United States Patent

Eshelman

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[54] CRANKCASE VENTILATION

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[73] Assignee: **Chrysler Corporation,** Highland Park, Mich.

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[52] **U.S. Cl.** ..... **123/119 B,** 137/480

[51] **Int. Cl.** **F02m 25/06,** F02f 9/00

[58] **Field of Search** ..... 123/119 B, 41.86; 137/480, 137/481, 539; 267/177

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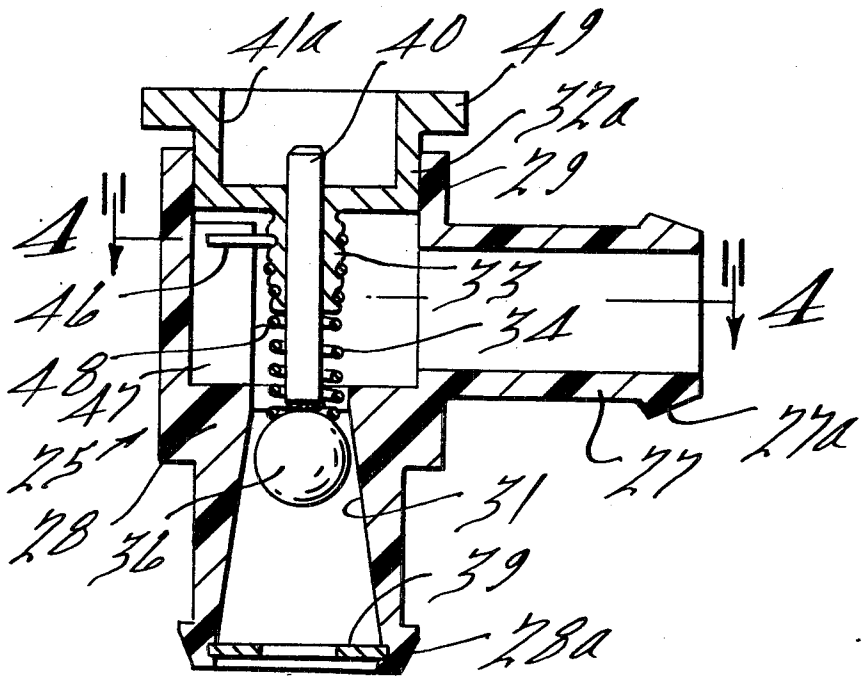
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Assistant Examiner—R. B. Rothman
Attorney—Talburtt & Baldwin

[57] **ABSTRACT**

The crankcase for an internal combustion engine is vented to the fuel-air inlet induction passage via a ventilation valve comprising a tubular L-shaped valve housing having a comparatively small metering orifice which cooperates with a movable valve element responsive to decreasing pressure in the induction conduit for restricting the orifice. A coil spring yieldingly opposes closing movement of the valve element and is seated on a spring retainer adjustably mounted in an opening through the sidewall of the housing at the exterior angle of its elbow to effect a predetermined rate of gas flow through the orifice when a predetermined low-pressure differential corresponding to part load operation of the engine is applied across the orifice. A movement limiting plunger extends adjustably through the retainer to engage and limit closing movement of the valve element to effect a predetermined low rate of gas flow through the orifice when a predetermined high-pressure differential is applied across the orifice corresponding to engine idling.

9 Claims, 5 Drawing Figures



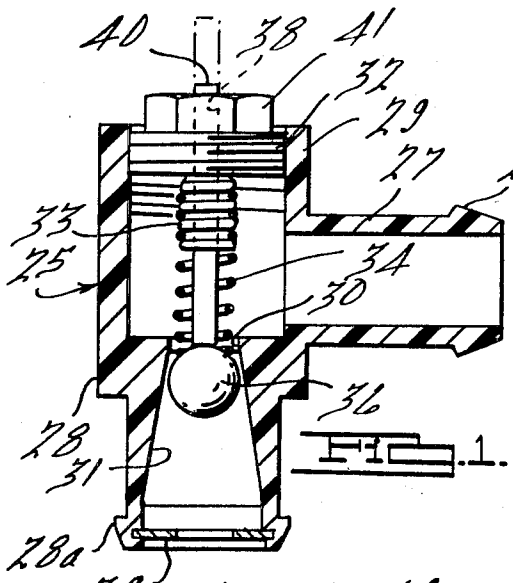


FIG. 1.

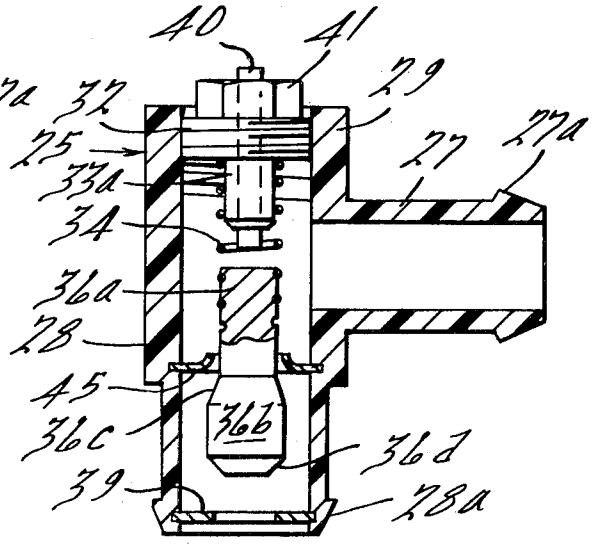


FIG. 2.

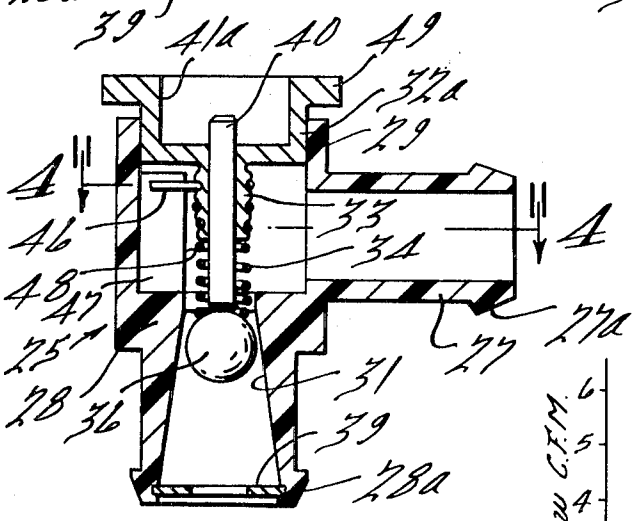


FIG. 3.

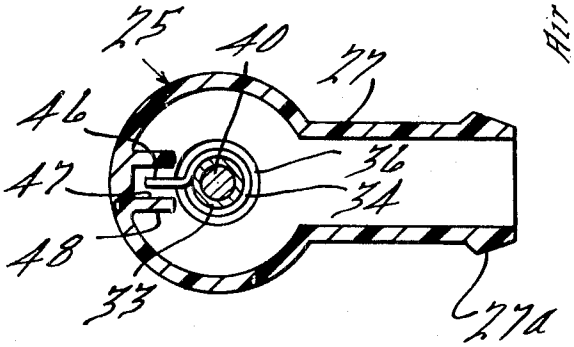


FIG. 4.

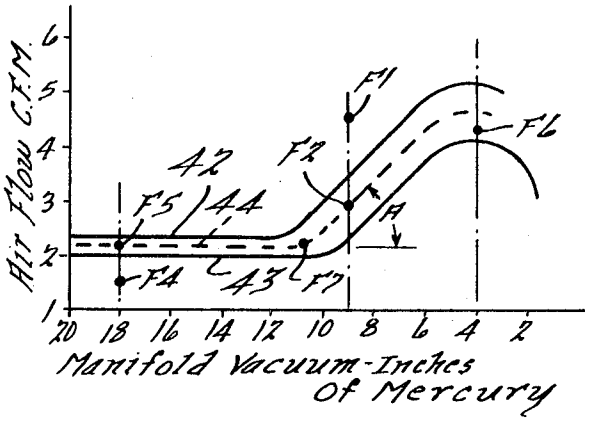


FIG. 5.

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CRANKCASE VENTILATION

BACKGROUND AND SUMMARY OF THE INVENTION

This application relates to improvements in a crankcase ventilating valve of the general type disclosed in the following representative U.S. Pats. for regulating the flow of gases from the crankcase of an internal combustion engine to the latter's air inlet system: No. 2,359,485; No. 2,716,398; No. 2,742,057; No. 3,105,477; No. 3,241,534; No. 3,263,699; No. 3,354,898; and No. 3,359,960.

In order to reduce the emission of unburned hydrocarbons from the fuel and exhaust systems of an automobile, it is customary to vent the fuel tank and carburetor bowl to the crankcase for storing fuel vapors therein when the engine is not operating, and to ventilate the crankcase during engine operation by controlled conduction of the crankcase gases comprising a mixture of fresh air and engine blowby products into the usual carburetor inlet induction conduit to supply a portion of the combustion supporting air to the inlet fuel. The carburetor is accordingly adjusted so that when the crankcase gases are added to the customary throttle controlled fuel and air supply, the desired fuel-air ratio for efficient engine operation will result. It is therefore necessary to control the ventilation flow of crankcase gases closely, otherwise inefficient engine operation and the exhausting of excessive incompletely burned fuel will result.

It has been common to provide a pressure responsive flow control valve in the ventilating conduit between the crankcase and induction conduit for controlling the ventilation flow in accordance with the engine operation. Such valves have been costly heretofore because of the close tolerances required for the component parts and the high rate of rejection of assembled valves that do not meet the required standards.

An important object of the present invention is to provide an improved crankcase ventilation valve of the foregoing character that can be economically manufactured by conventional low cost methods, as for example by molding and stamping operations, wherein the valve parts may be readily assembled and adjusted either during or after assembly to compensate for comparatively large dimensional variations in the parts and to avoid the scrapping of costly valve assemblies, yet still meet the exacting standards required for satisfactory engine operation and exhaust emission control. In particular it is an object to provide such a crankcase ventilating valve which is readily susceptible for adjustment at two critical regions of its pressure-flow relationship.

Another and more specific object is to provide such a valve comprising a tubular L-shaped body containing a metering orifice upstream of the elbow or bend of the L-body and having a spring retainer adjustably mounted in an opening through the sidewall of the housing at the region of the exterior angle of the elbow downstream of the metering orifice. A valve element movable within the housing is responsive to the pressure differential across the orifice for opening or restricting the latter. A coil biasing spring under compression between the valve element and the adjustable retainer opposes movement of the valve element in the direction of orifice closing and urges movement of the valve element in the opposite direction to enable increased flow of crankcase gases during part throttle acceleration as the pressure in the carburetor inlet induction conduit increases.

In the above regard the upstream end of the tubular valve housing is connected to the crankcase, whereas the downstream end of the housing is connected to the carburetor inlet induction conduit at a location downstream of the usual throttle valve and is thus subject to low induction pressure urging the valve element in the closing direction in opposition to the biasing spring. An adjustable movement limiting plunger extends axially through the retainer and coaxially with the orifice to engage the valve element and limit the closing movement at a predetermined position of maximum restriction for the orifice when the engine is idling. Both the retainer and the plunger extend to and are accessible at the exterior of the valve housing to enable their adjustment.

By virtue of the foregoing, during assembly of the valve parts, a predetermined pressure differential corresponding to part throttle acceleration may be applied across the opposite ends of the housing and the resulting gas flow measured by a meter. The spring retainer is then adjusted to move the biasing spring against the valve element until the desired gas flow through the housing results. Thus regardless of comparatively loose dimensional tolerances in the valve parts, the desired crankcase ventilation flow into the carburetor induction conduit will result when the aforesaid predetermined pressure differential exists between the inlet induction conduit and crankcase, which latter is vented to atmosphere and maintained approximately at atmospheric pressure at all times.

After adjusting the valve for a predetermined part throttle acceleration condition, the pressure differential across the opposite ends of the valve housing may be increased during assembly to a second predetermined value to simulate engine idle operation. The movement limiting plunger is then adjusted against the valve element until the gas flow through the housing desired for the engine idling condition results, again regardless of comparatively loose production tolerances in the dimensions of the valve components.

The position of the movable valve element with respect to the movement limiting plunger and accordingly the extent of opening of the orifice at any given pressure differential thereacross is determined by the spring rate of the valve biasing spring. Another object is to provide an improved crankcase ventilating valve of the above character wherein the spring rate is readily adjustable either during or after assembly of the valve components.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

FIG. 1 is a longitudinal sectional view of a crankcase ventilation valve embodying the invention.

FIGS. 2 and 3 are views similar to FIG. 1, showing modifications of the valve.

FIG. 4 is a section taken in the direction of the arrows substantially along the line 4—4 of FIG. 3.

FIG. 5 shows the relationship between airflow measured in cubic feet per minute through the valve and pressure in the inlet induction conduit, measured in inches of mercury manifold vacuum.

It is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a valve adapted for use in a conventional automobile engine having a fresh air inlet connected by a carburetor induction conduit with the combustion chamber of the engine, and a crankcase connected with the fresh air inlet to receive ventilating air and also connected by means of a ventilation duct with the induction conduit downstream of the usual throttle valve to discharge crankcase gases into the latter conduit during engine operation. The crankcase gases during engine operation comprise a mixture of combustion blowby products including air, inert gases, and incompletely burned hydrocarbons which leak past the engine pistons into the crankcase. The latter is normally maintained at or close to atmospheric pressure by means of its connection with the fresh air inlet.

When the engine is not operating, fuel vapors from the usual fuel tank and carburetor fuel bowl are vented to the crankcase. The foregoing may be conventional and is accordingly not described in further detail.

The flow of crankcase gases into the carburetor induction conduit during various conditions of engine operation is controlled by a pressure responsive ventilation flow control valve illustrated in each of FIGS. 1, 2, and 3. In FIG. 1, the valve may comprise a molded plastic L-shaped tubular body or housing 25 having an elbow joining a downstream arm 27 terminating at an annular hose retaining enlargement 27a (adapted for connection by conventional means with the carburetor induction conduit at a location downstream of the throttle valve) and an upstream arm 28 terminating at an annular hose retaining enlargement 28*a* adapted for connection with the crankcase by conventional means. Upstream of the elbow, a coaxial metering orifice 30 is defined by a conical upstream enlarging portion 31 of the passage through the tubular body 25.

Coaxially with the orifice 30 and opening through the sidewall of the housing 25 at the region of the elbow is an internally threaded tubular extension 29 of the body 25 closed by a plastic spring retainer 32 adjustably screwed into the extension 29. The retainer 32 has an integral coaxial threaded extension 33 of reduced diameter having the upper end of a coil biasing spring 34 adjustably screwed thereon. The spring 34 seats at its lower end against an axially movable ball or valve element 36 located upstream of the apex of orifice 30 and cooperable with conical portion 31 to restrict fluid flow therethrough upon upward or downstream movement of ball 36 against the force of spring 34.

A sheet metal annular seat 39 is embedded coaxially within the lower or upstream end of arm 28 at the thickened region 28*a* to provide an annular seat for the valve 36, which closes the opening through the annular seat 39 upon downward movement of the valve 36, thereby to prevent a reverse flow through the orifice 30 in the event of engine backfire for example. Also extending coaxially with the orifice 30 and valve 36 through a hole 38 in the retainer 32 at the region of the elbow is an axially adjustable movement limiting plunger 40 accessible from the exterior of the housing 25 for axial adjustment to limit the maximum restriction of the metering orifice 30. Exteriorily of the housing 25, the retainer 32 is provided with an integral nut portion 41 to facilitate its screw adjustment.

During engine idling, the low pressure (or high vacuum) within the carburetor inlet induction conduit downstream of the throttle induces a comparatively large pressure differential across the valve housing 25 and urges the valve 36 upward against the reaction of spring 34 to the limit permitted by plunger 40. The latter is adjusted axially to determine the maximum restriction for the orifice 30 and to permit a predetermined limited flow of crankcase ventilation gases through the housing 25 during idle operation, whereby fresh air is conducted into the crankcase via its conventional fresh air vent and the mixture of air and blowby gases are discharged into the induction conduit. As the engine throttle opens for operation under increasing load, the pressure differential across the housing 25 urging the valve 36 in the downstream orifice closing direction decreases and the spring 34 urges the valve 36 downwardly from the plunger 40 to increase the opening 30 and the flow of crankcase gases.

In order to obtain efficient engine operation during all operating conditions, it is essential to control the crankcase recirculating flow within comparatively narrow limits, so that the flow from the crankcase when admixed with the fuel and air supplied to the engine from the usual carburetor and fresh air inlet will result in the desired combustible mixture for efficient engine operation with a minimum of unburned hydrocarbons in the exhaust. During engine idling when the airflow through the carburetor induction conduit is a minimum, the variations in the crankcase ventilating flow must be narrowly limited because small changes in the ventilating flow will amount to a large percentage change in the idle fuel-air ratio. The relationships between airflow and engine operation as indicated by manifold vacuum in the carburetor induction conduit downstream of the usual throttle valve is illustrated in FIG. 5, wherein lines 42 and 43 represent the maximum and minimum limits permissible for the ventilating flow through the valve 25, and the dotted line 44 represents the desired or optimum flow.

In order to avoid the excessive costs of maintaining close dimensional tolerances of the valve components within the narrow limits required by the relationships indicated in FIG. 5, the present invention provides a valve which is susceptible of calibration at two important regions of the pressure-flow relationship during or after assembly. Thus the component parts, particularly the housing 25 including orifice 30 and spring retainer 32,33 may be formed by economical mass production molding processes.

Prior to the final adjustment of the retainer 32 within the extension 29 and the plunger 40 within the retainer 32, the assembly as shown in FIG. 1 may be secured in a calibration fixture wherein the arm 27 is connected to a controlled source of low pressure and the arm 28 is connected to atmospheric pressure through a flowmeter. A regulated pressure differential is then established across the valve, amounting to for example nine inches of mercury in a typical situation corresponding to engine operation under part acceleration. At this situation the flow through the valve might amount to about 4½ c.f.m. (cubic feet per minute) by way of example as illustrated by point F1 of FIG. 5. While the plunger 40 is retracted as indicated by the dotted position, FIG. 1, a controlled rotatable wrench member adapted to engage the nut 41 may then be moved into engagement with the nut 41 and rotated to adjust the axial position of the retainer 32 by screw action within extension 29 and thereby to adjust the position of the spring 34 and valve 36 with respect to the orifice 30 until the measured airflow through the housing 25 corresponds to point F2, which in the present situation will be slightly less than three c.f.m.

The operating point of the valve 24 will thus be shifted from point F1 to point F2 in FIG. 5. The retainer 32 may be maintained at its adjusted position within the extension 29 by friction, or a cement may be applied between the members 32 and 29 prior to the adjustment. The fresh cement will serve to lubricate these members and facilitate the adjustment. When the cement hardens, the members 29 and 32 will be secured against relative movement at a fluidtight seal.

While the valve is still confined within the calibration fixture, a new pressure differential may be established across the housing 25, which in a typical situation might be 18 inches of mercury corresponding to an idle operating condition. A typical flow at this position might be about 1.5 c.f.m. as indicated by point F4 of FIG. 5. The plunger 40 is then pushed inwardly to engage and move the ball 36 upstream of orifice 30 until the measured flow therethrough is increased to the desired value indicated by point F5 in FIG. 5, which is approximately 2.2 c.f.m. The plunger 40 may be retained in its adjusted position by a fluidtight frictional engagement with the retainer 32, or may be sheared flush with the exterior of nut 41 and heat sealed to the latter by a hot tool. Likewise a cement may be applied between the plunger 40 and retainer 32 prior to the adjustment to lubricate the parts and facilitate the adjustment and to secure the plunger 40 at a fluidtight seal in its finally adjusted position when the cement hardens.

A final check of the valve may be then made by establishing a new pressure differential amounting to approximately four inches of mercury across the housing 25. If the resulting flow through the orifice 30 as measured by the flowmeter falls within the limits determined by lines 42 and 43, as for example at point F6 in FIG. 5, the valve is acceptable and can be packed for shipping.

As illustrated in FIG. 5 by the portion of line 44 between points F5 and F7, the rate of flow through orifice 30 remains substantially constant and is independent of the pressure differential until the ball valve 36 moves out of contact with the movement limiting plunger 40. This is a well known small orifice phenomena at low pressure and prevails throughout engine idling and coasting at closed throttle conditions by virtue of the small effective orifice 30 when the ball 36 is at its position of maximum restriction.

When the throttle valve opens sufficiently with increasing engine load to reduce the vacuum in the carburetor induction conduit to below point F7, i.e., as the pressure in the induction conduit downstream of the throttle valve increases, the valve **36** will move upstream from the FIG. **1** position of maximum restriction for orifice **30**. As the latter opens, the crankcase ventilation flow increases as indicated by the slope of line **44** at the high-pressure side of F7, regardless that the pressure differential across orifice **30** actually decreases. Finally at a vacuum of about four inches or five inches of mercury in the induction conduit, the rate of ventilation flow will begin to decrease with decreasing pressure differential across the orifice **30**, as may be expected.

In the type of valve shown, after the valve **36** moves away from the finally adjusted position of plunger **40**; solid lines, FIG. **1**, the slope A of line **44** is determined by the spring rate of spring **34** and the taper **31** of the metering orifice **30**. The spring rate may be adjusted as illustrated in FIG. **1** by suitably varying the number of effective coils of the spring **34** by screwing more or less of the latter on the threaded retainer portion **33**. It is apparent that by adjusting the number of turns of the spring **34** between the lower end of extension **33** and the ball **36**, the effective spring rate may be adjusted to accommodate slight dimensional variations in the orifice **30** and the production spring **34** and to obtain the desired slope A illustrated in FIG. **5**.

FIG. **2** illustrates a crankcase ventilation valve wherein the upper portion of the spring **34** frictionally engages a cylindrical unthreaded extension **33***a* integral with retainer **32** in the manner of extension **33** of FIG. **1**, whereby valve oscillation is damped. The lower portion of spring **34** is adjustably screwed onto a threaded portion **36***a* of an axially reciprocable valve **36***b*. The latter is pressure responsive in the manner of ball valve **36**, but is formed with a conically tapered portion **36***c* which cooperates with orifice **30***a* provided coaxially with valve element **36***b* and retainer **33***a* by means of an annular orifice member **45** having its periphery embedded within the sidewalls of housing **25** at a fluidtight seal. The member **45** may comprise a sheet metal stamping and may be incorporated with the housing **25** as an insert during the molding process. The valve element **36***b* may comprise a molded plastic or die formed powdered metal of circular cross section. Its lower end is chamfered at **36***d* to seat at the annular insert **39** and close the passage through housing **25** in the event of engine backfire. In other respects, the valve of FIG. **2** is similar in structure and operation to the valve of FIG. **1** and is adjustable either during or after assembly as described above.

FIGS. **3** and **4** illustrate another modification of a crankcase ventilation valve wherein, instead of the screw threaded axial adjustment, a cylindrical retainer **32***a* is axially slidable within extension **29** and may be retained in its adjusted position by friction or cementing as described above. The biasing spring **34** adjustably screwed on the threaded extension **33** terminates at its upper end in a radial arm **46** which extends into the slot **47** of an axial guide **48**.

The retainer **32***a* is moved axially to its desired finally adjusted position within extension **29**, without recourse to screw action, by applying external force axially to the upper flange **49**. The latter may have a hexagonal exterior, or the recessed outer end of extension **32***a* may have a hexagonal interior wall **41***a*, whereby a suitable tool can be applied to rotate the retainer **32***a* and its integral extension **33** relative to coil spring **34**. By virtue of the arm **46** confined within slot **47**, the spring **34** may be adjustably screwed on extension **33** to adjust the spring rate and effect the desired angle A of FIG. **5**. In other respects, the valve of FIGS. **2** and **3** is adjusted during or after assembly to effect the operating points F2 and F5 as described above.

Preferably, in each of FIGS. **1**, **2** and **3**, the spring rate of spring **34** will be adjusted and tested first. The spring **34** will then be moved bodily against the valve element **36** or **36***b* as the case might be to establish the operating point F2, along the sloping portion of line **44**, which corresponds to a part load engine operating condition. Thereafter the plunger **40** will be adjusted to establish the point F5 along the substantially horizontal portion of line **44**, which corresponds to an idle operating condition of the engine.

I claim:

1. In a crankcase ventilating device for controlling the flow of gases from the crankcase to the fuel-air inlet induction conduit of an internal combustion engine to effect a predetermined low rate of flow when a large pressure differential exists between said crankcase and conduit corresponding to idle operation of said engine and to effect an increasing rate of flow when said pressure differential decreases within a range of pressures corresponding to part load operation of said engine,

a. a valve housing having a passage for gases extending therethrough and opening at upstream and downstream ends adapted respectively for connection with said crankcase and conduit, said passage defining a metering orifice,

b. valve means in said housing including movable means responsive to an increasing pressure differential thereacross for progressively restricting said orifice,

c. resilient means having opposed ends, one end engaging said movable means for yieldingly opposing its movement in the direction for restricting said passage,

d. means for bodily adjusting the position of the other of said ends in said direction to calibrate said resilient means and effect a predetermined flow through said passage when a predetermined pressure differential is applied thereacross comprising retaining means adjusted in said direction within an opening through the sidewall of said housing and engaging said other end to oppose movement thereof when said one end is opposing movement of said movable means in said direction,

e. means on said retaining means for adjusting the effective spring rate of said resilient means comprising a screw threaded portion having its axis extending in said direction, said resilient means comprising a coil spring adjustably screwed on said threaded portion, said retaining means completely closing said opening and being rotatable therein,

f. means on said retaining means engageable from the exterior of said housing for rotating said retaining means within said opening, and

g. means for securing said spring against rotation within said housing for effecting axial adjustment of said spring on said threaded portion upon rotation of said retaining means.

2. In the combination according to claim **1**, the portion of said retaining means within said opening being cylindrical and being slidably adjustable axially within said opening.

3. In the combination according to claim **1**, said retaining means having a screw threaded portion in adjustable screw threaded engagement with the portion of said housing defining said opening.

4. In the combination according to claim **3**, said housing having an elbow downstream of said orifice, said opening extending through the sidewall of said housing at the exterior angle of said elbow.

5. In the combination according to claim **1**, said housing having an elbow downstream of said orifice, said opening extending axially of said orifice through the sidewall of said housing at the exterior angle of said elbow.

6. In the combination according to claim **5**, means for limiting the maximum restriction for said orifice comprising an axially adjustable movement limiting plunger extending axially in said direction through said retaining means in sealing engagement therewith and into the path of said movable means to engage and limit the movement thereof in said direction, said plunger having a portion accessible from the exterior of said housing for adjusting said plunger axially.

7. In the combination according to claim **5**, said threaded portion being within said housing coaxial with said orifice, and said means for securing said spring against rotation within said housing including a portion adjustable axially of said housing.

8. In the combination according to claim 7, the portion of said retaining means within said opening being cylindrical and being slidably adjustable axially within said opening.

9. In the combination according to claim 7, said retaining means having a screw threaded portion in adjustable screw threaded engagement with the portion of said housing defining said opening.

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