United States Patent

[11] 3,626,455

[72] Inventors **Yoshio Toda; Mitsutaka Konno, both of Yokohama; Masao Nakajima, Kawasaki; Toshitake Kikuchi, Yokohama, all of Japan**

[21] Appl. No. **882,532**
[22] Filed **Dec. 5, 1969**
[45] Patented **Dec. 7, 1971**

[73] Assignee **Nissan Motor Company, Limited Yokohoma, Japan**

[32] Priorities **Dec. 10, 1968**
[33] **Japan**
[31] **43/90054; Dec. 10, 1968, Japan, No. 43/90055; Feb. 5, 1969, Japan, No. 44/8257**

[54] **IGNITION TIMING RESPONSIVE TO TRANSMISSION SETTING**
1 Claim, 19 Drawing Figs.

[52] **U.S. Cl.** ..... **74/860,** 123/117 R, 123/146.5 A
[51] **Int. Cl.** **B60k 21/00,** F02p 5/00, B60k 33/00
[50] **Field of Search** ..... 74/860; 123/117, 117.1, 146.5 A

[56] **References Cited**

UNITED STATES PATENTS

3,547,088	12/1970	Yagi et al.	123/146.5 AX
3,556,064	1/1971	Yamazaki et al.	123/117 R
1,861,417	5/1932	Klaiber	123/146.5 A
2,673,474	3/1954	Boyce	74/860
2,712,814	7/1955	Harr	123/117 X
3,252,450	5/1966	Dietrich et al.	123/117.1
3,320,770	5/1967	Bevacqua	123/117 X
3,327,553	6/1967	Peras	123/117 UX

Primary Examiner—Carlton R. Croyle
Assistant Examiner—Thomas C. Perry
Attorney—John Lezdey

ABSTRACT: An ignition system of which the ignition distributor has two interruptors, one for providing an ignition timing suited to provide a maximum engine power output at full engine load and a minimum fuel consumption at light engine loads and the other providing an ignition timing retarded from the timing dictated by the former interruptor, the latter interruptor being connected with the ignition coil through a control switch operating in accordance with the transmission setting, vehicle speed, engine speed vacuum in the throttle chamber of the carburetor or in the intake manifold of the engine, angular position of the throttle valve in the carburetor or combination of two or more of these factors.

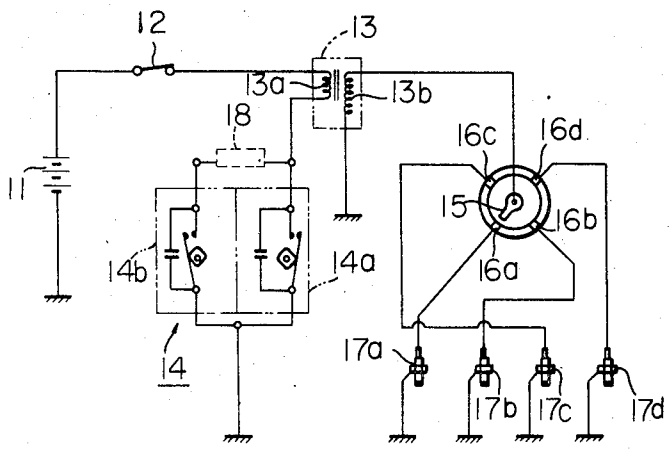


Fig. 1

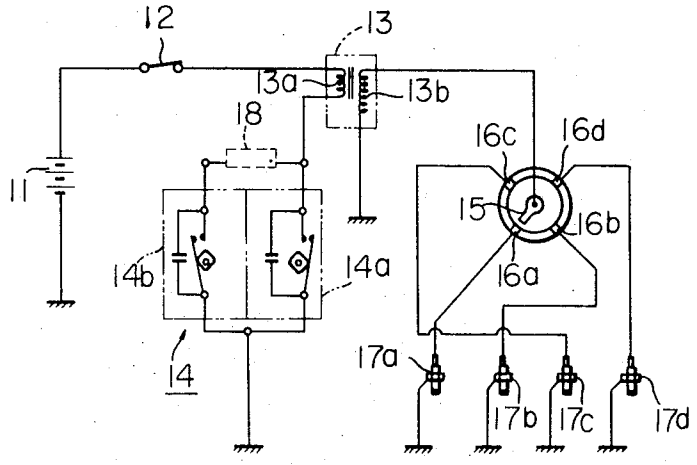
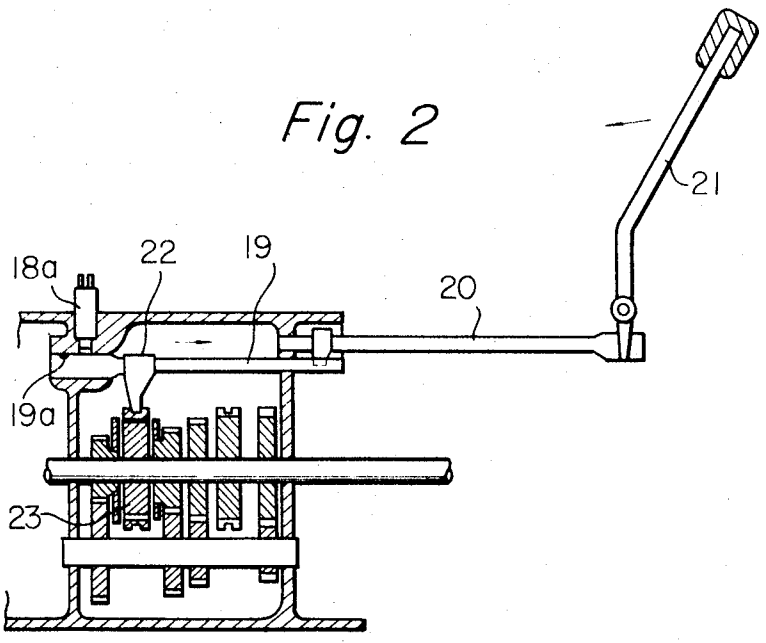


Fig. 2



INVENTORS
Yoshio Toda, Mitsutaka Konno, Masao Nakajima & Toshitake Kikuchi
BY
John Langley
ATTORNEY

Fig. 3

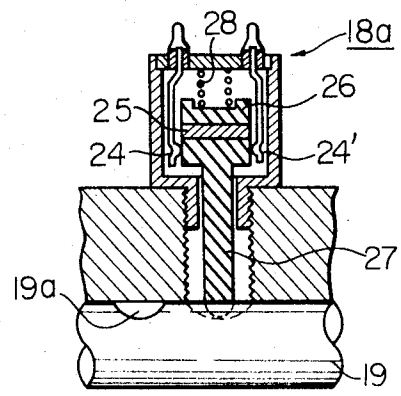


Fig. 4

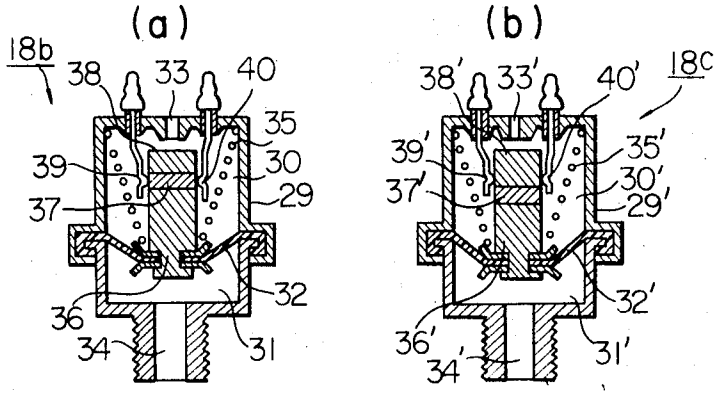
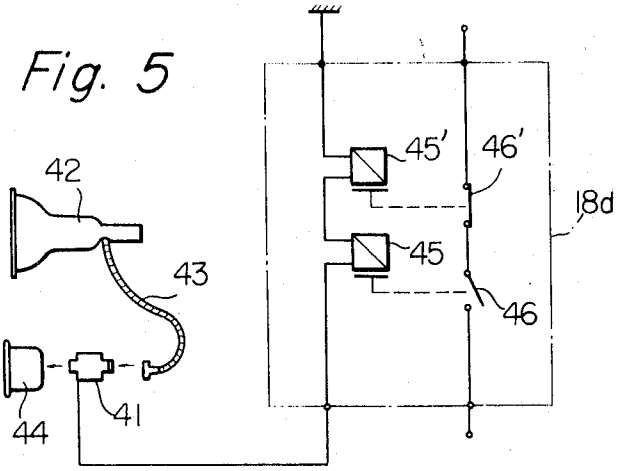


Fig. 5



INVENTORS

Yoshio Toda, Mitsutaka Konno, Masao Nakajima & Toshitake Kikuchi

BY

John Lezdey

ATTORNEY

Fig. 6

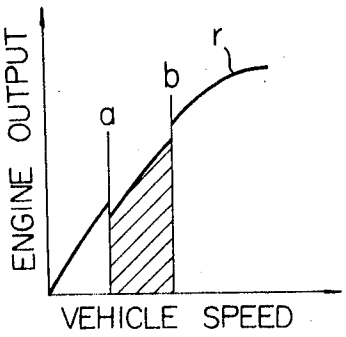


Fig. 7

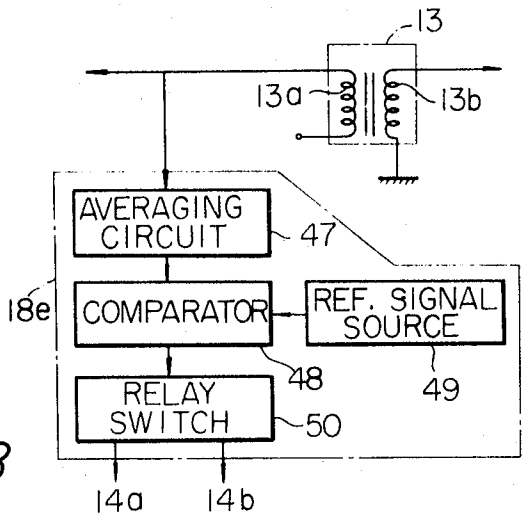


Fig. 8

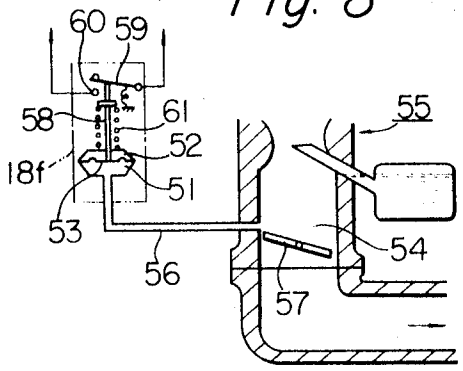


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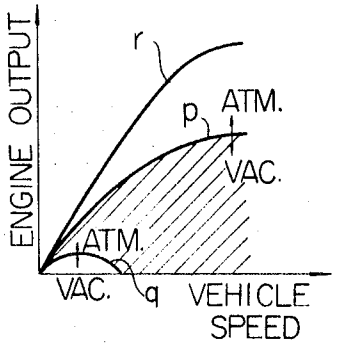
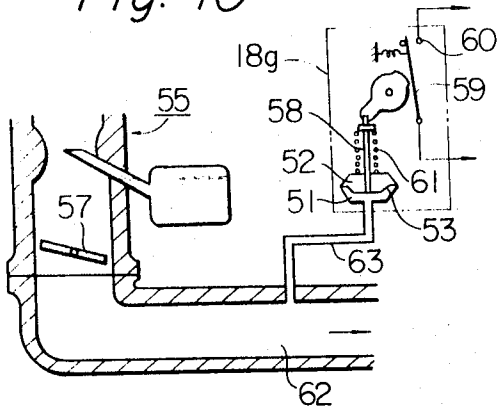


Fig. 10



INVENTORS

Yoshio Toda, Mitsutaka Konno, Masao Nakajima + Toshitake Kikuchi

BY John Lezdey

ATTORNEY

Fig. 11

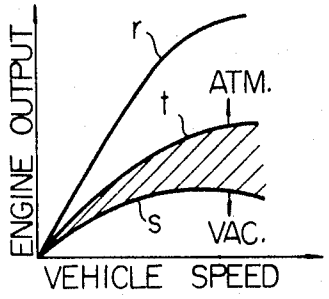


Fig. 12

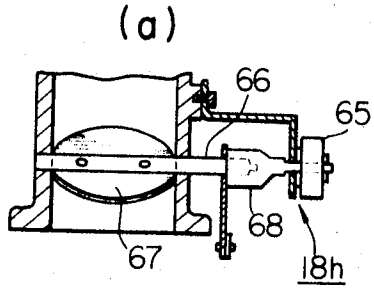


Fig. 13

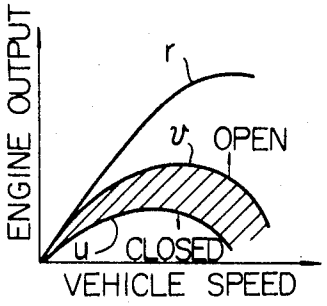


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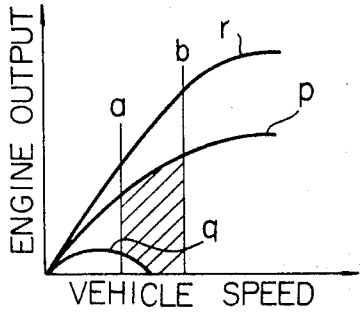
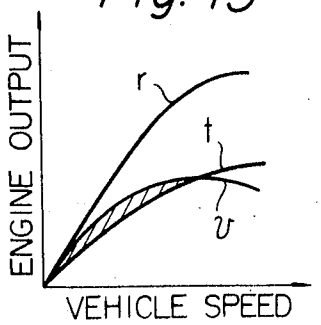


Fig. 15



INVENTORS

Yoshio Tuda, Matsutaka Konno, Masao Nakajima + Toshitake Kikuchi

BY

John Lezolley

ATTORNEY

Fig. 16

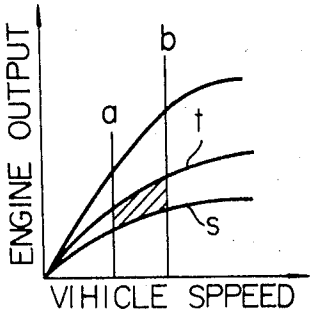
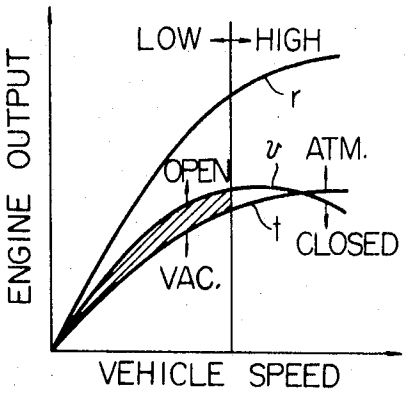


Fig. 17



INVENTORS
Yoshio Toda, Mitsutaka Konno, Masao Nakajima + Toshitake Kikuchi
BY
John Lezdey
ATTORNEY

IGNITION TIMING RESPONSIVE TO TRANSMISSION SETTING

This invention relates to an ignition system of an automotive internal combustion engine and, more particularly, to an ignition timing system of the nature adapted to retard the ignition timing when the motor vehicle is driven under predetermined conditions. The ignition timing system proposed by this invention is specifically intended to minimize the percentage of an unburned content of an air-fuel mixture in the exhaust gas from the engine.

The instants at which the ignition is timed are usually so determined as to provide a maximum of power output of the engine operating at a full load and a minimum of power consumption at light engine loads. The ignition timing determined in this manner, however, is known to be inappropriate from the view point of reducing the unburned residues (mostly of hydrocarbons) in the exhaust gas to a minimum.

The presence of unburned or partially burned content in the exhaust gas emitted from the engine is, as is well known, ascribed to the fact that the air-fuel mixture ignited in the combustion chamber of the engine is brought into contact with the less hot wall surfaces of the cylinder head, piston, gasket and cylinder block of the combustion chamber and accordingly that the temperature of the portion of the air-fuel mixture in contact with such wall surfaces is momentarily lowered. This particular portion of the air-fuel mixture, thus cooled down in the combustion chamber, remains unburned as it leaves the combustion chamber and, as a result, is exhausted to the open air as unburned toxic pollutants. In order to have the air-fuel mixture fully burned before the exhaust gas is discharged out of the engine, it will prove advantageous to have the ignition timing retarded for a suitable period of time in each combustion cycle. The thus retarded ignition timing will, however, be reflected by reduction in the maximum power output of the engine at full load and increase in the fuel consumption at light engine loads.

Whereas, the seriousness of the influence of air pollution problems varies according to geographical areas and it is particularly in urban districts with concentrated population that the emission of unburned toxic pollutants should be minimized. In recognition of this fact, we have found a tendency that a motor vehicle is usually driven at lower speeds on city roads and at higher speeds on expressways and suburban streets. This will imply that, if the ignition timing is retarded while in the city-road driving of the motor vehicle, the percentage of unburned hydrocarbons contained in the exhaust gas could be reduced without sacrifice to the engine power output and fuel economy throughout the varying driving conditions of the vehicle. In this instance, it should be remembered that the amount of unburned air-fuel mixture in the exhaust gas increases as the vehicle speed decreases.

Thus, the invention contemplates provision of an ignition timing system whereby the ignition timing is retarded under predetermined driving conditions of the vehicle while, in the remaining driving conditions, the ignition is timed in a usual manner to provide for a maximum power output at full engine load and a minimum fuel consumption at light engine loads.

It is therefore an object of the invention to provide an ignition timing system adapted to reduce the emission of unburned toxic pollutants of hydrocarbons without impairing the engine power output and fuel economy throughout the varying driving conditions of the vehicle.

It is another object of the invention to provide an ignition timing system whereby the ignition is timed, under predetermined driving conditions of the motor vehicle, with a certain period of delay from an ignition timing which is so determined as to provide a maximum power output of the engine at full load and a minimum fuel consumption at light engine loads.

It is still another object of the invention to provide an ignition timing system whereby a normal ignition timing is retarded in accordance with suitable control factors representing certain driving conditions of the motor vehicle while in the city-road driving.

A usual ignition system has a battery, switch, ignition distributor, ignition coil, spark plugs, and wiring. The ignition distributor has dual functions. First, it closes and opens a circuit between the battery and ignition coil. When the circuit closes, current flows in the ignition coil and builds up a magnetic field. When the circuit opens, the magnetic field in the coil collapses and a high-voltage surge of current is produced by the coil. The second function of the ignition distributor is to distribute each high-voltage to the correct spark plug at the correct instant by means of a distributor rotor and secondary winding of the ignition coil.

According to the invention, the ignition distributor has a first and second interruptors connected in parallel to the ignition coil, the first interruptor being arranged to provide a normal ignition timing and the second interruptor to provide a retarded ignition timing. Between the second interruptor and primary winding of the ignition coil is connected a control switch which, when closed, control the second interruptor to have the ignition timing retarded under predetermined driving conditions of the motor vehicle.

The control factors governing the actuation of the control switch may be any of the vehicle speed, engine speed, vacuum level at the intake manifold of the engine, angular position of the throttle valve in the carburetor, and combination of two or more of these factors. Where the vehicle speed, in particular, is to be utilized, it may be represented by a selected gear ratio or, more specifically, by the position of the speed selector lever if the timing system is used together with a manually controlled transmission system and by the hydraulic pressures applied to the front and rear clutches if the timing system is used with an automatic transmission system.

FIG. 1 shows schematically the overall electrical arrangements of the ignition system incorporating the ignition timing system according to the invention;

FIG. 2 is a sectional view showing essential parts of a manually controlled transmission system with an ignition timing control switch of the invention mounted thereon;

FIG. 3 is a sectional view showing, on an enlarged scale, the control switch mounted on the transmission system shown in FIG. 2;

FIGS. 4–(*a*) and –(*b*) are sectional views showing front and rear clutch piston switches, respectively, of an ignition timing system used in a motor vehicle having an automatic transmission system;

FIG. 5 shows schematic arrangements of another form of the ignition timing control switch used together with an automatic transmission system;

FIG. 6 is a graphical representation of a relationship between the engine power output and vehicle speed attained where the ignition timing system previously shown is used;

FIGS. 7 and 8 are schematic views illustrating further modified forms of the control switch used in the device according to the invention;

FIG. 9 shows a relationship between the engine power output and vehicle speed attained where the system shown in FIG. 8 is used;

FIG. 10 is a schematic view showing a further modified form of the ignition timing control switch;

FIG. 11 shows a relationship between the engine power output and vehicle speed attained where the system shown in FIG. 10 is used;

FIG. 12–(*a*) and –(*b*) are sectional views of a further modified form of the ignition timing control switch;

FIG. 13 shows a relationship between the engine power output and vehicle speed attained where the control switch shown in FIG. 12 is used; and

FIGS. 14 to 17 show relationships between the engine power output and vehicle speed attained where still further modified forms of the control switches are used.

Referring to FIG. 1, the ignition system as shown by way of example has a battery 11, ignition switch 12, ignition coil 13, ignition distributor 14, distributor rotor 15, electric contacts 16*a* to 16*d*, spark plugs 17*a* to 17*d*, and wiring connecting

these elements with each other. The ignition coil **13** has a primary and secondary windings **13***a* and **13***b*. The primary winding **13***a* is connected at one terminal with the battery **11** through the ignition switch **12**. The ignition distributor **14** has an interruptor **14***a* which is connected with the other terminal of the primary winding **13***a* of the ignition coil **13** and which is so arranged as to actuate the ignition coil **13** at an instant to provide a usual ignition timing. The second winding **13***b* of the ignition coil **13** is grounded at one terminal and is connected at the other with the distributor rotor **15**. The rotor **15** is selectively operatively connected to the contacts **16***a* to **16***d* disposed therearound. The contacts **16***a* to **16***d*, in turn, are connected with the spark plugs **17***a* to **17***d*, respectively, as shown.

According to the invention, the interruptor **14** is shunted by a second interruptor **14***b* through a control switch means **18**. The interruptor **14***b* is arranged in a manner to actuate the ignition coil **13** only when the switch means **18** is kept closed so as to provide an ignition timing retarded from the timing to be otherwise determined by the first interruptor **14***a*. More specifically, when the switch means **18** is closed, then the first interruptor **14***a* first opens with the second interruptor **14***b* kept closed. The primary winding **13***a* of the ignition coil **13** thus remains excited to induce no voltage in the secondary winding **13***b*. As soon as the second interruptor **14***b* opens, then a voltage is induced in the secondary winding **13***b* to effect an ignition. It is thus the second interruptor **14***b* which determines the ignition timing in this instance.

The control switch means may be constructed and arranged in different manners depending upon the control factors selected to govern the ignition timing during the city-road driving of the motor vehicle.

Although a variety of control factors may be conceivable, the invention proposes to use, as preferable any of the vehicle speed, engine speed, vacuum level at the intake manifold of the engine, angular position of the throttle valve in the carburetor, and combination of one or two of these factors.

Where the vehicle speed, in particular, is to be utilized, it may be preferable to have the control switch means **18** kept closed at lower vehicle speeds (such as the first, second and third speeds in a four-shift transmission, for instance) and open at higher vehicle speeds (such as the top or fourth speed). In this instance, the vehicle speed may be indexed as the position of the speed selector lever or as the position of the fork rod in the power train, if the ignition system is to be used together with a manually controlled transmission system. If, on the other hand, the transmission system is of automatically controlled type, the control switch may be controlled by the fluid pressures in the hydraulic control circuits in the transmission system.

In consideration of the fact that a motor vehicle is usually driven at the first and second speeds for only limited periods of time and accordingly that the aggregate amount of unburned pollutants emitted while the vehicle is running at these particular speeds can be deemed practically negligible, the control switch herein described and shown is exemplified as being closed only when the third speed is selected.

Now, FIGS. **2** and **3** illustrate an example in which the position of the fork rod in the transmission system is utilized to actuate the control switch.

In FIG. **2**, the transmission system, which is shown to be in its neutral position, has a fork rod **19** which is operatively connected through a striking rod **20** to a speed selector lever **21**, as customary. The fork rod **20** is also connected rigidly to a shifting rod **22** to selectively couple and uncouple the transmission gears (not numbered) through a coupling sleeve **23** as the striking rod **20** is moved back and forth by the selector lever **21**.

A recess **19***a* is provided in the peripheral wall of the fork rod **19** at a position suited to detect the third speed selected by the movement of the fork rod **19**.

As best seen in FIG. **3**, a control switch means which is generally designated by **18***a* is provided to work in association with the fork rod **19** having such recess **19***a*. The control switch **18***a* as shown has stationary contacts **24** and **24'** connected respectively with the primary winding **13***a* of the ignition coil **13** and the second interruptor **14***b* of the ignition distributor **14** (FIG. **1**). The switch **18***b* also has a moving contact **25** which is rigidly interposed between an insulating member **26** and moving member **27** extending toward the fork rod **19**. The moving member **27** is usually forced against the peripheral wall of the fork rod **19** by the action of a spring **28** mounted behind the insulating member **26**.

The control switch **18***a* being thus constructed, the moving contact **25** remains isolated from the stationary contacts **24** and **24'** when the moving member **27** is held in its retracted position, i.e., in the abutting engagement with the peripheral wall of the fork rod **19**. When, however, the fork rod **19** is moved by the lever **21** to select the third speed gear ratio (FIG. **2**), the moving member **27** is captured at its leading end by the recess **19***a* due to the action of the spring **28**. Thus, the moving member **27** protrudes into the recess **19***a* to permit the moving contact **25** to abut against the stationary contacts **24** and **24'**, connecting the interruptor **14***b* with the primary winding **13***a* of the ignition coil **13** (FiG. **1**).

If it is desired to have the control switch **18***a* closed at two or more vehicle speeds, there may be provided two or more recesses in the peripheral wall of the fork rod **19**.

Where, now, the ignition timing system according to the invention is to be installed in a motor using an automatic transmission system, the control switch may be actuated in accordance with changes in the fluid pressures in the hydraulic control circuit of the transmission system.

The fluid pressures occurring at the actuating elements of the brakes and clutches of an automatic transmission system are known to vary with the speed ranges as indicated, as typical, in table I, in which the sign "X" refers to a fluid pressure lower than 0.5 kg./cm^2.

TABLE I

Speed range	Hydraulic control circuit elements I	II	III	IV	V	Fluid pressures occurring at "0" in kg./cm.^{2}
Parking	X	X	X	X	O	3-10
Reverse	O	X	X	O	O	4-12
Neutral	X	X	X	X	X	
Drive, 3d	O	O	O	O	X	3-10
Drive, 2d	X	O	O	X	X	3-10
Drive, 1st	X	O	X	X	X	3-10

NOTE.—I = Front clutch piston; II = Rear clutch piston; III = Brake band, applying; IV = Brake band, releasing; V = Low-reverse brake piston.

Remarks: "I" = Front clutch piston
"II" = Rear clutch piston
"III" = Brake band, applying
"IV" = Brake band, releasing
"V" = Low-reverse brake piston

If, therefore, it is desired to have the ignition timing retarded in the first and second drive ranges of the vehicle speed, the control switch means shown by **18** in FIG. **1** may be a combination of two hydraulically operative switches to respond to changes in the fluid pressures applied to the front and rear clutch pistons, one of the switches opening responsive to a rise in the fluid pressure at the front clutch piston and the other opening responsive to a rise in the fluid pressure at the rear clutch piston. With the two switches combined in series with each other, "ON" and "OFF" signals are made available as shown in table II.

TABLE II

Speed range	Front clutch piston switch	Rear clutch piston switch	Combination of two switches
Parking	On	Off	Off.
Reverse	Off	Off	Off.

TABLE II – Continued

Speed range	Front clutch piston switch	Rear clutch piston switch	Combination of two switches
Neutral	On	Off	Off.
Drive, 3rd	Off	On	Off.
Drive, 2nd	On	On	On.
Drive, 1st	On	On	On.

Preferred constructions of the front and rear clutch piston switches are illustrated in FIGS. 4–(*a*) and –(*b*). First referring to FIG. 4–(*a*), the front clutch piston switch **18***b*, which is shown as closed, has a housing **29**. The housing **29** is divided into two chambers **30** and **31** by a diaphragm member **32**. The chamber **30** is an atmospheric chamber which is opened to the air through an aperture **33** and the chamber **31** is a fluid chamber communicating with the piston chamber (not shown) of the front clutch piston through a conduit **34**. The diaphragm member **32** is usually forced away from the atmospheric chamber **30** by the action of a spring **35** mounted in the chamber **30** and having a tension strength to overcome a predetermined pressure applied to the diaphragm member **32** through the conduit **34**. With the diaphragm member **32** is integrally mounted a moving member **36** extending into the atmospheric chamber **30**. The moving member **36** may be made of an insulating material. A moving contact **37** is rigidly mounted on the moving member **36** and the moving contact **37** is, in turn, connected to an insulating member **38** on its side remote from the moving member **36**. Stationary contacts **39** and **40** are mounted on the housing **29** in a manner to usually contact the moving contact **37** when the diaphragm member **32** is held in a position remotest from the stationary contacts **39** and **40**, as shown. These stationary contacts **39** and **40** are respectively connected to the primary winding **13***a* of the ignition coil **13** and the second interruptor **14***b* of the ignition distributor **14**. Thus, the front clutch piston switch **18***b* is kept closed when the fluid pressure applied to the diaphragm member **32** yields to the tension strength in the spring **35**.

When, however, the fluid pressure applied to the front clutch piston is increased to a predetermined level thereby to couple the front clutch (not shown), then the diaphragm member **32** is forced toward the atmospheric chamber **30** against the action of the spring **35** until the moving contact **37** leaves the stationary contacts **39** and **40**. The switch **18***b* is opened in this manner as a higher fluid pressure is applied to the front clutch piston.

The rear clutch piston switch, which is denoted generally as **18***c* in FIG. 4–(*b*), is essentially similar in construction to the front clutch piston switch **18***b* and, as such, the elements corresponding to those appearing in FIG. 4–(*a*) are numbered similarly with primes suffixed to the reference numerals used in FIG. 4–(*a*).

The rear clutch piston switch **18***c* differs from the switch **18***b* only in that the stationary contacts **39'** and **40'** are located in a manner to usually contact the insulating member **38°** when the diaphragm member **32'** is held in a position remotest from the stationary contacts **39'** and **40'**. Thus, the rear clutch piston switch **18***c* is kept opened when the fluid pressure applied to the diaphragm member **32'** yields to the tension strength in the spring **35'**. When, however, the fluid pressure in the conduit **34'** increases to a predetermined level thereby to couple the rear clutch (not shown), then the tension strength in the spring **35'** is overcome by the pressure applied to the diaphragm member **32'** so that the moving contact **37'** is moved complete with the moving member **36'** and contacts the stationary contacts **39'** and **40'**.

It will be understood that, as the fluid pressure is kept under a predetermined level at the front clutch piston and is increased to a predetermined level at the rear clutch piston, both of the switches **18***b* and **18***c* are closed to actuate the coil **13**. The ignition at the first or second speed in the drive range is thus timed by the second interruptor **14***b* through the switches **18***b* and **18***c* at an instant retarded from the usual timing dictated by the first interruptor **14***a* (FIG. **1**).

As an alternative to the combination of the front and rear clutch piston switches **18***b* and **18***c*, the control switch means **18** may be constituted as a switch responsive to the vehicle speed detected at the output shaft (not shown) of the transmission system. If, in this instance, it is desired to have the ignition timing retarded while the vehicle is driven at an intermediate speed, the control switch means may be constructed as to detect a predetermined limited range of the vehicle speeds and to be closed only in this particular range. An example of such switch means is illustrated in FIG. **5**.

In FIG. **5**, the switch generally designated as **18***d* is connected with a speed detector **41** detecting the vehicle speed selected by the transmission system **42** through a speed meter cable **43**. Indicated by **44** as connected to the speed detector **41** is a speed meter **44** to visually display the selected speed.

The switch **18***d* per se may be constructed in some suitable manners and the electrical arrangement as shown is presented solely for illustrative purpose.

As illustrated, the switch **18***d* has two relay switches **45** and **45'** connected in series with each other. The relay switches **45** and **45'** have contacts **46** and **46'**, respectively, which also are connected in series with each other.

The relay switch **45** is a normally-open relay switch, which is arranged to close the contact **46** when energized with a voltage in excess of a predetermined lower limit. The relay switch **45'**, on the other hand, is a normally-closed relay switch, which opens the contact **46'** when energized with a voltage exceeding a predetermined upper limit. The control switch **18***d* so constructed is kept closed only when the vehicle is driven at a speed within a range corresponding with the range between the upper and lower limits of the voltage applied to the relay switches **45** and **45'**. Thus, if these upper and lower limits are determined in a manner to correspond with the upper and lower limits, respectively, of the intermediate speed range, then the ignition coil **13** (FIG. **1**) will be excited only when the vehicle is driven at a speed falling within this particular range.

The ignition timing retarded in this manner will provide a relationship between the vehicle speed and engine power output as shown in FIG. **6**. The plot "*r*" in FIG. **6** indicates the variation of the power output of an engine at full load with respect to the vehicle speed and the area defined by the curve and abscissa includes all the operating conditions of the motor vehicle. The hatched area intervening between the lines "*a*" and "*b*" stands for the intermediate speed range of the vehicle.

When the vehicle is driven in the conditions falling within the hatched area, the interruptor **14***b* is initiated into action to have the ignition timing retarded, thus achieving the purpose of reducing the emission of unburned air-fuel mixture without critically affecting the engine performance. When, on the other hand, the vehicle is driven under conditions falling without the hatched area of FIG. **6**, then the ignition is timed at usual instants determined by the first interruptor **14***a* (FIG. **1**) so that a maximum power output at full engine load and a minimum fuel consumption at light engine loads can be assured.

Now, if preferred, the ignition timing in the ignition timing system according to the invention may be controlled in accordance with the engine speed.

As the primary winding **13***a* of the ignition coil **13** is deenergized with either of the interruptors **14***a* and **14***b* actuated, a pulse voltage corresponding to the engine speed is induced across the primary winding **13***a*. This pulse voltage may advantageously be utilized to control the ignition timing control switch, electrical arrangement of an example being illustrated in FIG. **7**.

As shown in FIG. **7**, the control switch which is represented generally by **18***e* has an averaging circuit **47** connected with the primary winding **13***a* of the ignition coil **13**. The averaging circuit **47** is adapted to average the pulse voltage derived from the primary winding **13***a*. A comparator **48** is connected with the averaging circuit **47** to compare the voltage from the averaging circuit with a reference voltage supplied from a reference signal source **49** connected to the comparator. The

comparator 48 is connected to a relay switch 50 and delivers a control signal to the relay switch 50. The relay switch 50 has two output terminals connected with the first and second interruptors 14*a* and 14*b*.

The voltage delivered from the averaging circuit 47 is a DC voltage substantially proportional to the engine speed so that the signal voltage appearing at the output of the comparator 48 represents a specific range of the revolution speed of the engine (not shown). Thus, if the reference signal voltage supplied from the reference signal voltage 50 is determined in a manner to permit the comparator 48 to deliver a signal voltage only when the engine is operating at a speed substantially corresponding to the intermediate speed of the vehicle, the second interruptor 14*b* of the distributor 14 can be closed when the vehicle is driven at a speed within the intermediate speed range.

It will be understood that the circuit arrangement shown in FIG. 7 is for illustration only and that different modifications will be carried out to selectively actuate the first and second interruptors 14*a* and 14*b*.

FIG. 8 shows a further modified example of the ignition control switch which can be used in the ignition system according to the invention. The control switch generally indicated by 18*f* is so arranged as to be actuated by the vacuum at the throttle chamber of the carburetor which varies in dependence upon the vehicle speed.

As shown, the control switch 18*f* if constituted as a diaphragm switch and has a vacuum chamber 51 and atmospheric chamber 52 separated from the former by a diaphragm member 53. The atmospheric chamber 52 is opened to the air and the vacuum chamber 51 communicates with the throttle chamber 54 of the carburetor 55 through a conduit 56. The conduit 56 may preferably debouch into the carburetor at a position close t the peripheral edge of the throttle valve 57 fully closed. A connecting member 58 is mounted on the diaphragm member 53, extending outwardly through the atmospheric chamber 52. A set of moving and stationary contacts 59 and 60 respectively is positioned relative to the leading end of the connecting member 58. The diaphragm member 53 is usually forced away from the vacuum chamber 51 by the action of a spring 61. The moving contact 59 is consequently forced away from the stationary contact 60. The control switch 18*f* is, in this manner, kept open in a normal state, that is, when the vacuum in the vacuum chamber 51 is not high enough to overcome the compression by the spring 61.

If, therefore, the spring 61 is so selected as to yield to a predetermine force exerted to the diaphragm member 53 by the vacuum in the vacuum chamber 51, then the control switch 18*f* will be closed when the vacuum in the throttle chamber 54 is maintained within a predetermined range.

The conditions in which the vehicle is driven with the vacuum in the throttle chamber maintained in such range is illustrated by way of example in FIG. 9. In FIG. 9, curves *p* and *q* stand for the relationship between the engine power output and vehicle speed to maintain at a constant level the vacuum in the throttle chamber. These two curves are dictated by the angular position of the throttle valve 57 and vehicle speed. The curve *r* shows the power output at full engine load.

Thus, if the control switch 18*f* is arranged in a manner to close when the vacuum in the throttle chamber falls within the hatched area defined by the curves *p* and *q* and abscissa, then the ignition timing will be retarded only when the vehicle is driven under the driving conditions falling within the range corresponding to the hatched area, thereby achieving the purpose of reducing the amount of unburned content in the exhaust gas discharged from the engine. When, on the other hand, the vehicle is driven under conditions outside the hatched area, then the engine will be driven with maximum power output at full load and with minimum fuel consumption at light loads.

If desired, the vacuum may be delivered from the intake manifold of the engine, an example being illustrated in FIG. 10.

The modified control switch 18*g* as shown in FIG. 10 is also constructed as a diaphragm switch which is essentially similar to the control switch 18*f* shown in FIG. 8 and, as such, corresponding elements are designated by like numerals. In the control switch 18*g*, however, the vacuum chamber 51 is arranged to communicate with the intake manifold 62 through a conduit 63 and the moving contact 59 is moved by means of a cam 64 operatively connected with the connecting member 58, as shown. The control switch 18*g* so constructed is closed when the intake manifold vacuum is maintained at a level falling within a predetermined range. This range of the vacuum in the intake manifold may be determined in numerous manners as will be observed from FIG. 11. In FIG. 11, the hatched area represents the conditions in which the vehicle is driven with the intake manifold vacuum maintained between predetermined upper and lower limits shown respectively by curves *s* and *t*. Thus, if the control switch 18*g* is constructed to close only when the vehicle is driven under the conditions represented by the hatched area, the ignition timing will be retarded under the particular driving conditions of the vehicle.

The ignition control switch used in the ignition system according to the invention may be actuated, if preferred, in accordance with the angular position of the throttle valve, i.e., the aperture at the throttle chamber of the carburetor as illustrated in FIG. 12.

As shown in FIG. 12, the ignition timing control switch 18*h* has a cam 65 having an enlarged peripheral edge portion 65*a*. The cam 65 is connected to and rotated by the shaft 66 of the throttle valve 67 through a connecting member 68. A switch arm 69 is mounted pivotally at one end 69*a* thereof and is held in abutting engagement with the peripheral edge of the cam 65. Near the other end of the switch arm 69 is located a stationary contact 70. The switch arm 69 is connected to the primary winding 13*a* of the ignition coil 13 and the contact 70 is connected to the second interruptor 14*b* (FIG. 1). The switch arm 69 is usually forced away from the contact 70 by the action of a spring 71 and held in contact with a stop 72.

When, now, the throttle valve shaft 66 is rotated, then the cam 65 connected therewith is accordingly rotated to force the switch arm 69 away from the stop 71 until it contacts the contact 70, thereby connecting the second interruptor 14*b* of the distributor 14 to the primary winding 13*a* of the ignition coil 13. As the throttle valve 67 is further opened, the arm 69 is released from the contact 70 when the enlarged peripheral edge portion 65*a* leaves the arm 69 so that the primary winding 13*a* is disconnected from the second interruptor 14*b*.

The cam 65 may be so shaped that the switch arm 69 is held in engagement with the contact 70 when the throttle valve 67 is in a predetermined range of angular position and is released therefrom when the throttle valve is further opened to provide an increased aperture at the throttle chamber. The control switch 18*h* can be thus kept closed when the vehicle is driven under the conditions shown by the hatched area in FIG. 13. In FIG. 13, the curves *u* and *v* stand for the conditions in which the vehicle is driven with the throttle valve in fixed positions to close and open, respectively, the control switch 18*h*.

It will now be understood that the ignition timing control switch to be used in the ignition system according to the invention can be controlled in accordance with the variation in the speed of either the vehicle or engine or in the vacuum in either the throttle chamber of the carburetor or intake manifold of the engine. These control factors representing the varying driving conditions of the motor vehicle may be, if desired, utilized in combination as has previously been noted.

For instance, the vehicle speed and the vacuum in the throttle chamber may be used together to control the control switch. For this purpose, the control switch may be constituted as a combination of the control switches 18*d* and 18*f* shown in FIGS. 5 and 8, respectively, connected in series with each other. Such combination switch will be closed only when both of the switches 18*d* and 18*f* are closed and will be opened when either of the switches 18*d* and 18*f* is opened.

FIG. 14 illustrates the conditions in which the vehicle is driven with the ignition timing retarded by the motion of the above-mentioned combination switch. As shown, the curves *p* and *q* are identical with those plotted in FIG. 9 and the lines *a* and *b* with those in FIG. 6.

Thus, when the vehicle speed exceeds a speed indicated by the line *a* then the control switch **18***d* is closed and when the vacuum in the throttle chamber exceeds a predetermined lower limit then the switch **18***f* is closed. The combination switch is opened as the vehicle speed is further increased in excess of a speed indicated by the line *a* or as the vacuum in the throttle chamber further increases in excess of a predetermined upper limit.

Here, it will be appreciated that the control switch **18***d* to be combined with the switch **18***f* may be, if preferred, replaced with the control switch **18***a* (FIGS. 2 and 3) or with the combination of the control switches **18***b* and **18***c* (FIG. 4).

Also, the ignition timing in the ignition system according to the invention may be controlled in accordance with the combination of the vacuum in the intake manifold of the engine and the angular position of the throttle valve in the carburetor. In this instance, the ignition timing will be controlled by the combination of the switches **18***g* (FIG. 10) and **18***h* (FIG. 12). The range of the driving conditions of the motor vehicle in which the ignition timing is controlled in this manner is indicated by the hatched area in the graph of FIG. 15. In FIG. 5, the curves *t* and *v* correspond with the counterparts shown in FIGS. 11 and 13, respectively.

FIG. 16 shows the driving conditions of the motor vehicle in which the ignition is timed in relation to the engine speed and vacuum in the intake manifold of the engine, in which instance the control switches **18***e* (FIG. 7) and **18***g* (FIG. 10) may be connected in series with each other to comprise a single combination switch. The lines *a* and *b* and the curves *s* and *t* correspond with the counterparts shown in FIGS. 6 and 11, respectively. In this example, the ignition is timed only when the motor vehicle is driven with the engine speed and intake manifold vacuum maintained within predetermined ranges defined by the lines *a* and *b* and curves *s* and *t*.

Furthermore, the ignition timing may be controlled in accordance with the combination of the vehicle speed, intake manifold vacuum and angular position of the throttle valve. In this instance, the combination switch to control the ignition timing may be constituted as a combination of the control switches **18***a* (or **18***b* and **18***c*), **18***g* and **18***h* connected in series with each other. Thus, the ignition timing is retarded when and only when the vehicle speed is lower than a predetermined level, the vacuum in the intake manifold of the engine is higher than a predetermined level and the throttle valve of the carburetor is opened to provide a predetermined range of aperture, as indicated by the hatched area defined by the line *b* and curves *t* and *v* in FIG. 7.

What is claimed is:

1. In an ignition system for an automotive internal combustion engine combined with a manually controlled transmission system having a fork rod operatively connected with a speed selector lever through a striking rod and a shifting rod rigidly connected with said fork rod, said fork rod being provided in its peripheral wall with a recess located suitably to detect a predetermined speed range selected by the movement of said fork rod, which ignition system includes a battery, an ignition coil having a primary and secondary windings, said primary winding being connected at one terminal thereof with said battery through an ignition switch and said secondary winding being connected selectively to ignition plugs, and an ignition distributor having a first and second interruptors means, said first interruptor means being connected with the other terminal of said primary winding so as to provide normal ignition timings, said second interruptor means being connected in parallel with said first interruptor means to said primary winding through an ignition timing control switch means which is normally kept open and arranged to provide ignition timings retarded from the timings determined by said first interruptor means, said ignition timing control switch means comprising two stationary contacts connected respectively with said primary winding and said second interruptor means, a moving contact which is rigidly connected with an insulating moving member extending toward said fork rod and usually forced against the peripheral wall of said fork rod by a spring action whereby said moving contact is moved beyond said stationary contacts, said moving member being forced to protrude into said recess by a spring action as said fork rod is moved axially by said speed selector lever to permit said moving contact to abut to said stationary contacts for connecting said second interruptor means with said primary winding, said ignition timing control switch means being closed when the motor vehicle is driven under predetermined conditions, whereby the ignition timing is retarded under said conditions.

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