

June 11, 1940.

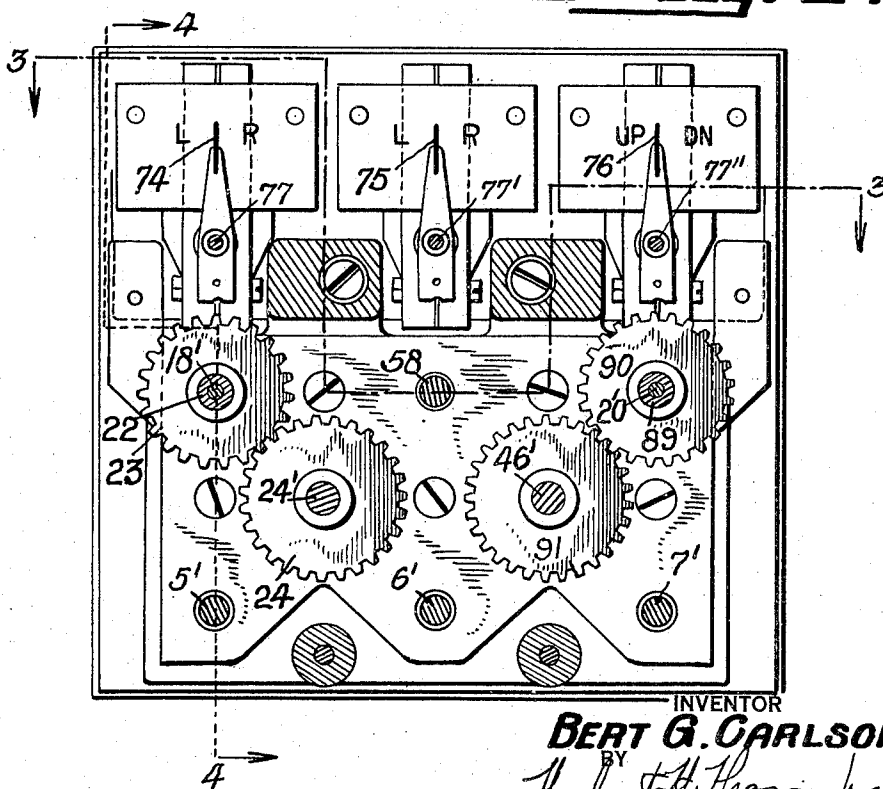
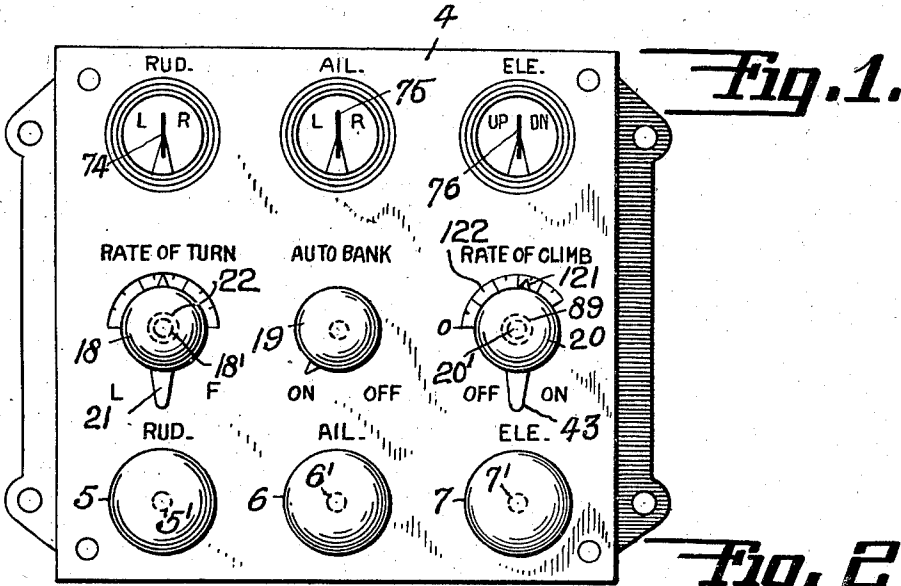
B. G. CARLSON

2,203,671

AIRPLANE AUTOMATIC PILOT

Filed Feb. 26, 1938

7 Sheets-Sheet 1



INVENTOR
BERT G. CARLSON
BY *Herbert A. Thompson*
HIS ATTORNEY

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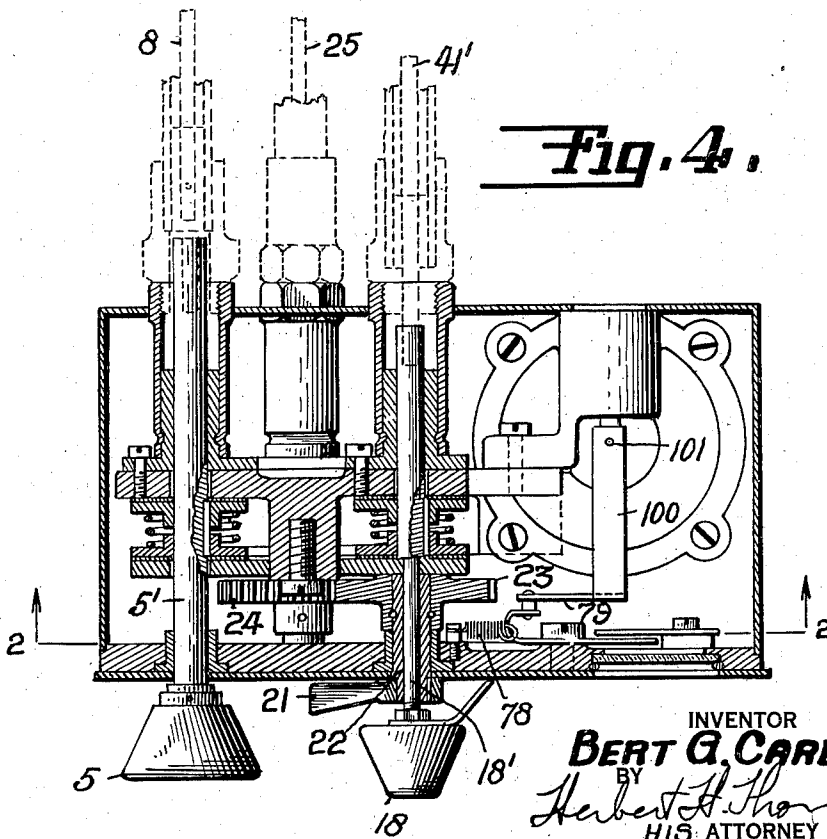
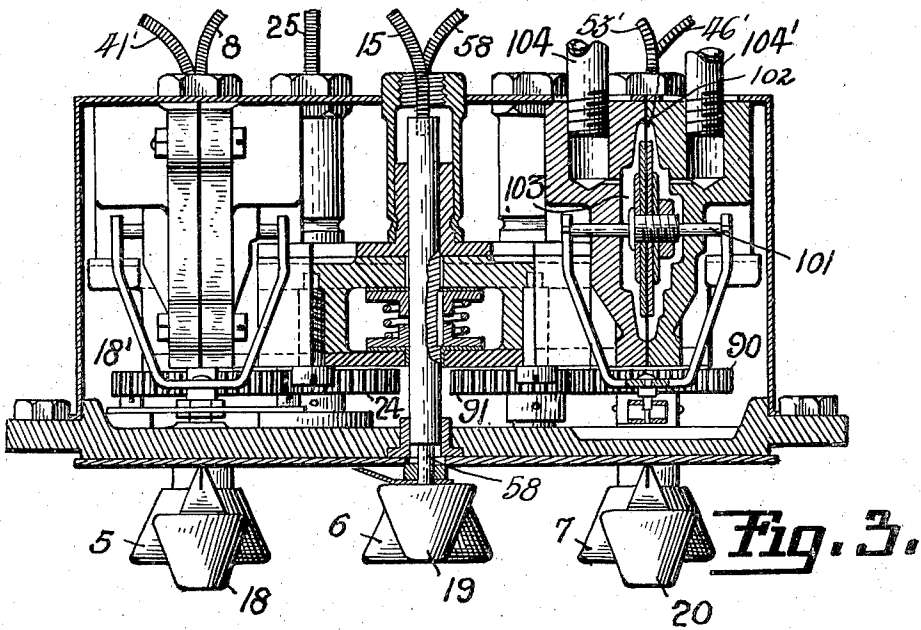
B. G. CARLSON

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7 Sheets-Sheet 2



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BERT G. CARLSON

BY
Herbert H. Thompson
HIS ATTORNEY

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B. G. CARLSON

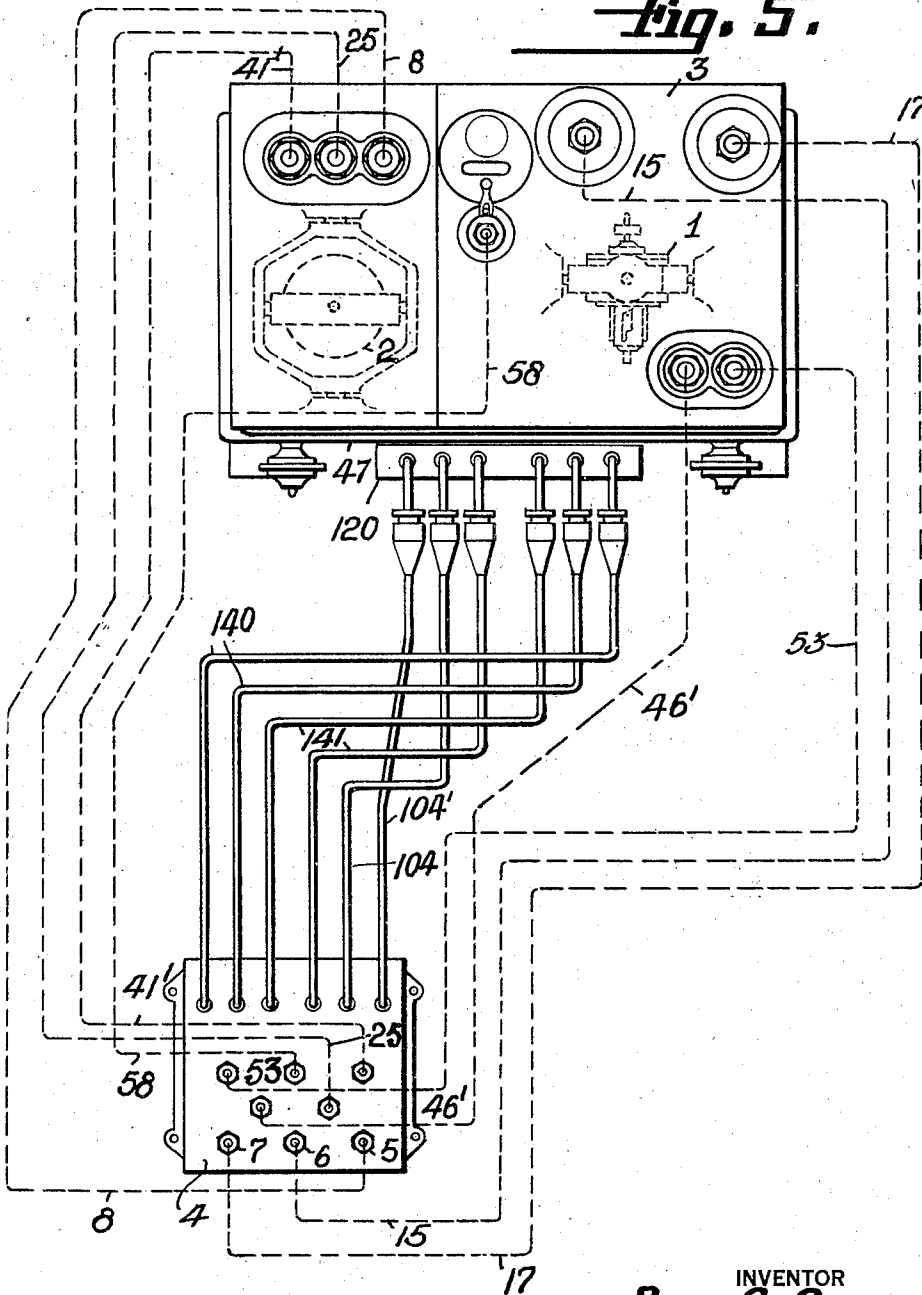
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Fig. 5.



INVENTOR
BERT G. CARLSON
BY
Herbert H. Thompson
HIS ATTORNEY

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Fig. 6.

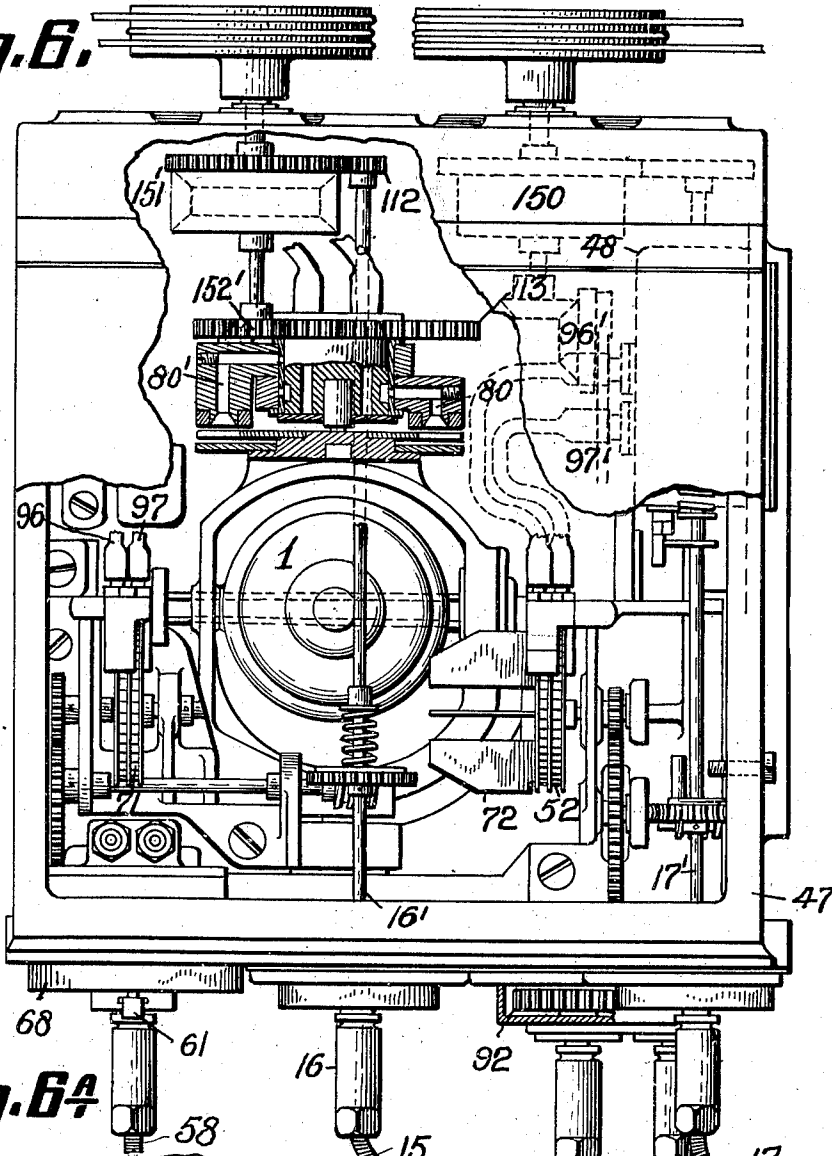
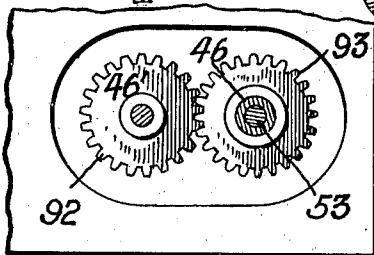


Fig. 6A



INVENTOR
BERT G. CARLSON
BY *Herbert H. Thompson*
HIS ATTORNEY

June 11, 1940.

B. G. CARLSON

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Fig. 7.

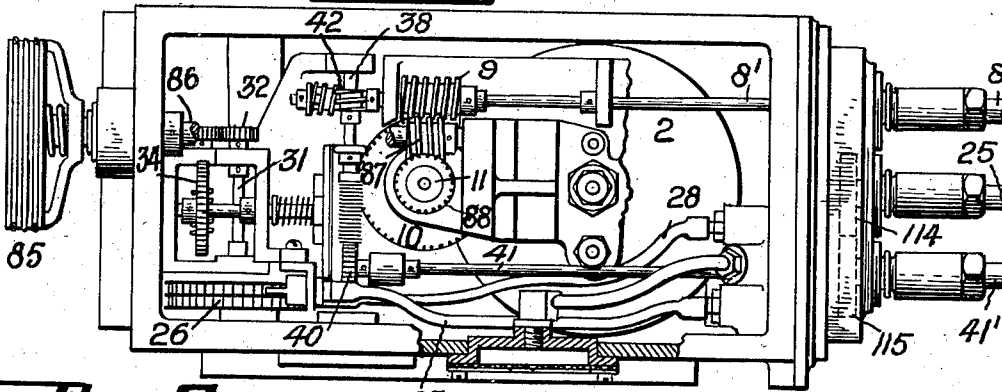


Fig. 8.

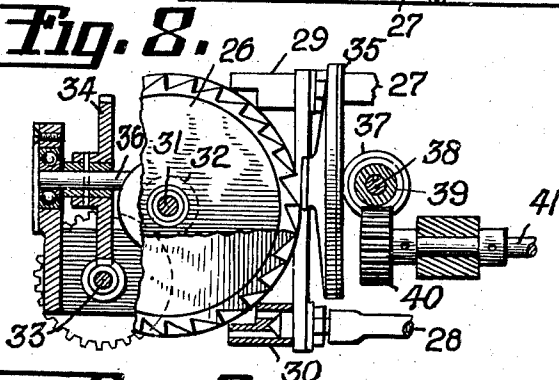


Fig. 11.

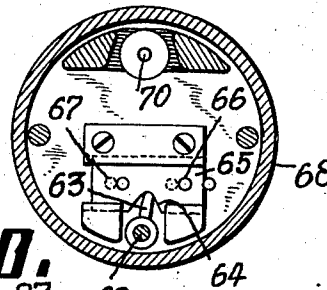


Fig. 9.

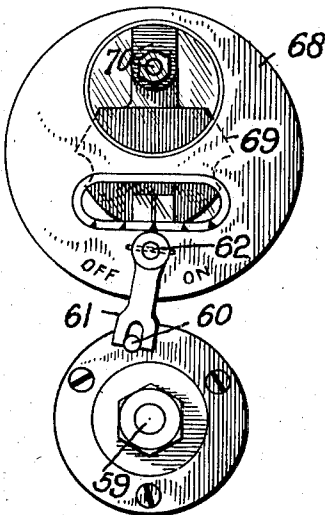


Fig. 10.

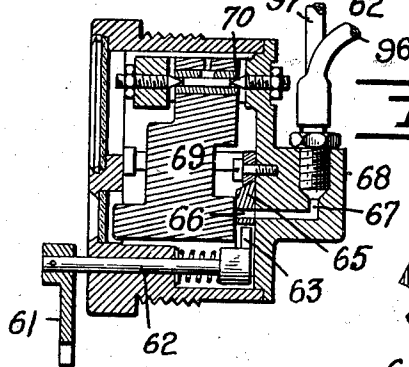
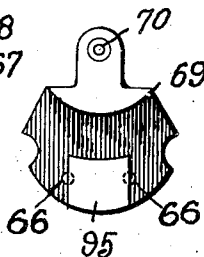


Fig. 12.



INVENTOR
BERT G. CARLSON
BY *Herbert H. Thompson*
HIS ATTORNEY

June 11, 1940.

B. G. CARLSON

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Fig. 14.

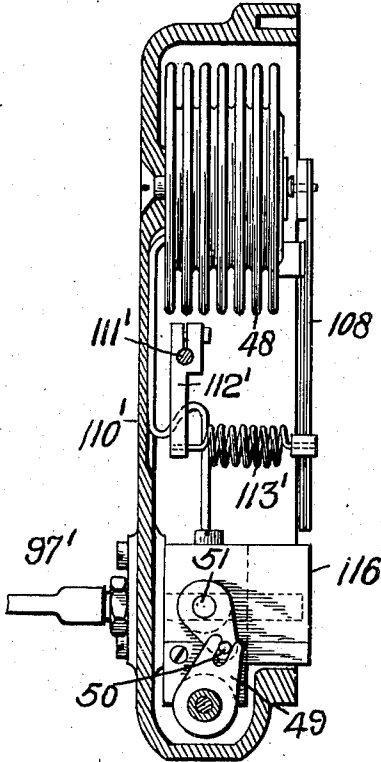


Fig. 13.

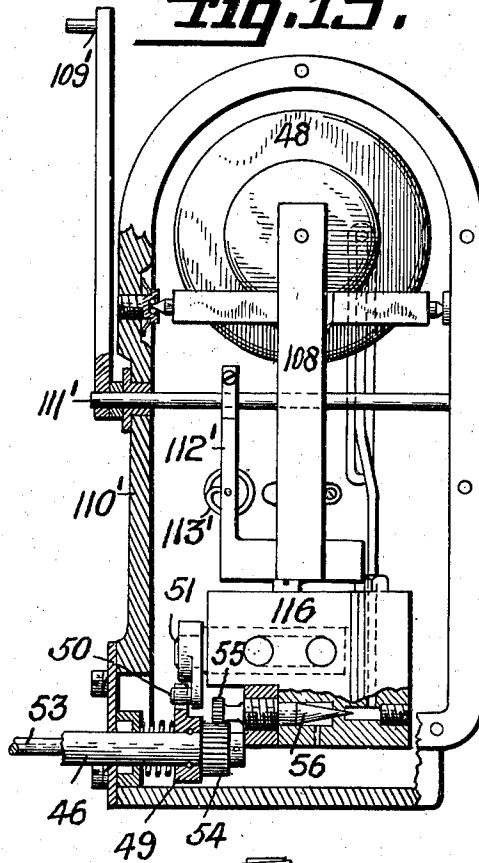


Fig. 13^a

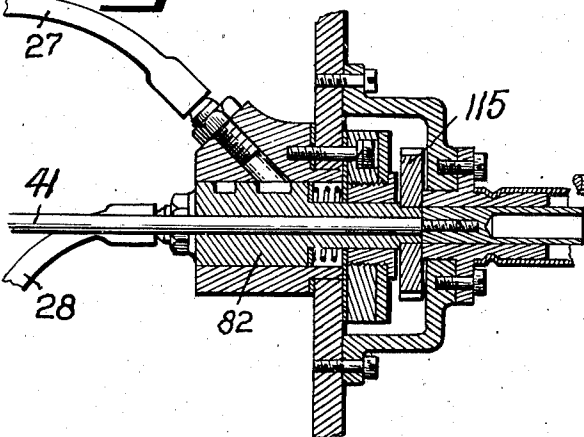
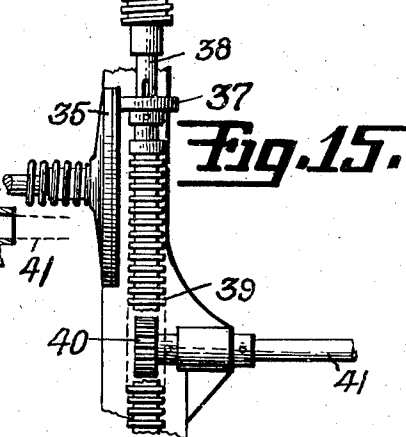


Fig. 15.



INVENTOR
BERT G. CARLSON
BY
Herbert H. Thompson
HIS ATTORNEY

June 11, 1940.

B. G. CARLSON
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Fig. 16.

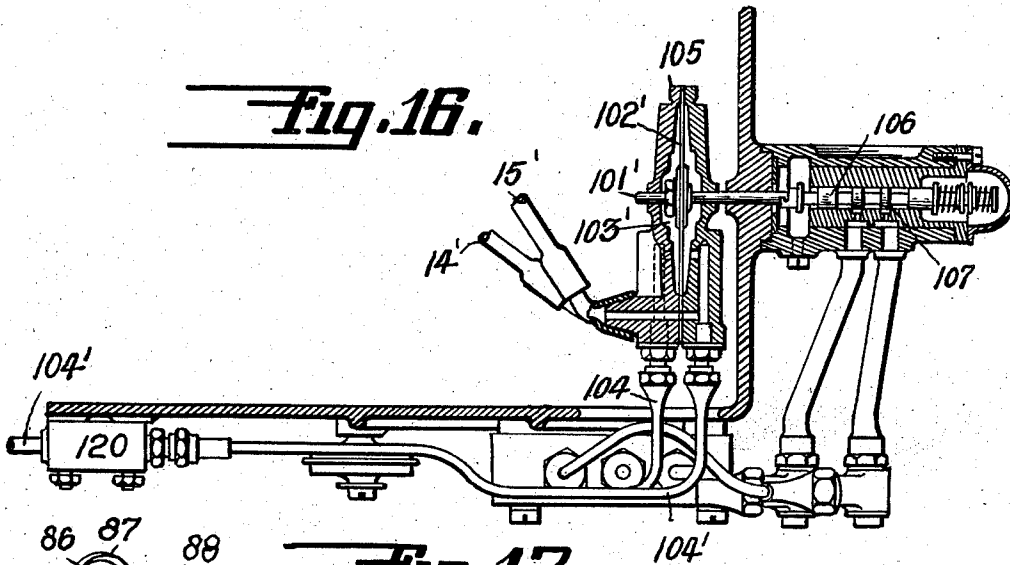
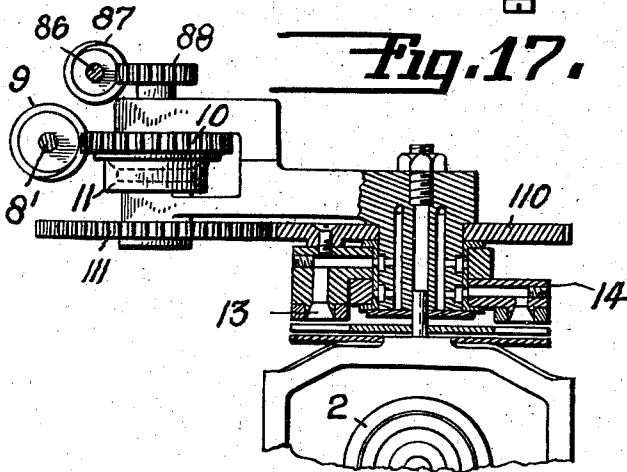


Fig. 17.



INVENTOR
BERT G. CARLSON
BY
Herbert H. Thompson
HIS ATTORNEY

UNITED STATES PATENT OFFICE

2,203,671

AIRPLANE AUTOMATIC PILOT

Bert G. Carlson, Freeport, N. Y., assignor to
Sperry Gyroscope Company, Inc., Brooklyn,
N. Y., a corporation of New York

Application February 26, 1938, Serial No. 192,717

9 Claims. (Cl. 244—76)

This invention relates to automatic pilots for aircraft. In the present design of automatic pilots, the control instruments and valves are placed on the instrument panel, but owing to the crowded condition of the panel, I propose in the invention to remove these instruments from the panel and place them in any convenient place on the craft and operate the same by remote control from a small control board on the instrument panel. This control board may contain nothing but the several control knobs for governing the rudder, ailerons and elevator through the automatic pilot and for governing the automatic banking and the rate of turn or rate of climb. The indications of the gyroscopes used in the pilot may be repeated or not, as desired, on the panel, but I prefer to place on the panel only small indicators showing the relative positions of the three air nozzles, namely, the rudder, ailerons and elevator with respect to the gyros. These indicators are used in synchronizing the control before engaging the pilot.

Referring to the drawings, illustrating one form the invention may assume,

Fig. 1 is a front elevation of the small control box adapted to be placed on the instrument panel.

Fig. 2 is an elevation, partly in section, of the same with the front plate removed.

Fig. 3 is a transverse section taken approximately on broken line 3—3 of Fig. 2, looking in the direction of the arrows.

Fig. 4 is a vertical section taken approximately on broken line 4—4 of Fig. 2, looking in the direction of the arrows.

Fig. 5 is a diagrammatic view of the automatic pilot, showing the connections running between the control panel and the control box.

Fig. 6 is a plan view of the artificial horizon portion of the control box, with the cover partly broken away.

Fig. 6A is a detail face view of the gear drive between two shafts entering the gyro box, with the small cover plate removed.

Fig. 7 is a plan view, partly in section, of the directional gyro portion of the control box.

Fig. 8 is a detail of the turbine drive for the variable speed gear.

Fig. 9 is a face view of the automatic banking control pendulum.

Fig. 10 is a vertical section of the same.

Fig. 11 is a vertical section of the same taken at right angles to Fig. 10.

Fig. 12 is a rear elevation of the pendulum.

Fig. 13 is an elevation, partly in section, of the

barometric control governing the rates of climb or dive.

Fig. 13A is a sectional view of the shaft couplings at the control box controlling turn and rate of turn.

Fig. 14 is a vertical section through the case of Fig. 13.

Fig. 15 is a side elevation of the variable speed rate of turn device shown in Fig. 8.

Fig. 16 is a sectional detail of one of the relay valves and connections.

Fig. 17 is a vertical section through a portion of the pick-off controls at the directional gyroscope.

The gyro instruments may be similar to those at present employed, namely, the artificial horizon or gyro vertical 1 (Figs. 5 and 6) and directional gyro 2 (Figs. 5, 7 and 17), the system being in general similar to that shown in the prior patent of E. A. Sperry, B. G. Carlson and M. F. Bates, #1,992,970, dated March 5, 1935. These instruments, however, may be made simpler than at present employed, since no indicators need be provided thereon as they are not visible to the observer. The control box or boxes containing the same may be placed at any convenient location on the craft, while the control panel 4 (Figs. 1 and 5) may alone be placed on the instrument board. In Fig. 5, the panel is viewed from the back to show the several connections running to the control box.

The control panel is shown as comprising essentially a plurality of knobs 5, 6 and 7 by which the rudder, ailerons and elevator may be manually controlled at will through the gyro pilot. For this purpose there is shown a flexible shaft 8 running from the shaft 5' of knob 5 to the directional gyro 2 to alter the relation between the follow-up controller thereat and the airplane for changing course through a predetermined angle. The shaft 8 is shown as coupled to shaft 8' journaled in box 3 and geared through worm 9 and worm wheel 10 which operates through a differential 11 to change the position of the pick-off ports 13, 14 at the gyroscope (Fig. 17), which ports turn with large gear 110 meshing with gear 111 turned from a second arm of differential 11.

A flexible shaft 15 runs from the shaft 6' of knob 6 to enter the artificial horizon gyro casing at coupling 16 to drive shaft 16' which alters the position of the banking pick-offs 80 and 80' at this gyroscope through pinion 112, differential 151, pinion 152, and large gear sector 113 to control the ailerons. Similarly, a flexible shaft

17 connects the shaft 7' of knob 7 to shaft 17' in the same casing for controlling the position of the similar pick-offs (not shown) which control the elevator, through differential 180.

5 The control panel also has a plurality of control knobs 18, 19 and 20, one (18) for causing the craft to turn at a predetermined rate, one (19) for automatic banking, and one (20) for climbing or diving at a predetermined rate of ascent or descent.

10 The knobs 18 and 20 preferably are in two parts, the former having a downwardly extending thumb piece 21 and a main knob 18 for the rate of turn. The latter is mounted on shaft 18' which is coupled to flexible shaft 41' leading to the gyro box (Fig. 13A) where it is coupled to shaft 41, hereinafter described. The thumb piece 21 is shown as mounted on a sleeve 22 having thereon a gear 23 meshing with a gear 24, the shaft 24' of which is connected to the shaft 25 which runs to the directional gyro box and operates, through gears 114 and 115 (Figs. 7 and 13A), a reversing intake air sleeve valve 82 (Fig. 13A) to control the direction of rotation of the reversible air turbine wheel 28 by controlling the flow of air through pipes 27 and 28 to the nozzles 29, 30. The turbine wheels drive through shaft 31, reduction gears 32, worm 33 and worm wheel 34, a disc 35 on the shaft 36 of the worm wheel. Frictionally engaging said disc is a roller 37 which is radially adjustable across the face of the disc by being splined on shaft 38. The roller is shown as having an extension sleeve 39 secured thereto, having circular teeth or grooves 39' therein with which meshes a pinion 40 on shaft 41 (Fig. 15). As stated above, said shaft is connected through suitable couplings and flexible shaft 41' to the knob 18, by which the rate of turn may be set in by varying the position of the roller on the roller. The shaft 38 of the disc drives through skew gears 42 the same worm gear 9 that is turned from shaft 8, so that the turn is effected in this manner at a predetermined rate. The third arm of differential 11 is driven from the follow-up pulley 45 through shaft 86, worm 87 and worm wheel 88.

The opposite knob 20 for the rate of climb likewise has an auxiliary thumb piece 43 by which the automatic climb may be turned off or on. The construction of the thumb piece may be the same as that of thumb piece 21, it turning a sleeve 89 to turn through gears 90 and 91 shaft 46', which in turn drives through gears 92 and 93 at the box 47 a sleeve 46 entering the box 47 containing the barometric device 48 of the aneroid type. Said sleeve is shown as having a forked member 49 secured thereto which is engaged by a pin 50 secured to the shaft 51 so that said shaft is rocked as the sleeve is turned, to open and close the ports in valve 116 connected to the turbine 52 through pipes 96' and 97' governing the climb and dive of the craft. The rate of climb is governed from the shaft 53, on which is mounted the pinion 54 meshing with a gear 55 on the threaded stem of the needle valve 56 to regulate the amount of opening of the valve, a flexible extension of the shaft 53 extending back to the instrument board and being connected to the shaft 20' of the aforesaid knob 20.

70 The barometer 48 is shown as temperature compensated by means such as a thermostatic strip 108, and has a follow back connection to the rudder servomotor, as disclosed in my prior application Serial No. 128,946, filed March 4, 1937, said connection including arm 109' pivotally mounted in casing 110' through cross shaft 111'

on which arm 112' is clamped, which arm is connected to strip 108 through spring 113'.

While I am aware that it has heretofore been proposed to employ barometric means which can be opened and closed to the atmosphere at will, and that it has also been proposed to employ a rate of climb or variometer type of barometer having a capillary leak to the atmosphere, in my present invention I combine the advantages of both types, since my needle valve may be either wide open, closed tightly, or opened a very small amount, so that my device may operate either as a sensitive barometer or as a variometer, at the will of the aviator. All of this may be effected merely by adjusting the knobs 20 and 43 on the instrument panel. To this end, the knob 20 is provided with a small pointer 121 reading on a scale 122, so that a definite rate of climb (or descent) may be set on the dial. It is interesting to note that the pointer 121 is set in the same position whether the airplane be climbing or diving, since it merely varies the rate of change of barometric pressure above which the automatic pilot comes into operation and prevents any greater rate of change.

In taking off, for instance, the aviator would first leave the needle valve wide open until he gets fairly into the air. He then may almost close it, leaving a minute opening, so that the airplane would ascend at a predetermined rate with the knob 7 set for ascent. After reaching the desired altitude, the needle valve would be closed so that the barometer would act as a true barometer to maintain the plane at that height. When it is desired to descend, the aviator may set knob 7 for descent and open the needle valve slightly so that he may descend at a predetermined rate. This has a great advantage in blind landings, since upon receiving the signal to descend, the pilot could be sure that he would descend at a rate to bring him to the ground at the landing field.

It is of course well known that rate of climb depends on engine speed as well as the position of the elevator, so that a throttle control could be provided in addition to or instead of the elevator control, if so desired, to increase the engine speed for ascent and decrease it for descent.

An automatic bank knob 19 is connected to shaft 58 to turn a shaft 59 within the horizon control box and having a pin 60 thereon engaged by the forked end of a rocker arm 61 (Figs. 9 to 12). Said arm is shown as mounted on a shaft 62 having a pin 63 at the inner end thereof engaging a notch 64 in a slidably mounted plate 65. Said plate has two holes 66 therein which, in one position, register with ports 67 in the casing 68, which supports and encloses a small pendulum 69. In the position shown in Fig. 11, however, the ports are closed to shut off the automatic bank control. The pendulum is shown as pivoted on axis 70. The ports 67 are normally bisected by a straight edge projection 95 on the back of pendulum 69 (Fig. 12) and lead to the automatic bank turbine 71 through pipes 96 and 97. Preferably, paddles or blades 72 are connected to one or both of the air turbines, at least to the elevator turbine to retard the same without interposing any resistance to starting and cause it to run at a uniform speed to give a uniform rate of climb or descent.

It is interesting to note that the auxiliary pendulum 69 performs an important function in maintaining level flight immediately after a turn. At this time the gyro vertical 1 is usually, or may be, deflected from the vertical several de-

grees through the action of the lateral acceleration forces during the turn on the erection device, so that without the pendulum 69, the airplane would fly with one wing down until the gyro erected itself. The short period pendulum 69, however, immediately returns to the vertical after a turn, and through the ports 66, the turbine 71 and the differential 151, the position of the pick-off ports 80 and 80' will be corrected so that the airplane will fly horizontal. As the gyro straightens up, the signal from the pendulum 69 decreases simultaneously, so that level flight is maintained. Therefore the knob 19 is preferably left in the "on" position most of the time, whether flying straight or turning.

Similarly, the barometric means acts to prevent the plane assuming a wrong attitude in case the gyro vertical becomes deflected in a fore and aft direction, for instance, after a marked change in speed. If the gyro vertical is so deflected, the airplane will start to climb or dive, resulting in a change in barometric pressure which results in operation of the barometric pick-off to move the turbine 52 to shift the positions of the pick-offs at the gyro through the differential 150.

Preferably, answer back indicators are provided on the panel, these being shown in the form of simple pointers 74, 75 and 76, one for each of the rudder, ailerons and elevator, and which are moved left or right according as air nozzles and gyros are not synchronized. The pointers are shown as pivoted to the panel at 77, 77' and 77'', and are centralized by springs 78 connected to a U-shaped bend at the lower ends. Since all three pointers are similarly arranged only the answer back system associated with the rudder will be described. Also pivoted thereto is a downward extension 79 from a U-shaped member 100 which is connected at its outer ends to the piston rod 101, connected to the diaphragm or movable wall 102 bisecting a chamber 103, to the two sides of which are connected pipes 104 and 104' leading back to pipe junction box connection 120 at the boxes 3 and 4. From there, the pipes lead to the two chambers on each side of the respective relay valves 105 which operate the pistons 106 of the oil control valve 107. Hence any differential air pressure in the relay valve will be reflected by a movement of the diaphragm 102 to operate the proper pointers 74, 75 or 76. It should be understood that the primary air impulses to chamber 105 are transmitted through pipes 14' and 15' from the pick-off ports 13 and 14 at the directional gyroscope or similar ports at the horizon gyroscope.

It is understood that the other two pairs of pipes 140 and 141 run to the elevator control valve and the aileron control valve in the same manner as the pipes 104 and 104' are connected to the rudder control valve 107, so that the pointers 75 and 76 will show whether or not the respective control valve and hence the respective servomotors have responded to the signals set in by the knobs on the panel.

The indicators 74, 75 and 76 have an important function in enabling the aviator to synchronize the pilot with the airplane's position before he throws in the automatic pilot. The present practice is to take off under manual control and to throw the automatic pilot in after the plane is well into the air. If the automatic pilot were suddenly thrown in without first synchronizing, the plane might be thrown into a dangerous position due to the fact that one of the turn, climb or bank knobs 5, 6 or 7 may have been left in a

non-centralized position. After leveling off, the aviator first throws the air on the system and then brings the aforesaid knobs to the position where the pointers 74, 75 and 76 are centralized, at which time he knows that the positions of the pick-off ports at the gyroscope are centralized with respect to the gyro cut-off plates. The pilot may then be thrown in safely without disturbing the attitude of the plane.

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.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In an automatic pilot for aircraft, a plurality of control knobs at the instrument panel, remotely located master controlled instruments, means connecting said knobs and instruments to change the attitude of the plane, fluid pressure relay valves thereat controlled by said instruments, and fluid pressure answer-back means from said relays to said panel adjacent said knobs.

2. An automatic pilot as claimed in claim 1, having separate knobs to put in either a predetermined change of course or a predetermined rate of change of course, or both, through the automatic pilot.

3. An automatic pilot as claimed in claim 1, having separate control knobs for putting in either a change of pitch attitude or a given rate of change of climb or dive, or both.

4. An automatic pilot as claimed in claim 1, having separate knobs to bank the plane at will or to bank it at the proper angle during a turn.

5. In an automatic stabilizer for airplanes, having a control panel and a remotely located control box, a gyro vertical in the latter, pick-off means governed by the relative position of said gyroscope and airplane about a fore and aft axis for positioning the ailerons, a pendulum also pivoted about a fore and aft axis, means responsive to the average position of the pendulum for shifting the said pick-off means to change the relation between gyroscope and airplane to cause automatic banking at the proper angle, and means for rendering said pendulum responsive means operative and inoperative at will from the control panel.

6. In an automatic pilot for aircraft having means for changing course and attitude and means for setting up predetermined rates of change of each, a remote control panel for said pilot comprising knobs for moving each of said first mentioned means, knobs for operating each of said second mentioned means, and indicating means adjacent said knobs, controlled from the automatic pilot, to assist in synchronizing the pilot with the craft's control surfaces before the pilot is thrown in.

7. In an automatic pilot for aircraft, the combination with a course maintaining means, a rudder control device actuated therefrom for steering any predetermined course, a horizon gyro and ailerons actuated therefrom, a servomotor for altering the relation between said means and rudder to cause turning, a variable speed drive between said motor and said device to vary the rate of turn at will, a second servomotor for altering the relation between said horizon gyro and

the ailerons, and a short period pendulum for actuating the second servomotor, whereby the aircraft may be caused to turn at a predetermined rate without side slipping.

8. In an automatic pilot for aircraft, a plurality of control knobs at the instrument panel, remotely located master controlled instruments, flexible shafts connecting said knobs and instruments to change the attitude of the plane, fluid pressure relay valves thereat controlled by said instruments, and fluid pressure answer-back means from said relays to said panel adjacent said knobs.

9. In an automatic pilot for aircraft, a plurality of control knobs at the instrument panel including a course change knob, a rate of turn knob and an automatic bank knob, direction

maintaining means and attitude maintaining means for maintaining the course and attitude of the plane, a variable speed servomotor for causing turns at predetermined rates through said direction maintaining means, an automatic bank device connected to said attitude maintaining means, means connecting said course change knob and said direction maintaining means for changing course by a predetermined amount, means connecting said rate of turn knob and said servo means for setting up a predetermined rate of turn, and means operated from said automatic bank knob for rendering operative and inoperative at will said automatic bank device.

BERT G. CARLSON.