Nov. 18, 1969 YASUO TADA 3,478,729

APPARATUS FOR CONTROLLING IGNITION TIME OF AUTOMOBILE ENGINE

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Fig. 1.

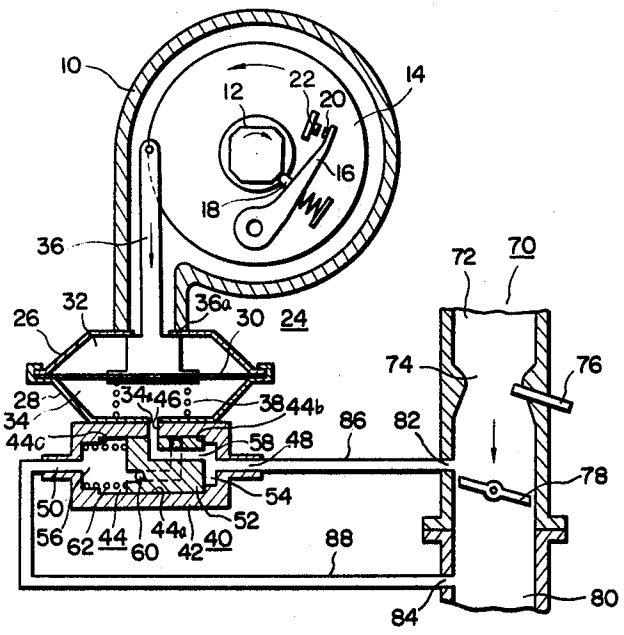
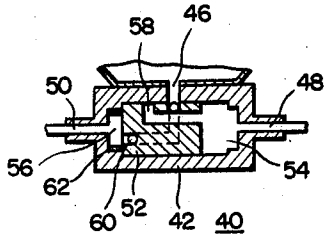



Fig. 2.



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# APPARATUS FOR CONTROLLING IGNITION TIME OF AUTOMOBILE ENGINE

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Int. Cl. F02p 5/10
U.S. Cl. 123—117 8 Claims

## ABSTRACT OF THE DISCLOSURE

The ignition timing of an internal combustion engine having a throttle valve in a fuel intake passage is controlled by a pressure responsive device to which negative pressure is supplied through a single control valve comprising a cylinder having chambers at opposite ends connected with the intake passage on opposite sides of the throttle valve and a floating piston having two passageways communicating respectively with said chambers. According to the running condition of the engine the piston is movable by fluid pressure to bring one or the other of said passageways into communication with a line leading the pressure responsive device.

This invention relates in general to an apparatus for controlling a time point at which an internal combustion engine equipped on an automobile is to be ignited, in accordance with a fuel pressure within a feed fuel line to the engine, and more particularly to improvements in a control valve for use with such an apparatus.

It is well known that the exhaust gas exhausted from any automobile engine during its idling operation and deceleration operation of applying a braking action to automobile wheels, generally contains large amounts of harmful ingredients such as hydrocarbons, carbon monoxide gas, etc., resulting in contamination of the air. It has been reported and sustained by the results of experiments that such harmful ingredients contained in the exhaust gas can reduce in amounts by adjusting an ignition time of an engine to a time point corresponding to a position of the associated piston behind to its upper dead point, for example its position lagging the upper dead point by approximately 10 degrees in terms of the crank angle for the idling operation. For a deceleration operation, the ignition time of the engine has been adjusted to a time point corresponding to a position of the piston sufficiently leading its upper dead point, for example its position in advance of the upper dead point thereof by approximately 20 degrees in terms of the crank angle.

One of apparatus for controlling an ignition time of an automobile engine during its deceleration operation on the basis of the adjustment just described is described and claimed in the corresponding U.S. application Ser. No. 656,580 "Apparatus for Controlling Ignition Time of Automobile Engine" filed on July 27, 1966 by H. Miyazaki et al. and assigned to the same assignee as the present application. According to the above cited application, the apparatus comprises a throttle valve disposed in a feed fuel line to the associated engine, first pressure sensing means communicating with that side of the throttle valve as in its minimum open position remote from the engine to sense a fuel pressure in the feed fuel line on the said throttle side, and second pressure sensing means communicating with that side of the throttle valve as in its minimum open position near to the engine to sense a fuel pressure in the feed fuel line on the last-mentioned throttle side. The arrangement is such that in a deceleration operation of the engine with the throttle valve maintained at its minimum open position the fuel pressure sensed by the first pressure sensing means is effectively for sufficiently putting an ignition time in advance of the upper dead point of the associated piston and that in the normal or an acceleration operation during which a degree of opening the throttle valve is increasing beyond its minimum open position a fuel pressure sensed by the second pressure sensing means is effective for controlling the ignition time to provide an angle of advance in accordance with the open position of the throttle valve and therefore with loading on the engine.



The apparatus just outlined comprises a single pressure responsive device including a single flexible diaphragm to define a single negative pressure chamber along with a housing for the device, and a separate duct connecting each of the pressure sensing means to the negative pressure chamber. This leads to the necessity of disposing one control valve in each of the ducts in order to selectively introduce the pressure sensed by both pressure sensing means into the negative pressure chamber. In other words, a pair of independent control valves are separately disposed in the ducts respectively. Therefore it is necessary to mount a pair of individual control valves to the pressure responsive device in predetermined different positions resulting in both a complicated construction and also an assemblage requiring labor and time.

Accordingly it is an object of the invention to provide an improved apparatus for controlling an ignition time of an automobile engine to decrease amounts of harmful ingredients contained in the exhaust gas from the engine during its deceleration operation which is simple in construction and easily assembled.

It is another object of the invention to provide a new and improved control valve of simple construction for use with the apparatus of the type described in the preceding paragraph.

Briefly, the invention accomplishes the above cited objects by the provision of a control valve structure for use with the apparatus as previously outlined, comprising a cylindrical valve chamber, a valve body in the form of a piston slidably fitted into the valve chamber. The valve body is provided with a pair of independent passageways communicating with the first and second pressure sensing means as previously described respectively and having a first stable operative position where one of the passageways communicates with the above-mentioned negative pressure chamber and a second stable operative position where the other passageway communicates with the negative pressure chamber.

The invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a schematic sectional view, partly in elevation of a control apparatus constructed in the teachings of the invention; and

FIGURE 2 is a schematic sectional view of a control valve shown in FIGURE 1 and illustrated in its operative position different from in FIGURE 1.

Referring now to the drawing and FIGURE 1 in particular, it is seen that within a distribution housing **10** there are disposed a cam **12** rigidly secured on a distributor shaft (not shown), and an apertured support plate **14** surrounding the cam **12** and rotatable in one or the other direction about the axis of the latter. The distributor shaft is adapted to be driven in the direction of the arrow by the associated internal combustion engine through a gearing though they are not illustrated in FIGURE 1. Mounted on the support plate **14** is a contact breaker **16**

including a cam follower **18** engaging the cam **12** and a movable contact **20** controlled by the cam **12** through the cam follower **18** to be contacted by and separated away from a stationary contact **22**. When the movable contact **20** contacts the stationary contact **22** a primary winding of an ignition coil (not shown) is permitted to be energized by a battery (not shown) while upon the movable contact disengaging from the stationary contact **22**, an ignition voltage is generated across a secondary ignition winding (not shown) to ignite one of combustion chambers in the engine. The above-mentioned components are of the conventional construction and need not be further described.

As shown in FIGURE 1, a pressure responsive device generally designated by the reference numeral **24** is disposed externally of the distributor housing **10**. The pressure responsive device **24** comprises a pair of hollow, frusto-conical housings **26** and **28** connected together into a unitary structure as by caulking with the enlarged open ends facing each other and with a flexible diaphragm **30** sandwiched between those enlarged open ends to divide the interior of the housings **26** and **28** into an atmospheric chamber **32** and a negative pressure chamber **34** sealed from the air. A control rod **36** extends from the center of the diaphragm **30** through the atmospheric chamber **32** into the distributor housing **10** for limited longitudinal movement. The control rod **36** has the other end pivotably connected to the support plate **14** at the periphery and serves to rotate the support plate **14** about the axis of the cam **12** for the purpose as will be apparent hereinafter. The control rod **36** has one portion of enlarged diameter extending through the atmospheric chamber **32** and a shoulder **36***a* formed on one end of that enlarged portion to normally abutting against the reduced end face of the atmospheric chamber **32** by the action of a compression spring **38** disposed within the negative pressure chamber **34**.

According to the teachings of the invention a single control valve of transfer type generally designated by the reference numeral **40** is operatively connected to the negative pressure chamber **34** for the purpose of selectively introducing a fuel pressure on either side of a throttle valve disposed in a feed fuel line to the engine, into the negative pressure chamber **34** dependent upon the operating condition of the engine. The control valve **40** includes a hollow cylindrical housing **42** suitably secured on that side of the pressure response device **24** remote from the distributor housing **10** or on the reduced end face of the negative pressure chamber **34** and defining a valve chamber in the form of a cylinder generally designated by the reference numeral **44**. The cylinder **44** has an outlet port **46** disposed on the middle portion of the cylindrical peripheral wall and aligned with an inlet port **34***a* formed on the reduced end face of the negative pressure chamber **34** to communicate with the interior of the latter chamber. The cylinder **44** further has a pair of inlet ports **48** and **50** disposed on the opposite end faces thereof and communicating with a feed fuel line to the engine as will be described hereinafter.

A valve body **52** in the form of a piston is slidably fitted into the cylinder **44** to divide it into two operating spaces **54** and **56**. The valve body **52** is adapted to slide along a cylindrical internal wall surface **44***a* of the cylinder **44** provided adjacent both ends with a pair of annular shoulders **44***b* and *c* respectively serving as stoppers for limiting movement of the valve body **52**. The valve body **52** has disposed therein a pair of passageways **58** and **60** not communicating with each other and opening at one end into the operating spaces **54** and **56** respectively and at the other ends into the peripheral wall surface thereof in such positions that, when the valve body **52** abuts against one of the shoulders **44***b* or *c* one of the passageways opening toward that shoulder abutting against the valve body communicates with the outlet port **46**. More specifically, with the valve body **52** abutting against the shoulder **44***b* as shown in FIGURE 1, the passageway **58** communicates with the port **46** to permit the operating space **54** to communicate with the interior of the negative pressure chamber **34** through the passageway **58**, the outlet port **46** and the inlet port **34***a*. On the other hand, if the valve body **52** abuts against the shoulder **44***c* the other space **56** communicates with the interior of the chamber **34** through the passageway **60**, the ports **46** and **34***a*.

A compressing spring **62** is disposed within the operating space **56** in order to force the valve body **52** to normally abut against the shoulder **44***b* in the opposite space **54**. The position of the valve body **52** where it abuts against the shoulder **44***b* is called a first stable operative position whereas its position where the valve body abuts against the shoulder **44***c* is called a second stable operative position.

In FIGURE 1 the reference numeral **70** generally designates a carburetor schematically shown as a section of pipe and serving to vaporize a fuel to be supplied to the engine (not shown). The carburetor **70** includes a passageway **72** for flowing air through its interior, a Venturi portion **74** where a nozzle **76** for injecting fuel is open and a throttle valve **78** controlled by an accelerator pedal (not shown). The fuel injected from the nozzle **76** is mixed with air passing through the passageway **72** and flows around the throttle valve **78** and through suction pipe **80** to the engine.

The carburetor **70** is further provided with a first and a second pressure sensing unit preferably in the form of apertures extending through its wall on both sides of the throttle valve **78** as in its minimum open position. More specifically, the first pressure sensing unit or aperture **82** opens upstream of the throttle valve **78** with respect to a flow of fuel or on that side thereof as in its minimum position as shown in FIGURE 1, remote from the associated engine (not shown) while the second pressure sensing unit or aperture **84** is downstream of the throttle valve **78** or on that side thereof as in its minimum open position, near to the engine. The second aperture **84** is shown as being provided on the suction pipe **80**. The first and second apertures **82** and **84** communicate with the inlet ports **48** and **50** of the control valve **40** through the respective connecting conduit **86** and **88**.

Pressures of fuel predominating in the first and second pressure sensing units **82** and **84** respectively depend upon loading on the associated engine and may generally be in ranges listed in the following Table I.

TABLE I.—FUEL PRESSURE UNDER VARIOUS OPERATING CONDITIONS OF ENGINE

| Operating Condition | Idling | Declaration | Normal.[1] |
|---|---|---|---|
| First Aperature 82 | 0 | 0 | 0–400 mm. Hg |
| Second Aperature 84 | 400 mm. Hg | 500–700 mm. Hg | 0–350 mm. Hg. |

[1] The term "Normal" means the operating conditions of the engine other than its idling and deceleration operation.

From the above Table I it is seen that during the normal operation including an acceleration operation a negative pressure of fuel predominating in the first pressure sensing unit or aperture **82** is higher than that in the second pressure sensing unit or aperture **84**. Under these

circumstances, the valve body **52** is held in its first stable operative position as illustrated in FIGURE 1 by the action of the compression spring **62**. This permits the pressure of fuel in the first aperture **82** to be transmitted through the conduit **86**, the inlet valve port **48** to the operating space **54** and thence to the negative pressure chamber **34** of the pressure responsive device **24** through the passageway **58**, the outlet port **46** and the inlet port **34***a*. Thus a suction force dependent upon the particular loading on the engine exerts upon the flexible diaphragm **30** against the action of the compression spring **38** to be operated through the control rod **36** and the support plate **14** to advance the operating position of the contact breaker **16** and hence an ignition position of the engine to a predetermined magnitude.

During the idling operation, a pressure in the second pressure sensing aperture **84** is higher than that in the first aperture **82**. Under these circumstances, the valve body **52** is held in its first stable operative position by the action of the compression spring **62**. In other words, the compression spring **62** is designed to have an initial resilience withstanding a negative pressure in the order of 400 mm. Hg.

If the engine is in a deceleration operation a negative pressure predominating in the second pressure sensing aperture **84** becomes high as compared with the idling operation. This permits the valve body **52** to move to its second stable operative position as illustrated in FIGURE 2 against the action of the compression spring **62** where the operating space **56** communicates with the negative pressure chamber **34**. Therefore the negative pressure in the second aperture **84** is similarly transmitted to the chamber **34** to advance the ignition position of the engine in the similar manner as described for the normal operation. It is to be noted that as a negative pressure in the second aperture **84** is higher in a deceleration operation than in the normal or an acceleration operation that an angle of advance in the deceleration operation can be substantially equal to or greater than that in the normal or acceleration operation. For example such an angle may reach the order of 20 degrees in advance of the upper dead point of the associated piston.

From the foregoing it will be apparent that without imparting the angle advance characteristics in the normal or an acceleration operation the aperture as previously described can sufficiently advance the ignition time of the engine during a deceleration operation with the result that the fuel is prevented from incompletely burning during such deceleration operation leading to a great decrease in contents of hydrocarbons, carbon monoxide in the exhaust gas.

Further, as compared with the use of two separate control valves the present apparatus is simple in construction and easily assembled because the conventional type of devices for controlling ignition times is operatively coupled to a single control valve including a single valve body movable between its first stable operative position where a negative pressure of fuel in a first pressure sensing unit is transmitted to a negative pressure chamber and its second stable operative position where a negative pressure of fuel in a second pressure sensing unit is transmitted to the negative pressure chamber. Particularly a valve housing having disposed therein the valve body is secured to a housing defining the negative pressure chamber to eliminate any conduit connecting in fluid communication relationship the valve to the negative pressure chamber.

The valve body has provided therein a pair of passageways opening into its opposed end faces to continuously communicate with the first and second pressure sensing units. Thus the pressures of fuel in both units are always applied to both end faces of the valve body to control the position of the latter to selectively communicate both units with the negative pressure chamber in simple manner. This causes simplification of the valve construction.

While the invention has been illustrated and described in conjunction with a single preferred embodiment thereof it is to be understood that various changes and modifications in the details of construction and the combination and arrangement of parts and elements may be resorted to without departing from the spirit and scope of the invention. For example, if the passageway **58** in the valve body **52** may communicate with the first pressure unit **82** through another connection means, the atmospheric chamber **32** may open directly into the surrounding air. In this case only the pressure of fuel in the second pressure sensing aperture **84** controls the position of the valve body **52**.

What I claim is:

**1.** An apparatus for controlling an ignition time of an automobile engine, comprising

(1) a pressure responsive device including a negative pressure chamber and operative to control an ignition time of the engine in accordance with a pressure predominating in said negative pressure chamber,

(2) a throttle valve disposed in a feed fuel line to the engine,

(3) a first pressure sensing unit communicating with said feed fuel line on that side of said throttle valve remote from the engine to sense a pressure of fuel on said side of said throttle valve,

(4) a second pressure sensing unit communicating with said feed fuel line on that side of said throttle valve near to the engine to sense a pressure of fuel on the last-mentioned side of said throttle valve, and

(5) a control valve device operatively coupled to said pressure responsive device and including a cylindrical valve chamber, and a spring biased cylindrical valve body movably disposed with said valve chamber and having a first and a second stable operative position,

(6) a communicating port provided on said valve chamber communicating with the said negative pressure chamber,

(7) a first passageway extending through said valve body continuously communicating with said first pressure sensing unit and capable of communicating with said communicating port when said valve body is in said first stable operative position, and

(8) a second passageway extending through said valve body so as not to communicate with said first passageway, and continuously communicating with said second pressure sensing unit, said second passageway being capable of communicating with said communicating port when said valve body is in said second stable operative position.

**2.** An apparatus for controlling an ignition time of an automobile engine as claimed in claim **1**, comprising

a flexible diaphragm in said pressure responsive device responsive to a pressure predominating in said negative pressure chamber,

a cam driven by the engine,

a support plate rotatable about the axis of said cam,

a contact breaker mounted on said support plate and controlled by said cam, and

a control member connecting said diaphragm to said support plate.

**3.** An apparatus for controlling an ignition time of an automobile engine as claimed in claim **1**, further comprising a housing defining said negative pressure chamber, said control valve device rigidly secured to said housing, and an inlet port formed on said housing so as to be aligned and communicate with said communicating port on said valve chamber.

**4.** An apparatus for controlling an ignition time of an automobile engine as claimed in claim **1**, wherein said valve body is responsive to a pressure in said second pressure sensing unit such that said valve body occupies said first stable operative position during an acceleration opera-

tion of the engine and said second stable operative position during a deceleration operation of the engine.

5. An apparatus for controlling an ignition time of an automobile engine comprising

(1) a pressure responsive device including a negative pressure chamber and operative to control an ignition time of the engine in accordance with a pressure predominating in said negative pressure chamber,

(2) a throttle valve disposed in a feed fuel line to the engine,

(3) a first pressure sensing unit communicating with said feed fuel line on that side of said throttle valve remote from the engine to sense a pressure of fuel on said side of said throttle valve,

(4) a second pressure sensing unit communicating with said feed fuel line on that side of said throttle valve near to the engine to sense a pressure of fuel on the last-mentioned side of said throttle valve,

(5) a control valve device operatively coupled to said pressure responsive device and including a cylindrical valve chamber, and a valve body movably disposed within said valve chamber and having a first and a second stable operative position, said valve body having a pair of opposed end faces bearing pressure in said first and second pressure sensing units respectively such that said valve body occupies said first stable operative position during an acceleration operation of the engine and said second stable operative position during a deceleration operation of the engine,

(6) a communicating port provided on said valve chamber to communicate with said negative pressure chamber,

(7) a first passageway extending through said valve body between the peripheral surface and one of said end faces thereof to continuously communicate with said first pressure sensing unit, said first passageway being capable of communicating with said communicating port when said valve body is in said first stable operative position, and

(8) a second passageway extending through said valve body between the peripheral surface and the other end face but not communicating with said first passageway, said second passageway continuously communicating with said second pressure sensing unit



and also being capable of communicating with said communicating port when said valve body is in said second stable operative position.

6. An apparatus for controlling an ignition time of an automobile engine as claimed in claim 5, further comprising a compression spring tending to normally force said valve body to said first stable operative position, said valve body being movable to said second stable position against the action of said compression spring, said compression spring preventing said valve body from moving to said second stable position under the pressures in the respective pressure sensing units during the idling operation of the engine.

7. An apparatus for controlling an ignition time of an automobile engine as claimed in claim 5, further comprising

a flexible diaphragm in said pressure responsive device responsive to a pressure predominating in said negative pressure chamber,

a cam driven by the engine,

a support plate rotatable about the axis of said cam,

a contact breaker mounted on said support plate and controlled by said cam, and

a control member connecting said diaphragm to said support plate.

8. An apparatus for controlling an ignition time of an automobile engine as claimed in claim 5, further comprising a housing defining said negative pressure chamber, said control valve device rigidly secured to said housing, and an inlet port formed on said housing to be aligned and communicate with said communicating port on said valve chamber.

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