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Ephraim, Jr. et al.

[11] **3,754,538**

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[54] **ENGINE CRANKCASE VENTILATION**

[75] Inventors: **Max Ephraim, Jr.**, Evergreen Park; **Ludvik F. Koci**, LaGrange Park, both of Ill.

[73] Assignee: **General Motors Corporation**, Detroit, Mich.

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[52] **U.S. Cl.** .... **123/41.86, 123/119 B, 123/198 D**

[51] **Int. Cl.** **F02f 9/02**

[58] **Field of Search** .... 123/119 B, 41.86

[56] **References Cited**

UNITED STATES PATENTS

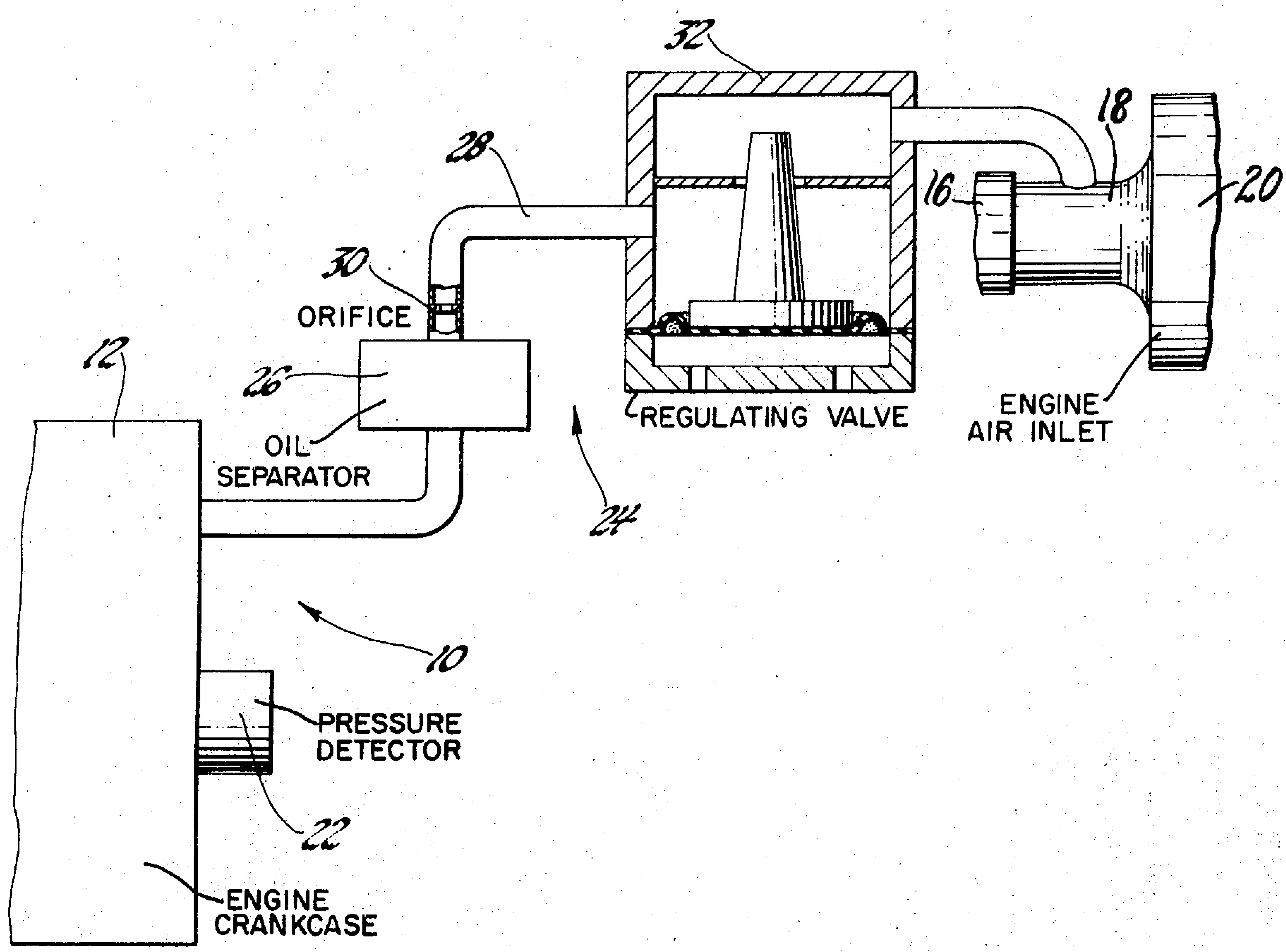
3,418,986	12/1968	Scherenberg	123/119 B
3,225,752	12/1965	Robinson	123/119 B
3,263,660	8/1966	Hyde	123/119 R
2,493,617	1/1950	Chubbuck	123/119 B
3,246,641	4/1966	Goehring	123/198 R

Primary Examiner—Al Lawrence Smith
Assistant Examiner—Dennis Toth
Attorney—J. L. Carpenter and Robert J. Outland

[57] **ABSTRACT**

In a preferred embodiment, a crankcase ventilation system utilizes the combination of a fixed orifice and a pressure actuated regulating valve downstream of the orifice to control vapor flow from the engine crankcase into its induction system. The arrangement provides controlled vacuum in the engine crankcase during normal operation but permits the development of pressure during abnormal conditions of excessive blowby or the like so as to permit actuation of a crankcase pressure actuated shutdown device associated with the engine.

4 Claims, 2 Drawing Figures



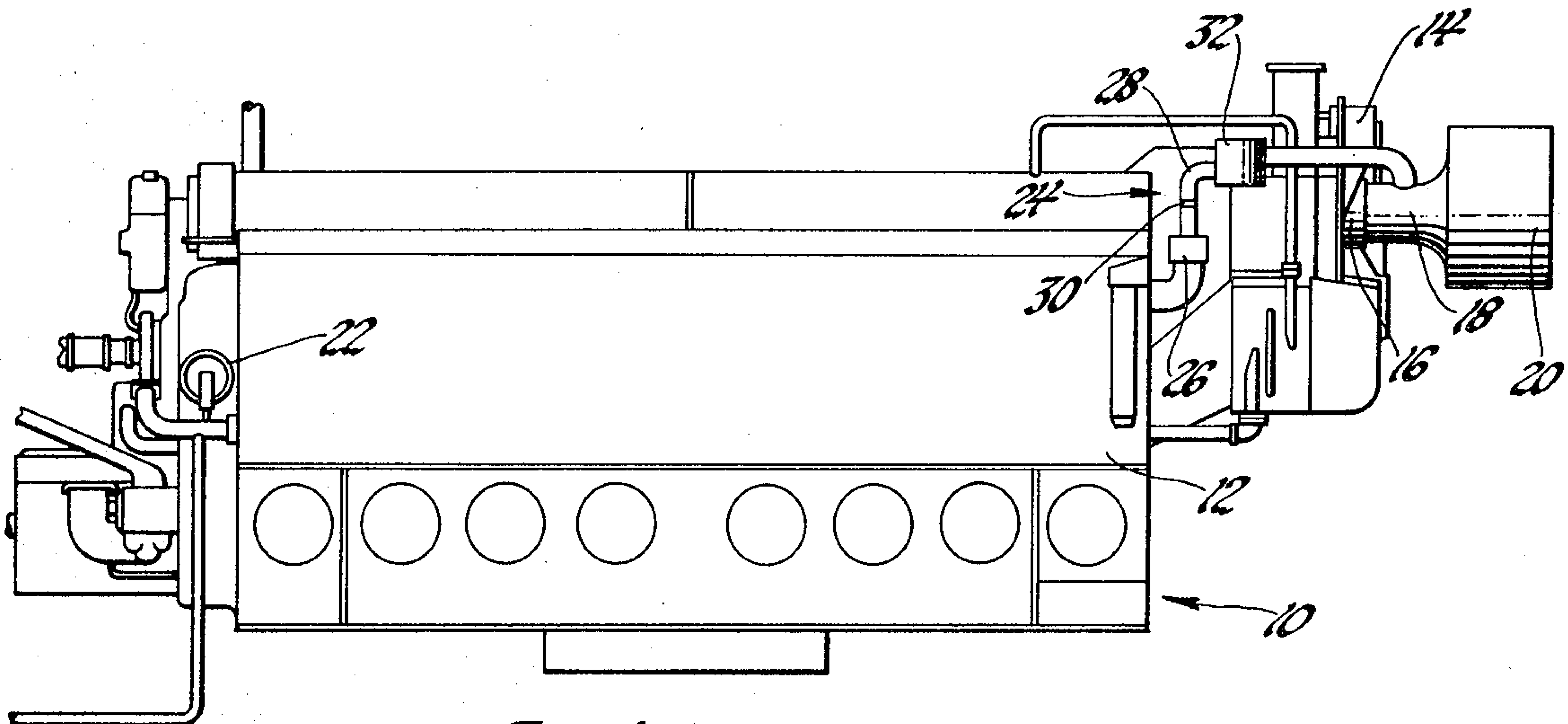

32
14
28
24
30
22
26
16
18
20
12
10

Fig. 1

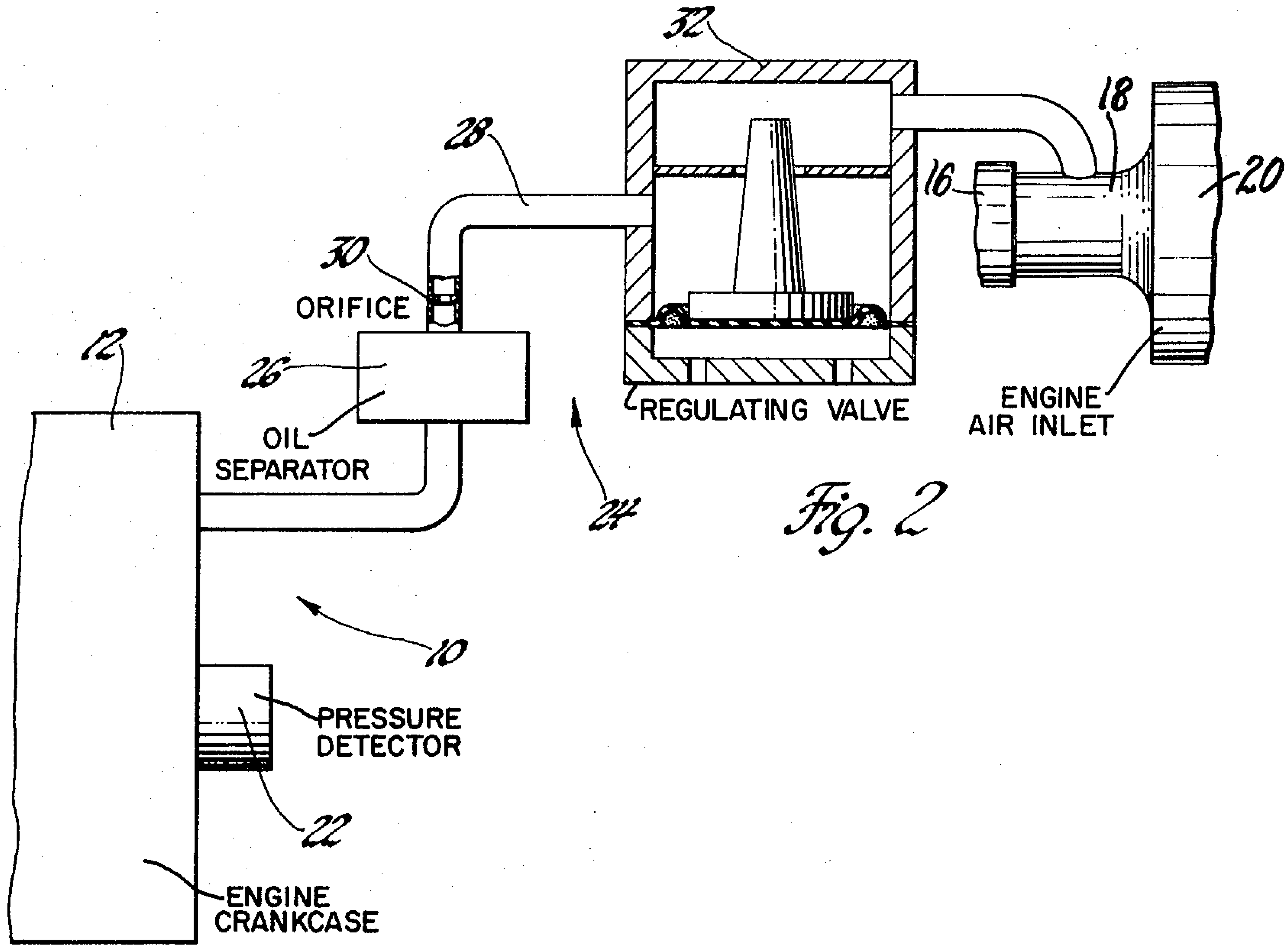

32
28
18
16
20
30
ORIFICE
12
26
OIL
SEPARATOR
REGULATING VALVE
ENGINE
AIR INLET
24
10
PRESSURE
DETECTOR
22
ENGINE
CRANKCASE

Fig. 2

ENGINE CRANKCASE VENTILATION

BACKGROUND OF THE INVENTION

This invention relates to crankcase ventilation systems for internal combustion engines and, more particularly, to a crankcase ventilation system having the capability of maintaining a predetermined vacuum in the engine crankcase under normal operating conditions, including varying inlet pressures while permitting the development of pressure in the crankcase under abnormal engine conditions of high blowby or the like.

In the operation of internal combustion engines and, specifically, large diesel engines used, for example, as power plants for diesel electric locomotives and the like, it is desirable to maintain a small vacuum in the crankcase under normal operating conditions. This has the advantage of reducing the amount of vapors maintained in the crankcase so that the possibility of a crankcase explosion is minimized. In addition, it provides a pressure differential which acts at the various seals and other openings in the crankcase to reduce the possibility of oil escaping from the interior of the engine. There are, however, abnormal operating circumstances for such engines which may result in excessive amounts of blowby escaping into the crankcase and indicate the possible or potential failure of certain engine parts. Continued operation under such conditions may cause serious engine damage and might lead to a crankcase explosion. Under such conditions, it is desired that the excess flow of blowby into the crankcase will create a positive pressure that will be detected by a crankcase-connected pressure detector that is provided to actuate an engine shutdown mechanism.

To maintain the desired crankcase vacuum, it has been known to provide means to exhaust the crankcase vapors, including the blowby gases which escape past the piston rings into the crankcase, through suitable conduit means into either the engine inlet or exhaust systems or, in some cases, to a separate exhaust device.

A typical system for recirculation of the crankcase gases into the engine inlet which is used on certain two-cycle diesel engines includes an engine-mounted oil separator that communicates with the crankcase and a conduit connecting the oil separator with the engine combustion air inlet, at a point between the air filtration means and the charging air blower. A similar system is shown, for example, in U.S. Pat. No. 2,688,316 Brill. In such systems it is known to include a restrictive orifice in the conduit to prevent an excessive flow of vapors through the system with the resultant carryover of oil from the oil separator. The orifice limits normal flow and provides for the development of positive pressure in the crankcase under abnormal conditions of high blowby. A pressure actuated protective device may be provided to actuate engine stopping means in response to the crankcase pressure, thus preventing continued abnormal operation of the engine. An example of such a protective device is shown in U.S. Pat. No. 3,246,641 Goehring.

Generally, the application of fixed orifices in the above-indicated manner has been limited to systems where the variation in inlet depression (negative pressure or vacuum) upstream of the blower is relatively small. Where significant variations in inlet depression exist, as in engines having the charging air supplied by a turbocharger, the above-described system is not especially suitable due to the excessive variations in flow through the system which would be encountered under normal operating conditions. A number of crankcase ventilation systems are knwon in the prior art which provide for the maintenance of a suitable vacuum in the engine crankcase under the control of a regulating valve. See, for example, U.S. Pat. Nos. 3,263,660 Hyde and 3,380,441 Lewis. While such systems might be suitable for the control of crankcase ventilation flow in large locomotive engines and the like under their normal operating conditions, this would not be true under the abnormal conditions caused by excessive blowby indicative of an engine malfunction and the possible occurrence of a crankcase explosion. Under such conditions, the regulating valves of the prior art systems would respond to the increased crankcase pressure by opening completely. This action would permit the flow through the ventilation conduit to become excessive and deter the buildup of pressure in the crankcase which is necessary to actuate the crankcase pressure detector of the protective device and shut down the engine so as to prevent or minimize damage due to the abnormal conditions.

SUMMARY OF THE INVENTION

The present invention provides a crankcase ventilation system which meets the requirements of large locomotive engines and the like where it is desired to ventilate the crankcase into the engine induction system upstream of the charging air blower or turbocharger. The system is particularly adapted for conditions where a significant variation in inlet depressions exists and it is desired to maintain a suitable vacuum in the crankcase under normal operating conditions but to permit the buildup of a crankcase pressure to actuate the engine shutdown mechanism under conditions of abnormally high engine blowby or other similar indication of actual or potential engine failure.

In essence, the system of the present invention involves the combination of both fixed restriction means and a regulating valve in series in the crankcase ventilation conduit with the fixed restriction located upstream of the regulating valve. Preferably, an orifice plate is used as the fixed restriction and the regulating valve is arranged to normally maintain a relatively constant vacuum in the space between the orifice plate and regulating valve. To provide flexibility of the system for application to various engine sizes and types, provision may be made for the alternative use of various sizes of fixed orifices. Additionally, the regulating valve may be made adjustable to permit varying the controlled pressure upstream thereof. The combination of the present invention provides for maintenance of crankcase vacuum in a desired range under normal engine operating conditions as controlled primarily by movement of the regulating valve while permitting a buildup of pressure in the crankcase to actuate the engine protector under conditions of excessive blowby or a crankcase explosion.

These and other advantages of the present invention will be more clearly understood from the following description of a preferred embodiment taken together with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a side view of an internal combustion engine having a crankcase ventilation system according to the invention; and

FIG. 2 is a diagrammatic illustration of the crankcase ventilation system as applied to the engine of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawing, numeral **10** generally indicates an internal combustion engine which may be of any suitable type, but in the present instance is shown as a large two-cycle diesel engine of a type commonly used to power diesel locomotives and for other purposes. Engine **10** includes a crankcase **12** which in known manner provides an enclosure for the engine cylinders and operating components. Within the crankcase, blowby gases from the engine cylinders mix with oil vapors and other gases to form a mixture of crankcase vapors which it is desirable to draw from the crankcase.

Mounted on the engine crankcase is a turbocharger **14** which is driven by the engine exhaust supplemented by an internal gear train, not shown, to supply combustion air to the interior of the engine for delivery to the cylinders. Turbocharger **14** includes an air inlet **16** which connects through suitable conduit means **18** with an air cleaner housing **20.** The engine crankcase further carries a protective device including a pressure detector **22** which is arranged to be actuated by a predetermined positive pressure in the crankcase to operate means for shutting down the engine in known manner. The crankcase pressure detector may, for example, be of the type shown in U. S. Pat. No. 3,246,641 Goehring.

Engine **10** is further provided with a crankcase ventilation system which will give the desired crankcase pressure characteristics. The crankcase ventilation system is generally indicated by numeral **24** and is shown schematically in FIG. **2.** System **24** includes an oil separator **26** which is preferably mounted directly on the engine crankcase to return thereto excess oil separated from the crankcase vapors. If desired, the oil separator **26** may be spacedly mounted from the crankcase and connected thereto by a conduit. Oil separator **26** is connected with the turbine inlet **16** through suitable conduit means **28** that also communicate, through the oil separator, with the engine crankcase **12.** A fixed orifice plate **30** is mounted within conduit **28** downstream of the oil separator to provide a resistance to excessive fluid flow through the system. A suitable regulating valve **32** is also mounted within the conduit **28** intermediate orifice plate **30** and the turbine inlet.

Regulating valve **32** may be of any suitable type which is adapted to be responsive to pressure upstream of the valve so as to control fluid flow as a function of such pressure. The valve is arranged so that during engine operation it controls the flow of fluids through the ventilation conduit to provide during normal operation a predetermined maximum vacuum in the conduit **28** between the orifice plate and the regulating valve. One type of valve which might be usable for this purpose is shown in the previously mentioned U. S. Pat. No. 3,263,660 Hyde, although any other suitable valve arrangement may be utilized.

In a specific example, the engine involved is such that vacuum in the turbocharger air inlet may vary between almost zero to 50 inches of water under various operating conditions. The valve **32** is arranged to control the upstream vacuum between the valve and the orifice plate at a maximum of about 10 inches of water. The orifice in plate **30** is then sized so that in the normal range of flow the pressure drop therethrough will result in a maximum vacuum of about four to 5 inches of water in the engine crankcase under normal blowby flow conditions.

In operation, vacuum created in the turbocharger air inlet by the drawing of inlet air through the air filters causes a pressure differential that establishes a flow of crankcase vapors through the ventilation system and into the turbocharger air inlet. When inlet vacuum is low, as at engine idle, regulating valve **32** remains fully open, permitting free flow of vapors therethrough and the pressure drop through orifice plate **30** is small.

As engine speed and load are increased, the vacuum between the valve **32** and orifice plate **30** increases until the predetermined control pressure is reached, after which the valve closes as necessary to limit the maximum vacuum between the valve and orifice plate to the desired control pressure (e.g. 10 inches of water) no matter how high the vacuum in the turbocharger air inlet becomes. Pressure drop through the orifice plate **30** remains relatively low (maximum of about 5 inches of water) under blowby conditions encountered during normal operation, since the orifice is sized not to greatly restrict normal vapor flow.

However, in the case of abnormal engine operation, such as might be caused by a cracked piston or a scored liner allowing excessive blowby to escape from the engine cylinders into the engine crankcase, the resulting increased flow will be increasingly restricted by the orifice plate **30** until a positive pressure is developed in the engine crankcase. This pressure will, at a predetermined value, actuate the crankcase pressure detector **22** which will in turn shut down the engine so that it may be inspected to determine the cause of the faulty operation.

The limitation of the maximum downstream vacuum acting on the orifice plate through the action of the regulating valve is important since it permits the use of a sufficiently large orifice to have only a small effect on normal blowby flows. The arrangement reduces the pressure differential required across the orifice to develop a pressure in the crankcase under abnormal high blowby conditions which thus allows the use of a larger, less restrictive, orifice than would be possible if the turbocharger air inlet vacuum was allowed to act directly on the orifice plate.

The function of the orifice plate in the system could, if desired, be performed by some other type of fixed resistance suitably arranged to provide the proper restriction to flow in relation to the normal and abnormal engine operating conditions which might be encountered. Such resistance might be provided merely by sizing the connections to the regulating valve to adequately restrict the passage of excessive flow for the particular engine arrangement. Preferably, where the devices making up the crankcase ventilating system are intended to be used on a line of engines of differing sizes and blowby characteristics, an arrangement will be utilized with provision being made for the system to accept any one of a number of different orifice plates with various sized orifices, depending on the engine application. In this way a single regulating valve can be made to serve for application to any of a number of different engines, with the system being properly balanced by the use of an orifice sized for the particular application. Also, if desired, the regulating valve may be made adjustable to provide for selection of the upstream controlled pressure best suited for a particular application.

It should be apparent that numerous other variations and changes could be made in the crankcase ventilation system disclosed herein without departing from the inventive concepts involved. Accordingly, it is intended that the invention be limited only by the language of the following claims.

We claim:

1. The combination with an internal combustion engine having a crankcase and a combustion air inlet of
engine shutdown means connected to the engine crankcase and responsive to a predetermined positive pressure therein to stop the engine,
crankcase ventilation means communicating said crankcase with said air inlet for drawing crankcase vapors into the combustion air stream,
orifice means in said communicating means and providing a fixed restriction to fluid flow therethrough, and
regulating valve means in said communicating means downstream of said orifice means, said valve means providing a variable restriction to fluid flow and being operative to limit the negative control pressures upstream thereof to a predetermined value regardless of greater negative pressures in the air inlet,
said control pressure limit being chosen and said orifice means being sized to permit passage of a sufficient flow of crankcase vapors during normal engine operation to maintain a predetermined maximum vacuum in the engine crankcase but to provide a sufficient flow restriction to cause development of positive pressure in the crankcase sufficient to actuate said shutdown means to stop the engine when there occurs an abnormally high flow of blowby into the crankcase indicative of engine malfunction.

2. A crankcase ventilation system in combination with an internal combustion engine having a combustion air inlet, a crankcase and engine shutdown means connected with said crankcase and adapted to be actuated by a predetermined positive pressure therein to terminate engine operation, said crankcase ventilation means comprising
means communicating said crankcase with said air inlet for drawing a flow of crankcase vapors into the combustion air stream,
regulating valve means in said communicating means and providing a variable restriction to fluid flow therethrough, said valve means being responsive to system pressures upstream thereof to vary said restriction in a manner to maintain a predetermined maximum vacuum upstream thereof, and
fixed orifice means in said communicating means between said regulating valve means and said crankcase, said orifice means being sized to restrict fluid flow sufficiently to cause development of a positive pressure in the crankcase to actuate said shutdown means under predetermined conditions of excess engine blowby but to allow the passage of sufficient ventilation flow to permit the establishment of a predetermined maximum crankcase vacuum under normal engine operating conditions.

3. The combination of claim 2 and further including an oil separator in said communicating means, upstream of said orifice means, said oil separator being adapted to separate and return to the engine crankcase excess oil passing into the ventilation system with the crankcase vapors.

4. An internal combustion engine having in combination
an exhaust-driven turbocharger operable to supply varying amounts of combustion air to the engine under various engine operating conditions,
a combustion air inlet to the turbocharger subject to substantial variations in sub-ambient air pressure under the varying air flows drawn into said turbocharger,
an enclosed crankcase into which engine blowby gases are received in varying amounts during engine operation,
pressure responsive means connected with said crankcase and responsive to a predetermined, positive pressure therein to stop said engine,
crankcase ventilation means communicating said crankcase with said air inlet for drawing crankcase vapors into the combustion air stream,
a regulating valve in said communicating means and providing a variable restriction to fluid flow therethrough, said valve being operable to vary said restriction so as to limit the vacuum immediately upstream thereof to a predetermined maximum, and
a fixed orifice in said communicating means between said regulating valve and said crankcase and sized to permit a sufficient flow of crankcase vapors through said communicating means to establish a substantial crankcase vacuum under normal engine operating conditions but to restrict flow sufficiently to cause development of a positive pressure in the crankcase sufficient to actuate said pressure responsive means under predetermined conditions to excess engine blowby.

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