United States Patent

Sarto

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[54] CONTROLLED FLOOR JET ENGINE EXHAUST RECIRCULATION

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 807,705, Mar. 17, 1969, Pat. No. 3,542,003.

[52] **U.S. Cl.** .....**123/119 A**, 123/127

[51] **Int. Cl.**.....**F02m 25/06**

[58] **Field of Search** .....123/119 A, 127

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[57] **ABSTRACT**

Automobile exhaust gases are recycled by means of a bypass duct which receives these gases at a restricted upstream end located within the environment of the hot gases of the exhaust system, passes in heat exchange relationship through the conventional intake manifold hotspot to facilitate heating of the latter, and discharges the hot exhaust gases in an upstream direction with respect to the inlet flow of the fuel-air mixture at a location directly below the throttle valve. The restriction of the upstream end is spaced from the hotspot to minimize heat loss to the latter, such that lead contaminants for example flow in a gaseous phase through the restriction without fouling the same. A bypass control plunger movable in response to the position of the throttle valve is insertable into the restriction to close and simultaneously clean the latter when the throttle valve moves either to its idle or wide open position.

13 Claims, 5 Drawing Figures

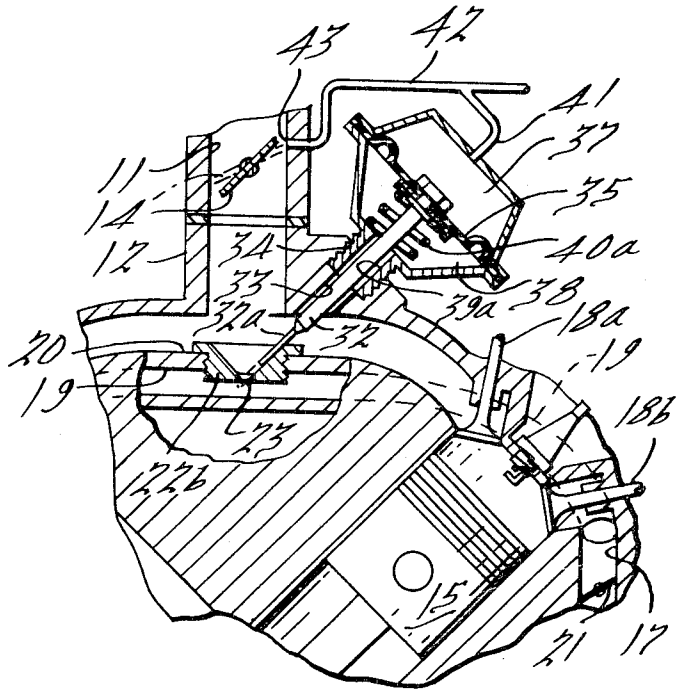
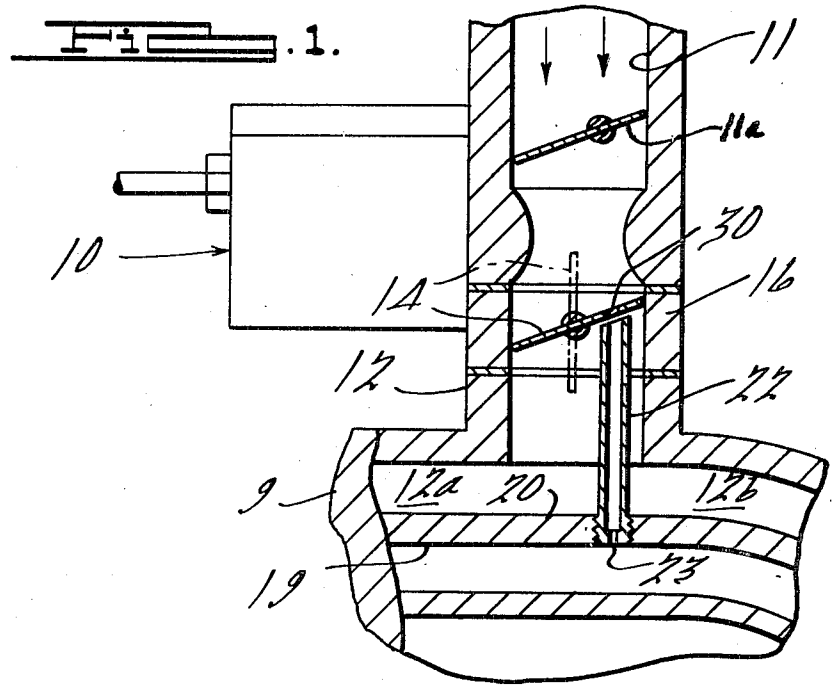


Fig. 1.



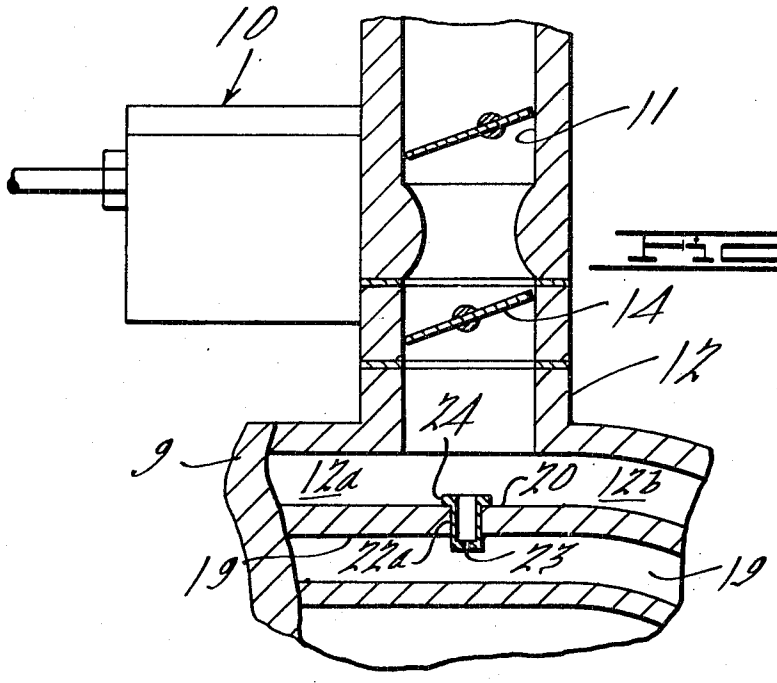


Fig. 2.

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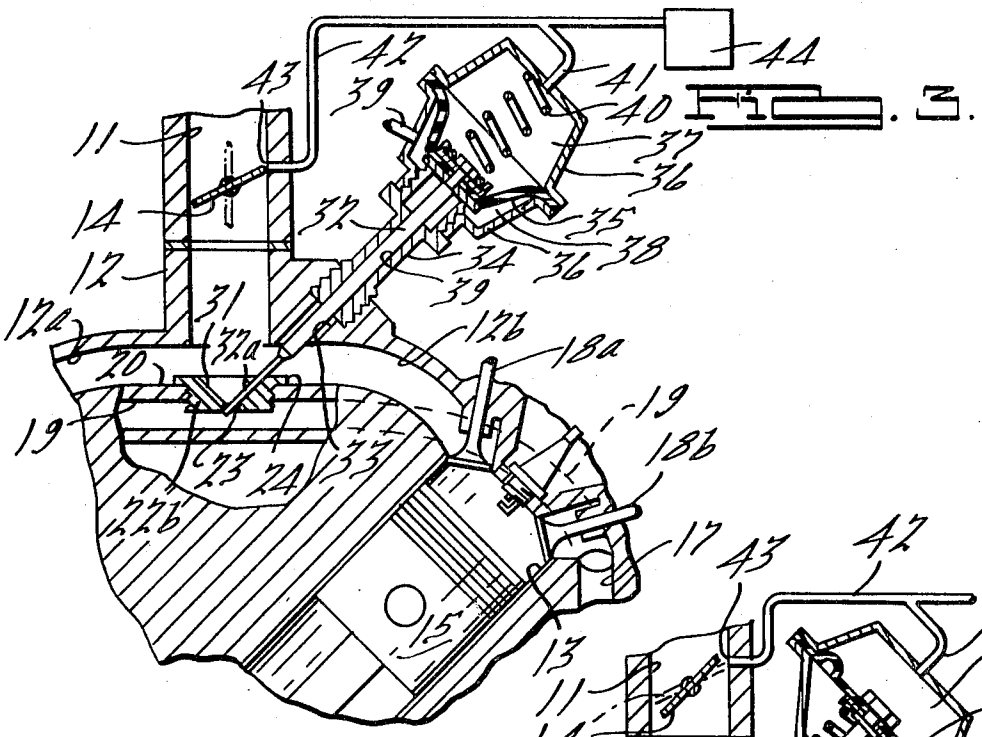


FIG. 3.

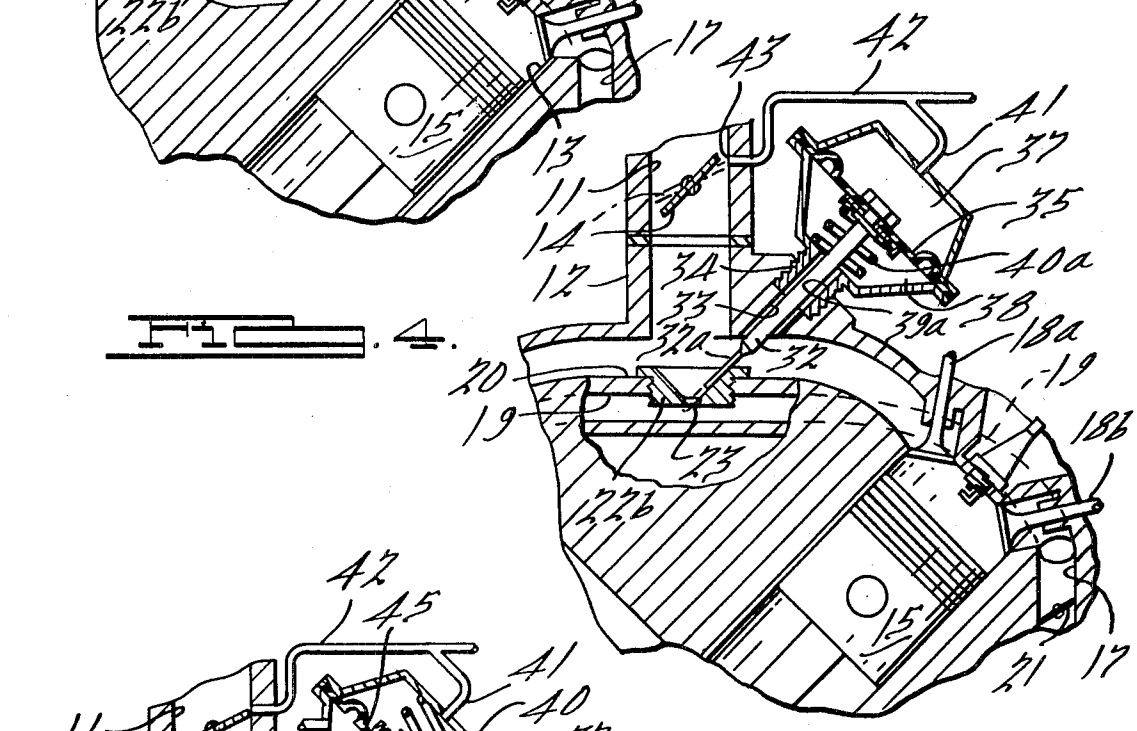


FIG. 4.

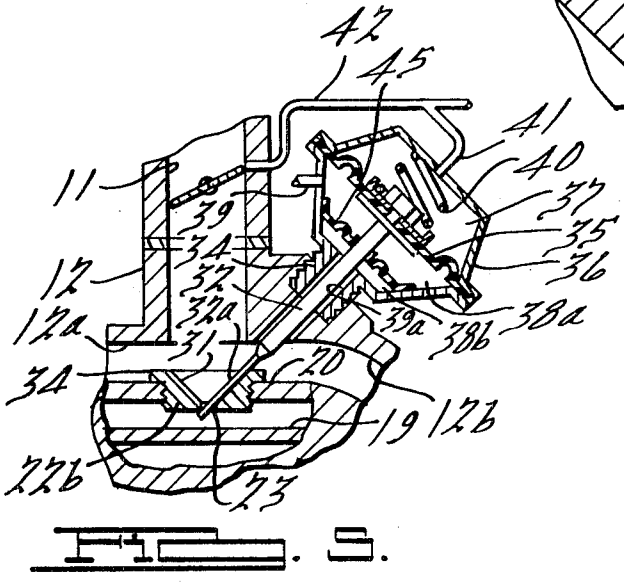


FIG. 5.

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CONTROLLED FLOOR JET ENGINE EXHAUST RECIRCULATION

RELATED APPLICATION

This application is a continuation in part of my copending application Ser. No. 807,705 filed March 17, 1969, now U.S. Pat. No. 3,542,003.

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 loads to substantially reduce the nitrogen oxide content of the exhaust gases discharged in the atmosphere, that is, to below about 1,000 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 1,200° F. The formation of nitrogen oxides does not become particularly objectionable until the combustion temperature exceeds about 2,200° 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 2,500° F. It is known that the recycling of at least 1/20th and not more than ¼ of the total exhaust gases through the engine, depending on the load or power demand, will reduce the combustion temperature to less than 2,200° 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 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 hotspot of the inlet system and terminates within the induction conduit in direction 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 and simultaneously cooling the exhaust gases in the bypass duct 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 such an exhaust recycling system wherein the restriction for the bypass duct is adjacent the latter's upstream end within the environment of the hot exhaust gases at temperatures appreciably greater than 700° F. and spaced from the hotspot to minimize heat loss thereto. Such a construction is particularly suitable for use with fuels containing lead additives to improve combustion characteristics.

The resulting lead oxides in the exhaust exist in a vapor phase at temperatures above approximately 700° F. The latter temperature is well below the exhaust temperature available but is somewhat higher than the usual temperature of the hotspot, which is continually cooled by impingement of the comparatively cold inlet fuel and air mixture and the vaporization of liquid fuel droplets within the mixture. Accordingly, by locating the bypass restriction within the environment of the hot exhaust gases, the temperature of the bypass restriction will preferably be maintained above 800° F. and the exhaust gases containing lead oxide vapors will pass readily through the hot restriction without condensing thereat. If any lead oxides do condense and deposit within a cooler portion of the bypass duct downstream of the restriction with respect to the direction of the bypass flow, these deposits will be within an enlarged portion of the bypass duct and will be relatively harmless. For this reason also the bypass duct will be comparatively short, so that the portion thereof exposed to the comparatively cool inlet fuel and air mixture will only be as long as necessary to assure cooling of the hot exhaust gases sufficiently to prevent ignition of the inlet fuel and air mixture.

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. The downstream opening of the bypass duct opposing the flow of the inlet mixture will be shielded by the throttle valve at the idle and part open positions, but will be exposed in the manner of a pitot opening to approximately the full velocity pressure of the inlet mixture at wide open throttle, whereby the bypass flow may be effectively reduced at wide open throttle. By suitably determining the size of the bypass restriction, the bypass flow will be contained approximately within the limits of more than five percent and less than 25 percent, and usually about 15 percent of the total exhaust gases when the throttle is partially open and the effective pressure differential between the ends of the bypass duct corresponds to cruising or part throttle acceleration conditions.

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 im-

proved 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.

Another object is to provide an exhaust recycling system as described wherein a bypass control valve plunger extends obliquely to the flow of the inlet mixture into the downstream opening of the bypass duct and through the latter's upstream restriction to close the same, and wherein operation of the plunger is responsive to the position of the throttle valve, so that the plunger is normally withdrawn from the upstream restriction to open the latter, but is moved into the upstream restriction to close the same when the throttle valve is at either its idle or wide open position.

The plunger operating mechanism preferably comprises pressure responsive means responsive to the pressure at the customary distributor vacuum advance port which opens into the inlet header adjacent and at the high pressure side of the leading edge of the usual blade type throttle valve when the latter is at its idle position. The high pressure at this port when the throttle valve is at either its idle or wide open position is transmitted to the pressure actuated means to move the plunger through the upstream restriction of the bypass duct to close the same and at the same time to maintain the restriction free of exhaust deposits.

By virtue of this construction, the bypass duct may be located to extend through the hotspot directly below the throttle valve. The oblique plunger will extend through the sidewall of of the inlet header to its operating means out of the flow path of the inlet mixture.

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 through an automobile engine induction systems showing a bypass duct for recycling exhaust gases.

FIG. **2** is a similar view showing a modification.

FIGS. **3**, **4** and **5** show three other modifications embodying a bypass control valve.

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

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, an application of the present invention is illustrated in FIG. **1** 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**, FIG. **3**. 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 **11***a*) 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 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** comprises the customary throttle body **16** containing the conventional butterfly-type throttle valve **14**. The inlet fuel-air mixture is conducted via the headers or manifolds **12***a* and **12***b*, comprising extensions of the header **12**, to the left and right banks of cylinders **13** respectively in timed relation by operation of the inlet valves **18***a*. After combustion of the fuel-air mixture above the pistons **15**, the exhaust gases are conducted in timed relationship by operation of the exhaust valves **18***b* to the exhaust manifolds or headers **17**, which discharge through a muffler to the atmosphere.

The left and right manifolds **17** are connected by a crossover conduit **19** which conducts the hot exhaust gases into heat exchange relationship with portion **20** of the wall of the inlet header **12**. The wall portion **20** extends transversely to the direction of flow of the inlet mixture and is commonly referred to as the "hotspot" which preheats the inlet mixture and enhances vaporization and mixing of liquid fuel droplets. A thermostatically controlled valve **21** in one header **17**, FIG. **4**, controls the flow of hot gases in the crossover conduit **19** to expedite heating of the hotspot **20** during the engine warmup period and to prevent overheating during operation of the engine under load. The structure described thus far may also be conventional.

Associated with the throttle valve **14** and extending through the hotspot **20** is a restricted nozzle **22** which extends directly from the exhaust crossover conduit **19** and has an orifice or restriction **23** at its lower or upstream end opening flush with the interior of conduit **19**. Thus nongaseous combustion products cannot readily enter and accumulate within the nozzle **22** 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 hotspot **20**, these residues have less tendency to deposit within the hot passage **19** than in the cooler stem of the nozzle **22** which is cooled by the inlet fuel and air mixture.

The nozzle **22** is directed 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**. 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 **22** and orifice **30** move out of alignment, the effective pressure differential across orifice **30** decreases, and the pressure differential across the restriction of nozzle **22** increases, all to the end of increasing the bypass flow or exhaust recirculation from conduit **19** into conduit **11**. Also during part throttle opening, the upper open end of nozzle **22** is protected by throttle valve **14** from the dynamic or velocity pressure of the inlet gases. At wide open throttle, dotted position, the upper end of nozzle **22** is exposed to the inlet velocity flow in the manner of a pitot tube, thereby to oppose and reduce the exhaust recirculation.

The nozzle **22** is suitably secured removably to the hotspot **20**, as for example by the screw connection shown and preferably is formed from stainless steel to resist corrosion and fouling and, by virtue of the construction shown will ordinarily serve properly for many thousands of miles. In the event of eventual plugging of the restriction **23**, or in the event it is

desirable to change the latter's dimensions to accommodate changing operating conditions for the engine, the nozzle **22** may be removed and replaced through the riser portion of header **12** when the carburetor **10** and throttle body **26** are removed.

For operation during normal cruising conditions, the fixed restricted orifice **23** is dimensioned to enable controlled recycling of a portion of the exhaust gases into the inlet header **11** to pass at least five 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**, each 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 the low resistance tubular stem or stand pipe shown having a length depending upon the specific geometry and location of the portion of the hotspot **20** through which it extends. Each bypass duct **22** may thus have the same resistance to gas flow. The flow of the hot exhaust gases through the hotspot **20** and nozzle **22** facilitates preheating of the hotspot **20** and throttle valve **14** to assure vaporization 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 hotspot and inlet mixture. Also by directing the exhaust gases oppositely 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 the cylinders **13**.

Where the condensation of exhaust matter would otherwise be particularly objectionable, as for example with certain fuels containing lead additives, the structure of FIG. **2** may be employed, wherein a comparatively short stainless steel nozzle **22***a* is screwed into the hotspot **20** coaxially with the inlet conduit **11** directly below the throttle valve **14**. An enlargement or bolthead **24** of the nozzle **22***a* has a hexagonal exterior to facilitate assembly and removal of the nozzle **22***a* as described above in regard to FIG. **1** and also serves as a stop to locate the restriction **23** at a predetermined position below the hotspot **20** and within the environment of the hot exhaust gases within passage **19**. Thus heat loss from the region of the restriction **23** to the cooler hotspot **20** is reduced and the temperature at the restriction **23** will approximate the temperature of the hot exhaust gases within passage **19** which is customarily maintained well above the temperature at which lead contaminants in the exhaust precipitate. Also by virtue of the comparatively short length of the nozzle **22***a*, cooling of the head **24** by the inlet fuel and air mixture is likewise reduced, and the temperature of the head **24** may be maintained at approximately the temperature of the hotspot **20**, such that fouling of the nozzle **22***a* and its restriction **23** is rendered nominal with many fuels and is less objectionable in any event, as compared to conventional bypass conduits employed for exhaust recycling.

Except for the feature of the opposed jets shown in FIG. **1**, the nozzle **22***a* operates substantially in the manner of nozzle **22**, the restriction **23** being dimensioned to maintain the amount of exhaust recycling within the desired range described above. Also as described above, the throttle **14** shields the upper opening of nozzle **22***a* from the inlet flow of fuel and air during idle and part throttle operation to enable a progressive increase in the exhaust bypass flow with increasing pressure in conduit **19** resulting from increasing engine load, and to decrease the bypass flow with the consequent decreasing exhaust pressure in passage **19** as the engine attains its cruising speed for any given part throttle opening at wide open throttle the nozzle **22***a* is exposed to the full velocity pressure of the inlet fuel and air to inhibit exhaust recycling.

FIGS. **3**, **4** and **5** show modifications of the present invention wherein the exhaust flow through the bypass nozzle is controlled by a valve mechanism responsive to the position of the throttle valve **14**. In FIG. **3** a stainless steel nozzle **22***b* similar to the nozzle **22** or **22***a* but provided with an upwardly enlarging conical opening **31** underlies valve **14**. A reduced diameter rod or valve element **32***a* of a reciprocable plunger **32** extends obliquely to the inlet flow of the fuel-air mixture in parallel supported relationship along the conical wall of opening **31**, so as to be insertable into the restricted orifice **23**. The upper portion of the plunger **32** extends through a bore **33** in the wall of header **12** to a pressure actuated valve operating mechanism remote from the flow of the inlet mixture.

The plunger **32** extends axially through a tubular guide **34** in closely fitting relationship and is secured at its upper end to a flexible diaphragm **35** that divides a housing **36** into upper and lower pressure chambers **37** and **38** respectively. The guide **34** screws into the exterior of bore **33**, supports housing **36** at its outer end, and opens into the chamber **38**. The latter also opens to the atmosphere via duct **39** which may communicate with a source of clean fresh air, as for example at the downstream side of the conventional carburetor air filter. By virtue of the close fit between the plunger **32** and tubular guide **34**, a high resistance annular leakage path **39** amounting in essence to a seal is provided between the chamber **38** and the inlet header **12** downstream of throttle valve **14**. A coil spring **40** seated between an upper portion of the housing **36** and diaphragm **35** urges the latter and plunger **32** downward for normally restricting or closing the orifice **23** by insertion of the rod or valve portion **32***a* thereinto.

The chamber **37** is connected by means of a duct **41** with the customary vacuum advance duct **42** which connects the distributor vacuum advance port **43** with the customary vacuum actuated mechanism **44** for advancing or retarding the ignition spark distributor in accordance with varying engine operating conditions. The port **43** opens as is customary adjacent and at the upstream or high pressure side of the upper leading edge of the blade of throttle valve **14** when the latter is at its idle position shown. Accordingly when the throttle valve **14** is at either the idle position illustrated by solid lines or the wide open position illustrated by dotted lines, the resulting high pressure at port **43** substantially balances the atmospheric pressure in chamber **38** and enables spring **40** to urge plunger **32** downward to restrict or close orifice **23** and at the same time clear the latter of any deposits that might have formed during cold operation of the engine, for example. During part throttle operation, the pressure at port **43** will gradually decrease as the throttle valve **14** opens from the idle position, whereby the reduced pressure at port **43** is conducted via conduits **42** and **41** to chamber **37** to withdraw plunger **32** and open orifice **23**, as illustrated by the dotted position, FIG. **4**. Simultaneously, as the throttle valve opens from the idle position, the resulting reduction in pressure at port **43** is communicated to mechanism **44** to actuate the latter to advance the spark distributor in accordance with customary practice.

The nozzle **22***b* in other respects is substantially the same as nozzle **22** or **22***a* and is releaseably secured within the hotspot **20** coaxially with the inlet conduit **11**. The latter is not shown to scale in the schematic drawings and will ordinarily be appreciably oversize with respect to the maximum diameter of the nozzle head **24** to enable installation of the nozzle **22***b* through the riser portion of the header **12** when the carburetor and throttle body are removed as above described.

FIG. **4** shows a similar structure where the operating parameters for rod valve **32***a* are modified to close orifice **23** only during idle operation. Instead of the spring **40**, a spring **40***a* is employed within chamber **38** between a lower portion of housing **36** and diaphragm **35** to urge the latter upwardly and normally hold the plunger **32** at the open position of orifice **23** as shown. The annular space **39***a* between plunger **32**

and bore 33 and also tubular guide 34 is enlarged with respect to the corresponding space 39 of FIG. 3 to provide an annular passage communicating freely between chamber 38 and the inlet header 12 downstream of throttle 14. Accordingly, when the latter is at the idle position, the low pressure downstream of the throttle 14 is communicated to chamber 38 to move diaphragm 35 and plunger 32 downwardly and insert the valve extension 32*a* into the orifice 23 to close or restrict the latter, dotted position FIG. 4.

During part open throttle operation of the engine, the pressure at port 43 and the pressure downstream of throttle valve 14 will tend to be the same, so that spring 40*a* will move diaphragm 35 upwardly to open the orifice 23. At wide open throttle, a similar situation will prevail and plunger 32 will remain at the open position shown. Also the nozzle 22*b* will no longer be shielded from the flow of the inlet fuel-air mixture, so that this flow will oppose and partially reduce the bypass flow of exhaust gases into the header 12, thereby to prevent undue dilution of the combustible mixture when maximum power is required. On the other hand, the upward flow of the hot exhaust gases provide effective means for enhancing the mixing and vaporization of liquid fuel droplets with the inlet air to enable increased power at wide open throttle.

FIG. 5 illustrates a structure which operates substantially in the manner described with respect to FIG. 3, except that in place of the high resistance annular leakage path 39 relied upon in FIG. 3 to separate chamber 38 from the inlet header 12, a flexible sealing diaphragm 45 is provided to partition chamber 38 into upper chamber 38*a* and lower chamber 38*b*, the former being in communication with the atmosphere via duct 39 as described above. This structure avoids the necessity of maintaining close tolerances between the tubular guide 34 and plunger 32 and provides a positive seal to prevent fluid flow between chamber 38*b* and header 12.

I claim:

1. In an internal combustion engine adapted to use a gasoline fuel containing a lead additive,

B. an exhaust header for discharging the hot combustion products from said engine and having a wall portion comprising a hotspot exposed to the flow of said fuel-air mixture in said inlet header to heat said mixture,

A. an inlet header for conducting a fuel-air inlet mixture into said engine for combustion therein,

C. and means for effectively inhibiting the formation of oxides of nitrogen during said combustion by limiting the combustion temperature comprising a bypass duct for conducting hot exhaust gases from said exhaust header into said inlet header, said bypass duct extending through said hotspot in heat transfer relationship to facilitate heating thereof and having

1. one end opening into said exhaust header at a location within the hot exhaust gases and spaced from said hotspot,

2. a second end opening into said inlet header, and

3. a restriction in said bypass duct adjacent the opening of said one end within said hot gases and spaced from said hotspot to reduce heat loss thereto from said restriction to obtain a temperature at the latter above the precipitation temperature of lead contaminants in said exhaust gases.

2. In the combination according to claim 1, said hotspot extending transversely to the flow of said fuel-air mixture in said inlet header for impingement of said mixture thereagainst.

3. In the combination according to claim 1, the second end of said bypass duct opening into said inlet header in an upstream direction with respect to the flow of said mixture to direct a stream of hot exhaust gases in opposition to said flow to enhance mixing and vaporization of said mixture.

4. In the combination according to claim 3, a throttle valve in said inlet header upstream of said one end and movable between idle and wide open positions, said second end opening into said inlet header at a location increasingly exposed to the opposing flow of said mixture as said throttle valve moves to its wide open position.

5. In the combination according to claim 1, a throttle valve in said inlet header movable between idle and wide open positions, said restriction comprising a restricted orifice in said bypass duct, and normally open valve means responsive to the position of said throttle valve for restricting said orifice when said throttle valve is adjacent either its idle or wide open position.

6. In the combination according to claim 1, said restriction being spaced within said exhaust header from said hotspot sufficiently to maintain an operating temperature at said restriction above 700° F.

7. In the combination according to claim 1, said bypass duct having a comparatively short length on the order of magnitude of the wall thickness of said hotspot and extending directly through said hotspot and terminating within said inlet header proximate the surface of said hotspot exposed to said inlet mixture.

8. In the combination according to claim 7, said bypass duct being comparatively resistance free to the flow of exhaust gases therethrough downstream of said restriction.

9. In the combination according to claim 7, the opening of said bypass duct enlarging downstream of said restriction.

10. In the combination according to claim 9, a throttle valve in said inlet header movable between idle and wide open positions, a valve plunger within said inlet header movable obliquely within the enlarging downstream opening of said bypass duct, and means responsive to the position of said throttle valve for normally maintaining said plunger out of said restriction and for moving said plunger into said restriction when said throttle valve is adjacent either its idle or wide open position.

11. In the combination according to claim 1, the opening of said bypass duct enlarging conically downstream of said restriction, a throttle valve in said inlet header movable between idle and wide open positions, a valve plunger reciprocable along the conical surface of the conically enlarging opening of said bypass duct and within said restriction to reduce the opening of the latter, and plunger operating means responsive to the position of said throttle valve for normally maintaining said plunger out of said restriction and for moving said plunger into said restriction when said throttle valve is adjacent either its idle or wide open position.

12. In the combination according to claim 11, said second end of said bypass duct opening into said inlet header at a location shielded from the opposing flow of said mixture by said throttle valve when the latter is at its idle position and exposed to said opposing flow when said throttle valve moves to its wide open position.

13. In the combination according to claim 11, said bypass duct being located centrally with respect to the flow of said mixture downstream of said throttle valve, said plunger having a remote end out of said flow, and said plunger operating means engaging said remote end to operate said plunger.

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