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2L3BX 2L4X

(54) TEMPERATURE SENSITIVE APPARATUS FOR CONTROLLING THE AIR INTAKE OF INTERAL COMBUSTION ENGINES

(71) We, NIPPONDENSO CO. LTD., a Japanese Company of 1-1 Showa-cho, Kariya City, Aichi Pref, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to temperature sensitive apparatus for centralling the air intake of an internal combustion engine.

Conventionally, a thermostatic valve is provided to detect temperature of intake air during a time when the temperature of the ambient is cold especially during a winter season and to actuate a vacuum motor as a function of the detected temperature so as to introduce warmed air to a downstream portion of a throttle valve mounted in a carburetor and to control the amount thereof. In this conventional system another thermostatic valve is provided to introduce additional air into an intake manifold downstream of the carburetor for the purpose of preventing an extreme richness of an air-fuel mixture fed to the engine during a time when the ambient temperature is relatively high, especially during a summer season.

The conventional thermostatic device just described is disadvantageous in view of necessity of two kinds of thermostatic valves, complicated pipe lines for communicating the thermostatic valves with the associated portions such as the intake manifold, the carburetor and so on in an automotive engine compartment, and its high cost.

In another known thermostatic device one valve is employed to serve the above two functions. In this known device a valve member is slidably but sealingly disposed in a valve housing, being actuated to move down-and-upwardly by a temperature responsive expanding material such as wax, the down-and-upward movement of the valve member controlling both the amount of warmed air supplied to an engine through a carburetor and the amount of additional air fed to the engine. This last mentioned known device has, however a disadvantage that a reliable operation may not be ensured for a long time since clearance between the outer surface of the valve member and the surrounding inner surface of the valve housing for the valve member becomes larger as it is used.

According to this invention, temperature sensitive apparatus for controlling the air intake of an internal combustion engine comprises a vacuum motor and a thermostatic valve having temperature responding means, an inlet connected to an intake manifold of the engine, an outlet connected to a vacuum chamber of the motor, a first passageway communicating between the inlet and the interior of the valve, a second passageway connecting the interior of the valve to the atmosphere; a valve member connected to the temperature responding means and constructed and arranged to open and close the third passageway so producing or shutting off a supply of additional air to the intake manifold, when the temperature detected by the temperature responding means is respectively higher and lower than a predetermined value; and a control member coupled to the said valve member and operative to vary the opening area of the first passageway in accordance with the detected temperature at said temperature responding means.

In a preferred embodiment, the temperature responding portion of the thermostatic valve is disposed within an air cleaner connected to an air intake manifold of the engine, said air cleaner having an inlet pipe opening to the atmosphere; a valve pivotally mounted in said pipe adjacent to an aperture in the pipe wall for closing and opening the aperture; the vacuum motor being mounted on the throat and having a movable diaphragm, the diaphragm being connected to said valve and being arranged to cause the valve to close and open said aperture respectively in response to the application of and release of vacuum pressure to the chamber; a conduit connected to said aperture at one end and opening to a portion of an exhaust manifold of the engine so as to introduce warmed air around said exhaust manifold into said air cleaner when said aperture is opened.

By constructing the thermostatic valve in this way it is possible to provide a product which is durable in use for a long time and enables a reliable and minute control for the amount of additional air fed to the engine to prevent extreme richness of air-fuel mixture.

Particular embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a schematic view partly in section of a temperature responsive device for an internal combustion engine in accordance with the present invention,

Fig. 2 is a top plan view of a thermostatic valve according to the present invention,

Fig. 3 is an enlarged sectional view taken along a line III—III in Fig. 2 showing an embodiment of the present invention,

Figs. 4 and 5 are graphs respectively showing the variation in a vacuum pressure and the variation is the amount of additional air fed to the engine, with temperature variations in an air cleaner is operated by the thermostatic valve shown in Fig. 3,

Fig. 6 is a sectional view of a thermostatic valve showing a modified embodiment of the present invention,

Fig. 7 is also a sectional view of a thermostatic valve showing a further modified embodiment of the present invention,

Fig. 8 is a sectional view taken along line VIII—VIII in Fig. 7, and

Fig. 9 is a sectional view taken along line IX—IX in Fig. 7.

Referring to Fig. 1, an air cleaner 1 is communicated with the cylinders of an internal combustion engine E through a conventional carburetor 4. A filter element 2 is mounted in the air cleaner 1 for filtering air entering the carburetor 4 from a pipe 1*a* of the air cleaner 1, which opens to the atmosphere. The carburetor 4 mixes fuel with air flowing therethrough as in the conventional manner to supply an air-fuel mixture to the engine E, wherein a throttle valve 4*a* linked with an acceleration pedal (not shown) is pivotally mounted to control the amount of the air-fuel mixture. An exhaust manifold 31 is communicated with the atmosphere to convey the exhaust gas to the atmosphere.

A switching valve 5 is pivotally mounted in the throat 1*a* to open and close an aperture 1*b* for permitting warmed air A to enter the air cleaner 1 when the aperture 1*b* is opened. The aperture 1*b* is connected through a conduit 33 to a heat conducting plate 32 which surrounds a portion of the exhaust manifold 31. Air from the atmosphere enters the conduit 33 passing along the plate 32 while being warmed by hot outer walls of the exhaust manifold 31 surrounded by the plate 32. When the valve 5 closes the aperture 1*b*, the ambient air B enters the air cleaner 1.

Operation of the valve 5 is by a vacuum motor 3 mounted on the pipe 1*a* which includes an upper and a lower housings 3*a* and 3*b* fixed to the upper portion of the pipe 1*a* a diaphragm 3*a* interpased between the housings 3*a* and 3*b* to form a sealed vacuum chamber 3*g*, a spring 3*c* disposed in the chamber 3*g* for resiliently urging the diaphragm 3*d* in a downward direction, and a rod 3*e* connecting the diaphragm 3*d* with the valve 5 for actuating the same to open and close the aperture 1*b* in accordance with the down-and-upward movement of the diaphragm 3*d*. When the vacuum is applied to the chamber 3*g*, the diaphragm 3*d* moves upwardly against the resilient force of the spring 3*c* with the valve 5 being opened as shown in Fig. 1, while when the vacuum is removed from the chamber 3*g* the diaphragm 3*d* moves downwardly due to the urging force of the spring 3*c*. The chamber 3*g* is communicated with the inside 6*a* of the intake manifold 6 through a passage defined by a conduit 8, a thermostatic valve 7 and a conduit 9 to apply the intake vacuum at the intake manifold to the chamber 3*g* when the thermostatic valve 7 connects the conduit 9 with the conduit 8 as a function of the temperature in the air cleaner 1.

The detailed construction and operation will be explained with reference to Figs. 2 and 3 hereinafter.

A temperature responding portion 10 comprises a top portion 10*a* made of a heat conducting material such as copper, a temperature responsive expanding material 10*b* such as wax sealed in the top portion 10*a* by means of a diaphragm 10*e* so that the diaphragm 10*e* is expansible in accordance with the expansion of the wax 10*b*, a housing 10*d* fixed to the top portion 10*a*, and a driving rod 10*c* slidably supported in a bore of the housing 10*d* so that the driving rod is moved back and forth in accordance with the expansion of the wax thereby moving the diaphragm 10*e*. The temperature responding portion 10 is exposed inside of the air cleaner 1 for detecting the temperature thereof.

The lower end of the housing 10*d* is screwed into a housing 15 made of a synthetic resin, which includes a central bore 12 for providing a space to enable a free up- and downward movement of the driving lever 10*c*, vent apertures 11 communicating the bore 12 with the atmosphere (the inside of the air cleaner 1 according to the invention), a valve seat 13 of a semi-spherical surface formed at an undersurface of the housing 15 at which the lower end of the bore 12 terminates, and a shoulder 14 at which the upper end of the bore 12 terminates for abutting the lower end of the housing 10*d*.

A valve casing 16 made of a synthetic resin is secured to the housing 15 by means of, for example ultrasonic-wave welding to thereby seal the inside of the valve casing 16 from the atmosphere, wherein the housing 15 serves as an upper wall of the valve casing 16. The valve casing 16 comprises an outlet pipe 18 having a restriction of 0.7 mm. diameter for preventing a rapid air flow therethrough and connected to the vacuum motor through the conduit 8, another inlet pipe 19 connected to the intake manifold 6 through the conduit 9, and a flanged portion 29 formed at the upper peripheral portion of the valve casing 16 and having holes 30 through which bolts (not shown) would be inserted to secure the thermostatic valve 7 to the air cleaner 1.

Inside of the valve casing 16, a valve member 20, a spring 25 and a cup-shaped member 26 are disposed to proceed dual functions in response to the temperature detected by the temperature responding portion 10.

The valve member 20 includes a flanged portion 23 formed at an outer periphery of a valve body 20*a*, a convex portion 22 of semi-spherical formed on the valve body 20*a*, a concave portion 21 provided at the valve body for receiving the lower end of the driving lever 10*c*, and a rod 24 directed in a direction opposite to the convex portion 22. The lower end of the rod 24 is formed with an enlarged section 24*a* having a diameter of 3.9 mm. which is larger than that of 2.0 mm. diameter of an upper small section 24*c*. A tapered section 24*b* connects the enlarged section 24*a* with the small section 24*c*.

The spring 25 is interposed between the flanged portion 23 of the valve member 20 and a flanged portion 28 of the cup-shaped member 26 for urging the valve member 20 upwardly, that is, in a direction of the valve seat 13, so that the semi-spherical convex portion 22 of the valve body 20*a* seats on the valve seat 13 to shut off the air flow from the air cleaner 1 through the apertures 11 and the central bore 12 into the inside of the valve casing 16.

The cup-shaped member 26 includes the flanged portion 28 seating on the base of the valve casing 16 by the urging force of the spring 25, a cylindrical side wall and a top wall at which an opening 27 is formed with a diameter of 4.0 mm. The lower end of the rod 24 is inserted into the opening 27, so that the clearance between the rod 24 and the opening 27 changes in accordance with the down-and-upward movement of the valve member 20 actuated by the temperature responding portion 10.

In the above-described thermostatic valve 7, the opening 27 formed at the cup-shaped member 26 forms a first passageway for communicating the inlet 19 with the interior of the valve casing 16, the restriction 17 formed in the pipe portion 18 forms a second passageway for communicating the outlet 18 with the inside of the valve casing 16, and the apertures 11 and the central bore 12 forms a third passageway for communicating the inside of the valve casing with the inside of the air cleaner 1.

As noted from the above description, the valve member 20, especially the convex portion 22 in this embodiment, is disposed in the third passageway for opening and closing the same in accordance with the detected temperature at the temperature responding portion 10. The rod 24 of the valve member is operatively disposed in the first passageway and acts as a control member for varying the opening area of the passageway in accordance with the detected temperature at the temperature responding portion 10.

The operation of the thermostatic valve 7 just described will be explained with reference to Figs. 4 and 5.

When the ambient temperature is below 27°C, the temperature responsive expanding material 10*b* does not expand so that the valve member 20 is urged at its uppermost position by the urging force of the spring 25 as shown in Fig. 3, with the convex portion 22 seating on the valve seat 13 (the third passageway is thereby closed). At this stage, the negative pressure from the intake manifold 6 through the pipe portion 19 is transmitted to the vacuum chamber 3*g* of the negative pressure motor 3 through the clearance between the rod 24 and the opening 27 (that is the first passageway), the restriction 17 of the pipe portion 18 (second passageway) and the conduit 8, so that the diaphragm 3*d* is moved upwardly together with the valve 5 by means of the rod 3*e*. When the valve 5 opens the aperture 1*b*, warmed air A is permitted to enter the air cleaner 1 and then to the engine E, thus ensuring a smooth starting and operation of the engine. Since the vacuum pressure is applied to the vacuum motor through the restriction 17, the operation of the valve 5 is smoothly carried out.

On the other hand, since the valve member 20 is seating on the valve seat 13 (or the third passageway is closed), no air flows from the apertures 11 through the third passageway and the first passageway to the conduit 9 and then to the intake manifold 6.

Fig. 4 shows a graph of the vacuum negative pressure in the chamber 3*g* of the vacuum motor 3 plotted against temperature variations in the air cleaner 1, while Fig. 5 shows graph of additional air fed to the engine through the thermostatic valve 7 plotted against the temperature variations in the air cleaner 1.

The characteristic curves of Figs. 4 and 5 measured when the vacuum at the intake manifold 6 is constant at 450 mmHg.

When the temperature in the air cleaner 1 is above 27°C but below 60°C, the temperature responsive expanding material is expanded so that the valve member 20 is moved downwardly against the urging force of the spring 25 via the driving lever 10*c*. When the valve member 20 is moved downwardly and the convex portion 22 is departed from the valve seat 13, the third passageway is opened and thereby the vacuum inside of the valve casing 16 is decreased to almost the ambient pressure, whereby the vacuum is removed from the chamber 3*g* to actuate the valve 5 to close the aperture 1*b*.

On the other hand, when the convex portion 22 of the valve member 20 is departed from the valve seat 13, air is introduced into the inside of the valve casing through the third passageway including the apertures 11 and the bore 12. The air is then conveyed through the clearance between the rod 24 and the opening 27, that is the first passageway to the intake manifold as additional air for preventing an excess of fuel to be supplied to the engine, wherein the amount of additional air is determined by the area of the clearance (the opening area of the first passageway). Under the temperature variations of 27°C to 60°C in the air cleaner 1, the enlarged section 24*a* is designed to be always positioned in a plane of the opening 27, so that the area of the clearance determined by the enlarged section 24*a* and the opening is constant with the result that the amount of the additional air flowing therethrough is likewise constant.

When the temperature in the air cleaner 1 is between 60°C and 100°C, the valve member 20 is further moved downwardly so that the tapered section 24*b* reaches in the plane of the opening 27, while the third passageway remains open. Therefore, as the rod 24 is moved downwardly, the area of a clearance determined by the tapered section 24*b* and the opening 27 (the opening area of the first passageway) is increased so that the amount of the additional air is increased as shown in Fig. 5.

During this period, since the third passageway remains open the aperture 1*b* in the pipe 1*a* of the air cleaner remains closed by the valve 5.

When the temperature in the air cleaner 1 rises above 100°C, the valve member 20 is furthermore moved downwardly, so that the small section 24*c* of the rod 24 becomes in the plane of the opening to define the clearance therebetween, while the third passageway remains opened. Since the diameter of the small section 24*c* is arranged to be constant along its entire length, the amount of the additional air is constant as shown in Fig. 5.

When the temperature in the air cleaner 1 is decreasing, the amount of the additional air fed to the engine is likewise decreased corresponding to the characteristic shown in Fig. 5. Fig. 6 shows a modified construction of the thermostatic valve 7 according to the present invention, wherein like reference numerals designate the same or equivalent parts of that shown in Fig. 3.

A threaded portion 15*a* is formed at the outer periphery of the housing 15, so that the valve 7 is secured to the air cleaner 1 by means of a screw-fitting.

Apertures 11 for introducing air to the inside of the valve casing 16 are formed in the housing 15 being directed upwardly and opened inside of the air cleaner.

Figs. 7, 8 and 9 show a further modified construction of the thermostaic valve 7 according to the present invention, wherein like reference numerals likewise designate the same or equivalent parts as that shown in Fig. 3.

A convex portion 22 of the valve member 20 projects into the bore 12 of the housing 15, and guide portions 22*a* axially formed at and along the length of the outer periphery of the convex portion 22 are guided by the inner surface of the bore as shown in Fig. 8, so that the axial movement of the valve member 20 is smoothly carried out and air from the air cleaner 1 can enter inside of the valve casing 16 along the outer surface of the convex portion 22.

A ring-formed sealing member 34 made of a silicon rubber is attached on the upper surface of the flanged portion 23 of the valve member 20 and fixedly secured thereto by means of a plurality of protrusions 34*a*, one of which is shown in Fig. 7. The protrusions 34*a* are made of the silicon rubber and formed integral with the sealing member 34. Enlarged portions are provided at the respective free ends of the protrusions 34*a* which are inserted into a plurality of through holes formed at the valve member 20, so that the sealing member 34 is fixedly secured to the valve member 20.

The sealing member 34 is seated on the undersurface of the housing 15 when the valve member 20 is positioned at its uppermost position as shown in Fig. 7, so that the inside of the valve casing 16 is shut off from the atmosphere.

A packing 35 made of rubber is interposed between the base of the valve casing 16 and the flanged portion 28 of the cup-shaped member 26 for the purpose of ensuring sealing between the base and the flanged portion 28.

At the inner wall of the valve casing 16, there are provided a plurality of projections 16*a* inwardly directed and formed along the axial length of the inner wall as shown in Fig. 9, so that the valve member 20 moves upwardly and downwardly being guided at the flanged portion 23 along the plurality of projections 16*a*.

WHAT WE CLAIM IS:—

1. Temperature responsive apparatus for controlling the air intake of an internal combustion engine, comprising a vacuum motor and a thermostatic valve having temperature responding means, an inlet connected to an intake manifold of the engine, an outlet connected to a vacuum chamber of the motor, a first passageway communicating between the inlet and the interior of the valve, a second passageway communicating between the outlet and the interior of the valve, and a third passageway connecting the interior of the valve to atmosphere; a valve member connected to the temperature responding means and constructed and arranged to open and close the third passageway so producing or shutting-off a supply of additional air to the intake manifold, when the temperature detected by the temperature responding means is respectively higher and lower than a predetermined value; and a control member coupled to the said valve member and operative to vary the opening area of the first passageway in accordance with the detected temperature at said temperature responding means.

2. Apparatus according to claim 1 in which the control member is a rod.

3. Temperature responsive apparatus for an internal combustion engine according to claim 1 or claim 2 wherein the temperature responding portion of the thermostatic valve is disposed within an air cleaner connected to an air intake manifold of the engine, said air cleaner having an inlet pipe opening to the atmosphere; a valve pivotally mounted in said pipe adjacent to an aperture in the pipe wall for closing and opening the aperture; the vacuum motor being mounted on said pipe and having a movable diaphragm, the diaphragm being connected to said valve and being arranged to cause the valve to close and open said aperture respectively in response to the application of and release of vacuum pressure to the chamber; a conduit connected to said aperture at one end and opening to a portion of an exhaust manifold of the engine so as to introduce warmed air around said exhaust manifold into said air cleaner when said aperture is opened.

4. Apparatus according to any one of claims 1 to 3 wherein said temperature responding portion comprises: a top portion; a temperature responsive expanding material encased in said top portion; a diaphragm attached to said top portion for sealing the said material so that the diaphragm expands in response to expansion of said expanding material; and an actuating rod associated with said diaphragm to move back and forth in accordance with the movement of the diaphragm.

5. Apparatus according to claim 2, wherein the valve casing includes an upper wall on which the temperature responding portion is mounted, said upper wall having a central bore through which the activating rod extends the bore terminating at a valve seat formed at an undersurface of said upper wall, and being in communication with the atmosphere to form the said third passageway.

6. Apparatus according to claim 3, further comprising a spring disposed in the valve for biasing the valve member in a direction of the valve seat, so to close the third passageway.

7. Apparatus according to claim 4, wherein the valve seat is formed with a semi-spherical surface and a corresponding portion of the valve member is likewise formed with a semi-spherical surface.

8. Apparatus according to claim 1, wherein the second passageway comprises a restriction so that a sudden application and removal of the vacuum pressure for the vacuum pressure chamber is avoided.

9. Apparatus according to any preceding claim wherein the first passageway comprises a cup-shaped member disposed in the valve and covering the inlet, the cup-shaped member having an opening through which the inlet communicates with the interior of the valve.

10. Apparatus according to claim 7, wherein the rod of the valve member comprises an enlarged section at its lowest portion, a small section at its upper section; and a tapered section formed between said enlarged section and the small section, whereby the opening area of the first passageway is varied in response to the detected temperature at said temperature responding portion.

11. Temperature responsive apparatus for controlling the air intake of an internal combustion engine, substantially as described with reference to Figs. 1 , 2 and 3 of the accompanying drawings and substantially as illustrated therein.

12. Temperature sensitive apparatus for controlling the air intake of an internal combustion engine, substantially as described with reference to Figs. 1 and 6 of the ac-

companying drawings and substantially as illustrated therein.

13. Temperature sensitive apparatus for controlling the air intake of an internal combustion engine, substantially as illustrated therein.

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1567334 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1.

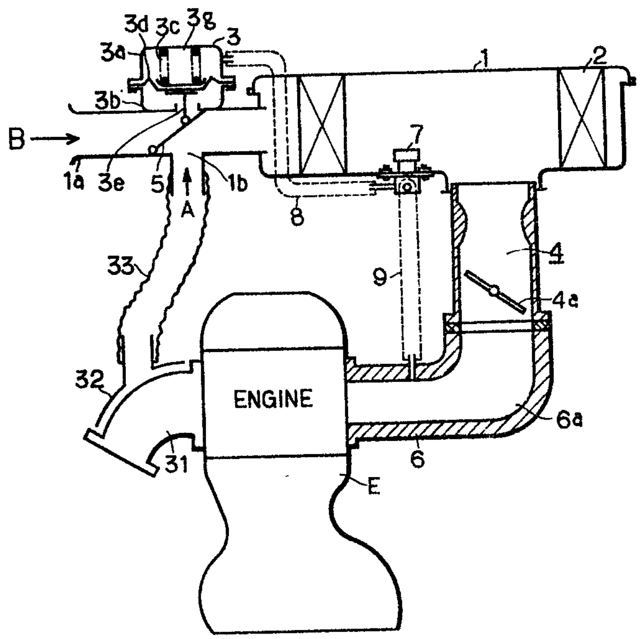


FIG. 2.

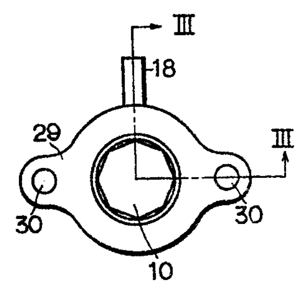
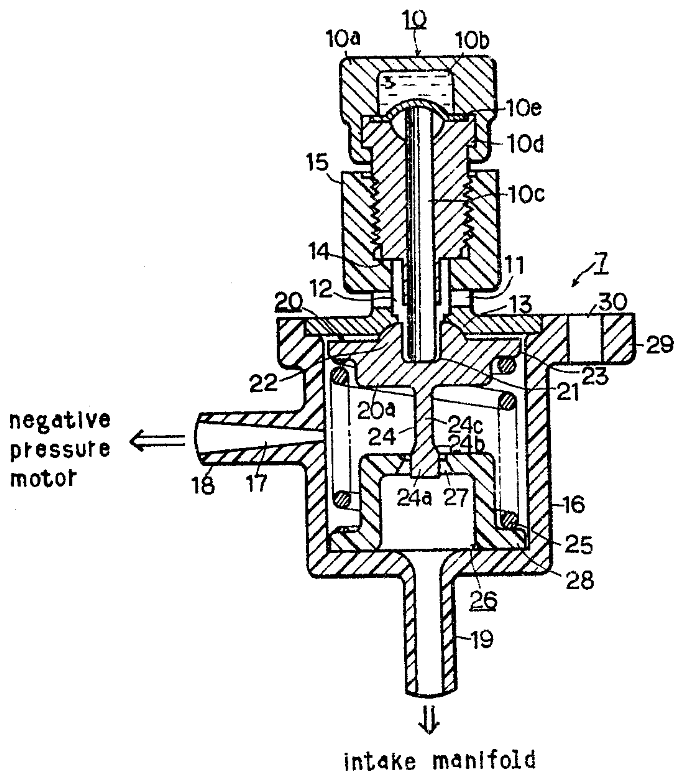


FIG. 3.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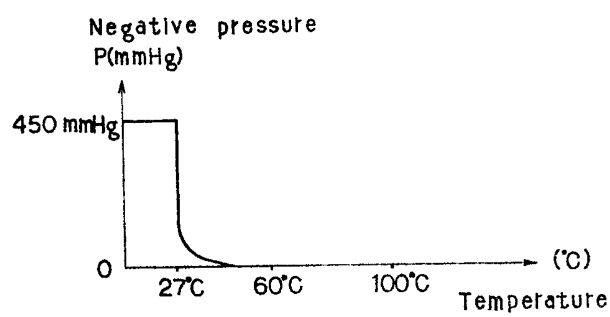
10a
10b
10e
10d
15
10c
14
11
7
12
13
20
30
29
22
23
21
20a
24c
24
24b
negative pressure motor
18
17
24a
27
16
25
28
26
19
intake manifold

FIG. 4.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450 mmHg
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27°C
60°C
100°C
(°C)
Temperature

FIG. 5.

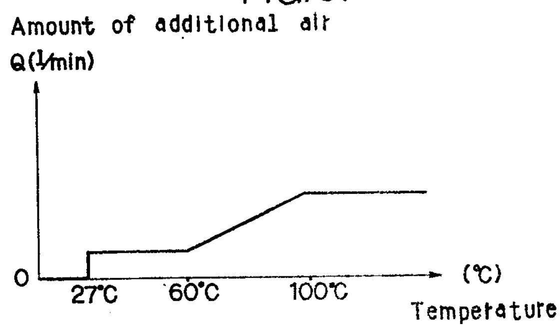
Amount of additional air
Q(l/min)
0
27°C
60°C
100°C
(°C)
Temperature

FIG. 6.

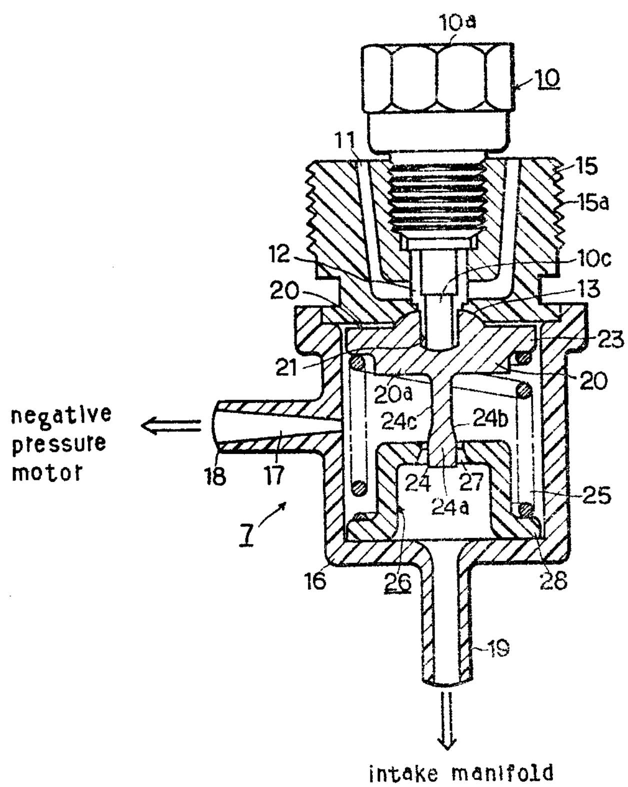
10a
10
11
15
15a
12
10c
20
13
23
21
20
20a
24c
24b
negative pressure motor
18
17
24
27
24a
25
7
16
26
28
19
intake manifold

FIG. 7.

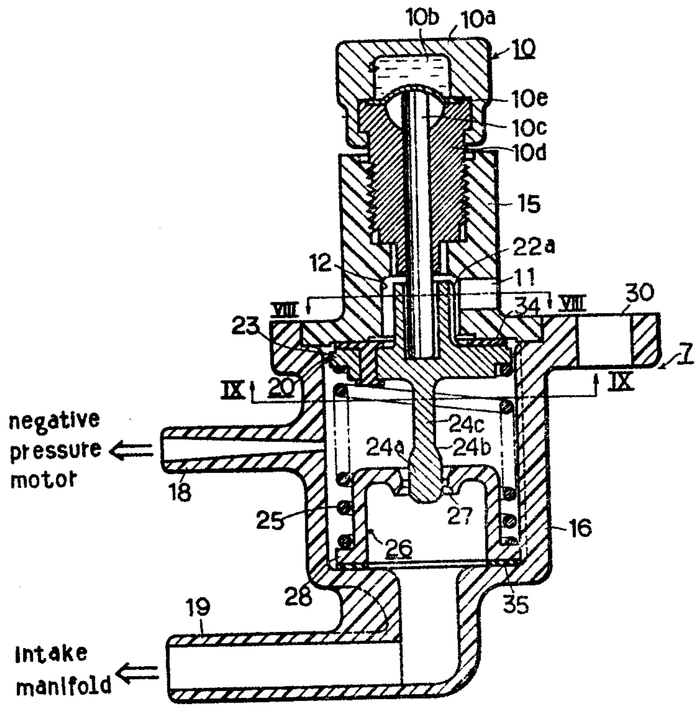

FIG. 8.

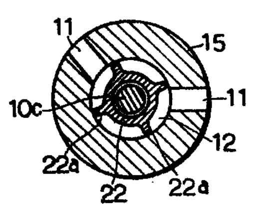

FIG. 9.