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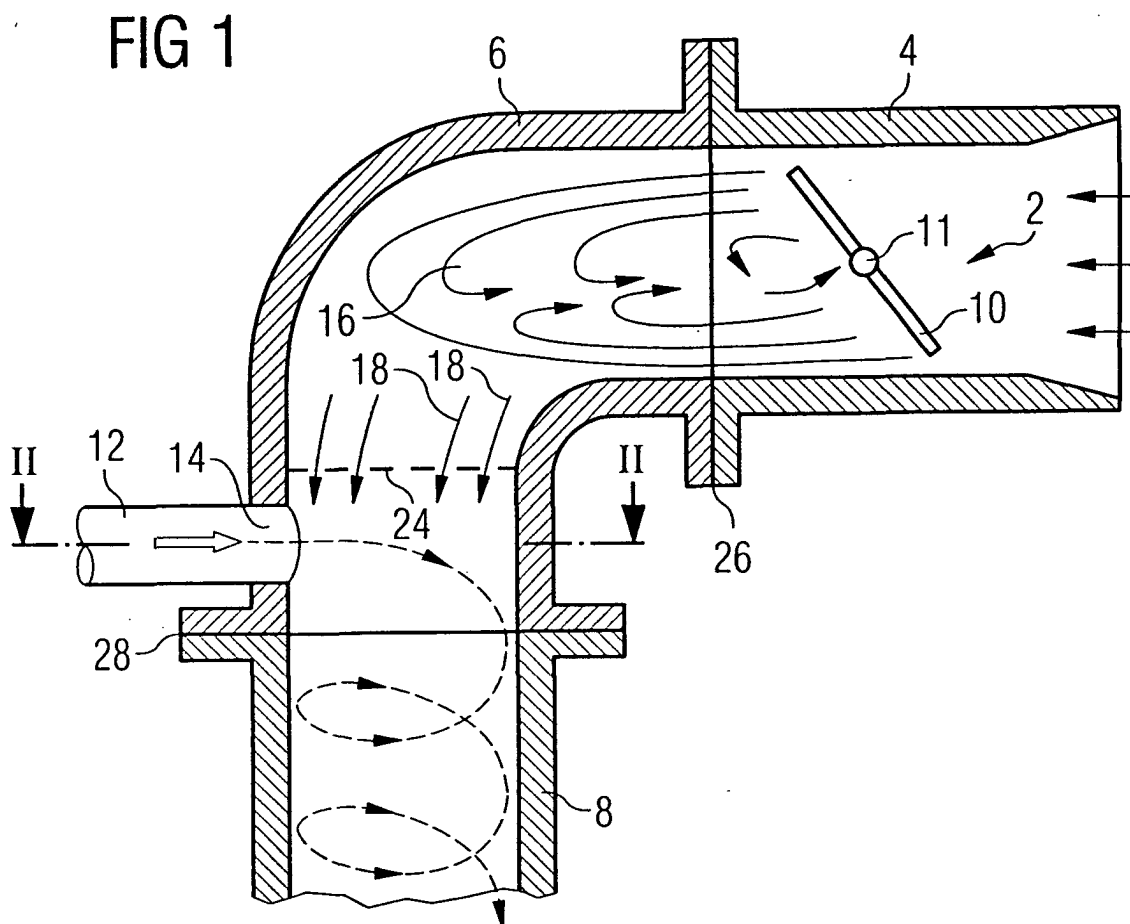
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(54) **Apparatus for recirculating exhaust gas into an inlet air stream**

(57) An apparatus for recirculating exhaust gas into an inlet air stream in an internal combustion engine. The intake passage (2) comprises an elbow section (6) be-

tween the throttle blade (10) and an exhaust gas inlet (14) for preventing entry of exhaust gas into a backflow region downstream of the throttle blade (10).



Description

Field of the Invention

[0001] This invention relates to an apparatus for recirculating exhaust gas into an inlet air stream in an internal combustion engine.

Background of the Invention

[0002] A conventional air intake and exhaust gas recirculation assembly comprises a housing including an intake passage for inlet air, a throttle valve including a throttle blade arranged in the intake passage so as to be rotatable about a pivot axis between opening and closing positions, and an exhaust gas recirculation conduit communicating with said intake passage downstream of the throttle valve so as to introduce exhaust gas into the inlet air flowing through the intake passage.

[0003] There are a number of problems related to such an air intake and exhaust gas recirculation assembly:

[0004] The exhaust gas should be introduced into the inlet air stream so as to be evenly distributed to every engine cylinder. When using a single entry point in the inlet system between the throttle body and the inlet ports at the cylinder head it is very important to provide good mixing of the exhaust gas with the inlet air.

[0005] The exhaust gas contains many products of the combustion process and residual substances carried away from the combustion chamber during the exhaust process. Such components of the exhaust gas are known to cause deposit build-up on the throttle body surfaces with which they come in contact. Deposits on the throttle body represent a serious concern in that they may cause the throttle blade to stick. For electronically controlled throttle valves deposits cause a serious problem also in that they may block the airflow past the throttle blade in the limp home mode. For engine safety concepts this is a serious problem.

[0006] During cold ambient operation of the internal combustion engine it is possible that ice can form on the throttle body. Ice forms where there is sufficient moisture in the inlet air to condensate on cold surfaces and then to change to ice. Ice formation influences the airflow through the intake passage in a similar way to deposits and therefore affects the operation of the engine severely. Icing of the throttle body occurs when the throttle body surfaces are cold and sufficient moisture is present in the inlet air. Inside the inlet manifold moisture comes from both the exhaust gas and blow-by gas from the crank case.

[0007] When the inlet manifold downstream of the throttle body is made of plastic material, it is necessary to manage the thermal inputs so as to avoid damage of the plastic material. The introduction of exhaust gas into the inlet air stream poses a difficult problem in that gases may be introduced at a temperature above the temper-

ature allowable for the plastic material. In order to avoid deposit build-up in the exhaust gas recirculation circuit it is necessary to maintain a gas temperature above 350°C. Most plastic manifolds have an operating limit of about 170°C. So the exhaust gas should be introduced in such a way that it does not cause any damage to the plastic inlet manifold.

[0008] The following patent publications which attempt to solve at least certain of the above described problems have become known:

[0009] EP 0 881 378 A3 describes a method of introducing exhaust gas in such a way that it is drawn into the inlet manifold downstream of the throttle body through tangential openings. The tangential introduction results in a spiral motion of the entering gas which is said to facilitate good mixing with the inlet air.

[0010] US-A-4 697 569 describes a method of introducing exhaust gas at the throttle body through semi-circular annular openings to facilitate good mixing with the inlet air.

[0011] US-A-4 461 150 describes a method of introducing exhaust gas into the inlet manifold downstream of the throttle body through a number of symmetrically arranged angled inlets so as to produce a spiral gas flow into the inlet manifold. Similar as in the above mentioned EP 0 881 378 such spiral gas flow is said to provide for good mixing of the inlet air and the exhaust gas. Furthermore, such spiral gas flow is intended to prevent the exhaust gas from contacting the throttle body. To this end the exhaust gas is fed into a region downstream of the throttle blade so as not to get entrained into the back-flow air region formed in the wake of the throttle blade.

[0012] DE 4 420 247 A1 describes a method of introducing exhaust gas into the inlet manifold downstream of the throttle body through a plurality of openings arranged in a circular symmetrical pattern about the axis of the intake passage. This patent discloses also another embodiment wherein the plurality of openings is replaced by a single annular opening. The intake passage includes a venturi section at the area into which the exhaust gas is introduced by the openings. Such a venturi section will create higher inlet air velocity which may improve the mixing of inlet air and recirculated exhaust gas. Furthermore, this patent talks about a thermal insulation between the throttle body and the plastic inlet manifold to prevent damage to the plastic manifold.

Summary of the Invention

[0013] It is a primary object of this invention to provide an apparatus for recirculating exhaust gas into an inlet air stream wherein deposit build-up and ice formation on the surfaces of the throttle valve and adjacent walls of the intake passage are minimized.

[0014] A further object is to provide for good mixing of inlet air and recirculated exhaust gas.

[0015] A further object is to optimise heating of the throttle body of the throttle valve.

[0016] The invention has been defined in patent claim 1. Further developments and modifications of the invention have been defined in the dependent claims.

[0017] According to the apparatus of the present invention the intake passage comprises an elbow section between the throttle member of the throttle valve and an exhaust gas inlet for preventing entry of exhaust gas into the backflow region downstream of the throttle member.

[0018] The elbow section of the present invention allows for the introduction of exhaust gas into a region where there is no recirculating or backflowing air. Rather the exhaust gas is introduced into a region of the air stream that is free flowing directly into the inlet manifold. By preventing exhaust gas from contacting the interior surfaces of the throttle valve housing (throttle body) and the throttle member (throttle blade) it is possible to prevent deposit from forming in those area. Furthermore it is known that exhaust gas carries with it large quantities of moisture which when in contact with cold surfaces forms ice. By preventing the exhaust gas from contacting the throttle valve surfaces it is also possible to significantly reduce the possibility of icing.

[0019] Preferably, the throttle member is disposed closely adjacent to an upstream end of the elbow section so that the backflow region extends into the elbow section. Also preferably the exhaust gas inlet is disposed closely adjacent to a downstream end of the elbow section. This allows to mix the entering hot exhaust gas with cooler inlet air as soon as possible downstream of the throttle valve so that the mixing time is maximized and therefore the heat of the exhaust gas is diluted well before it reaches the interior surfaces of the inlet manifold. It has been calculated that for a 350°C exhaust gas (highest temperature expected) entering a 40°C inlet air stream (highest ambient temperature expected) at a proportion of 30 % by mass exhaust gas (highest exhaust gas expected) the final bulk gas temperature would be around 170°C assuming perfect mixing. 170°C is the maximum temperature that a typical plastic manifold can withstand. Placing the elbow section as close to the throttle valve as possible and introducing the gas in such a way as to maximize the mixing will ensure that the exhaust gas cannot damage an inlet manifold made from plastic.

[0020] A further modification of the invention provides that the elbow section is comprised of a separate housing member fitted between the throttle body and the inlet manifold. Preferably the elbow housing member and the throttle body are connected to each other so as to provide for optimal heat transfer therebetween. As a result thereof heat from the exhaust gas is used to warm the elbow housing member which transfers heat to the throttle body so as to raise the temperature thereof.

[0021] As mentioned above it is thought that the moisture present in the exhaust gas is the major cause for icing on the throttle valve surfaces. It is therefore intended to provide heat to the throttle body only when it is required. The thermal inertia of the elbow section and

throttle body should be minimized so that they can be heated rapidly as required to prevent ice formation. The level to which the temperature of the throttle body is raised must be carefully checked to ensure that it is not too high. This could be done using appropriate CFD-analysis.

[0022] The optimal heat transfer connection of the elbow section housing member to the throttle body is there to optimise the heating of the throttle body not so much to reduce the temperature of the elbow section housing member. A further result of such optimal heat transfer and minimal thermal inertia is that during a hot soak condition the throttle body can cool at the fastest possible rate dependent on the ambient temperature surrounding it.

[0023] To summarize the present invention and modifications thereof provide for the following advantages:

[0024] The elbow section between the throttle member and the inlet manifold is used to introduce the exhaust gas so as to avoid the air backflow region downstream of the throttle member thereby preventing deposit and ice formation.

[0025] The elbow housing member is connected to the throttle body so as to transfer heat from the exhaust gas to the throttle body to avoid ice formation.

[0026] The elbow housing member and the throttle body are provided with the lowest possible thermal inertia to reduce the hot soak temperature and the time to effect heating of the throttle body.

[0027] The exhaust gas is introduced into the inlet air stream in such a way that the temperature of the exhaust gas is reduced sufficiently during mixture with fresh inlet air so it cannot damage an inlet manifold made from plastic.

Brief Description of the Drawings

[0028] These and other objects, features and advantages of this invention will be apparent from the following detailed description of the preferred embodiment and best mode, appended claims, and accompanying drawings, in which:

Fig. 1 is a schematic sectional view of an intake passage of the present invention;

Fig. 2 is a schematic section view as indicated by arrows II-II in Fig. 1.

Detailed Description of the Preferred Embodiment

[0029] Referring to Fig. 1, an air intake passage 2 is provided to feed inlet air to a pluralities of cylinders of an internal combustion engine (not shown). Inlet passage 2 comprises a throttle body 4 and an elbow section 6 which is connected to an inlet manifold 8.

[0030] Throttle body 4 contains a throttle member 10. In the embodiment as shown throttle member 10 is a

conventional throttle blade rotatable about an axis 11 between opening and closing positions to control the flow rate of the inlet air stream.

[0031] An exhaust gas recirculating conduit 12 which receives exhaust gas from an exhaust gas system (not shown) of the internal combustion engine terminates in an exhaust gas inlet 14 introducing exhaust gas into the intake passage 2 for mixing with the inlet air stream.

[0032] During operation inlet air flows through the intake passage 2 past throttle member 10. As a result thereof an air backflow region 16 exists downstream of throttle member 10 the extent of which depends on the angular position of throttle member 10.

[0033] As explained above, elbow section 6 which is of 90° design is used to prevent exhaust gas introduced into the inlet air stream from reaching the backflow region 16. Nevertheless exhaust gas is introduced into the inlet air stream at a location as close as possible to the throttle member 10 and backflow region 16 in order to provide for good mixing of inlet air and exhaust gas.

[0034] More particularly throttle member 10 is disposed closely adjacent to the upstream end of elbow section 6 so that backflow region 16 extends into the interior of elbow section 6. Furthermore, exhaust gas inlet 14 is disposed closely adjacent to the downstream end 24 (indicated by dashed lines) of elbow section 6.

[0035] As shown in Fig. 2 the exhaust gas inlet 14 comprises a single orifice arranged to introduce the exhaust gas into the intake passage tangentially with respect to the circumferential wall 20 of the intake passage so as to provide for a spiral exhaust gas flow pattern 22. The tangential entry of the exhaust gas helps to ensure that the exhaust gas does not travel back up the neck of the elbow section into the backflow region 16. Furthermore, it is important to note that the exhaust gas inlet 14 introduces the exhaust gas at a location where the inlet air stream is free flowing as indicated by arrows 18.

[0036] While the throttle body 4 and inlet section 6 could be made as an integral part, they are preferably made of separate housing members. The elbow section 6 housing member is provided with the exhaust gas inlet 14 so that exhaust gas is used to heat elbow section 6. Elbow section 6 is connected to throttle body 4 through flange means 26 so as to provide for good heat transfer therebetween. Throttle body 4 and elbow section 6 are made of metal of low thermal inertia, preferably of die cast aluminium. To improve heat transfer between elbow section 6 and throttle body 4, a thermally conducting sealing means (not shown) could be provided within flange means 26.

[0037] As a result of this structure heat from the exhaust gas is rapidly transferred to the throttle body 4 in order to prevent ice formation thereon. Furthermore, during hot soak conditions the throttle body 4 can cool at the fastest possible rate.

[0038] As shown in Fig. 1 elbow section 6 is connected to inlet manifold 8 by flange means 28. Preferably

inlet manifold 8 is made of plastic material. Flange means 28 could be designed so as to provide for thermal isolation between inlet manifold 8 and the housing member of elbow section 6. In any case the design of the arrangement as shown including throttle body 4, elbow section 6 and exhaust gas inlet 14 provide for good mixing of fresh inlet air and exhaust gas to prevent damage of the inlet manifold 8.

Claims

1. An apparatus for recirculating exhaust gas into an inlet air stream in an internal combustion engine, comprising

an intake passage (2) for communicating inlet air to an inlet manifold (8),

a throttle valve including a throttle member (10) disposed in said intake passage (2) so as to be movable between opening and closing positions, with a back flow region (16) existing downstream of said throttle member (10) during operation, and

an exhaust gas recirculating conduit (12) arranged to introduce exhaust gas into said intake passage (2) through an exhaust gas inlet (14) downstream of said throttle member (10),

characterized in that

said intake passage (2) comprises an elbow section (6) between said throttle member (10) and said exhaust gas inlet (14) for preventing entry of exhaust gas into said backflow region (16).

2. The apparatus of claim 1 wherein said elbow section (6) comprises a 90° elbow.
3. The apparatus of claim 1 or claim 2 wherein said throttle member (10) is disposed closely adjacent to an upstream end of said elbow section (6) so that said backflow region (16) extends into said elbow section (6).
4. The apparatus of any of claims 1 to 3 wherein said exhaust gas inlet (14) is disposed closely adjacent to a downstream end of said elbow section (6).
5. The apparatus of any of the preceding claims wherein said exhaust gas inlet (14) is a single orifice inlet.
6. The apparatus of claim 5 wherein said exhaust gas inlet (14) is arranged to introduce the exhaust gas

into said intake passage (2) tangentially with respect to a circumferential wall (20) of said intake passage (2) so as to provide for a spiral exhaust gas flow pattern (22).

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7. The apparatus of any of the preceding claims wherein said elbow section (6) is comprised of a separate housing member fitted between a throttle body (4) and said inlet manifold (8).

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8. The apparatus of claim 7 wherein said exhaust gas inlet (14) is disposed in said elbow section (6) housing member.

9. The apparatus of claim 8 wherein said elbow section (6) housing member and said throttle body (4) are connected to each other so as to provide for optimal heat transfer therebetween.

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10. The apparatus of claim 8 or claim 9 wherein said elbow section (6) housing member and said throttle body (4) are of minimal thermal inertia.

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FIG 1

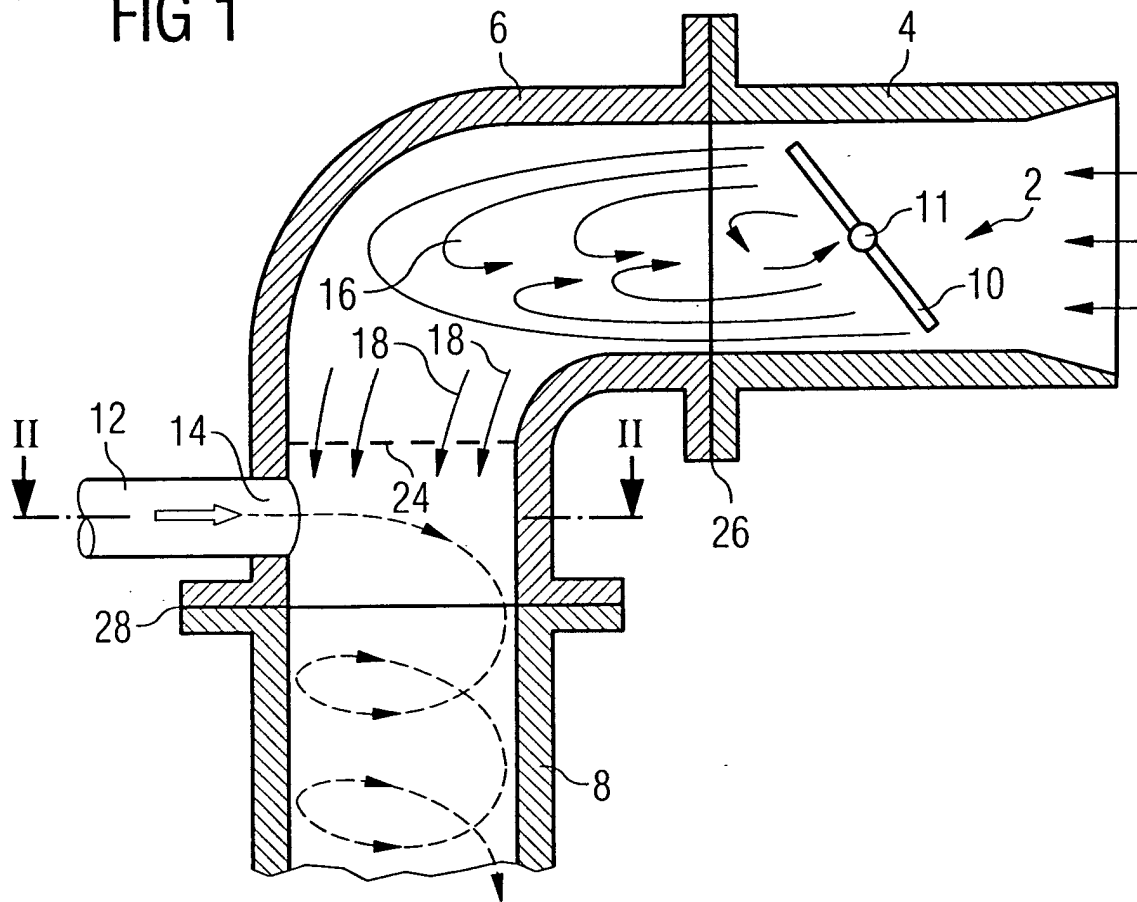
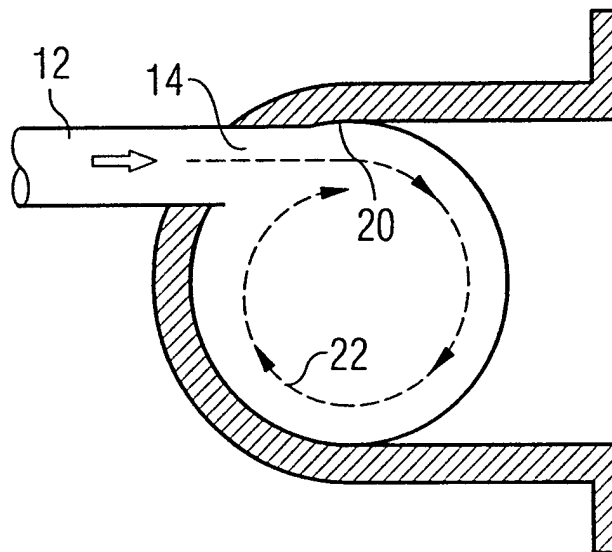


FIG 2





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 11 5521

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Place of search THE HAGUE		Date of completion of the search 21 November 2001	Examiner Van Zoest, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 01 11 5521

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The members are as contained in the European Patent Office EDP file on
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