PUBLISHED
JUNE 1, 1943.
BY A. P. C.

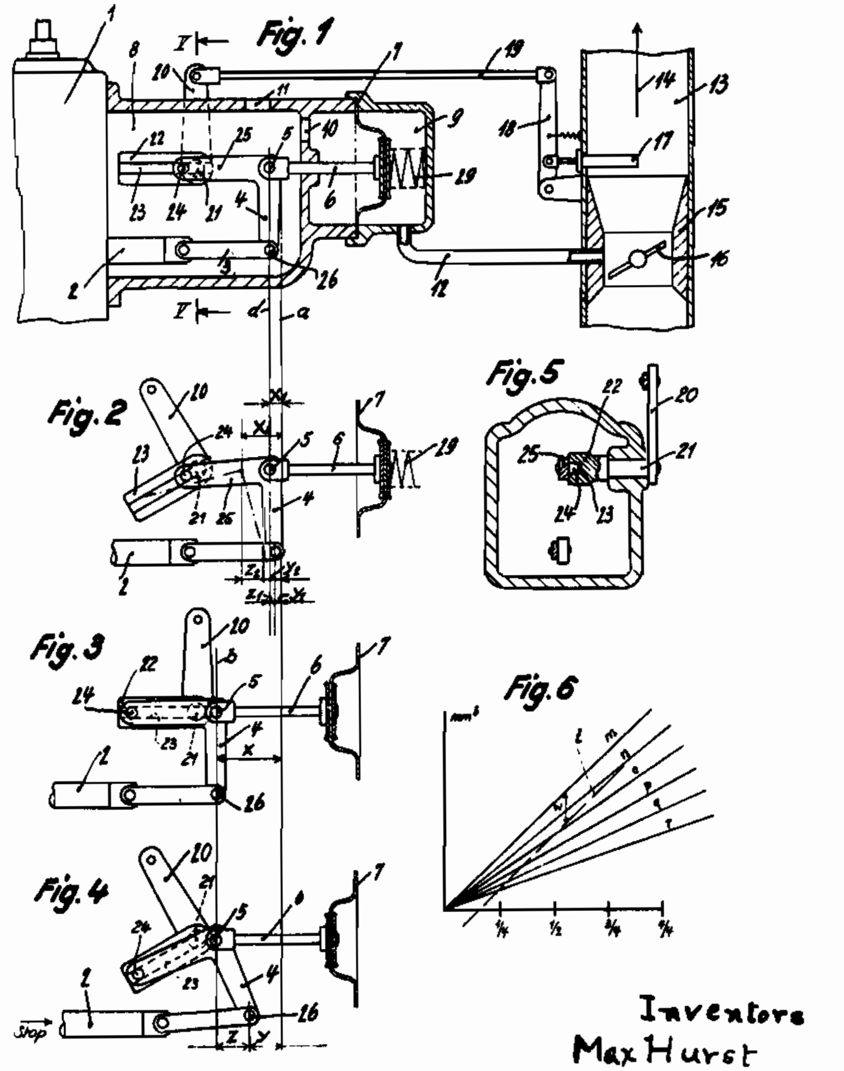
M. HURST ET AL

APPARATUS FOR CONTROLLING THE FUEL SUPPLY OF INTERNAL COMBUSTION ENGINES

Filed July 6, 1939

Serial No.
283,096

4 Sheets-Sheet 1



Inventors
Max Hurst
Hans Holmschrott
Fritz Hermann

By Roy F. Steward
their Attorney

PUBLISHED

JUNE 1, 1943.

BY A. P. C.

M. HURST ET AL

APPARATUS FOR CONTROLLING THE FUEL SUPPLY
OF INTERNAL COMBUSTION ENGINES

Filed July 6, 1939

Serial No.
283,096

4 Sheets-Sheet 2

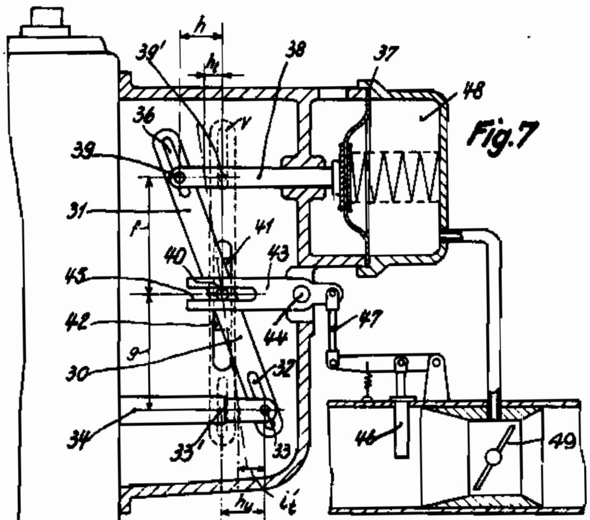


Fig.7

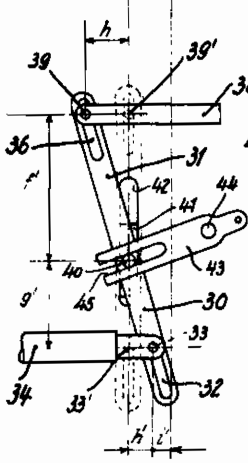


Fig.8

Inventors
Max Hurst
Hans Helmschrott
Fritz Hermann
By Roy F. Steward
their Attorney

PUBLISHED
JUNE 1, 1943.
BY A. P. C.

M. HURST ET AL

APPARATUS FOR CONTROLLING THE FUEL SUPPLY OF INTERNAL COMBUSTION ENGINES

Filed July 6, 1939

Serial No. 283,096
4 Sheets-Sheet 3

Fig. 9

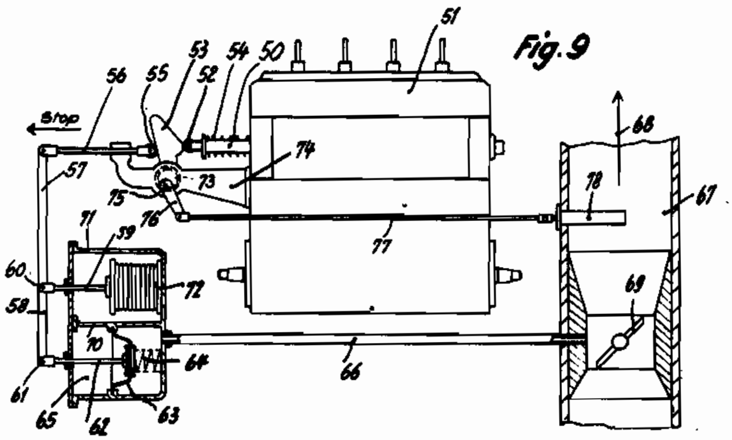


Fig. 10

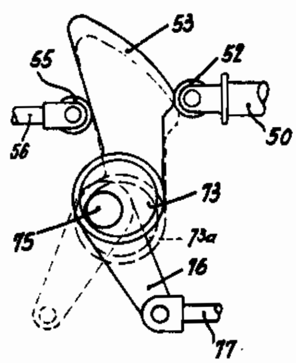
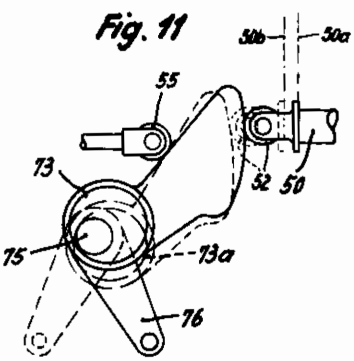


Fig. 11



Inventors
Max Hurst
Hans Helmschrott
Fritz Hermann

By Roy F. Steward
their attorney

PUBLISHED

JUNE 1, 1943.

BY A. P. C.

M. HURST ET AL

APPARATUS FOR CONTROLLING THE FUEL SUPPLY OF INTERNAL COMBUSTION ENGINES

Filed July 6, 1939

Serial No. 283,096

4 Sheets-Sheet 4

Fig. 12

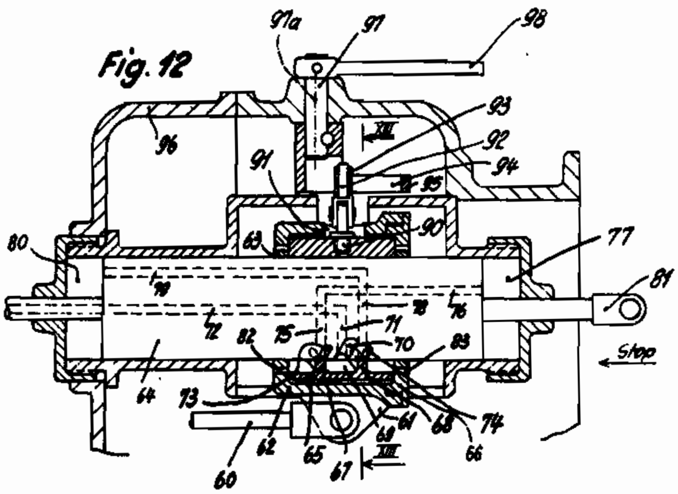
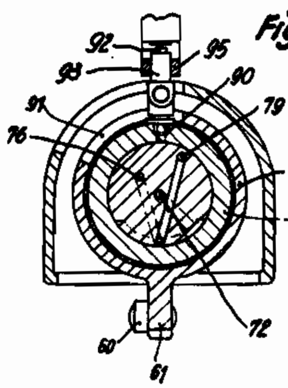


Fig. 13



Inventors
Max Hurst
Hans Helmschrott
Fritz Hermann

By Roy F. Steward
their attorney

Published June 1, 1943 Serial No. 283,096

ALIEN PROPERTY CUSTODIAN

APPARATUS FOR CONTROLLING THE FUEL SUPPLY OF INTERNAL COMBUSTION ENGINES

Max Hurst, Hans Helmschrott, and Fritz Hermann, Stuttgart, Germany; vested in the Alien Property Custodian

Application filed July 6, 1939

The invention relates to an apparatus for controlling the fuel supply of internal combustion engines having a fuel delivery control member which, in addition to being actuated by a governor member dependent upon changes of pressure, i. e. pressure measured with respect to atmosphere pressure, in the induction pipe of the engine, is also actuated by a thermostat, in such a manner that an increase in the temperature of the air in the induction pipe results in a reduction of the fuel supply.

In known apparatus of this type the thermostat always adjusts the fuel delivery control member by the same amount for any given change of temperature (such as for example 20°) irrespective of whether the engine is idling and requires only a small amount of fuel or is working at full load and requires a large amount of fuel.

The object of the invention is to overcome this disadvantage and to provide a thermostatic adjustment of fuel supply which has a progressive effect on the fuel delivery control member throughout the different loads of the engine and ranges of pressures existing in the induction pipe respectively.

According to the invention, in an internal combustion engine having a fuel delivery means, a movable member of pneumatic governor is arranged to displace a fuel delivery control member through an intermediate member which is variably coupled to an operating member connected to a movable thermostat member in such a manner that a movement of the operating member, occasioned by a change in temperature, has a progressively smaller effect on the fuel delivery control member as the load of the engine decreases.

The invention will be more particularly described with reference to the following examples with reference to the accompanying drawings in which:

Figure 1 shows a longitudinal section through a governor housing, together with the induction pipe of the internal combustion engine, which is shown on a smaller scale.

Figures 2–4 illustrate the moving parts of Fig. 1 in different positions.

Figure 5 is a section along the line V—V of Fig. 1.

Figure 6 is a graph.

Figures 7 and 8 show another form of construction in different positions.

Figure 9 shows a third form of construction.

Figures 10 and 11 show parts of Fig. 9 on a larger scale and in various positions.

Figure 12 illustrates a fourth form of construction.

Figure 13 is a section along the line 13—13 of Fig. 12.

Part of an injection pump 1 of an internal combustion engine, has a control rod or fuel delivery adjustment member 2 which is connected by means of a connecting rod 3 to a cranked lever 4. The cranked lever 4 is pivotally mounted on a pin 5 attached to a rod 6, which is mounted so as to be axially displaceable in the housing and the right hand end of which is connected to a diaphragm 7. The diaphragm 7 forms a movable partition between two chambers 8 and 9 of a pneumatic governor. One of these chambers 8 communicates through apertures 10 and 11 with the atmosphere whilst the other chamber 9 communicates through a pipe 12 with the induction pipe 13 of the internal combustion engine. The pipe 12 leads into the induction pipe 13 directly behind an adjustable throttle valve 16 in the direction of flow 14 of the air. The throttle valve 16 is contained in a venturi-like constriction 15. When the vacuum rises in the chamber 9, the diaphragm 7, operating as the governor member of the pneumatic governor, moves towards the right whilst when the vacuum decreases, it moves in the opposite direction under the action of a spring 29. In the induction pipe 13 is disposed a thermostat 17, the expanding member of which is connected through the elements 18 and 19 to a lever 20. The lever 20 is fixed to the pivot 21 of a lever 22 which is pivotally mounted on a side wall of the housing as shown in Fig. 5. Into a longitudinal slot 23 of the lever 22 there extends a pin 24 which is disposed on one arm 25 of the cranked lever 4, which is shown in the horizontal position in Fig. 1.

When the lowest temperature prevails in the induction pipe 13 of the engine, for example at —20° C the thermostat 17 stands in the position shown in Fig. 1, in which case the lever 22 and the slot 23 are horizontal. Under these conditions, when the throttle valve 16 remains in the idling position as shown in Fig. 1, the high degree of vacuum prevailing behind the throttle valve, and consequently, also in the chamber 9 causes the parts of the apparatus to move into the position shown in Fig. 1. If the vacuum increases still more, for example in an over-run, the pin 24 can be moved still further towards the right in Fig. 1 until its axis coincides with that of the fulcrum 21 of the lever 22, when the governor rod 2 comes into its stop position whilst the connecting pin 26 stands in the position *a* and the injection pump supplies no fuel. If the same minimum temperature is maintained in the induction pipe whilst the throttle valve is opened, that is adjusted to the full load position, then a comparatively low degree of vacuum prevails in the chamber 9, right up to the maximum engine speed. The spring 29 is thus able to move the diaphragm 7 and the other moving parts into the position shown in Fig. 3, in which position the injection pump is adjusted to give full load fuel supply. Under these conditions the connecting pin 26 reaches the position *b*.

This manner of operation which applies to minimum temperatures is changed when the temperature rises. When, at a temperature of +30° C for example, the lever 20 is moved by the thermostat 17 into the position shown in Figs. 2 and 4 then the change of pressure in the chamber 9 causes the pin 24 to slide in the slot 23 which is now in a diagonal position. Under these conditions the displacement of the diaphragm 7 forces the cranked lever 4 to turn about the pivot 5 (when the slot is in the horizontal position shown in Figs. 1 and 3, the cranked lever 4 is simply displaced horizontally without at the same time turning about the pivot 5). When the temperature rises above −20° for example, the free end of the lever arm 22 which is shown in Figs. 2 and 4 inclined downwards, at one temperature, now turns the angular lever 4 towards the left, in an anti-clockwise direction, as a consequence of the movement of the diaphragm 7. This movement produces a displacement of the governor rod 2 towards the right, thus reducing the fuel supply. This displacement of the governor rod to the right, as a result of rising temperature, always remains less than the simultaneous displacement of the diaphragm 7 towards the left, so that every displacement of the diaphragm towards the left, as a result of a decrease of vacuum in the chamber 7, is accompanied by a movement of the governor rod towards the left, which movement merely decreases in relation to equal changes of vacuum and equal adjusting movements of the diaphragm, on account of the increasing slope of the slot 23, that is of the increasing temperature. Whilst, for example at −20° a displacement of the diaphragm 7 or of the pin 5 connected thereto from the stop position *a* into the full load position *b* as shown in Fig. 3 would correspond to a displacement of the governor rod through the distance x, yet at +30° an equally large displacement of the diaphragm 7 and of the pin 5 of the governor rod, would in the position shown in Fig. 4, result in displacement only through the distance y, which is smaller than the distance x by the distance z.

This reduction of the displacement by the distance z which applies to variations of loading between zero and full load and to the temperature variation of 50°, between −20° and +30°, does not remain constantly uniform for the same temperature variations, but changes according to the amount of load. For example, when the engine is idling, if the diaphragm 7 moves so that the pin 5 is displaced from the stop position *a* into the idling position *d* shown in Figs. 1 and 2, thus moving through the distance x_1, then the governor rod at −20° moves through the distance x_1 as shown in Fig. 1, whilst at +30° according to Fig. 2, the governor rod moves through the distance y_1 which varies from x_1 only by the negligible amount z_1. In the partial load position shown in dotted lines in Fig. 2, the corresponding distances x_2 and y_2 differ rather more, namely by the amount z_2. It will be seen that the same change of temperature produces a movement towards the right which increases with increase of engine load. Therefore, when the engine is heavily loaded and is receiving a large amount of air, whilst rises of temperature considerably decrease the weight of the inducted air, then the fuel supply is reduced accordingly, whilst if the engine is idling and the air and fuel supplies are small, then the fuel supply is reduced by only a small amount. Under these conditions therefore the lever 22 is a control member dependent upon the thermostat and inserted in the rod between the diaphragm 7 and the governor rod and engaging with the pin 24, in such a manner that the movement of the governor rod depends increasingly upon the temperature influences as the engine load increases. In the example described the relations are such that $x:z=x_1:z_1=x_2:z_2$ etc.

Fig. 6 is a graph showing this relation, of which the abscissa indicates the engine load whilst the ordinate indicates the fuel supplied by the injection pump. The line m represents the increase of fuel required by the engine and of the fuel supplied by the injection pump as the load increases, at the minimum temperature (example −20°) of the inducted air, corresponding to the increased air supply required through increasing loading in mixed fuel engines with foreign ignition. The lines n, o, p, q, r indicate smaller fuel supplies such as are required when less air passes into the cylinder as a result of increase in the temperature of the inducted air and which are obtained according to the present invention by means of the various diagonal positions of the slot 23. The dotted line t merely indicates that it would be incorrect to arrange the thermostat so that the fuel supply is always reduced by the same amount w, or alternatively so that the governor rod is always displaced through the same distance for any given change of temperature, irrespectively of the prevailing engine load, or alternatively of the amount of air in the cylinder. In this case, at high temperatures under idling and partial load conditions, the governor rod would be displaced too far in the stop direction, whilst at full load the displacement would not be sufficient. This arrangement might at most be possible in engines which are constantly run at full load.

The slot 23 in the lever 22 may naturally also be curved if this is desirable for some particular purpose, such as for example producing a richer mixture under idling and partial load conditions.

Figs. 7 and 8 show another example of construction of the invention. A two-armed lever 30, 31 is connected by means of a slot 32 in one of its arms 30 to a pin 33 attached to the governor rod 34 of the injection pump, whilst a slot 36 in the other arm 31 connects the lever with a pin 39 disposed on a rod 38 leading to the diaphragm 37 on a pneumatic governor. The two armed lever 30, 31 is mounted on a pivot 40 fixed to a guide element 41 which slides in a slot 42 in the housing. The guide element 41 is displaceable by means of a lever 43 mounted on a pivot 44 in the housing and engages by means of a slot 45 with the pin 40. To the right of the pivot 44 in Figs. 7 and 8 the lever 43 is connected to a rod 47 leading to a thermostat 48. When the temperature rises in the induction pipe, the rod 47 is displaced in the upward direction by the thermostat 46, thus causing the lever 43 to be rotated in an anti-clockwise direction. As a result the guide element 41 is displaced in the downwards direction in the slot 42 of the housing and carries with it the lever 30, 31, into the position shown in Fig. 8 for example.

Fig. 7 shows the lever 43 in a position corresponding to the lowest temperature allowed for (e. g. −30° C). When a low degree of vacuum prevails in the governor chamber 48, the diaphragm 37 and the lever 30, 31 are in the position shown in full lines, in which position the governor rod 34 is adjusted to the highest fuel supply required at full load. In the position *v* shown in dotted lines, the pins 38 and 33 stand at 38′ and 33′ and the governor rod 34 is adjusted to the stop position. The operative lever arms *f* and *g* of the two-armed lever 31 are of equal length as shown in Fig. 7. Consequently, when the diaphragm 37 or the pin 39 are displaced by the amount *h*, then the pin 33 or the governor rod 34 are displaced by an equal amount h_u.

On the other hand, when a higher temperature prevails in the induction pipe and the lever 43 stands in the position shown in Fig. 8, in which case the lever ratio *f*:*g* shown in Fig. 7 is changed to the ratio *f′*:*g′* shown in Fig. 8, then the same displacement *h* of the pin 39, which moves with the diaphragm 37, into the position 39′ produces a displacement of the pin 33 only by the amount *h′*. Thus it will be seen that at a higher temperature and at full load the governor rod 34 is displaced from the stop position by an amount which is less by the amount *i′* in Fig. 8 than the displacement taking place at the lowest temperature, and at the same full load adjustment. This distance *i′* changes with every variation of the engine load, while lever ratio *f′*:*g′* and the variation from minimum temperature both remain constant. For example the distance *i′* changes to *i′*, *t* when the pin 39 moves from the position of no fuel supply 39′ into the partial load position *h*, *t* of the lever 31, shown in dotted lines. Given the same temperature changes, this variation is proportional to the change of engine load, or alternatively to the degree of vacuum prevailing in the governor chamber, which in turn depends upon the volume of air flowing into the cylinder through the induction pipe. What is true for the lever ratio *f′*:*g′* is also true when this ratio changes as a result of a change of temperature in the inducted air, and in fact it is always true that the influence of a rise in temperature on the reduction of fuel supply is proportional to the degree of engine load and consequently to the weight of air passing into the engine at each piston stroke.

In a third form of construction shown in Fig. 9 a roller 52 attached to a governor or rod 50 of a benzol injection pump 51 is pressed by a weak spring 54 against one side of a cam shaped member 53. The other side of the cam engages with a second roller 55 which is mounted on the right hand end of the longitudinally displaceable rod 56. The left hand end of the rod 56 is connected to a two-armed lever 57, 58, which is mounted on a pivot 60 on the left hand end, of a rod 69, the lower end of which two armed lever is connected by a pin 61 to a rod 62. The rod 62 is connected to the governor diaphragm 63. From one chamber 64 of the governor, a duct 66 leads to the induction pipe 67 of the engine into which it opens at a point behind an adjustable throttle valve 69 in the direction of flow of the air 66, the other governor chamber 65 communicates through apertures 70 and 71 in the housing with a space which is maintained at a pressure equal to that in the induction pipe outside the throttle valve 69, that is, in the present example, which is designed for self inducting engines, the atmosphere. The diaphragm box 72 is also exposed to the pressure prevailing in front of the throttle valve, which box expands as soon as the engine of a vehicle is exposed to a low air pressure, for example at high altitudes. This expansion of the diaphragm box 72 causes the pin 60 of the lever 57, 56 to swing towards the left about the point 61, thus causing the cam 53 which is pivoted on an eccentric 73 to displace the governor rod 50 towards the left into the stop position. The governor rod is similarly moved in the same direction when the vacuum increases in the chamber 64, as a result of an increase of engine load, thus causing the diaphragm 63 and the lower pivot 61 of the lever 57, 58 to be drawn towards the right.

The eccentric 73 is rotatable about the pin 75 which is locally fixed in an arm 74 of the injection pump 51. To the pin 75 is connected a lever 76 which is connected by a rod 77 to a thermostat 78 arranged within the induction pipe 67. When the temperature rises in the induction pipe 67, the rod 77 is moved towards the left in Fig. 9, with the result that the eccentric 73 is angularly displaced by means of the lever 76 and the cam 53 moves in the downward direction. With reference to Figs. 10 and 11, which show enlarged views of the cam 53, it will be explained how, under various engine load conditions, the changes of temperature in the induction pipe, acting through the thermostat, the eccentric and the cam, affect the position of the governor rod and consequently the supply of fuel through the injection pump.

In Fig. 10 the governor rod 50 and the rod 56 connected to the governor, stand in the stop position, in which position the injection pump is adjusted so as to supply no fuel. When the eccentric 73 is rotated by the thermostat 78 out of the position shown in full lines, corresponding to the minimum temperature, into a position 73*a* shown in dotted lines, corresponding to a higher temperature, then the cam moves in the downward direction without causing any movement of the governor rod 50. Therefore in the stop position changes of temperature have no effect on the position of the governor rod.

However conditions are different when the engine is loaded and the injection pump, as shown in Fig. 11, is adjusted to give a large fuel supply under full load conditions. The position 50*a* of the governor rod corresponds to the position of the eccentric 73 at the minimum temperature, for example −20°, and with the diaphragm 63 standing in the full load position. With the diaphragm 63 in this full load condition an increase in temperature causes the eccentric 73 to move into the position 73*a* shown in dotted lines, so that the left hand side of the cam 53 slides on the roller 55, whilst the right hand side of the cam allows the governor rod to move into the position 50*b*, thus supplying a smaller amount of fuel at full load to correspond to the higher temperature. In the same manner, when the diaphragm 63 is adjusted for partial load, the cam 53 causes the fuel supply to be progressively reduced as the cam descends from its topmost position. However, at partial load, the influence of a change of temperature of for example 20° is less than at full load. It will be seen that in this case also, temperature changes exert progressively less influence on the fuel supply as the engine load rises.

In a fourth form of construction shown in Fig. 12, the control rod of the governor is connected by means of a rod 60 to an eye 61 of a ring 62. The ring 62 fits closely by means of a flange 63 on its inner periphery around a piston 64 of a servomotor and contains an operating slide 65 which also fits closely around the piston 64. On the side of the ring remote from the internal flange 63 is fitted a cover 68 which prevents longitudinal displacement of the operating slide 65 within the ring 62.

The operating slide 65 is provided with two operating abutments 67 and 68 which rest against the outer periphery of the piston 64. A space 69 between the operating edges 67, 68 communicates through ducts 71 and 72 in the piston, (indicated by dotted lines in the drawing), with an oil inlet pipe which is not shown. Moreover, operating grooves 73 and 74 are provided in the outer periphery of the piston. The left hand groove 73 communicates through two ducts 75, 76 in the piston 64 with a space 77 to the right of the piston, whilst the right hand groove 74 communicates through ducts 78 and 79 with a space 80 on the left hand side of the piston. A rod 81 connects the piston 84 to the control rod of an injection pump, the two latter not being shown in the drawing.

It is to be understood that the governor connected to the rod 60 moves the operating slide 65 towards the right in Fig. 12 as the engine load increases. This movement forces oil out of the space 69 through the groove 74 and the ducts 78, 79 into the space 80. Consequently the piston 64 follows the operating slide 65 towards the right until the operating surfaces 67, 68 again cover the grooves 73, 74. A state of equilibrium is then established in the new position. The oil forced out of the space 77 by the movement of the piston towards the right, flows through the ducts 76, 75, the groove 73, the space to the left of 67 and ducts 82. This movement towards the right carries the rod 81 towards the right and adjusts the governor rod of the injection pump so as to give a larger fuel supply corresponding to the increased engine load.

In the case of a decrease in engine load the rod 60 moves the operating slide 65 towards the left, forcing oil from the space 69 through the groove 73 and the ducts 75, 75 into the space 77. In this case the piston 64 follows the movement of the operating slide towards the left, adjusts the control rod so as to give a smaller fuel supply and forces the oil from the space 80, through the ducts 79, 78, 74, through the space in the operating slide 65 to the right of the operating edge 66, and through ducts 83.

The operating slide 65 is also provided with a pin 90 which passes through a slot 91 extending round part of the circumference of the ring 62. The pin 90 is pivotally connected to a second pin 92 which slides in a barrel 93 which is loosely disposed in a slot 94 of a lever 95. The lever 95 is fixed to one end of a spindle 97 which is rotatably disposed in the servomotor casing, whilst the other end of the spindle carries a lever 98 which is connected to the thermostat. In the present example as shown in the drawing, the connection of the thermostat to the lever 98 is such that at the lowest temperature of the inducted air, the slot 94 of the lever 95 is parallel to the axis of the piston 64. In the partial load position as shown in the drawing, the slide 65 is disposed so that the pin 92 stands approximately in the middle of the slot 94. However, if the slide 65 is adjusted to the position of no fuel supply, then the pin 92 stands at the left hand end of the slot 94, so that the axis of the pin 92 coincides with the axis 97*a* of the spindle 97. In the position of no fuel supply, when the axes coincide in this manner, angular displacement of the levers 98 and 95 have no effect on the pins 90 and 92. However, if the operating slide 65 stands in the middle or partial load position, shown in the drawing, then any rotary movement of the lever 98 causes the pin 92 to be moved out of the plane of the drawing, carrying with it the pin 90 and thus causing angular displacement of the operating slide 65 relatively to the piston 64.

In the partial load position as shown, the operating edges 67, 68 and the grooves 73, 74 extend forwardly and rearwardly out of the plane of the drawing and have the shape of spiral lines. When on a rise of temperature, the lever 95 is moved forward out of the plane of the drawing from its position parallel to the axis of the piston, then as the upper half of the operating slide 65 moves forward and the lower half backwards, the operating edges 67, 68 are displaced towards the right relatively to the grooves 73, 74. With the spiral grooves 73, 74 directed as shown in the drawing, the result of this movement is that the space 69 comes into communication with the duct 75 opening into the groove 73 and consequently with the space 77, so that the governor rod is adjusted so as to reduce the fuel supply. A further reduction of fuel supply at the same temperature, and consequently with the levers 98 and 95 adjusted to the same position, is produced when at high engine load the slide 65 stands further towards the right in Fig. 12 and is consequently still further angularly displaced by the pin 92 sliding in the spiral slot 94. This naturally causes the piston 64 and the governor rod 81 to be displaced further towards the left. Therefore the movement of the governor rod in a direction producing a decrease of fuel supply for any given rise of temperature varies directly with the engine load, that is with the influence exerted by the rise of temperature upon the weight of air supply to the engine.

The invention may be applied to supercharged engines in addition to self inducted engines.

MAX HURST.
HANS HELMSCHROTT.
FRITZ HERMANN.