Oct. 29, 1946.

B. M. HARRISON

2,410,067

SUBMARINE SIGNALING

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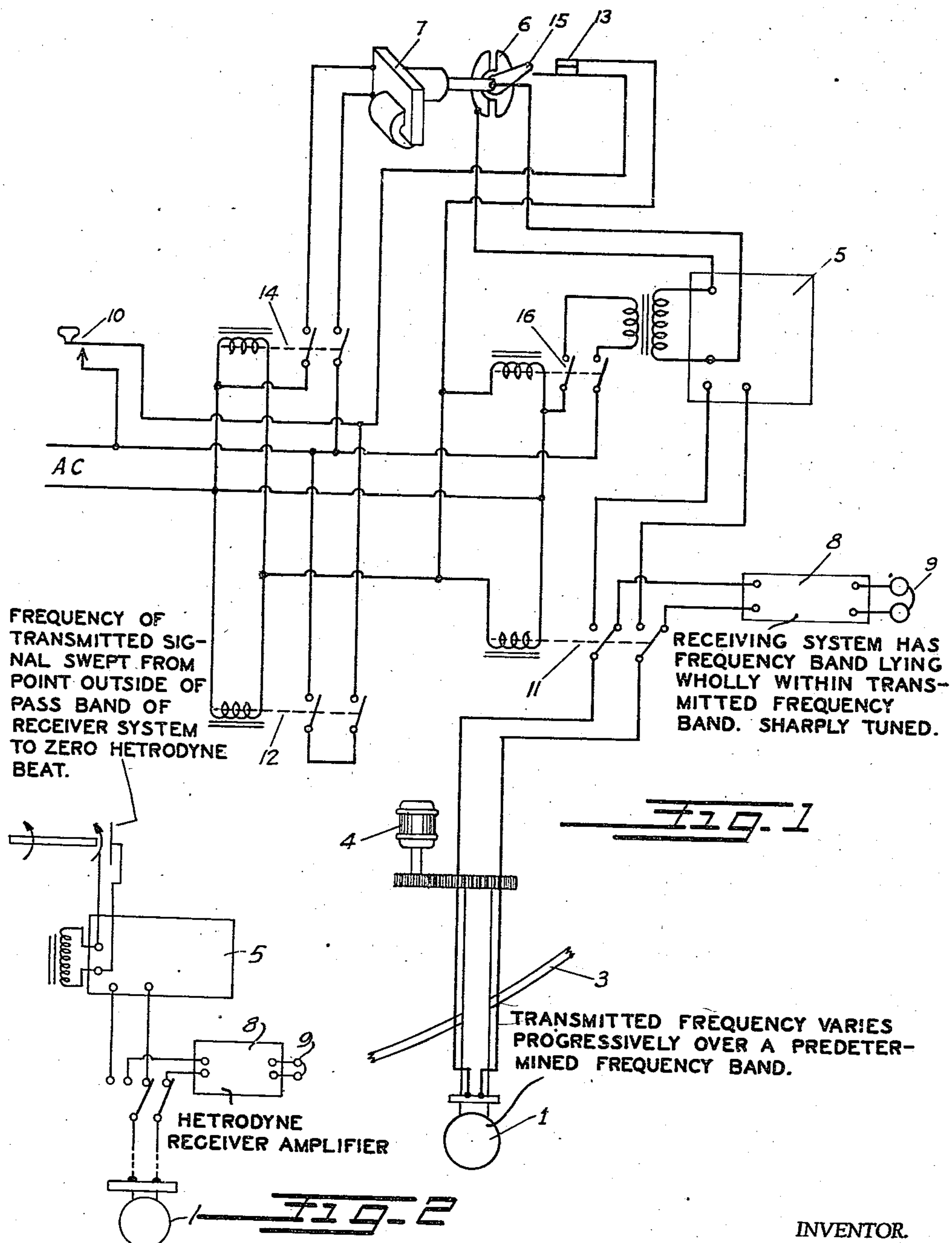

Fig. 1

Fig. 2

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GLIDE ATTACHMENT FOR BOMB SIGHTS

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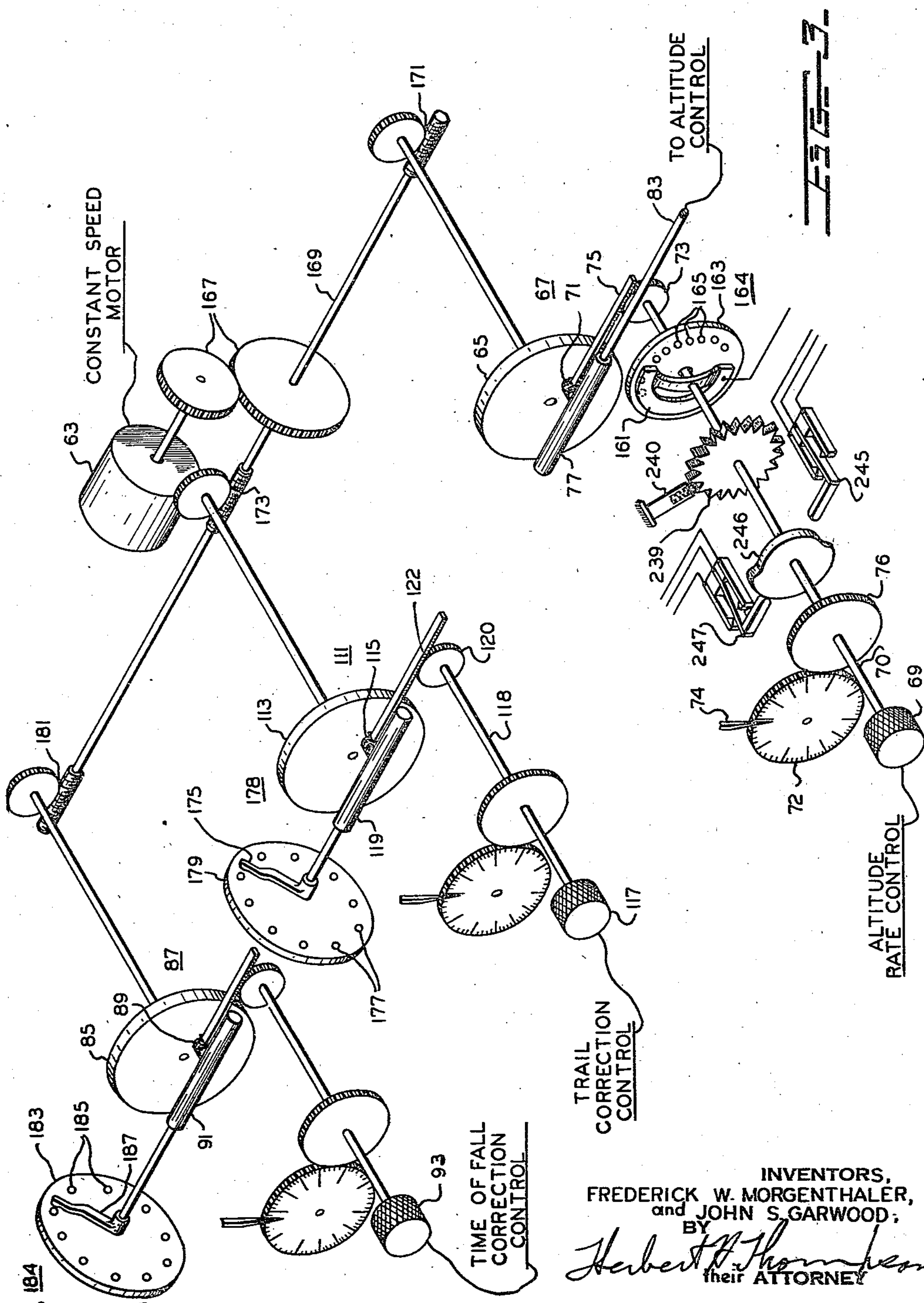

FIG. 3

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GLIDE ATTACHMENT FOR BOMB SIGHTS

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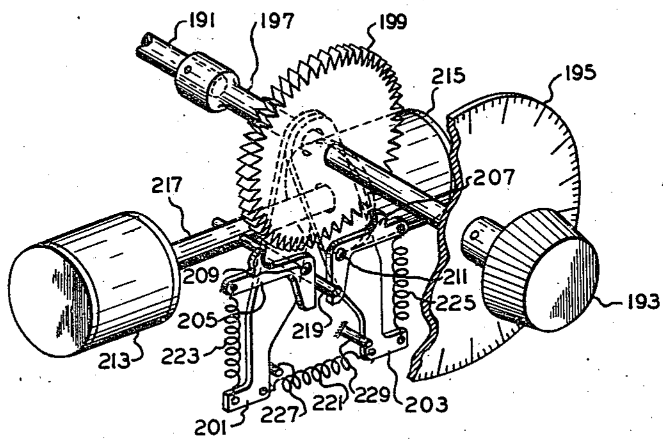
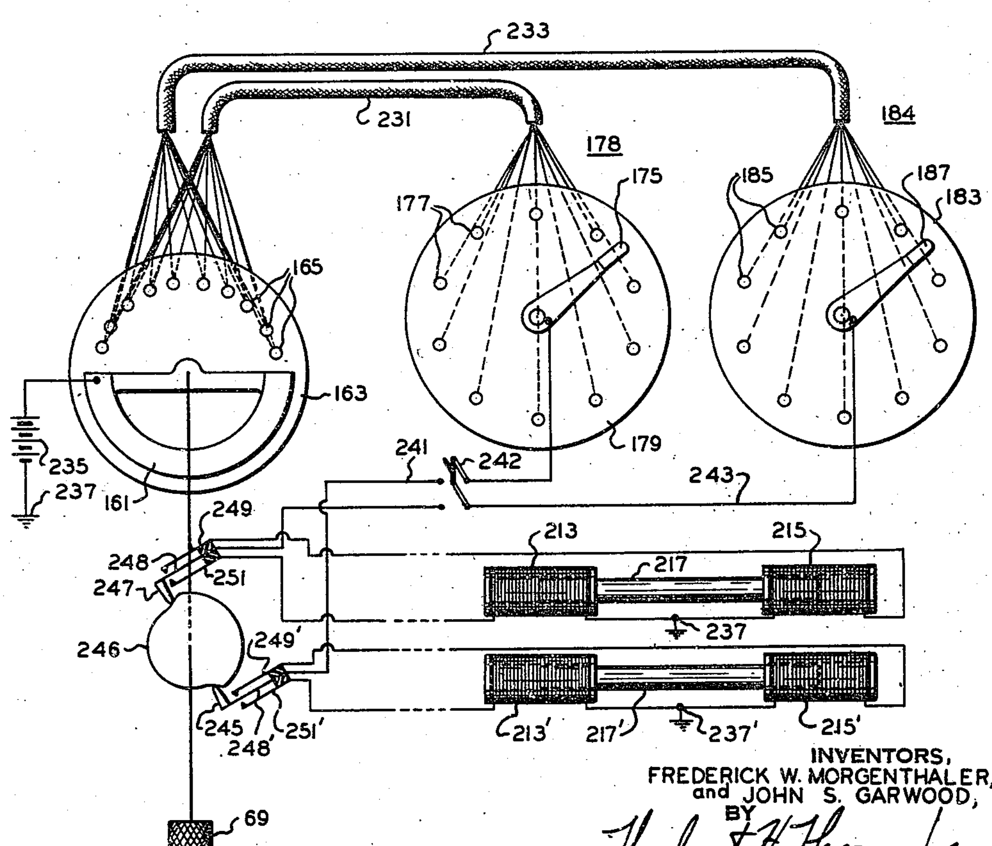


FIG. 4.

FIG. 5.



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UNITED STATES PATENT OFFICE

2,410,097

GLIDE ATTACHMENT FOR BOMB SIGHTS

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Application January 17, 1942, Serial No. 427,162

5 Claims. (Cl. 244—77)

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The present invention is concerned with a glide attachment for bombsights. The present case is concerned with a modification and improvement of the device shown in copending application for Automatic climb and glide control for aircraft, Serial No. 269,838, filed April 25, 1939 in the names of C. A. Frische and G. N. Hanson.

In prior application Serial No. 387,574, for Bomb sights, filed April 9, 1941 in the names of H. C. Van Auken and F. N. Esher, there is disclosed a bomb sight and automatic pilot system whereby the bombardier is enabled to control the course of the craft by means of the automatic pilot during bombing operations. However, the device of the above application is restricted to use during level flight, and is incapable of effective use during other than level flight operations. Since during level flight the bombing craft is especially susceptible to attack from anti-aircraft equipment or other aircraft, it is desirable to permit bombing operations during other than level flight conditions, such as during climbing or gliding.

According to the present invention, an attachment is provided for such a system as disclosed in the above mentioned application Serial No. 387,574, whereby the automatic pilot is controlled in such a manner that the craft is caused to assume a constant rate of climb or rate of glide, and at the same time, the settings of the bomb sight, especially those for time of fall and for trail, are automatically corrected so that accurate sighting and bombing may be automatically maintained during the climb or glide.

Accordingly, it is an object of the present invention to provide an improved glide attachment for bomb sight and automatic pilot systems whereby effective bombing may be performed during climbing or gliding of the craft.

It is still another object of the present invention to provide improved control means for bomb sight controls which will permit effective bombing during climbing or gliding.

It is a further object of the present invention to provide means for synchronizing the rate of change of altitude of a craft with the controls of a bomb sight to permit effective bombing at other than level flight conditions.

It is yet a further object of the present invention to provide improved means for correcting the time of fall and trail controls of a bomb sight in accordance with the change in altitude of an aircraft.

Other objects and advantages of this invention

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will become apparent as the description proceeds.

In the drawings,

Fig. 1 shows one form of the present invention employing a manual adjustment of the bomb sight correction controls.

Fig. 2 shows a modification of the system of Fig. 1 using automatic adjustments of the bombsight controls.

Fig. 3 shows another modification of the systems of Figs. 1 and 2.

Fig. 4 shows a perspective schematic view of the solenoid ratchet motor device used with the system of Fig. 3.

Fig. 5 shows a wiring diagram of the system of Fig. 3.

In Fig. 1, there is shown a glide or climb attachment especially useful with a bomb sight of the type shown in application Serial No. 387,574. It has been determined that during constant rate of change of altitude, as in constant rate of climb or glide, the required time of fall and trail settings of the bomb sight vary substantially proportionally to the instantaneous altitude, for quite wide variations of altitude. The proportionality factor depends on the altitude at which climb or glide starts, and, in the case of trail, upon the air speed.

The device of Fig. 1 provides means for continuously correcting the trail and time of fall controls of the bomb sight in accordance with altitude. Here, a common control is used for producing climb or glide and for simultaneously adjusting the control mechanism to vary the bomb sight controls at a rate proportional to rate of change of altitude, whereby the settings of these controls are synchronized with the altitude of the craft.

Thus, referring to Fig. 1, altitude rate control knob 69 translationally positions a ball carriage 71 of a variable speed drive 67, as by means of a pinion 73 and a rack 75. The drive disc 65 of variable speed 67 drive is driven at constant speed from a constant speed motor 63 and, as a result, the driven cylinder 77 is rotated at a speed dependent upon the position of ball carriage 71 and altitude rate control 69. Cylinder 77 is connected to a shaft 79 and drives an altitude control shaft 83, as by gears 81. Shaft 83 is connected to any suitable type of altitude-controlling automatic pilot to actuate the altitude setting thereof, and thereby directly controls the altitude of the craft. A suitable type of aircraft altitude control is shown in copending application Serial No. 429,754 for Aircraft altitude control, filed February 6, 1942 in the names of C. A. Frische and G. N. Hanson.

The rate of climb or glide may be indicated on altitude rate dial 72 geared to altitude rate control 69 and cooperating with a fixed index 74.

It will be clear that the angular displacement of shaft 83 from a predetermined datum setting will be proportional to the instantaneous altitude of the craft, since shaft 83 is directly connected to the craft altitude control. Also, the speed of rotation of shaft 83 (and of shaft 79 connected thereto) is proportional to the rate of change of altitude, that is, to the rate of climb or glide. This shaft 79 is connected to drive disc 85 of another variable speed drive unit 87 having a ball carriage 89 and a driven cylinder 91. The ball carriage 89 may be positioned from a time of fall correction knob 93 as by way of pinion 95 and rack 97. A time of fall correction indicator scale 99 cooperating with an index 101 is also driven from time of fall correction knob 93 as by way of gear 103.

It will thus be clear that the speed of rotation of output shaft 105 of variable speed drive 87 will be proportional to the setting of altitude rate control 69, the proportionality factor depending on the setting of knob 93. This output shaft 105 is connected to the rotor of a remote position transmitter 107, which may be of any suitable type, such as the conventional "selsyn" type, being energized from a suitable source of alternating current 37 and having its output connected to a cable 109. Cable 109 leads through a suitable control switch (not shown) to a corresponding remote position receiver or repeater which directly positions the usual time of fall setting control of the bombsight, such as shown in the prior application Serial No. 387,574. If necessary, any conventional type of servo mechanism or torque amplifier may be inserted between the transmitter 107 and its receiver.

In this way, the time of fall setting of the bombsight is continuously changed at a rate proportional to the speed of control shaft 105 and will therefore be continuously varied at a rate proportional to the rate of change of altitude and to the setting of time of fall correction control 93. The setting of control 93 as indicated on scale 99 is obtained by the operator from a suitable chart and for certain set of conditions may be once set and left unchanged. In this way, during change of altitude of the craft, the time of fall setting of the bombsight is continuously corrected as the altitude changes and is thus continuously kept at the proper setting for accurate bombing.

A further correction required on the bombsight during climbing or gliding is that for trail. Here again, for a particular airspeed and over a fairly wide range of change of altitude, it has been determined that the trail setting is substantially proportional to the altitude. Hence, a similar type of control is provided for the trail setting control of the bombsight, namely, a variable speed drive 111 whose disc 113 is driven from the output shaft 79 of variable speed drive 67 and hence proportional to altitude rate. The ball carriage 115 of variable speed drive 111 is actuated by trail correction knob 117 and the driven cylinder 119 of variable speed drive 111 acts to drive a shaft 121 connected to the rotor of a remote position transmitter 123 similar to transmitter 107, whose output cable 125 is connected through a suitable control switch (not shown) and amplifiers, if desired, to a similar remote position repeater or receiver connected to drive the trail setting control in the bombsight. A suitable trail correction indicator 127 and an index 129 are also provided.

In this manner, as the craft changes altitude, the trail and time of fall bombsight controls are continuously maintained in correspondence with the position of the craft, and accurate bombing may be effected during the entire maneuver.

In practice, the following procedure has been found desirable: When the operator has determined that he wishes to perform glide or climb bombing, he will open the control switches connecting the position transmitters 107 and 123 to their respective repeaters. Then he positions time of fall correction knob 93 and trail correction knob 117 to the setting corresponding to the particular altitude and air speed at which he intends to start his operations, these settings being determined from suitable charts. Also, the bombsight controls are set to the positions corresponding to this altitude and air speed. Then, by adjusting altitude rate knob 69, the aircraft is caused to start its climb and glide, thereby passing through the pre-selected altitude, at which time, the glide correction mechanism is rendered effective to automatically control the bombsight, by closing the switches connected to the output of the position transmitters. Thereafter the bombsight controls are automatically actuated, as has been described.

Fig. 2 shows a modification of Fig. 1 adapted for complete automatic control. Similar elements are given similar reference numerals. Thus the manual time of fall and trail correction knobs 93 and 117 have been eliminated, and instead the time of fall variable speed drive 87 now has its ball carriage 89 directly actuated in accordance with altitude as by means of cam 131 driven by shaft 133, gears 135, shaft 137 and gears 139 from shaft 79, which, as was shown above, is rotated proportionally to altitude.

Cam 131 is so designed as to insert into the motion of ball carriage 87 and the rotation of shaft 105 the proper proportionality factors as a function of the altitude of craft. This method is somewhat more accurate than that shown in Fig. 1, since it allows for varying proportionality factors while in Fig. 1 the factor was assumed constant.

In a similar way, ball carriage 115 of trail variable speed drive 111 is actuated by the follower 114 of a three-dimensional cam 143 which is axially translated in accordance with altitude, as by way of shaft 79, gears 139, shaft 137, gears 135, shaft 133, pinion 145 and rack 147. Cam 143 is also rotated as by gear 149 in accordance with airspeed, as by shaft 151, which may be connected to an airspeed indicator or follow-up mechanism of any suitable type. Cam 143 is so designed that the motion of its follower 114 is proportional to the proper trail proportionality factor to be inserted into variable speed drive 111 at each value of airspeed and altitude.

In this manner, the output rotation of shaft 121 is kept accurately in correspondence with the required setting of the trail control of the bombsight, which it actuates by means of transmitter 123 and its repeater, as the altitude and/or airspeed changes, and hence the system is entirely automatic.

In operating the device of Fig. 2, the system is disconnected from the bombsight as by opening the control switches in the output circuits of the position transmitters 107 and 123. Then the trail and time of fall settings of the bombsight are adjusted to correspond to a suitable preselected value of altitude and to the actual airspeed of the craft. Then the altitude rate control 69 is actuated to introduce a suitable rate of change of altitude. At the instant that the craft passes through the predetermined value of altitude as evidenced by a suitable altimeter indicator, the control switches are closed and the system thereafter is automatically actuated as described above.

Figs. 3 to 5 show a further embodiment of the invention. Thus, referring to Fig. 3, altitude rate control 69 is connected to shaft 70. An altitude rate indicator 72 cooperates with an index 74 to and is driven by a gear 76 to indicate the setting of altitude rate control knob 69. Connected to shaft 70 is a connecting member 161 which is thereby rotated with respect to a fixed contact bearing disc 163. Disc 163 is shown as carrying a number of contacts 165 illustrated as being ten in number distributed over a semi-circle. The function of this contact and connector arrangement will be more fully described later.

Control 69 and shaft 70 are adapted to be rotated in steps as defined by a star-wheel 239 fastened to shaft 70 and cooperating with a spring-driven ball detent 240. For each step, member 161 connects to one more or one less of the contacts 165. Also fastened to shaft 70 is a cam 246 which operates two switches 245, 247 as will be described below.

Fixed to shaft 70 is a pinion 73 actuating a rack 75 and thereby translating ball carriage 71 of the variable speed drive 67, whose disc 65 is driven from constant speed motor 63 by means of gearing 167, shaft 169 and worm and worm wheel arrangement 171. The cylinder 77 of variable speed drive 67 is connected directly to shaft 83 and serves to actuate the same type of climb and glide control as was explained with respect to Figs. 1 and 2.

Constant speed motor 63 also drives disc 113 of trail variable speed drive 111 by means of worm and worm wheel arrangement 173 and gearing 167. The speed of rotation of the driven cylinder 119 of this drive 111 is determined by the setting of trail correction control 117 operating through shaft 118, pinion 120 and rack 122 to displace the usual ball carriage 115. Cylinder 119 drives a contact arm 175 which thereby continuously wipes across a plurality of fixed contacts such as 177, mounted in a fixed insulating plate 179. Contacts 177 are the same in number as contacts 165 and their function will be described more particularly with relation to Figs. 4 and 5.

In a similar manner, time of fall variable speed drive 87 is driven from constant speed motor 63 by way of gearing 167, shaft 169 and worm and worm wheel arrangement 181. A similar contact and wiping contactor arrangement 183, 185 and 187 is provided driven by the output of variable speed drive 87 under the control of time of fall correction knob 93 acting in the same manner as the trail correction just described.

Rotating contactor devices 178 and 184 in cooperation with device 164 are each adapted to produce periodic impulses whose number per unit time depends upon the setting of the respective controls 93 and 117 and upon the setting of the control 69. These impulses, in the manner to be presently described, serve to continuously reposition the trail and time of fall settings of the bombsight, and thereby maintain these settings in correspondence with the altitude of the craft during changes of altitude.

Fig. 4 shows the solenoid-actuated operating mechanism for changing the setting of the bombsight trail control. An exactly similar mechanism operates the time of fall control. Thus, shaft 191 represents the shaft of the trail control of the bombsight. Connected to this shaft is the attachment shown in Fig. 4. Normally, in the absence of this attachment, shaft 191 would be controlled by a knob such as 193 cooperating with a scale 195 whereby the control shaft 191 may be manually set to a predetermined setting corresponding to desired trail as evidenced by the position of dial 195. When the present glide and climb attachment is in use, knob 193 is removed. The device shown in Fig. 4 is then attached at one end to shaft 191 and at the other end to knob 193, and thereby, as will be clear from the following description, shaft 191 may either be actuated manually from knob 193 or automatically by the attachment.

Thus, an operating shaft 197 is attached at one end to the control shaft 191 and at the other end to knob 193 and dial 195. Operating shaft 197 carries a two-way ratchet wheel 199 fixed thereto. Rotatably supported on shaft 197 are a pair of arms 201 and 203, each carrying a pawl 205 and 207, respectively, pivotally connected thereto as at pivots 209 and 211.

Fixed to the casing of the bombsight are a pair of solenoid windings 213 and 215 having a common plunger 217, which is adapted to be moved to the left when solenoid 213 is energized or to the right when solenoid 215 is energized. Plunger 217 carries a pin 219 extending transversely thereof and positioned between pawls 205 and 207. Arms 201 and 203 are urged together by a spring 221 and pawls 205 and 207 are urged away from ratchet wheel 119 by means of springs 223 and 225 connecting them to the arms 201 and 205, respectively. In this manner, pawls 205 and 207 are maintained in contact with pin 219 when centralized.

Upon energization, for example, of solenoid 213, pin 219 moves to the left. Springs 223 and 225 are made weaker than spring 221, and stops 227 and 229 prevent arms 201 and 203 from proceeding to the right and left, respectively. In this way, when pin 219 moves to the left, the first action ensuing is the pivoting of pawl 205 about pivot 209, whereby pawl 205 is caused to engage ratchet 199. Upon obstruction of the movement of pawl 205 by ratchet 199, further movement of pin 219 causes the rotation of arm 201 to the left carrying with it ratchet wheel 199 and thereby rotating shaft 191 by a predetermined fixed increment.

It will be clear that energization of the other solenoid 215 causing motion of pin 219 to the right will cause an opposite incremental rotation of control shaft 191 in the same manner as just described. Hence, each time a solenoid is energized, control shaft 191 is rotated by a fixed amount.

Referring to Fig. 5, there is shown a schematic wiring diagram of the entire system. Thus, each of the contacts 165 of contactor plate 163 is connected to a respective one of contacts 177 and contacts 185 of contactor plates 179 and 183, respectively, as by way of cables 231 and 233. Connecting member 161 is connected to one terminal of a battery 235 whose other terminal is grounded as at 237. Member 161 is so arranged on shaft 70 that, with altitude rate control 69 at its zero position, member 161 does not contact any of the contacts 165. Each step of rotation of shaft 70 changes the number of contacts 165 connected to member 161 by one.

Accordingly, in this zero position, it will be clear that none of the contacts 165, 177 or 185 are energized from battery 231. If altitude rate control 69 is moved to the right by a fixed increment determined by the detent mechanism 239 of Fig. 3, say, one notch in a clockwise direction, it will be clear that member 161 will now connect battery 235 to the first one of the contacts 165 and accordingly one contact 177 and one contact 185 will be energized. If member 161 is moved two notches clockwise, two contacts 165 will be energized from battery 235 and hence two contacts 177 and two contacts 185 will be energized, etc. Hence, for each discrete value of altitude rate set in by way of control 69 a corresponding number of contacts 165, 177 and 185 will be energized from battery 235.

In a similar manner, if instead of climb, to which clockwise rotation of control 69 may correspond, glide is ordered, control 69 will be rotated counter-clockwise and in the same manner for each value of glide rate a corresponding number of contacts 177 and 185 will be energized from battery 235.

Moving arms 175 and 187 continuously rotate at the speeds corresponding to the settings of trial control 117 and time of fall correction 93, and a voltage pulse is produced each time one of these arms passes over an energized contact. Accordingly, the number of voltage impulses produced per unit time in the output wires 241 and 243 connected to these arms 175 and 187 will be proportional, firstly, to the setting of altitude rate control 69 and secondly, to the setting of the respective controls 93 or 117.

The outputs of contacting devices 184 and 178 as appearing on wires 241 and 243 are connected to cam-operated switches 245 and 247 through a double-pole, single-throw control switch 242. Each of these switches 245, 247 is a single-pole double-throw switch and serves, as will be described, to connect the proper one of solenoids 213 and 215 to the voltage pulses produced, corresponding to whether climb or glide is taking place.

Thus, switches 245, 247 are actuated by a cam 246 fixed to altitude rate control shaft 70. With zero altitude rate setting, central members 248, 248′ are completely disconnected from their respective outer contacts 249, 251 and 249′, 251′. With one sense of altitude rate, such as climb, set in, contacts 248, 248′ are connected to 249, 249′, respectively. With a glide setting, contacts 248, 248′ are connected to 251, 251′, respectively.

Solenoids 213, 215 of the time of fall solenoid motor shown in Fig. 4 each have one terminal grounded as at 237, the other terminals being connected to switch terminals 251, 249, respectively. Similarly, trail solenoids 213′, 215′ have one terminal connected to ground at 237 and the other terminals connected to switch contacts 251′, 249′, respectively.

For each impulse delivered from the inpulsing devices 178 or 184, the corresponding bombsight control will be moved by a fixed amount, the direction of adjustment being determined by switches 245, 247 and hence by the sense of altitude rate. In this manner, both trail and time of fall settings of the bombsight will be adjusted in the direction corresponding to climb or glide and at a rate corresponding to the number of impulses produced in these contact devices per unit time. As has been shown, this number of impulses per unit time is proportional both to the altitude rate as set into contact device 163 and to the setting of trail and time of fall correction knobs 117 and 93. The latter settings are chosen

from a table which may be supplied to the operator, whereby the remaining variables affecting the proper setting of trail and time of fall are properly taken into account.

The operating procedure of this device of Figs. 3 to 5 is as follows: With switch 242 open, the operator will set the time of fall and trail settings of the bombsight corresponding, for example, to shaft 191, at the proper setting corresponding to an altitude slightly lower than his present altitude if he intends to glide, or slightly higher if he intends to climb. At the same time, the settings of controls 93 and 117 are made, as determined from proper tables which show the proper rate of change of trail and of time of fall for the particular altitude and wind speed encountered at the beginning of the glide or climb.

With switch 242 still open, so that solenoid motors are inoperative, the operator will commence his climb or glide by setting in the desired rate of climb or glide by means of altitude rate control 69. At the instant that the craft passes through the altitude for which the settings have been made, as indicated by any suitable altimeter, switch 242 is closed, whereupon the craft proceeds to change its altitude at the rate determined by the setting of the control 69, and the trail and time of fall settings of the bombsight are continuously adjusted to maintain them in proper relationship as the craft changes altitude.

Accordingly, the time of fall and trail settings of the bombsight are maintained at their proper values so that as soon as the target is centered in the sight and release of the bomb occurs the proper corrections for accurate bombing will be included in the bombsight settings.

It will be clear that the device of Figs. 3 to 5 is an approximation only to the proper synchronism of the trail and time of fall settings with the altitude change, since it occurs in incremental steps. However, these increments are made very small, such as of the order of one hundredth of a second per increment of time of fall, so that a good approximation to continuous resetting of the bombsight controls, such as may be obtained by the device of Fig. 2, is obtained. In order to improve the action, it is desirable that the impulses produced should be as equally spaced as possible. This means that the connections between contacts 165 and contacts 177 and 185 should be designed to provide substantially equal spacing among the energized contacts for any setting of contact member 161. For example, if ten contacts are used as illustrated, and supposing that contacts 165 are numbered from one to ten in a clockwise direction beginning at the left, and contacts 177 and 185 are similarly numbered, a suitable set of connections may be as shown on the following table, wherein the first column denotes the number of a contact 165 connected to a contact 177 or 185 whose number is given in the second column. This table is:

1	1
2	5
3	9
4	3
5	7
6	8
7	4
8	2
9	6
10	10

In this manner, when contact member 161 is rotated in one position clockwise, only contact

#1 of contacts 177 or 185 will be energized. When two contacts 165 are energized by member 161, contacts #1 and #5 of 177 or 185 will be energized, and, it will be seen that these are approximately equally spaced. If three contacts are energized, these will be #1, #5 and #9, again approximately equally spaced. Four contacts will be #1, #5, #9 and #3, and five contacts will be #1, #5, #9, #3 and #7, again in each case approximately equally spaced.

If contact member 161 is rotated in the opposite direction from its zero position, for one contact energized, contact #10 will be energized. For two contacts, #10 and #6 will be energized. For three contacts, #10, #6 and #2 will be energized. Four contacts will be #10, #6, #2 and #8. Five contacts, #10, #6, #2, #8 and #4. Accordingly, it will be clear that, for either direction of rotation and for any number of contacts energized, approximately equal time intervals will be produced by the pulses.

It will be evident that the invention is not restricted to the use of ten contacts, with respect to which it has been illustrated, but any suitable number of contacts and any suitable connection of contacts 165 with contacts 177 or contacts 185 may be used.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An aircraft provided with an automatic pilot having an altitude control, a bombsight carried by the aircraft having control means, means for actuating the altitude control to change the altitude of the aircraft, and means responsive to the operation of the actuating means for continuously adjusting the control means of the bombsight to compensate for the effect of changing altitude.

2. In an aircraft carrying a bombsight having at least one control, altitude control means for the aircraft, a variable speed device having its output connected to said altitude control to change the altitude of the aircraft at a constant rate, and means controlled by the variable speed drive for adjusting said bombsight control at a rate proportional to said altitude rate, whereby said bombsight control is compensated for the effect of changing altitude.

3. In an aircraft carrying a bombsight having at least one control, altitude control means for the aircraft, a variable speed device having its output connected to said altitude control to change the altitude of the aircraft at a constant rate, means controlled by the variable speed drive for adjusting said bombsight control at a rate proportional to said changing altitude rate, whereby said bombsight control is compensated for the effect of changing altitude, and means for adjusting the last mentioned means to vary the proportionality between said altitude rate and the rate at which the bombsight is adjusted.

4. In an aircraft having altitude control means, a bombsight carried thereby having control means, a variable speed device having its output connected to said altitude control means to change the altitude of the aircraft at a constant rate, and means controlled by the variable speed drive for adjusting said bombsight control means at a rate proportional to said altitude rate, whereby said bombsight control means is compensated for the effect of changing altitude, wherein the means controlled by the variable speed drive includes a disc, ball and cylinder type of variable speed drive, means for driving said disc by the output of the first variable speed drive, means for actuating said bombsight control means by said cylinder, and means for adjustably positioning said ball to thereby change the proportionality between the bombsight control means adjustment rate and said altitude rate.

5. In an aircraft having altitude control means, a bombsight carried thereby having at least one control, a variable speed device having its output connected to said altitude control to change the altitude of the aircraft at a constant rate, and means controlled by the variable speed drive for adjusting said bombsight control at a rate proportional to said altitude rate, whereby said bombsight control is compensated for the effect of changing altitude, wherein said last means comprises means for generating impulses at a rate proportional to said altitude rate and a motor controlled by said impulses connected to actuate said bombsight control.

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