Nov. 9, 1948. H. A. WHEELER 2,453,170

CONTROL DEVICE AND SYSTEM

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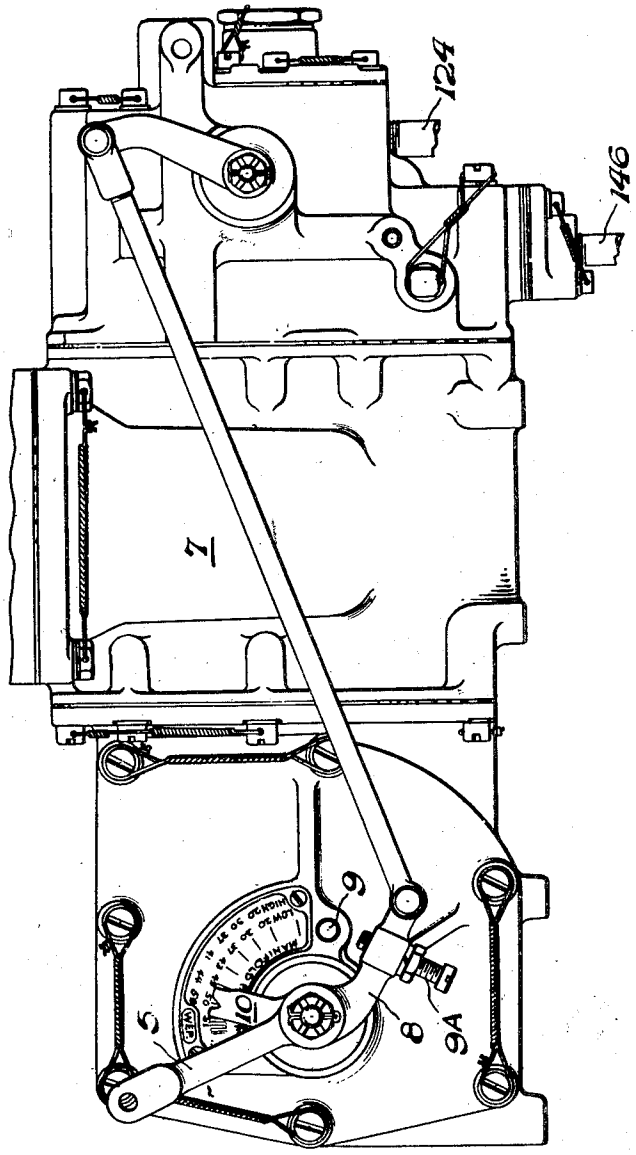


Fig. 1.

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CONTROL DEVICE AND SYSTEM

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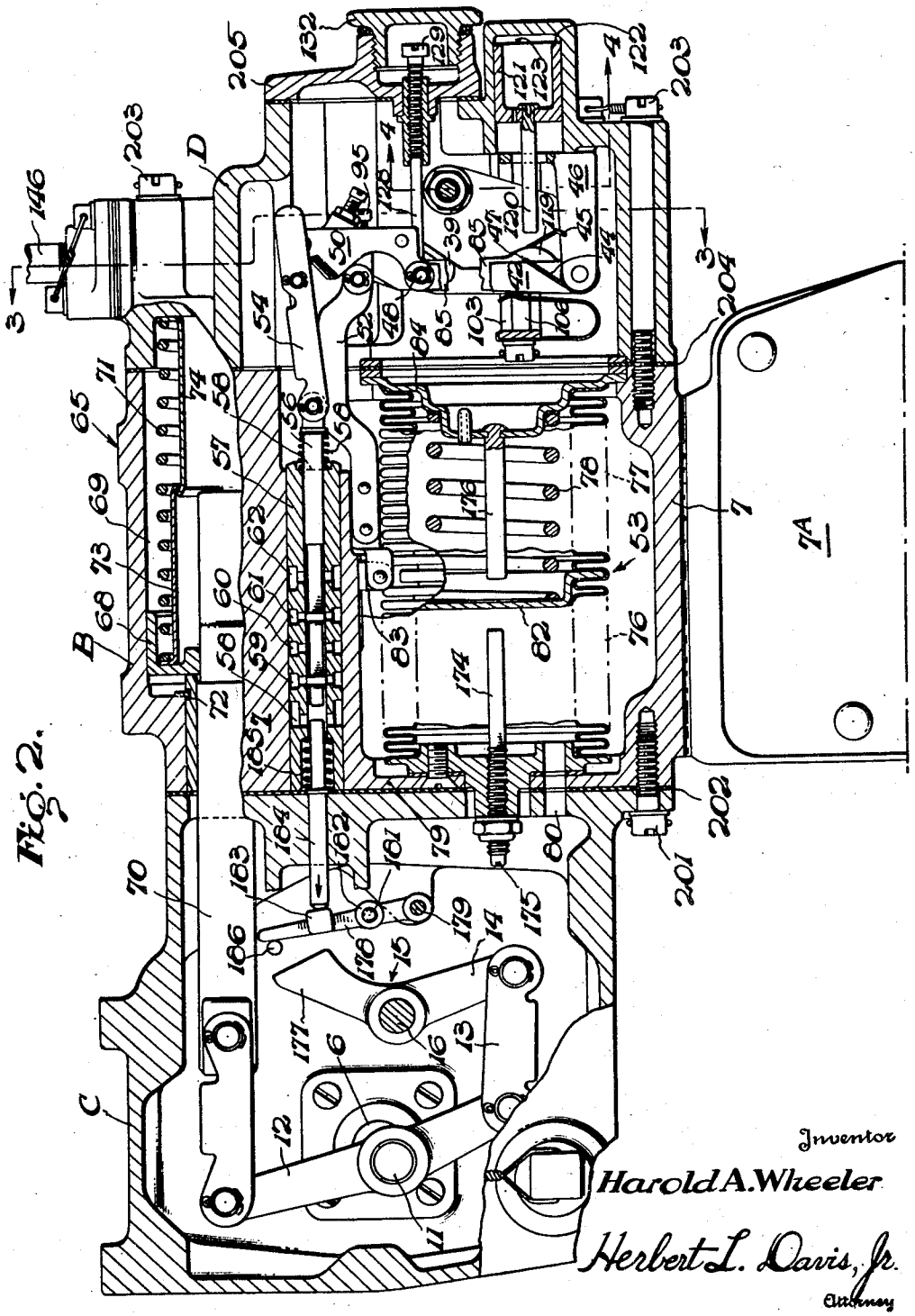


Fig. 2.

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Fig. 3.

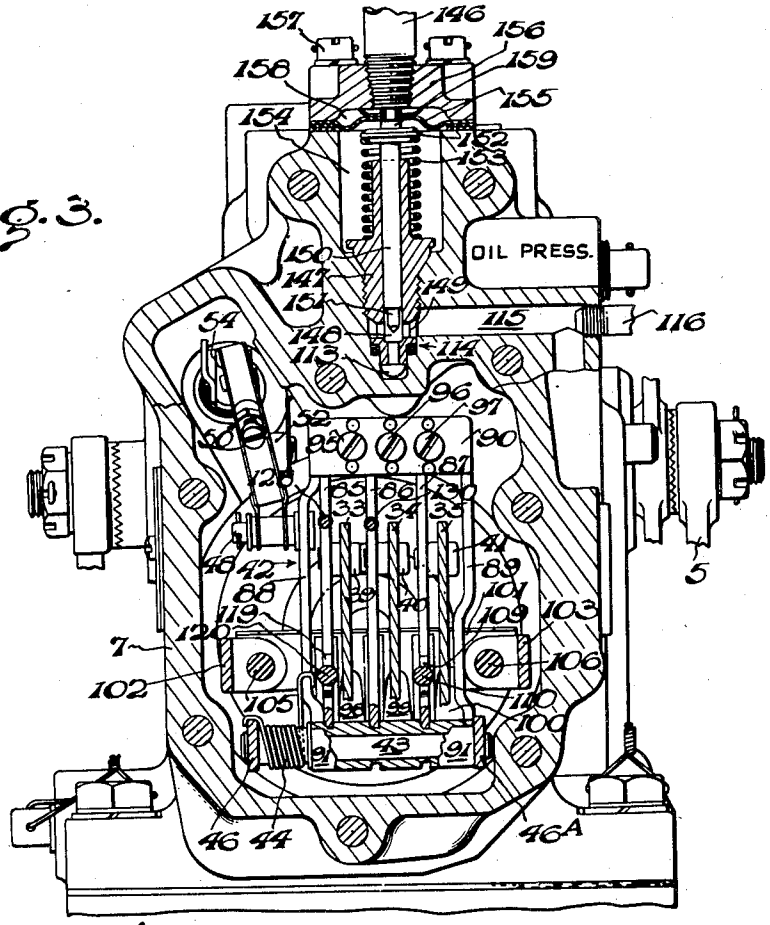
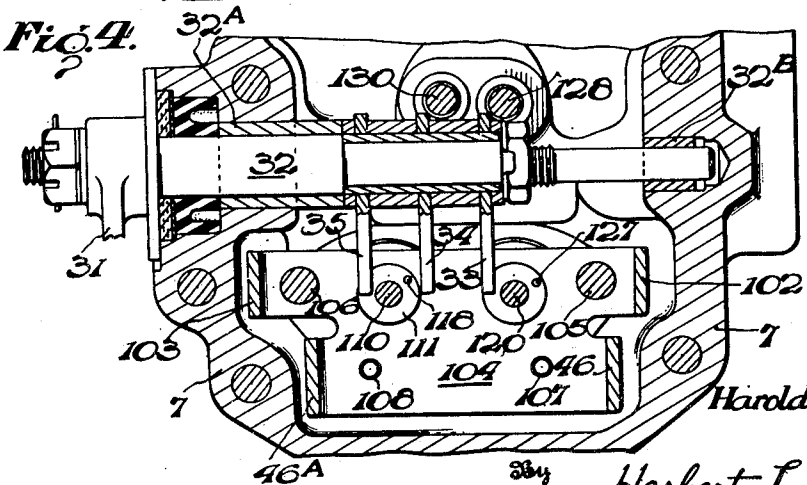


Fig. 4.



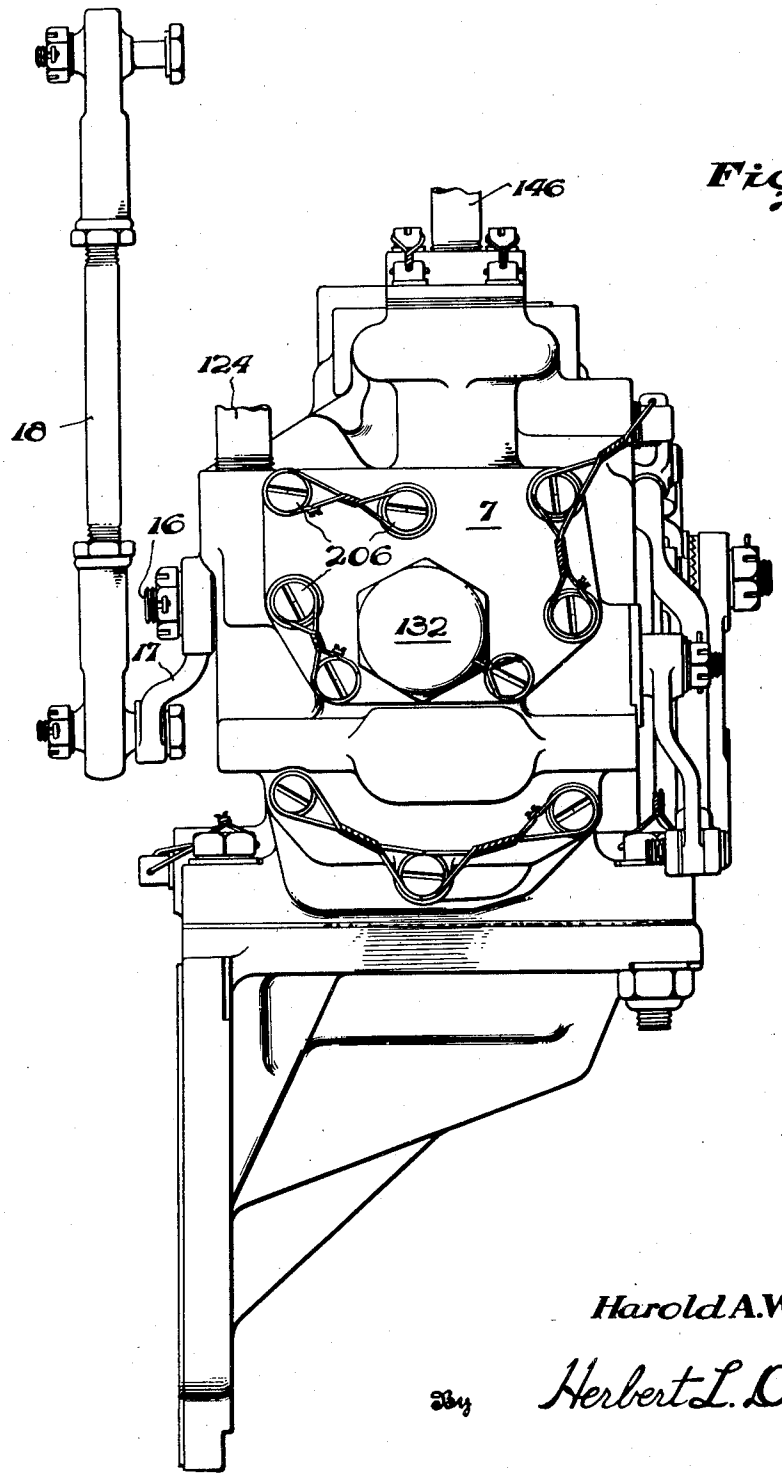
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CONTROL DEVICE AND SYSTEM

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Fig. 5.



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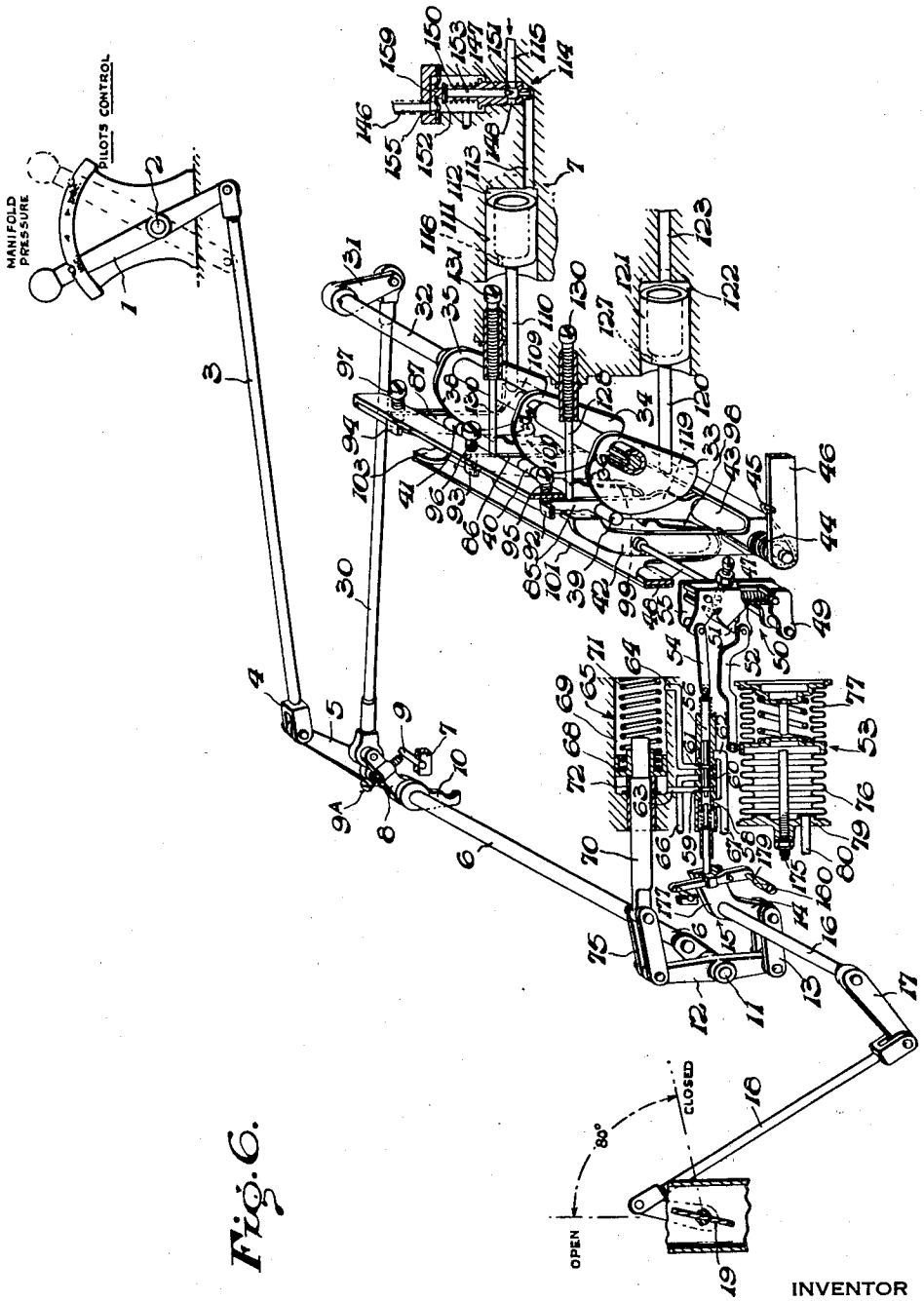


Fig. 6.

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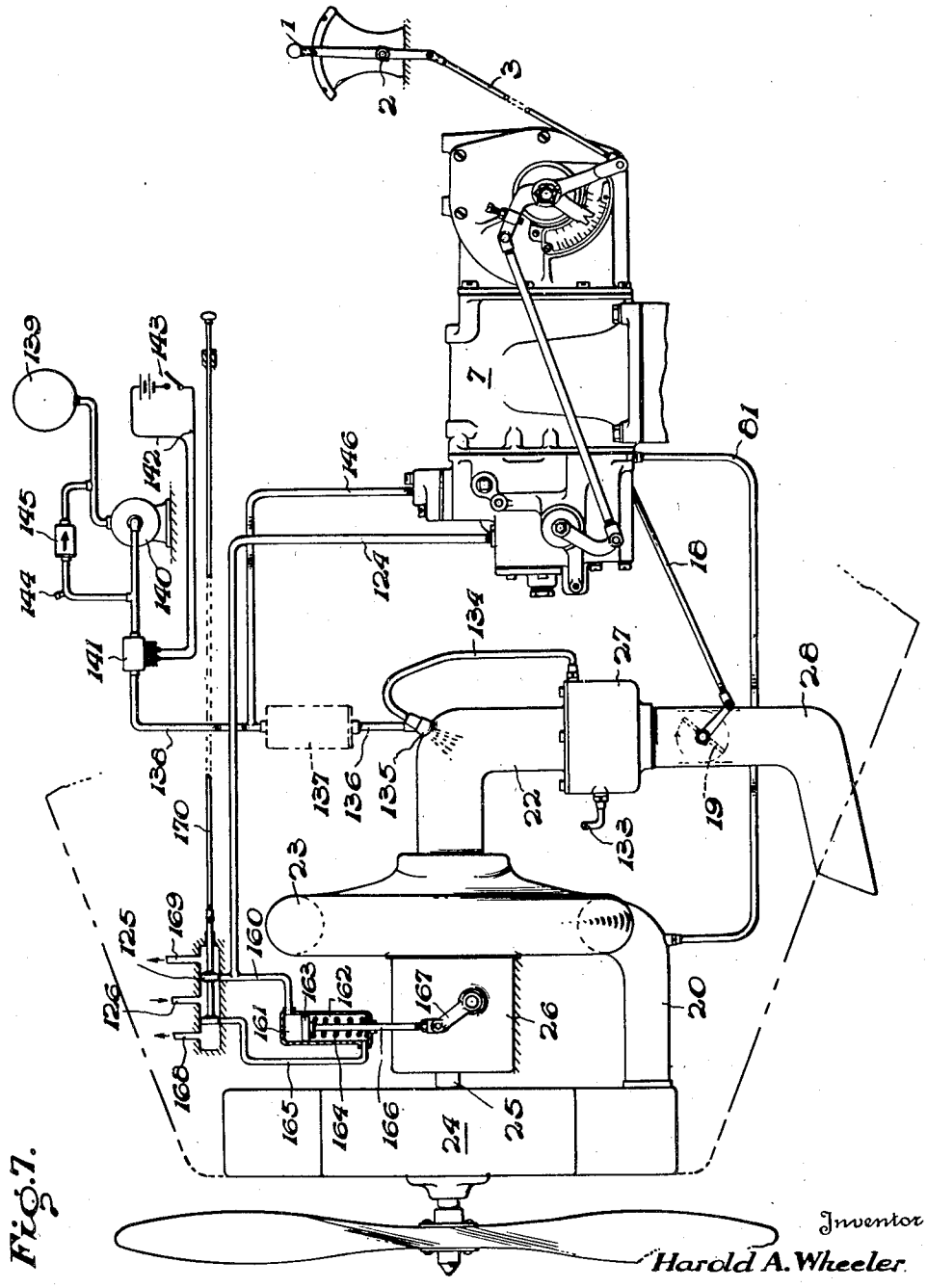


Fig. 7.

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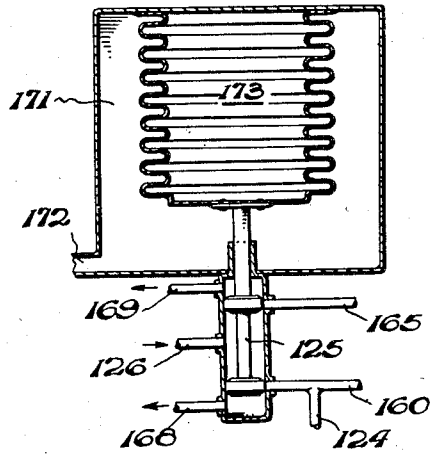
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CONTROL DEVICE AND SYSTEM

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Fig. 8.



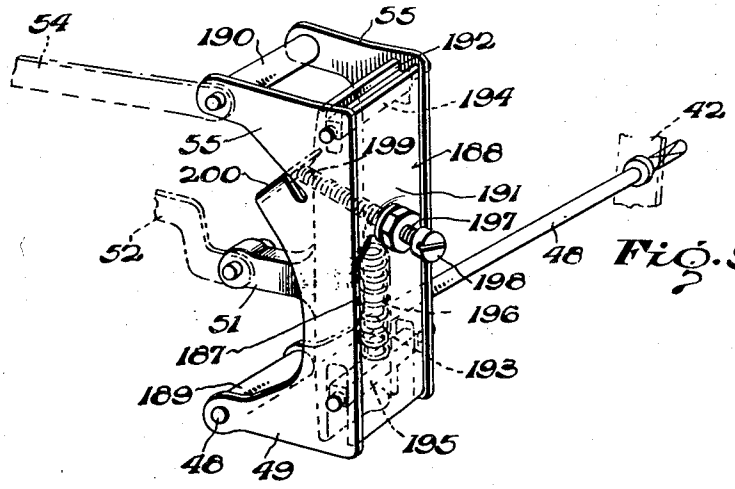


Fig. 9.

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Fig. 10.

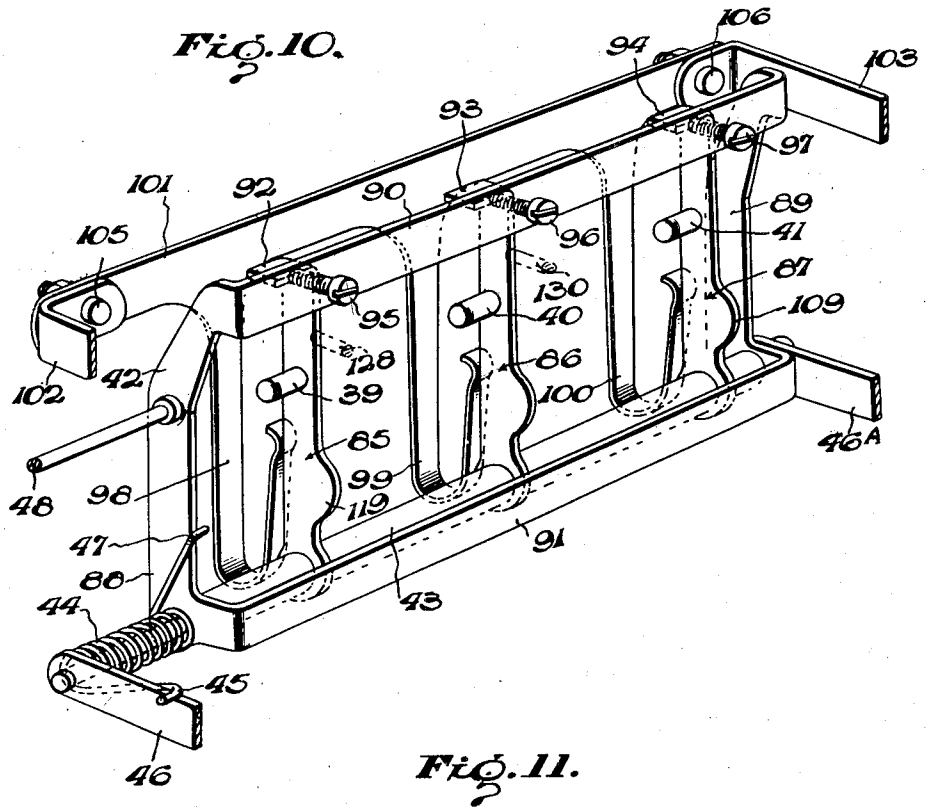
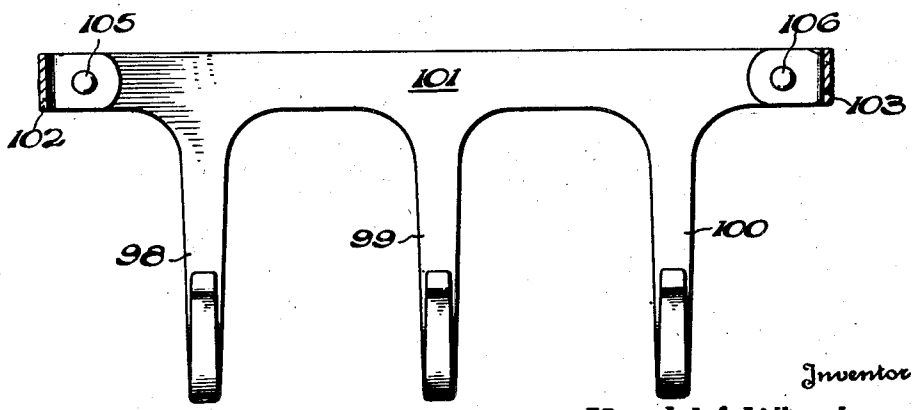


Fig. 11.



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CONTROL DEVICE AND SYSTEM

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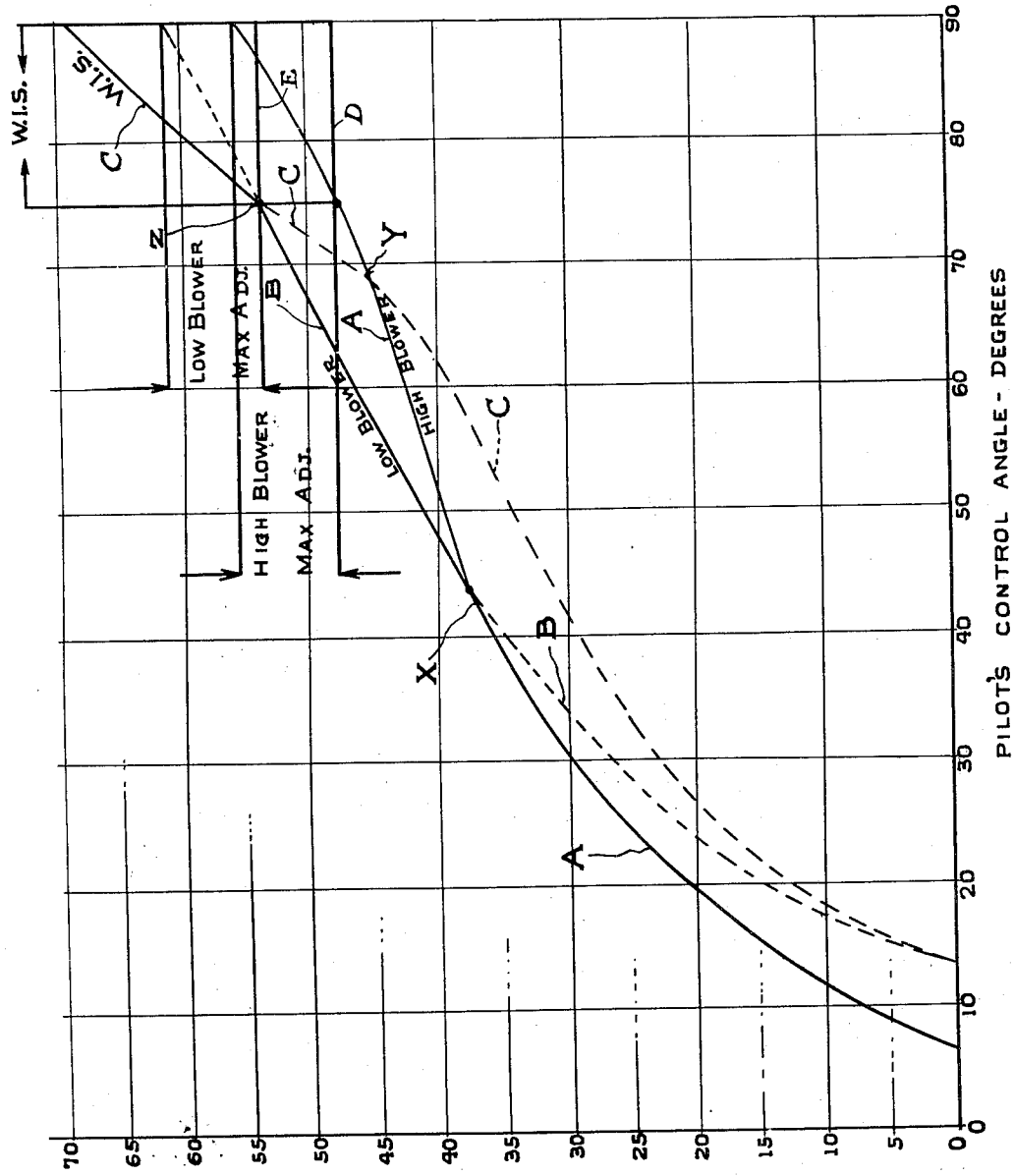


Fig. 12.

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Patented Nov. 9, 1948

2,453,170

UNITED STATES PATENT OFFICE

2,453,170

CONTROL DEVICE AND SYSTEM

Harold Arthur Wheeler, Grand Rapids, Mich., assignor to Bendix Aviation Corporation, Teterboro, N. J., a corporation of Delaware

Application June 11, 1945, Serial No. 598,767

28 Claims. (Cl. 123—119)

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The present invention relates to improved control devices and systems of the class disclosed by application Serial No. 783,237, filed October 31, 1947, by Howard A. Alexanderson as a continuation of application Serial No. 508,724, filed November 2, 1943, now abandoned, and application Serial No 551,036, filed August 24, 1944, by Howard A. Alexanderson, and application Serial No. 581,878, filed March 9, 1945, by Howard A. Alexanderson and Harold A. Wheeler. More specifically, the present invention relates to a novel and improved control mechanism for a supercharged aircraft engine which provides means for effecting automatic control of two or more intake manifold pressure selection programs for such an engine in response to an operating condition thereof.

An object of the invention is to provide novel means responsive to the intake manifold pressure for adjusting a throttle valve so as to approximate predetermined pressure values together with a novel pair of adjustable members for selecting such pressure values and means for selectively actuating one or the other of said members into operating relation in response to an operating condition.

Another object of the invention is to provide a novel adjustment means for directly actuating an automatic carburetor throttle control in a first sense, and a second novel intake manifold pressure responsive means for directly actuating the throttle control in an opposite sense so as to maintain a predetermined selected pressure value, which value is variable in accordance with a first selected program, and adjustable means for varying such value in accordance with a second or more selected programs.

Another object of the invention is to provide a novel selector linkage arrangement, whereby the datum of the boost control may be selected in accordance with two or more predetermined programs.

Another object of the invention is to provide a novel control mechanism for selecting in accordance with a first selected program the intake manifold pressure of the aircraft engine, including novel adjustable means for varying the relationship of the intake manifold pressure of the aircraft engine in accordance with a second selected program brought into operation by a predetermined operating condition.

During the operation of so-called "water" or "anti-knock" fluid injection systems for suppressing predetonation in internal combustion engines, an increase in the air inlet pressure of the induction system for the engine is permissible and desirable in order that greater engine power may be obtained than when such injection system is not in operation. Therefore, an object of the present invention is to provide a novel regulator responsive to operation of such an injection system for effecting a predetermined increase in the air pressure in the induction system.

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Another object of the invention is to provide a novel regulator for effecting smooth control throughout the range of operation of the "anti-knock" fluid injection system.

Another object of the invention is to provide a novel regulator for effecting automatic control in accordance with a first predetermined program during low speed supercharger operation, and automatic control in accordance with a second predetermined program during high speed supercharger operation.

Another object of the invention is to provide a novel regulator for effecting automatic control in accordance with a first predetermined program during operation of the supercharger at low speed; a second predetermined program during operation of the supercharger at high speed; and a third predetermined program during operation of the anti-knock fluid injection system.

Further, during the operation of the aircraft engine at high altitudes it is desirable to operate the supercharger at greater speeds and the intake manifold pressure under a different selected pressure program than at lower altitudes. Accordingly, it is an object of the present invention to provide manually adjustable means or automatic altitude responsive means for effecting such operation.

These and other objects of the invention are pointed out in the following description in terms of the embodiment thereof which is shown in the accompanying drawings. It is to be understood, however, that the drawings are for the purpose of illustration only, and are not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawings:

Figure 1 is a side view showing the control mechanism;

Figure 2 is a view with the control mechanism of Figure 1 turned over and the opposite side broken away to better illustrate the operating parts;

Figure 3 is a sectional view taken along the lines 3—3 of Figure 2;

Figure 4 is a sectional view of Figure 2 taken along the lines 4—4 of Figure 2;

Figure 5 is an end view of the control mechanism;

Figure 6 is a diagrammatic view of the operating mechanism;

Figure 7 is a schematic view showing the control mechanism in operative relation with the aircraft engine controlled thereby;

Figure 8 is a diagrammatic view of an altitude responsive device for controlling the speed of the supercharger and effecting the operation of the regulator;

Figure 9 is an enlarged perspective view illustrating the range adjustment linkage;

Figure 10 is an enlarged perspective view illustrating the cam follower linkage arrangement;

Figure 11 is an enlarged plan view of the leaf spring arrangement for the cam follower arms;

Figure 12 is a graphical illustration of the operating characteristics of a typical control mechanism embodying the present invention.

The control mechanism as shown in Figures 6 and 7 is preferably operated by a main control lever 1 pivotally mounted at 2 within the cabin of an aircraft. There is pivotally connected to the control lever one end of a main control rod 3.

As shown in Figure 6, there is pivotally connected at the opposite end of the main control rod 3 at 4, an arm 5 mounted on a main control shaft 6 and positioned exteriorly of a casing 7 as shown in Figures 1 and 3. The casing 7 houses the novel control mechanism and may be conveniently mounted on a bracket 7A as shown in Figures 2 and 5.

As shown in Figure 1, there is formed integral with the arm 5, a second arm 8 likewise mounted on the main control shaft 6 and positioned exteriorly of the casing 7. Movement of the arm 8 may be limited as indicated in Figure 6 by a stop 9, which is arranged for engagement by an adjustable limiting screw 9A provided on the arm 8 and a second engaging arm 10 formed integral with the arm 8.

The main control shaft 6 extends into the casing 7 and is rotatably mounted on suitable anti-frictional roller bearings, not shown.

Positioned within the casing 7 and fixedly mounted at the inner end of the main control shaft 6 is a crank pin 11, as best shown in Figure 2 The crank pin 11 has pivotally mounted at the free end thereof a walking beam 12. The walking beam 12 is pivotally connected at one end to a link 13 which is in turn pivotally connected at the other end to an arm 14 of a bell crank lever 15. as shown in Figure 2. The bell crank lever 15 is mounted on a shaft 16.

The shaft 16 is mounted on anti-frictional roller bearings, not shown. and projects through the casing 7, as shown in Figures 5 and 6. Mounted at the outer end of the shaft 16 is an arm 17 having pivotally connected at the free end a throttle control rod 18 for adjustably positioning a throttle valve 19 positioned within the air intake conduit of a conventional aircraft internal combustion engine, as indicated diagrammatically in Figure 7.

The throttle valve 19 is arranged so as to regulate the pressure at the intake manifold 20 of the engine 21 by regulating the air inlet through conduit 22 to a supercharger 23. The supercharger 23 is driven by an aircraft engine 24 through a drive shaft 25 and change speed gear or hydraulic coupling 26. The supercharger 23 is arranged to supply air to the intake manifold 20. A carburetor 27 is provided on conduit 22 of conventional type and a conduit 28 leads from

the carburetor 27 to a suitable air supply or air intake scoop 29.

Pivotally connected to the arm 8, previously described, is one end of a linkage rod 30. The opposite end of the rod 30 is pivotally connected to one end of a lever arm 31 mounted on a pressure selector shaft 32, as shown in Figure 6. The shaft 32 projects into the casing 7 and is preferably mounted therein on bearings 32A and 32B.

The shaft 32 has fixedly mounted thereon, cams 33, 34, and 35 which may be adjustably positioned by the adjustment of the shaft 32. The cams 33, 34, and 35, have provided variable cam surfaces 36, 37, and 38, respectively, which are arranged to bear upon cam follower members 39, 40, and 41 as will be explained hereinafter, so as to operably connect the shaft 32 to an adjustable frame or lever member 42. As shown in Figure 3, the lever 42 is pivotally mounted within the casing 7 on a shaft 43.

There is connected to the lever 42 at the lower end, as viewed in Figure 6, a spring 44. The spring 44 is coiled about the shaft 43 and one end 45 bears upon a fixed member 46, while the opposite end 47 biases the lever 42 in a counter-clockwise direction about the shaft 43. Projecting from the lever 42 at a point intermediate the opposite ends thereof is a pin 48 to which there is pivotally connected an end 49 of a novel range adjustment floating lever 50.

The floating lever 50 is pivotally connected at a point 51, intermediate its opposite ends to one end of a linkage arm 52. The linkage arm 52 is operatively connected at the opposite end to a pressure responsive mechanism indicated generally by the numeral 53 which will be described hereinafter.

Servo-motor mechanism

A third link 54 is pivotally connected at one end to the floating lever 50 at an end 55 opposite from the end 49. The opposite end of the link 54 is affixed to a slidably adjustable member 56 for controlling a servo-valve of conventional type. As shown in Figure 2, the member 56 is slidably mounted within a valve sleeve 57, positioned within the wall of the casing 7. Carried by the servo-valve control 56 is a tension spring 58 which exerts a force biasing the link 54 toward the floating lever 50. The valve sleeve 57 has provided ports 58, 59, 60, 61 and 62, as shown in Figures 2 and 6. The ports 59 and 61 are connected by suitable conduits 63 and 64, respectively, to a servo-motor indicated generally by the numeral 65, while a conduit 66 is connected to the port 60 and serves as an inlet to the servo-valve of a suitable fluid medium under pressure such as oil under engine pressure for operation of the servo-motor 65. A drain conduit 67 is further connected to the ports 58 and 62 and serves as an outlet for the fluid pressure medium supplied to the servo-valve in the conventional manner.

As shown in Figures 2 and 6, a servo-piston 68 is slidably mounted within a cylinder wall 69 of the servo-motor 65. The piston 68 is connected to a piston rod 70 in any conventional manner. A tension spring 71 biases the piston 68 in a direction tending to slide the rod 70 outwardly from the cylinder 69 for a purpose which will be explained hereinafter. Movement of the piston 68 in response to the biasing force of the spring 71 is limited by a collar 72 against which the piston 68 abuts in the extreme biased position.

As shown in Figure 2, suitable telescoping tubular members 73 and 74 are provided for protect-

ing the spring 71 and limiting the extent of movement of the piston 68 in the opposite direction.

The conduits 63 and 64, previously described, lead to opposite sides of the piston 68 so that adjustment of the servo-valve control 56 to the left of the neutral position shown in Figure 6, will cause the conduit 23 to serve as an inlet of pressure to the servo-motor 65 and thereby exert a biasing force upon the piston 68 to the right. Likewise, adjustment of the servo-valve control 56 to the right of the neutral position shown in Figure 6, will cause the conduit 64 to serve as an inlet of pressure to the servo-motor 65 and exert biasing force upon the piston 68 to the left. Thus it will be seen that in the conventional manner the direction of movement of the piston rod 69 may be controlled by the adjustment of the servo control valve 56.

While there has been shown in the present embodiment of the invention a hydraulic control and power means, it will be readily seen that other forms of controls and power means such as well known, mechanical and electronic controls and power means, may be readily substituted therefor.

It will be further noted that the outer end of the piston rod 70 under control of the power means aforesaid, is pivotally connected by a link 75 to the opposite end of the walking beam 12 from that at which the link 13 is connected, as previously described. It will thus be seen that the adjustment of the walking beam 12, and accordingly the throttle control shaft 16 is dependent upon the effect thereon of the adjustment of the main control shaft 6 and the servo-motor 65.

The adjustment of the servo-motor 65 is dependent upon the adjustment of the pressure selector cams 36, 37 and 38, previously described; the position of the pressure responsive mechanism 53, as will be further described, in relation to the adjustment of the pressure selector cam; and upon the adjustment of the main control shaft 6 irrespective of the position of the pressure selector cams or the pressure responsive mechanism 53, as will be explained.

Pressure responsive mechanism

The pressure responsive mechanism 53, previously noted, comprises preferably a pair of bellows 76 and 77 mounted within the casing 7, as best shown in Figure 3. The bellows 77 is preferably partially evacuated and balanced by a coil spring 78 mounted within the bellows 77 so as to act against the biasing force of the bellows 76. A wall 79 formed within the casing 7 has mounted thereon the bellows 76 which is connected through a passage 80 passing through the wall 79, and a conduit 81 connecting the passage 80 to the intake manifold 20 of the internal combustion aircraft engine 24, as shown in Figures 6 and 7, in such a manner that the biasing force of the bellows 76 will vary in response to the intake manifold pressure. A plate 82 is mounted between the bellows 76 and 77 and is movable upon variance in the pressure exerted within the bellows 76, as is well known in the art. The plate 82 has provided a projecting arm 83 to which there is pivotally connected an end of the linkage arm 52 previously described. The opposite end of the bellows 77 is mounted on a plate 84 secured in the side wall of the casing 7 as shown in Figure 2.

From the foregoing it will be seen that the adjustment of the servo-valve control 56 will be dependent upon the intake manifold pressure acting upon the pressure responsive mechanism 53 and the corresponding adjustment thereof in relation to the adjustment of the operating cams 33, 34, or 35. It should be pointed out here that the tension exerted by the spring 44 and acting upon the arm 42, has a considerably greater biasing force upon the servo control valve member 56 than the force exerted thereon by the relatively light tension spring 58 mounted on the member 56.

Thus it will be seen that in normal operation a decrease in the intake manifold pressure due to a rise in altitude for example, decrease in atmospheric pressure or other cause, would affect the bellows 76 and 77 so as to cause the relative contraction of the bellows 76 and the relative expansion of the bellows 77. Such action would cause the movement of the plate 82 and the longitudinal movement of the linkage arm 52 toward the left, as viewed in Figures 2 and 6.

Since, as previously explained, the spring 44 exerts a greater biasing force than the spring 58, it will be readily seen that such longitudinal movement of the arm 52 would cause the floating lever 50 to pivot in a counter-lockwise direction on its pivotal connection to the arm 42 resulting in a corresponding longitudinal movement of the link 54 and servo control valve member 56 to the left.

Thus with the control valve member 56 first in the neutral position, such adjustment of the servo control valve member 56 would cause the opening of the port 59 to the inlet of the pressure medium provided through the port 60 resulting in the shifting of the piston 68 to the right as viewed in Figures 2 and 6 and the mechanical adjustment of the throttle 19 to a relative increased open position through the action of the piston rod 70 on the link 75, walking beam 12, link 13, bell crank lever 15, throttle control shaft 16, arm 17, and rod 18, and thereby increasing the pressure exerted at the intake manifold 20.

Conversely, an increase in the intake manifold pressure would cause the relative expansion of the bellows 76 and contraction of the bellows 77, resulting in the longitudinal movement of the linkage arms 52 to the right.

Obviously, since the movement of the lever arm or frame 42 would be prevented by the spring 44, the latter adjustment of the linkage arm 52 would cause the clockwise movement of the floating lever 50 about its pivotal connection 48 to the arm 42, causing a corresponding longitudinal movement of the servo-control valve member 56 to the right. Thus with the control valve member first in the neutral position, such adjustment of the servo-control valve member 56 would cause the opening of the port 61 to the inlet of the pressure medium provided through the port 60 causing a shifting of the piston 68 and the mechanical adjustment of the throttle 19 to a relative decreased open position and thereby decreasing pressure exerted at the intake manifold 20.

Thus is will be seen that there is provided automatic means for compensating for either an increase or decrease in the pressure at the intake manifold 20, so that a predetermined standard pressure condition may be approximated. Obviously, upon standard pressure conditions being approximated, the pressure responsive mechanism 53 will cause the adjustment of the servo-control valve member 56 to a neutral position.

It will be further seen that there has been provided adjustment means whereby the value of the predetermined standard pressure condition may be varied. Thus upon movement of the con-

trol lever 1, as shown in Figures 6 and 7, in a counter-clockwise direction, a clockwise movement of the main control shaft 6 will result, causing a corresponding clockwise movement of the walking beam 12 about its pivotal connection to the link 75 and causing in turn the clockwise movement of the throttle control shaft 16 so as to move the throttle 19 to a relative open position.

Furthermore, it will be seen that such adjustment of the control arm 1 will cause also the clockwise movement of the arm 8 and a corresponding clockwise rotation of the cams 33, 34, and 35, as viewed in Figure 6, for changing the datum or setting of the pressure responsive mechanism 53.

Pressure selection mechanism

The cams 33, 34 and 35 are operably connected to the adjustable frame or lever 42 through the cam follower members 39, 40 and 41 which project respectively from arm members 85, 86 and 87, shown in Figures 3, 6 and 10. The arm members 85, 86 and 87 are freely mounted respectively in spaced relation on the shaft 43. The frame or lever member 42 includes, as best shown in Figure 10, arm portions 88 and 89 provided at opposite ends of the shaft 43, and having the upper and lower ends thereof connected respectively by plates 90 and 91.

The upper ends of the arm members 85, 86 and 87 have end portions 92, 93 and 94 projecting laterally therefrom and arranged to contact the ends of adjustable screws 95, 96 and 97 which project through the top plate 90. The cam follower arms 85, 86 and 87 are spring loaded in a clockwise direction under the biasing force of spring fingers 98, 99 and 100, respectively. The spring fingers 98, 99 and 100, as shown in Figures 3, 10 and 11, project from a spring plate 101 fastened at opposite ends by bracket arms 102 and 103 which project from a bracket plate 104, as shown in Figure 4. The plate 104 is secured to the inner surface of the casing 7, by bolts 105 and 106, and dowel pins 107 and 108. There also projects from the plate 104 the fixed arm members 46 and 46A in which is screw threadedly engaged the opposite ends of the shaft 43, as best shown in Figure 3.

As thus shown, the spring fingers 98, 99 and 100 tend to bias the cam follower members 85, 86 and 87 in a clockwise direction into contacting relation with the adjustable screws 95, 96 and 97, respectively, projecting from the plate 90 of the frame or lever 42. The lever 42 is biased by the spring 44 in an opposite counter-clockwise direction, as viewed in Figure 10, but the force exerted by any one of the spring fingers 98, 99 and 100 through the cam follower arms 85, 86 and 87 exceeds the force exerted by the spring 44 on the plate 90 so that the frame 42 is biased in a clockwise direction under force of the same against the force exerted by spring 44.

It will be noted moreover, that the movement of the cam follower arms 85, 86 and 87 are limited by the cams 33, 34 and 35 which contact respectively the cam follower members 39, 40 and 41 so that the counter-biasing force exerted through any one cam follower arm and the position of the lever member 42 is dependent upon the cam surface controlling the controlling cam follower arm.

It will be noted, moreover, that as the lever member 42 moves in a clockwise direction, the pressure setting of the bellows 53 is increased. Thus the highest pressure setting is obtained at the lowest cam rise, while the lowest pressure setting results at the highest cam rise.

It will be readily seen from Figure 6 that as the control lever 1 is adjusted in a counter-clockwise direction the shaft 32 is adjusted in a counter-clockwise direction and thereby decreasing the cam rise of the respective cams 33, 34, and 35. The cam surfaces 36, 37 and 38 are arranged so as to provide a different cam rise program so as to effect a different program of pressure settings from the other cams, when brought into operating relation with the lever 42 through the cam follower arms 85, 86 and 87.

There is further provided novel means for selectively placing one or the other of the cams in an operating relation. The cam surface 38 of the cam 35 is arranged so as to provide the lowest cam rise or highest pressure setting program of the three cams, while the cam surface 36 of the cam 33 is arranged to provide the second highest pressure setting program or a pressure setting program higher than that set by the cam surface 37 of the cam 34.

As shown in Figures 6 and 10, the cam follower arm member 87 has a raised portion 109 arranged so as to be operably engaged by one end of a piston rod 110. The piston rod 110 is connected at the opposite end to a cup shaped piston 111 slidably mounted in a piston chamber 112 formed in the end wall of the casing 7.

A fluid pressure inlet passage 113 is formed in the end wall of the casing 7 and opens at one end into the piston chamber 112, while the opposite end of the passage 113 is controlled by a valve mechanism indicated generally by the numeral 114 so as to open and close the passage 113 to a suitable fluid medium under pressure such as oil under engine pressure and entering through a second passage 115 formed in the casing 7 and into which opens an oil pressure conduit 117 leading from the source of pressure. The latter fluid medium under pressure provides means for operating the piston 111. The cup shaped piston 111 has a restricted orifice 118 formed in the bottom thereof for draining the fluid medium from the cup shaped piston 111 into the interior of the casing 7, here the same is drained from the casing 7 through suitable passages not shown.

Thus upon the valve 114 being opened the fluid medium or oil under pressure passes through the passage 115, valve 114, passage 113 and into the piston chamber 112 biasing the piston 111 towards the left as viewed in Figure 6. The latter action of the piston 111 forces the free end of piston rod 110 into contact with the raised portion 109 of the cam follower arm member 87 forcing the arm 87 and cam follower member 41 out of contacting relation with the cam surface 38 of the cam 35 and in a counter-clockwise direction. During the latter action, as the biasing force exerted by the spring finger 100 on the lever 42 is removed, the frame or lever member 42 is biased under force of the spring 44 in a counter-clockwise direction following the movement of arm 87. When a point is reached where the end of the screw 95 contacts the projection 92 of the cam follower arm 85 such movement of lever 42 stops. Further movement of the frame or lever 42 is then prevented by the force exerted by the spring finger 98, which biases the cam follower arm 85 in a clockwise direction. The position of the cam follower arm 85 is determined by the cam surface 36 of the cam 33, which contacts the cam follower member 39 projecting from the arm 85.

The piston 111 thus under force of the fluid pressure biases the arm 87 to an inoperative position relative to the frame 42. However, upon the valve 114 being closed the spring finger 100 biases the piston 111 through arm 87 and rod 110 to a return position; the fluid medium within piston 111 being forced out through the restricted passage 118 under the biasing force of spring 100 and the cam follower arm 87 being biased to a position at which the cam follower member 41 once again contacts the cam surface 38 of cam 35. The passage 118, however, is sufficiently restricted as not to effect the position of the piston 111 upon the valve 114 being opened and the pressure medium or oil being exerted upon the piston 111 through the passage 113.

In the latter case upon the cam follower arm 87 being adjusted to an inoperative position, the cam follower arm 85 is placed in operative relation to the lever 42 as previously explained. The cam follower arm 85 has a raised portion 119 arranged so as to be operably engaged by one end of a piston rod 120. The piston rod 120 is connected at the opposite end to a cup shaped piston 121 slidably mounted in a piston chamber 122 formed in the end wall of the casing 7.

There is formed in the casing 7 a passage 123 opening into the chamber 122 for conducting a fluid medium under pressure such as oil under engine pressure into the piston chamber 123. The latter pressure medium is conducted to the passage 123 through a suitable conduit 124, as shown in Figure 7, having a slide valve 125 for controlling the application of pressure through said conduit 24 from a main pressure line 126 as will be explained.

Upon the valve 125 opening the conduit 124 to the pressure line 125, the fluid medium entering the piston chamber 122 through passage 123 will bias the piston 121 towards the left as viewed in Figures 2 and 6 causing the free end of the piston rod 120 to contact the raised portion 119 of the cam follower arm 85 forcing the arm 85 and cam follower member 39 out of contacting relation with the cam surface 36 of the cam 33 and in a counter-clockwise direction. During the latter action, as the biasing force exerted by the spring finger 98 on the lever 42 is moved, the frame or lever member 42 is biased under force of the spring 44 in a counter-clockwise direction following the movement of cam follower arm 85. When a point is reached where the end of the screw 96 contacts the projection 93 of the cam follower arm 86 such movement of lever 42 stops. Further movement of the frame or lever 42 is then prevented by the force exerted by the spring finger 99, which biases the cam follower arm 86 in a clockwise direction. The position of the cam follower arm 86 is determined by the cam surface 37 of the cam 34 which contacts the cam follower member 40 projecting from the arm 86.

The cup shaped piston 121 has a restricted passage 127 formed in the bottom thereof for draining the fluid medium from the piston 121 into the interior of the casing 7, where the same is drained from the casing 7 through suitable passages not shown. The passage 127, is however sufficiently restricted as not to effect the position of the piston 121 upon the valve 125 opening the conduit 124 to the pressure medium.

The piston 121, thus under force of the fluid pressure, biases the arm 85 to an inoperative position relative to the frame 42. However, upon the valve 125 closing the conduit 124 to the pressure medium in the line 126, the spring finger 98 biases the piston 121 through arm 85 and rod 120 to a return position, the fluid medium within piston 121 being forced out through the restricted passage 127 under the biasing force of spring 98 and the cam follower arm 85 being biased to a position at which the cam follower member 39 once again contacts the cam surface 36 of cam 33.

Upon both the cam follower arms 85 and 87 being placed in an inoperative relation to the lever 42, the cam follower arm 86 is placed in operative relation to the lever 42 and the cam surface 37 of cam 34 controls through cam follower member 40 the pressure setting of the bellows 53.

Moreover in the event the operating pressure medium is relieved from both pistons 111 and 121, then since cam surface 38 of the cam 35 has the lowest cam rise, the cam follower arm 37 will control over arms 85 and 86 which are controlled by the cams 33 and 34.

As shown in Figures 2, 3 and 6, there is further provided an adjustable pin 128 screw threadedly engaged in the wall of the casing 7 and having a cleft head portion 129 providing convenient means for adjustment. The pin 128 projects into the interior of the casing 7 and is arranged to contact at the inner end the arm 85 and thereby limit the extent of movement of the arm 85 in a pressure increasing direction.

A second adjustable pin 130 having a cleft head portion 131 is also screw threadedly engaged in the casing 7 and projects into the interior of the casing 7. The pin 130 is arranged to contact at its inner end the arm 86 so as to thereby limit the extent of movement of the arm 86 in a pressure increasing direction. The adjustable pins 128 and 130 thus provide convenient means for limiting the maximum pressure setting afforded by the arms 85 and 86, respectively. A cover cap 132 screw threadedly engaged in the casing 7 protects the adjustable pins 128 and 130 from accidental adjustment.

Water injection system

As best shown schematically in Figure 7, there is connected to the carburetor 27 a conduit 133 leading from a suitable source of fluid fuel for the aircraft engine. There is also provided a conduit 134 for injecting the fuel into the induction system through a nozzle 135. There is further provided a conduit 136 for injecting into the induction system through nozzle 135 a supplemental or so-called "anti-knock" fluid medium such as water, water-alcohol or other suitable fluid well known in the art for suppressing predetonation of the engine 24.

The conduit 136 is connected to a suitable metering device shown in dotted outline and indicated generally by the numeral 137. The latter metering device may be of a suitable type well known in the art for determining the rate of flow of the "supplemental" fluid, and, since the herein invention resides in the regulator means rather than in the metering device, the same has been shown diagrammatically by the outline indicated by numeral 137.

A conduit 138 leads to the metering device 137 from a suitable source of "supplemental" fluid indicated by numeral 139. In the conduit 138, there is provided a pump indicated by numeral 140 driven by a suitable power means not shown. The pump 140 supplies the fluid medium under pressure to the metering device 137. A valve 141 is provided in the conduit 138 between the pump and metering device 137 for "off" and "on" con-

trol of the "supplemental" fluid injection system. The control valve 141 may be of any suitable type, but is shown herein as of an electromagnet controlled type having an electrical control circuit 142 and switch 143 which is preferably mounted within the aircraft cabin for convenient operation by the pilot. Thus the supplemental fluid injection system may be placed in operation by the pilot closing the switch 143 so as to effect the opening of the valve 141. Conversely, the valve 141 may be closed by opening the switch 143. A by-pass conduit 144 and relief valve 145 is provided for recirculating the fluid medium from the pump outlet to the pump inlet at such times as the valve 141 is closed and the injection system is not in operation.

A conduit 146 is connected to the conduit 138 between the valve 141 and the metering device 137. The conduit 146 leads to the control valve 114 so that, during operation of the injection system, the control valve 144 is closed by the pressure of the supplemental fluid medium acting under force of the pump 25, as will be explained hereinafter. It will be readily seen that when the injection system is in operation the fluid medium will exert through the conduit 146 a greater pressure under force of the pump 140 than when the injection system is not in operation.

Control mechanism responsive to operation of water injection system

The control valve 114 includes, as shown in Figures 3 and 6, a plug 147 screw threadedly engaged in the casing 7 and projecting into the passage 115. The plug 147 has formed therein a passage 148 extending vertically therein and opening at the opposite ends of the plug 147. The plug 147 has lateral ports 149 formed therein and leading from the passage 115 into the vertical passage 148. A stem 150 is slidably mounted in the passage 148 and has a stem valve 151 at the lower end arranged upon the extreme inward adjustment of the stem 150 to close the lower end of the passage 148 to the passage of fluid medium from passage 115 to passage 113.

The upper end of the stem 150 has affixed thereto a head member 152. A spring 153 has one end bearing upon the plug 147 while the opposite end bears upon the head member 152 biasing the stem 150 in an upward direction as viewed in Figure 3. The head member 152 and spring 153 are positioned in a chamber 154 formed in the casing 7. Across the chamber 154 extends a diaphragm 155 clamped at the outer edge between the casing 7 and a cap member 156 fastened to the casing 7 by bolts 157. The cap member 156 has formed therein a recess 158 and opening into the recess 158 is the conduit 146.

The diaphragm has a button 159 which bears upon the head member 152 of the stem 150. A suitable orifice or passage 160 as shown in Figure 6, opens the chamber 154 to atmospheric pressure or other suitable reference pressure.

Thus upon operation of the water injection system there is effected an increase in the water pressure exerted in the chamber 158. The diaphragm under such increased pressure actuates the stem 150 so as to cause the valve stem 151 to close the lower open end of the passage 148, and thereby the passage 113 to the pressure medium.

The latter action as previously explained will release the pressure tending to hold the cam follower arm 87 in an inoperative position relative to lever 42, whereupon cam 35, through cam follower member 41 and lever 87 will control the pressure setting of the bellows 53 during operation of the water injection system.

Upon the valve 141 being closed by the pilot so as to terminate the operation of the water injection system, the pressure applied through conduit 146 will decrease whereupon the diaphragm 155 and valve stem 151 under force of the spring 154 will be forced upward in a direction opening the passage 113 to the fluid pressure medium in passage 115. The latter action will cause piston 111 to position the cam follower arm 87 to an inoperative position relative to the lever 42, as previously explained.

Control mechanism responsive to operating condition

As shown in Figure 7, there leads from the pressure conduit 124 which controls the operation of piston 121, a second conduit 160. The conduit 160 opens into a piston chamber 161 of a servo-motor 162. Slidably mounted in the piston chamber 161 is a piston 163 having a spring 164 biasing the same in one direction, while the fluid medium entering through the conduit 160 biases the piston 163 in the opposite direction. A conduit 165 leads from the servo valve 125 and opens at the other side of the piston 163.

A piston rod 166 extends from the piston 163 and operates an arm 167 of a change speed gear or variable speed hydraulic coupling 26 through which the engine 24 drives the supercharger 23.

The servo valve 125 has pressure outlet conduits 168 and 169 and may be manually operated by the pilot through a push rod 170 from the cabin of the plane.

When the valve 125 is shifted to the left as viewed in Figure 7, a fluid pressure medium such as oil under engine pressure may be applied through the conduit 165 to the lower side of the piston 163, whereupon the fluid medium at the upper side will exhaust through conduit 160 and outlet conduit 169.

The latter action causes the piston 163 to adjust the arm 167 in a clockwise direction to the position shown, at which position the supercharger 23 may be driven by shaft 25 through the variable speed coupling 26 at a relatively low speed ratio.

In the latter case, it will be seen that the conduits 124 and 160 are closed to the fluid pressure medium in the conduit 126 and the cam 33 will control through cam follower member 39 and arm 85 the pressure setting of the bellows 53 during the low speed operation of the supercharger 23.

Now upon the pilot shifting the valve 125 to the right as viewed in Figure 7, the fluid pressure medium supplied through conduit 126 will be applied through conduit 160 so as to shift the piston 163 downward and moving the arm 167 in a counter-clockwise direction.

The fluid medium at the lower side of the piston 163 will exhaust through conduit 165 and outlet conduit 168. The latter adjustment of the arm 167 will cause the variable speed coupling 26 to be shifted so that the supercharger may be driven by shaft 25 through the variable speed coupling 26 at a relatively high speed ratio.

Moreover, the fluid pressure medium when applied through conduit 160 will also cause a fluid pressure to be applied through conduit 124 and passage 123 forcing the piston 121 in a direction for actuating the cam follower arm 85 out of operative relation with the cam 33.

Thus with the water injection system, not in operation, and the supercharger 23 being driven at a high speed ratio, the cam 34 will control through arm 86 the pressure setting of the bellows 53.

The supercharger 23 is normally brought into high blower operation at relatively high altitudes, while low blower operation is effected at relatively low altitudes. It is desirable under such conditions to provide a relatively lower pressure setting at high altitudes, while a higher pressure setting is desirable at relatively low altitudes. Through the novel cam selection means provided herein, a higher pressure setting program is provided during low blower operation than during high blower operation.

In Figure 8, there is shown novel means for effecting such operation automatically. In the latter arrangement, there is provided a casing 171 open through a conduit 172 to atmospheric pressure. Mounted within the casing 171 is a bellows 173 of conventional type and operably connected so as to position the control valve 125. Thus at low altitudes the bellows 173 tends to collapse, moving the valve 125 so as to open conduit 165 to the fluid pressure medium in passage 126. This action causes the servo-motor 162 to adjust the variable speed coupling 26 so as to effect low speed operation of the supercharger 23. However, at a predetermined low atmospheric pressure or high altitude the bellows 173 expands sufficiently to adjust valve 125 so as to open conduit 160 to the pressure medium in conduit 126 and close conduit 165 to such fluid pressure.

Upon the latter operation the variable speed coupling is adjusted by the servo-motor 162 so as to effect high speed operation of the supercharger 23. In the latter event there will be applied a fluid pressure medium through conduit 124 to shift the low blower cam follower arm 85 out of operation, and the cam follower arm 86 into an operative relation with lever 42 during high blower operation.

Lock out limiting means

There is further provided means to lock out the automatic means, whereby upon adjustment of the main control lever 1 to a predetermined minimum standard pressure selecting position, the opening of the throttle 19 may be affected only by the manual adjustment of the control lever 1 without regard to the pressure existing at the intake manifold or the condition of the pressure responsive mechanism. This is specifically accomplished by providing an adjustable abutment rod 174 best shown in Figure 2 and explained in detail in the copending application of Howard A. Alexanderson Serial No. 508,724, filed November 2, 1943. The abutment rod 174 is screw threadedly engaged in the wall 79 and projects through the wall 79 into the bellows 76. A suitable cleft 175 is provided in the abutment rod 174 and is positioned exteriorly of the bellows 76 so that the abutment rod 174 may be conveniently adjusted longitudinally for calibration purposes. The abutment rod 174 is arranged so as to engage the plate 82 upon the pressure in the intake manifold decreasing to a predetermined low value equal to the critical standard value at which the automatic control for opening the throttle is to be discontinued and manual control alone remains.

A second abutment rod 176 is also mounted within the bellows 77 as shown in Figure 2, for the purpose of limiting the excessive expansion of bellows 76 and contraction of bellows 77 which might otherwise cause mechanical damage thereto.

There is further provided a third safety means for preventing the automatic opening of the throttle 19 past a predetermined maximum critical point, and the said safety means so arranged that such opening of the throttle past such point, may only be accomplished under the positive manual control of the lever 1.

This function is specifically accomplished by providing the bell crank lever 14, previously described, with a knocker arm 177 arranged for actuating the arm 178. The arm 178, as shown in Figures 2 and 6, is pivotally mounted at one end on an eccentric pin 179 carried by an adjustment screw 180. The adjustment screw 180 is screw threadedly engaged in the wall of the casing 7. The position of the arm 178 in relation to the knocker arm 177 may be conveniently adjusted for calibration purposes by means of the screw 180 which extends through the wall of the casing 7 to the exterior, as shown and described in detail in the copending application of Howard A. Alexanderson, Serial No. 508,724, filed November 2, 1943.

Carried by the arm 178 is a pin 18, on which is mounted a roller 182 arranged for engagement by the knocker arm 177, as shown in Figure 2. There further projects from the arm 178, a member 183 which is arranged to engage a valve actuating stop pin 184 slidably mounted within a sleeve member. The stop pin 184 projects through the sleeve into the valve sleeve 57 where it is adapted to engage in its inward position, the free end of the servo control valve rod 56. The pin 184 is normally biased by a spring 185 into a disengaging relation from the rod 56. In the latter position the pin 184 under the biasing force of the spring 185 actuates the arm 178 in a counter-clockwise direction against a stop pin 186 mounted in the wall 7. Upon the throttle 18 being opened to a predetermined point the bell crank lever 15 will be positioned so as to cause the knocker arm 177 to engage the roller 182 mounted on the arm 178. Continued clockwise adjustment of the bell crank lever 15 will cause arm 178 to actuate the pin 184 inward so as to prevent control valve rod 56 from being adjusted through the lever 50 to a position to the left of the neutral position. In the latter locked position a decrease in pressure at the intake manifold 20 would cause merely a contraction of the bellows 76 and the actuation of the lever 50 so as to cause the movement of the lever 42 in a counter-clockwise direction against the biasing force of the spring fingers 98, 99 or 100. Further clockwise movement of the bell crank lever 15 will cause the pin 184 to actuate valve rod 56 to the right of the neutral position and the piston 68 to the extreme left hand position shown, whereupon further opening of the throttle valve 19 may be directly effected by manual operation of lever 1.

Initial pressure setting and range adjustment

There is further provided novel range adjustment means in the form of the lever 50 which includes as shown in Figure 9, side plates 187 and 188 fastened together by members 189 and 190 at ears 59 and 55, respectively.

Positioned between the plates 187 and 188 is a central block member 191 having a slot 192 formed at the upper end and a slot 193 formed at the lower end. A member 194 is slidably mounted in the slot 192 and the same is fas-

tened at opposite ends to the plates 187 and 188. A similar member 195 is slidably mounted in the slot 193 and fastened at opposite ends to the plates 187 and 188.

A spring 196 is positioned between the member 195 and the block 191 and biases the block 191 in an upward direction as viewed in Figure 9.

An adjustable screw 197 having a cleft end portion 198 extends at an angle through the block 191 and an end 199 is arranged so as to contact the inclined surface of a plate 200 which projects from the plate 187 and is bent at an angle thereto.

A third ear 51 projects from the block 191 and is adjustably positioned in relation to the ears 49 and 55 by varying the adjusted position of the screw 198. Thus with the screw 197 at an extreme inward position the ear 51 will be adjusted downward toward the ear 49, since the screw 197 under the biasing force of the spring 193 will engage the plate 200 at a lower position than with the screw 197 adjusted more outwardly.

Through adjustment of the screw 197, the position of the ear 51 in relation to the ears 49 and 55 may be varied so as to adjust the pressure adjusting range of the bellows 53, since the position of the servo valve 56 relative to the bellows 53 and the extent of movement imparted to the servo valve for increment of movement of the bellows 53 is directly effected.

The pressure setting of one cam in relation to the others may be further conveniently adjusted by varying the relative position of the screws 95, 96 and 97 which determines the position of lever 42 relative to the cam follower arms 85, 86 and 87. The adjustable screws 95, 96 and 97, moreover, provide convenient means for making the initial adjustment for the low blower, high blower and water injection pressure programs respectively.

Casing structure

As shown in Figure 2, the casing 7 includes the three sections B, C and D.

The B section houses the pressure responsive bellows mechanism 53, the servo valve 56 and the servo-motor 65.

The C section houses the throttle control linkage and is fastened to the B section at one end thereof by bolts 201. A suitable sealing gasket 202 is positioned between the section B and C.

The D section houses the pressure setting mechanism and is fastened at the other end of the section B by bolts 203. A suitable sealing gasket 204 is positioned between the sections B and D.

A removable end plate 205 carrying the adjustable pins 128 and 130 is fastened to the section D by bolts 206. A sealing gasket 207 is positioned between the plate 205 and section D.

There is thus provided convenient means for effecting the assemblage in a unitary device of the control mechanism herein described.

Operation

The present invention provides novel means for control of various operating characteristics of aircraft engines and provides means specifically for controlling automatically two or more manifold pressure selection programs.

While the present embodiment of the invention is shown as applied to a single stage supercharger with a variable speed drive it will be readily apparent that the same may be also applied to (1) a single stage supercharger driven by a two speed engine; (2) a two stage supercharger with a two speed drive on the auxiliary stage or a variable speed drive; (3) an auxiliary stage turbo-driven supercharger or; (4) the invention may be applied as means for controlling automatically two or more selection programs.

As shown in Figure 6, the cam shaft 32 operated from the main control lever 1 may control any number of cams desirable for the various engine functions or manifold pressure programs. In the present embodiment of the invention, three such cams 33, 34, and 35 are shown. Each cam operates individual cam followers, indicated herein by the numerals 85, 86 and 87 which are spring loaded to the cams by separate finger springs 98, 99 and 100, respectively. A pressure adjusting lever 42 is biased under tension of a spring 44 into contacting relation with whichever of said cam followers is positioned so as to select the highest pressure setting.

The high blower cam follower 86 remains in contacting relation with its cam 34 during all operating programs. The low blower cam follower 85 and the water injection system cam follower 87 has hydraulic pistons 121 and 111, respectively, for releasing it from selecting or contacting its respective cam profiles.

In high blower operation, the low blower and water injection system cam followers 85 and 87 are released from contacting their cams 33 and 35 by operation of the pistons 121 and 111, and the high blower cam follower 86 is positioned by cam 34 so as to control the pressure adjusting lever 42.

During low blower operation, the low blower release piston 121 automatically allows follower 85 to contact the cam 33 and to control the position of the pressure adjusting lever 42. The low blower cam 33 thus controls through cam follower 85 and lever 42 the pressure setting throughout its range of operation. While the high blower cam follower 86 is in contacting relation with cam 34, the cam selecting the highest pressure setting controls the position of the lever 42.

Upon operation of the water injection system, the piston 111 automatically allows follower 87 to contact its cam 35. Cam 35 selects a higher pressure setting than the other cams. Thus, while all cams may be positioning their respective cam followers, the follower 87 under control of cam 35 calls for a higher setting than the others and therefore dominates the control of the pressure adjusting lever 42.

The low blower release piston 121 is operated by oil pressure to the oil pressure to the piston when the supercharger is operated at high blower. In low blower operation a control valve 125 is so arranged as to place the piston 121 under oil drain pressure so as to release the follower 85. The control valve 125 may be manually controlled as in Figure 7 or may be controlled by an atmospheric pressure or altitude responsive device as in Figure 8.

The piston 111 is operated by oil pressure applied to the piston 111 so as to maintain the follower 87 in an inoperative relation when the water injection pressure is off as during non-operation of the water injection system. This is accomplished by a diaphragm controlled valve 114. One side of the diaphgragm 155 is subjected to water pressure, the other side to atmospheric pressure or other suitable reference pressure. Upon the water injection system being placed in operation, the

increased water pressure causes the valve 114 to be closed so that the oil pressure is released from the piston 111 permitting the follower 87 to return to operating relation with cam 35.

However, upon the operation of the water injection system being discontinued the water pressure applied to the diaphragm 155 is released and the valve 114 is opened so that oil pressure may once again be applied to the piston 111 so as to place the follower 87 out of operating relation.

While hydraulic means has been shown for effecting the foregoing operation, it will be readily seen that the same may be also effected through electrically operated solenoids, air pressure or manual linkage and may be applied in selecting for electric, electronic or hydraulic control systems.

Graphical illustration of operation

In Figure 12, there is illustrated graphically the operating characteristics of a typical control mechanism embodying the aforenoted invention.

Line A of the above graph illustrates the pressure setting program of the high blower cam 34, which in the latter arrangement predominates until the pilot's control lever 1 is moved to a position corresponding to X. At the latter position, if the low blower lies in operation then the cam 33 will control along the line B as the throttle control lever 1 is adjusted to a further increased position.

However, if the low blower is not in operation then increasing the adjustment of the throttle control lever 1 will cause the pressure program to follow the line A until the point Y is reached. At the latter point, if the water injection system be in operation, then continued increased adjustment of the lever 1 will cause the pressure setting program as determined by the cam 35 to follow the line C.

Moreover, the low blower and water injection system, if both be in operation, then upon increased adjustment of the throttle control lever 1 past the point Z, the cam 35 will control and the pressure setting program will follow the line C.

Moreover the maximum setting of the cams 33 and 34 are limited by the pins 128 and 130 so that low blower and high blower pressure settings will follow the lines D and E respectively at the maximum adjustment of the same. The latter maximum adjustment may be varied by adjustment of the pins 128 and 130.

From the foregoing it will be seen that the cam in operating relation and setting the highest pressure will control. The line A indicates the pressure setting program of the cam 34; the line B indicated the pressure program of the cam 33; while the line C indicated the pressure setting program of the cam 35. Where the pressure setting program of one cam falls below that of the other, such other cam will control.

The relation of the several pressure setting programs may be, of course, varied within limits by adjustment of the screws 95, 96 and 97.

Although only two embodiments of the invention have been illustrated and described, various changes in the form and relative arrangements of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. A device of the character described, comprising, in combination, condition responsive means for automatically adjusting a control device, a first control member for adjusting the datum of said automatic means in accordance with a first predetermined program, a second control member for adjusting the datum of said automatic means in accordance with a different second predetermined program, and another condition responsive means for selectively placing said first and second control members in and out of operative relation with said automatic means.

2. A device of the character described, comprising, in combination, condition responsive means for automatically adjusting a control device, a first control member for adjusting the datum of said automatic means in accordance with a first predetermined program, a second control member for adjusting the datum of said automatic means in accordance with a different second predetermined program, another condition responsive means for selectively placing said first and second control members in and out of operative relation with said automatic means, and a single manually operable control lever means for simultaneously adjusting said first and second control members and selectively placing said first and second control members in an operative relation with said automatic means.

3. A device of the character described, comprising, in combination, condition responsive means for automatically adjusting a control device, a first control member for adjusting the datum of said automatic means in accordance with a first predetermined program, a second control member for adjusting the datum of said automatic means in accordance with a different second predetermined program, and atmospheric pressure responsive means for selectively placing said first and second control members in and out of operative relation with said automatic means.

4. A device of the character described, comprising, in combination, first condition responsive means for automatically adjusting a control device, first, second and third control members for adjusting the datum of said automatic means in accordance with predetermined programs, second condition responsive means for placing said second control member in and out of operating relation, third condition responsive means for placing said third control member in and out of operating relation, said second control member so arranged as to control the datum of said automatic means over said first control member, and said third control member so arranged as to control the datum of said automatic means over said first and second control members.

5. A device of the character described, comprising, in combination, first condition responsive means for automatically adjusting a control device, first, second and third control members for adjusting the datum of said automatic means in accordance with predetermined programs, second condition responsive means for placing said second control member in and out of operating relation, third condition responsive means for placing said third control member in and out of operating relation, said second control member so arranged as to control the datum of said automatic means over said first control member, and said third control member so arranged as to control the datum of said automatic means over said first and second control members, and manually operable means for simultaneously adjusting said first, second and third control members.

6. A device of the character described, comprising, in combination, first condition responsive means for automatically adjusting a control device, first, second and third control members for adjusting the datum of said automatic means in accordance with predetermined programs, second condition responsive means for placing said second control member in and out of operating relation, third condition responsive means for placing said third control member in and out of operating relation, said second control member so arranged as to control the datum of said automatic means over said first control member, and said third control member so arranged as to control the datum of said automatic means over said first and second control members, and manually operable means for simultaneously adjusting said first, second and third control members when in said operating relation so as to place the third and then the second of said members out of controlling relation with said automatic means.

7. A device of the character described, comprising, in combination, condition responsive means for automatically adjusting a control device, a control member for adjusting the datum of said automatic means, a plurality of cam members, means for adjusting said cam members, followers for said cams, first spring means for biasing said cam followers into contacting relation with said cam members, second spring means for biasing said control member into contacting relation with one of said cam followers, and actuating means for biasing said one cam follower out of contacting relation with one of said cams so that another of said cam followers may control the position of said control member.

8. A regulator for the induction system of a supercharged aircraft engine, comprising, in combination, a boost control for regulating said induction system so as to maintain the pressure thereof at a predetermined value, first means for changing the datum of said boost control in accordance with a first predetermined program, second means for changing the datum of said boost control in accordance with a different second predetermined program, and condition responsive means for selectively placing said first and second datum changing means in and out of operative relation.

9. The combination comprising a plurality of cams, follower elements for said cams, a pivotally mounted control member, first spring means biasing said cam follower elements into contacting relation with said cams, second spring means biasing said control member in an opposite direction into contacting relation with one of said cam follower elements, and means for actuating said one element out of contacting relation with said control member so as to permit another of said elements to control the position of said control member.

10. The combination comprising three cams rotatably mounted, follower elements for each of said cams, a pivotally mounted control member, first spring means biasing said cam follower elements into contacting relation with said cams, second spring means biasing said control member in an opposite direction, one of said cam follower elements limiting the movement of said control member in said opposite direction, motor means for releasably actuating the other of said follower elements out of limiting relation with said control member so as to permit the one remaining follower element to control the position of said control member.

11. A throttle control for supercharged aircraft engines, comprising a pilot's control lever, an induction throttle valve, means connecting said lever to said throttle valve, a boost control connected to said connecting means and arranged to vary the position of said throttle valve relatively to that of said control lever according to the intake manifold pressure of said engine, first means for changing the datum of said boost control in accordance with a first predetermined program, second means for changing the datum of said boost control in accordance with a different second predetermined program, means for operating said first and second datum changing means simultaneously by said pilot's control lever, and means for selectively placing said first and second datum changing means in and out of operative relation with said boost control in accordance with altitude.

12. A throttle control for supercharged aircraft engines, comprising a pilot's control lever, an induction throttle valve, means connecting said lever to said throttle valve, a boost control connected to said connecting means and arranged to vary the position of said throttle valve relatively to that of said control lever according to the intake manifold pressure of said engine, first means for changing the datum of said boost control in accordance with a first predetermined program, second means for changing the datum of said boost control in accordance with a different second predetermined program, means for operating said first and second datum changing means simultaneously by said pilot's control lever, and means for selectively placing said first and second datum changing means in and out of operative relation with said boost control in accordance with an operating condition of said engine.

13. In an aircraft internal combustion engine of the type including a carburetor for supplying a combustible mixture to said engine, a supercharger for supplying air to the induction system of said engine, operable means for injecting a supplemental fluid for suppressing predetonation of said engine, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, a pilot's control lever operably connected to said first and second datum changing means, and fluid pressure responsive means for placing the first of said datum changing means in control of said regulating means during the operation of said supplemental fluid injection means, and said fluid pressure responsive means arranged so as to place the second of said datum changing means in control of said regulating means upon cessation of operation of said supplemental fluid injection means.

14. In an aircraft internal combustion engine of the type including a carburetor for supplying a combustible mixture to said engine, a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, operable means for injecting a supplemental fluid for suppressing predetonation of said engine, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, third means for changing the da-

tum of said regulating means, a pilot's control lever operably connected to said first, second and third datum changing means, atmospheric pressure responsive means operatively connected to said speed changing means so as to change the driven speed of said supercharger from a first to a second driven speed at a predetermined atmospheric pressure, and said atmospheric pressure responsive means arranged so as to place the first of said datum changing means in control of said regulating means at the first driven speed and the second of said datum changing means in control of said regulating means at the second driven speed, and supplemental fluid pressure responsive means for placing the third of said datum changing means in control of said regulating means over said first and second datum changing means during operation of said supplemental fluid injection means.

15. In an aircraft internal combustion engine of the type including a carburetor for supplying a combustible mixture to said engine, a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, operable means for injecting a supplemental fluid for suppressing predetonation of said engine, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, third means for changing the datum of said regulating means, a pilot's control lever operably connected to said first, second and third datum changing means, manually operable means for changing the speed of said supercharger from a first to a second driven speed, and said manually operable means so arranged as to place the first of said datum changing means in control of said regulating means at the first driven speed and the second of said datum changing means in control of said regulating means at the second driven sped, and supplemental fluid pressure responsive means for placing the third of said datum changing means in control of said regulating means over said first and second datum changing means during operation of said supplemental fluid injection means.

16. In an aircraft internal combustion engine of the type including a carburetor for supplying a combustible mixture to said engine, a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, operable means for injecting a supplemental fluid for suppressing predetonation of said engine, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, third means for changing the datum of said regulating means, a pilot's control lever operably connected to said first, second and third datum changing means, control means for changing the speed of said supercharger from a first to a second driven speed, and said control means so arranged as to place the first of said datum changing means in control of said regulating means at the first driven speed and the second of said datum changing means in control of said regulating means at the second driven speed, and supplemental fluid pressure responsive means for placing the third of said datum changing means in control of said regulating means over said first and second datum changing means during operation of said supplemental fluid injection means.

17. In an aircraft internal combustion engine of the type including a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, said second means acting independently of said first means, a pilot's control lever operably connected to said first and second datum changing means, operable means connected to said speed changing means and arranged to change the driven speed of said supercharger from a first to a second speed, and said operable means arranged so as to place the first of said datum changing means in control of said regulating means at the first driven speed of said supercharger and the second of said datum changing means in control of said regulating means at the second driven speed of said supercharger.

18. In an aircraft internal combustion engine of the type including a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, and means for regulating the pressure in the induction system of said engine; the improvement comprising first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, said second means acting independently of said first means, a pilot's control lever operably connected to said first and second datum changing means, atmospheric pressure responsive means connected to said speed changing means and arranged to change the driven speed of said supercharger from a first to a second speed, and said atmospheric pressure responsive means arranged so as to place the first of said datum changing means in control of said regulating means at the first driven speed of said supercharger and the second of said datum changing means in control of said regulating means at the second driven speed of said supercharger.

19. In an aircraft internal combustion engine of the type including a carburetor for supplying a combustible mixture to said engine, a supercharger for supplying air to the induction system of said engine, means for changing the driven speed of said supercharger, operable means for injecting a supplemental fluid for suppressing predetonation of said engine, and means for regulating the pressure in the induction system of said engine; the improvement comprising a shaft, three cams mounted on said shaft, a pilot's control lever operably connected to said shaft, follower elements for each of said cams, a pivotally mounted frame for controlling the datum of said regulator, first spring means for biasing said cam follower elements into contacting relation with said cams, second spring means for biasing said control frame in an opposite direction, one of said cam follower elements limiting the movement of said control frame in said opposite direction, a first motor means for actuating another of the cam follower elements into an inoperative relation during operation of the supercharger at a first driven speed and into a position controlling the position of said control frame at a second driven speed, operable means for controlling the first motor means, a second

motor means for effecting movement of a third cam follower element into an operative and inoperative relation, supplemental fluid pressure responsive means for controlling the operation of said second motor means and so arranged as to cause said second motor means to effect movement of said third cam follower element into a position controlling the position of said control frame over said other cam follower elements during operation of the supplemental fluid injection means.

20. For use with an aircraft engine having a pilot's main control element; a regulator comprising, in combination, condition responsive means for automatically adjusting a control device of said engine, a first cam member for adjusting the datum of said automatic means in accordance with a first predetermined program governed by the position of said main control element, a second cam member for adjusting the datum of said automatic means in accordance with a different second predetermined program governed by the position of said main control element, and another condition responsive means for selectively connecting one or the other of said cam members in an operative relation with said automatic means.

21. For use with an aircraft engine having a pilot's main control element; a regulator comprising, in combination, condition responsive means for automatically adjusting a control device of said engine, a first cam member for adjusting the datum of said automatic means in accordance with a first predetermined program governed by the position of said main control element, a second cam member for adjusting the datum of said automatic means in accordance with a different second predetermined program governed by the position of said main control element, another condition responsive means for selectively placing one or the other of said cam members in an operative relation with said automatic means, and said first and second cam members being arranged for simultaneous adjustment and so as to selectively place one or the other of said cam members in an operative relation with said automatic means dependent upon the position of said main control element.

22. A regulator for the induction system of a supercharged aircraft engine, comprising, in combination, a boost control for regulating said induction system so as to maintain the pressure thereof at a predetermined value, first means for changing the datum of said boost control in accordance with a first predetermined program, second means for changing the datum of said boost control in accordance with a different second predetermined program, and condition responsive means for selectively placing said first datum changing means in and said second datum changing means out of operative relation.

23. For use with an aircraft engine having means for injecting a supplemental fluid for suppressing predetonation of said engine; means for regulating the pressure in the induction system of said engine including first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, a control member operably connected to said first and second datum changing means, means dependent upon the presence of a supply of said supplemental fluid for placing the first of said datum changing means in control of said regulating means during operation of said supplemental fluid injection means, and said last mentioned means arranged so as to place the second of said datum changing means in control of said regulating means only during cessation of operation of said supplemental fluid injection means.

24. For use with an aircraft engine having means for injecting a supplemental fluid for suppressing predetonation of said engine; means for regulating the pressure in the induction system of said engine including first means for changing the datum of said regulating means, second means for changing the datum of said regulating means, a control member operably connected to said first and second datum changing means, means for placing the first of said datum changing means in control of said regulating means only during operation of said supplemental fluid injection means, and said last mentioned means arranged so as to place the second of said datum changing means in control of said regulating means only during cessation of operation of said supplemental fluid injection means.

25. For use with an aircraft engine; a regulator, comprising, in combination, condition responsive means for automatically adjusting a control device for said engine, control means for said automatic means including a cam, a follower for said cam arranged to vary the datum of said regulator, means for adjusting said cam, and stop means for limiting the adjustment of said cam follower by said cam and hence variance in the datum of said regulator, and a second condition responsive means for biasing said stop means out of said limiting relation with said cam follower so as to thereby permit a further variance in the datum of said automatic means by adjustment of said cam.

26. For use with an aircraft engine; a regulator, comprising, in combination, condition responsive means for automatically adjusting a control device for said engine, control means for said automatic means including a cam, a follower for said cam arranged to vary the datum of said regulator means for adjusting said cam, and stop means for limiting the adjustment of said cam follower by said cam and hence variance in the datum of said regulator, and operator operative means for biasing said stop means out of said limiting relation with said cam follower so as to thereby permit a further variance in the datum of said automatic means by adjustment of said cam.

27. For use with an aircraft engine having an induction system; a boost regulator comprising power means for controlling the induction system of said engine, a pressure sensitive device for actuating said power means upon changes of pressure in the induction system so as to maintain a predetermined pressure condition, a boost selector, a cam adjustable in operation and connected to said boost selector, a follower element for said cam, spring means for biasing said cam follower element into contacting relation with said cam, said cam follower element operably connected to said pressure sensitive device for changing the datum thereof, stop means for limiting the adjustment of said cam follower element, and means for actuating said stop means out of said limiting relation with said cam follower element so as to thereby permit further adjustment of said follower element through operation of said cam to vary the datum of said pressure sensitive device.

28. For use with an aircraft engine; a regulator, comprising, in combination, an adjustable cam, a follower element for said cam, a member

for changing the datum of said regulator, spring means for biasing said cam follower element into contacting relation with said cam, another spring means for biasing said member in an opposite direction and into contacting relation with said cam follower element, stop means for limiting the adjustment of said element by said cam and condition responsive means for biasing said stop means out of limiting relation with said element so as to permit an additional range of adjustment of said member under the biasing force of said first mentioned spring means upon further adjustment of said cam.

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The following references are of record in the file of this patent:

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