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[54] **EXHAUST GAS CLEANING SYSTEM FOR INTERNAL COMBUSTION ENGINES**

[75] Inventors: **Kenji Goto; Norikatsu Ishikawa,** both of Susono, Japan

[73] Assignee: **Toyota Jidosha Kogyo Kabushiki Kaisha,** Toyota-shi, Japan

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **123/119 A;** 123/122 AA; 123/141
[51] **Int. Cl.** **F02b 33/00**
[58] **Field of Search** .... 123/119 A, 141, 122 AA, 123/119 B

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Primary Examiner—Manuel A. Antonakas
Assistant Examiner—Daniel J. O'Connor
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

Herein disclosed is an engine exhaust gas cleaning system in which a portion of engine exhaust gases are recirculated from an engine exhaust system to an intake system of an internal combustion engine so as to reduce nitrogen oxide content in the engine exhaust gases. The engine exhaust gas cleaning system comprises a cylindrical chamber interposed between a carburetor and an intake pipe of the engine, an exhaust gas recirculation conduit providing fluid communication between an exhaust pipe of the engine and said cylindrical chamber, and a mixture conduit providing fluid communication between the carburetor and said cylindrical chamber and having its outlet tangentially connected to the latter for establishing a swirling flow therein to promote mixing between the air-fuel mixture from the carburetor and the recirculated exhaust gases from the exhaust pipe. Said exhaust gas recirculation conduit may also have its outlet tangentially connected to said cylindrical chamber. The engine exhaust gas cleaning system may further comprise richer mixture means including a second carburetor for producing an air-fuel mixture having a mixture ratio richer than the air-fuel mixture which is to be mixed with the recirculated exhaust gases, and a second intake pipe providing fluid communication between the second-named carburetor and a combustion chamber of the engine in the vicinity of a spark plug so as to direct the richer air-fuel mixture to the spark plug so that the combustion in the combustion chamber may be stably anchored in the vicinity of the spark plug although the overall mixture ratio in the combustion chamber can be maintained within a proper range.

13 Claims, 10 Drawing Figures

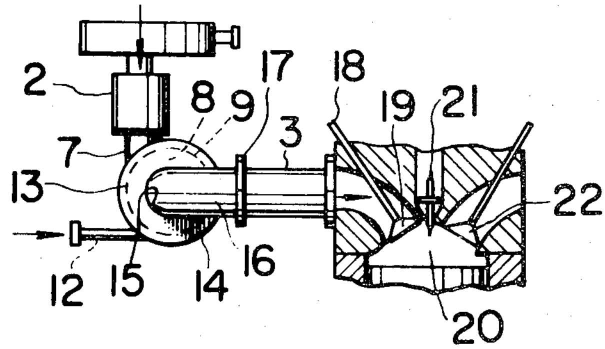


FIG. 1

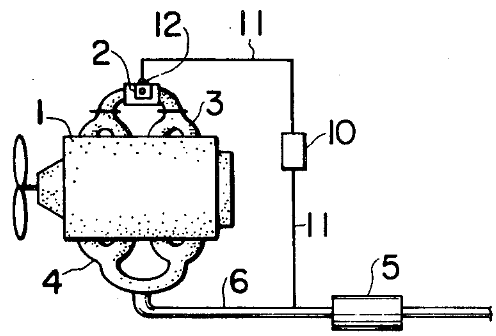


FIG. 2

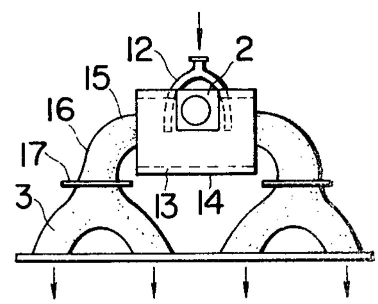


FIG. 3

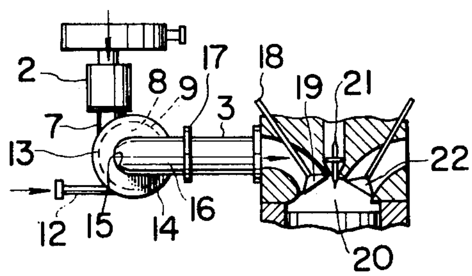


FIG. 4

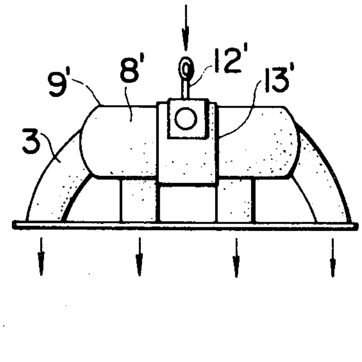


FIG. 5

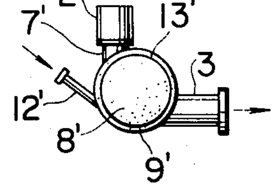


FIG. 6

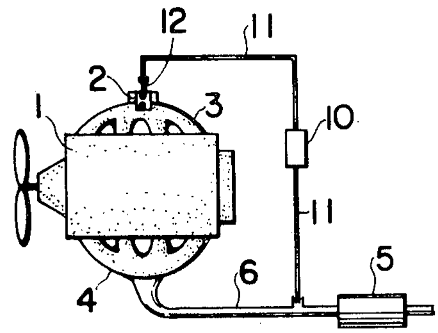


FIG. 7

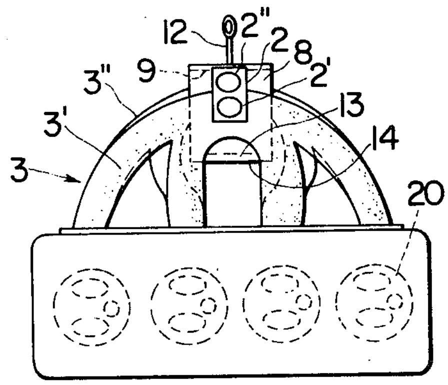


FIG. 8

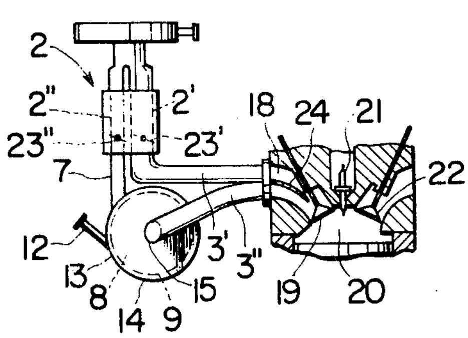


FIG. 9

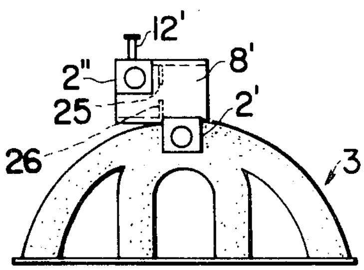
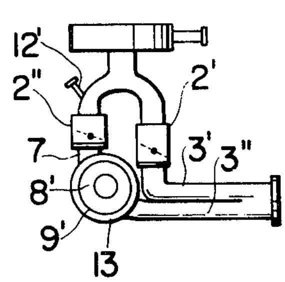


FIG. 10



EXHAUST GAS CLEANING SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an exhaust gas cleaning system in which a portion of engine exhaust gases are recirculated from an engine exhaust system to an intake system of an internal combustion engine so as to reduce nitrogen oxide content in the engine exhaust gases. More particularly, the present invention relates to an exhaust gas cleaning system of the above type in which the recirculated exhaust gases are introduced into the intake system downstream of a carburetor.

2. Description of the Prior Art

In view of the outstanding air pollution problem, there have been proposed a variety of engine exhaust gas cleaning systems, among of which an exhaust gas recirculation system is found highly effective to reduce the nitrogen oxide content in the engine exhaust gases. In this exhaust gas recirculation system, a portion of the engine exhaust gases are recirculated from an engine exhaust system to an intake system of an internal combustion engine. In one type of the exhaust gas recirculation system more specifically, the intake pipe downstream of the carburetor is formed with an injection hole through which the engine exhaust gases are partially introduced. In another type, moreover, a partition is interposed between the carburetor and the intake pipe, and the exhaust gases are introduced into the latter with use of the partition. In addition of these, various types of the recirculation system have been put into practice, on the basis of different concepts in respect of position and manner of the exhaust gas introduction. In all of these conventional recirculation systems, however, mixing of the introduced exhaust gases with the air-fuel mixture cannot be accomplished so much. This means that a local region in the engine combustion chamber contains the recirculated exhaust gases in an especially low ratio. As a result, when the frame front propagates to such local region during the expansion stroke of the engine, then a great amount of nitrogen oxides are produced, thus making the recirculation of the exhaust gases in proper amount useless. The nitrogen oxides thus produced cannot be consumed in the engine exhaust system to be emitted into the air.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide an improved engine exhaust gas cleaning system which is free from the above drawbacks.

Another object of the present invention is to provide an improved engine exhaust gas cleaning system of the above type in which a portion of the engine exhaust gases are recirculated from an engine exhaust system to an intake system of an internal combustion egine so as to reduce nitrogen oxide content in the exhaust gases.

Still another object of the present invention is to provide an improved engine exhaust gas cleaning system of the above type in which the recirculated exhaust gases are forcedly admixed with the air-fuel mixture before they are introduced into the engine combustion chamber.

According to a feature of the present invention, a cylindrical chamber is interposed between a carburetor and an intake pipe of the engine, to which chamber an air-fuel mixture is introduced tangentially for establishing a swirling flow to promote mixing between the air-fuel mixture thus introduced and such exhaust gases as are recirculated from the engine exhaust pipe to the cylindrical chamber.

According to another feature of the present invention, the exhaust gases to be recirculated are also introduced tangentially to the cylindrical chamber.

According to still another feature of the present invention, richer mixture means is additionally provided, which includes another carburetor for producing an air-fuel mixture having a mixture ratio richer than the air-fuel mixture ratio to be mixed with the recirculated exhaust gases, and an additional intake pipe providing fluid communication between the additional carburetor and the engine combustion chamber in the vicinity of a spark plug so as to introduce the richer air-fuel mixture to the vicinity of the spark plug so that the combustion in the combustion chamber can be stably anchored.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a diagrammatical view showing construction of an internal combustion engine into which an engine exhaust gas cleaning system according to the present invention is incorporated.

FIG. **2** is a top plan view showing the essential portions of the present exhaust gas cleaning system.

FIG. **3** is a side elevation showing the essential portions of FIG. **2.**

FIG. **4** is similar to FIG. **2,** but shows a second embodiment of the present invention.

FIG. **5** is similar to FIG. **3,** but shows more simple the second embodiment of FIG. **4.**

FIG. **6** is similar to FIG. **1,** but shows construction of an internal combustion engine into which a third embodiment of the present invention has been incorporated.

FIG. **7** is similar to FIG. **2,** but shows the third embodiment of FIG. **6.**

FIG. **8** is similar to FIG. **3,** but shows a third embodiment of FIGS. **6** and **7.**

FIG. **9** is similar to FIG. **2,** but shows a fourth embodiment of the present invention.

FIG. **10** is similar to FIG. **3,** but shows a fourth embodiment of FIG. **9.**

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The first embodiment of the present exhaust gas cleaning system will now be described with reference to FIGS. **1** to **3.** Indicated generally at reference numeral **1** is an internal combustion engine, in which an intake manifold **3** and an exhaust manifold **4** are mounted. As shown, an air-fuel mixture, which is metered to have a proper air-fuel ratio in a carburetor **2,** is supplied to the engine **1** by way of the intake manifold **3.** The air-fuel mixture is combusted in the engine **1** to produce the engine exhaust gases, which are then sent to the exhaust manifold **4.** Downstream of this exhaust manifold **4,** there is provided an exhaust pipe **6** including a silencer **5,** through which the exhaust gases are emitted to the outside. To a downstream portion of the carburetor **2,** on the other hand, is connected a mixture conduit 7 which is connected to a chamber 8 in a manner to have its axis directed tangential to the inner periphery of a cylindrical wall 9 of said cylindrical chamber 8. Thus, fluid communication between the carburetor 2 and the cylindrical chamber 8 is established. In order to introduce a portion of the exhaust gases from the exhaust pipe 6 into the cylindrical chamber 8, on the other hand, an exhaust gas recirculation conduit 11 is interposed between the exhaust pipe 6 and the cylindrical chamber 8. In the midway of this conduit 11, there is preferably provided a flow regulator 10 which may be of any type so long as it is capable of properly regulating the flow rate of the passing exhaust gases in accordance with the modes of the engine 1. This flow regulator 10 may, for example, be of the type which is disclosed in the copending U.S. patent application Ser. No. 23,763, filed 3/30/70, now U.S. Pat. No. 3,708,081, if desired. The recirculation conduit 11 has its outlet 12 tangentially connected to the inner periphery of the cylindrical wall 9 of the cylindrical chamber 8. This outlet 12 may have a bifurcated shape but its connected portion should be located substantially on the same periphery as that of the mixture conduit 7. Moreover, the angle between the axial directions of the mixture conduit 7 and the recirculation conduit 11 is, in the illustrated embodiment, a right angle. With these construction arrangements, therefore, both the recirculated exhaust gases from the outlet 12 of conduit 11 and the air-fuel mixture from the conduit 7 are swirled in the cylindrical chamber 8 to be admixed with each other to a sufficient extent.

It should be noted here that in a modification the cylindrical chamber 8 can be replaced by an annular chamber which is suitable for allowing the swirling flow. In another modification, moreover, the outlet 12 of the recirculation conduit 11 may also be made of a single pipe, if it meets the above requirements. The right angle between the two conduits 7 and 11 is representative and it may take a different value so long as the resultant intensity of the swirling flow is large enough.

As shown in FIG. 3, there is formed between the cylindrical wall 9 and an additional outer wall 14 an annular chamber 13 in which a heated fluid is passed to interchange heat with the air-fuel mixture and the recirculated exhaust gases in the cylindrical chamber 8. This heat exchange will aid in atomization of the fuel content in the chamber 8. The heated fluid which is suitable for this purpose is, for example, cooling water which is warmed in the engine 1, or the remaining exhaust gases which are recirculated from the exhaust pipe 6. Since, in this embodiment, the two conduits 7 and 11 are open to a longitudinally central portion of the cylindrical chamber 8, the annular chamber 13 is so positioned that it is passed through by the two conduits 7 and 11. In this instance, moreover, the both side ends of the cylindrical chamber 8 are formed with central bores 15, to which the bifurcated intake manifolds 3 are connected through conduits 16 and flanges 17. The connecting portion of the engine 1 with each of the branch pipes of the intake manifolds 3 is formed with a fluid passage 18, through which the mixed combustible gases of the air, fuel and exhaust gases from the intake manifolds 3 are introduced through an intake valve 19 into the combustion chamber 20. The combustion gases are then ignited by a spark plug 21, and the resultant exhaust gases are discharged to the exhaust manifold 4 through an exhaust valve 22.

The foregoing description has been directed to the case in which the recirculated exhaust gases are directly introduced into the cylindrical chamber 8. It should, however, be emphasized here that the indirect introduction of the exhaust gases into the intake system, namely, into a portion upstream of the carburetor 2 can produce similarly satisfactory results with respect to the mixing with the air-fuel mixture in the cylindrical chamber 8.

As will be understood from the foregoing description, the air-fuel mixture, which is supplied from the carburetor 2 to the conduit 7, is introduced into the cylindrical chamber 8 tangentially of the inner periphery of its cylindrical wall 9. Then, the mixture is made to swirl in the cylindrical chamber 8. At the same time, a portion of the exhaust gases from the exhaust pipe 6 is also introduced into the cylindrical chamber 8 through the conduit 11 and its outlet 12 tangentially of the inner periphery of the cylindrical wall 9. Thus, the recirculated exhaust gases are also made to swirl in the cylindrical chamber 8 and are forcedly admixed with the swirling air-fuel mixture. The resultant combustible mixture uniformly containing the exhaust gases is heated by the heated fluid in the annular chamber 13, so that the fluid vapors, if any, may be atomized quickly. After that, the fully gasified combustible mixture is helically moved longitudinally outwardly of the cylindrical chamber 8. The combustible mixture, which reaches the side ends of the chamber 8, is introduced during the suction stroke of the engine 1 into the combustion chamber 20 through the conduit 16 and the intake manifolds 3.

The cylindrical wall 9 is made to face or define the annular chamber 13, so that trouble due to overheat might be expected. However, although the heat of the annular chamber 13 will be conducted to the conduit 16 by way of the cylindrical wall 9, the heat so conducted will not be transferred to the intake manifolds 3 thanks to the presence of the flange 17.

Turning now to FIGS. 4 and 5, a second embodiment of the present invention will be described in the following text. In this embodiment, the connection between the cylindrical wall 9′ defining the cylindrical chamber 8′ and the conduit 7′ in communication with the carburetor 2 is carried out similarly to the former embodiment of FIGS. 1 to 3. The outlet 12′ of the recirculation conduit 11 is also connected to the cylindrical wall 9′ in a manner to have its axis arranged tangentially of the inner periphery of the wall 9′.

However, the second embodiment is different from the first embodiment in the following items. That is, the angle between the axes of the conduits 7′ and 12′ is acute. Furthermore, the cylindrical wall 9′ and accordingly the cylindrical chamber 8′ is elongated so as to dispense with the conduit 16 of the first embodiment. More precisely, the intake manifold 3 has no trunk pipe, but is formed with a plurality of pipes, each of which has its inlet connected to the cylindrical wall 9′ tangentially of the inner periphery of the same. Since, in this embodiment, the cylindrical chamber 8′ is elongated, the annular chamber 13′ is formed on that central outer periphery of the cylindrical wall 9′ which is connected to the conduit 7′.

With these construction arrangements, both the air-fuel mixture from the carburetor 2 and the recirculated exhaust gases from the exhaust pipe 6 are also introduced into the cylindrical chamber 8′ tangentially of the inner periphery of the cylindrical wall 9′. As a reture is ignited by the spark plug **21** to form a stable flame front. This flame front then propagates outwardly toward the surrounding leaner mixture region, acting as a stable heat source. Thus, the overall combustion can be stably maintained.

The fourth wmbodiment of the present invention will now be described with reference to FIGS. **9** and **10**. In this embodiment, the carburetor is also composed of the first carburetor **2'** and the second carburetor **2''**. The second carburetor **2''** has its downstream side connected to the conduit **7**, which in turn is connected to one end portion of the cylindrical wall **9'** in a manner to have its axis arranged tangentially of the inner periphery of the wall **9'**. Thus, the conduit **7** has fluid communication with the cylindrical chamber **8'** which is defined by the cylindrical wall **9'**. It is preferable in this instance that a partition **26** (although dispensable) be mounted in the cylindrical chamber **8'** in a longitudinally central portion of the same. This partition **26** is formed at its radially central portion with a bore **25**. To the other end portion of the cylindrical wall **9'**, on the other hand, is connected the intake manifold **3''** such that it has its axis arranged tangentially to the inner periphery of the cylindrical wall **9'**. As a result, the air-fuel mixture in the cylindrical chamber **8'** is supplied to the second intake manifold **3''**. In this embodiment, moreover, a portion of the exhaust gases **6** are introduced from the exhaust pipe **6** into the upstream side of the second carburetor **2''** by way of the conduit outlet **12'**. However, the exhaust gases to be recirculated can be directly supplied to the cylindrical chamber **8'**, as has been described in the foregoing embodiments.

With these construction arrangements, therefore, the richer air-fuel mixture from the first carburetor **2'** is introduced to the combustion chamber in the vicinity of the spark plug **21**, as is the case of the third embodiment. On the other hand, the leaner air-fuel mixture from the second carburetor **2''** is tangentially introduced into the cylindrical chamber **8'** together with the exhaust gases, which are supplied to the upstream side of the second carburetor **2''** by way of the exhaust pipe **6**, the conduit **11**, the flow regulator **10** and the conduit outlet **12'**. Both the leaner mixture and the recirculated exhaust gases thus introduced are made to swirl in the cylindrical chamber **8'** so that they are fully admixed with each other. Then, the resultant combustible mixture uniformly containing the exhaust gases is once constricted at the central bore **25** and then is expanded in the other end portion of the cylindrical chamber **8'** so as to promote mixing inbetween. The obtained uniform mixture is then introduced into the combustion chamber, that is, into the surrounding region around the richer mixture region by way of the second intake manifold **3''**. As a result, the stable combustion can be maintained, as has been described in the third embodiment.

As has been described in detail, according to the present invention, both the recirculated exhaust gases and the air-fuel mixture are made to swirl in the cylindrical chamber so that they are forcedly admixed fully with each other. When the air-fuel mixture is to be burnt in the combustion chamber, therefore, the exhaust gases can be uniformly distributed in the flame front in the particular mixture. As a result, the concept of the exhaust gas recirculation can be fully utilized so as to lower the combustion temperature to thereby minimize the nitrogen oxide emission.

According to another feature of the present invention, the air-fuel mixture is divided into a richer mixture and into a leaner mixture, so that the former mixture may be first ignited to form a stable heat source without inviting unnecessary increase in the combustion temperature. Thus, the succeeding combustion of the latter mixture can be stably anchored at the particular heat source. As a result, the nitrogen oxide content in the exhaust gases can be remarkably reduced.

According to still another feature of the present invention, the air-fuel mixture and the recirculated exhaust gases in the cylindrical chamber are heated by the surrounding annular not chamber, so that the atomization of the fuel content can be promoted to thereby shorten the time period required for warming up the engine.

What is claimed is:

1. In an engine exhaust gas cleaning system in which a portion of engine exhaust gases are recirculated from an engine exhaust system to an intake system of an internal combustion engine so as to reduce nitrogen oxide content in the engine exhaust gases,

the improvement comprising a cylindrical chamber interposed between a carburetor and an intake pipe of the engine, an exhaust gas recirculation conduit providing fluid communication between an exhaust pipe of the engine and said cylindrical chamber, and a mixture conduit providing fluid communication between the carburetor and said cylindrical chamber and having its outlet tangentially connected to the latter for establishing a swirling flow therein to promote mixing between the air-fuel mixture from the carburetor and the recirculated exhaust gases from the exhaust pipe.

2. An improved engine exhaust gas cleaning system according to claim **1**, wherein said exhaust gas recirculation conduit is directly connected to said cylindrical chamber.

3. An improved engine exhaust gas cleaning system according to claim **1**, wherein said exhaust gas recirculation conduit has its outlet tangentially connected to said cylindrical chamber.

4. An improved engine exhaust gas cleaning system according to claim **3**, wherein the angle between the outlets of said mixture conduit and said exhaust gas recirculation conduit is at most 90°.

5. An improved engine exhaust gas cleaning system according to claim **3**, wherein the outlet of said exhaust gas recirculation conduit has a bifurcated shape.

6. An improved engine exhaust gas cleaning system according to claim **1**, wherein said exhaust gas recirculation conduit is indirectly connected to said cylindrical chamber.

7. An improved engine exhaust gas cleaning system according to claim **6**, wherein said exhaust gas recirculation conduit has its outlet connected to the intake system upstream of a throttle valve of the carburetor.

8. An improved engine exhaust gas cleaning system according to claim **1**, wherein the intake pipe includes an intake manifold.

9. An improved engine exhaust gas cleaning system according to claim **8**, wherein said intake manifold has at least one of its trunk pipes connected to the side walls of said cylindrical chamber.

10. An improved engine exhaust gas cleaning system according to claim **1**, wherein the intake pipe includes sult, the air-fuel mixture and the exhaust gases are swirled in the cylindrical chamber 8′ and are uniformly admixed with each other. Then, the combustible mixture thus obtained is helically moved longitudinally outwardly in the cylindrical chamber 8′. Thus, the combustible mixture is smoothly and progressively passed into the branch pipes of the intake manifold 3. As has been described in detail in the above, according to the present invention, both the air-fuel mixture and the recirculated exhaust gases are made to swirl in the cylindrical chamber to be forcedly admixed uniformly. Thus, the nitrogen oxide emission, which is found to mainly result from irregularities in the combustion in the engine combustion chamber due to irregularities in the distribution of the recirculated exhaust gases, can be minimized. Since, moreover, the cylindrical chamber is heated by the outer annular chamber, the atomization of the fuel content promoted to result in early stabilization of the engine drivability especially when the engine is started.

Turning now to FIGS. 6 to 8, a third embodiment of the present invention will be described. In this embodiment, a leaner air-fuel mixture, to which a portion of the exhaust gases are recirculated, and a richer air-fuel mixture are separately introduced into the engine combustion chamber, thereby stably anchoring the combustion of the leaner mixture at the combustion of the richer mixture although the overall mixture ratio in the combustion chamber is at a lean side.

In the internal combustion engine 1, there are mounted the intake manifold 3, to which the air-fuel mixture is introduced from the carburetor 2, and the exhaust manifold 4 through which the exhaust gases from the engine 1 are discharged. This intake manifold 3 is composed of two separate portions, namely, a first intake manifold 3′ and a second intake manifold 3″, in the third embodiment. Downstream of the exhaust manifold 4, there is provided the exhaust pipe 6 including the silencer 5, through which the exhaust gases are discharged to the outside. The carburetor 2 is, in this embodiment, composed of a first carburetor 2′ for producing a richer air-fuel mixture and of a second carburetor 2″ for producing a leaner air-fuel mixture. Two throttle valves 23′ and 23″ are mounted in these carburetors 2′ and 2″, respectively.

The downstream side of the first carburetor 2′ has fluid communication with an inlet passage 18 of the engine, which will be explained later, through the first intake manifold 3′. To a downstream portion of the second carburetor 2″, on the other hand, is connected the mixture conduit 7 which in turn is connected to a longitudinally central wall of the cylindrical member 8 in a manner to have its axis arranged tangential to the inner periphery of the cylindrical wall of the chamber 8, so that fluid communication between the conduit 7 and the cylindrical wall 8 can be established. In order to introduce a portion of the exhaust gases from the exhaust pipe 6 into the cylindrical chamber 8, the exhaust gas recirculation conduit 11 is interposed between the exhaust pipe 6 and the cylindrical chamber, and it is provided with the flow regulator 10. The conduit 11 has its outlet 12 tangentially connected to the inner periphery of the cylindrical wall 9 of the cylindrical chamber 8. This outlet 12 is located substantially at the same periphery as that of the mixture conduit 7. In this third embodiment, moreover, the angle between the axial directions of the two conduits 7 and 11 is made acute, but this is not limitative. With these construction arrangements, therefore, both the exhaust gases from the conduit outlet 12 and the leaner air-fuel mixture or air from the conduit 7 are made to swirl in the cylindrical chamber 8 to be uniformly admixed with each other to a sufficient extent.

In a modification, the cylindrical chamber 8 may be replaced by an annular chamber, if it is suitable for allowing the swirling flow. As shown in FIG. 8, there is formed between the cylindrical wall 9 and the outer wall 14 the annular chamber 13 in which a heated fluid is passed to interchange heat with the air-fuel mixture and the recirculated exhaust gases in the cylindrical chamber 8. This heat exchange will aid in atomization of the fuel content in the chamber 8. The heated fluid which is suitable for this purpose is, for example, cooling water which is warmed in the engine 1, or the remaining exhaust gases which are recirculated from the exhaust pipe 6.

In this embodiment, moreover, the annular chamber 13 is so positioned that it is traversed by two conduits 7 and 11. The both side ends of the cylindrical chamber 8 are formed with the central bores 15, which have fluid communication with the fluid passage 18 through the second intake manifold 3″. The first intake manifold 3′ has also fluid communication with the fluid passage 18. It should be noted in this third embodiment that there is mounted in the passage 18 a partition 24 which separates the richer air-fuel mixture from the intake manifold 3′ from the leaner air-fuel mixture from the intake manifold 3″. In more detail, the richer mixture is supplied to the engine combustion chamber in the vicinity of the spark plug 21, whereas the leaner mixture is supplied to the surrounding region around the richer mixture region. Thus, the overall combustion in the combustion chamber 20 can be stably at the local combustion of the richer mixture. The exhaust gases thus produced are then discharged to the exhaust manifold 4 through the exhaust valve 22.

As will be apparent from the above description, the richer air-fuel mixture from the first carburetor 2′ is supplied to the fluid passage 18 through the first intake manifold 3′. This richer mixture is introduced into a region in the vicinity of the spark plug 21 in the combustion chamber 20. Meanwhile, the leaner air-fuel mixture from the second carburetor 2″ is introduced by way of the conduit 7 tangentially into the cylindrical chamber 8, where it is made to swirl. At the same time, due to the vacuum in the intake manifold 3 or to the pressure of the exhaust gases themselves, a portion of the exhaust gases are introduced from the exhaust pipe 6 into the cylindrical chamber 8 through the conduit 11 and its outlet 12 tangentially of the inner periphery of the cylindrical wall 9. Thus, the recirculated exhaust gases are made to swirl in the cylindrical chamber 8 and are forcedly admixed with the swirling leaner airfuel mixture. The resultant combustible mixture uniformly containing the exhaust gases is then heated by the heated fluid in the annular chamber 13, so that the fuel vapors, if any, may be atomized quickly. After that, the fully gasified combustible mixture is helically moved longitudinally outwardly of the cylindrical chamber 8. The combustible mixture is then introduced into the combustion chamber 20 around the richer mixture region by way of the second intake manifold 3″ and the passage 18. When in the explosion stroke of the engine 1, therefore, the inner richer mixa plurality of pipes each having its inlet connected to said cylindrical chamber.

11. An improved engine exhaust gas cleaning system according to claim **1**, wherein said cylindrical chamber includes a two-wall portion defining an annular chamber in which a heated fluid is passed to interchange heat with the air-fuel mixture in said cylindrical chamber to promote atomization of the fuel.

12. An improved engine exhaust gas cleaning system according to claim **1**, further comprising a partition mounted in said cylindrical chamber between the outlet of said mixture conduit and the inlet of the intake pipe and formed with an aperture through which the swirled air-fuel mixture and recirculated exhaust gases are once constricted and then expanded in said cylindrical chamber so as to further promote mixing inbetween.

13. An improved engine exhaust gas cleaning system according to claim **1**, further comprising richer mixture means including a second carburetor for producing an air-fuel mixture having a mixture ratio richer than the air-fuel mixture which is to be mixed with the recirculated exhaust gases, and a second intake pipe providing fluid communication between the second-named carburetor and a combustion chamber of the engine in the vicinity of a spark plug so as to supply the richer air-fuel mixture to the spark plug so that the combustion in the combustion chamber may be stably anchored in the vicinity of the spark plug although the overall mixture ratio in the combustion chamber can be maintained within a proper range.

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