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INTERNAL COMBUSTION ENGINE

3,523,418

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2 Sheets-Sheet 1

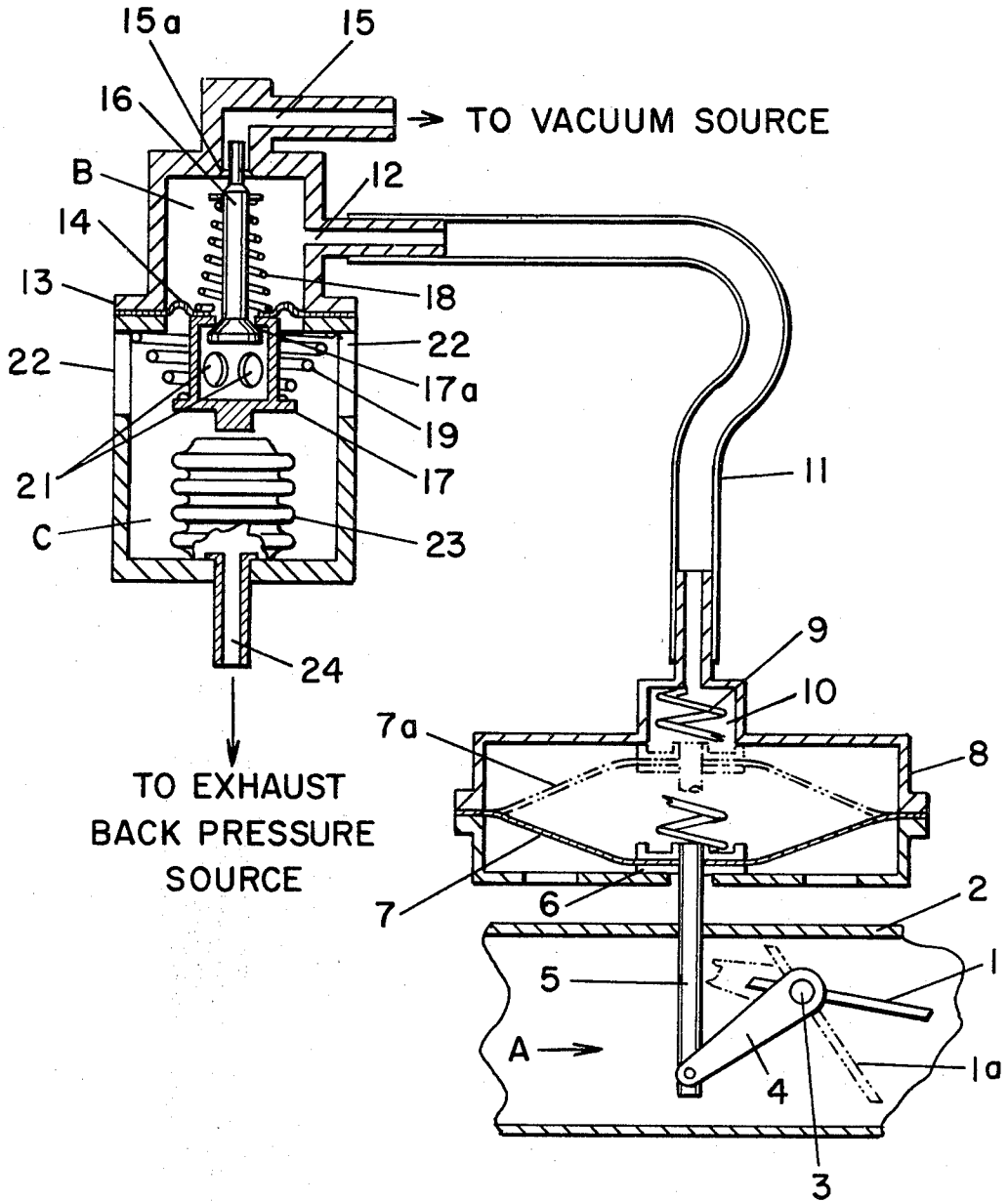


FIG. 1

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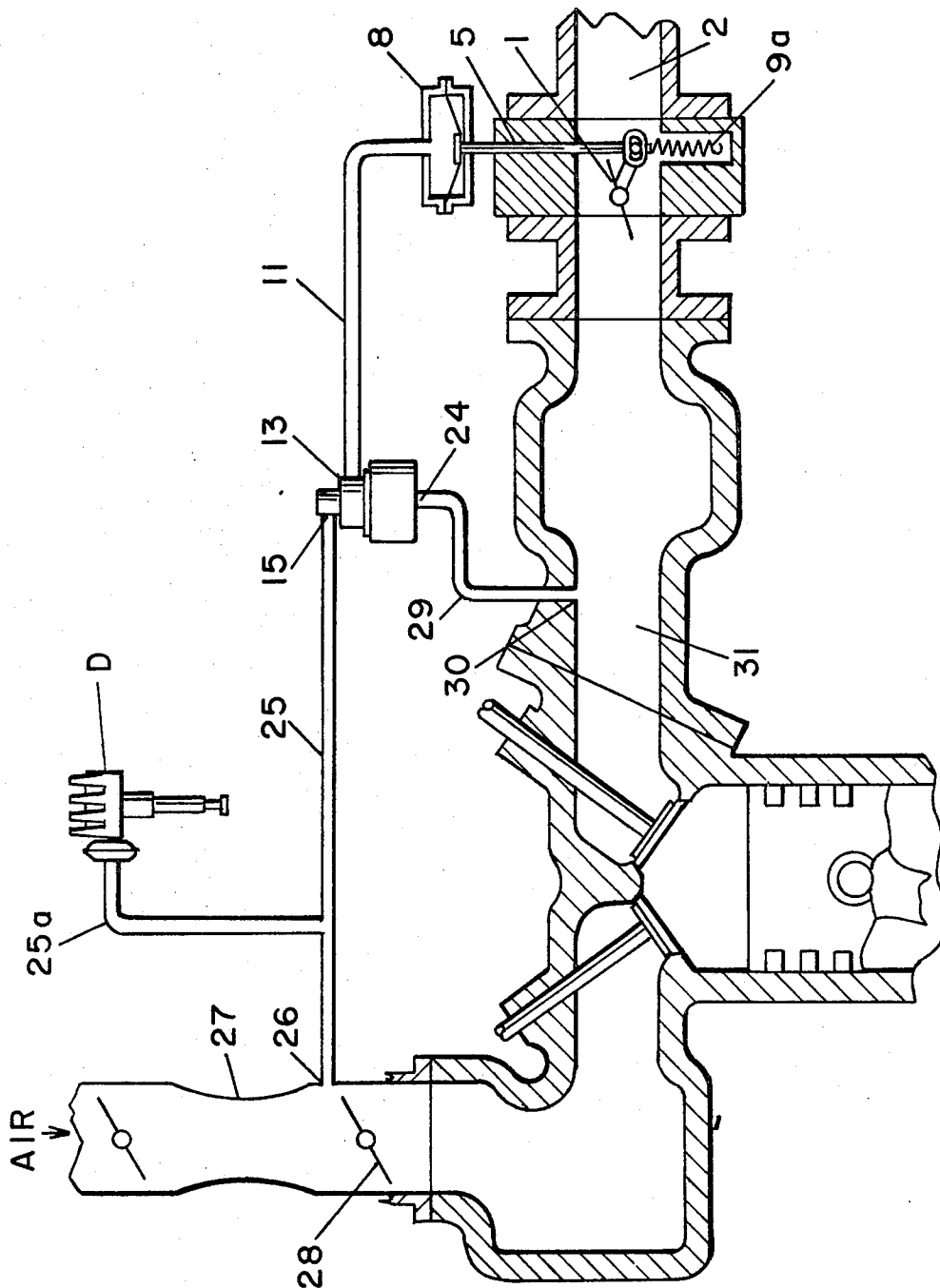


FIG. 2

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EXHAUST BACK PRESSURE CONTROL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

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U.S. Cl. 60—29

3 Claims

ABSTRACT OF THE DISCLOSURE

An exhaust back pressure control system for a spark ignition internal combustion engine is described. The control system combines a throttling element in the exhaust pipe, a vacuum activated control unit and a sensing element which modulates the control unit in response to the engine vacuum and the exhaust back pressure. The exhaust flow is throttled during part load engine operation; no throttling occurs at high load engine operation. In a preferred embodiment, no throttling of the exhaust occurs at idle.

The system also effects a reduction in unburned hydrocarbons in the exhaust gases.

BACKGROUND OF THE INVENTION

Systems for controlling exhaust back pressure in internal combustion engines are known. A simple system is one in which a throttling element is placed in the exhaust pipe; the throttling action is generally controlled by a heat sensing element and spring arrangement. This type of system throttles the exhaust gases while the engine is warming up. This system is responsive principally to the heat of the exhaust; its function ordinarily is to reduce engine warm-up time. There is essentially no throttling with such a system after the engine has warmed up.

A more sophisticated back pressure control system is described in U.S. 3,234,924 issued to Michael G. May. There an exhaust back pressure system is described which is responsible in one embodiment to engine vacuum from the engine intake manifold and is further controlled by a mechanical linkage to the engine accelerator control; this system is operative while the engine is idling and when it is operating under a particularly small load. This system also reduces the unburned hydrocarbon content of the exhaust gases. The embodiment of May's back pressure control system which is responsive to manifold vacuum will not operate without the mechanical acceleration linkage. Linkages of this sort are prone, in general, to malfunction due, for example, to rusting of the pivot points, etc. If this mechanical linkage would break down for any reason, the vacuum control unit would hold the back pressure throttling element closed and result in engine stalling and the like.

A back pressure control system without a mechanical linkage such as the one in the May device is desirable. A device which furthermore is controlled directly by the engine and is responsive to the back pressure is also desirable. The device of the present invention provides such a simple and efficient control system.

SUMMARY OF THE INVENTION

A system for controlling back pressure of the exhaust formed during the operation of the spark ignition internal combustion engine which comprises exhaust pipe having a throttling element therein, a vacuum operator unit which controls the throttling element and a sensing unit responsive to both engine vacuum and exhaust back pressure, said sensing element providing a vacuum signal

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to said vacuum operator unit to control the throttling element during low power engine operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial section view through an exhaust pipe having a throttling element situated therein, a vacuum operator for controlling said throttling element and a sensing element in combination.

FIG. 2 is a partial section view schematic illustration of the control system and its arrangement in an internal combustion engine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the invention is a system for controlling the back pressure of the exhaust formed in a spark ignition internal combustion engine which comprises in combination (1) an exhaust pipe through which said exhaust is transmitted into the atmosphere, (2) a throttling means situated inside said exhaust pipe, (3) a vacuum operator placed outside of said exhaust pipe, said operator being linked directly to and controlling said throttling means, and (4) a sensing element responsive to said exhaust back pressure and engine vacuum, said element being connected to said operator by a conduit through which a vacuum signal is provided to said operator during part load engine operation, said system effectively maintaining a substantially uniform back pressure in said exhaust.

In a more preferred embodiment, the sensing element receives its engine vacuum signal from a point just above the throttle blade in the carburetor and its back pressure signal from the exhaust manifold.

A feature of this back pressure control system is that it is responsive to engine operating conditions and the exhaust back pressure. No mechanical linkages to other functional parts of the engine, for example the carburetor throttle, are required. The engine provides the means of actuating the elements of the back pressure control system. Another feature of this system is that throttling of the exhaust gas flow occurs only during low load engine operation. Thus, there is no danger of throttling the exhaust gas flow at high power engine operation which would affect the performance of the engine. In addition, in the most preferred embodiment, there is no throttling of the exhaust gas stream at idle. The reason for this is that there is no vacuum signal available from the carburetor at idle and consequently the throttle means in the exhaust pipe is fully open.

In all embodiments of this invention at high power operation, the velocity of the exhaust gases coupled with a spring operator is sufficient to overcome any vacuum signal from the engine; and therefore the exhaust stream is fully open and not throttled at high power that is substantially wide open throttle, engine operation. By having a system which is responsive to both back pressure and engine vacuum, the back pressure may be held at a substantially constant level at less than high power engine demand.

Better understanding of how the system operates will be obtained in the following detailed description of the system as illustrated in the drawings.

FIG. 1 is a partial section view through the combination of the present back pressure control system. In FIG. 1 an exhaust throttle blade 1 is mounted inside exhaust pipe 2 on a shaft 3, in a position perpendicular to the flow of the exhaust stream (arrow A indicating its direction) from an unillustrated engine. The shaft 3 is attached to one end of an arm; the other end of said arm 4 is pivotally attached to one end of a control rod 5. The position of the throttle blade 1 in the exhaust pipe

2 is determined by the position of the control rod 5. The other end of the control rod 5 is seated in a holding member 6 which is integrally connected to a flexible diaphragm 7. The flexible diaphragm is contained within the vacuum operator unit 8. The spring 9 is mounted within the vacuum operator unit 8 behind the control rod 5, spring 9 is seated at one end in the holding member 6 and at the opposite end in a well 10 in said vacuum operator unit 8. This spring 9 normally maintains the diaphragm 7 in the down position; as will be shown later, a vacuum signal will raise the diaphragm 7 to the up position 7a (phantom illustration). The vacuum operator 8 is connected by conduit 11 to a port 12 in a sensing unit 13. The flexible diaphragm 14 divides the sensing unit 13 into two compartments, B and C. Compartment B is connected to the vacuum operator 8 by conduit 11; and B is also connected to an engine vacuum source (preferably above the carburetor throttle blade as will be described below) through opening 15. Compartment B contains a metering element 16 mounted vertically and seated at 17a in a bleed control element 17 which is integrally connected to the diaphragm 14; a spring 18 encircles metering element 16. This spring 18 maintains the metering element 16 in an upright position in compartment B and holds the lower end of metering element 16 in contact with the bleed control element 17 at 17a. The bleed control element 17 extends below said diaphragm 14 into compartment C. A spring 19 encircles the bleed control element 17 to maintain it in a vertical position in compartment C. Bleed control element 17 has a plurality of ports (openings) 21 which permits bleeding of the vacuum in compartment B as will be described below. Compartment C is open to the atmosphere at 22. Compartment C also contains a flexible bellows 23 which is connected through outlet 24 to an exhaust back pressure source. This source is most conveniently the exhaust manifold source as will be brought out in the discussion of FIG. 2 below. The sensing unit 13 is thus responsive to the exhaust back pressure as well as a vacuum signal.

The combination in FIG. 1 operates as follows. When a vacuum signal is received through opening 15 into compartment B, it is directly transmitted via outlet 12 and conduit 11 to the vacuum operator 8. The vacuum acts on the flexible diaphragm 7 pulling it upwards towards position 7a, against the action of spring 9. This movement of the diaphragm 7 moves rod 5 upwardly; this movement in turn actuates arm 4 to move the exhaust throttle blade 1 to a closed position (position 1a). The flow of the exhaust gas in exhaust pipe 2 is thereby throttled and the exhaust back pressure increases.

As the exhaust back pressure begins to increase, this increase is communicated to the bellows 23 through opening 24. Opening 24, as pointed out above, is connected to an exhaust back pressure source which is shown in the embodiment illustrated in FIG. 2 to be the exhaust manifold. The bellows 23 expands in response to this exhaust back pressure signal. As the bellows 23 expands, it contacts the bleed control element 17 and pushes it upwardly. This action in turn raises metering element 16 until the upper end of element 16 seats in the outlet 15 at the seat 15a. When the element 16 is so seated, the vacuum signal entering compartment B through opening 15 is cut off. However, the vacuum in compartment B continues to act on diaphragm 7 in the vacuum operator 8. As the exhaust back pressure continues to increase, the bleed control element 17 continues to be raised by the bellows 23 until the bleed control element 17 becomes disengaged from the lower end of metering element 16 at point 17a. This then permits the vacuum in compartment B to be bled off via the ports 21 in the bleed control element 17. As the vacuum is bled from compartment B in this way, the spring 9 acts to move diaphragm 7 downward, thereby moving the exhaust throttle blade 1 to the open position. This opening of the exhaust throttle blade 1 effects a reduction of

the exhaust back pressure. The vacuum is bled out of compartment B until the back pressure of the exhaust system is decreased to the point where the bellows 23 in response to this back pressure reduction moves down far enough to allow the bleed control element 17 to once again engage the lower portion of the metering element 16 at 17a; this terminates the bleeding. If the back pressure decreases further, then the metering element 16 drops away from its seat 15a again allowing the vacuum signal from an engine vacuum source to again enter compartment B and the sequence described above is repeated. By balancing the force of spring 9 against the vacuum communicated to the vacuum operator 8 from compartment B of the sensing unit 13 and relating it to the rate of expansion of the bellows 23 acting against spring 19 in response to exhaust pressure, the exhaust back pressure can be controlled at a substantially uniform level under low power demand engine operation.

A feature of the present system then is that the exhaust back pressure modulates the vacuum signal which is provided the vacuum operator to control the exhaust valve. Thus, the exhaust valve response is rapid; by proper balancing of the elements in the sensing and operating units a minimum back pressure can be substantially maintained under all engine operating conditions.

FIG. 2 is a schematic illustration (partial section view) of an embodiment of the back pressure control system of the present invention and its arrangement in relationship to other engine components.

As in FIG. 1, the sensing unit 13 is attached directly to vacuum operator unit 8 via conduit 11. A vacuum operator unit 8 is directly connected to rod 5 which moves the exhaust throttle plate 1 in exhaust pipe 2. In FIG. 1 a spring 9 was positioned inside the vacuum operator unit 13; in FIG. 2 a spring 9a is placed outside the vacuum operator 8 in an alternate position. Its function, however, is not changed. Conduit 25 connected to outlet 15 of the sensing unit 13 is tapped into the carburetor barrel throat 27 at a point 26 just above the carburetor throttle plate 28. This provides a vacuum signal to sensing element 13; this same vacuum signal is also provided via conduit 25a to the distributor D for controlling the spark advance. The sensing unit 13 is also connected at outlet 24 via conduit 29 to an opening 30 in the exhaust manifold 31. The operation of the back pressure control system has been described in the discussion of FIG. 1 above and will not be repeated here. A feature of obtaining the vacuum signal for sensing unit 13 from the carburetor barrel 27 at opening 26 is that no vacuum signal is obtained (a) when the engine is idling and (b) when the carburetor throttle 28 is substantially wide open. By substantially wide open is meant that the throttle plate 28 is substantially parallel to the long axis of the carburetor throat 27. Since there is no vacuum signal during idle or wide open throttle (carburetor), the exhaust stream is not subject to throttling by the exhaust throttle valve during these two engine operating conditions. Obtaining the vacuum signal from the carburetor as illustrated in FIG. 2 then is a preferred embodiment. However, the vacuum signal provided to the sensing unit 13 might also be obtained from the intake manifold; or vacuum might be provided by an auxiliary vacuum pump driven by the engine. In any event, the basic operation of the back pressure control system as described above is not altered regardless of the vacuum signal source.

Operating an engine equipped with the exhaust back pressure control system described above reduces the unburned hydrocarbon content of exhaust gas. This was determined using standard V8 engines of various cubic inch displacement and compression ratios with and without the present back pressure system in operation. The data obtained are tabulated below. The effect of the back pressure system on reducing unburned hydrocarbons in

the exhaust is expressed as "Percent Reduction in Hydrocarbon Content." This was calculated as follows:

Percent reduction=hydrocarbon content without back pressure control—
hydrocarbon content with back pressure control
hydrocarbon content without back pressure control ×100

TABLE I.—HYDROCARBON EMISSION REDUCTION

Engine	Test	Back pressure system operating	Hydrocarbon ² content of exhaust (p.p.m.)	Percent reduction in hydrocarbon content
V8, 302	1A	No	149	
CID ¹	1B	Yes	115	22.8
V8, 455	2A	No	342	
CID ¹	2B	Yes	322	5.8
V8, 350	3A	No	150	
CID ¹	3B	Yes	134	10.7

¹ CID=cubic inch displacement.
² Hydrocarbon content was determined using the "Test Procedure for Vehicle Exhaust Emissions" in "California Test Procedure and Manual for Motor Vehicle Exhaust Emission Control," March 9, 1966 Revision.

The data in Table I illustrates the effectiveness of the back pressure control system in reducing unburned hydrocarbons in the exhaust.

Another advantage the present back pressure system affords is that it does not adversely effect the drivability of a vehicle powered by an internal combustion engine using this back pressure system. This drivability factor is not susceptible to definite inspection, but it has been ascertain that the driving characteristics of an automobile are not noticeably changed when the present system is incorporated into the engine. This is primarily due to the fact that the present system (a) does not modulate back pressure at idle and (b) does allow back pressure signal to override vacuum control, preventing undue exhaust back pressure buildup. These features thus reduce the tendencies of an engine to stall because of improper control of back pressure. The back pressure system of the present invention has been fully described above. It is

to be limited only within the spirit and scope of the following claims.

I claim:

1. A system for controlling the back pressure of the exhaust formed in a spark ignition internal combustion engine which comprises in combination (1) an exhaust pipe through which said exhaust is transmitted into the atmosphere, (2) a throttling means situated inside said exhaust pipe, (3) a vacuum operator placed outside said exhaust pipe, said operator being linked directly to and controlling said throttling means, and (4) a sensing unit responsive to an exhaust back pressure signal and a vacuum source, said unit being connected to said operator by a conduit through which a vacuum signal is provided to said operator during part load engine operation, said system effectively maintaining a substantially uniform back pressure in and reducing the unburned hydrocarbon content of said exhaust.

2. The system of claim 1 wherein said engine is a multicylinder engine having a carburetor/induction manifold fuel induction system and wherein said vacuum source is the engine vacuum obtained at a point in said carburetor above the carburetor throttle plate.

3. The system of claim 2 wherein said exhaust back pressure signal is obtained at a point in the exhaust manifold of said engine.

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