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**Sandhagen**

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[54] **EXHAUST GAS RETURN MEANS FOR INTERNAL COMBUSTION ENGINES**


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[52] **U.S. Cl.**.....**123/119 A**

[51] **Int. Cl.**.....**F02m 7/00**

[58] **Field of Search**.....123/119 A



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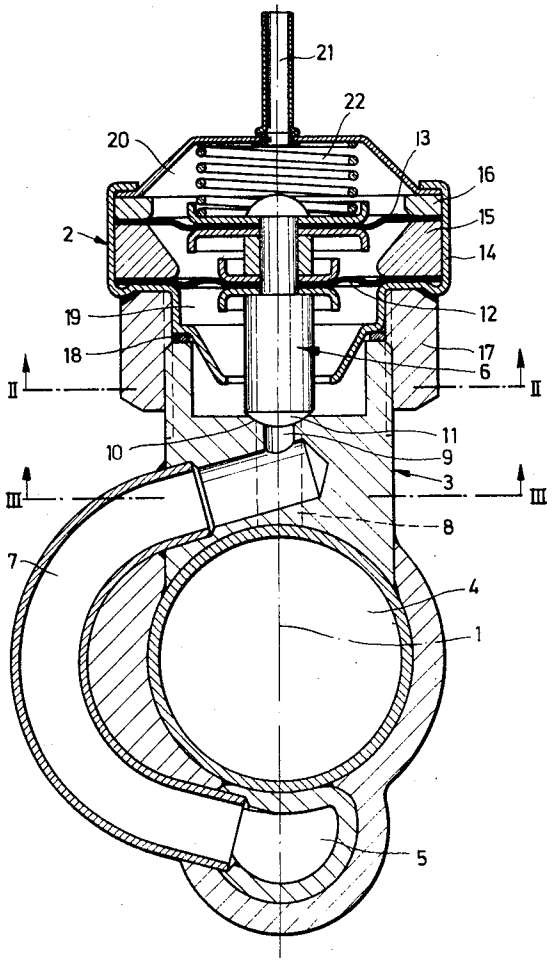
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[57] **ABSTRACT**

An intake system for an internal combustion engine in which intake of air and fuel into the combustion chambers is controlled by a throttle valve. An exhaust gas passage recirculates exhaust gas from the exhaust line back into the combustion chamber together with the incoming air. The flow of exhaust gas through such passage is under the control of a shutoff valve, the operating mechanism for which is controlled in response to differences between the pressure prevailing within the intake system and the pressure in the region of the metering element or throttle valve, to open the shutoff valve only during certain predetermined load conditions of the engine.


**15 Claims, 4 Drawing Figures**

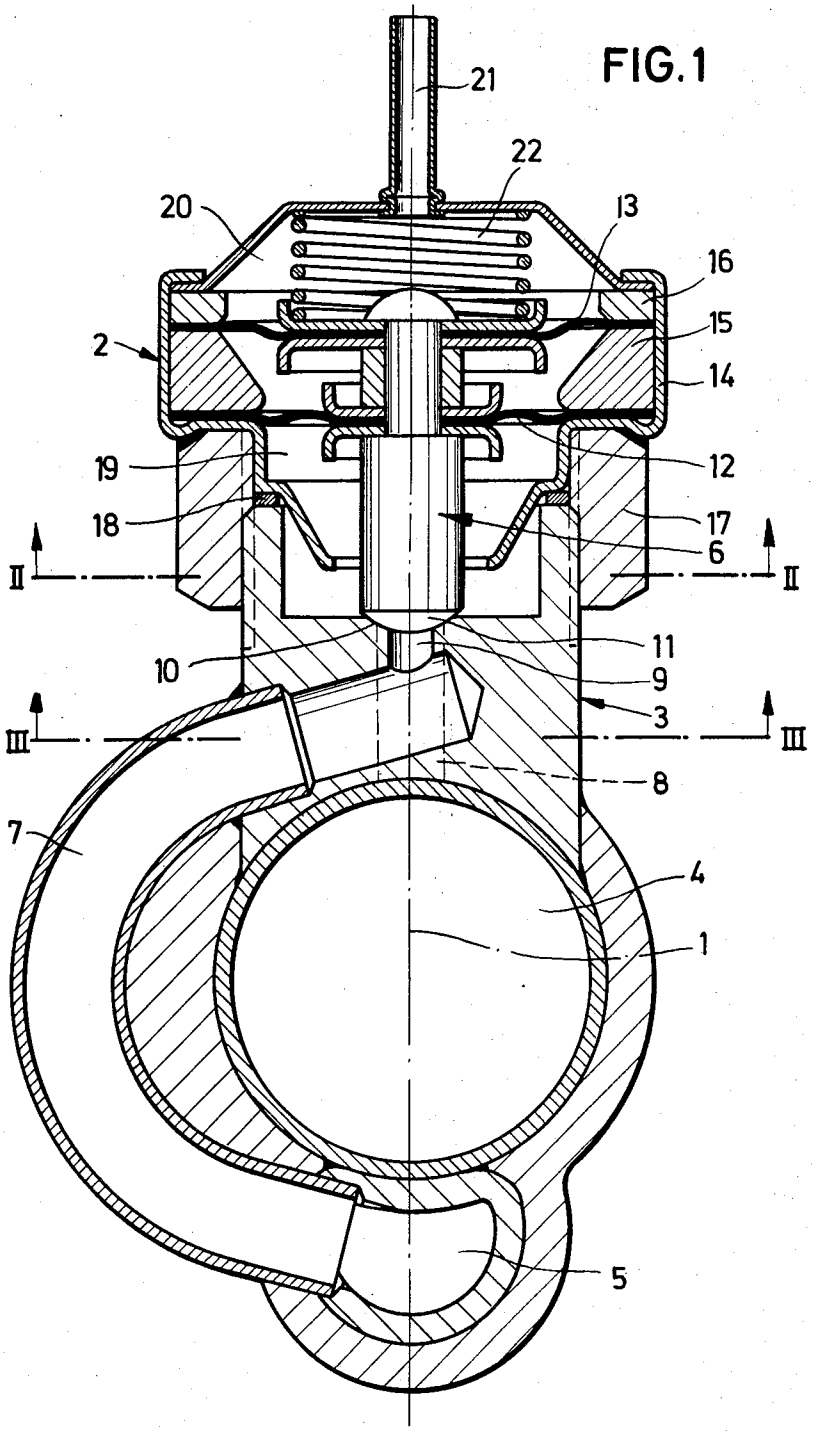


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FIG.1




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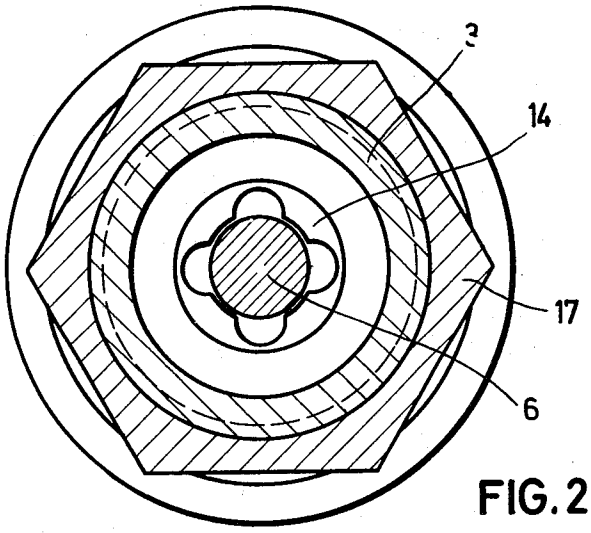



FIG. 2

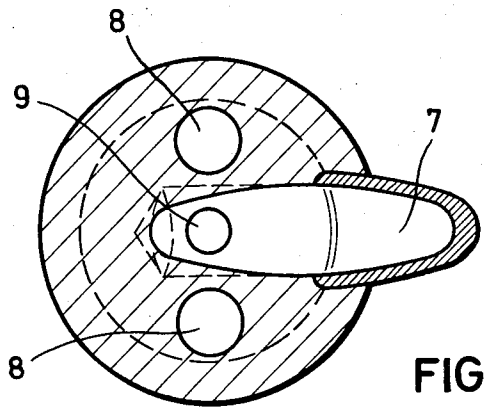



FIG. 3

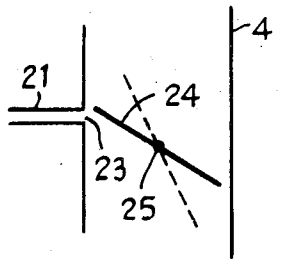



FIG. 4

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# EXHAUST GAS RETURN MEANS FOR INTERNAL COMBUSTION ENGINES

This invention relates to improvements in an internal combustion engine intake system which includes an air metering element or throttle feeding air or a mixture of fuel and air to the combustion chamber, there being an exhaust line, together with means for the return of some of the exhaust gas from the exhaust line to the combustion chamber.

While adapted primarily for use in connection with the engine of a motor vehicle, the invention can also be used advantageously in the case of other engines, for example stationary engines. Furthermore, the invention is by no means limited to use with carburetor equipped engines, but is adapted as well for use with the intake systems of engines having direct or indirect fuel injection.

The recycling or return of exhaust gasses through the combustion chamber or chambers of an internal combustion engine, is desirable from the following standpoints.

First, any unburnt components may be in the exhaust gases, such as hydrocarbons and carbon monoxide, are again subjected to the combustion process to secure a decrease in the undesirable components of the gas discharged into the atmosphere. Also, through recycling of the exhaust in this manner there is achieved a reduction of the nitric oxyde emission of the engine, resulting from a decrease of the peak combustion temperature, so that even during the creation of the exhaust gases, their composition is improved.

It has been found that the return or recycling of the exhaust gas, however, should occur only during certain operational conditions of the engine. Thus, a recycling of the exhaust gas during idling of the engine is generally undesirable, as it may result in certain undesirable instabilities. Similarly, a recycling of the exhaust gas through the combustion chamber at full load, is disadvantageous, in many cases, as resulting in a reduction in the performance of the engine.

The invention overcomes the problems of creating an internal combustion engine having an exhaust gas recirculating means and, through an economical construction and arrangement of parts, takes into account the foregoing requirements. According to the invention, the return line for the exhaust gas, bypassing the engine chambers, extends from the exhaust pipe to the intake system. Interposed in this return line is a shutoff valve having an operating mechanism which is arranged to be responsive to differences between the pressure prevailing in the induction system and the pressure in the region of the air metering element or throttle valve, which pressure varies as the gas velocity is increased or decreased due to changes in the position of the latter. The arrangement is such that the shutoff valve is opened to permit recycling of exhaust gases only in the middle or partial load condition of the engine between its idling and heavily loaded conditions.

Thus, in accordance with the present invention, during idling, the shutoff valve is closed. It commences to open at a predetermined minimum load condition of the engine, and is fully opened at the mid-portion of the load range. It closes as the engine becomes fully loaded, so that the return or recycling of the exhaust gas occurs only between the minimum and maximum load conditions of the engine.



The opposing pressures which control the valve, will change similarly and simultaneously with changes of atmospheric pressure. The invention, therefore, has the advantage of automatically adjusting to change in atmospheric pressure without requiring provision for adjustment to the particular altitude at which the given engine operates.

As already mentioned, the pressure in the intake system is automatically compared with a second pressure varying in accordance with the position of the air metering element during idling of the engine. Where the air metering element is a conventional butterfly throttle valve, the shutoff valve operating mechanism is responsive, in part, to the pressure in the region adjacent to the edge of the engine throttle valve, when the latter is in its idling or nearly closed position. For this reason, the induction or intake manifold in the region of the throttle valve has an opening through which the pressure in the region adjacent the edge of the throttle valve is transferred to the shutoff valve operating mechanism.

As a rule, the operating mechanism for the shutoff valve will include at least one diaphragm which is deflected in response to the differences between the opposing pressures and which, in deflecting, will move the shutoff valve. The preferred design of the invention is characterized by the fact that the operating mechanism includes two diaphragms, both operatively connected to the shutoff valve stem at spaced-apart locations and whose relatively remote surfaces are exposed to pressures in two different pressure chambers. In one chamber, the pressure of the induction system prevails, and in the other, a second pressure from the region of the throttle valve prevails. In one of the two pressure chambers, the diaphragm is spring-biased in a direction to close the shutoff valve and it is necessary to overcome the spring pressure in order to open the shutoff valve.

Also, in accordance with the invention, it is desirable that the shutoff valve be supported and guided in its movement by the relatively spaced diaphragms.

Further, in the preferred embodiment, the exhaust gas return passage is formed in several parts or sections, the first of which extends from the exhaust pipe to a first pressure chamber, in which the pressure of the induction system prevails, and the second of which extends from the said pressure chamber to the induction system for delivery of exhaust gases into the air flowing through the induction system. The valve seat for the shutoff valve is formed at the port through which the first part of the return pipe or passage communicates with the first pressure chamber. In order that the pressure of the exhaust gas acting on the shutoff valve and on the diaphragms will not impede the operation of that valve, the said port defines a constriction at the entrance to the first chamber.

In order to achieve a compact construction occupying a minimum space, the pressure chambers and shutoff valve, the induction system and the exhaust pipe are combined into a single structural unit in which said parts are relatively aligned in a common plane, and the first part of the return passage is defined by the pipe which extends around the intake manifold in the form of an arch. In accordance with a further feature, the above port, at the junction of the first part of the return

passage with the first pressure chamber, extends through a connecting block between the pressure chambers and the induction system, and channels or passages extend through this block from the first pressure chamber to the air intake system for the purpose of transferring the pressure in the induction system back to the first pressure chamber, as well as for delivering recycled exhaust gas back into the intake manifold.

To secure easy accessability to the shutoff valve and its seat for the purpose of cleaning and servicing, it is desirable to releasably connect the valve operating mechanism, including the valve itself, with the block, preferably by means of a threaded connection, in which the threads are shielded against contact with the exhaust gas.

The preferred embodiment of the invention is illustrated by way of exemplification in the accompanying drawings, in which:

FIG. 1 is a longitudinal section through the invention and the parts of an engine to which it is applied.

FIGS. 2 and 3 are sectional views along the lines II—II and III—III, respectively, of FIG. 1.

FIG. 4 is a diagrammatic illustration of the throttle valve of the internal combustion engine and the way in which it communicates with the second pressure chamber.

Referring now in detail to the accompanying drawings, the block 3, the induction or intake manifold 4, and the exhaust gas-pipe 5, preferably are aligned in a common plane represented by the line 1 of FIG. 1, and extending through the operating mechanism 2. The exhaust pipe 5 and the air intake manifold 4 are connected with one another through an exhaust gas return passage under the control of the tappet valve 6. The exhaust gas return passage comprises two parts designated 7 and 8, in addition to the port 9 and chamber 19. The first part 7 of this passage is defined by a pipe which partially encircles the induction manifold system 4 in the form of an arch, while the second part 8 of the return passage extends preferably in a straight line through the block 3 and establishes communication between the pressure chamber 19 and the intake manifold 4. The port 9 leading into the pressure chamber 19 is of smaller diameter than the passage 7, to serve as a restricter, while the block 3 around the upper end of the port 9 constitutes a concave valve seat for the valve 6. The end surface 11 of the valve 6 is correspondingly formed in a convex manner to secure a self centering of the valve with regard to its seat.

The valve 6 is supported and guided for operative movement by the two diaphragms 12 and 13, it being noted that the valve stem extends in fluid-tight manner through and is connected to both diaphragms. The outer peripheries of the respective diaphragms 12 and 13 are supported in a fluid-tight manner, respectively, between registering annular portions of the valve housing or casing 14 and the clamping rings 15 and 16.

The entire valve operating mechanism 2 is releasably connected to the block 3 by means of a nut 17 which is welded to the casing or housing 14 in a manner to achieve great stability. It is to be noted that the thread of nut 17 is isolated from chamber 19 by gasket 18 and thus is shielded from the exhaust gas when the latter passes through chamber 19.

The two diaphragms 12 and 13, respectively, constitute deflectable walls of the two pressure chambers 19 and 20, of which the first pressure chamber 19 is at all times connected with the intake manifold 4 by way of the channel or passage 8, so that the intake pressure prevails in chamber 19, while (referring jointly to FIGS. 1 and 4), the other or second pressure chamber 20 is connected by way of pipe 21 with an opening 23 in the intake manifold in the region closely adjacent the edge of the conventional engine throttle valve 24 in the form of a disc which is medially fulcrumed at 25 within the intake manifold or passage 4, for rotary adjustment about an axis 25 disposed diametrically to the passage 4. It will be noted that the pipe or conduit 21 opens into the intake manifold or passage 4 at a location 23 which is closely adjacent the edge of the butterfly throttle valve 23 when the latter is just slightly open or at its idling position, substantially as shown in full lines in FIG. 4, so that the throttle valve, at this time, coats with the casing 4 in defining a restricted passage adjacent the opening 23, through which the air must pass at an accelerated velocity and, therefore, at a lowered pressure. This lowered pressure is communicated to the second pressure chamber 20 through the pipe 21. Also, in the second compression chamber 20 is housed the compression spring 22 which exerts a pressure tending to seat the lower end of the valve 6 against the valve seat 10.

The relative pressures in the two chambers 19 and 20, therefore, change in accordance with the operating conditions of the engine. Thus, the pressure in the first pressure chamber 19 is higher than that in the second pressure chamber 20, whenever the engine is operated at or near a no load condition.

However, the area of diaphragm 12 exposed to pressure within the chamber 19 is less than the area of diaphragm 13 exposed to pressure within the second pressure chamber 20. The strength of the spring 22 is such that as loading of the engine commences, the valve 6 will be lifted slightly off the valve seat 10 to permit a small recycling flow of exhaust gas from the exhaust pipe 5 through passage 7, port 9, pressure chamber 19 and passage 8, into the intake manifold 4. With an increasing load, the two pressure values approach each other until they become equalized substantially at the mid-load range of the engine, at which time the valve 6 is fully opened to recycle a maximum amount of exhaust gases through the combustion chamber. As the load on the engine approaches or reaches full load, the two pressure values within the chambers 19 and 20 remain practically equalized, but decrease so considerably that the force of the spring 22 prevails and closes the valve 6 to discontinue the recycling of exhaust gases.

Thus, in accordance with the invention, it will be seen that the return or recycling of the exhaust through the combustion chambers by way of the return passage 7, 8, will occur only when the engine is operated through the medial portion of its load range.

Having thus described my invention, I claim:

1. In an internal combustion engine with an intake manifold containing an air metering element for feeding a mixture to the combustion chambers, and an exhaust gas pipe, and means for the return of the exhaust gas to the combustion chambers, the improvement which comprises means defining an exhaust gas return

passage (7, 8) for delivering exhaust gas from the exhaust gas pipe (5) to the intake manifold (4), a shutoff valve (2, 6) controlling the flow of exhaust gas through said passage (7, 8), and valve operating mechanism responsive to differences between the pressure in the intake manifold and the pressure in the region of the air metering element to open the shutoff valve (6) only in the means partial load operation of the engine.

2. An internal combustion engine according to claim 1, characterized in that the air metering element is a throttle valve and the operating mechanism (2) is fed the pressure in the area of the edge of the throttle valve in its position during idling.

3. An internal combustion engine according to claim 1, characterized in that the operating mechanism (2) comprises two diaphragms (12, 13) supporting a tappet valve (6) for operative movement, said diaphragms respectively cooperating with pressure chambers (19, 20) in one of which the pressure of the intake manifold (4) prevails and in the other of which another pressure prevails.

4. An internal combustion engine according to claim 3, characterized in that a spring (22) forcing the shutoff valve (6) in the direction of the valve seat (10), has been disposed in one (20) of the two pressure chambers (13, 20), the strength of said spring and the relative areas of the respective diaphragms being such that only in the event of equality of the two pressures in the said chambers is the valve (6) opened.

5. An internal combustion engine according to claim 4, characterized in that the valve (6) is suspended movably by means of diaphragms (12, 13), and is formed for self-centering engagement with a valve seat (10).

6. An internal combustion engine according to claim 5, characterized in that said valve (6) is formed with a convex end (11) and the valve seat (10) is concave.

7. An internal combustion engine according to claim 3, characterized in that the return passage comprises two parts (7, 8), the first of which (7) extends from the exhaust pipe (5) up to the first pressure chamber (19) in which the pressure of the induction system (4) prevails and the second part (8) extends from this pressure chamber (19) to the induction system (4), and in that the valve seat (10) is formed at the junction (9) of the first part (7) of the return passage with the first pressure chamber (19).

8. An internal combustion engine according to claim 7, characterized in that the first part (7) of the return pipe contains a restrictor in the form of a valve part 9 adjacent to the valve seat (10).

9. An internal combustion engine according to claim 7, characterized in that the pressure chambers (19, 20), the valve (6), the intake manifold (4), and the exhaust gas pipe (5) are disposed in a common plane (1) and that the first part (7) of the return pipe encirlces the cross-section of the intake manifold (4) in the form of an arc.

10. An internal combustion engine according to claim 9, characterized in that the junction (9) of the first part (7) of the return pipe comprises a valve part defined by a connecting block (3) between the pressure chambers (19, 20) and the intake system (4), said block (3) being formed with a channel (8) for transferring the pressure in the intake system 4 to the adjoining pressure chamber (19).

11. An internal combustion engine according to claim 10, characterized in that the valve operating mechanism (2) including the valve (6) is releasably associated with the block (3).

12. An internal combustion engine according to claim 11, characterized in that said valve operating mechanism is connected to the block (3) by way of screw connections (17) shielded against contact with the exhaust gas.

13. In an internal combustion engine having an intake manifold delivering air from the atmosphere into its combustion chamber, a throttle valve in said manifold for controlling the flow of air therethrough, an exhaust pipe for discharging exhaust gases from the combustion chambers, and means defining an exhaust gas return passage for establishing communication between the exhaust pipe and said intake manifold, a shutoff valve controlling the flow of exhaust gases through said return passage and means for operating said valve in response to varying differences between the pressure prevailing within said manifold in the region of said throttle valve and the pressure within said manifold remote from said throttle valve.

14. The combination defined in claim 13, including resilient means constantly urging the said shutoff valve toward closed position.

15. The combination of claim 13 further including a housing for said shutoff valve, flexible diaphragm means within said housing dividing same into first and second pressure chambers, said diaphragm means being subjected to the opposing pressures in the respective chambers, said first pressure chamber being interposed in said exhaust return passage and including a valve seat for cooperation with said shutoff valve, said seat defining a valve port constituting a part of said exhaust gas passage, said shutoff valve being a tappet valve carried by said diaphragm means for movement into and from seating relation with said valve seat to control the flow of exhaust gases through said return passage; said second pressure chamber communicating with said intake manifold in the region of said throttle valve to be subjected to changes in pressure in response to changes in the operating position of said throttle valve.

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