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(54) **Emission control system.**

(57) An emission control system for an internal combustion engine having an inlet manifold 11, an exhaust manifold 12 and an exhaust system including a catalytic converter 13 has a connection between the exhaust manifold 12 and inlet manifold 11 for recirculating exhaust gases from the exhaust manifold 12 to the inlet manifold 11, a first gas flow control valve 14 controlling flow of exhaust gases from the exhaust manifold 12 to the inlet manifold 11 ; a connection to the exhaust manifold 12 by which air may be supplied to the exhaust manifold 12, a second gas flow control valve 16 being provided to control flow of air to the exhaust manifold 12 the first and second gas flow control valves 14, 16 each being driven by a fluid pressure differential actuator 60-72 ; 140-154, a common regulatable pressure source 21 being adapted to selectively drive either the first gas flow control valve 14 or the second gas flew control valve 16.

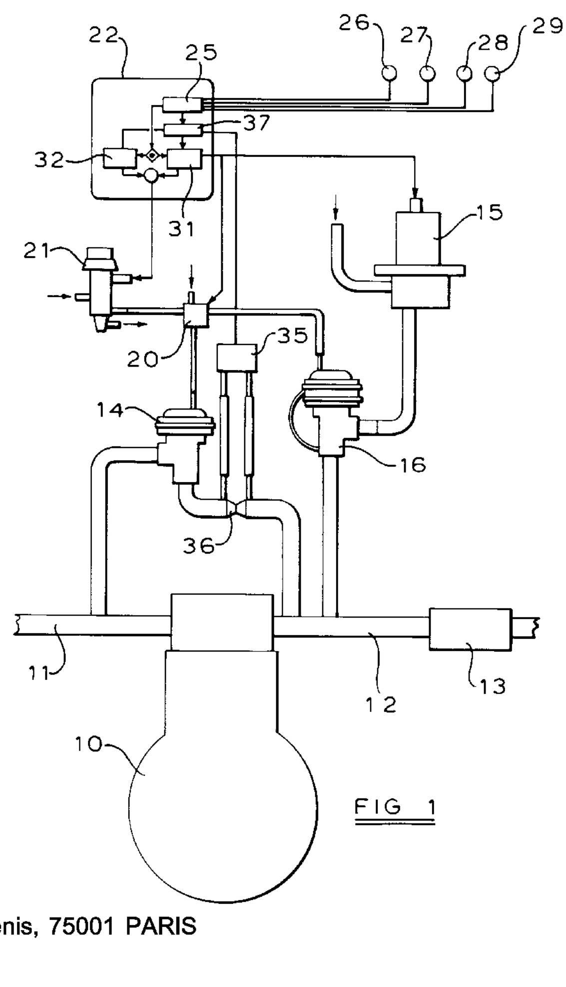

FIG 1

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The present invention relates to emission control systems for internal combustion engines.

One technique conventionally used to reduce NOx and other pollutants in exhaust gases of internal combustion engines, is to recirculate a proportion of the exhaust gases. The volume of exhaust gases that can be recirculated will depend on the load, speed and operating temperature of the engine. Typically valve means is provided to control the rate of flow of exhaust gases to the inlet manifold. The valve means may be driven by a vacuum actuator, an electronic control module controlling an electronic vacuum regulator to control the vacuum actuator.

The engine exhaust system may also be fitted with a catalytic convertor to further reduce pollutants in the exhaust gases. In order to reduce the time taken for the catalytic converter to reach its optimum operating temperature when the engine is started up, air may be pumped to the exhaust manifold, to react with the exhaust gases to preheat the catalyst. In such systems, air is pumped into the exhaust manifold for several minutes after starting the engine and must then be shut down quickly. The amount of air mixed with the exhaust gases is critical, too little air prolonging the warming up period and too much air over heating the catalyst so that there is a risk it will melt. As the volume of exhaust gases will depend upon the engine speed, it is desirable that the flow of air to the exhaust manifold is modulated to maintain optimum proportions of air and exhaust gases at all engine speeds.

GB 2,002,548B discloses an internal combustion engine with both exhaust recirculation and secondary air systems in which each system is controlled by a separate gas flow control valve. The gas flow control valves are driven by pressure differential from independently regulatable sources and while under common electrical control, it is possible for both valves to be open at the same time thus permitting the secondary air to be fed back to the inlet manifold, which will result in lean running of the engine with possible damage to the engine.

According to one aspect of the present invention an emission control system for an internal combustion engine having an inlet manifold, an exhaust manifold and an exhaust system including a catalytic converter, comprises; a connection between the exhaust manifold and inlet manifold for recirculating exhaust gases from the exhaust manifold to the inlet manifold, a first gas flow control valve being provided to control flow of exhaust gases from the exhaust manifold to the inlet manifold; a connection to the exhaust manifold by which air may be supplied to the exhaust manifold, a second gas flow control valve being provided to control flow of air to the exhaust manifold, the first and second gas flow control valves each being driven by a fluid pressure differential actuator; characterised in that a common regulatable pressure source is adapted to selectively drive either the first gas flow control valve or the second gas flow control valve.

Using a common regulatable pressure source to drive both valves in accordance with the present invention, will prevent both valves opening at the same time, thus avoiding the risk of damage to the engine due to lean running. The present invention will also avoid duplication of the pressure regulating device with consequent reduction in cost and the number of components that can malfunction.

An embodiment of the invention is now described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 illustrates diagrammatically an emission control system in accordance with the present invention;

Figure 2 illustrates diagrammatically the gas flow control valve for controlling flow of exhaust gases from the exhaust manifold to the inlet manifold in the system illustrated in Figure 1; and

Figure 3 illustrates diagrammatically the gas flow control valve for controlling flow of air to the exhaust manifold of the system illustrated in Figure 1.

Figure 1 illustrates diagrammatically an engine 10 with inlet manifold 11 and exhaust manifold 12. An exhaust system including a catalytic converter 13 is connected to the exhaust manifold 12.

The exhaust manifold 12 is connected to the inlet manifold 11 via a first gas flow control valve 14 by which a regulated proportion of the exhaust gases leaving the engine 10 via the exhaust manifold 12 may be recirculated via the inlet manifold 11.

An air pump 15 is connected to the exhaust manifold 12 via a second gas flow control valve 16, by which a regulated volume of air may be pumped to the exhaust manifold 12.

As illustrated in Figure 2, the first gas flow control valve 14 has a valve housing 50 which defines a cylindrical valve chamber 51 having an outlet 52 and inlet 53. The valve chamber 12 defines a valve seat 54, the valve chamber 51 increasing in diameter from the valve seat 54 to the outlet 52.

A valve member 56 is located coaxially of the valve chamber 51, a valve stem 57 being slidably mounted in a bearing 58 mounted at the end of the valve chamber 51 remote from the inlet 53. A valve head 59 is located at the end of valve stem 57 adjacent to seat 54 so that the valve member 56 may be moved between a position in which the valve head 59 engages and closes the valve seat 54 and a position in which the valve head 59 is spaced axially away from the valve seat 54 towards the outlet 52.

A cylindrical gas-tight casing 60 is bolted to the valve housing 50 coaxially of the valve chamber 51. The end of the valve stem 57 remote from valve head 59 extends into the casing 60. The casing 60 is formed from two parts 61 and 62 which are clamped together in suitable manner. A flexible annular diaphragm 65 is mounted within the cylindrical casing 60, an outer peripheral bead portion 66 being clamped between parts 61 and 62 of casing 60, to provide a gas-tight seal therebetween. The inner periphery 67 of diaphragm 65 is secured to a plate 68 which is mounted on and secured to the end of valve stem 57. The diaphragm 65 thereby divides the casing 60 into two gas-tight compartments 70 and 71. A port 72 is provided through part 61 of casing 60 to connect compartment 70 to atmosphere, and a port 73 is provided in part 62 of casing 60 by means of which compartment 71 may be connected to a controllable vacuum source. A helical compression spring 75 acts between the end of casing 60 remote from valve seat 54 and the plate 68, to apply a load to the valve stem 57 urging the valve head 59 into engagement with valve seat 54.

The second gas flow control valve 16, as illustrated in Figure 3, comprises a valve housing 111 of similar construction to that of valve 14. The valve housing 111 defines a cylindrical valve chamber 112 having an inlet 114 and outlet 115. The valve chamber 112 defines a valve seat 113, the valve chamber 112 increasing in diameter from the valve seat 113 towards the inlet 114.

A valve member 116 is located coaxially of the valve chamber 112, a valve stem 117 being slidably mounted in bearing 118 mounted at the end of valve chamber 112 remote from outlet 115. A valve head 119 is located at the end of valve stem 117 adjacent to seat 113, so that the valve member 116 may be moved between a position in which the valve head 119 engages and closes the valve seat 113 and a position in which the valve head 119 is spaced axially away from the valve 113 towards inlet 114.

A cylindrical gas-tight casing 120 is bolted to the valve housing 111 coaxially of the valve chamber 112. The end of the valve stem 117 remote from valve head 119 extends into casing 120. The casing 120 is formed from two parts 122 and 123, which are clamped together in suitable manner. A flexible annular diaphragm 125 is mounted within the casing 120, an outer peripheral bead portion 126 being clamped between parts 122 and 123 of casing 120, to provide a gas-tight seal therebetween. The inner periphery 127 of diaphragm 125 is secured to the valve stem 119 at an axially fixed position. The diaphragm 125 thereby divides the casing 120 into two gas-tight compartments 130 and 131. Compartment 130 is connected to the inlet 114 by means of a bore 132 passing through the housing 111 and casing 120 and compartment 131 is connected via inlet 133, pressure tube 134 and bore 135 to the valve chamber 112 on the side of the seat 113 adjacent to the outlet 115.

A second cylindrical gas-tight casing 140 is bolted to casing 120 with sealing means 141 and a bearing 142 therebetween. An extension 143 is secured to the end of valve stem 117 in suitable manner and extends through the bearing 142 into casing 140. The casing 140 is formed from two parts 144 and 145, in similar manner to casing 120. The outer periphery 147 of a second diaphragm 146 is clamped between parts 144 and 145 of casing 140. The inner periphery 148 of diaphragm 146 is secured to a plunger 149 located coaxially within the casing 140. A helical compression spring 150 acts between the end of casing 140 remote from valve housing 111 and the plunger 149, to urge the plunger 149 into engagement with an abutment 151 on the end of the extension 143 of valve stem 117, thus applying a load to valve stem 117 which will urge the valve head 119 into engagement with the valve seat 113. The diaphragm 146 thereby divides the casing 140 into two gas-tight compartments 152 and 153. A port 154 is provided in the wall of part 144 of casing 140 by which compartment 152 is connected to atmosphere and a port 155 is provided in part 145 of casing 140 by which compartment 153 may be connected to a controllable vacuum source.

Compartments 71 and 153 of valves 14 and 16 respectively are connected by ports 73 and 155, via a vacuum diverter solenoid 20, to an electronic vacuum regulator 21. The vacuum diverter solenoid 20 under the control of an electronic control module 22, will selectively connect one of the compartments 71, 153 to the electronic vacuum regulator 21 while connecting the other compartment 153, 71 to atmosphere.

The electronic vacuum regulator 21 under control of the electronic control module 22, selectively connects the compartment 71, 153 connected thereto, to a source of vacuum or to atmosphere, to regulate the pressure within the compartment 71, 153.

The electronic control module 22 includes an input circuit 25 for processing signals from sensors 26 to 29, which measure, for example, engine load, engine speed, engine operating temperature and catalyst operating temperature. The signals from the sensors 26 to 29 are processed and depending on the parameters measured, the electronic control unit 22 will energise either a secondary air circuit 31 or an exhaust recirculation circuit 32.

When the engine is first started and the catalytic converter 13 is cold, the electronic control unit 22 will actuate the secondary air circuit 31. The secondary air circuit 31 will switch on the air pump 15 and switch the vacuum diverter solenoid 20, to connect compartment 153 of valve 16 to the electronic vacuum regulator 21 and compartment 71 of valve 14 to atmosphere.

With chambers 70 and 71 of valve 14 connected to atmosphere, the spring 75 will maintain valve head 59 in engagement with the valve seat 54, so that the valve 14 will be closed preventing recirculation of exhaust gases.

The air pump 15 will deliver air under pressure to the inlet 114 of valve 16. When the pressure at the inlet 114 and in compartment 130 of valve 16 is in excess of the pressure at the outlet 115 and in compartment 131, which will be at the same pressure as the exhaust manifold 12, the pressure differential across the diaphragm 125 will apply a load to the valve stem 117, urging valve member 116 upwardly against the load applied by spring 150. In addition, the electronic vacuum regulator 21 will connect chamber 153 to the source of vacuum producing a pressure differential across diaphragm 146 applying an upward load on plunger 149, this upward load opposing the downward load applied by spring 150. When the loads applied to the valve member 116 by the pressure differential across diaphragm 115 and to the plunger 149 by the pressure differential across diaphragm 146 are in excess of the load applied by the spring 150, the valve 116 will move upwardly opening the valve seat 113 and permitting air to flow from inlet 114 through outlet 115 to the exhaust manifold 12. Because of the varying diameter of the valve chamber 112 the area of the opening between inlet 114 and outlet 115 will depend upon the axial movement of the valve member 116. This may be controlled by controlling the strength of the vacuum in compartment 153 which is achieved by means of the electronic vacuum regulator 21 by switching between vacuum and atmosphere under the control of the electronic control module 22. The degree of opening of valve 16 may thus be controlled to control the proportion of air mixed with the exhaust gases, so that the warming up period of the catalytic converter 13 may be optimised.

If, for example, the engine should backfire while air is being supplied to the exhaust manifold 12 and the pressure in the exhaust manifold 12 becomes greater than that at the inlet 114 to valve 16, the pressure in compartment 131 will then be in excess of that in compartment 130 and the pressure differential across the diaphragm 125 will move the valve member 116 downwardly, so that the valve head 119 will engage and close the valve seat 113, thereby preventing exhaust gases from being fed back to the pump 15. Similarly, if the pump is switched off or should fail, the pressure at the inlet 114 will fall below the pressure at the outlet 115 so that the pressure differential across diaphragm 125 will again close the valve 16 irrespective of the state of the electronic vacuum regulator 21.

When the catalytic converter 13 has reached its optimum operating temperature, the electronic control module 22 will switch off the secondary air circuit 31 which in turn will de-energise the air pump 15 and will switch the vacuum diverter solenoid so that chamber 71 of valve 14 is connected to the electronic vacuum regulator while chamber 153 of valve 16 is connected to atmosphere.

Connection of chamber 153 of valve 16 to atmosphere will remove the pressure differential across diaphragm 146 re-applying the full load of spring 150 to valve member 116, thus ensuring that the valve 16 remains closed.

When the measured parameters of the engine indicate that exhaust gas recirculation would be beneficial, the exhaust gas recirculation circuit 32 will control the electronic vacuum regulator 21 to create a vacuum in compartment 71 of valve 14. Reduction of pressure in compartment 71 of valve 14 will create a pressure differential across diaphragm 65 which will oppose the load applied to the valve member 56 by spring 75, thus moving the valve member 56 upwardly and opening the valve seat 54. The axial movement of the valve member 56 and consequently the rate of flow of gases through the valve 14 may be controlled in similar manner to the valve 16, by means of the electronic vacuum regulator 21, so that the proportion of exhaust gas that is recirculated may be controlled in accordance with the operating conditions of the engine.

A pressure differential transducer 35 measures the pressure across a restriction 36 in the connection between the exhaust manifold 12 and valve 14. This pressure differential transducer 35 provides a signal to a feedback circuit 37 in the electronic control module 22, which will cause the electronic vacuum regulator 21 to connect compartment 71 to atmosphere, shutting valve 14, if the pressure on the downstream side of the restriction 36 falls below that on the upstream side, which would result if pressure in the exhaust manifold 12 fell below that in the inlet manifold 11.

Various modifications may be made without departing from the invention. For example, while in the system described above a vacuum diverter solenoid 20 is used to switch between the vacuum actuators of valves 14 and 16, any motorised switching means may be used. Furthermore instead of being driven by vacuum actuators the valves 14 and 16 may be driven by pressure actuators, for example by connecting chambers 70 and 152 to a regulatable source of fluid under pressure and chambers 71 and 153 to atmosphere or drain.

Claims

1. An emission control system for an internal combustion engine (10) having an inlet manifold (11), an exhaust manifold (12) and an exhaust system including a catalytic converter (13) comprising; a connection between the exhaust manifold (12) and inlet manifold (11) for recirculating exhaust gases from the exhaust manifold (12) to the inlet manifold (11), a first gas flow control valve (14) being provided to control flow of exhaust gases from the exhaust manifold (12) to the inlet manifold (11); a connection to the exhaust manifold (12) by which air may be supplied to the exhaust manifold (12), a second gas flow control valve (16) being provided to control flow of air to the

exhaust manifold (12), the first and second gas flow control valves (14, 16) each being driven by a fluid pressure differential actuator (60-72; 140-154) characterised in that a common regulatable pressure source (21) is adapted to selectively drive either the first gas flow control valve (14) or the second gas flow control valve (16).

2. An emission control system according to Claim 1 characterised in that the exhaust manifold (12) is connected to an air pump (15) via the second gas flow control valve (16).

3. An emission control system according to Claim 1 or 2 characterised in that the first and second gas flow control valves (14, 16) are each driven by a vacuum actuator (60-72; 140-154).

4. An emission control system according to any one of Claims 1 to 3, characterised in that the actuator (60-72; 140-154) comprises a pair of fluid tight compartments (70,71; 152,153) separated by a flexible diaphragm (65; 146).

5. An emission control system according to Claim 4 characterised in that one of the compartments (71; 153) of each of the first and second gas flow control valves (14; 16) is selectively connected to a regulatable fluid source (21) by a motorised valve (20).

6. An emission control system according to Claim 5 characterised in that one of the compartments (71; 153) associated with each of the first and second gas flow control valves (14; 16) is selectively connected to a regulatable fluid source (21) by means of a solenoid valve (20).

7. An emission control system according to any one of Claims 4 to 6 characterised in that one of the compartments (71; 153) of the actuator (60-72; 140-154) associated with each of the gas flow control valves (14; 16) is selectively connected via a common pressure regulator (21) to a fluid source.

8. An emission control system according to Claim 7 characterised in that the valve (20) and pressure regulator (21) are controlled by an electronic control module (22).

9. An emission control system according to any one of the preceding claims characterised in that the second gas flow control valve (16) includes means (120-132) to prevent backflow of exhaust gases from the exhaust manifold (12).

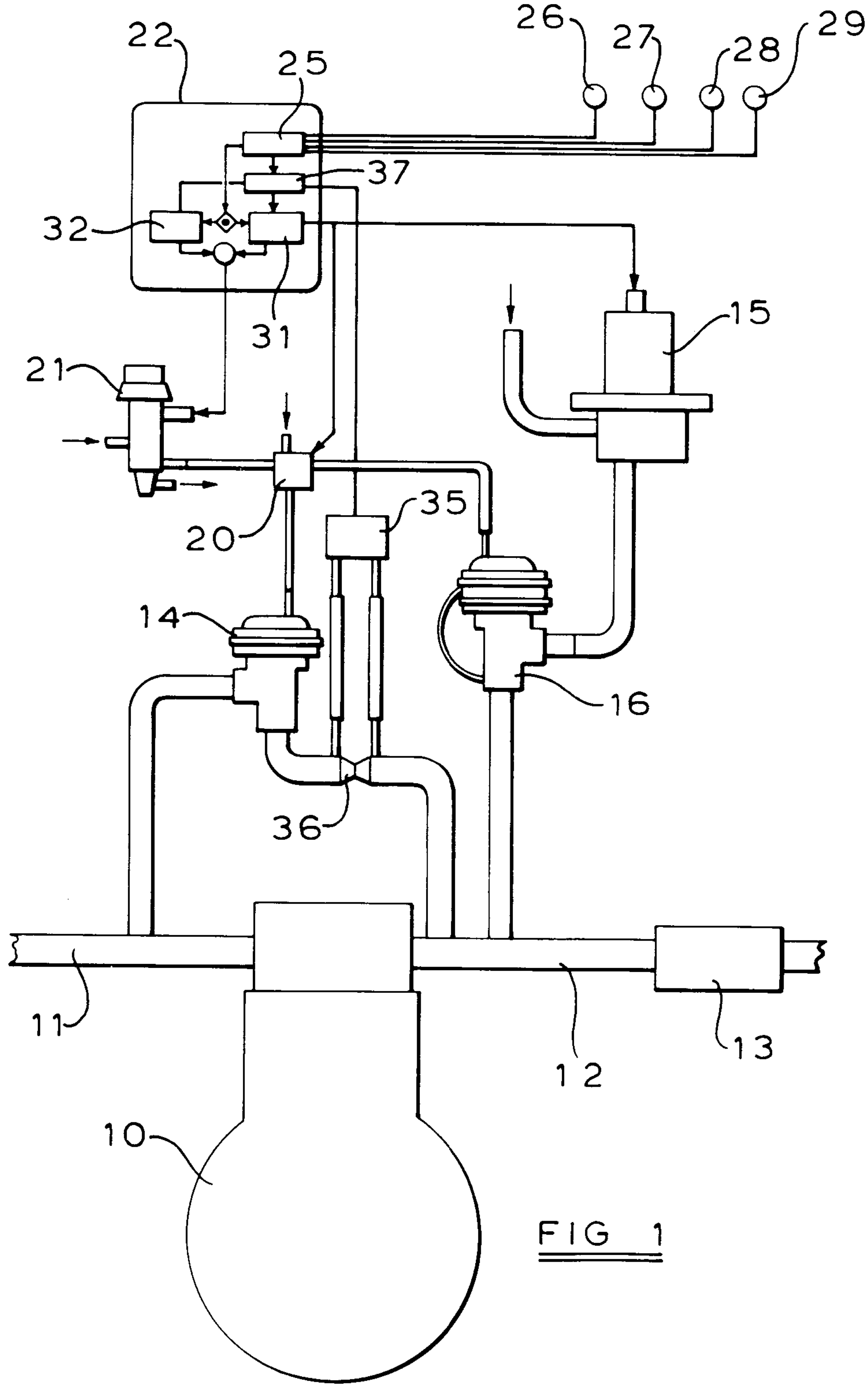

FIG 1

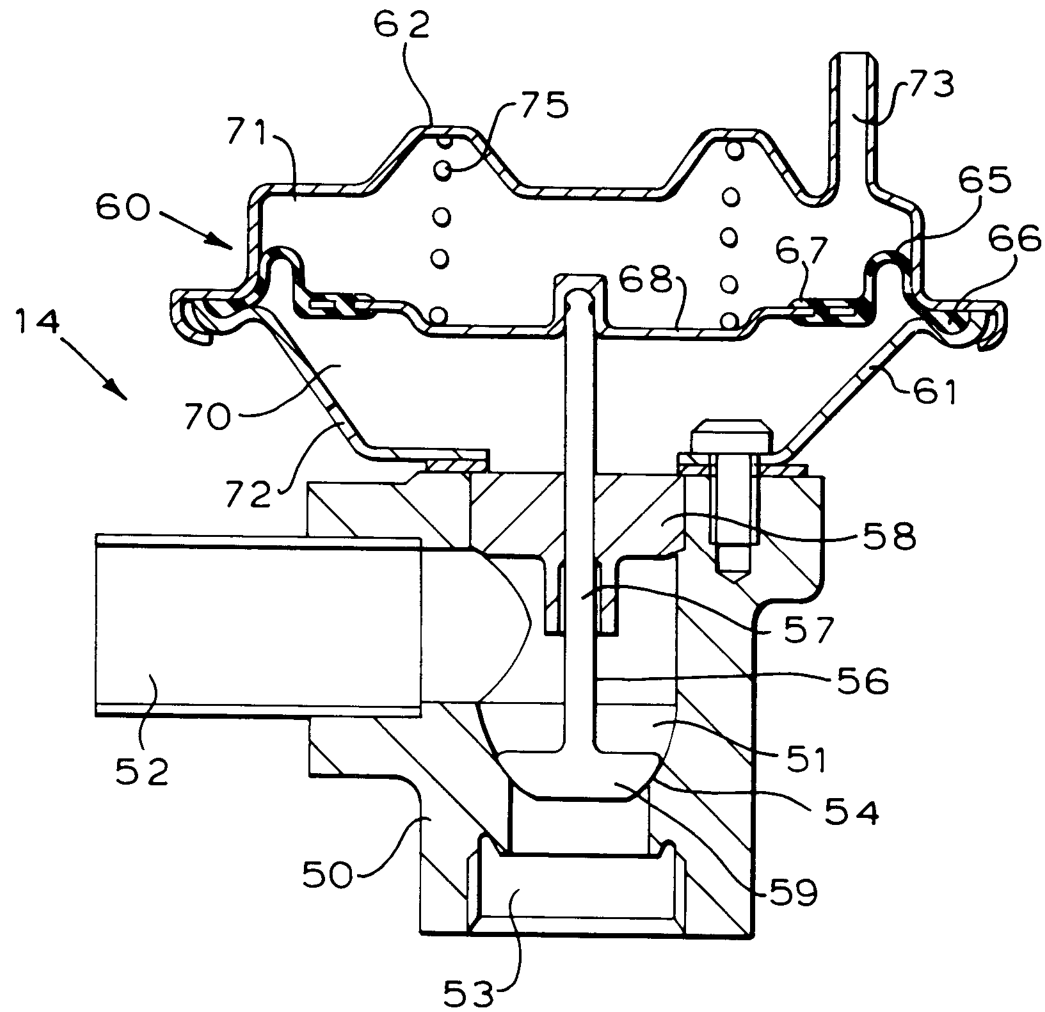

FIG 2

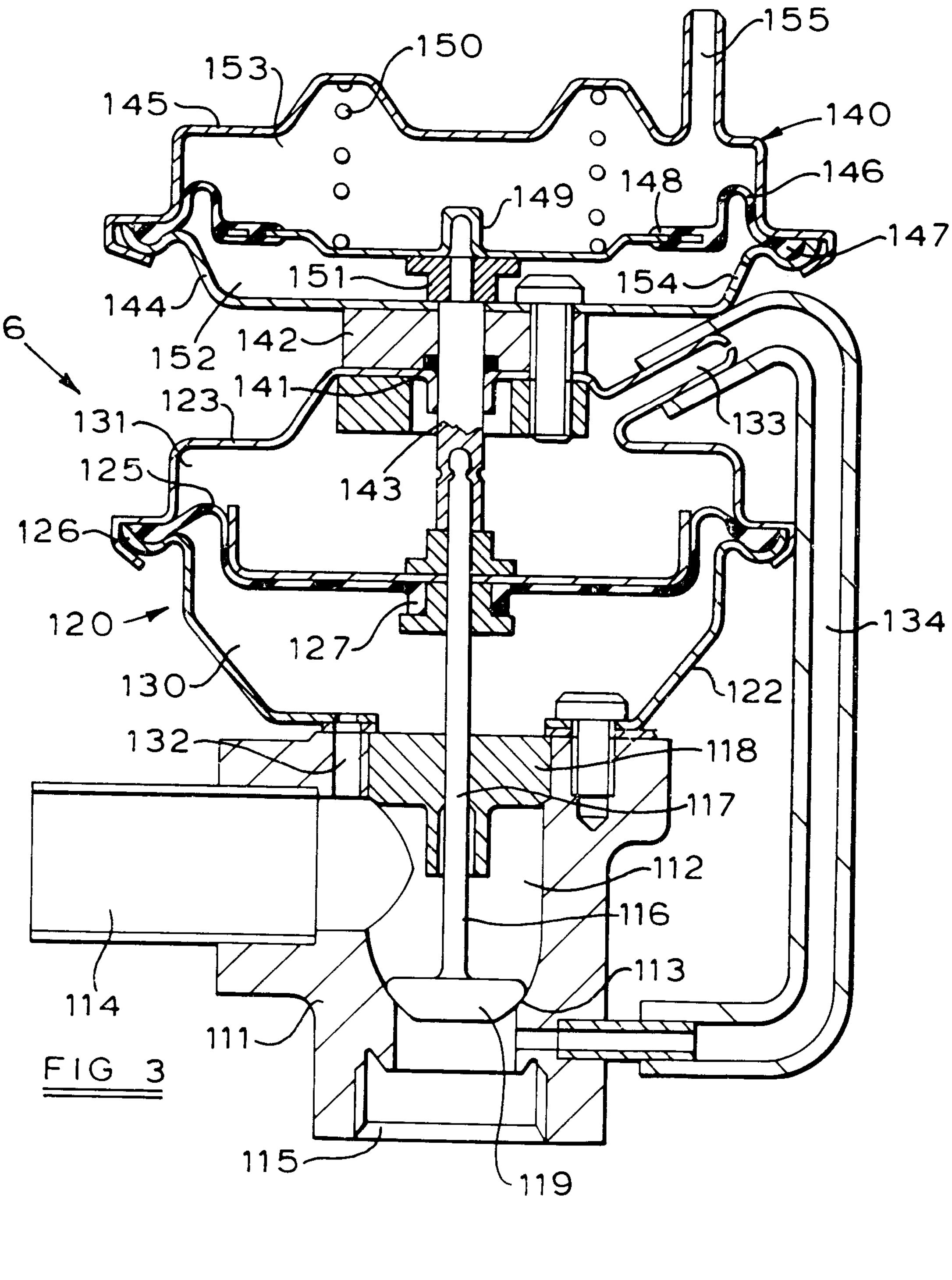
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FIG 3

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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 0045

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 149 377 (Y. TAKAGI ET AL.) * column 10, line 32 - column 12, line 68; figures 5,6 * ---	1-6,9	F01N3/22 F02M25/07
Y	US-A-3 992 878 (J. W. MOORMAN) * column 1, line 28 - line 48 * * column 5, line 57 - column 6, line 3; figure * ---	1-6,9	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 372 (M-544)(2429) 11 December 1986 & JP-A-61 164 046 (NISSAN MOTOR COMPANY LTD.) 24 July 1986 * abstract * ---	1-6	
A	US-A-4 202 173 (N. WAKITA) * column 2, line 64 - column 4, line 15; figures 1-3 * -----	1-4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F01N F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 APRIL 1992	HAKHVERDI M.

CATEGORY OF CITED DOCUMENTS

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