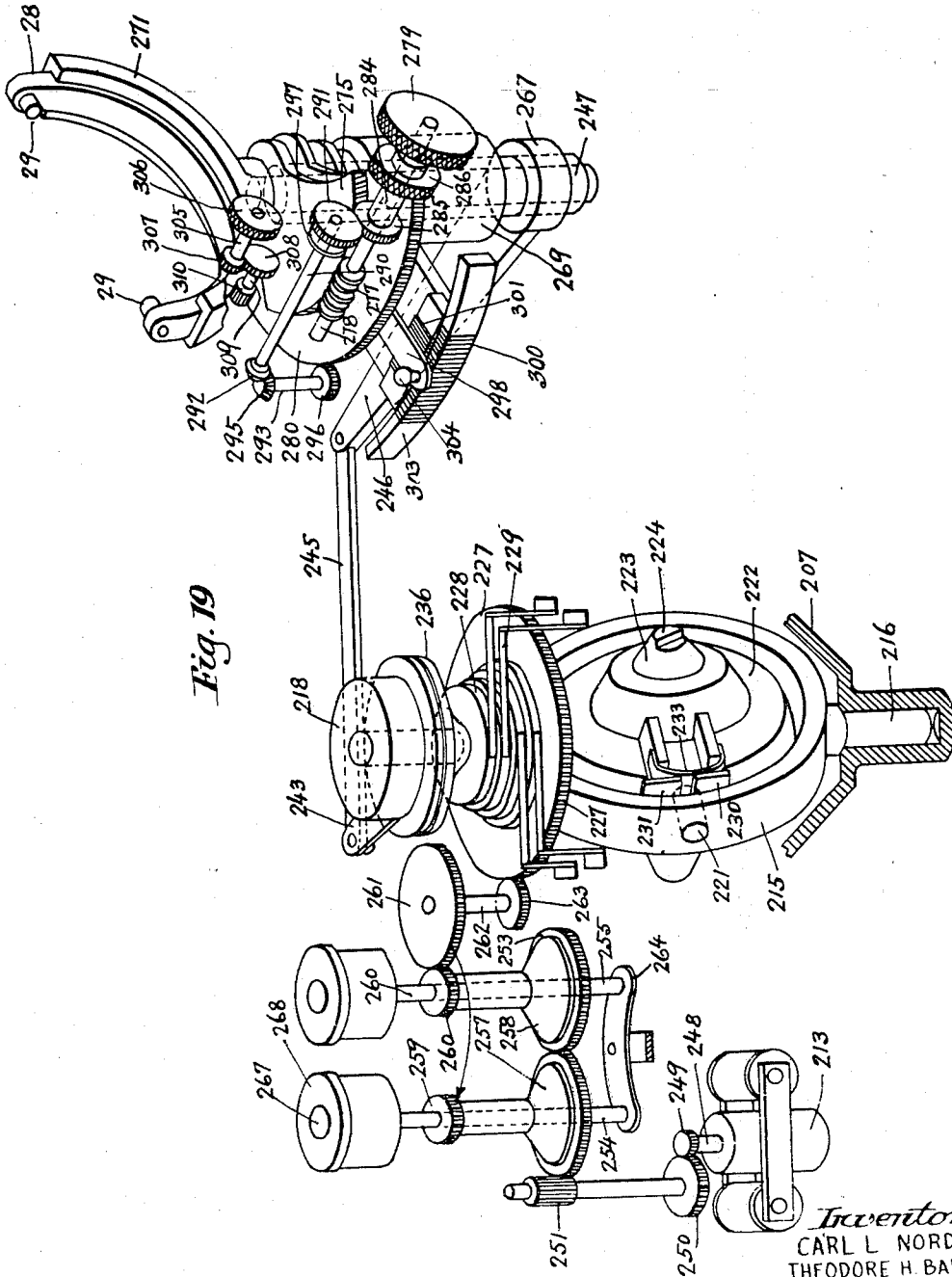


Fig. 19

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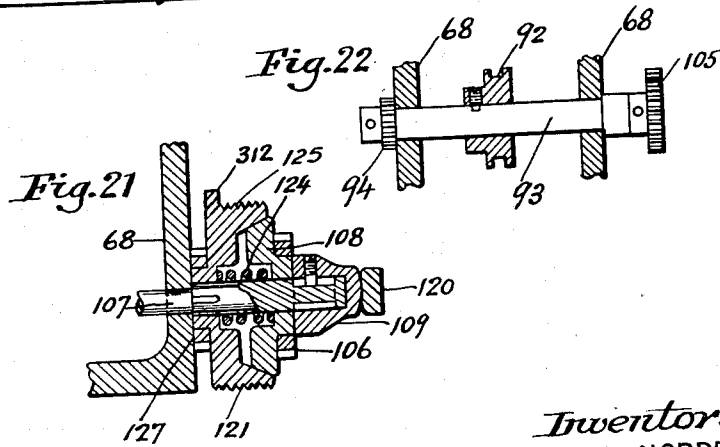
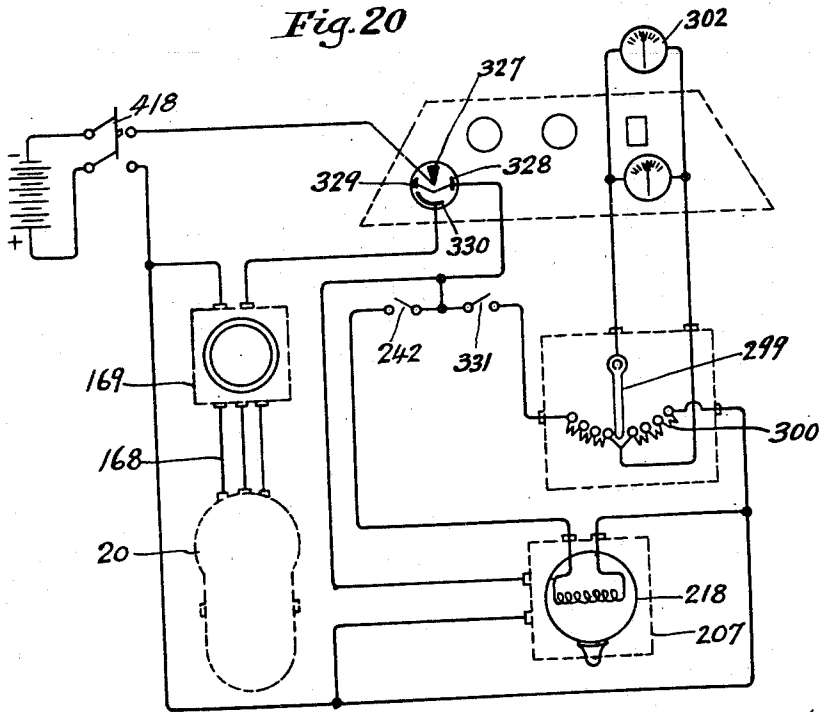
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2,428,678

11 Sheets-Sheet 11



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UNITED STATES PATENT OFFICE

2,428,678

BOMB SIGHT

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Application May 27, 1930, Serial No. 456,168

33 Claims. (Cl. 33—46.5)

1

Our invention relates broadly to an improvement in bomb sights and more particularly to a device that can be easily installed on an aircraft for the purpose of sighting and aligning a target at the proper angle to accurately drop a bomb from the air.

An object of our invention is to provide a bomb sight wherein the optics are stabilized relative to the aircraft for the fore and aft position and for the athwartship position and the sight is stabilized about the vertical axis.

Another object of our invention is to provide in a bomb sight a stabilized optical system that can be moved without disturbing the stabilization thereof.

A further object of our invention is to provide with a bomb sight installed on an aircraft a mounting for the sight having apparatus thereon to indicate deflection and to allow overcorrection, thereby permitting steadier flying just before dropping the bomb.

Still a further object of our invention is to provide a bomb sight with a system of pilot directing wherein the bomb sight mounting and therefore the bomb sight is stabilized about the vertical axis. In this system, inasmuch as the sight optics are directly stabilized for the other two axes, the field picture should, when not on the "collision course," show steady target drift unaffected by yawing of the aircraft or bumpy air.

With the above and other objects in view, our invention consists in the construction, combination and arrangement of parts as will be described more fully hereinafter.

Reference is to be had to the accompanying drawings forming a part of this specification, in which like reference characters indicate corresponding parts throughout the several views, and in which:

Fig. 1 is a diagrammatic view of the arrangement of our invention;

Fig. 2 is a sectional view of the optical system used in our improved device;

Fig. 3 is a plan view of the bomb sight in our improved device with the top removed and partly shown in section;

Fig. 4 is a longitudinal section through the bomb sight of our improved device showing the gyro in elevation and the remaining parts in section;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 4;

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Fig. 7 is a sectional view taken on line 7—7 of Fig. 4;

Fig. 8 is an end view of our improved bomb sight with a portion thereof removed;

Fig. 9 is an operating knob for the end of our improved bomb sight;

Fig. 10 is a plan view of the clock for our improved device with the face removed;

Fig. 11 is a central longitudinal section of the clock for our improved device;

Fig. 12 is a detail view of a portion of the clock for our improved device;

Fig. 13 is a longitudinal section through the pilot director of our improved device, shown partly in elevation and partly in section;

Fig. 14 is a detail sectional view of a portion of the pilot director of our improved device;

Fig. 15 is a plan view of the pilot director of our improved device;

Fig. 16 is a side view of the pilot director of our improved device;

Fig. 17 is an end view of the bomb sight, shown partly in section, of our improved device;

Fig. 18 is a plan view of the pilot director bracket unit, showing a portion thereof in section, of our improved device;

Fig. 19 is a schematic arrangement of the pilot director and pilot director bracket unit of our improved device;

Fig. 20 is a wiring diagram for our invention;

Fig. 21 is a cross section of the clutch mechanism used in the bomb sight of our improved device;

Fig. 22 is a detail view partly in section of a portion of our invention.

Referring more particularly to the drawings, 20 indicates a sight casing consisting of an upper unit 21 and a lower unit 22 secured together by screws 23, and the end pieces 24 and 25. A circumferential groove 26 is machined at the center of the casing 20 to take a two-part ring collar 27 that is pivoted above the center line of the casing 20 by a fork 28 and pins 29. A cardan ring 30 is mounted longitudinally in the center of the casing 20 by ball bearings 31 carried on gudgeons 32 at each end of the casing 20. The fork pins or pivots 29 being above the center line of the sight makes the sight pendulic in the fork 28.

A gyro 33 is mounted in the left portion of the ring 30 by pins 34 and ball bearings 35. The gyro 33 has its cardan axis running fore and aft and at right angles to the axis of cardan 30. A rotor shaft 36 is mounted vertically in ball bearings 37 at the top and ball bearings 38 at the bottom of the gyro casing 33, and mounted on the shaft

36 are armature 39 and rotor 40. A field casing 41 secured to the bottom portion of gyro casing 33 has field 42 and field plate 43 fixed thereto by bolts 44 for operating the armature 39. The lower portion of the casing 33 is provided with a recess 45 for brushes 46 that bear against a commutator 47 secured adjacent the lower end of shaft 36. A cap 48 having a locking pin 49 extending therefrom closes the top of the casing 33.

Fore and aft bubble or level 50 and athwartship bubble or level 51 (Fig. 3) are positioned on the top of the casing 33 by clips 52 secured to the casing by screws 53. The clips 52 are provided with pointers 54 that extend over the center of the levels 50 and 51. Also positioned on top of the casing 33 by means of screws 55 and clips 56 are threaded shafts 57 for an athwartship adjustable balance weight 58 and for a fore and aft adjustable balance weight 59.

Unit 21 of casing 20 has the apertured boss 60 in and around which is placed a gyro locking knob 61. The knob 61 when pushed down forces by means of hollow shaft 62 a cone 63 on the inside of the casing over the pin 49 on the cap 48 of the gyro casing. A pin 64 projecting from shaft 62 rides in groove 65 in the boss 60 and when the knob 61 is pushed down and turned, pin 64 is adapted to rotate in a groove 66 thus locking the shaft and cone. The cone 63 is quickly released from a locking position by the spring 67 when the knob 61 is turned. When locking the gyro the locking knob 61 should be pressed down and turned anticlockwise. This will then cause the gyro to precess toward the central position, in which case the top of pin 49 will fit into the hollow of shaft 62 and lock the gyro.

A cradle 68 carrying an objective 69, a back sight 70 and their operating mechanism is mounted on the right side of the cardan 30 by means of sockets 71 secured with bolts 72 to the cardan 30 and cradle bearing pins 73 (Fig. 7) riding in the socket 71. The tilting axis of the cradle is parallel to that of the gyro, and since the gyro and cradle are both mounted in the cardan they tilt together about the athwartship axis with the cardan. A rod 74 secured to a clip 75 attached by screws 76 to the cradle 68 and secured to clip 77 attached by screws 78 to the gyro 33, connects the gyro and cradle and insures that the gyro and cradle tilt together about their fore and aft axes. An objective mount 79 pivots in bearing 80 on each side of the cradle and can swing with the objective 69 through an angle.

The optical system as shown in Figure 2 consists of the tube or objective 69 and the eye piece 81. In the objective 69 are mounted a cross line lens or reticle 82, a first objective lens doublet 83 and a second objective lens doublet 84. The eye piece has the erecting prism 85 and doublet eye piece lens 86. The objective is placed in the mount 79 and is stabilized in the cradle while the eye piece is secured to unit 21 of the casing 20 and is not stabilized. The objective also has independent motion in the cradle 68, that is, it can be swung about the horizontal athwartship axis by manually operated mechanisms, while the plane of swing of the line of sight is held vertical by the gyro. The eye piece is lined up with the objective 69 by rotating the casing 20 in the fork 28 and by tilting the casing 20 about the fork pivots 29. Fore and aft line 87 and athwartship cross line 88 are engraved on the reticle 82 (Fig. 3).

The back sight 70 is simply a pointer secured by screws 89 to a shaft 90 rotatably placed on one of

the bearings 80 that acts as the axis for the mount 79 of the objective 69, but the back sight 70 turns independently of the objective mount 79. The pointer or back sight 70 extends one-half way across the field of the reticle 82 and is sufficiently clear of the objective 69 to allow independent motion of the back sight 70 and objective 69.

An operating cable 91 leads through the center of the after cradle bearing 73, and several turns are taken around a cable drum 92 which is keyed on an athwartship shaft 93 rotatably mounted on the sides of cradle 68. On one end of the shaft 93 outside of the cradle 68 is a drum pinion 94 meshed with a large rack gear 95 that is concentric with the objective mount axis. The large gear 95 meshes in racks 96 and 97 which slide in grooves 98 and 99, one at the top and one at the bottom of the cradle, respectively. The operating rack 97 carries a pin 100 which projects through and slides in a slot 101 in guide lever 102 made fast to the objective mount 79 by a screw 103 so that motion of the rack 97 in the groove 99 swings the lever 102 and with it the objective 69 through an arc in a fore and aft vertical plane. The top rack 96 moves in an opposite direction from the rack 97 and acts as a counter weight or balance to prevent the cradle 68 from being unbalanced due to movement of rack 97. A spiral spring 104 tends to turn the rack gear 95 connecting the racks 96 and 97 in a clockwise direction when viewed from the left. The tension on spring 104 opposes the pull on the operating cable 91. A pull on cable 91 moves the objective 69 so that the line of sight approaches the vertical position. When the cable 91 is eased off, spring 104 moves the objective 69 in the opposite direction and winds up the slack cable on the drum 92.

Keyed on the right end of drum shaft 93 is a small gear 105 (see Fig. 7) that meshes with gear 106 turning idly on a clutch shaft 107 rotatably mounted through the right side of the cradle. Gear 106 has integral therewith a male clutch disk 108 (Fig. 21) and is held on to the shaft 107 by a cap 109 on the end of the shaft so that when the clutch is disengaged, the gear 106, disk 108 and cap 109 turn idly on shaft 107 permitting the drum 92 to move independently. An electro magnet 110 secured to the right side of the cradle by stud 111 (Fig. 3), arm 112 and stud 113 is energized by pressing a contact ring 114. The contact ring 114 is secured to end piece 115 of the casing by spring 115 and screws 116 and is positioned by positioning pin 117. When the electromagnet 110 is energized one end 118 of a clutch operating lever 119 is drawn toward the magnet and the other end 120 bears against and pushes inward on cap 109. The cap 109 in turn forces the gear 106 and disk 108 to move into and become engaged with a female clutch disk 121 that is keyed to shaft 107. The lever 119 is pivoted by pin 122 to a projecting end 123 of the arm 112. A spring 124 positioned around shaft 107 between clutch disks 108 and 121 pushes disk 108, gear 106 and cap 109 to the idle position on the shaft when the magnet 110 is not energized. The disk 121 is threaded as at 125 and secured to end 118 of lever 119 is a pad 126 that bears against threads 125 when the clutch is disengaged, thus setting up a braking means for shaft 107. Secured to the shaft 107 is a pinion gear 127 that meshes when the clutch is engaged to a large rack gear 128. The gear 128 meshes with racks 129 and 130 in machine grooves 131 and 132 respectively, one at the top and one at the bottom right side of the cradle so that the same are sim-

ilarly arranged as the racks 96 and 97 on the left side of the cradle. A pin 133 projecting from rack 130 engages in a slot 134 in the lower end of the back sight arm 90. The rack 129 simply acts as a counter balance for rack 130 like rack 96 counterbalances rack 97. Thus, the back sight moves only with the objective when the electro magnet is energized and when the magnet is not energized the back sight remains in whatever position it is placed in, a spring 135 serving to take up the back lash of the arm 90.

A range angle scale 136 marked in degrees is fixed to the left side of the cradle 68 by means of arm 137 and screws 138. The scale 136 extends over the edge of the objective 69, between the objective and eye piece 81, and when viewed through the eye piece the graduations are erected and magnified. The position of the athwartship cross line 88 on the reticle 82 of the objective read against the scale gives the angle of the line of sight forward of the vertical or the range angle when set for dropping. The position of the back sight 70 can be read by aligning the cross line of the objective with the back sight and reading the scale from the objective cross line.

An athwartship bubble setting knob shaft 139 (Fig. 3) projects through the casing and has a cone surface 140 machined on its end. A spring 141 holds it clear of the cardan but when a knob 142 is pressed in, the cone surface bears against an oppositely disposed cone surface 143 on the cardan so that when the knob 142 is rotated it will exert a torque on the cardan tending to tilt the cardan about the cardan axis in a direction depending upon which way the knob 142 is turned. Applying torque to the cardan about the cardan axis causes the gyro to precess in a direction at right angles to the torque. In this case the gyro and the cradle will tilt together about their respective axes. The direction of spin of the gyro is such that the athwartship bubble 51 moves in the same direction as the top of the bubble setting knob 142. The fore and aft bubble or level 50 is set by applying torque to the gyro case about the gyro case axis, thus producing precession of the gyro in a direction that will tilt the cardan about the cardan axis. This torque is applied by pressing in on a button 144 (Fig. 4) which has a shaft 145 bearing against a spring 146 that presses against the contact surface on the gyro case. The spring 146 is secured by studs 147 to the cardan 30. A spring 340 holds button 144 and shaft 145 clear of spring 146.

Suitably placed on the upper unit 21 of the casing are gyro inspection window 148 and cradle and sight inspection window 149 and in the under side of unit 22 is an objective window 150.

The end 25 is provided with a cylindrical projection 151 in which is rotatably mounted by set screws 152 a shaft 153. Keyed to shaft 153 is bevelled gear 154 having a drum 155 for operating the cable 91, and a stop 156. An operating knob 157 fits over the outside of the projection 151 and turns on it. The knob 157 is held in place by a key 158 (Figs 4 and 17) that has the retaining portion 159 positioned in groove 160 of the knob 157. The key is pivoted by screw 161 and is held against the knob 157 by coil spring 162 having one end secured to arm 163 of the key and the other end to spring 115. A bevelled gear 164 fastened by screws 165 to the plane inner side of knob 157 meshes with the gear 154 on the shaft 153. Thus, the operating knob 157 will wind up or ease off the cable 91 on the drum 155 thereby moving mount 79 with objective 69 to the

desired angle. The end of the cable 91 is secured to the drum 155 by set screw 166, and the stop 156 limits the number of turns that can be given the knob 157, thus preventing the breaking of cable 91 by winding the same on the drum 155. The cable 91 enters the casing 20 through the center of the cardan gudgeon 32 and is guided to the drum 92 by means of pulleys 167 suitably placed on the cardan 30.

Positioned near the sight casing 20 and connected by wires 168 is a clock 169 (see Figs. 10-12). The clock 169 comprises a reed 170, secured to a terminal block 171 by screws 172, vibrating between an energizing coil 173 and a de-energizing coil 174 fixed to base 175 of the clock by studs 176. The circuit through coil 173 includes a resilient conducting element 173' that touches a suitable breaker point 173a on reed 170 when the reed is stationary and so maintains this part of the circuit closed. When current flows through coil 173 the reed is drawn toward the coil and the circuit through this coil is broken, but a point 174a on the reed touches contact element 174' and closes the circuit through coil 174 which then draws the reed toward the last mentioned coil. The length of the reed 170 is such that it will vibrate at a predetermined rate per second, thus providing the means for time keeping. A motor coil 177 secured to base 175 is energized once every vibration of the reed 170 which causes a ratchet bar 179 that is pivoted at 179' to oscillate the same number of times per second. The oscillation of bar 179, acting through a feed ratchet 180, which is held in operative position by spring 181, causes a ratchet wheel 182 keyed to a shaft 183 to turn one tooth each oscillation of the bar. A drive pinion 184 on top of wheel 182 meshes with a larger gear 185 keyed on a main shaft 186 rotatably mounted in a standard 187 secured by studs 188 to the base 175. The gear 185 is thus turned at a predetermined set rate. A fibre timing disk 189 turns with gear 185 by friction caused through pads 190 on the under side of disk 189 and spring 191 placed in a setting knob 192 bearing against the top of disk 189. The disk 189 may be moved independently of the gear 185 by the knob 192. The timing disk 189 has cut into its periphery a stop notch 193. A pointer 194 secured by stud 195 to the disk 189 and also to the setting knob 192 turns with the disk 189 and indicates on an altitude scale 196 the position of notch 193. The pointer 194 is pointing to zero on scale 196 when a contact 197 that is secured by screws 172 to block 171 is just dropped down into the notch 193. A relay coil 198 secured to an arm 199 of standard 187, when energized pulls an armature 200 and closes contact 201 against contact 197 provided contact 197 is in any place on disk 189 except in notch 193. Armature 200 is pivoted to frame 199 by pin 203. The armature 200 is pulled away from coil 198 when not energized by a spring 204 held by pin 205 secured to the standard 187. When contact 197 is in the notch 193 the contact between 197 and 201 because of the distance between the two, is broken, even though relay coil 198 is energized. In like manner the ratchet bar 179 is held away from coil 177 by spring 178 held by pin 206 secured to standard 187.

A different clock dial or altitude scale 196 is necessary for each type of bomb, depending particularly upon the weight of the bomb to be dropped. All difficulties are overcome by using on the sight a series of calibrated clock scales which can be made as necessary. The scales may be

readily shifted and replaced whenever the type of bomb is changed.

The clock is started in operation by closing main switch 418, shown in Figure 20, thus supplying current to coils 173 and 174, which sets the reed 170 into vibration, but the other mechanisms remain stationary. The clock is set for the time corresponding to the altitude. When ready to start the timing operation, the contact ring 114 on the bomb sight is pressed which closes the timing switch and energizes the relay coil 198. The relay coil 198 pulls contact 201 against contact 197 which closes the circuit through coil 110 and engages the back sight clutch, thus causing the back sight 70 to be driven through rack 132, gear 128 and the other gears that connect the rack, through the back sight clutch, to shaft 93 and cable drum 92, which drum is rotated at a rate proportional to the ground speed. As above set forth, the back sight clutch is released at the end of the timing interval and hence the back sight stops at a position determined by its rate of motion and the duration thereof. The rate of movement of the back sight is a function of the ground speed of the craft, and since the two arguments of the dropping angle are the time of fall (altitude) and the ground speed of the craft, the back sight will, when positioned in the manner set forth, indicate the correct dropping angle. Contacts 197 and 201 complete another circuit to the relay coil 198 so that this coil remains energized even though the circuit is broken at the timing switch after the momentary touch given the contact ring 114. Contacts 197 and 201 also complete one leg of the circuit to motor coil 177. The other leg is completed by reed contact 170 once every vibration of the reed. A touch on contact ring 114 has thus hooked up the back sight 70 to the objective 69 and started the clock pointer 194 turning around its zero position. When the timing disk 189 rotates to zero seconds, contact 197 drops into notch 193 breaking the circuit to the motor coil 177, relay coil 198 and to the back sight clutch coil or electromagnet 110. The back sight 70 then remains in whatever position it is even though the movement of objective 69 continues.

To re-set the objective 69 the clock pointer 194 should be in the zero position. Contact ring 114 is held in while the operating knob 157 is turned in such a direction as to move the back sight 70 toward its vertical position. A stop 312 (Fig. 7) on clutch disk 121 will bear against a pivoted pointer 313 that will indicate on a stationary pointer 314 secured to the cradle by studs 315 the vertical position of the back sight 70.

A terminal box 316 with terminals 317 for all outside electrical connections for the bomb sight is provided as an integral part of the end 25. The electromagnet 110 is energized when contact ring 114 is pressed against contact pin 318 that in turn comes in contact with terminal 319 in the terminal box 316. Suitable wires 320 connect terminal 319 to a suitable terminal such as 341 for the magnet 110.

One of the pulleys 167 is positioned on the cardan 30 by means of an arm 321 pivoted by a set screw 322. A spring disposed around screw 322 is engaged therewith and with arm 321 and is under torsional stress in a direction to tend to impart to arm 321 a clockwise rotation about pivot 322 until stopped by pin 324 so that when there is slack in the cable 91 the contacts 325 and 326 will be separated to break the circuit through the coil 110 and release the back sight clutch to prevent the back sight from getting out of proper relation to the

objective. The cable 91 will normally be kept taut by the pull of spring 104 which tends to move objective 69 to a position away from the vertical. When the cable 91 is wound tight between the drums 92 and 155' the force on the pulley 167 will pull arm 321 back until the circuit is again closed through contacts 325 and 326.

A pilot director and azimuth stabilizer for the sight are shown on top of and contained in a casing 207 below the bomb sight casing 20. The casing 207 (see Figs. 13 and 15) has a top or cover plate 208 secured thereto by screws 209, inspection plates 210 and 211, a cover plate 212 for a servo motor 213 secured to the side thereof, and a bolting face 214 for suitably securing the unit.

A cardan 215 is positioned by gudgeons 216 that turn in ball bearings 217 fitted into the top and bottom of the casing 207. The gudgeons 216 are constructed longer than necessary for bearing surfaces in order to fit an electromagnet clutch 218 on the top gudgeon shaft. The clutch 218, as shown in the drawings, is fitted on the top gudgeon, while the bottom gudgeon is covered by a protective cap 219. In the actual use or construction of the unit, if desired, the protective cap 219 may be shifted to the upper gudgeon and the clutch 218 to the lower gudgeon.

Fitted into cardan 215 at right angles to the gudgeons 216 are ball bearings 220 in which fit pins 221 for mounting a gyro in casing 222 to stabilize the sight casing in azimuth. The gyro tilts in the cardan about a horizontal axis. The gyro 222 is of the same design and construction as gyro 33 used and described in the bomb sight casing 20. Caps 223 secured to the casing 222 for the gyro bearings and shaft, not shown, are extended to form tilting stops 224 to limit the tilt of the gyro to a predetermined number of degrees each side of the horizontal by being brought up to the inner sides of the casing 207. Fixed to the shoulders 225 on the cardan 215 by screws 226 is a circular gear 227, upon which the servomotor 213 exerts its torque. The cardan 215 also carries adjacent the top gudgeon, slip rings 228 (Fig. 19) for distributing electric current to the various parts of the instrument. By use of the rings 228 and the brushes 229 that bear against the rings 228, the cardan stabilization is not affected by whatever course the craft takes or by any position the cardan happens to be in when the stabilizer is started. The cardan also has fastened thereto insulated control sectors 230 and 231, separated by a neutral gap 232 (Fig. 13), and riding on the sectors is the brush 233 which is secured to arms 234 on the gyro casing by screws 235.

The electromagnet clutch 218 consists of a disk 236 keyed on the gudgeon 216 by nut 238 threaded on the end of the gudgeon 216, and an electromagnet 239 having a non-magnetic bushing or friction plug 240 adapted to bear against disk 236. The magnet 239 houses an energizing coil 241 controlled by a switch 242. A lever 243 (Fig. 19) is secured to the clutch by studs 244, and a rod 245 connects the clutch lever 243 to a clamp lever 246 that is secured to a sleeve 247 (Fig. 6) for the sight fork 28, thus establishing parallel motion between the clutch 218 and the fork 28. When the switch 242 is closed, the magnet is coupled to cardan 215 and the sight fork 28 is directly stabilized in azimuth by the gyro which maintains its plane of rotation and holds the line of sight through objective 69 constant even though the craft yaws or changes course.

An armature shaft 248 (Fig. 19) of the servo-

motor has a pinion 249 on one end thereof, which drives through intermediate gear 250 and pinion 251 a clutch gear 252 which in turn drives a similar clutch gear 253 in a reverse direction at the same speed. The gears 252 and 253 turn constantly in opposite directions on shafts 254 and 255 respectively when current is on the instrument. The gears 252 and 253 have inserted in their upper surfaces a number of friction plugs 256. Fixed on the shafts 254 and 255 upon which the clutch gears 252 and 253 turn idly, are clutch disks 257 and 258 which have smooth slipping surfaces on their under sides, and each of said shafts 254 and 255 have keyed thereto pinions 259 and 260 which mesh with an intermediate gear 261. The gear 261 is keyed on one end of a shaft 262 that has on its other end a pinion 263 which in turn meshes with gear 227 secured to the cardan.

The clutch disks 257 and 258 are kept out of contact with gears 252 and 253 by flat springs 264 pushing up against the lower ends of shafts 254 and 255 which end below the bearing plates 266 that hold them. The clutch disks 257 and 258 are forced down against the plugs 256 of the gears 252 and 253 respectively by armatures 267 working in solenoids 268 which are energized by the tilting control sectors 230 and 231 on the cardan 215 and the brush 233 on the gyro casing 222.

When the gyro 222 in the cardan 215 tilts in space about the gyro case tilting axis, the brush 233 of the gyro case 222 carries current to one or the other of the sectors 230 or 231 on the cardan, and thereby energizes one of the solenoids 268 for the servomotor clutch disks 257 and 258 and clutch gears 252 and 253, thereby applying a torque on the cardan 215 which precesses the gyro back to the neutral gap position.

The pilot director bracket unit has a sleeve bracket 269 secured to either the aircraft or pilot director casing, as desired. This bracket 269 has inserted sleeve 247 which is connected to the cardan 215 through the magnet clutch 218, rod 245 and levers 243 and 246, mounted, in a vertical position. A fork shaft 270 holding bomb sight fork 28 by means of grooved arms 271 and clips 272 extends into the sleeve 247 which provides journal and thrust bearings for the shaft 270. The shaft 270 is free to turn in the sleeve 247. Integral with sleeve 247 is a bracket 273 to which is secured by studs 274 (Fig. 18) a helical gear sector 275 that is also stabilized for the vertical axis.

A worm gear housing 276 is affixed to the arm 271 and mounted therein is the worm gear 277 that is an integral part of a training shaft 278 extending from the housing 276. Worm gear 277 meshes with the sector gear 275. A training knob 279 is keyed to the free end of shaft 278. The gears 275 and 277 are such that one turn of the knob displaces the sight fork 28 a predetermined amount. Thus, for quick training or for target finding the electromagnet clutch 218 is released, making the sight fork 28 free to rotate within plus or minus 45 degrees from the fore and aft center-line of the aircraft. The helical gear sector 275 is toothed for 120 degrees so that after rough training, there is ample space for great changes of line of sight in space. Although we have used certain definite values in degrees, it is to be understood that these values may be varied as desired.

A second tooth or brush gear sector 280 rides on a bushing 281 that is an integral part of the

sleeve 247. Sliding axially along the training shaft 278 (Fig. 18) and keyed to it by pin 282 extending into slot 283 is a gear shift sleeve 284. On the left end of this sleeve, a gear 285 is fixed and on the other end is a knob 286 for moving the sleeve to engage gear 285 with, and disengage it from, gear 291. Springs 287 fixed to knob 279 and working in corresponding notches 288 in the sleeve 284 keep the sleeve in the selected position.

Mounted in brackets 289 above the gear housing 276 is a horizontal shaft 290 that has on one end thereof gear 291 which is adapted to mesh with gear 285 when the sleeve 284 is moved to its innermost position. Keyed on the other end of the shaft 290 is bevelled pinion 292 that drives a small vertical shaft 293, rotatably mounted in housing 294, by means of bevelled gear 295 on the end thereof. On the lower end of shaft 293 is keyed gear 296 that meshes with the brush sector gear 280. Fixed to bracket 289 is a star-shaped spring 297 which presses against the flat surface of the gear 291 on the end of the horizontal shaft 290. The tension on the spring 297 is sufficient to prevent gear 291 from turning when the training knob 279 is turned, except when gears 285 and 291 are engaged. The brush gear sector 280 carries a brush arm 298 to which is fixed a brush 299. The brush 299 rides over a commutator bar 300 which is fixed to the stabilizing unit bracket 269 and therefore to the aircraft. The commutator bar 300 consists of a number of segments on each side of a neutral gap. The brush moves over an arc of $4\frac{1}{8}$ -inch radius for which $\frac{1}{13.15}$ -inch motion = 1° . Although certain definite dimensions have been stated for the brush movement, we desire it to be understood that these dimensions may be changed as desired. The segments are connected to parts of a resistance coil 301 which in turn is in circuit with a double reading volt meter 302. With the brush 299 on the neutral gap, the needle of the volt meter 302 will be in the central position, indicating straight flight to the pilot. With the brush 299 on any other segment of bar 300, the volt meter will read to the right or left by an amount depending upon which segment the brush 299 is resting and indicating to the pilot the direction and proportionate amount of the change of course. Owing to the non-yielding coupling of the brush gear 280 to the training shaft 278 when the gear shift 284 is in the engaged position, it is necessary to provide the commutator with extensions 303. While the brush rides over these extensions 303, the pilot's instrument will show maximum angles. A brush adjusting knob 304 which is attached to the brush arm 298 permits hand shifting of the brush 299 and adjustment to the neutral gap when the gear shift 284 is disengaged. When the gear shift is engaged, knob 304 cannot be moved.

Rotatably positioned on one arm 271 of fork shaft 270 is shaft 305 that has a knob 306 on one end thereof and pinion 307 on the other end. Pinion 307 meshes with a gear 308 keyed to shaft 309 mounted in the arm 271, and gear 308 in turn meshes with a pinion 310 also keyed on shaft 309. The pinion 310 meshes with rack teeth 311 on the fork 28 so that by turning knob 306 the fork 28 may be turned in arm 271 of the fork shaft. Thus, the sight may be kept in a horizontal position at all times regardless of the position of the aircraft to which the device is attached.

The action of the pilot director mechanism is as follows: When the gear shift sleeve 284 is in the disengaged position turning the training knob 279, turns the training shaft 278 and the worm

277 which is in the worm gear housing 276. The worm 277 tends to turn the helical gear sector 275 but this sector being secured to the stabilized sleeve 247 remains fixed in space in the worm gear 277 and housing 276 and fork shaft 270 which are fixed together and hence the bomb sight and the line of sight turn in reference to cardan 215. The brush gear sector 280 is also carried on the stabilized sleeve 247, but by friction only. Ordinarily, turning the training knob 279 which causes the bomb sight fork shaft 270 to turn in reference to the helical gear 275 would cause the gear shift train to turn idly by being rotated about the gear shift or brush sector 280. But the star-shaped spring 297 has sufficient friction to lock the gear 291 on the end of the horizontal shaft 290 and the rest of the gear train so that the brush gear sector 280 slips on its hub bearing and the brush gear sector 280 is turned on the sleeve 247 together with the bomb sight fork shaft 270. The brush 299 is thus displaced the same amount as the line of sight and the director is set to have a one to one correction ratio.

When the gear shift sleeve 284 is in the engaged position turning the training knob 279, moves the fork shaft 270, the fork 28, bomb sight and line of sight as before. It also turns the gear shift train, the gear 291 on horizontal shaft 290 slipping against the friction of the spring 297. The gear shift train turns the brush gear sector 280 on the stabilized sleeve 247 against the friction on its hub bearing. The gear ratio and the gear shift train is such that the brush 299 is displaced 6.2 times as much as the line of sight and therefore, there is a 6.2 overcorrection which brings the craft more quickly upon a collision course.

When the gear shift sleeve 284 is in either position and the aircraft turning but the knob 279 remaining stationary, the helical gear sector 275, fork 28, bomb sight, line of sight, brush gear sector 280 and brush 299 are all on the stabilized sleeve 247 and remain fixed in space. The commutator bar 300 being fixed to the aircraft moves with reference to the brush 299 and the pilot receives an indication on the volt meter 302 to return to his course.

In the practical use of our improved device the bomb sight is mounted on the pilot director bracket unit that may be affixed separately on the aircraft at any place suitable for a bomber or it may be mounted on the stabilizing or pilot director casing. The pilot director may be secured to the aircraft in any convenient position where the clutch lever 243 can be coupled by connecting rod 245 to the bracket unit.

About ten minutes before starting a bombing run, it is best to turn on the master switch 327 shown in Figure 20. This switch 327 is so designed that the first snap is on contact 328 that delivers power to the stabilizer unit. The stabilizer is permitted to run a minute or two, then the switch snapped twice to contact 329 which delivers current to both stabilizer and bomb sight as well as all other accessories. The second contact 330 of the switch 327 delivers power to the bomb sight alone and need not be used except for test purposes.

Before setting the sight on the target the back-sight should be at zero, which is shown when pointer 313 connected to the back sight is aligned with stationary pointer 314 (Fig. 7). These pointers are in the field of the eye piece 81 when the objective 69 is at its maximum angle with the vertical.

The clock 169 is then set for the altitude at which the bombs are to be released. The indicator switch 331 is then turned on and the sight is swung right and left to inform the pilot that the sight is ready for approach. As soon as the target comes into view, manual directing is done by knob 279 until the target is approximately in the center of the eye piece 81. The bomb sight gyro 33 is then unlocked by releasing locking knob 61 and the bubbles 50 and 51 are leveled exactly by the levelling knob 142 and the button 144. The bomb sight case is then placed in the horizontal position by operating knob 306. The switch 242 is snapped so as to engage clutch 218, and then engage overcorrection sleeve 284 and pilot director, until cross line 87 is on the target.

It is better to allow the vertical cross line 87 to keep off and give fairly large changes in course, than to be continually turning pilot directing knob 279 to keep cross line 87 exactly on the target and, therefore, at intervals of a few seconds turn the pilot directing knob 279 to put the vertical cross line 87 on the target. As soon as the vertical cross line 87 settles fairly steady on the target, disengage the overcorrection sleeve 284 and pilot direct with the one to one gearing. A minute is ample to settle the vertical line 87 on the target after which the target should follow very closely down the vertical cross line 87 as the objective 69 is continuously rotated by means of knob 157, cable 91, and the gears associated therewith. The clock setting is then checked with the actual altitude and the gyro levels 50 and 51 are also rechecked. When the target is on the horizontal cross line and the objective 69 is approximately 40 degrees from the vertical, place the cross line 88 just ahead of it and when the target comes again exactly on cross line 88, press the timing ring 114, rotating the objective to keep the cross line 88 on the target until the clock stops. It is very important that cross line 88 is on the target when the clock is started and also when the clock stops to insure that the back-sight will be driven proportionately to the ground speed during the timing interval. The operating knob 157 is then turned to keep cross line 88 on the target until the cross line 88 is aligned with the back-sight pointer 70, at which point the bomb is released. The time interval from the end of timing to the release of the bomb is usually of sufficient length to permit of slight correction of pilot direction; one to one ratio should always be used in this case and the operator should use discretion in applying it.

Immediately after release, the bomb sight gyro 33 is locked, the back-sight is returned to zero, and all the electrical switch connections are shut off, thus completing the bomb run.

What we claim is:

1. In combination, a bomb sight having an optical system therein, means stabilizing at least a portion of the said optical system for the fore and aft position and for the athwartship position, a pilot director and pilot director bracket, means connecting said director and bracket to said sight whereby said sight is stabilized about the vertical axis.

2. In combination with an aircraft, a bomb sight, a pilot director, a pilot director bracket, overcorrection means carried thereby to bring the aircraft more quickly upon a collision course in sighting a target, and means connecting said director and bracket to said sight.

3. In combination with an aircraft, a bomb sight having an optical system therein, means

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stabilizing said sight for the fore and aft position, and for the athwartship position, a pilot director, a pilot director bracket having overcorrection means thereon for indicating the correct course of the aircraft in sighting a target, and means connecting said director and bracket to said sight whereby said sight is stabilized about the vertical axis.

4. In combination with an aircraft, a bomb sight, an optical system in said sight comprising a fore-sight and a back-sight, a clock adapted to run for a period corresponding to the time of fall at a set altitude, means controlled by said clock for setting the back-sight at the proper dropping angle, means for setting said fore-sight, means stabilizing said optical system for the fore and aft position and for the athwartship position, a pilot director and pilot director bracket, and means connecting said director and bracket to said sight whereby said sight is stabilized about the vertical axis.

5. In combination with an aircraft, a bomb sight, a cradle in said sight, an optical system mounted in said cradle comprising an objective and a back-sight, a clock in which the altitude of the aircraft is set and which is adapted to transmit to the bomb sight the time said back-sight will move in the fore and aft direction, means for moving said objective, a clutch means secured to said cradle for moving said back-sight with said objective when the clock is setting said back-sight to the proper dropping angle, means in said sight stabilizing said cradle for the fore and aft position and for the athwartship position, and means connected to said bomb sight stabilizing the same about the vertical axis.

6. In combination with an aircraft, a bomb sight, a cradle in said sight, an optical system mounted in said cradle comprising an objective and a back-sight, a clock, means controlled by said clock for setting said back-sight to the proper dropping angle, means for moving said objective, a clutch means secured to said cradle for moving said back-sight with said objective when the clock is setting said back-sight to the dropping angle, means in said sight stabilizing said cradle for the fore and aft position and for the athwartship position, a pilot director, a pilot director bracket, and means connecting said director and bracket to said sight whereby said sight is stabilized about the vertical axis.

7. In combination with an aircraft, a bomb sight having a cardan therein, a cradle positioned in said cardan, an optical system mounted in said cradle, said system comprising an objective, an objective mount, and a back-sight positioned on a portion of said mount, means adapted to move said objective and mount independently of said back-sight, said moving means having counterbalanced racks whereby said cradle is not disturbed from its stabilized position, a clock connected with said sight, means controlled by said clock for setting said back-sight to the correct dropping angle, a clutch means secured to said cradle for moving said back-sight with said objective when the clock is setting said back-sight, a gyro mounted in said cardan, means connecting said gyro to said cradle for stabilizing the cradle and means connected to said sight stabilizing the sight about the vertical axis.

8. In combination with an aircraft, a bomb sight, a cardan pivoted in said sight, a cradle mounted in said cardan, means stabilizing said cradle, an objective mount in said cradle, an objective positioned in said mount, a back-sight po-

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sitioned on said mount, means for moving said objective and mount independent of said back-sight, said means having counterbalanced racks, and means for moving said back-sight having counterbalanced racks whereby the movement of said objective and back-sight racks will not disturb the cradle from its stabilized position.

9. In combination with an aircraft, a bomb sight, a cardan pivoted in said sight, a cradle mounted in said cardan, means stabilizing said cradle, an objective mount in said cradle, an objective having a cross line reticule positioned in said mount, a scale reading against said reticule secured to said cradle, a back-sight rotatably positioned on said mount opposite said scale, means moving said mount independent of said back-sight, means for moving said back-sight, and clutch means adapted to engage the moving means for both the objective and back-sight.

10. In combination with an aircraft, a bomb sight having a cardan pivoted therein, an optical system mounted in said cardan, a gyro positioned in said cardan, means connecting said gyro to said optical system for stabilizing the same, a fore and aft level and an athwartship level positioned on said gyro, and means adapted to set said gyro and cradle to a vertical position while the aircraft is flying a straight level course.

11. In combination with an aircraft, a bomb sight having a cardan pivoted therein, a cradle positioned in said cardan, an optical system mounted in said cradle, a gyro positioned in said cardan parallel to said cradle, means connecting said gyro to said cradle for stabilizing the same, a fore and aft level and an athwartship level affixed to said gyro, means for applying torque to the cardan to cause the gyro to precess in a direction at right angles to the torque applied and means for applying torque to the gyro to cause the cardan to tilt about the cardan axis.

12. In combination with an aircraft, a bomb sight, an objective, means movably mounting said objective in said sight, means stabilizing said objective for the fore and aft and the athwartship positions, a back-sight, a scale for reading the position of said objective and back-sight, a cable, and means whereby said objective may be moved by said cable.

13. In combination with an aircraft, a bomb sight having an optical system, means whereby a portion of said system may be stabilized for the fore and aft and for the athwartship positions, a back-sight mounted in said optical system, and a clock connected with said back-sight in said bomb sight, said clock comprising a removable face marked with an altitude scale, altitude being an argument of time of fall, a hand adapted to run for a period corresponding to the time of fall at a set altitude, means for operating said hand, and means controlled by said clock for setting said back-sight at the correct dropping angle.

14. In combination with an aircraft, a bomb sight having an optical system, means whereby a portion of said system may be stabilized for the fore and aft and for the athwartship positions, a back-sight mounted in said optical system, and a clock connected with said back-sight in said bomb sight, said clock comprising a removable face marked with an altitude scale, altitude being a function of time of fall, a hand adapted to run for a period corresponding to the time of fall at a set altitude, frequency vibrating means for operating said clock and hand,

and means controlled by said clock for setting said back-sight at the correct dropping angle.

15. In combination with an aircraft, a bomb sight, a pilot director, a pilot director bracket unit for mounting said bomb sight, overcorrection means on said bracket unit for indicating the correct course of the aircraft in sighting a target and means on said bomb sight mounting for keeping the sight in a horizontal position regardless of the position of the aircraft.

16. In combination with an aircraft, a bomb sight having an optical system therein, means whereby a portion of said system may be stabilized for the fore and aft and for the athwartship positions, a pilot director having stabilizing means therein, and means for transmitting motion of said stabilizing means to said sight whereby the sight is stabilized about the vertical axis.

17. In combination with an aircraft, a bomb sight, a pilot director and a pilot director bracket unit, said pilot director comprising a stabilizing means, and means connecting said pilot director to said bomb sight to stabilize the sight about the vertical axis, means connecting said sight to said pilot director whereby movements of the sight around the vertical axis are transmitted to said director as indications of changes in course, and means associated with said sight and said director to move said sight about the vertical axis and cause such movement to be transmitted to the director with increased magnitude.

18. In combination with an aircraft, a bomb sight, a pilot director comprising means for stabilizing the sight about the vertical axis, means connecting said director to the bomb sight whereby movement of said sight about the vertical axis is transmitted to the pilot director, and a pilot director bracket unit having overcorrection mechanism for moving said sight about the vertical axis including means thereon for augmenting the pilot director indication of such movement.

19. In combination with an aircraft, a bomb sight, an objective, means movably mounting said objective in said sight, means stabilizing said objective for the fore and aft and for the athwartship positions, a pilot director, means for stabilization about the vertical axis, means connecting said director to said bomb sight whereby said sight will be stabilized about the vertical axis and a pilot director bracket unit having overcorrection means thereon of indicating the correct course of the aircraft in sighting a target.

20. In combination with an aircraft, a pilot director bracket unit, a bomb sight mounted on said unit, a pilot director comprising a gyro stabilized about the vertical axis, and means connecting said director to said bracket unit whereby said gyro stabilizes the sight about the vertical axis.

21. In combination with an aircraft, a pilot director bracket unit, a bomb sight mounted on said unit, an objective positioned in said sight, means stabilizing said objective for the fore and aft and for the athwartship positions, a pilot director comprising a gyro stabilized about the vertical axis, and means connecting said director to said bracket unit whereby the gyro in the director stabilizes the sight about the vertical axis.

22. In combination with an aircraft, a bomb sight, a pilot director bracket unit in which said sight is mounted, a pilot director, a cardan, gudgeons positioning said cardan in the director, a gyro mounted in said cardan, means for causing precession of said gyro, means on said cardan

and gyro controlling the said precession causing means, and means connecting said director to said bracket unit whereby the gyro stabilizes the sight about the vertical axis.

23. In combination with an aircraft, a pilot director bracket unit, a bomb sight mounted on said bracket unit, a pilot director, a cardan, two gudgeons positioning said cardan in the director, a gyro mounted in said cardan, a servomotor, means connecting said cardan to said servomotor, whereby said servomotor can precess said gyro, means responsive to relative tilting movement between the gyro and the cardan to control the application of the precessing effort and means connecting said director to said bracket unit whereby to stabilize the sight about the vertical axis.

24. In combination with an aircraft, a pilot director bracket unit having a lever extending therefrom, a bomb sight mounted on said bracket unit, a pilot director, a cardan, two gudgeons positioning said cardan in the director, a gyro mounted in said cardan, a servomotor, means connecting said cardan to said servomotor whereby said servomotor can precess said gyro, means responsive to relative tilting movement between the gyro and the cardan to control the precessing force, a clutch having a clutch lever attached thereto on one of said gudgeons, an energizing coil in said clutch adapted to engage members of said clutch and a rod connecting the clutch lever to said bracket lever whereby the cardan is linked to said sight to stabilize the sight about the vertical axis.

25. In combination with an aircraft, a pilot director bracket unit having a lever extending therefrom, a bomb sight mounted on said bracket unit, an optical system positioned in said sight, means stabilizing a portion of said system for the fore and aft and for the athwartship positions, a pilot director, a cardan, two gudgeons positioning said cardan in the director, a gyro mounted in said cardan, a servomotor, means connecting said cardan to said servomotor whereby said servomotor can precess said gyro, means responsive to relative tilting movement between the gyro and the cardan to control the precessing force, a clutch having a clutch lever attached thereto on one of said gudgeons, an energizing coil in said clutch adapted to engage members of said clutch and a rod connecting the clutch lever to said bracket lever whereby the cardan is linked to said sight to stabilize the sight about the vertical axis.

26. In combination with an aircraft, a pilot director bracket unit having overcorrection means thereon for bringing the aircraft quickly on a collision course in sighting a target, a bomb sight mounted on said bracket unit, an optical system positioned in and on said sight, means stabilizing a portion of said system in said sight for the fore and aft and for the athwartship positions, a pilot director comprising a gyro for stabilization about the vertical axis, means for precessing said gyro to a predetermined relative position, means controlling said precessing means and means linking said gyro to said bracket unit whereby the sight is stabilized about the vertical axis.

27. In combination with an aircraft, a pilot director bracket unit having overcorrection means thereon for bringing the aircraft quickly on a collision course in sighting a target, a bomb sight, mounted on said bracket unit, a cradle mounted in said sight, means stabilizing said cradle for the

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fore and aft and for the athwartship positions, an objective mounted in the cradle, a back-sight, means for moving said objective, a clock adapted to run for a period corresponding to the time of fall at a set altitude, means controlled by said clock for setting the back-sight at the proper dropping angle, a pilot director comprising a gyro for stabilization about the vertical axis, means for precessing the gyro to a predetermined relative position, means controlled by the movement of said gyro for regulating said precessing means, and means linking the gyro to said bracket unit whereby the sight is stabilized about the vertical axis.

28. In combination with an aircraft, a bomb sight having an objective therein, means stabilizing said objective for the fore and aft and for the athwartship positions, a double reading voltmeter, a pilot director bracket unit in which said bomb sight is mounted, said unit comprising a sleeve bracket secured to the aircraft, a sleeve movably positioned in said bracket, a fork shaft rotatably mounted in said sleeve, a segmented commutator secured to the sleeve bracket and electrically connected with said voltmeter, a brush adapted to ride over said commutator thereby registering movement on said voltmeter, training means for moving said fork and brush on said commutator thereby indicating on the voltmeter the correct course to be taken in sighting a target, and a pilot director stabilized about the vertical axis, and means connecting said director to said sleeve to stabilize the bomb sight about the vertical axis.

29. In combination with an aircraft, a bomb sight having an objective therein, means stabilizing said objective for the fore and aft and for the athwartship positions, a double reading voltmeter, a pilot director unit in which said bomb sight is mounted, said unit comprising a sleeve bracket secured to the aircraft, a sleeve movably positioned in said bracket, a fork shaft rotatably mounted in said sleeve, a segmented commutator secured to the sleeve bracket and electrically connected with said voltmeter, a brush gear sector on said sleeve, a brush secured to said sector and adapted to ride on said commutator, thereby registering movement on said voltmeter, a training shaft having gears meshing therewith for moving said brush at a one to one ratio, a

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shift sleeve on said shaft, and gears meshing with said sleeve when in the engaged position whereby said brush is displaced an overcorrection ratio, and a pilot director stabilized about the vertical axis having means connecting said director to said sleeve to stabilize the bomb sight about the vertical axis.

30. In combination, a bomb sight having an optical system, means to stabilize at least a portion of said optical system about the horizontal axis, a pilot director, and means connecting said sight and said pilot director whereby the pilot director is actuated to indicate a change in course of said craft when such occurs after a line of sight has been established through said sight.

31. In combination, a bomb sight having an optical system, means to stabilize at least a portion of said optical system about the horizontal axis, a pilot director, and means connecting said sight and said pilot director whereby the pilot director will be caused to indicate a course to be followed in conformity with a line of sight through said bomb sight.

32. The combination of a bomb sight unit having means to stabilize the optics only and a pilot director unit that includes means for stabilizing the sight unit as a whole about one axis.

33. The combination of a bomb sight unit having means to stabilize the optics thereof and a pilot director unit that includes means for stabilizing the sight unit as a whole.

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