

United States Patent

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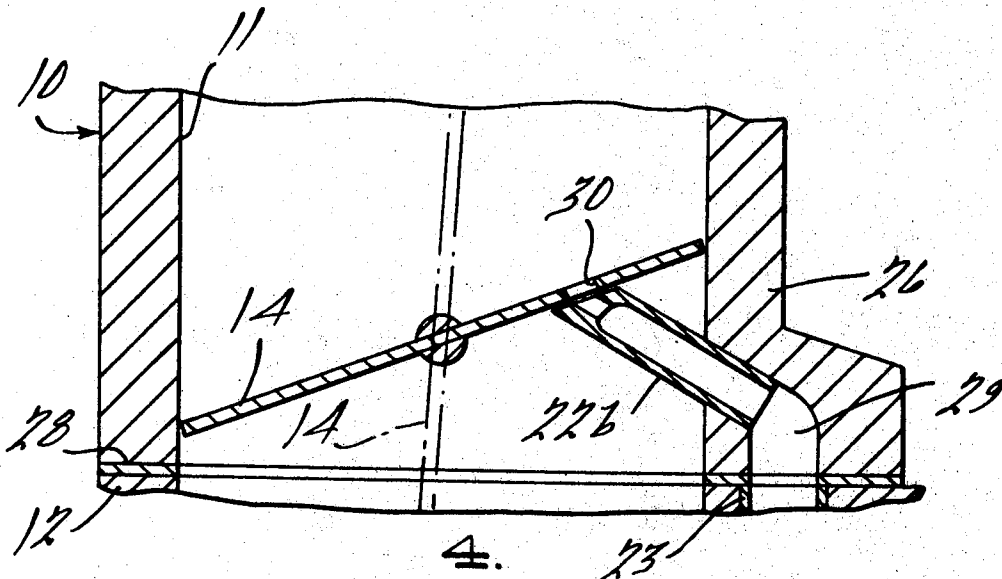
[54] ENGINE EXHAUST RECIRCULATION 40 Claims, 12 Drawing Figs.

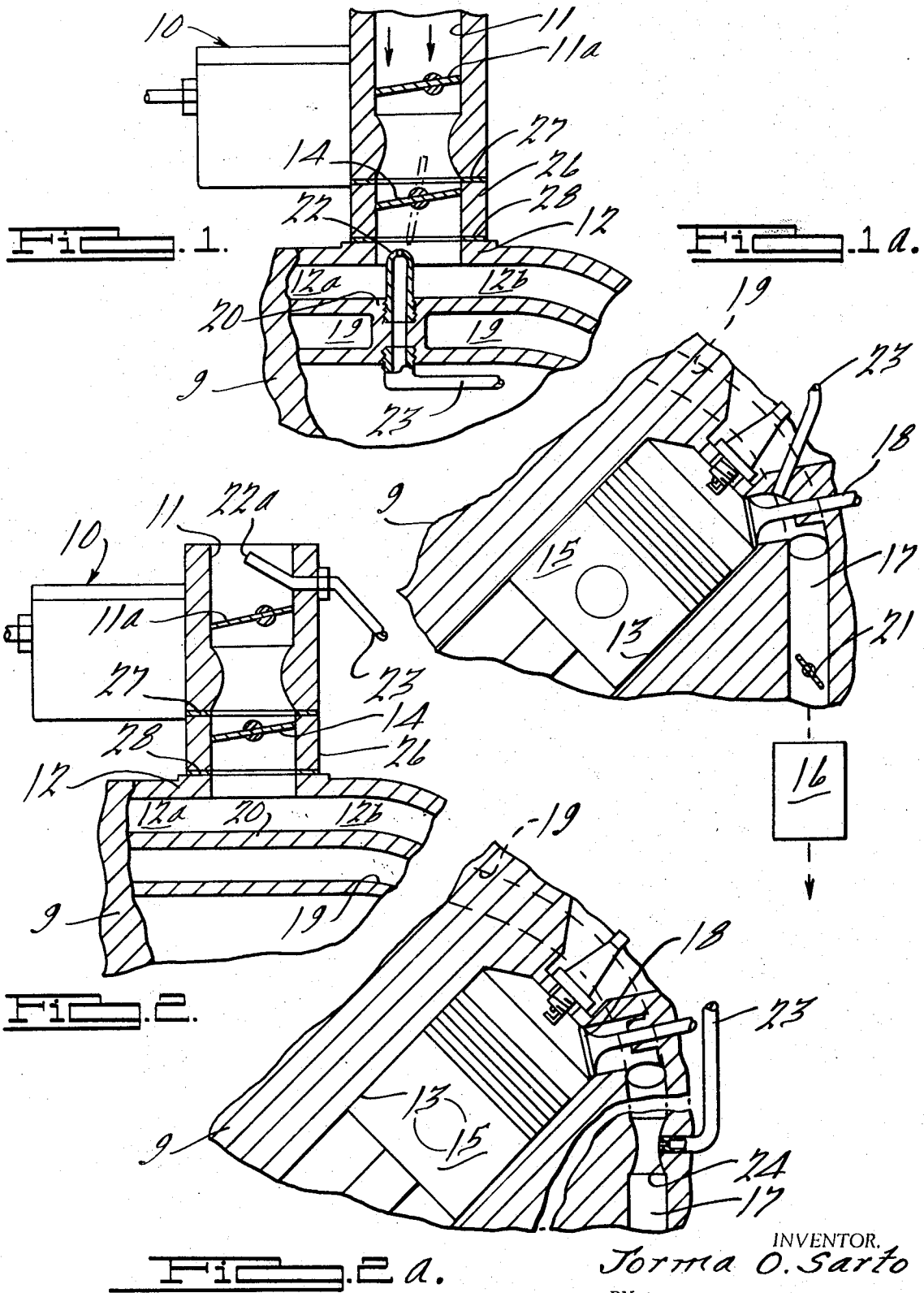
[52] U.S. Cl. 123/119
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[50] Field of Search 123/119A,
119

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ABSTRACT: Automobile exhaust gases are recycled by means of a bypass conduit communicating with the exhaust system and discharging into the fuel and air inlet system in opposition to a jet of inlet gases discharging through an orifice in the throttle valve when the latter is at the idle position, such that during engine idling, the bypass flow of exhaust gases into the inlet system is inhibited, but upon opening movement of the throttle valve from the idle position, the jets move out of opposition with each other to enable increased exhaust recycling with increasing engine load.



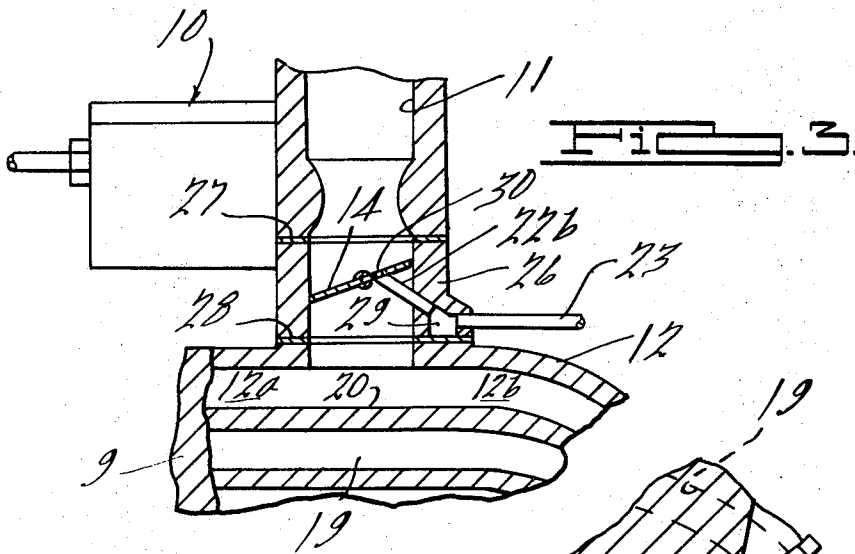
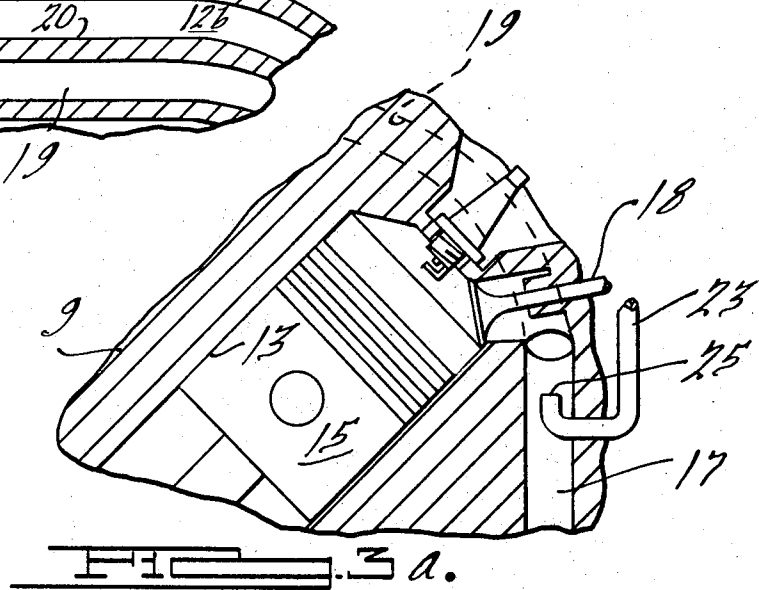
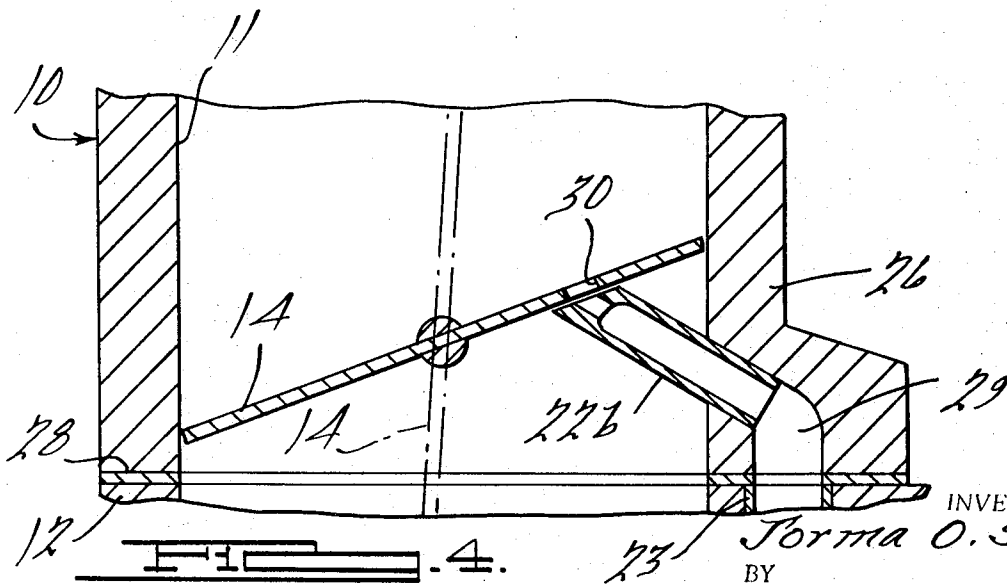


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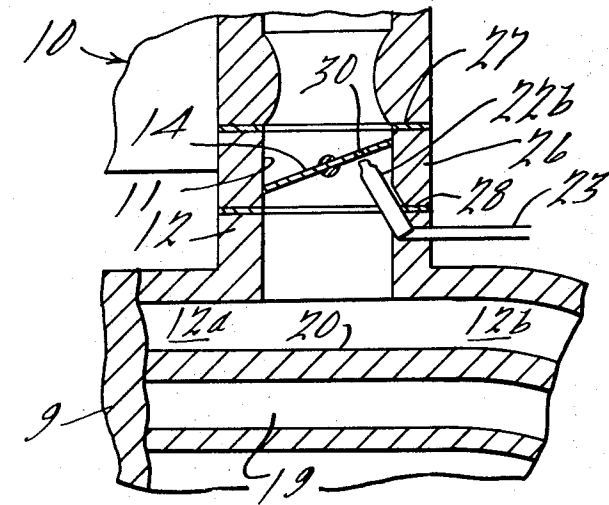


FIG. 5.

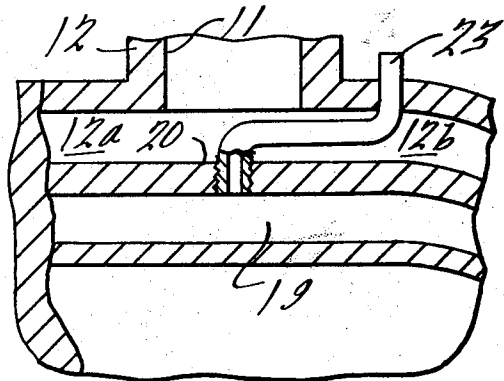


FIG. 6.

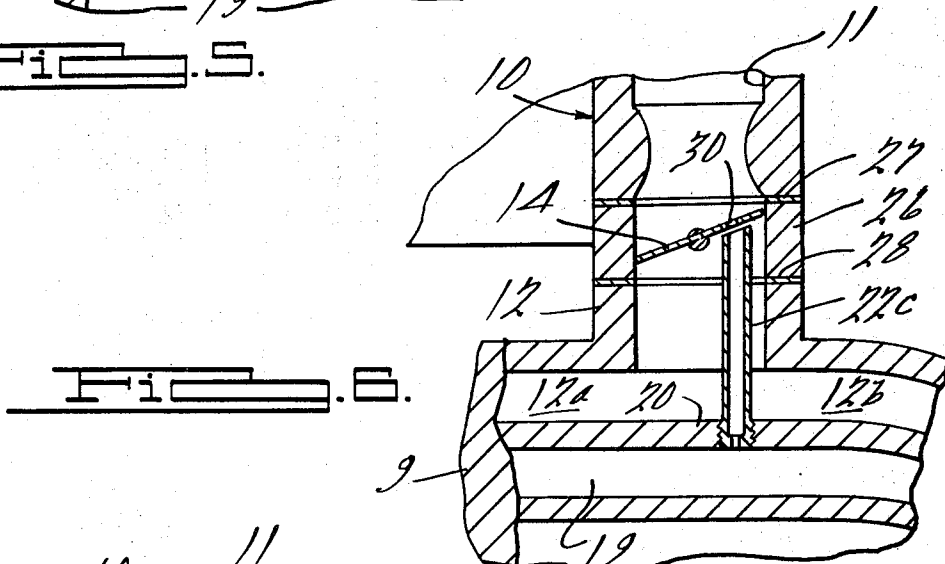


FIG. 7.

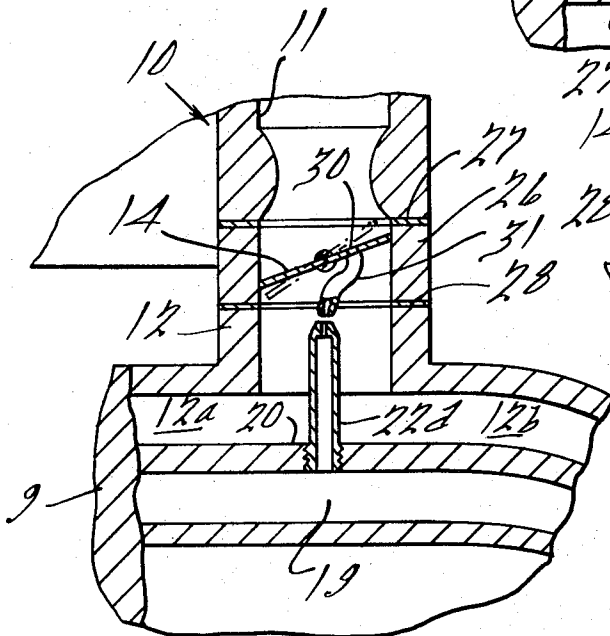


FIG. 8.

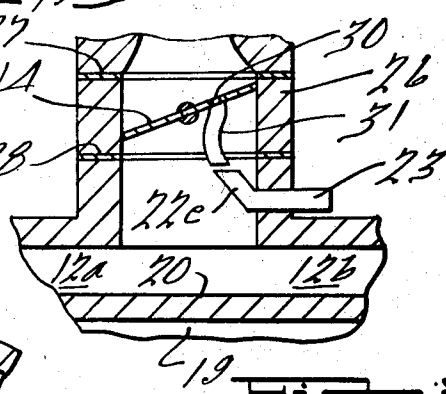


FIG. 9.

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ENGINE EXHAUST RECIRCULATION

BACKGROUND AND SUMMARY OF THE INVENTION

In the prior art, numerous systems have been devised to recycle exhaust gas into the fuel-air induction system of an automobile engine for the purposes of preheating and vaporizing the incoming air-fuel mixture to facilitate its complete combustion in the combustion zone, for reusing the unignited or partially burned portions of the fuel which would otherwise pass out the exhaust pipe and into the atmosphere, and for reducing the oxides of nitrogen emitted from the exhaust system into the atmosphere. It has been found that approximately 15 percent exhaust gas recycling is required at moderate speeds to substantially reduce the nitrogen oxide content of the exhaust gases discharged in the atmosphere, that is, to below about 1000 parts per million.

Although the prior art structures have had the desired effect of reducing the content of nitrogen oxides in the exhaust by reducing the maximum combustion temperature in consequence of diluting the fuel-air mixture with recycled exhaust gases during certain operating conditions of the engine, these structures have not been commercially acceptable from the standpoints of both cost and operating efficiency and have been complicated by the desirability of reducing the recycling during conditions of both engine idling when nitrogen oxide emission is a minor problem and wide open throttle when maximum power is required, while progressively increasing the recycling of exhaust gases with increasing engine speed during cruising condition or with increasing engine load at part open throttle. The nitrogen oxide emission is a direct function of combustion temperature and for that reason is less critical during engine idling when the rate of fuel combustion and the consequent combustion temperature are minimal, and during wide open throttle conditions which are ordinarily of short duration.

In the usual gasoline or hydrocarbon fuel type engine, fuel combustion can take place at about 1200°F. The formation of nitrogen oxides does not become particularly objectionable until the combustion temperature exceeds about 2200°F., but the usual engine combustion temperature which increases with engine load or the rate of acceleration at any given speed frequently rises to about 2500°F. It is known that the recycling of at least one-twentieth and not more than one-fourth of the total exhaust gases through the engine, depending on the load or power demand, will reduce the combustion temperature to less than 2200°F. The desired result is usually obtained with the ordinary engine upon the recycling of about 15 percent of the total exhaust gases during partially open throttle as aforesaid.

An important object of this invention is to provide improved means uncomplicated by moving parts comprising a restricted recycling or bypass duct for recirculating a portion of the combustion products from the exhaust system to the inlet system of an automobile engine to overcome or avoid the problems and deficiencies of the prior art, as well as to achieve a number of important results including preheating and improved mixing and carburetion of the fuel-air mixture in the inlet header, the reduction of ice formation on the customary throttle blade, and the reduction of noxious nitrogen oxides in the exhaust.

Another object is to provide such a construction wherein the bypass duct extends in heat exchange relationship through the customary throttle body of the inlet system and terminates within the induction conduit in a nozzle directed to discharge hot exhaust gases upstream against the flow of the fuel-air mixture in the induction conduit and also against the usual throttle valve, thereby to provide simple, economical and effective means for accomplishing the foregoing as well as for preheating the throttle body and simultaneously cooling the exhaust gases in the bypass conduit below the fuel ignition temperature, and for diluting the fuel-air mixture with substantially incombustible exhaust gases to lower the combustion temperature in the engine and thereby reduce the formation of nitrogen oxides during the combustion process.

Another and more specific object is to provide an exhaust recycling system comprising a bypass duct which opens within the induction conduit so as to discharge the exhaust gases against an oppositely directed stream of inlet gases when the throttle valve is in its idle operating position. The stream of inlet gases may be effected, for example, by means of a restricted inlet gas orifice in the customary butterfly type throttle valve. The bypass duct terminates adjacent the downstream side of the throttle valve in opposition to the inlet gas orifice, whereby the recycling of exhaust gases is rendered nominal during idle operation. However the bypass duct has a fixed restriction dimensioned so that more than 5 percent but less than approximately 25 percent and usually about 15 percent of the total exhaust gases are conducted through the bypass duct when the throttle is partially open and the effective pressure differential between its ends corresponds to cruising or part open throttle acceleration conditions.

By virtue of the foregoing, communication will exist at all times between the exhaust and inlet systems and a portion of the hot exhaust gases will be directed against the throttle valve to prevent or minimize carburetor icing during fast idling of a cold engine when ice formation is most likely to occur. During cold engine idling when the throttle is held partially open by the usual fast idle cam during this condition, as is customary, the flow of hot exhaust gases against the throttle blade will increase, as compared to normal warm idling, because the increased engine speed at fast idle will increase the gas pressure in the exhaust system and the opposed gas jets from the bypass duct and throttle orifice will move partially out of the opposing alignment that exist when the throttle valve is at its normal warm idle position.

In addition, within the range from idle to light or moderate load conditions, the total fluid flow through a fixed bypass or recycling orifice of the type comprising the present invention increases at any given engine speed with increasing engine load. For example in a conventional automobile engine, the pressure downstream of the throttle varies roughly in the neighborhood of from one-half atmosphere during idling to approximately one atmosphere at wide open throttle, while the exhaust pressure simultaneously varies roughly from one to two atmospheres. These factors compensate for the increasing combustion temperature with increasing load and result in a desirable increase in the effectiveness of the exhaust recycling through the fixed bypass restriction with increasing load or acceleration.

As the engine load or acceleration decreases and the speed increases to the cruising condition, the combustion temperature and the pressure differential across the fixed bypass restriction, as well as the total quantity of exhaust gases, decrease and the rate of exhaust recycling declines for improved fuel economy, again as desired because less recycling is required to maintain the combustion temperature below the level at which nitrogen oxide formation is objectionable. As the pressure differential between the inlet and exhaust headers increases with increasing load, the effective resistance of the fixed restriction to the recycling flow increases because the flow rate varies approximately as the square root of the pressure differential. Thus at wide open throttle, the proportion of the total exhaust gases that is recycled is somewhat less than the proportion recycled at partially open throttle. This factor also is as desired because the customary excess fuel enrichment at wide open throttle in cooperation with the recycled exhaust gases is adequate to prevent overheating during the combustion process and reduce the formation of nitrogen oxides to the tolerable level.

A more specific object is to provide an exhaust recycling system wherein the restricted orifice in the throttle valve opens into a duct carried by the throttle valve. This latter duct extends downstream within the induction conduit and terminates in a nozzle for directing the jet of inlet gases against the jet of recycling exhaust gases when the throttle valve is in its closed or normal warm idle position. Thus a slight opening movement of the throttle from the idle position will be magnified to move the two jets out of opposing alignment. Also the

choice of location of the bypass duct is liberalized, and the latter may be centered more conveniently within the induction conduit and its upstream end located below the base of the throttle body to prevent damage prior to assembly of the carburetor and engine.

Other objects are to provide the restriction for the bypass duct adjacent its upstream end, as for example at its communication with the exhaust system, where the accumulation of deposits from the exhaust is minimized; and to locate the upstream end of the bypass duct within a venturi portion of the exhaust system, as for example adjacent the exhaust valve seat where the speed of exhaust flow is a maximum, thereby to provide means for decreasing the effective pressure differential between the ends of the bypass conduit, or in fact if desired to reverse the direction of the pressure differential (with respect to the customary pressure differential at idle) during engine operation under high load. Thus the recycling of exhaust gas may be reduced at wide open throttle for example when maximum power is desired or in the situation where it is desirable to reverse the pressure differential with respect to the usual idle or cruise condition, a portion of the inlet fuel-air mixture, or of fuel free air if the opening of the bypass duct within the induction conduit is upstream of fuel nozzle, may be admitted to the exhaust to facilitate the complete combustion of exhaust combustibles, as for example in an exhaust reactor or afterburner.

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.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic fragmentary cross-sectional view, as also are FIGS. 2 and 3, through three different automobile engine induction systems showing three embodiments of the downstream ends of the exhaust bypass duct.

FIGS. 1a, 2a, and 3a are similar views showing modifications of the upstream ends of the bypass duct.

FIGS. 4 through 9 are schematic fragmentary cross-sectional views showing additional modifications of the present invention.

It is to be understood that any one of the downstream ends of the bypass conduit shown in the aforesaid views can be employed with any one of the upstream ends thereof, the desired amount of exhaust recirculation during different engine operating conditions being obtained by predetermining the dimensional and angular relationships of the cooperating parts, including the venturi restrictions in the exhaust system and the location of the bypass duct restriction and the upstream and downstream openings of the bypass duct into the venturi restriction and inlet induction conduit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, particularly FIGS. 1 and 1a, an application of the present invention is illustrated by way of example with an automobile engine 9 having a carburetor 10 providing the inlet fuel-air induction conduit 11, which comprises the upstream portion of an inlet header 12 for supplying a combustible fuel and air mixture to the engine cylinders 13. The carburetor 10 may comprise any conventional type which has the usual air inlet at the upstream end of the induction conduit 11, the usual fuel metering system and nozzles or jets for supplying idle and operating fuel to the conduit 11 during various operating conditions and for enriching the fuel supply during acceleration and wide open throttle, and the usual automatic choke (including choke valve 11a) and thermostatic means for controlling idle enrichment and fast idle operation during cold starting conditions. An example of such a carburetor is illustrated by way of example in Ball, U.S. Pat. No. 2,966,344, so that the foregoing conventional features disclosed in the latter patent are incorporated herein by reference and are not described in detail.

The downstream portion of the induction conduit 11 comprised the customary throttle body containing the conventional butterfly type throttle valve 14. The inlet fuel-air mixture is conducted via the headers or manifolds 12a and 12b, comprising extensions of the header 12, to the left and right banks of cylinders 13 respectively in timed relation with operation of the engine pistons 15. After combustion of the fuel-air mixture above the pistons 15, the exhaust gases are conducted in timed relationship with respect to the reciprocation of the pistons 15 and exhaust valves 18 to the exhaust manifolds or headers 17, which may discharge through an afterburner or exhaust reactor 16 and thence through a muffler to the atmosphere. The exhaust reactor or afterburner 16 operates to complete the combustion of incompletely burned fuel before discharging the exhaust to the atmosphere, and may be supplied with additional fuel and air to facilitate combustion therein in accordance with known practice.

The left and right manifolds 17 are connected by a crossover conduit 19 which conducts the hot exhaust gases into heat exchange relationship with portions 20 of the wall of the inlet header. The wall portions 20 extend transversely to the direction of flow of the inlet mixture and are commonly referred to as the "hot spot" which preheats the inlet mixture and enhances vaporization and mixing of liquid fuel droplets. A thermostatically controlled valve 21 in one header 17 controls the flow of hot gases in the crossover conduit 19 so as to expedite heating of the hot spot 20 during the engine warmup period and to prevent overheating during operation of the engine under load. The structure described thus far may be conventional.

Associated with the throttle valve 14 and extending through the hot spot 20 is a restricted nozzle 22 connected by means of a bypass or recycling conduit 23 with the exhaust header 17 at a location proximate the annular seat for valve 18 which connects the upper end of cylinder 13 with header 17. A venturi effect at the restricted opening defined by the annular seat for valve 18 results in a reduced pressure at the location of the opening of conduit 23 into header 17, so that during periods of high engine load, as for example near wide open throttle conditions, the effective static pressure at said opening causing bypass flow of exhaust gases through nozzle 22 will be reduced with respect to the total exhaust pressure in header 17. At the same time, the increased inlet pressure within conduit 11 at the region of nozzle 22 and the corresponding increased rate of inlet flow of fuel and air opposing the exhaust jet from nozzle 22 at or near wide open throttle conditions effectively reduces the recycling of exhaust gases into the induction conduit.

The reduced exhaust recycling at high engine load conditions is accomplished both by reason of the reduced effective pressure differential across the nozzle 22 and the increased rate of inlet flow dynamically opposing the upwardly directed exhaust jet from nozzle 22 adjacent the under portion of throttle valve 14. These factors may be predetermined to achieve a reverse flow through nozzle 22 at or near wide open throttle conditions, whereby a highly combustible mixture of fuel and air is added to the exhaust header 17 by aspirator action to facilitate complete combustion of the exhaust products in the reactor 16.

For operation during normal cruising conditions, the nozzle 22 has a fixed restriction dimensioned to enable controlled recycling of a portion of the exhaust gas into the inlet fuel-air to pass at least 5 percent and not more than 25 percent of the total exhaust gases, depending upon the specific engine and its operating conditions. In the usual situation effective reduction of nitrogen oxides in the exhaust is accomplished by recycling approximately 15 percent of the exhaust gases as aforesaid, preferably through several nozzles 22 arranged in the manner of the nozzle shown where a multiple barrel carburetor is involved.

In climatic regions where icing is a problem, each nozzle 22 may be extended into proximity with its associated throttle valve 14 by means of an integral low resistance tubular stand pipe having a length depending upon the specific geometry

and location of the portion of the hot spot 20 through which it extends. Each bypass conduit 22, 23 thus has the same resistance to gas flow. The flow of the hot exhaust gases through the hot spot 20 and nozzle 22 also facilitates preheating of the inlet mixture and the prevention of ice formation adjacent the edges of the throttle valve 14. Simultaneously the recycled exhaust gases are cooled below the ignition temperature of the combustible inlet mixture. To this end the nozzle 22 is preferably of heat conducting material and is sufficiently long to achieve the necessary heat transfer from the exhaust gases to the hot spot and inlet mixture. Also by directing the exhaust gases directly in opposition to the flow of the inlet mixture, improved breaking up, dispersion and vaporization of liquid fuel droplets are achieved with consequent improved mixing of the combustible inlet gases and uniform predictable combustion characteristics within cylinders 13.

A modification of the exhaust recycling system is illustrated in FIG. 2 wherein the exhaust jet is directed angularly into induction conduit 11 through nozzle 22a located upstream of the choke valve 11a, which is also upstream of the conventional fuel nozzles discharging into conduit 11. By predetermining the angle of the nozzle 22a and its restriction, a balance between static and dynamic pressures can be obtained for controlling the recycling of the exhaust gases under various engine operating conditions. The lower end of duct 23 communicates with exhaust header 17 at the location of a venturi restriction 24 for operation substantially as described above. In FIG. 2a, the venturi restriction 24 is located sufficiently remote from valve 18 so as to minimize pressure pulsing that occurs on the region of valve 18 in consequence of its opening and closing. Where the pressure pulsing is not objectionable, the lower end of conduit 23 in FIG. 2 may be located as described with reference to FIG. 1a and of course the lower end of conduit 23 in FIG. 1 can readily be located as illustrated in FIG. 2a.

In FIG. 2, direct heating of throttle valve 14 is not as effective as in FIG. 1, but the FIG. 2 construction is preferred where it is desirable to add clean air without fuel to header 17 during wide open throttle conditions by causing reverse flow in bypass duct 23 from induction conduit 11 to header 17, so as to increase the efficiency of the exhaust reactor 16 in combusting exhaust products before these are discharged to the atmosphere.

In other respects, the structure of FIG. 2 operates to accomplish substantially the same exhaust recycling as in FIG. 1. In both structures, the exhaust recycling during normal idle is a minimum, when the formation of noxious nitrogen oxides during combustion is also a minimum. During partly-open throttle conditions, the effective pressure differential between the exhaust pressure in header 17 and the inlet pressure in conduit 11 and the resulting rate of exhaust recycling will increase as the throttle opening increases, so as to effect the desired amount of exhaust recycling until at or near wide open throttle, the venturi effect at the lower end of conduit 23 substantially reduces the exhaust recycling. Also in both structures, a reverse flow of fuel and air (FIG. 1) or clean air (FIG. 2) from conduit 11 to header 17 and reactor 16 may be effected if desired at wide open throttle conditions, depending on the arrangement and relative dimensions of the parts involved, especially the restrictions for nozzles 22 and 22a and the angles of their respective jets into the inlet conduit 11, and the effectiveness of the venturis described.

FIGS. 3 and 3a illustrate other modifications of the exhaust recycling system wherein the overall arrangements of the engine 9 and inlet system 11, 12 and exhaust system 17, 19 are the same as above described. Instead of connecting the lower end of conduit 23 at the region of a venturi as in FIGS. 1a and 2a, conduit 23 terminates in a pitot-type opening 25 within header 17, so as to be responsive to the velocity force or pressure of the exhaust flow, as well as the static pressure of the exhaust. This arrangement is particularly suitable for trucks that usually operate at high engine load, or for small engines

that seldom operate at low pressure in conduit 11. The pitot or total pressure opening 25 compensates for the higher pressure in conduit 11.

In FIG. 3, the upper end of conduit 23 terminates in a restricted nozzle 22b. The nozzle 22b extends through the throttle body 26 in heat transfer relationship therewith at a location between the customary gaskets 28 and 27 which serve to insulate the throttle thermally from the adjacent manifold 12 and upper portion of the conduit 11 thereby to enable controlled heating of the throttle body 26 in accordance with the extent of bypass flow or exhaust recirculation. An enlargement in the conduit 23 comprising a chamber 29 formed in throttle body 26 predetermines the throttle body surface in heat exchange relationship with the exhaust bypass flow.

The nozzle 22b is directed angularly toward and terminates adjacent the throttle valve 14 when the latter is at its idle position shown and directs a jet of exhaust gases in opposition to a jet of inlet gases flowing through a restricted opening 30 in valve 14, FIG. 4. The opening 30 may comprise part of the idle air supply for the engine, especially during fast idle, and is dimensioned with respect to the dimensions of the exhaust bypass duct system to substantially block exhaust recirculation when the throttle valve 14 is at its warm idle position shown.

As valve 14 progressively opens with increasing engine load, the opposing jets from nozzle 22b and orifice 30 move out of alignment the effective pressure differential across orifice 30 decreases, and where the lower upstream end of duct 23 comprises the pitot opening 25, the pressure differential between the latter end and the discharge opening of nozzle 22b increases, all to the end of increasing the bypass flow or exhaust recirculation from header 17 into conduit 11. Also during part throttle opening, the upper open end of nozzle 22b is protected by throttle valve 14 from the dynamic or velocity pressure of the inlet gases. At wide open throttle, dotted position, FIG. 4, the upper end of nozzle 22b is exposed to the inlet velocity flow in the manner of a pitot tube, thereby to oppose the pitot action at end 25 and reduce the exhaust recirculation.

It is apparent that the nozzle 22b of FIG. 4 can be employed with a bypass conduit 23 having a lower end opening at a venturi portion of header 17 as in either FIG. 1a or FIG. 2a. Likewise either of the nozzle arrangements of FIGS. 1 and 2 can be employed with the pitot end 25 of FIG. 3a.

FIG. 5 illustrates a nozzle 22b similar to that shown in FIG. 4, but arranged to extend into conduit 11 at a location below gasket 28 so as to reduce heat transfer to the throttle body 26. In other respects, the exhaust recirculation is the same as in FIG. 4. Structures similar to those shown in FIGS. 1 and 2 for example may also be employed where heating of the throttle body 26 is to be minimized.

FIG. 6 illustrates a nozzle 22c extending directly from the exhaust crossover conduit 19 and having its restriction at its lower end opening flush into conduit 19. Thus nongaseous combustion products cannot readily enter and accumulate within the nozzle and clog the bypass system. Where the exhaust contains appreciable quantities of materials that tend to form gummy residues upon cooling, as for example in giving up heat to the hot spot 20, FIG. 1, or throttle body 26, FIG. 4, these residues have less tendency to deposit within the hot passage 19 or header 17 than in the cooler nozzle 22b, for example. Where desired the restriction in the bypass conduit 23 illustrated in the other FIGS. can be made at the juncture with either header 17 or 19 as the case might be. In other respects the nozzle structure of FIG. 6 cooperates with the opposed jet passing through throttle orifice 30 as described in regard to FIGS. 3, 4 and 5.

FIG. 7 illustrates a construction wherein the bypass nozzle 22d extends directly from the cross over conduit 19, as in FIG. 6, and the exhaust jet therefrom is opposed by an inlet jet directed from throttle orifice 30 through a nozzle 31 integral with throttle blade 14. An advantage of this structure is that the effect of a slight opening movement of valve 14, in moving

the opposed jets of inlet and exhaust gases out of opposing alinement is magnified. Thus at fast idle conditions when valve 14 is opened only slightly, phantom position, FIG. 7, the jet of exhaust gases into conduit 11 from nozzle 22d is no longer opposed by the jet of inlet gases through nozzle 31. In consequence, exhaust recirculation will be effective to warm the throttle valve 14 and prevent icing during the cold engine operating condition when fast idle is required.

When the engine warms to its normal idle operating condition, the throttle valve 14 will close to its warm idle condition shown in solid lines. The opposing jets will then reduce the exhaust recirculation. Also, in accordance with the structure shown, the nozzle 31 can terminate at any reasonably desired position, so that the nozzle 22d can be located at any desired position and can be readily centered within the conduit 11 to minimize distortion of the customary inlet flow. Also the nozzle 22d can terminate below the level of gasket 28, so as to be protected against accidental damage prior to and during assembly of the upper portions of the carburetor, including throttle body 26.

It is apparent that the lower end of the bypass nozzle or conduit 23 illustrated in any one of FIGS. 4 through 7 can be connected with the exhaust header system as illustrated in any one of the preceding FIGS., in accordance with the mode of operation desired and the specific requirements of the particular engine.

FIG. 8 shows a modification where the inlet nozzle 31 terminates off center of the axis of the induction conduit 11 so as to oppose an angularly directed nozzle 22e of the bypass duct means 23. The lower upstream end of duct 23 may be connected with the exhaust header system as illustrated in any of the preceding FIGS. A slight opening movement of throttle 14 from the normal warm idle position shown, as for example to a fast idle position, will move the opposed nozzles 22e and 31 out of alinement and tend to increase the exhaust gas recycling through the conduit 23. Also as illustrated particularly in FIGS. 1, 3, 4, 5 and 6, the throttle 14 shields the upper end of nozzle 22e from the inlet flow through induction conduit 11 during part open throttle conditions, but exposes the nozzle 22e to the velocity pressure of the inlet flow at wide open throttle so as to inhibit exhaust recirculation.

FIG. 9 shows a modification wherein the bypass duct 23 opens into the exhaust header system at the region of the crossover passage 19, so as to pass through the hot spot as described with reference to FIGS. 1, 6 and 7 for example. The upper or downstream end of the bypass duct 23 may be connected with the inlet header 11 in any of the ways illustrated in the preceding FIGS.

I claim:

1. In an internal combustion engine:

- A. an inlet header for conducting a fuel-air mixture into said engine for combustion therein;
- B. an exhaust header for discharging the combustion products from said engine;
- C. and means for effectively inhibiting the formation of noxious oxides of nitrogen during said combustion by limiting the temperature thereof comprising restricted bypass duct means having:

- 1. one end opening into said exhaust header to receive exhaust gases; and
- 2. a second end opening into said inlet header to discharge a jet of said exhaust gases thereinto;
- D. a throttle valve in said inlet header for controlling the flow of said fuel-air mixture therein, said throttle valve having a restricted:

- 1. orifice extending therethrough for directing a jet of inlet gases in opposition to said jet of exhaust gases when said throttle valve is at an idle position; and
- 2. said orifice being movable with said throttle valve to direct said jet of inlet gases out of opposition with said jet of exhaust gases upon opening movement of said throttle valve from said idle position.

2. In an engine according to claim 1, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position.

3. In the combination according to claim 1, the restriction in said bypass duct being at the opening thereof into said exhaust header.

4. In the combination according to claim 1, said one end of said bypass duct opening into said exhaust header adjacent a restricted region thereof to reduce the static pressure at said one end when the exhaust gas flow in said exhaust header approximates wide open throttle engine operation.

5. In the combination according to claim 4, said engine having a cylindrical combustion chamber, a piston reciprocable within said combustion chamber, and a valve controlled restricted opening connecting said chamber and exhaust header for discharging exhaust gases thereinto from said chamber, said restricted region of said exhaust header comprising said valve controlled opening.

6. In an engine according to claim 4, said restricted region of said exhaust header and said bypass duct being dimensioned to effect a flow of inlet gases from said inlet header to said exhaust header during wide open throttle operating conditions for said engine.

7. In the combination according to claim 2, said orifice comprising an inlet duct carried by and extending downstream of said blade to terminate adjacent said second end of said bypass duct to direct said jet of inlet gases in opposition to said jet of exhaust gases when said throttle valve is at its idle position.

8. In the combination according to claim 7, said second end of said bypass duct extending coaxially into the portion of said inlet header immediately downstream of said throttle valve.

9. In the combination according to claim 1, said inlet header including a throttle body portion having said throttle valve mounted therein and spaced from the adjacent downstream portion of said inlet header by a heat insulating gasket, said bypass duct having a portion contained within the sidewall of said throttle body to heat the latter by said exhaust gases.

10. In the combination according to claim 1, said inlet header including a throttle body portion having said throttle valve mounted therein and spaced from the adjacent downstream portions of said inlet header by a heat insulating gasket to reduce conduction of engine heat to said throttle body, said bypass duct having a portion contained within the sidewall of said inlet header downstream of said gasket, and said second end of said bypass duct comprising a nozzle extending angularly upstream into said inlet header toward said throttle valve.

11. In the combination according to claim 1, said inlet header including a throttle body portion having said throttle valve mounted therein and spaced from the adjacent downstream portions of said inlet header by a heat insulating gasket to reduce conduction of engine heat to said throttle body, the second end of said bypass duct terminating downstream of said gasket, and said orifice comprising an inlet duct carried by said throttle valve and extending downstream thereof within said inlet header and terminating adjacent said second end to direct said jet of inlet gases in opposition to said jet of exhaust gases when said throttle valve is at its idle position.

12. In the combination according to claim 1, said one end of said bypass duct comprising a pitot-type opening subject to the velocity pressure of the exhaust gas flow in said exhaust header.

13. In an engine according to claim 12, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position.

14. In the combination according to claim 2, said engine comprising an automobile engine, said second end comprising

a pitot-type opening directed in an upstream direction within said inlet header and at a location with respect to said blade exposed to the velocity pressure of the inlet gases when said blade is at a wide open throttle position and shielded from said velocity pressure when said blade is at a part throttle opening corresponding to cruising condition.

15. In the combination according to claim 2, said exhaust header having a portion extending transversely to the flow of inlet gases in said inlet header downstream of said throttle valve to provide a hot wall of said header portion for impingement of said inlet gases thereagainst, said bypass duct opening into the last named portion to receive exhaust gases therefrom and extending through said hot wall to facilitate heating thereof.

16. In the combination according to claim 15, the restriction in said bypass duct being at the opening thereof into said header portion.

17. In the combination according to claim 2, the restriction in said bypass duct being at the opening thereof into said header portion.

18. In the combination according to claim 4, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position.

19. In the combination according to claim 18, said engine comprising an automobile engine, said second end comprising a pitot-type opening directed in an upstream direction within said inlet header and at a location with respect to said blade exposed to the velocity pressure of the inlet gases when said blade is at a wide open throttle position and shielded from said velocity pressure when said blade is at a part throttle opening corresponding to cruising condition.

20. In the combination according to claim 19, said restricted region of said exhaust header and said bypass duct being dimensioned to effect a flow of inlet gases from said inlet header to said exhaust header during wide open throttle operating conditions for said engine.

21. In the combination according to claim 5, said inlet header including a throttle body portion having said throttle valve mounted therein and spaced from the adjacent downstream portion of said inlet header by a heat insulating gasket, said bypass duct having a portion contained within the sidewall of said throttle body to heat the latter by said exhaust gases.

22. In the combination according to claim 21, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position.

23. In the combination according to claim 5, the restriction in said bypass duct being at the opening thereof into said exhaust header.

24. In the combination according to claim 1, said second end comprising a pitot-type opening directed in an upstream direction within said inlet header at a location exposed to the velocity pressure of the inlet gases when said valve is wide open.

25. In the combination according to claim 24, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position, said second end being located at a position shielded by said blade from said velocity pressure when said valve is at a part throttle position.

26. In the combination according to claim 24, said bypass duct being dimensioned to effect a flow of inlet gases from said inlet header to said exhaust header during wide open throttle operation of said engine.

27. In the combination according to claim 24, said one end of said bypass duct comprising a pitot-type opening subject to

the velocity pressure of the exhaust gas flow in said exhaust header.

28. In the combination according to claim 27, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position, said second end being located at a position shielded by said blade from said velocity pressure when said valve is at a part throttle position.

29. In the combination according to claim 27, said bypass duct being dimensioned to effect a flow of inlet gases from said inlet header to said exhaust header during wide open throttle operation of said engine.

30. In the combination according to claim 29, said throttle valve comprising a blade-type valve having said orifice extending through the blade thereof, said second end of said bypass duct terminating adjacent said orifice at the downstream side of said blade at the idle position.

31. In the combination according to claim 7, said exhaust header having a portion extending transversely to the flow of inlet gases in said inlet header downstream of said throttle valve to provide a hot wall of said header portion for impingement of said inlet gases thereagainst, said bypass duct opening into the last named portion to receive exhaust gases therefrom and extending through said hot wall to facilitate heating thereof.

32. In the combination according to claim 31, said inlet header including a throttle body portion having said throttle valve mounted therein, the second end of said bypass duct terminating downstream of said throttle body.

33. In the combination according to claim 7, said one end of said bypass duct opening into said exhaust header adjacent a restricted region thereof to reduce the static pressure at said one end when the exhaust gas flow in said exhaust header approximates wide open throttle engine operation.

34. In the combination according to claim 33, said engine having a cylindrical combustion chamber, a piston reciprocable within said combustion chamber, and a valve controlled restricted opening connecting said chamber and exhaust header for discharging exhaust gases therinto from said chamber, said restricted region of said exhaust header comprising said valve controlled opening.

35. In the combination according to claim 33, said restricted region of said exhaust header and said bypass duct being dimensioned to effect a flow of inlet gases from said inlet header to said exhaust header during wide open throttle operating conditions for said engine.

36. In the combination according to claim 7, said engine comprising an automobile engine, said second end comprising a pitot-type opening directed in an upstream direction within said inlet header and at a location with respect to said blade exposed to the velocity pressure of the inlet gases when said blade is at a wide open throttle position and shielded from said velocity pressure when said blade is at a part throttle opening corresponding to cruising condition.

37. In the combination according to claim 7, said one end of said bypass duct comprising a pitot-type opening subject to the velocity pressure of the exhaust gas flow in said exhaust header.

38. In the combination according to claim 37, said second end comprising a pitot-type opening directed in an upstream direction within said inlet header at a location exposed to the velocity pressure of the inlet gases when said valve is wide open.

39. In the combination according to claim 38, said second end being located at a position shielded by said blade from said velocity pressure when said valve is at a part throttle position.

40. In the combination according to claim 7, the major portion of said bypass duct within said inlet header being coaxial therewith.