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Nambu et al.

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[54] **INTAKE AIR CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE OF FUEL INJECTION TYPE**

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[52] **U.S. Cl.** ..... **261/43**, 261/64 B, 123/139 AW, 123/103 D, 137/484

[51] **Int. Cl.** **F02m 69/00**

[58] **Field of Search** ... 137/484; 123/139 AW, 103 D; 261/64 B, 64 C, 43

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[57] **ABSTRACT**

An intake air control device adapted for use in an internal combustion engine of fuel injection type. One embodiment comprises a butterfly type control valve provided in an intake air passage upstream or downstream of a throttle valve mounted therein. The control valve includes a flap member rotatable about a shaft secured thereto slightly off the center of the air passage. Thus, upon actuation of an acceleration control member, the control valve is opened by the flow of intake air after a predetermined time lapse from the moment the acceleration control member is actuated, thereby gradually increasing the amount of the intake air. Another embodiment employs a Venturi type piston valve to serve the same purposes.

1 Claim, 6 Drawing Figures

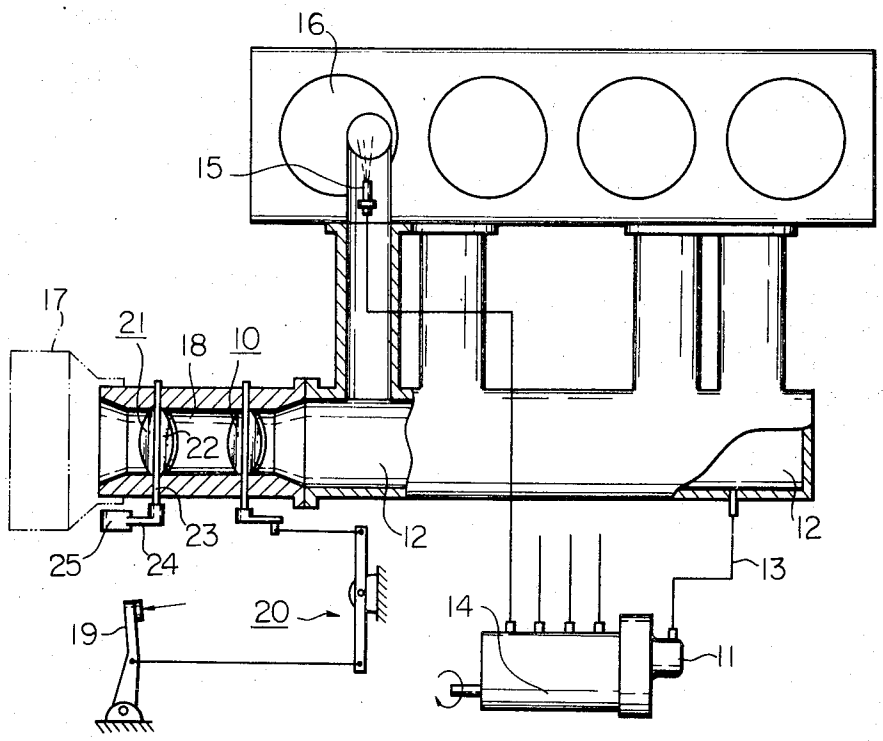


Fig. 2

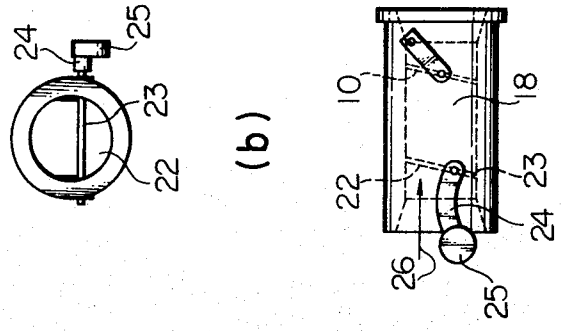
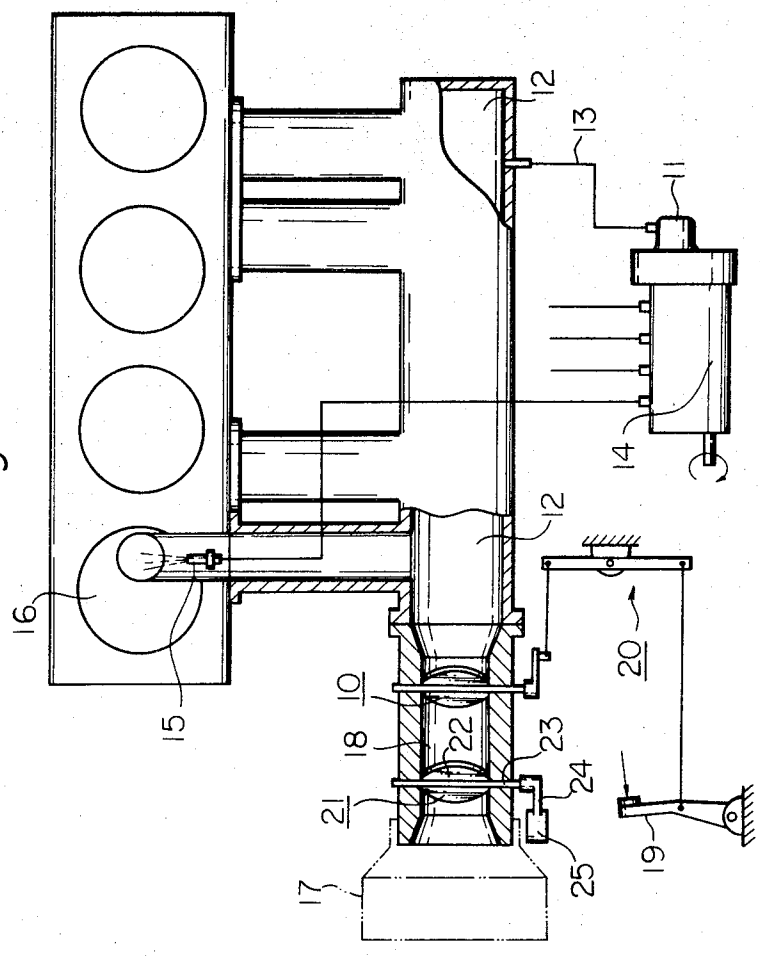


Fig. 1



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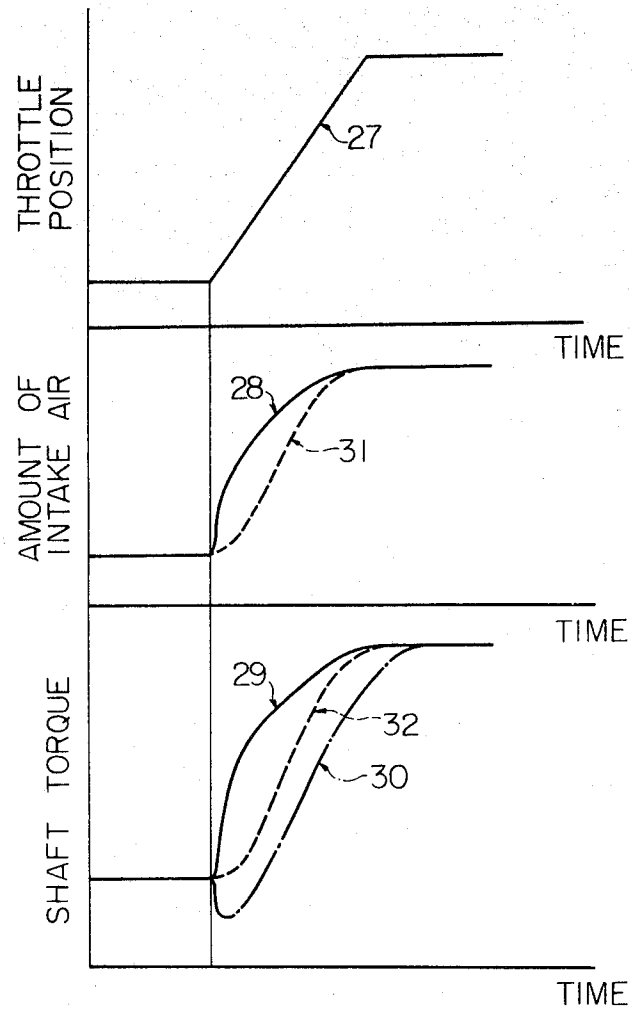
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Fig. 3



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Fig. 4

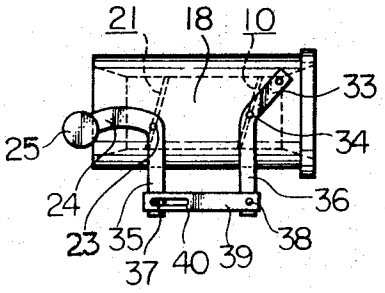
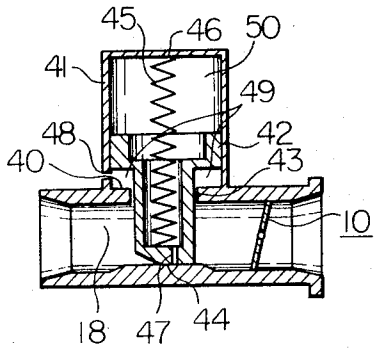


Fig. 5



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INTAKE AIR CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE OF FUEL INJECTION TYPE

This invention relates generally to a fuel injection system for an internal combustion engine of a motor vehicle and more particularly to devices adapted for use in such a system and capable of controlling the flow rate of intake air to be supplied to the individual combustion chambers of the engine during acceleration.

In a fuel injection system for an internal combustion engine, mixing of fuel with air is made by injecting the fuel into the air existing in the combustion chambers or into the air in the intake manifold relatively close to the respective chambers. Therefore, the problem of uneven distribution of the fuel is encountered due to the geometry of the intake manifold. It is, therefore, a usual practice to provide, in the internal combustion engine of fuel injection type, a throttle valve and an intake manifold designed for high output performance. The throttle valve thus designed is usually located in an intake air passage leading to the intake manifold and includes a flap member having a relatively large diameter. However, when such a flap member is suddenly tilted to its open position, the amount of intake air increases so abruptly that the amount of the fuel can not increase proportionally to the increase in the amount of air, resulting in the failure to effect smooth acceleration of a vehicle. Or otherwise, if the increase in the amount of fuel can follow the increase in the amount of air, the shaft torque rises too sharply, causing the persons on the vehicle to feel a shock.

It is, therefore, an object of this invention to provide an improved intake air control device adapted for use in an internal combustion engine of fuel injection type with a view to overcoming the above-stated disadvantages.

It is another object of this invention to provide an improved intake air control device, as above, which operates to gradually increase the amount of intake air in response to actuation of an acceleration member for acceleration purposes of a vehicle.

It is a further object of this invention to provide an improved intake air control device, as above, having a butterfly valve of the same type as a throttle valve.

It is yet a further object of this invention to provide an improved intake air control device, as above, having a Venturi type piston valve.

In the drawings:

FIG. **1** is a schematic view, partially in section, of a fuel injection system having incorporated therein an intake air control device according to one embodiment of this invention;

FIGS. **2**(*a*) and (*b*) are front and side views of the butterfly type intake air control device shown in FIG. **1**;

FIG. **3** is a graph showing a time relationship between throttle position, amount of intake air and shaft torque;

FIG. **4** is a side view of an intake air control device constructed in accordance with another embodiment of this invention; and

FIG. **5** is a side section of a piston type intake air control device according to a further embodiment of this invention.

Referring now to FIG. **1**, there is shown a fuel injection system having incorporated therein an intake air control device of this invention. The fuel injection system as shown is of speed-density-metering type in which the amount of intake air is controlled by a throttle valve **10**, while the amount of fuel to be mixed with the intake air is controlled by a metering device **11** pneumatically connected to an intake manifold **12** by way of a conduit **13**. The metering device **11** is mounted on an injection pump **14** which is adapted to be driven by an engine (not shown) to deliver fuel under pressure to injection nozzles **15** provided in the intake passage of the individual combustion chambers **16** of the engine.

The intake air is admitted through an air cleaner **17** into an intake air passage **18** having the throttle valve **10** mounted therein. The throttle valve **10** is operatively associated with an acceleration control member or an accelerator pedal **19** through a mechanical linkage, as generally indicated at **20**, so as to allow a predetermined amount of air to flow through the air passage **18** in response to the movement of the accelerator pedal **19**. The intake air leaving the air passage **18** is fed to the individual combustion chambers **16** of the engine by way of the intake manifold **12**.

Mounted in the intake air passage **18** upstream of the throttle valve **10** is the intake air control device of this invention which may comprise a butterfly valve **21** of the same type as the throttle valve **10**. This butterfly valve **21** is also adapted to be tilted in the intake air passage **18** to allow a predetermined amount of air to flow therethrough. While the butterfly valve **21** is shown as located in the air passage **18** upstream of the throttle valve **10**, it is to be understood that the butterfly valve **21** could equally as well be located downstream of the throttle valve **10**.

Reference should now be made to FIGS. **2**(*a*) and (*b*) wherein the intake air control device according to one embodiment of this invention is shown in more detail. The butterfly valve **21** comprises a flap member **22** adapted to be tilted in the air passage **18**, a shaft **23** secured to the flap member **22** for rotating therewith, an arm member **24** secured to one end of the shaft **23** so as to extend substantially perpendicularly thereto and a weight member **25** secured to the free end of the arm member **24**. As shown, the shaft **23** is pivotally mounted on the wall slightly off the center of the air passage **18**, so that when the intake air is caused to pass through the air passage **18** in the direction of arrow **26** the flap member **22** is tilted in a clockwise direction as viewed in FIG. **2**(*b*) to a position at which an equilibrium exists between the moment of rotation developed by the intake air and that developed by the weight **25**. Thus, the tilting position effects a gradual increase in the amount of air flow passing through the effective area defined by the circumferential edge of the flap member **22** and the inner wall of the air passage **18**. It is to be noted that since a combination of the arm member **24** and the weight **25** has a certain amount of inertial mass the butterfly valve **21** begins to open after a predetermined time lapse from the moment the throttle valve **10** begins to open in dependence on the actuation of the acceleration control member **19**. The period of time depends upon the inertial mass provided by the arm member **24** and the weight member **25**.

FIG. **3** graphically shows a time relationship between throttle position, amount of intake air and shaft torque.

As the throttle valve **10** is opened as shown by a solid line **27**, the amount of intake air increases abruptly as shown by a solid line **28** and the shaft torque may also increase abruptly as shown by a solid line **29**. Such an abrupt change in the shaft torque would often tend to make the persons in a car feel a shock. Or otherwise, some difficulties are experienced in effecting accelereration since the increase in the fuel delivered cannot follow the increase in the amount of intake air so that the mixture is relatively lean, with the resultant momentary decrease in the shaft torque as indicated by a phantom line **30**.

However, with the present intake air control device **21** mounted in the air passage **18**, the above-stated disadvantages can be overcome. That is, upon opening of the throttle valve **10**, the butterfly valve **21** commences to open after the lapse of a certain period of time due to the inertia inherent to the arm member **24** and the weight member **25**. Thus, the amount of intake air increases more gradually as shown by a broken line **31**. As a result, the shaft torque is increased in proportion to the less abrupt increase in the amount of intake air, as indicated by a broken line **32**.

It is to be noted here that the manner in which the amount of intake air and the shaft torque increases can be modified by varying the length of the arm member **24** and the weight of the weight member **25**. However, in the case where the arm member **24** is too long and the weight member **25** is too heavy, the butterfly valve **21** tends not to be fully opened even when the throttle valve **10** is fully opened. When this occurs, the butterfly valve **21** provides for resistance to air intake, causing a reduction in the output torque.

FIG. **4** illustrates a modification of the intake air control device shown in FIGS. **1** and **2**, in which the above-said problem concerning the resistance to air intake is eliminated. As shown, this modification includes a linkage for controlling the opening of the flap member **22**, which linkage is operatively connected to the flap member **22** and throttle valve **10** for tilting the flap member **22** to its fully open position in dependence on the full opening of the throttle valve **10**. The arm members **24** and **33** are secured to the respective shafts **23** and **34** for the butterfly valve **21** and the throttle valve **10** and provided with bell crank portions **35** and **36** extending downwards in substantially parallel relationship to each other when the valves are closed. Each of the bell crank portions **35** and **36** has pins **37** and **38**, respectively, secured to one end thereof.

Mounted on the pin **38** for rotating thereabout is a rod member **39** having an elongated slot **40** longitudinally formed near one end portion thereof to movably receive the pin **37** provided at the end portion of the bell crank **35**. With such an arrangement, the butterfly valve **21** is forcedly moved to its fully open position by the action of the rod member **39** when the throttle valve **10** is fully opened.

FIG. **5** illustrates a further embodiment of the present intake air control device. As shown, there is provided on the outer wall **40** of the air passage **18** a cylindrical housing **41** having a hollow piston **42** reciprocally accommodated therein. The wall **40** of the air passage **18** is formed with an opening **43** through which the piston **42** extends into the air passage **18**. The piston **42** is biased through the opening **43** toward the inner flat wall or bottom **44** of the air passage **18** by the action of a spring member **45** accommodated between the end wall **46** of the cylindrical housing **41** and the end of the piston **42** projecting into the air passage **18**. The piston **42** is hollow and is formed at its end projecting into the air passage **18** with a small opening **47**. The cylindrical housing **41** is formed in its side wall near the air passage **18** with a vent hole **48** which introduces atmospheric pressure into a space **49** defined by the cylindrical housing **41**, piston **42** and outer wall **40** of the air passage **18**. The opening **47** is adapted to communicate the air passage **18** with a space **50** defined by the piston **42** and cylindrical housing **41**.

Between the end of the piston **42** projecting into the air passage **18** and the bottom **44** of the air passage **18** there is provided a Venturi of a constricted section (not numbered) through which the intake air flows. As the air flows through the constricted section, a partial vacuum is produced at the Venturi. Since the piston **42** has the small opening **47** formed at the extending end thereof, the partial vacuum develops within the space **50**. Thus, the piston **42** is moved toward the end wall **46** against the action of the spring member **45** by the pressure difference between the two spaces **49** and **50**. The effective area of the Venturi is controlled by the displacement of the piston **42** depending upon the amount of the intake air passing therethrough. It is to be noted that in this embodiment, also, the piston **42** begins to permit a flow of the intake air through the air passage **18** after a predetermined time lapse controlled by the inertial mass provided by the piston **42**.

What is claimed is:

1. An air intake control device for an internal combustion engine of fuel injection type of a motor vehicle having an air intake passage communicating with individual combustion chambers of the engine and a throttle valve disposed in said air intake passage, said air intake control device comprising a control means adapted to be provided in said air intake passage for effecting a gradual increase in the amount of air flow passing therethrough after a predetermined time lapse from the moment an acceleration control member is actuated to open said throttle valve for acceleration of the motor vehicle, said control means including a flap member adapted to be tilted in said air intake passage for allowing a gradually increasing amount of air to flow through the effective area defined by the circumferential edge thereof and the inner wall of said air intake passage, a shaft member pivotally mounted on the wall slightly off the center of said air intake passage, an arm member secured to one end of said shaft member and extending substantially perpendicularly to said shaft member, a weight member secured to one end of said arm member for controlling the period of said time lapse by the inertial mass thereof together with said arm member, and an opening control means operatively connected to said flap member and said throttle valve for tilting said flap member to its fully open position in dependence on the fully opening of said throttle valve, said opening control means including a first bell crank secured to the shaft of said throttle valve for rotating therewith and having a first pin at one end thereof, a second bell crank secured to said shaft member for rotating therewith and having a second pin

at one end thereof, and a rod member mounted on said first pin for rotating thereabout having an elongated slot longitudinally formed near one end thereof for movably receiving said second pin.

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