Sept. 19, 1944. F. W. TRUESDELL 2,358,363

CONTROL FOR INTERNAL-COMBUSTION ENGINES OR THE LIKE

Filed Nov. 7, 1942 2 Sheets-Sheet 1

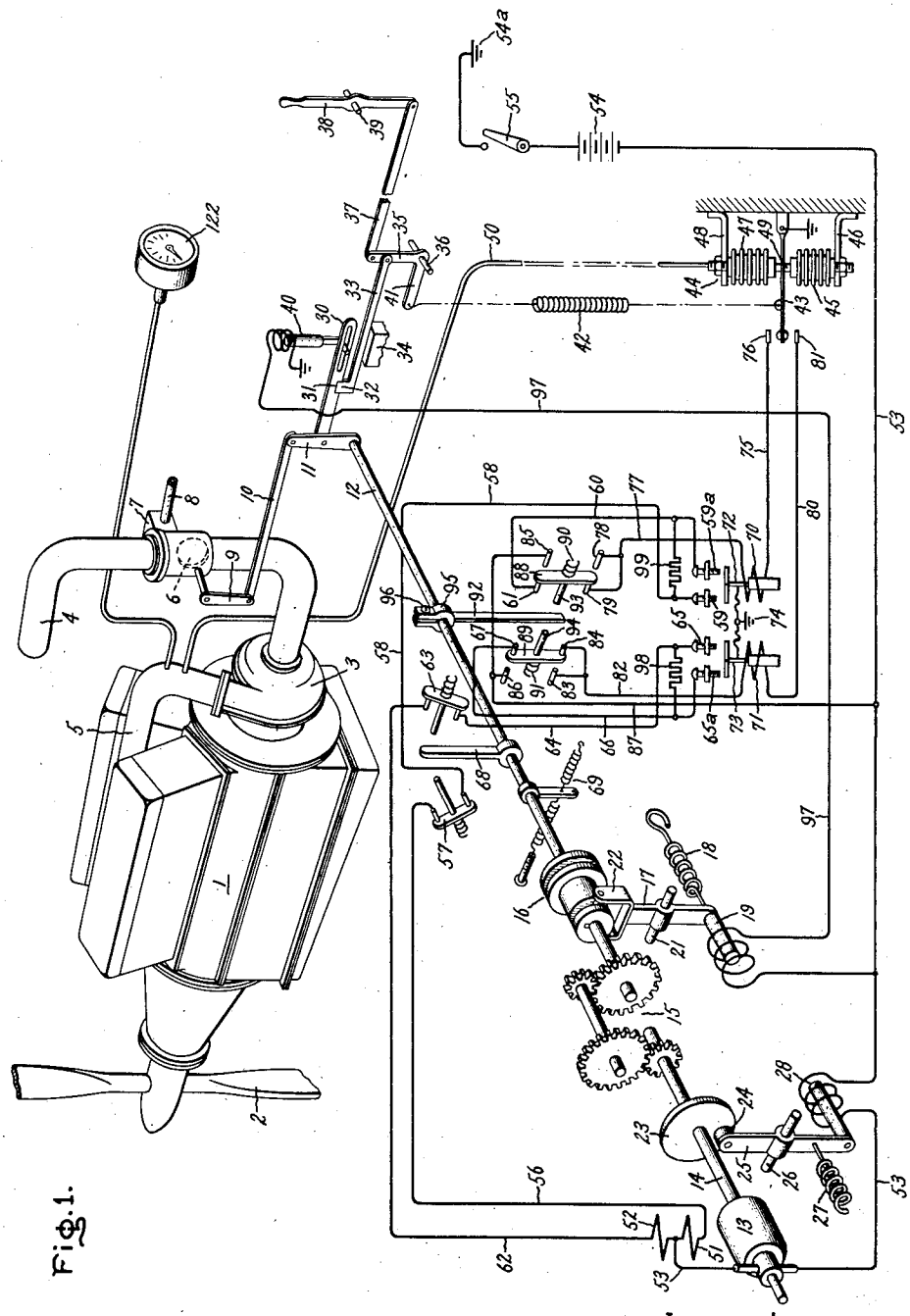


Fig. 1.

Inventor:
Francis W. Truesdell,
by Harry E. Burnham
His Attorney.

Sept. 19, 1944. F. W. TRUESDELL 2,358,363

CONTROL FOR INTERNAL-COMBUSTION ENGINES OR THE LIKE

Filed Nov. 7, 1942 2 Sheets-Sheet 2

Fig. 2.

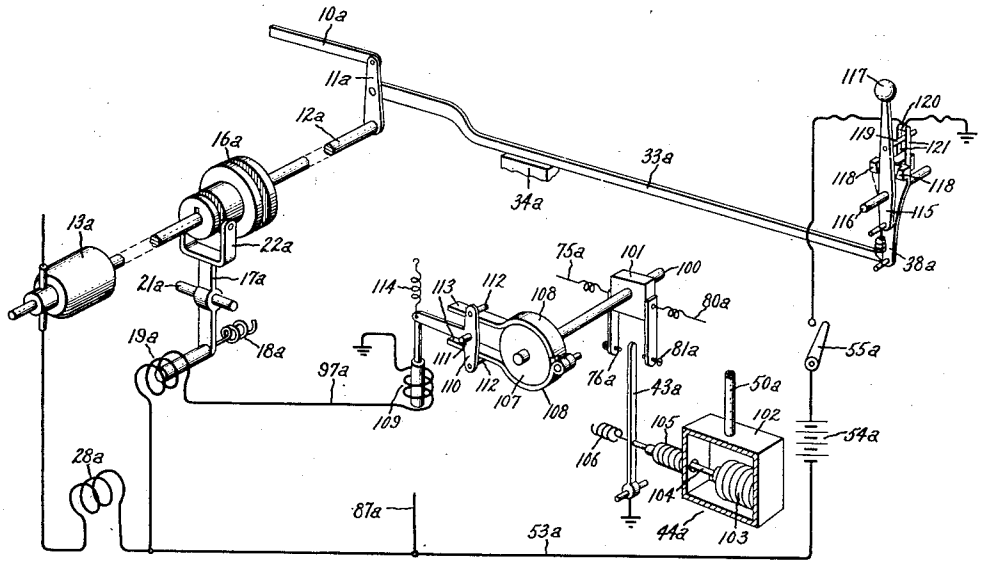
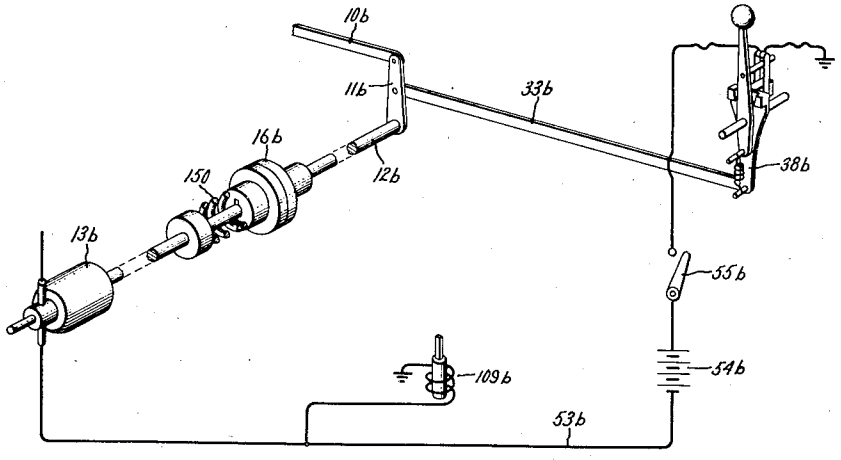


Fig. 3.



Inventor:
Francis W. Truesdell,
by Harry E. Dunham
His Attorney.

Patented Sept. 19, 1944 2,358,363

UNITED STATES PATENT OFFICE

2,358,363

CONTROL FOR INTERNAL-COMBUSTION ENGINES OR THE LIKE

Francis W. Truesdell, Marblehead, Mass., assignor to General Electric Company, a corporation of New York

Application November 7, 1942, Serial No. 464,882

21 Claims. (Cl. 123—102)

The present invention relates to control arrangements for internal combustion engines or the like. It is especially useful in connection with aircraft internal combustion engines and it is this application of my invention which I have elected to illustrate and describe. It is to be understood, however, that this is only by way of example and that the invention may be used wherever found applicable.

An object of my invention is to provide an improved construction and arrangement for adjusting automatically the throttle valve or other regulating means of an engine, such as an internal combustion engine, in response to changes in an operating condition of the invention, such as, for example, changes in engine intake manifold pressure, to maintain such operating condition at a desired value.

For a consideration of what I believe to be novel and my invention, attention is directed to the following specification and the claims appended thereto.

In the drawings, Fig. 1 is a diagrammatic view of an embodiment of my invention, and Figs. 2 and 3 are diagrammatic views of modifications.

Referring to the drawings, 1 indicates an internal combustion engine, which may be an aircraft engine driving a propeller 2. At 3 is indicated a gear driven supercharger for the engine having its inlet connected to an air supply conduit 4 and its outlet connected to the engine intake conduit or manifold 5. In conduit 4 is a throttle valve 6 which controls the flow of air and fuel to the intake manifold. A carburetor is indicated at 7 and a fuel supply pipe at 8. Air to the carburetor may be obtained from any suitable source, for example, a ram facing into the slip stream of the aircraft with which conduit 4 is connected. On the spindle of throttle valve 6 is fixed an arm 9 through which the throttle valve is adjusted.

According to one embodiment of my invention, I provide a control system whereby throttle valve 6 may be manually controlled or whereby it may be automatically controlled by means responsive to an operating condition of the engine. Preferably, I control the throttle valve by the pressure in manifold 5 to maintain constant the manifold pressure and it is this application of my invention which I have elected to specifically illustrate and describe.

Arm 9 is connected by a link 10 to an arm 11 fixed on a rotatable shaft 12 whereby as shaft 12 is oscillated in one direction and the other, the throttle valve 6 is opened and closed. Shaft 12 is driven by a reversing motor 13, the shaft 14 of which is connected to shaft 12 through a suitable reduction gearing 15 and a clutch 16. Clutch 16 is actuated by a lever 17 to one end of which is connected a spring 18 which biases the clutch to open position. It is adapted to be closed by a solenoid 19, the plunger of which is connected to lever 17. When the winding of solenoid 19 is energized, clutch 16 is closed against the action of spring 18. When the solenoid 19 is deenergized, spring 18 opens the clutch. Lever 17 is shown as being fulcrumed at 21 and it is provided at its one end with a fork 22 having inwardly directed pins which engage in a groove in the clutch collar. The clutch member with which the pins on fork 22 engage is keyed to its shaft but is adapted to slide axially thereon to permit the engagement and disengagement of the clutch. Fixed on motor shaft 14 is a brake disk 23 adapted to be engaged by a friction brake member 24 on one end of a lever 25. Lever 25 is pivoted at 26 and is biased to a position wherein friction brake member 24 engages disk 23 by a spring 27. The brake member is adapted to be released by a solenoid 28, the plunger of which is connected to the other end of lever 25.

Pivotally connected to arm 11 is a link 30 having in one edge a notch 31 adapted to fit over a head 32 on the end of a sliding link 33 which slides across a fixed block 34. Link 33 is pivotally connected to one arm 35 of a bell crank lever pivoted at 36. Also connected to lever arm 35 is a rod 37 which at its other end is pivotally connected to the lower end of manually operable control lever 38 pivoted at 39. When notch 31 engages head 32, throttle valve 6 may be moved by means of hand lever 38, a movement toward the left acting to move valve 6 toward closed position and a movement toward the right acting to move valve 6 toward open position. Link 30 is adapted to be moved to disconnect it from link 33 by a solenoid 40, the plunger of which is provided with a pin which engages in an elongated slot in link 30. Link 30 is biased to a position wherein notch 31 engages head 32 by its weight. With this arrangement, when solenoid 40 is energized, hand lever 38 is disconnected from the throttle valve. When solenoid 40 is deenergized, it is connected to the throttle valve.

The other arm 41 of the bell crank lever is connected through a tension spring 42 to the movable contact arm 43 of an absolute pressure responsive device 44. The absolute pressure responsive device is shown diagrammatically as comprising an evacuated bellows 45 carried on

a fixed support 46 and a second opposed bellows 47 carried on a fixed support 48, the free ends of the two bellows being connected by a pin 49, which pin in turn is connected to contact arm 43. The interior of bellows 47 is connected by a pipe line 50 to intake manifold 5 at a point beyond gear driven supercharger 3. The pressure responsive device 44 responds, therefore, to the absolute pressure in the intake manifold. An increase in pressure acts in a direction to move contact arm 43 down and a decrease in pressure permits spring 42 to move it upward. The tension spring 42 may be set for different manifold pressures by hand lever 38.

Motor 13 has two windings, a winding 51 which when energized effects turning movement of shaft 12 in a direction to open valve 6 to increase the pressure in manifold 15, and a winding 52 which operates the motor to turn shaft 12 in a direction to move valve 6 toward closed position to decrease the manifold pressure. The common terminal of motor windings 51 and 52 is connected by a conductor 53 through a source of electrical energy 54 to ground at 54a, such circuit including the winding of solenoid 28 and a main control switch 55 located in the vicinity of hand lever 38 so that it may be opened and closed by the operator. The other terminal of motor winding 51 is connected by conductor 56 to one terminal of a limit switch 57, the other terminal of which is connected by a conductor 58 to one contact 59 of a pair of relay contacts, the other contact 59a of the pair being connected by a conductor 60 to a switch contact 61. Similarly the other terminal of motor winding 52 is connected by a conductor 62 to one terminal of a limit switch 63, the other terminal of which is connected by a conductor 64 to one contact 65 of a pair of relay contacts, the other contact 65a of the pair being connected by a conductor 66 to a switch contact 67. Limit switches 57 and 63 are adapted to be opened by an arm 68 fixed on shaft 12 and turning with it. Connected with shaft 12 is a spring structure 69 which acts to bias shaft 12 to a predetermined position, for example, to a position in which valve 6 is open or to a position in which it is partially open. The limit switches are biased to closed positions by suitable springs, as is indicated diagrammatically in the drawings. Contacts 59, 59a and 65, 65a are contacts of relays 70 and 71, respectively, the cores 72 and 73 of which are grounded, as indicated at 74. When energized, relay 70 engages contacts 59 and 59a and relay 71 engages contacts 65 and 65a. The winding of relay 70 is on one side connected by a conductor 75 to control contact 76 and on the other side by a conductor 77 to a pair of spaced contacts 78 and 79. Similarly, one side of the winding of relay 71 is connected by a conductor 80 to control contact 81 and on the other side by a conductor 82 to a pair of spaced contacts 83 and 84. Opposite contacts 61 and 67 are contacts 85 and 86 which are connected by conductors 87 and 53 to source 54. Contacts 61, 79 and 85, 78 are adapted to be bridged by connector 88, the connector when in one position bridging contacts 61 and 79 and when in the other position bridging contacts 85 and 78. Similarly, contacts 67, 84 and 86, 83 are adapted to be bridged by a connector 89, the connector when in one position bridging contacts 67 and 84 and when in the other position bridging contacts 86 and 83. Connector 88 is biased into engagement with contacts 61 and 79 by a spring 90 and connector 89 is biased into engagement with contacts 67 and 84 by a spring 91. Connectors 88 and 89 are adapted to be moved from the one set of contacts into engagement with the other set of contacts by an arm 92 which engages pins 93, 94 carried by connectors 88 and 89, respectively. The arm is provided with a head 95 which engages shaft 12 and is frictionally clamped thereto by a screw 96. The screw 96 is adjusted so that frictional contact between the head and shaft 12 is such that when shaft 12 turns, arm 92 moves with the shaft until arm 92 engages one or the other of the pins 93, 94 and moves connector 88 or 89 into engagement with its other set of contacts after which shaft 12 will turn in head 95, arm 92 remaining stationary.

The windings of solenoids 19 and 40 are connected in a circuit in series with each other and with source 54 by conductors 97. At 122 is a pressure gauge which is connected to manifold 5 for indicating the pressure in the manifold. Connected across contacts 65, 65a is a resistance 98 and similarly connected across contacts 59, 59a is a resistance 99.

The operation is as follows: Assume that the engine is operating with manual control, the parts being in the positions shown in Fig. 1. By moving lever arm 38 the operator can control the engine manually in the usual manner, adjusting the throttle valve 6 for the desired intake manifold pressure, using gauge 122 to direct him. Such movement of lever arm 38 adjusts also the tension of spring 42 to set the pressure regulator for a corresponding pressure but this has no immediate effect.

Now if it is desired to utilize the automatic control, switch 55 is closed. When switch 55 is closed, a circuit is closed on the windings of solenoids 19 and 40 by conductors 53 and 97 whereupon solenoid 19 effects engagement of clutch 16 and solenoid 40 lifts link 30 to disengage notch 31 from head 32, thus disconnecting the manual control. If at this time the pressure in manifold 5 is that for which pressure regulator 44 is set, then contact arm 43 will stand midway between contacts 76 and 81, as shown in the drawings. If now the pressure in the intake manifold increases, contact arm 43 will move into engagement with contact 81. This closes a circuit on the winding of relay 71 as follows: From ground 54a, switch 55, conductor 53, winding of solenoid 28, motor winding 52, conductor 62, limit switch 63, conductor 64, resistance 98, conductor 66, connector 89, conductor 82, winding of solenoid 71, conductor 80, contact 81 and contact arm 43 to ground, causing the relay to pick up and engage contacts 65 and 65a. The circuit just traced includes motor winding 52 and the winding of solenoid 28. However, these windings are of relatively low resistance and few turns as compared to the winding of relay 71 which is of relatively high resistance and many turns so that neither the motor nor the brake is affected when this solenoid winding circuit is closed.

Relay contact 65 controls an operating circuit for motor 13 and relay contact 65a controls a short-circuiting circuit for short-circuiting the winding of relay 71. Contacts 65 and 65a are adjustable relatively to each other. They are adjusted to give the desired period of closing for the motor circuit. They may be adjusted so that the bridging member of relay 71 engages first the short-circuiting relay contact 65a and then the motor circuit contact 65, so that it engages contacts 65a and 65 simultaneously, or so that it en-

gages contact 65 prior to its engagement with contact 65a. In the drawings, contact 65a is shown as being so adjusted that the bridging member of relay 71 engages it prior to the time it engages contact 65 (the bridging member may have sufficient flexibility or be otherwise arranged to permit of its engaging the contacts successively) but this is only by way of example.

When the bridging member of relay 71 engages contact 65a, a circuit is closed in shunt to the winding of relay 71 as follows: source 54, conductor 53, solenoid winding 28, motor field winding 52, conductor 62, limit switch 63, conductor 64, resistance 98, and contact 65a to ground 74. As a result, the winding of relay 71 is deenergized and the relay is free to drop to open position. Here again, the circuit just traced includes the winding of solenoid 28 and the field of motor 13. However, resistance 98 is of a value such that the solenoid 28 and the motor 13 will not be operated.

When the relay bridging member engages contact 65, it closes a motor and brake circuit as follows: source 54, conductor 53, winding of brake solenoid 28, motor winding 52, conductor 62, limit switch 63, conductor 64, and contact 65 to ground 74. Thus the full voltage of source 54 is applied to the solenoid and motor windings effecting release of the brake and starting the motor to operate in a direction to move throttle valve 6 toward closed position to effect a decrease in the manifold pressure.

With the above described arrangement, it will be seen that when the circuit on the winding of relay 71 is closed and the relay operates, two things occur: the motor circuit is closed by the one relay contact and a shunt circuit is closed around the relay winding by the other relay contact. As a result, the relay immediately returns to open position, opening the motor circuit. As soon as relay 71 moves to open position, the shunt around the winding of the relay is opened and the relay is again energized to again connect the motor in circuit and the cycle just described is repeated. Thus the motor circuit is successively closed for short intervals to successively start and stop the motor, the throttle valve being moved by successive small movements toward open position.

With contacts 65 and 65a adjusted as shown, the engagement of the bridging member of solenoid 71 with contact 65 is effected due to the inertia of the moving parts, the winding of the solenoid being actually deenergized prior to the time the bridging member engages contact 65. Contacts 65 and 65a are so adjusted relatively to each other that the motor circuit is closed for the desired length of time. Preferably, the arrangement is such that the relay operates at relatively high speed. For example, it may be closed for an interval of the order of 1/60 to 1/100 second. The arrangement may be such that brake solenoid 28 does not have time to re-engage between relay operations. Thus the brake is held released and the motor circuit is closed for successive short intervals to effect successive small movements of valve 6.

The relay functions in substance to form a speed reducing means for motor 13 whereby it may be operated at a fraction of its normal speed. By way of example, in the case of a motor having normal speed with full voltage continuously applied of the order of 4 R. P. M., I may, in effect, by applying to it successive short current impulses by the means described, reduce its speed to a value of the order of one-half R. P. M. The resistance 98, in addition to preventing full voltage being applied to motor 13 to prevent operation of it when the short-circuiting circuit for the winding of relay 71 is closed prior to the closing of the motor circuit, performs also the function of tending to prevent arcing at the contacts.

After the motor has turned shaft 12 a predetermined amount, arm 92 engages pin 94 to move connector 89 from engagement with contacts 87 and 84 and into engagement with contacts 86 and 83. This then closes a circuit directly on the winding of solenoid 71 as follows: source 54, conductors 53, conductor 87, contacts 86, 83, conductor 82, winding of solenoid 71, conductor 80, contact 81 and contact arm 43 to ground, thus maintaining the solenoid winding continuously energized. The motor circuit is now held permanently closed by solenoid 71 and the motor will operate continuously at its full speed until such time as valve 6 has been opened an amount to decrease the pressure in manifold 5 to a value such that pressure responsive device 44 moves contact 43 out of engagement with contact 81. When this occurs, the various parts are restored to their normal positions.

If a decrease in manifold pressure occurs, contact arm 43 is moved into engagement with contact 76 whereupon an operation similar to that just described takes place through actuation of relay 70, motor winding 51 being energized to effect operation of motor 13 in the opposite direction to effect an opening movement of throttle valve 6 to increase the pressure in intake manifold 5. The circuits for relay 70 and motor winding 51 are similar to those already described for relay 71 and motor winding 52 and will be clear from an inspection of the drawings.

At any time, the operator can set the pressure regulator 44 for a higher or lower intake manifold pressure by moving hand lever 38 in a direction to increase or decrease the tension of spring 42. When the tension of spring 42 is changed, immediately control arm 43 engages either contact 76 or 81 to cause actuation of the throttle.

By the foregoing arrangement, it will be seen that when regulator 44 calls for an adjustment of the throttle valve, in the first instance the valve is given a number of successive small movements, i. e., a number of successive jogs toward open or closed position, as the case may be. If there has been but a small departure in the manifold pressure from the desired value, then one or more small jogs may be sufficient to restore the pressure and bring contact arm 43 to normal position where it is out of engagement with contacts 76 and 81. On the other hand, if there has been a substantial departure from the desired manifold pressure, then when several successive jogs have failed to restore the pressure, the motor is connected permanently in circuit to effect continuous movement of the throttle valve until such time as the pressure is restored to the desired value. Ordinarily, when this occurs, the pressure will move beyond the desired value, bringing the contact arm 43 out of engagement with the one contact 76 or 81 and into engagement with the other of these contacts, whereby the throttle valve will be given a series of successive jogs in the other direction. In other words, the pressure will overshoot so that a restoring in the opposite direction is required. This serves to effect a more prompt return of the pressure to the desired value and gives stability in operation. When the motor

circuit is opened at the end of an interval of operation, the brake member 24 engages brake disk 23 to quickly stop the motor 13. This serves to prevent the motor from overtraveling or drifting.

At any time, the operator may restore the mechanism to manual operation by opening switch 55. When switch 55 is opened, clutch solenoid 19 is deenergized, permitting the clutch to open whereupon spring structure 69 turns shaft 12 to a predetermined position, thus setting valve 6 at a predetermined point. For example, spring structure 69 may be arranged to move throttle valve 6 to idling position or substantially idling position. After the operator has opened switch 55, he moves hand lever 38 to a position wherein notch 31 drops over head 32, if this has not already occurred when switch 55 was opened and shaft 12 turned by spring structure 69. The operator can now control the throttle manually in the usual way.

As stated above, the successive increments of movement imparted to motor 13 by the successive closings of its circuit by solenoids 70 and 71 amounts in substance to operating the motor through a reduction speed gearing. It has the advantage that by adjusting contacts 59, 59a or 65, 65a relatively to each other, the amount of the speed reduction in either direction can be adjusted accurately and in small steps.

In Fig. 2 is shown a modification wherein the operator first sets the throttle valve manually for a desired intake manifold pressure after which he may change to automatic pressure control to maintain automatically the intake manifold pressure for which the throttle has been set. If the operator desires to hold automatically a manifold pressure other than that for which valve 6 was set manually, then he changes from automatic to manual control, resets the throttle valve to give the desired intake manifold pressure and again shifts back to automatic control. In Fig. 2, reference characters the same as those used in Fig. 1 with the exponent *a* added have been used to designate corresponding parts.

At 100 is a shaft mounted in suitable bearings, not shown, and adapted to turn about its longitudinal axis. Carried by shaft 100 is a block of insulation 101 on which are mounted the two adjustable contacts 76a and 81a and between which stands the contact arm 43a connected to an absolute pressure responsive device 44a here shown in the form of a sealed casing 102 with which the pressure pipe 50a leading from the engine manifold is connected and in which is located an evacuated bellows 103, the stem 104 of which extends out through an opening in casing 102 and is connected to contact arm 43a. The opening in casing 102 through which the stem passes is sealed by means of a flexible extensible sleeve 105 which at one end is attached to casing 102 and at the other end to the stem 104. At 106 is a spring which opposes movement of bellows 103. Fixed on shaft 100 is a disk 107 which is located between a pair of straps 108 which are pivoted to each other and are adapted to be pulled together to clamp disk 107 to hold shaft 100 stationary by means of the plunger of a solenoid 109. In the present instance, this is accomplished by a bell crank lever 110 pivoted at 111 and provided with pins 112 which stand on opposite sides of spaced arms 113 on straps 108. When solenoid 109 is energized, its plunger moves downward, turning bell crank lever 110 to force arms 113 toward each other, and thus causing straps 108 to clamp disk 107. The plunger of solenoid 109 is biased to a position wherein straps 108 do not clamp disk 107 by a spring 114. The winding of solenoid 109 is in circuit 97a in series with the winding of clutch solenoid 19a, arm 11a is connected directly to hand lever 38a by link 33a.

Associated with hand lever 38a is a switch means so arranged that whenever the hand lever is moved, the main circuit including conductor 53a is opened. To this end, I have shown in the present instance an arm 115 which is pivoted at 116 and has a knob 117 by means of which it is moved. It lies between and in spaced relation to two projections 118 on lever 38a. On arm 115 is a pin 119 which stands between a pair of separable contacts 120 carried by spring arms 121 located in circuit 53a. Normally contacts 120 are in engagement with each other. Whenever arm 115 is moved in either direction to effect movement of hand lever 38a, the contacts 120 are first separated by the initial movement of arm 115 after which the arm engages a projection 118 to move lever 38a. The lost motion between arm 115 and projections 118 is sufficient to insure separation of contacts 120 prior to any movement of lever 38a.

When main switch 55a in circuit 53a is open, the throttle valve is under direct control of hand lever 38a, clutch 16a being open. The operator by adjusting lever 38a may adjust the throttle for the desired intake manifold pressure, the pressure being shown on the manifold pressure indicator. The intake manifold pressure is applied to absolute pressure gauge 103 through pipe 50a causing bellows 103 to assume a position corresponding to the pressure. As bellows 103 moves, the contact arm 43a engages either contact 76a or contact 81a, effecting turning movement of shaft 100 and bringing contacts 76a and 81a to a predetermined position corresponding to the intake manifold pressure. Shaft 100 can turn readily at this time since solenoid 109 is deenergized so that clamps 108 do not clamp disk 107.

If now the operator desires to operate with automatic control, he closes the switch 55a. This effects energization of solenoids 19a and 109. Energization of solenoid 19a closes clutch 16a, and energization of solenoid 109 causes straps 108 to clamp disk 107, thus clamping contacts 76a and 81a in the position to which they have been moved by arm 43a, this being a position which corresponds to the manifold intake pressure. Now as the intake manifold pressure departs from the desired value, contact 43a is moved into engagement with either contact 76a or contact 81a, effecting adjustment of the throttle valve through operation of motor 13a in the manner already described in connection with the operation of Fig. 1. When switch 55a is closed, if contact arm 43a is in engagement with either contacts 76a or contacts 81a, there will be an initial small adjustment of the throttle valve to effect the positioning of contact arm 43a so that it stands between contacts 76a and contacts 81a, being out of engagement with each. As shaft 12a turns, hand lever 38a moves with it since it is directly connected to shaft 12a by arm 11a and link 33a.

Without further attention from the operator, the intake manifold pressure for which contacts 76a and 81a are positioned will be automatically maintained. If now the operator desires to increase or decrease the intake manifold pressure, he has merely to grasp knob 117 to adjust

lever 38ª to move the throttle valve in the desired direction. Initial movement of lever 115 effects separation of contacts 120, thus opening circuit 53ª and deenergizing solenoids 19ª and 109. This serves to open clutch 16ª and release shaft 100. The operator can now move lever 38ª through the intermediary of lever 115 to change the position of the throttle valve so as to bring the intake manifold pressure to the desired value. At this same time, contacts 76ª and 81ª will be adjusted in the manner already described to a position corresponding to the new intake manifold pressure. After the throttle has been adjusted for the new intake manifold pressure, the operator releases lever 115 whereupon it immediately returns to its central position between projections 118, permitting contacts 120 to again close, thus closing the main circuit through conductor 53ª and again energizing solenoids 19ª and 109. The mechanism will now operate automatically to maintain the new intake manifold pressure.

With the above described arrangement, it will be seen that the operator manually adjusts the throttle valve for the intake manifold pressure at which he desires to run the engine, after which the mechanism automatically maintains such pressure.

In Fig. 3 is shown another modification of my invention wherein the solenoid 40 of Fig. 1 or 40ª of Fig. 2 is omitted, the link 33ᵇ corresponding to link 33 of Fig. 1 and 33ª of Fig. 2 being connected directly to shaft 12ᵇ and throttle lever link 10ᵇ, thereby doing away with the releasable connection between links 30 and 33 of Fig. 1 or links 30ª and 33ª of Fig. 2. In the Fig. 3 arrangement, there is substituted for the solenoid actuated clutch of Fig. 1 or Fig. 2 a friction clutch 16ᵇ which is biased toward closed position by a spring 150. Clutch 16ᵇ is held closed with sufficient friction so that when motor 13ᵇ, corresponding to motor 13 of Fig. 1 or motor 13ª of Fig. 2, is operated, it can effect adjustment of the throttle valve, at the same time effecting adjustment of manual lever 38ᵇ. At any time, the operator can adjust the throttle manually by means of lever 38ᵇ, the adjustment taking place in opposition to the friction of clutch 16ᵇ. In other words, clutch 16ᵇ is capable of being readily slipped by means of the hand lever. Otherwise, the arrangement shown in Fig. 3 may be the same as that shown in either Fig. 1 or Fig. 2 and the same reference characters with the exponent b added have been applied to corresponding parts. Only sufficient of the mechanism is shown in Fig. 3 to illustrate the modified parts. The application of the Fig. 3 modification to either the Fig. 1 system or the Fig. 2 system will be obvious from the description already given.

By my invention, I provide an automatic throttle control, the use of which is optional with the operator and which is capable of maintaining a desired intake manifold pressure with a high degree of accuracy. At the same time, the apparatus is simple in structure and reliable in operation.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination with an internal combustion engine having an intake conduit and a throttle valve for controlling flow of combustible mixture to said intake conduit, of manual means for positioning said valve, automatic means responsive to engine intake pressure for positioning said valve, means for transferring from manual to automatic control at will, and means responsive to movement of said manual means for adjusting the setting of said automatic means.

2. The combination with an internal combustion engine having an intake conduit and a throttle valve for controlling flow of combustible mixture to said intake conduit, of manually operable lever means for positioning said valve, automatic means responsive to engine intake pressure for positioning said valve, means for disconnecting said lever means from the valve and connecting said automatic means thereto, and means for setting the automatic means for the desired intake pressure.

3. In combination, an engine, regulating means controlling the output of the engine, an electric motor for positioning said regulating means, manual means for positioning said regulating means, circuit closing means responsive to an operating condition of the engine, and circuits connecting said circuit closing means to said motor, said circuits including a motor circuit and means for closing said motor circuit for successive spaced intervals of time to impart to said regulating means successive adjustments.

4. In combination, an engine, regulating means controlling the output of the engine, an electric motor for positioning said regulating means, circuit closing means responsive to an operating condition of the engine, and circuits connecting said circuit closing means to said motor comprising a motor circuit, a relay circuit for closing the motor circuit, means for effecting successive operations of the relay circuit, and means operated by the motor after a predetermined number of successive operations of the relay circuit for effecting continuous operation of the relay circuit.

5. The combination with an internal combustion engine having regulating means, of automatic means responsive to an operating condition of said engine for positioning the regulating means comprising means for initially imparting to said regulating means a plurality of successive small adjustments which, if insufficient, are followed by a greater adjustment.

6. The combination with an internal combustion engine having an intake throttle valve, of automatic means responsive to engine intake pressure for positioning said valve comprising means which on a departure of engine intake pressure from a desired value effects initially a plurality of successive small adjustments of said valve followed by a greater adjustment if the initial adjustments are insufficient to restore the intake pressure to the desired value.

7. The combination with an engine and regulating means for controlling the output of the engine, of automatic means responsive to an operating condition of the engine which upon departure of said operating condition from a desired value first imparts to said regulating means a plurality of small successive adjustments which if insufficient to restore said operating conditions to the desired value is followed by continuous adjustment until such desired value is restored.

8. The combination with an engine and regu-

lating means for controlling the output of the engine, of a motor for moving said regulating means, a device responsive to an operating condition of said engine, and means connecting said device to said motor to impart to said motor a plurality of small successive actuations followed by continuous actuation.

9. The combination with an internal combustion engine having an intake throttle valve, of a shaft connected to the valve for moving it, a reversing electric motor for turning the shaft, circuits for operating the motor in each direction, means responsive to engine intake pressure for effecting successive closings of said motor circuits of short durations, and means actuated by turning movements of the shaft for effecting closings of said motor circuits of longer duration.

10. The combination with an internal combustion engine having an intake throttle valve, of a shaft connected to the valve for moving it, a reversing electric motor for turning the shaft, motor circuits, a pressure responsive device connected to the engine intake, a circuit closer actuated by the pressure responsive device, a pair of relays, circuits connecting the relay windings to the circuit closer, each relay having a contact in a motor circuit and a contact for short-circuiting its winding whereby the relays may effect successive closings of the motor circuits.

11. In combination, an engine, regulating means for controlling the output of the engine, a shaft for positioning said regulating means, a reversing electric motor for moving said shaft, circuits for operating the motor in each direction, means responsive to an operating condition of the engine for effecting successive closings of said motor circuit of short durations, and means actuated by turning movements of the shaft for effecting closings of said motor circuits of longer durations.

12. The combination with an internal combustion engine having an intake throttle valve, of a shaft connected to the valve for moving it, a reversing electric motor for turning the shaft, motor circuits, a pressure responsive device connected to the engine intake, a circuit closer actuated by the pressure responsive device, a pair of relays, circuits connecting the relay windings to the circuit closer, each relay having a contact in a motor circuit and a contact for short-circuiting its winding whereby the relays may effect successive closings of the motor circuits, and means effective after said shaft has moved a predetermined amount for rendering ineffective the contacts for short-circuiting the relay windings.

13. In combination, an engine, regulating means for controlling the output of the engine, a shaft for positioning said regulating means, a reversing electric motor for moving said shaft, circuits for operating the motor in each direction, a control member moved in response to changes in an operating condition of the engine, a circuit closer actuated by said control member, a pair of relays, circuits connecting the relay windings to said circuit closer, each relay having a contact in a motor circuit and a contact for short-circuiting its winding whereby the relays may effect successive closings of the motor circuits.

14. In combination, an engine, regulating means for controlling the output of the engine, a shaft for positioning said regulating means, a reversing electric motor for moving said shaft, circuits for operating the motor in each direction, a control member moved in response to changes in an operating condition of the engine, a circuit closer actuated by said control member, a pair of relays, circuits connecting the relay windings to said circuit closer, each relay having a contact in a motor circuit and a contact for short-circuiting its winding whereby the relays may effect successive closings of the motor circuits, and means effective after said shaft has moved a predetermined amount for rendering ineffective the contacts for short-circuiting the relay windings.

15. In combination, an internal combustion engine, means for controlling the fuel supply thereto, a hand lever for positioning said means, automatic means responsive to changes in an operating condition of the engine for positioning said means, and means connecting automatic means to said hand lever for adjusting the setting of said automatic means whereby when said hand lever is moved to position said first-named means, it simultaneously adjusts the setting of said automatic means.

16. The combination with an internal combustion engine having fuel regulating means, of an electric motor for positioning said regulating means, control contact means actuated by a control force appurtenant to an operating condition of the engine, and means whereby said control contact means when actuated by changes in the value of said force effects initially slow adjustment of said regulating which, if insufficient, is followed by more rapid adjustment.

17. An internal combustion engine having a fuel regulating means, an automatic control actuated by an operating condition of said engine, adjustable means for varying the setting of said automatic control, a single hand lever, and means connecting the hand lever to both said adjustable means and the fuel regulating means whereby by means of the hand control the fuel regulating means and the adjustable means may be simultaneously positioned.

18. An internal combustion engine having a throttle valve for regulating the fuel supply thereto, automatic means responsive to intake manifold pressure for positioning said throttle valve, adjustable means for setting said automatic means for a desired intake manifold pressure, a single hand lever, and means connecting it to said throttle valve and to said adjustable means for simultaneously positioning said throttle valve and setting means.

19. An internal combustion engine having a throttle valve for regulating the fuel supply thereto, automatic means responsive to intake manifold pressure for positioning said throttle valve, adjustable means for setting said automatic means for a desired intake manifold pressure, a single hand lever, means connecting it to said throttle valve and to said adjustable means for simultaneously positioning said throttle valve and setting means, and means whereby after being set, said automatic means regulates said throttle valve independently of said hand lever.

20. An internal combustion engine having a throttle valve for regulating the fuel supply thereto, a motor for positioning the throttle valve, a pressure responsive device, means for setting it for a desired pressure, means connecting the pressure responsive device to said motor to effect adjustment of said throttle valve in response to changes in the pressure applied to said pressure responsive device, a hand lever, and means connecting it to said throttle valve and to

said setting means for positioning them simultaneously.

21. An internal combustion engine having a throttle valve for regulating the fuel supply thereto, a motor for positioning the throttle valve, a pressure responsive device, means for setting it for a desired pressure, means connecting the pressure responsive device to said motor to effect in response to changes in the pressure applied thereto initially a slow adjustment of said throttle valve which, if insufficient, is followed by a more rapid adjustment of said throttle valve, a hand lever, and means connecting it to said throttle valve and to said setting means for positioning them simultaneously.

FRANCIS W. TRUESDELL.

DISCLAIMER

2,358,363.—*Francis W. Truesdell*, Marblehead, Mass. CONTROL FOR INTERNAL-COMBUSTION ENGINES OR THE LIKE. Patent dated Sept. 19, 1944. Disclaimer filed Mar. 18, 1947, by the assignee, *General Electric Company*.

Hereby enters this disclaimer to claims 15, 17, 18, 19, and 20 of said patent.

[*Official Gazette April 15, 1947.*]

DISCLAIMER

2,358,363.—*Francis W. Truesdell*, Marblehead, Mass. CONTROL FOR INTERNAL-COMBUSTION ENGINES OR THE LIKE. Patent dated Sept. 19, 1944. Disclaimer filed Mar. 18, 1947, by the assignee, *General Electric Company*.

Hereby enters this disclaimer to claims 15, 17, 18, 19, and 20 of said patent.

[*Official Gazette April 15, 1947.*]