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Lorenz

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[54] **MALFUNCTION INDICATOR FOR EXHAUST GAS RECIRCULATION VALVE**

[75] Inventor: **Jerome L. Lorenz,** Columbus, Ohio

[73] Assignee: **Ranco Incorporated,** Columbus, Ohio

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[52] **U.S. Cl.** ..... **123/119 A,** 123/198 R, 123/198 D

[51] **Int. Cl.** **F02m 25/06**

[58] **Field of Search** ..... 123/119 A, 198 R, 123/198 D

[56] **References Cited**

UNITED STATES PATENTS

2,419,747	4/1947	Wassman	123/119 A
2,988,069	6/1961	Smith	123/198 D X
3,066,527	12/1962	Stein	123/198 D
3,202,161	8/1965	Richards	123/198 D X
3,291,461	12/1966	Pope	123/119 F X

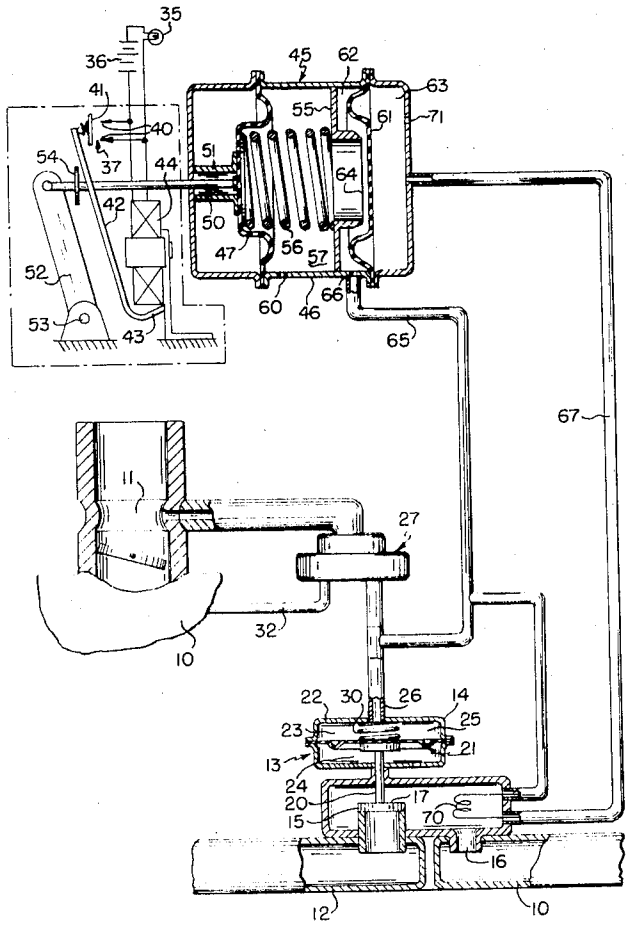
Primary Examiner—Wendell E. Burns

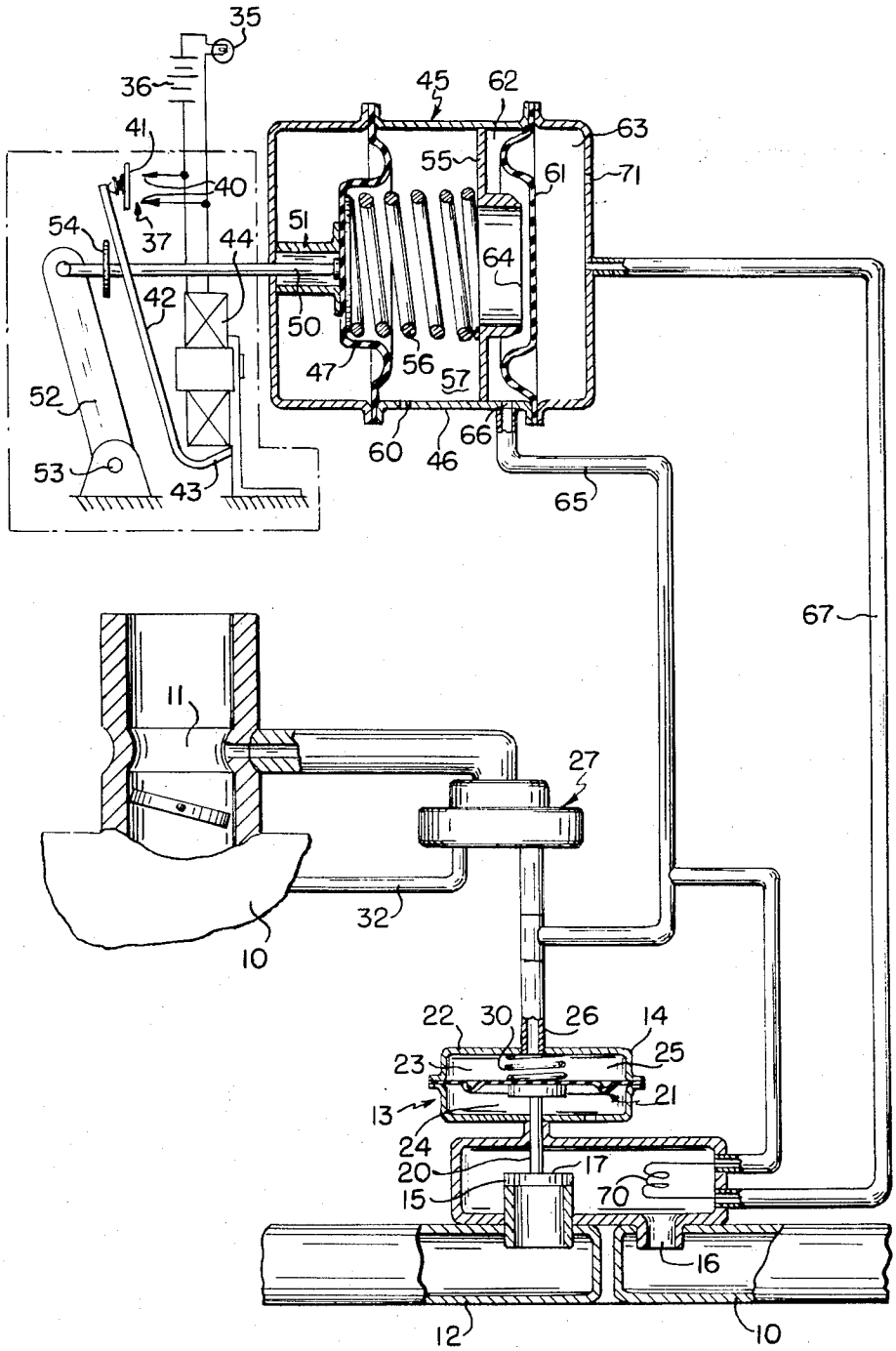
Attorney—Roy E. Raney

[57] **ABSTRACT**

A malfunction indicator for a vacuum operated exhaust recirculation valve in an internal combustion engine comprises an indicator means actuated in response to attainment of a gradually drawn vacuum in a chamber communicating with the valve operating vacuum source, the chamber adapted to be cut off from the vacuum source prior to attainment of the actuating vacuum by a valve operated in response to a given increase in resistance to flow of air through a capillary tube comprising a section of conduit connected to the vacuum source and subjected to the high temperatures of exhaust passing through the valve.

4 Claims, 1 Drawing Figure




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MALFUNCTION INDICATOR FOR EXHAUST GAS RECIRCULATION VALVE

BACKGROUND OF THE INVENTION

It has been found desirable to reduce or eliminate oxides of nitrogen in the exhaust of internal combustion engine driven automobiles by directing a portion of the exhaust into the fuel intake of the engines during normal, relatively unloaded driving conditions of the automobiles. This practice is referred to as a recirculation of exhaust. Under certain other operating conditions of the automobiles, such as at idle, heavy loading of the engine and wide open throttle, recirculation of exhaust is unnecessary because little if any nitric oxides are produced under such conditions and, furthermore, recirculation of exhaust under these conditions results in rough and otherwise unsatisfactory operation of the engines. Valves have been provided to control the recirculation of exhaust so that the valves are closed when recirculation is unnecessary. Thus, the valves will at times be open and at other times closed during normal operation thereof. The failure of a valve of the type mentioned to open due to sticking or other malfunction cannot be readily detected by the operator of the automobile and consequently in the event the valve did not open the engine would emit nitric oxides without the knowledge of the operator. Therefore, it is desirable that means be provided for indicating to the operator of the automobile that the exhaust recirculation valve is not opening during the conditions requiring opening thereof so that the malfunctioning valve may be corrected or replaced.

THE PRESENT INVENTION

The present invention provides a valve for effecting the recirculation of exhaust in an internal combustion engine during operating conditions requiring such recirculation and shutting off recirculation of exhaust during other operating conditions, and means for indicating a failure of the valve to effect recirculation when such recirculation is desired.

In carrying out the invention, a valve is provided between the exhaust manifold and the intake manifold and is operated by a fluid pressure responsive motor, the fluid for operating the motor being regulated by suitable control means for causing proper opening and closing of the valve by the motor, and indicating means responding to the regulated fluid pressure to initiate a delayed signal producing operation when the fluid pressure is normally effective to cause opening of the valve, the delayed signal operation being deactivated by means responsive to exhaust passing through the valve.

Another object of the invention is the provision of an exhaust recirculation control valve and indicator means of the type mentioned in which one of the conduit means comprises a capillary tube subjected to the temperature of gases passing through the valve.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention, reference being made to the accompanying drawing which is a schematic showing of a valve for controlling the flow of exhaust of an internal combustion automotive engine with the intake manifold and an indicator for sensing a malfunction of the valve.

DESCRIPTION OF THE PREFERRED FORM OF THE INVENTION

In the drawing, a conventional internal combustion automotive engine, not fully shown, includes an intake manifold **10**, a carburetor feeding air and fuel into the manifold and comprising a venturi throat **11**, and an exhaust manifold **12**. Recirculation of exhaust gases into the intake manifold to reduce nitric oxide emissions is controlled by a valve **13**. The valve **13** comprises a body **14**, having an inlet port **15** connected with the exhaust manifold, and an outlet **16** connected with the intake manifold. The opening of the port **15** is controlled by a valve plate **17** which is moved to and from the inlet opening by a stem **20** attached thereto.

The stem **20** is reciprocated to open and close the port **15** by a vacuum motor **21** which comprises a casing **22** having a flexible diaphragm **23** dividing the casing into separate chambers **24,25**. The chamber **24** is open to atmosphere and the chamber **25** is connected by a conduit **26** with the intake manifold **10** through a vacuum control means **27**. A compression spring **30** in the chamber **25** urges the diaphragm **23** in a direction to cause the stem **20** to move the valve member **17** to close the port **15**. A vacuum drawn in the chamber **25** will cause atmospheric pressure to shift the diaphragm **23** against the spring **30** and remove the valve member **17** from the inlet opening. The degree of vacuum drawn in chamber **25** will depend upon the vacuum in the intake manifold **10** and the regulation thereof by the control means **27**. Typically, the vacuum fed to the motor **21** through the control means will be insufficient to open the valve **13** until the vacuum in the intake manifold rises to 4 inches Hg.

The control means **27** is shown schematically and it may take any suitable form. For example, it may be like the control means disclosed in copending U.S. Pat. applications Ser. Nos. 168,595 and 202,783 assigned to the assignee of the present application. Suffice to say, the control means **27** is connected with the intake manifold **10** by a conduit **32** so that the vacuum for operating the motor **21** is derived from the intake manifold. The control means **27** increases the vacuum in the conduit **26** when conditions prevail which indicate that the valve **13** should open. Conversely, where conditions are such that no exhaust recirculation is desired, the degree of vacuum in the conduit **26** is reduced so that the valve **13** closes.

According to the invention, means is provided for indicating the failure of the valve **13** to open in spite of the fact that vacuum source in conduit **26** exceeds 4 inches Hg. The indicating means comprises a signal lamp **35** which is connected in a circuit including a battery **36**, and a normally open switch **37**. The lamp may be located in any convenient position so as to be readily seen by the operator of the automobile. It is to be understood that the indicator could take any form desired. The switch **37** comprises contacts **40** which may be bridged by a contact bar **41** carried by a switch arm **42**. The arm **42** is pivoted at **43** and is inherently biased from the contacts **40**. The switch **37** is closed when the arm **42** is momentarily drawn to the right, as viewed in the drawing, and is retained in the switch closing position by an electromagnet **44**. The circuit for the magnet **44** includes the switch **37** so that once the magnet is energized, the switch arm **42** is retained in its switch closed position until the circuit for the magnet is bro-

ken. For example, the magnet circuit could also include the ignition switch which opens the circuit when the ignition is turned off.

The switch arm **42** is adapted to be moved to close the switch **37** and into the field of the magnet **44** by a fluid operated motor **45**. The motor **45** comprises a cylindrical shell or casing **46** having a transversely extending diaphragm **47**. The diaphragm **47** has a connecting rod **50** attached thereto which extends through a bushing **51** in the end wall of the casing **46**. The rod **50** is attached to a lever **52** pivoted at **53**, which lever guides the rod in reciprocating movements. A stop **54** on the rod engages the switch arm **42** during movement of the rod to the right and causes the switch arm to close the switch **37**. The rod **50** may move to the left independently of the switch arm so that while the magnet **44** is energized the switch **37** is closed irrespective of the movement of the rod **50**. The inner end of the bushing **51** limits movement of the diaphragm **47** and rod **50** to the left.

A relatively rigid wall **55** extends transversely of the casing **46** and is spaced from the diaphragm **47**. A compression spring **56** between the diaphragm **44** and the wall **55** urges the diaphragm and the rod **50** to the left. The area in the casing between the diaphragm **47** and the wall **55** comprises a chamber **57** and an opening **60** in the casing wall connects the chamber **57** with atmosphere.

A second diaphragm **61** extends transversely of the casing **46** and cooperates with the walls of the side and end of the casing and the wall **55** to form chambers **62,63**. The chambers **62,63** are sealed from one another except by way of a valve port **64** formed in the wall **55**. The port **64** is adapted to be closed by the diaphragm **61** moving thereover in response to a fluid pressure differential established between the chambers **62,63**.

The fluid pressure in chamber **62** is affected by connecting the chamber with the regulated valve operating vacuum conduit **26** by way of a conduit **65**. The conduit **65** communicates with the chamber **62** through a restrictor orifice **66**. The fluid pressure in the chamber **63** is affected by connection of the chamber with the vacuum conduit **26** through a conduit **67** which includes a section of a capillary tube **70**. The chamber **63** is vented to atmosphere through a restrictor orifice **71**. The length and internal diameter of the capillary tube **70** is such that when the temperature of the tube is increased from about 250°F. to the neighborhood of 350°F. The viscosity of the air in the tube correspondingly increases so that an appreciable resistance to the flow of air through the conduit **67** is established. When the capillary **70** is at temperatures of 250°F. and below the resistance to the flow of air therethrough is substantially reduced from that effected by a temperature of 350°F. as just mentioned. U.S. Pat. No. 2,589,251 discloses the effect on the viscosity of air passing through a capillary tube.

When the engine is inopertive, the diaphragm **47** is moved to the open position for the switch **37** by the spring **56**. Upon starting of the engine and the creation of a vacuum in conduit **26** for opening the valve **13**, initially substantially equal vacuums will be drawn in the chambers **62,63** through the conduits **65** and **67** connected with the vacuum conduit **26**. With the opening of the valve **13** hot exhaust gases flow through the valve body **14** and heat the capillary tube **70** to about 350°F. This increases the resistance to the flow of air therethrough and as a result a higher vacuum is drawn in chamber **62** than in chamber **63**. The ensuing pressure differential of the chambers causes the diaphragm **61** to close on the port **64**, shutting off the chamber **57** from the vacuum induced in the chamber **62**. Thus, the action of the spring **56** maintains the switch **37** in its open position.

Should the valve **13** fail to open in response to the usual valve opening control vacuums established in the conduit **26** by the control means **27**, the capillary tube **70** will not become heated above about 250°F. and the flow of air passing from chamber **63** to the conduit **26** is relatively unimpeded. This results in a relatively low pressure in the chamber **63** substantially equal to the low pressure in the chamber **62** and the diaphragm **61** cannot be closed on the port **64** or maintained on the port. Consequently, the chamber **57** will be subjected to the vacuum signal of the conduit **26**, less the slight influx of atmosphere through the restricted orifice **60**. This reduction in pressure in the chamber **57** results in movement of the diaphragm **47** to the right which closes the switch **37**.

To avoid false malfunction signals due to the relatively short period required for the capillary tube **70** to become heated by the exhaust flowing through the valve body, the opening **60** is of such diameter that several seconds are required to evacuate the chamber **57** to the degree necessary to cause the diaphragm **47** to shift to the switch closing position. If during this period of delay in closing the switch **37** the tube **70** becomes heated by the passage of exhaust through the valve, the vacuum drawn in chamber **63** through the capillary tube is rapidly reduced and the diaphragm **61** will be shifted to close the port **64** and seal the chamber **57** from the vacuum conduit **26**. Thus, the means to effect the delayed operation of the signal switch **37** is deactivated in response to the passage of exhaust through the valve, as desired.

I claim:

1. A valve for controlling the flow of exhaust into the intake manifold of the internal combustion enging comprising, motor means for opening and closing said valve, control means regulating said motor means in response to operating conditions of said engine, indicator means for indicating a malfunction of said valve, delayed action means responsive to said control means to activate said indicator means a period after control of said motor is established, and means responsive to the flow of exhaust gas through said valve for interrupting operation of said delayed action means whereby activation of said indicator means is prevented.

2. A valve for controlling the flow of exhaust into the intake manifold of the internal combustion engine comprising, fluid motor means for opening and closing said valve, means providing fluid flow, control means regulating the flow of fluid for operating said motor means, indicator means for indicating a malfunction of said valve, means responsive to said controlled fluid flow and operative to activate said indicator means a period after a given fluid flow condition is established, and means responsive to the flow of exhaust gas through said valve for interrupting operation of said means whereby activation of said indicator means is prevented.

3. A valve as defined in claim 2 further characterized by said means providing a fluid flow comprising a conduit connected with said intake manifold.

4. A valve as defined in claim 2 further characterized by said means to activate said signal comprising a chamber having a movable wall, means to gradually apply said controlled fluid to opposite sides of said wall, and means responsive to the presence of exhaust gas passing through said valve to change the fluid pressure applied to one side of said wall.

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