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Suda et al.

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[54] **SPARK IGNITION INTERNAL COMBUSTION ENGINE**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **F02d 5/00**
[58] **Field of Search**..... 261/51; 123/32 EA, 139 BG

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[57] **ABSTRACT**

An intake throttle valve operating member is rendered movable independently of an intake throttle valve, disposed in an intake pipe, after the intake throttle valve has reached its maximum open position while holding the throttle valve in said maximum open position, and the amount of movement of the throttle valve operating member after the throttle valve has reached its maximum open position is transmitted to an electronic fuel injection control, unit, which in turn controls electrically the degree of opening of an electromagnetic fuel injection valve, whereby before the intake throttle valve reaches its maximum open position, the air fuel ratio can be adjustably maintained at a value at which the concentrations of the harmful components in the exhaust gas are low over the entire range of the internal pressure of the intake pipe, while after the throttle valve has reached its maximum open position, the amount of fuel only is increased to make the air fuel ratio smaller so as to obtain a greater torque.

7 Claims, 3 Drawing Figures

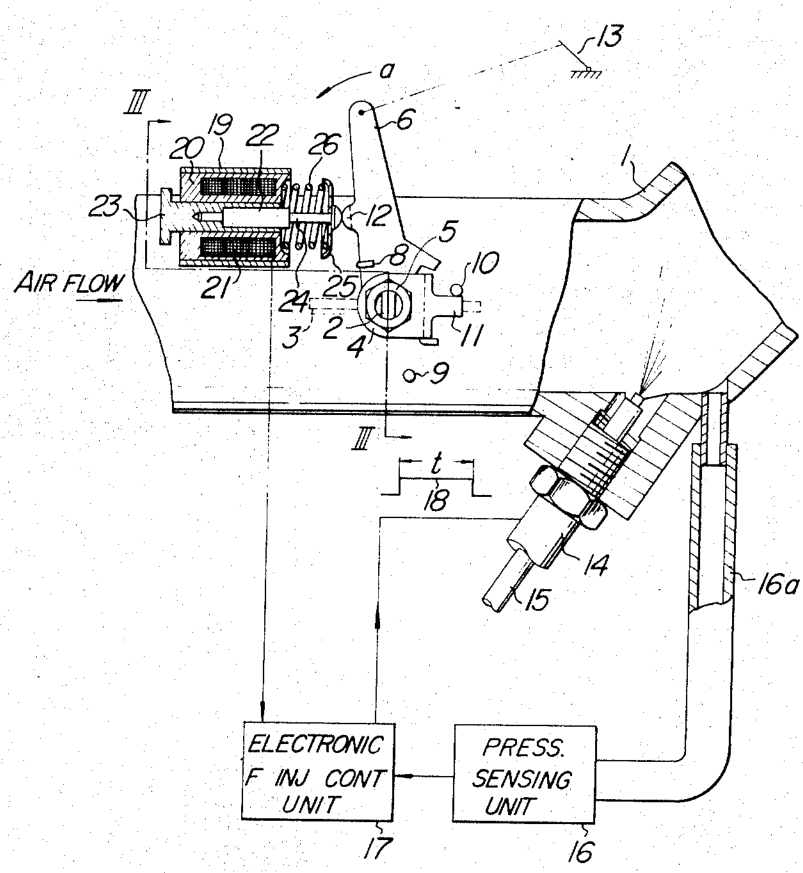

FIG. 1

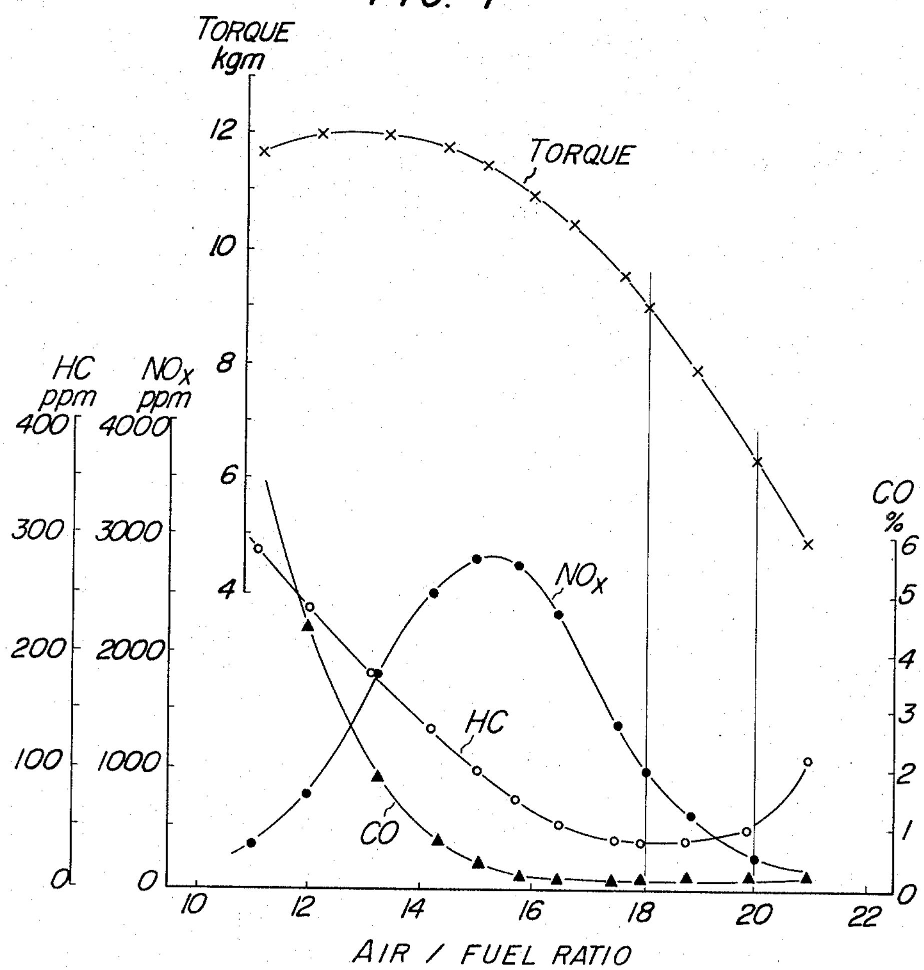

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FIG. 2

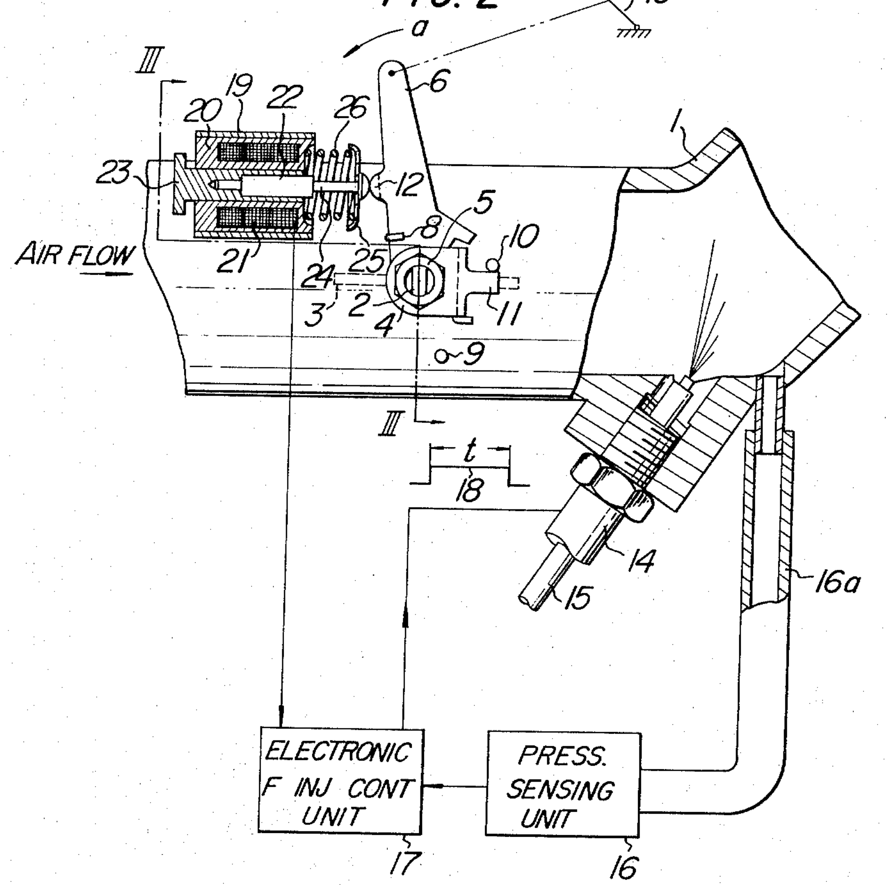
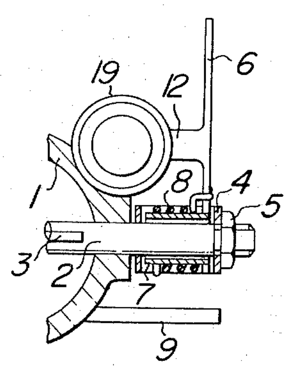


FIG. 3



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SPARK IGNITION INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a spark ignition internal combustion engine, e.g., a fuel injection type spark ignition internal combustion engine comprising an electromagnetic fuel injection valve (hereinafter referred to simply as injection valve) disposed in the intake pipe and electronic fuel injection control means electrically connected with said injection valve, the open period of time of said injection valve being controlled by a signal from said fuel injection control means according to the conditions under which the engine is operated, whereby the quantity of fuel supplied into the intake pipe is determined.

2. DESCRIPTION OF THE PRIOR ART

In conventional internal combustion engines of the type described, e.g., a fuel injection type internal combustion engine, the injection valve is operated in synchronism with the engine r.p.m. utilizing the absolute pressure in the intake pipe as a main controlling parameter, so that the quantity of fuel supplied may be adjusted to meet the demand of the engine. In this case, it is customary to adjust the open period of time of the injection valve by electronic fuel injection control means in such a manner that an air fuel mixing ratio (hereinafter referred to simply as air fuel ratio or A/F) of 12 – 14 to one may be obtained in a high load region (e.g., an intake pipe internal pressure region of higher than 640 mmHg abs.) so as to obtain the maximum output torque and an air fuel ratio of 15 – 17 to one at which the fuel consumption ratio is minimum and the concentrations of the harmful components in the exhaust gas are generally low, may be obtained in a partial load region (e.g., the intake pipe internal pressure region of lower than 640 mmHg abs.) in which the economical use of fuel and the presence of harmful components in the exhaust gas at low concentrations are required. The air fuel ratio in a spark ignition internal combustion engine having a carburetor is also determined in the similar manner. This is parimarily used on the concept that the air fuel ratio during operation of the engine with partial load should be determined simply by attaching the importance to the fuel consumption and the concentrations of the harmful components in the exhaust gas rather than to the output torque and, on the contrary, that during operation of the engine with high load should be determined simply by attaching the importance to the output torque, as stated above.

However, with the conventional air fuel ratio adjusting method as described above, it is impossible to satisfy the demand for lessening the harmful components in the exhaust gas, which is particularly strong in these days. This is because the harmful components contained in the exhaust gas are largely influenced by the air fuel ratio and it has been confirmed through many experiments that especially nitrogen oxides of the harmful components are generated in large amounts in the high load region of the engine operation.

The relationships between the concentrations of hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx), and the torque, with respect to the air fuel ratio are shown in FIG. 1. FIG. 1 shows the case

of the engine in the high load region in which nitrogen oxides are generated in large amounts.

As may be seen, substantially no carbon monozide is exhausted at the air fuel ratio higher than 16 to one. The concentration of hydrocarbon decreases as the air fuel ratio becomes larger but increases again as the air fuel ratio becomes more larger (exceeding 20) and misfire starts to occur. As contrasted, the concentration of nitrogen oxides varies following a curve quite different from those of the aforesaid two harmful components, and is highest at about the air fuel mixing ratio of 16 and decreases as the air fuel ratio becomes larger or smaller than said value. The torque becomes smaller with the air fuel ratio increasing.

Therefore, the concentrations of all of the three harmful components (HC, CO and NOx) can be decreased to a minimum by operating the engine, for example, with the air fuel ratio of 18 – 20, to one but on the other hand, the torque decreases to about the half, which is extremely disadvantageous in the case when the maximum torque is required, such as during running of the vehicle on a steep ascending slop or controlling of the vehicle to escape from a dangerous condition.

SUMMARY OF THE INVENTION

In view of the foregoing fact and with a view to eliminating the above-described disadvantage of the conventional engines, the present invention aims to operate the engine with such a large air fuel ratio as mentioned above (e.g., the air fuel ratio of 18 – 20) as far as possible throughout the load region and yet to enable the torque to be increased smoothly whenever a large torque is required. Namely, the object of the present invention is to provide an extremely useful spark ignition internal combustion engine comprising an intake throttle valve disposed in an intake pipe, means for opening and closing said intake throttle valve including a lever and links operatively connected with said lever, means for enabling said intake throttle valve operating means to operate independently of said throttle valve after said throttle valve has been placed in the maximum opening position while holding said valve in said position, a fuel injection valve and means for electrically controlling said fuel injection valve in such a manner that the amount of fuel injected by said fuel injection valve is increased according to the amount of movement of said throttle valve operating means independently of said throttle valve after said valve has assumed said maximum opening position, whereby before the throttle valve is brought into the maximum opening position, the air fuel ratio is adjusted to a value, e.g., 18 – 20, to one at which the concentrations of the harmful components in the exhaust gas are low, throughout the entire internal pressure range of the intake pipe (and hence the internal pressure of the intake pipe is highest when the opening of the throttle valve is largest), while after said intake throttle valve has been brought into the maximum opening position, the fuel only is increased according to the amount of movement of said throttle valve operating means by the operation of said fuel injection valve under control of said fuel injection valve control means, whereby the air fuel ratio is decreased to a value, e.g., 12 – 14 to one and thus the concentrations of the harmful components in the exhaust gas can be substantially decreased without sacrificing the output torque of the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graph showing the performance curves of an engine and used in explaining the process of achievement of the present invention;

FIG. 2 is a sectional view of the essential portion of one embodiment of the internal combustion engine according to the invention; and

FIG. 3 is a sectional view taken along the line III—III of FIG. 2.

DESCRIPTION OF THE REFERRED EMBODIMENT

The present invention will be described with reference to an embodiment thereof shown in the drawings.

Referring to FIGS. 2 and 3, reference numeral **1** designates an intake pipe of an engine. An intake throttle valve shaft **2** is rotatably mounted in the intake pipe, with its opposite ends extending through the wall of said intake pipe. An intake throttle valve **3** is fixedly mounted on the shaft **2** within the intake pipe to open and close said intake pipe. Further, a substantially U-shaped coupling member **4** is fixedly mounted on the shaft exterior of the intake pipe **1** by means of a nut **5**. Reference numeral **6** designates a lever for operating the throttle valve **3**, which is fixedly mounted at one end on a sleeve **7**. The sleeve **7** is rotatably mounted on the shaft **2** within the U-shaped coupling member **4**. The lever **6** and the coupling member **4** are coupled by a coil spring **8** and movable integrally with each other. Reference numerals **9** and **10** designate stopper pins such that a projection **11** formed on the coupling member **4** abuts against the stopper pin **9** or **10**, thereby defining the maximum closed position or maximum open position of the throttle valve **3**.

The lever **6** is formed with a bent lug **12** integrally therewith. This bent lug **12** serves to actuate a differential transformer to be described later when the lever **6** is operated beyond the maximum open position of the throttle valve **3**. The lever **6** is operatively connected to an operating lever, e.g., an accelerator pedal **13**, through a linkage not shown.

The intake pipe **1** is provided with an electromagnetic fuel injection valve **14** and a fuel conduit **15** is connected with said injection valve for supplying fuel from a fuel pump not shown to said injection valve **14** therethrough.

Reference numeral **16** designates a pressure sensing unit for sensing the absolute pressure interior of the intake pipe **1** through a conduit **16***a*. This pressure sensing unit **16** generates an electrical output according to the magnitude of the absolute pressure sensed thereby and impresses the same on an electronic fuel injection control unit **17**. The output of the electronic fuel injection control unit **17** is a pulse of a rectangular waveform as shown and the pulse width t is proportional to the absolute pressure interior of the intake pipe **1**. The arrangement is such that the injection valve **14** is held open for the period of time corresponding to the pulse width t and, therefore, an amount of fuel proportional to the pulse width t is fed into the intake pipe **1**.

Reference numeral **19** designates the differential transformer comprising a spool **20**, coils **21** wound on said spool **20** and a movable core **22** received in said spool **20**. The movable core **22** has a guide member **23** fixed to one end thereof which is smoothly slidable in the spool **20**, and a pin **24** fixed to the other end thereof for abutting engagement with the bent lug **12** of the lever **6**. The pin **24** has a spring seat **25** mounted thereon and a compression spring **26** is mounted between said spring seat **25** and the spool **20**. The differential transformer **19** constructed as described above generates an output corresponding to the amount of displacement of the movable core **22** and said output is supplied to the electronic fuel injection control unit **17**. The output pulse width t of the electronic fuel injection control unit **17** increases gradually according to the magnitude of the output of the differential transformer **19** thus supplied to said control unit.

Now, the operation of the construction described above will be explained. When the lever **6** is moved in the direction of the arrow *a* by actuating the operating lever **13**, the throttle valve **3** is shifted from the maximum closed position to the maximum open position incident to the movement of said lever **6**, because the lever **6** and the coupling member **4** are integrally connected with each other by the coil spring **8** while the projection **11** of the coupling member **4** is located between the stopper pins **9** and **10**.

Within this range, the pressure interior of the intake pipe **1** generated at the rate of rotation of the engine with respect to the particular position of the throttle valve **3** is sensed by the pressure sensing unit **16** and the electrical output of said sending unit is supplied to the electronic fuel injection control unit **17**, so that said control unit **17** imparts the fuel injection valve **14** a valve open period of time proportional to the internal pressure of the intake pipe **1**. Therefore, an arrangement is previously made such that, within this range, an air fuel ratio of 18 – 20, to one for example, at which the concentrations of the harmful components in the exhaust gas become lowest, may be obtained with respect to the internal pressure of the intake pipe, until the throttle valve **3** reaches its maximum open position.

As the lever **6** is further moved in the direction of the arrow *a* after the projection **11** of the coupling member **4** has abutted against the stopper pin **10** or after the throttle valve **3** has reached its maximum open position, the coupling member **4** is held stationary by the abutting engagement between the projection **11** and the stopper pin **10** and hence the throttle valve **3** is held in its maximum open position, but the lever **6** only moves in the direction of the arrow *a* against the biasing force of the coil spring **8** while pushing the pin **24** and, therefore, the movable core **22** of the differential transformer **19** by its bent lug **12**. The differential transformer **19** generates an electrical output according to the amount of displacement of the movable core **22** and said output is supplied to the electronic fuel injection control unit **17**. Consequently, the output pulse width t of the control unit **17** is increased and the open period of time of the injection valve **14** becomes longer, so that the amount of fuel injected is increased. The amount of the intake air remains unchanged since the throttle valve **3** is held stationary in its maximum open position as stated above. Therefore, it will be understood that, with this range, the air fuel ratio can be made progressively smaller and the torque can be progressively increased by operating the lever **6**. Therefore, when the vehicle ascends a steep slope or is operated to get out of a dangerous condition, it is only necessary to operate the operating lever **13** until an air fuel ratio of 12 – 14 is obtained.

Although the present invention has been described in detail hereinabove with reference to a fuel injection-type spark ignition internal combustion engine, it will be obvious that the present invention is also applicable to a spark ignition internal combustion engine comprising a carburetor. In applying the present invention to the carburetor-type spark ignition internal combustion engine, this can be achieved, for instance, by employing the above-described mechanism associating with the lever **6,** providing the carburetor with a jet which is used solely for increasing the amount of fuel, and progressively increasing the opening area of said jet according to the magnitude of the output of the above-described differential transformer **19.**

It is to be understood that while in the embodiment described herein the differential transformer **19** is actuated by the lever **6,** it may be actuated by the other intake throttle valve operating members, namely the operating lever **13** or the linkage coupling said operating lever with said lever. It is also to be understood that the means for progressively increasing the amount of fuel injected in proportion to the amount of movement of the intake throttle valve operating member after the throttle valve has reached its maximum open position is not restricted to the type illustrated herein but any other types may be used without deviating the spirit of the present invention.

As described herein, in the present invention the intake throttle valve operating member for opening and closing the throttle valve disposed in the intake pipe is rendered movable independently of said throttle valve after said throttle valve has reached its maximum open position, while holding said throttle valve in said maximum open position, and there is provided the means for progressively increasing the amount of fuel in proportion to the amount of movement of said intake throttle valve operating member after the throttle valve has reached its maximum open position. Therefore, there can be obtained such excellent advantage that before the intake throttle valve reaches its maximum open position from its maximum closed position, an air fuel ratio advantageous for the prevention of generation of harmful components in the exhaust gas can be obtained over the entire range of the internal pressure of the intake pipe, while after the throttle valve has reached its maximum open position, the air fuel ratio can be made progressively smaller according to the amount of movement of the intake throttle valve operating member, whereby the operational range in which the concentrations of the harmful components in the exhaust gas are low can be expanded. Furthermore, according to the present invention the air fuel ratio can be changed smoothly from a large to a small value, which is a great contribution to the safety operation of the engine.

We claim:

1. A spark ignition internal combustion engine comprising:

an intake throttle valve disposed in an intake pipe of said engine,

an injection valve provided on said engine for injecting compressed fuel into said engine,

throttle valve operating means provided in conjunction with said throttle valve which is operable independently of said throttle valve after said throttle valve has reached its maximum open position while holding said throttle valve in said maximum open position,

means disposed in conjunction with said throttle valve operating means for producing an electrical signal in proportion to the amount of displacement of said throttle valve operating means after said throttle valve has reached said maximum open position,

an electronic fuel injection control unit connected with said electrical signal producing means and with said injection valve for activating said injection valve according to the electrical output signal produced therefrom, wherein the electrical output signal of said unit is corrected by the electrical signal from said electrical signal producing means to inject increased amounts of compressed fuel into said engine through said injection valve according to the amount of movement of said throttle valve operating means after said throttle valve has reached said maximum open position.

2. A spark ignition internal combustion engine as claimed in claim **1,** wherein said unit controls the injection valve to produce a lean air-fuel mixture with which the amount of harmful components in the exhaust gas from the engine is reduced until said throttle valve reaches said maximum open position, said harmful components consisting of hydrocarbons, carbon monoxide and nitrogen oxides, and further said unit controls said injection valve to produce a rich air-fuel mixture with which increased engine power is obtainable after said throttle valve has reached said maximum open position.

3. A spark ignition internal combustion engine as claimed in claim **2,** wherein said injection valve is disposed on said intake pipe for injecting said compressed fuel into said intake pipe.

4. A spark ignition internal combustion engine as claimed in claim **2,** wherein said electrical signal producing means is composed of a differential transformer

5. A spark ignition internal combustion engine as claimed in claim **2,** wherein said lean air-fuel mixture is a mixture having an air fuel ratio of about 18–20 to one, and said rich air-fuel mixture is a mixture having an air fuel ratio of about 12–14 to one.

6. A spark ignition internal combustion engine as claimed in claim **3,** wherein said lean air-fuel mixture is a mixture having an air fuel ratio of about 18–20 to one, and said rich air-fuel mixture is a mixture having an air fuel ratio of about 12–14 to one.

7. A spark ignition internal combustion engine as claimed in claim **4,** wherein said lean air-fuel mixture is a mixture having an air fuel ratio of about 18–20 to one, and said rich air-fuel mixture is a mixture having an air fuel ratio of about 12–14 to one.

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