June 2, 1942. E. SCHIMANEK 2,284,687

MEANS FOR CONTROLLING THE CHARGE OF INTERNAL COMBUSTION MOTORS

Filed Sept. 26, 1936 2 Sheets-Sheet 1

Fig. 1

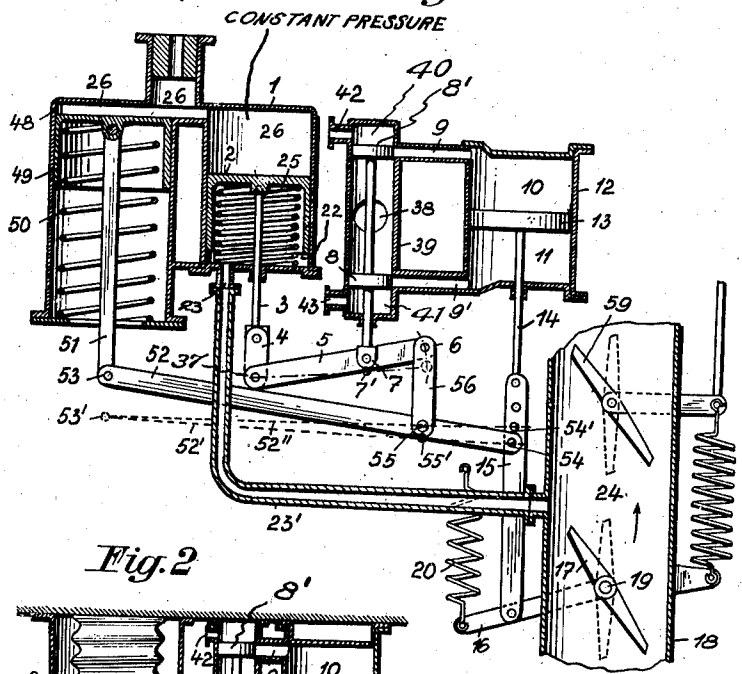
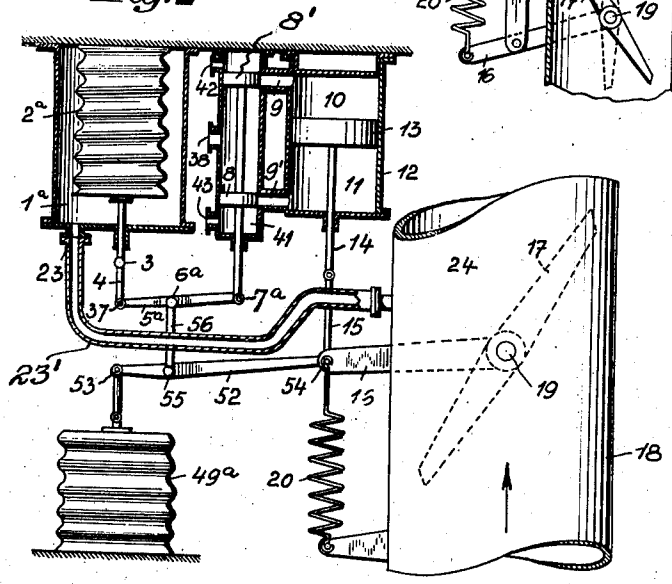


Fig. 2



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Fig. 3

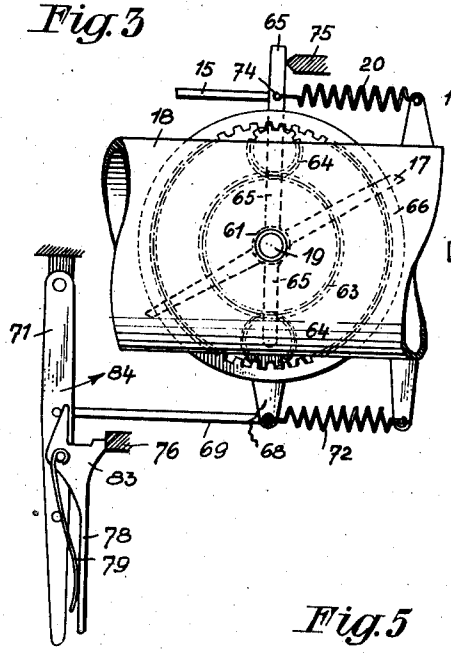


Fig. 4

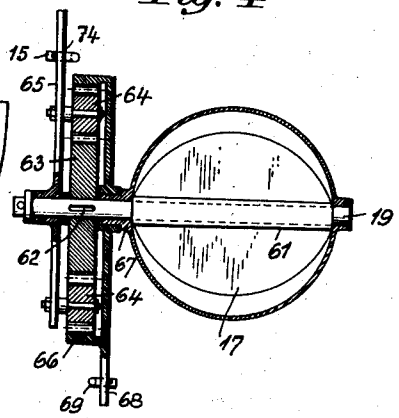
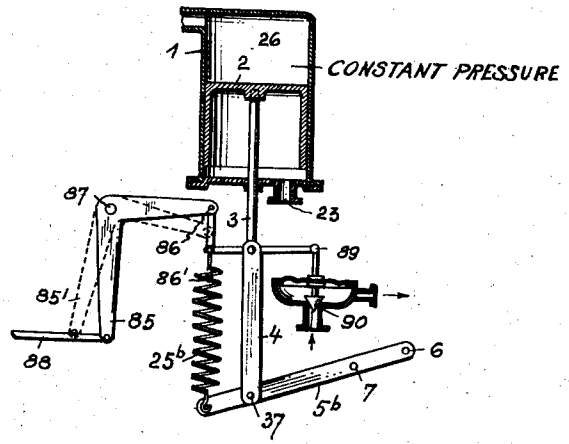


Fig. 5



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Patented June 2, 1942 2,284,687

UNITED STATES PATENT OFFICE

2,284,687

MEANS FOR CONTROLLING THE CHARGE OF INTERNAL COMBUSTION MOTORS

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Application September 26, 1936, Serial No. 102,808
In France October 1, 1935

9 Claims. (Cl. 123—103)

This invention relates to apparatus for automatically limiting the charging pressure of aircraft engines at different flying altitudes and has for its object to provide improved means for effecting such regulation. As is well known, the degree of admission in the case of internal combustion engines is proportional to the charging pressure, the term charging pressure being used to denote the pressure obtaining in the induction pipe of the engine. It is necessary to limit the degree of admission to aircraft engines designed for flying at high altitudes, since the atmospheric pressure or density varies very considerably according to the elevation, and if the engine is designed to receive a normal charge at high altitudes it would take in a greater weight of air at lower altitudes, so that a dangerous and injurious overcharging of the engine would occur when flying near the earth. The invention provides for effecting automatic limitation of the charging pressure. The means used for this purpose according to the invention differs from that adopted in any known type of apparatus for the same purpose, in that according to the invention the regulation is effected on the one hand by atmospheric pressure and on the other hand by the pressure in the induction pipe of the engine.

The apparatus forming the subject-matter of the present invention is characterized by the essential feature that the regulation is effected in two phases, namely by a rough regulation and by a fine regulation. The basic or approximate regulation (coarse regulation) is effected by the atmospheric pressure, while the fine regulating, which is complementary to the coarse regulating, is effected by the charging pressure to be regulated. Thus the atmospheric pressure and charging pressure co-operate to effect the regulation. The invention ensures reliable and rapid functioning of the regulating device, with the result that the length of time for which the engine is overcharged is considerably shortened.

The means for carrying out the invention consist of two regulator members which are subjected to the action of a constant pressure, and which both control the pressure in the induction pipe of the engine, through the intermediary of means acting in the manner of a servo-motor, to limit the degree of admission to the engine.

Forms of construction of regulating apparatus embodying the invention are shown in the appended drawings by way of example, in which:

Fig. 1 shows one form of construction employing piston regulating members.

Fig. 2 shows a modified form using aneroid regulating members.

Figs. 3 and 4 are two views of a composite throttle valve and its actuating means.

Fig. 5 shows further features of the throttle control means according to the invention.

Fig. 1 of the drawings illustrates a constructional example in which the regulating action is initiated by the co-operation of a constant fluid pressure on the one hand with the atmospheric pressure then prevailing and on the other hand with the charging pressure, and by the movement of the regulating members brought about on disturbance of the equilibrium. The automatic limitation of the charging pressure (pressure in the induction pipe of the engine) can be effected by means of a throttle valve provided in the induction pipe. An essential requirement in such charge regulators is that the pilot shall be free to throttle the charge at will but not to increase the charge beyond a predetermined limit. The regulating apparatus is thus required to limit only the maximum charging pressure.

Referring to Fig. 1, there are provided two throttle valves of which the valve to be operated by the pilot is denoted by **59**, and the valve controlled by the automatic regulator by **17**. The valve **17** is operated on the one hand by a member which responds to altitude, and which effects a coarse regulation, and on the other hand by a second regulating member (fine regulation) which only serves the purpose of correcting or supplementing the coarse regulation.

In the constructional example shown in Fig. 1 there is disposed in a cylinder **1** a piston **2** which is forced upwards by a spring **25**. This piston is mechanically connected to a piston valve at the point **7**, through the intermediary of a rod **3**, links **4**, and a lever **5**. The piston valve comprises two pistons **8** and **8'** connected by a rod and the pistons are adapted to move in a cylinder **39** to which oil or the like is supplied under pressure through the port **38**, while the chambers **40** and **41** of this cylinder communicate through passages **42**, **43** with return flow pipes for the oil or the like medium. The piston valve controls the supply of oil to the chambers **10** and **11** of a cylinder **12** through the conduits **9** and **9'** and also the escape of oil from the cylinder **39** through the passages **42**, **43**.

In the cylinder **12** there works a piston **13** which is moved in either direction by the pressure of the oil. This piston **13** actuates in its turn, through the intermediary of a rod **14**, a link **15**, an arm **16**, the throttle valve **17** which is pivoted by a shaft **19**, and which serves for the automatic limiting of the degree of admission to the engine. The chamber **22** of the cylinder **1** beneath the piston **2** is connected by means of a pipe union **23** and a pipe **23'** with the chamber **24** in the induction pipe **18** behind the throttle valve **17**. In the chamber **26** of the cylinder **1**

there is set up in any desired manner a constant pressure of oil or the like.

In the cylinder **48** there is arranged a piston **49** which is forced upwards by a spring **50**. From above this piston is loaded, like the piston **2** in the cylinder **1**, with a pressure (of oil or the like) which is maintained constant.

The piston **49** is connected by means of a link **51**, a lever **52**, a link **56**, and the lever **5**, to the piston valve. The lever **52** is coupled, at the right-hand end, to the link **15** by means of a pin **54**.

With this form of construction the regulating apparatus works as follows: When the aircraft ascends the atmospheric pressure decreases. The difference between the atmospheric pressure bearing against the under side of the piston **49**, on the one hand, and the constant oil pressure in the chamber **26**, on the other hand, therefore corresponds to the difference between the atmospheric pressure at the ground level and that at the altitude of flight.

The oil pressure in the chamber **26** then presses the piston **49** downwards, compressing the spring **50**. The spring **50** is so designed that at a given atmospheric pressure it becomes compressed approximately to the extent to which the piston **49** has to adjust itself in order to impart to the automatic throttle valve **17** an angular adjusment in the direction of opening, which is necessary to maintain the required degree of admission, in spite of the fact that the atmospheric pressure is reduced according to the altitude attained.

This adjustment of the throttle valve is effected as follows: At the moment at which the piston **49** descends the pin **53** assumes the position **53'**, the lever **52** swinging the pivot point **55** downwards about the pin **54** into the position **55'**. The pistons **8** and **8'**, in consequence of the connection between the levers **5** and **52**, are thus pulled downwards by the link **56** to an extent corresponding to the movement of the pivot point **7** to the position indicated at **7'**. By this movement of the piston **8** the conduit **9'** is opened, and the oil under pressure passes into the chamber **11** of the cylinder **12** and pushes the piston **13** upwards. In its movement the piston **13** pulls the rod **14** and the link **15** upwards, with the result that the pin **54** engaging the link **15** moves to **54'** and the lever **52** assumes the position indicated in a dotted line at **52''**. These movements have the result that the pivot point **55** is brought back from its position **55'** into its original position **55**. By this latter movement equilibrium is re-established under the condition that the automatic throttle valve assumes a position which ensures the maintenance of the desired pressure in the chamber **24**.

The piston **2** plays no part in the above described operation so long as a supplementary regulation is not necessary.

In order to obtain this result, however, a sensitive and empirical adjustment of the connecting links would be required. For this reason the regulating is always effected in such a manner that, when the piston **49** is in a position corresponding to a certain definite altitude, the automatic throttle valve **17** is opened somewhat wider than is necessary. A pressure greater than that required is thereby set up in the induction pipe **18** at the point indicated at **24**.

When such conditions exist the supplementary regulating system comes into action. Owing to the excess pressure at **24** the piston **2** is pressed upwards, and thereby effects, through the intermediary of the connecting parts, an upward movement of the piston valve so as to open the conduit **9** to pressure from the port **38**. The oil under pressure is thereby brought to bear upon the upper side of the piston **13**, and depresses this latter, with the result that the automatic throttle valve is actuated in the direction of closure, this continuing until the pressure at **24** has been restored to the desired value.

The invention thus includes two control systems of which one responds and comes into action independently of the other and in harmony with the alteration of different factors, but both have the effect of actuating the throttle valve **17** and of bringing the same into a certain definite position.

This system is essentially different from the known systems in whch either the atmospheric pressure alone or the charging pressure alone adjusts the throttle valve.

In order to elucidate this difference, the same regulating apparatus is shown in Fig. 2 equipped with aneroid boxes. The place of the piston **2** in the cylinder **1** is taken by a box **2a** which is filled with air at a pressure equal to that at which the charging pressure is to be limited. The box is housed in a chamber **1a** to which the pressure in the induction pipe at **24** is transmitted through the pipe line **23'** and connection **23**. The place of the piston **49** is in this case taken by the aneroid box **49a** which is filled with air at atmospheric pressure. Otherwise there is no change in the construction as compared with that shown in Fig. 1.

The mode of operation is as follows: As the aircraft ascends the atmospheric pressure decreases. The box **49a** expands upwards, and thereby moves the lever **5a** upwards about the pivot point **37**, by virtue of the fact that the lever **52** rocks upwards about the pivot point **54**. The piston valve ascends, and admits oil under pressure through the conduit **9** above the piston **13** into the chamber **10**, with the result that the piston **13** is moved downwards and the valve **17** opened. Since this opening movement—as already mentioned—is excessive the charging pressure at **24** becomes too great. This pressure compresses the box **2a** in the chamber **1a** with the result that the lever **5a** is pivoted about the point **6a** and the point **7a** moved downwards. The conduit **9'** for the oil under pressure is thereby opened, the piston **13** moved upwards, and the throttle valve **17** turned in the direction of closure until the pressure in the space **24** and in the chamber **1a** communicating therewith has attained the desired value.

The advantages of the two-stage regulation according to the present invention over the hitherto known devices for the same purpose are the following:

With the known forms of apparatus when manoeuvring the aircraft the regulating takes place in certain cases slowly, with the result that the engine is overcharged for a considerable length of time, bringing about an excessive pressure in the combustion chamber, which is dangerous to the life of the engine. The following case may be taken for purposes of illustration: The aircraft is assumed to be flying at low altitude, and the pilot is assumed to have reduced the degree of admission to the engine by means of the manually operated throttle valve **59**, since this is rendered necessary by the particular manoeuvre he is carrying out. With

the known types of apparatus the automatic throttle valve 17 is opened, and in fact fully opened. As soon as the pilot opens the throttle valve 59 to obtain full admission, the charge flows in unrestricted, since both throttle valves are fully open, and the engine will be overloaded as long as the automatic regulating device does not close the throttle valve in proportion to the atmospheric pressure prevaling at the time. The engine is thus unnecessarily and dangerously overcharged until the pressure in the space 24 has become re-adjusted to the desired value.

With the apparatus according to the present invention, on the other hand, when the same manoeuvre is carried out the automatically operated throttle valve is only opened to the extent to which it is re-adjusted by the means effecting the fine regulation. This throttle valve is at all events never moved beyond the position determined by the coarse regulating means (in dependence on atmospheric pressure), so that no appreciable overcharging of the engine can occur.

In accordance with the invention there may be employed an automatically operated throttle valve which is independent of the manually operated throttle valve, or a single combined throttle valve. In the former case the manually operated throttle valve should be disposed behind the throttle valve effecting automatic limiting of the supply of mixture, considered in the direction of flow of the mixture (see Figs. 1 and 2).

Figs. 3 and 4 show an example of a combined throttle valve in accordance with the last-mentioned case. The throttle valve 17 disposed in the pipe 18 is rigidly connected with the spindle 19. The spindle 19 is adapted to be rotated by a gear wheel 63 keyed at 62 to the shaft 19. Two planet wheels 64 rotatably arranged on a lever 65 are in mesh on the other hand with the gear wheel 63 and on the other hand with an internally toothed wheel 66 which is rotatable about the spindle 19 independently of this latter. The lever 65, with the planet wheels 64, is freely rotatable on the spindle 19.

The toothed wheel 66 is connected with the hand lever 71 through the intermediary of the lug 68 and the rod 69. A spring 72 pulls the toothed wheel 66 in the direction corresponding to the opening of the throttle valve 17, the throttle valve 17 being adjusted in the desired position by the hand lever 71. The movement of this lever 71 is limited by a stop 76 with which an arm 83, of a lever 78 subject to the action of the spring 79, comes into contact.

The lever 65 that carries the planet wheels 64 is pivotally connected at 74 to the rod 15 which is connected with the piston 13.

The spring 20 is attached to the lever 65 and acts upon the throttle valve 17 through the intermediary of the lever 65, the planet wheels 64, and the gear wheel 63 in the opening direction, the movement of the lever 65 in a clockwise direction being limited by the stop 75. This arrangement ensures a combined action of the regulating means for the air and gas supply arbitrarily through the lever 71 and automatically through the regulating device.

In Fig. 3 of the drawings the actuating lever 71 is shown in the position corresponding to the maximum opening of the throttle valve limited by the regulating device.

An extraordinary necessity may however arise for a momentary overcharging of the engine notwithstanding the automatic limitation of the supply of gas thereto. In order therefore to increase the output of the engine a device is provided to enable the lever 71 to be shifted out of the position shown in the drawings in the direction of the arrow 84, and thereby to enable the throttle valve 17 to be opened further. For this purpose the lever 78 is depressed against the action of the spring 79, with the result that the arm 83 of this lever is brought out of reach of the stop 76.

In consequence of this increased opening of the throttle valve 17 a greater pressure will adjust itself in the induction pipe when the aircraft is flying near the ground. Consequently the automatic regulating means will come into action for the purpose of re-adjusting the prescribed pressure. There will therefore happen just what must be avoided under these circumstances, since it is desired to increase this pressure by 20–25%, or more.

In order to obtain the desired result, the arrangement shown in Fig. 5 may be adopted.

With this arrangement the spring 25b forces the piston 2 upwards by means of the lever 5b. This spring however is not secured to a fixed point but to a movable point 86 of a bell-crank lever 85 which is pivoted on a fixed pin 87. The lever 85 is connected by means of a rod 88 with the hand lever 71 in such a manner that, when the lever 71, for the purpose of overcharging the engine, is moved in the direction indicated by the arrow 84, the bell-crank lever 85 assumes the position 85' shown in broken lines. The point 86 is thereby moved into the position 86', with the result that the tension of the spring 25b is relaxed. In this manner the spring loses its effect when the pressure prevailing beneath the piston 2 is increased. The regulator then works under the action of forces other than those that operate during normal working, so that the throttle valve remains in its position of maximum opening, since now the action of the increased pressure in the space 24 and beneath the piston 2 is compensated for by the decrease in the force of the spring 25b.

Fig. 5 also shows the possibility of enriching the mixture when overcharging. This is effected by lifting or opening the fuel valve 90 by adjusting the bell-crank lever 85 through the intermediary of the lever 89.

The essential advantage of this arrangement, which allows of momentary overcharging of the engine, consists in the fact that the overcharging is effected directly by the act of the pilot, which is not the case with the known arrangements.

I claim:

1. Apparatus for controlling the charging pressure in the induction pipe of an internal combustion engine comprising, a throttle valve arranged in and adapted to open and close the induction pipe, means associated with the valve operably responsive to the atmospheric pressure tending to open said valve so as to increase the pressure in the induction pipe between the valve and the engine slightly over the desired pressure, and means operably responsive to the increased pressure in the induction pipe tending to close said valve whereby the position of the valve is determined by the differential action of said means.

2. Apparatus for controlling the charging pressure of an internal combustion engine adapted to operate at different altitudes comprising,

an induction pipe for feeding the fuel to the engine, a throttle valve arranged in the pipe, means associated with said valve operably responsive to the atmospheric pressure tending to open said valve so as to increase the pressure in said induction pipe between the valve and the engine slightly over the desired pressure, means operably responsive to the increased pressure in the induction pipe for urging said valve towards a closed position, and means interposed between said first mentioned means whereby the valve is actuated in response to the differential action of both of said first mentioned means.

3. Apparatus for controlling the charging pressure in the induction pipe of an internal combustion engine comprising, a throttle valve arranged in the induction pipe for opening and closing the same, a housing, means connected to the valve operably responsive to a reduced atmospheric pressure for moving the valve to an open position so as to increase the pressure in the induction pipe between the valve and the engine slightly over the desired pressure, a tube extending from the induction pipe to said housing so as to transmit the increased pressure in the induction pipe to the housing, movable means arranged in said housing operably responsive to said increased pressure for moving the valve to a closed position, and means associated with both of said means and said valve whereby the same is actuated in response to the differential action of said first mentioned means and said movable means.

4. In an internal combustion engine adapted to be operated at different altitudes, an air induction pipe leading to the cylinders of the engine, a valve arranged for opening and closing the induction pipe, coarse control means for the valve subjected to the atmospheric pressure, fine control means for the valve subjected to the pressure prevailing in the induction pipe, a servo-motor associated with said valve for limiting the maximum opening thereof, movable control means for the servo-motor, said last mentioned control means being operably connected to said coarse control means and said fine control means in such a manner that on actuation of the servo-motor, the control means thereof is moved back to a position which keeps the servo-motor in a position of rest.

5. In an internal combustion engine adapted to be operated at different altitudes, an air induction pipe leading to the cylinders of the engine, a valve arranged for opening and closing the induction pipe, an open end cylinder having a piston movable therein, a constant source of pressure acting on the head of the piston and the other face of the piston being subjected to the atmospheric pressure entering the open end of the cylinder, said piston being moved by the constant source of pressure when the atmospheric pressure decreases, a pivoted lever associated with said piston for opening said valve in response to the decreased atmospheric pressure so as to increase the pressure in the induction pipe between the valve and the engine cylinder slightly over the desired pressure, a second cylinder having a second piston movably mounted therein and subjected on one face to the constant source of pressure, a tube for imparting the increased pressure in the induction pipe to the opposite face of the second piston so as to move the same against the force of the constant pressure, a second lever associated with the second piston and attached to the first lever so as to form the pivot mounting thereof, and means operably responsive to the movement of the second lever for moving the throttle valve to a closed position whereby the throttle valve is moved by the differential action of said pistons.

6. In an internal combustion engine adapted to be operated at different altitudes, an air induction pipe leading to the cylinders of the engine, a valve arranged for opening and closing the induction pipe, an aneroid member having one end thereof rigidly supported so that the free end may move in accordance with the atmospheric pressure acting on the aneroid member, a pivoted lever associated with the free end of the aneroid member for moving the valve to an open position in response to a decreased atmospheric pressure so as to increase the pressure in the induction pipe between the engine cylinders and the valve slightly over the desired pressure, a second aneroid member encased in a housing, a tube extending from the induction pipe to the housing for compressing the second aneroid member in response to the increased pressure in the induction pipe, a second lever connected to said aneroid member and attached to the first lever in such a manner as to form the pivot mounting thereof, and means operably responsive to the movement of the second lever for moving the valve to a closed position whereby the throttle valve is moved by the differential action of said aneroid members.

7. Means for controlling the charging pressure in the induction pipe of an internal combustion engine including an intake throttle, a differential linkage controlling the opening and closing of said throttle and having a plurality of differentially controllable positions, means actuated by the external atmosphereic pressure for moving said linkage to one series of positions, and means actuated by the pressure existing in said induction pipe for moving the linkage to other positions.

8. Apparatus for controlling the charging pressure in an induction pipe of an internal combustion engine comprising, a valve arranged for opening and closing the induction pipe, means associated with the valve actuated by the atmospheric pressure for biasing the valve in one direction, and means operably responsive to the pressure in the induction pipe between the valve and the engine biasing the valve in an opposite direction whereby the position of said valve is determined by the differential action of said means.

9. In an induction pressure regulator for an internal combustion engine, having a servomotor with an energizing member and a power member operating a device in the engine intake for regulating the amount of charge admitted to the engine, said device separating a posterior zone comprising the portion of the intake posterior to said device and an anterior zone comprising the portion of the intake anterior to said device and the atmosphere, a control of said energizing member, which comprises, in combination, a first manometric member responsive to pressure conditions in said posterior zone, another manometric member responsive to pressure conditions in said anterior zone, means operative by said first manometric member for controlling said energizing member, and means operative by said other manometric member for altering the control of said energizing member by said first manometric member.

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