United States Patent

[11] 3,561,410

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[54] **ENGINE IGNITION TIMING ARRANGEMENT**
5 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **123/117, 92/99**
[51] **Int. Cl.** **F02p 5/04**
[50] **Field of Search** 123/117, 117.1

[56] **References Cited**

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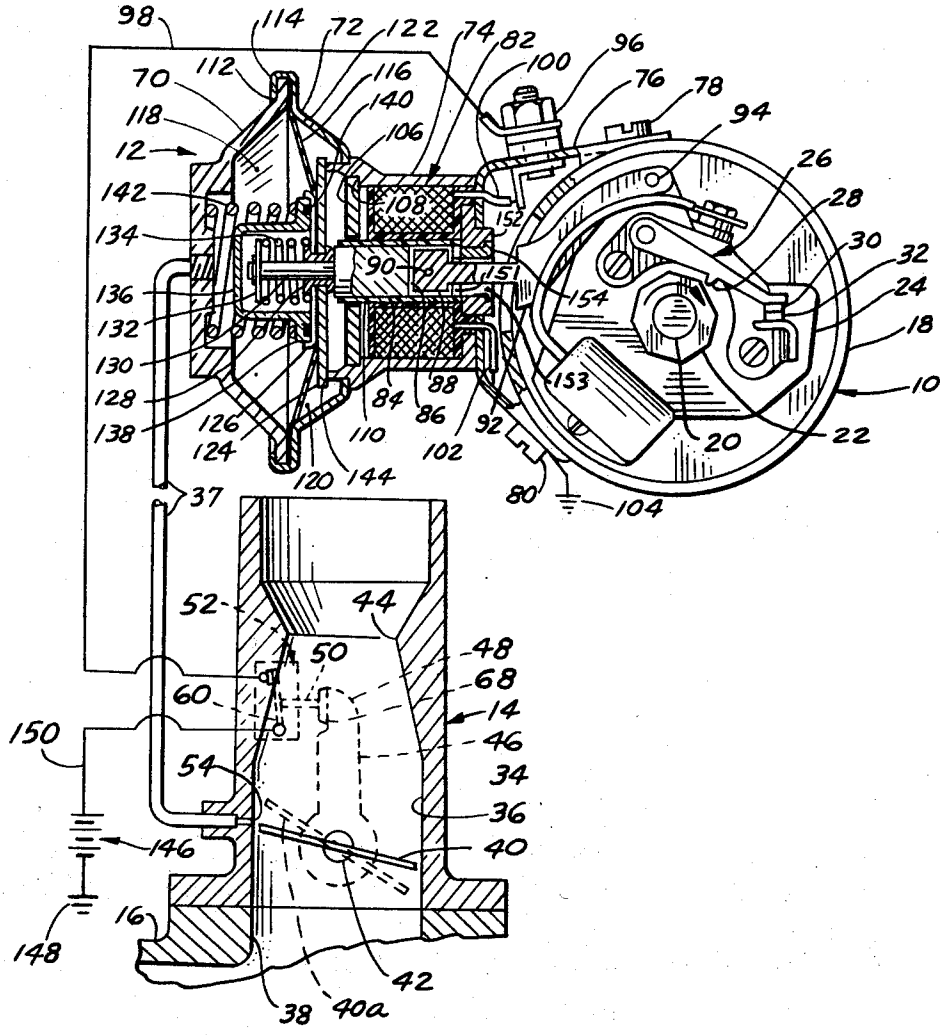
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ABSTRACT: A primary embodiment of the invention employs a control assembly having a pressure responsive section and an electrically energizable section connected to each other and to the cooperating ignition distributor as by an arm pivotally connected to the distributor breaker plate; the pressure responsive section is connected so as to be responsive to engine intake vacuum, during certain predetermined conditions of engine operation, in order to advance the timing of the ignition spark while the electrically energizable section, comprised of a solenoid coil and armature, is operatively connected to electrical switch means also opened and closed to in accordance with preselected indicia of engine operation.



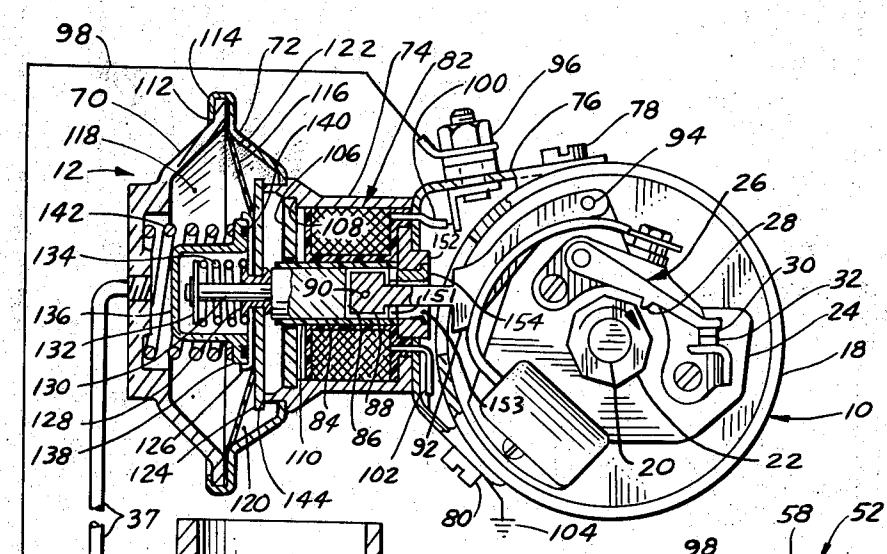


FIG. 1

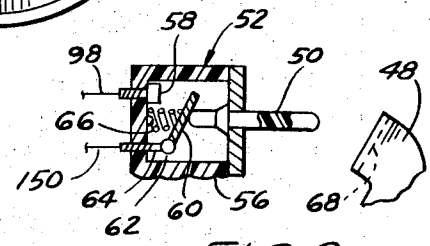
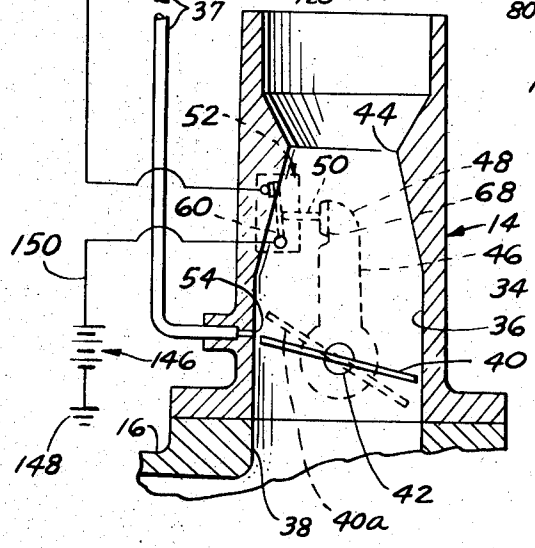


FIG. 2



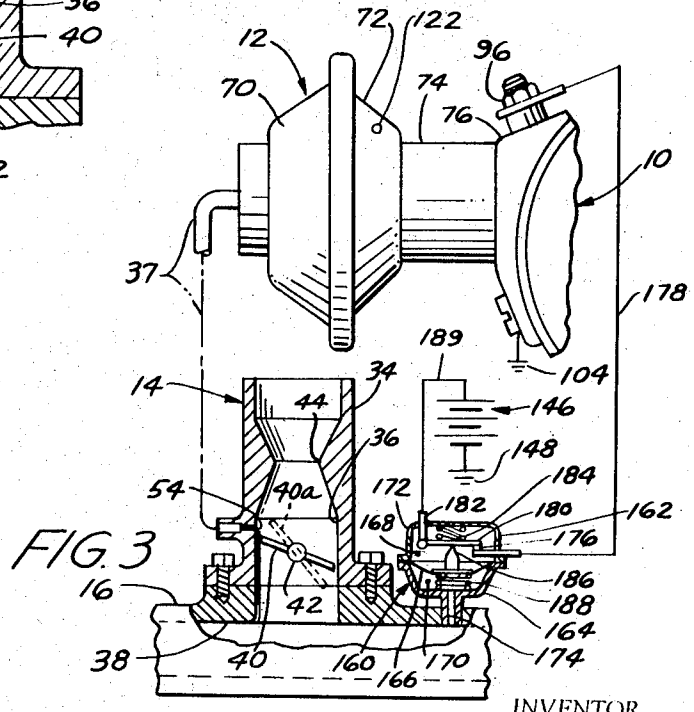
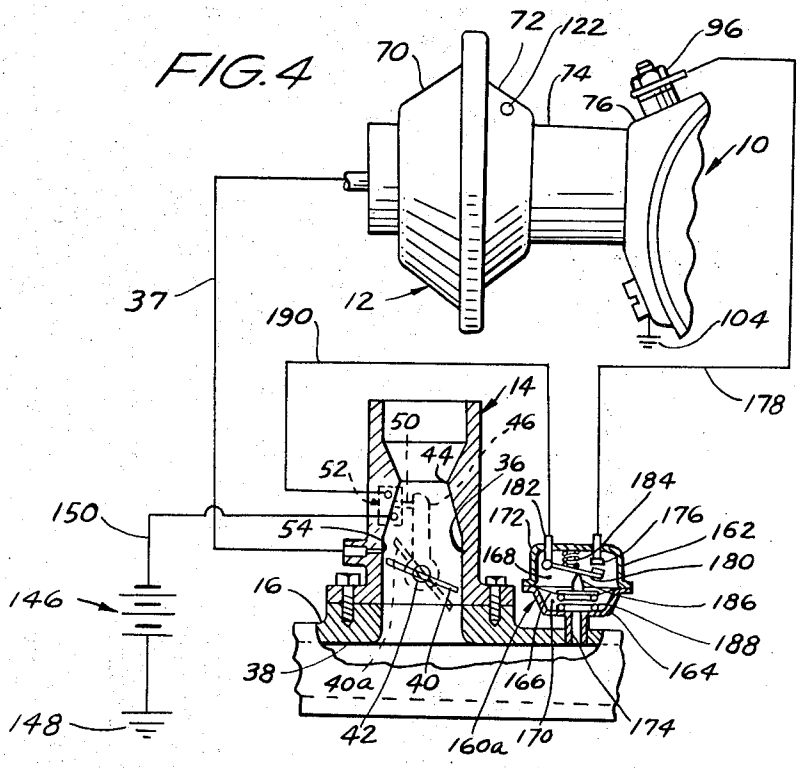


FIG. 3

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FIG. 4



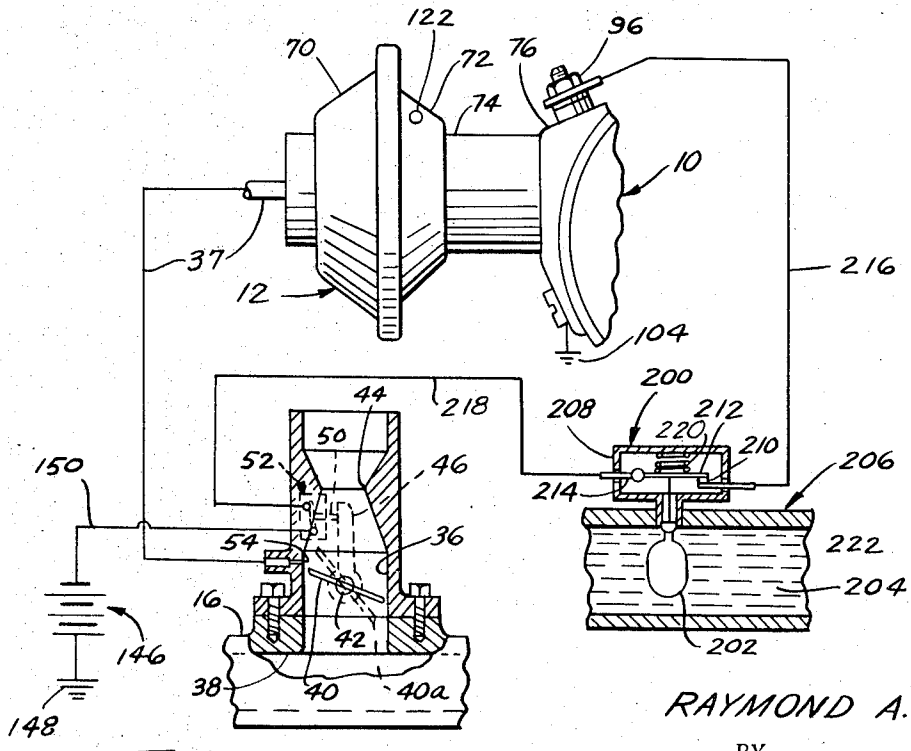


FIG. 5

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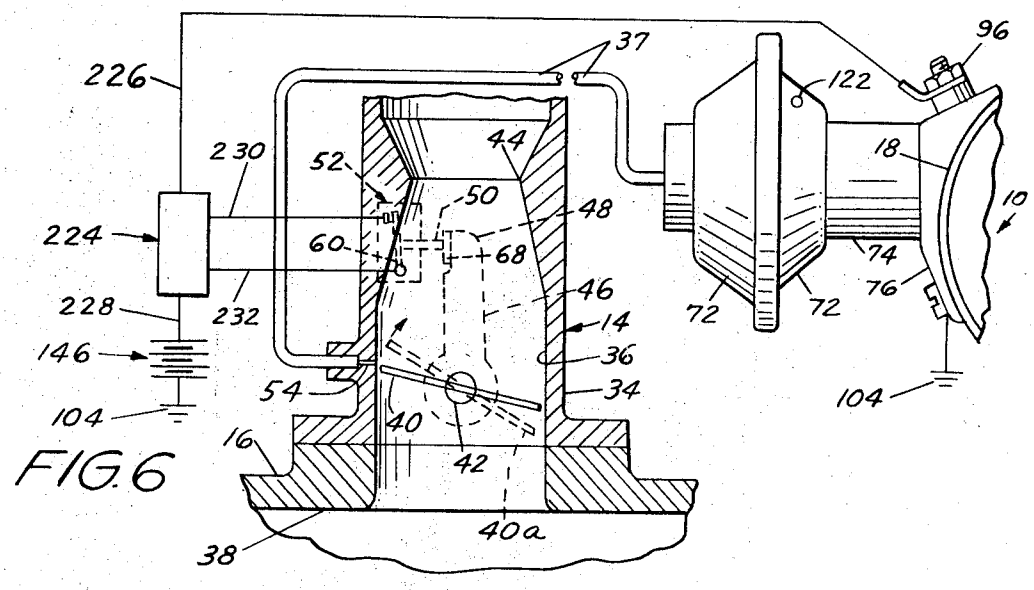


FIG. 6

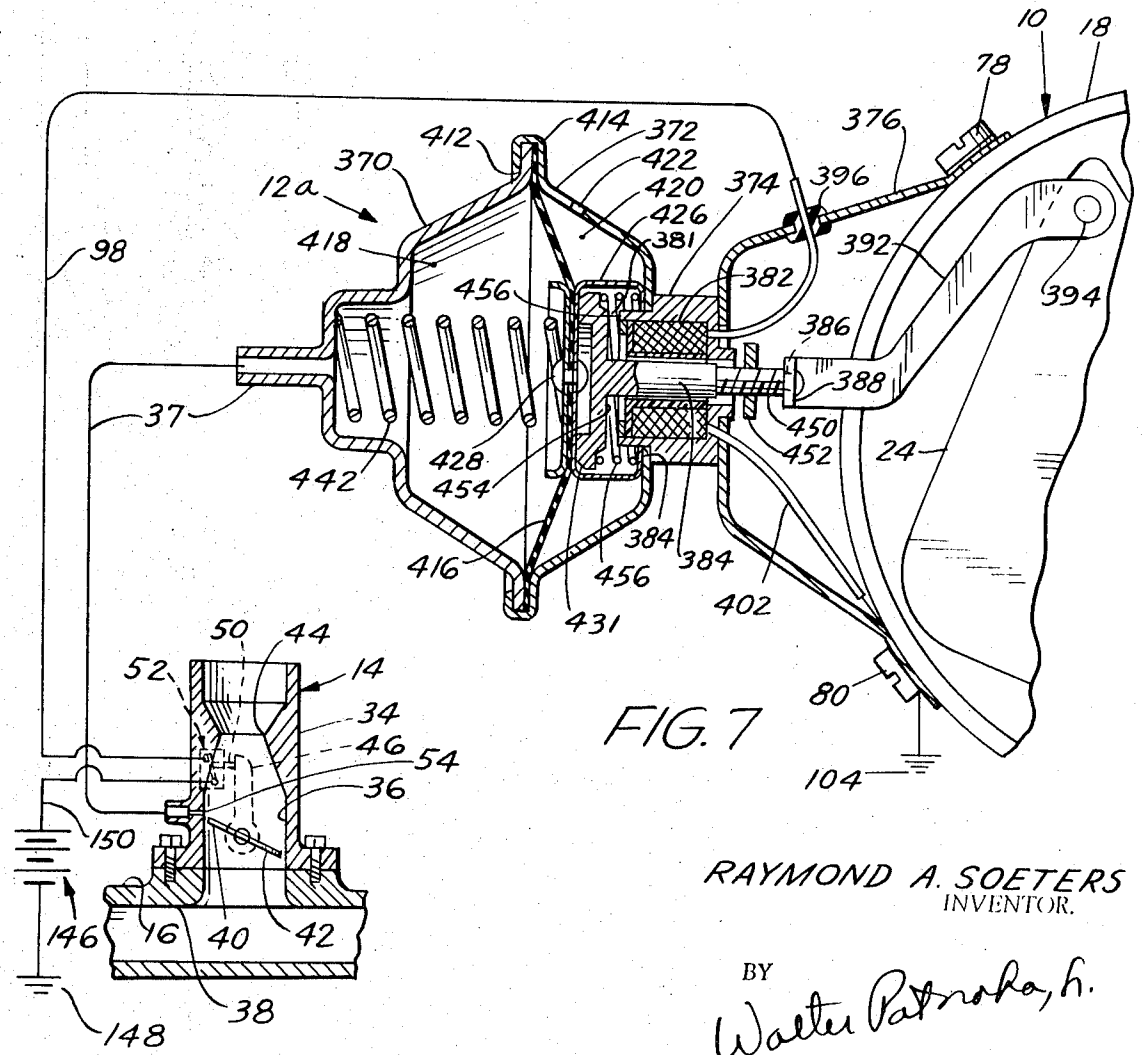


FIG. 7

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ENGINE IGNITION TIMING ARRANGEMENT

BACKGROUND OF THE INVENTION

Various ignition-timing control arrangements have been proposed by the prior art. Some of these have employed a single pressure responsive diaphragm for controlling the advance and retard of the ignition timing; others have employed two pressure responsive diaphragms, forming two pressure responsive chambers, each of which was placed in communication with two separate sources of vacuum.

However, such prior art devices have been found to be rather difficult in a calibration and tailoring to meet the specific requirements of a particular engine design. This often results from the fact that, for example, in the dual diaphragm type of distributor control, the indicia of engine operation as well as the motivating force for actuating the respective diaphragms is attained from two separate (but operationally related) sources of vacuum. Consequently, it becomes difficult, where required, to vary the operational characteristics of one of the diaphragms without producing some effect on the other diaphragm.

Further, the responsiveness of the prior art arrangements often has been relatively slow because movement of any of the diaphragms in both the ignition advance and ignition retard direction required the accompanying flow of a considerable volume of air.

SUMMARY OF THE INVENTION

According to the primary invention, an engine ignition-timing control arrangement for advancing and retarding the timing of an associated ignition distributor mounted in driven relationship to an internal combustion engine having an air induction passage controlled by a variably positioned throttle valve mounted therein comprises first pressure responsive means, second electrically responsive means, housing means containing said first pressure responsive means and said second electrically responsive means, said first means and said second means being operatively connected to said ignition distributor in order to effect both an advance and a retard of the timing of said ignition distributor, said first pressure responsive means being effective when exposed to vacuum generated in accordance with indicia of engine operating conditions for advancing said timing of said ignition distributor, and said second electrically responsive means being effective to retard said timing of said ignition distributor upon the occurrence of certain predetermined engine operating conditions.

Accordingly, a general object of this invention is to provide a control for an internal combustion engine ignition distributor which will have pressure responsive means for advancing the ignition timing of said ignition distributor and separately actuated electrically responsive means for retarding the ignition timing of said ignition distributor.

Another object of this invention is to provide a control as set forth above which will be responsive in its advance and retard of said ignition timing to such conditions of engine operations as, for example, engine idle operation, vehicle deceleration, engine temperature and part-throttle engine operation.

Other more specific objects and advantages of the invention will become apparent when reference is made to the following detailed description when considered in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 illustrates in general axial cross section an ignition-timing control arrangement, in association with an ignition distributor assembly (with portions thereof omitted for purposes of clarity), constructed in accordance with the teachings of this invention;

FIG. 2 is a somewhat enlarged schematical illustration, in cross section, of a switch assembly as employed in, for example, the arrangement of FIG. 1;

FIGS. 3, 4, 5 and 6 respectively illustrate other embodiments of the invention; and

FIG. 7 illustrates a further embodiment of the control structure of FIG. 1 and applicable for use in any of the systems or arrangements disclosed by either of FIGS. 3, 4, 5 or 6.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now in greater detail to the drawings, FIG. 1 illustrates an ignition distributor 10 provided with spark timing control assembly 12, constructed in accordance with the teachings of this invention, and an air induction structure 14 situated on the intake manifold 16 of an internal combustion engine.

The ignition distributor 10 may be comprised generally of a housing 18 having provision therein for the reception of a driving shaft 20 to which a cam 22 is secured so as to rotate therewith. A breaker plate 24 mounted on a suitable bearing member, as is well known in the art, is adapted to rotate, to a limited degree, about the driving shaft 20 and cam 22. The breaker plate 24 carries thereon a breaker arm assembly 26 which includes a cam engaging portion 28 to effect the make and break of the circuit of the contacts indicated at 30 and 32. The cam 22 and the shaft 20 on which it is mounted are, of course, rotated in timed relation with the engine by means of any transmission means well known in the art.

The air induction structure 14, having a body 34 with an induction passage 36 formed therethrough communicating at opposite ends with, for example, the atmosphere and the intake manifold passage 38, is provided with a throttle valve 40 secured to a transversely extending throttle shaft 42 so as to be capable of pivotal rotation within the induction passage 36. In actual practice the induction structure 14 may in fact be a carburetor and as such provided with a venturi 44 within passage 36 for purposes of metering fuel from an associated reservoir (not shown but well known in the art) to the air flowing through the induction passage and into the intake manifold conduit or passageway 38.

Throttle shaft 42 may be rotatably positioned, as is well known in the art, by suitable control linkage means secured as to one end thereof. Throttle shaft 42 is also provided with an actuating member 46 secured to one end thereof in a manner so as to be rotatable with the throttle shaft. The upper or free end 48 of member 46 to adapted to engage an actuating plunger 50 of a switch assembly 52 and to close an electrical circuit through the switch assembly 52 whenever the throttle valve and shaft are rotated so as to place the throttle valve 40 in a nominally closed position as illustrated in FIG 1. Further, as also shown in FIG. 1, the body 34 has formed therein a conduit portion or port 54 which communicates between the induction passage 36 and suitable conduit means 37 leading to the spark timing control assembly 12. When the throttle valve 40 is in its nominally closed (idle) position, which may be fully closed in a carburetor of the type having an idle air bypass or closed to a stop permitting sufficient flow to sustain engine idle operation in a carburetor having no idle air bypass, the port 54 is placed in communication with the pressure upstream of throttle valve 40 which, in effect, may be substantially atmospheric pressure.

FIG. 2 illustrates, somewhat schematically, and in cross section, switch assembly 52 as being comprises of a suitable housing 56 containing a fixed electrical terminal contact 58 and a movable switch member 60 pivotally secured at 62 to a second terminal 64. Suitable resilient means such as a spring 66 normally urges switch member 60 in the circuit open position and against actuating plunger 50. The upper end 48 of lever or arm 46 may be provided with a transverse abutment portion 68 for engaging and releasing plunger 50 depending, of course, upon the movement of throttle shaft 42. It is, of course, to be understood that the construction of switch assembly 52 as herein disclosed is merely exemplary since many different switch assemblies, each of which is well known in the art, could be employed to perform the desired function, namely, to open and close the related circuitry in accordance with the position or positions attained by throttle valve 40 and throttle shaft 42.

The spark timing control assembly **12** is illustrated as being comprised of housing sections **70**, **72** and **74** which, in assembled relationship, are secured, as by welding, to a support bracket assembly **76** in turn secured to distributor housing **18** as by screws **78** and **80**.

A solenoid coil assembly **82**, fixedly secured within housing **74** generally slidably receives a movable core or armature **84**, centrally thereof. One end of armature **84** has formed therein a generally medially disposed slot **86** for the relatively loose reception therein of a tongue portion **88**, pivotally secured therein as by a transversely extending pivot pin **90**, of a control arm **92** having its other end pivotally connected as to **94** to the rotatable breaker plate **24**.

Bracket **76** also supports thereon, in electrically insulated relationship thereto, an electrical terminal assembly **96** connected at one end to electrical conductor **98**, leading to terminal or fixed contact **58**, and at its other end to a conductor **100** leading to solenoid winding or coil **82**. The coil **82** is also provided with a second electrical lead or conductor **102** which may be ground as through the distributor housing **18** as generally indicated at **104**.

An annular support member **106**, of preferably magnetically permeable material is suitably retained as at its outer peripheral edge by housing section **74** so as to be fixedly retained therein as against an internally formed shoulder **108**. The inner aperture of member **106** relatively tightly engages the outer diameter of a sleevelike tubular bushing **110** which is preferably formed of brass. Bushing **110** as well as bearing or bushing support member **106** are retained in the positions shown while, of course, armature or core **84** within bearing **110** is axially movable with respect thereto.

Housing sections **70** and **72** cooperate with each other to peripherally retain therebetween, as by flange portions **112** and **114**, a flexible or pressure responsive diaphragm **116** which defines at opposite sides thereof two variable but distinct chambers **118** and **120**. Chamber **118** is in constant communication with conduit **37** while chamber **120** may be vented directly to the atmosphere as by suitable ports or apertures indicated typically at **122**. Accordingly, it can be seen that, generally, housing sections **70**, **72** and diaphragm **116** cooperate to define a pressure responsive motor assembly and that such motor assembly is in turn fixedly secured, through any suitable fastening, joining or securing means, to housing section **74**.

A washerlike abutment or stop member **124** is secured to one side of diaphragm **116** while a spring plate or perch **126** is secured to the opposite side of diaphragm **116**. Oppositely disposed members **124** and **126** may be retained as by a hollow rivetlike fastener **128** peened at its opposite ends against such members **124** and **126**. As can be seen, the interior of fastener **128** slidably accommodates therethrough an extension **130** of core **84** which carries, secured thereto, an annular spring perch or abutment **132** serving to axially contain a compression spring **134** between the abutment **132** and diaphragm plate member **126**. Normally, spring **134** tends to cause relative motion as between, for example, abutment plate or member **124** and core extension **130** and in this way normally maintain the core **84** and plate **124** in axial abutting engagement as through the end of fastener **128**.

A cup shaped caplike member **136**, located generally within chamber **118**, has a radiating flange **138** with a circular groove formed therein for receiving a seal **140**. A second compression spring **142** engaging, at one end, housing section **70** and the flange **138** of cap **136** urges the cap **136** into sealing engagement with diaphragm plate **126**. The sealing effect is, of course, provided by seal **140** so as to prevent pressure leakage as from chamber **120** to chamber **118** via the sliding tolerances as between core extension **130**, rivet or fastener **128** and associated elements. Spring **142** also serves to urge diaphragm **116** and its associated plate members to the right, as viewed in FIG. **1**, to a point whereat abutment plate **124** abuts against an abutment surface **144** which may be of annular configuration and formed by housing section **74**.

OPERATION

As is generally well known in the art, internal combustion engines of the reciprocating piston type, require, in order to attain optimum operating efficiencies, a degree of regulation in the timing of the ignition spark with respect to the angle of rotation of the crankshaft. Such regulation is usually referred to as either advancing or retarding the spark with the terms "advance" (or advancing) and "retard" (or retarding) being employed with regard to the instant of ignition spark occurrence with reference to a predetermined angular position of the crankshaft as well as the direction of change in such timing as when, for example, the ignition spark timing is at a maximum advance position but is being changed slightly to a lesser advanced position. This interim movement or change could be referred to as "retarding" the spark and as such the term of reference is in the sense of the direction of change of timing.

Further, as is also well known in the art, a maximum manifold vacuum is generated when the throttle valve is in its closed position and the vehicle is decelerating and simultaneously driving the engine. Another indicium of engine operation can be sensed by the high manifold vacuum (less than at deceleration) generated by the engine during idle engine operation at which time, of course, the throttle valve is closed, which means closed to the engine idle position. Such manifold vacuums will of course exist below or posterior to the closed throttle valve and generally, such manifold vacuums will decrease in value (so as to have the pressure thereof more nearly approach atmospheric pressure) as the throttle valve is rotated from its closed position toward a position of wide-open throttle.

Referring now specifically to the construction of FIG. **1**, it can be seen that with the engine assumed to be at idle operation and throttle valve **40** closed the port **54** leading to conduit means **37** is prevented from exposure to the manifold vacuum below throttle valve **40** but is exposed to the substantially atmospheric pressure within induction passage **36** anterior or upstream of the throttle valve **40**. Consequently, both chambers **118** and **120** of spark timing control assembly **12** are at substantially identical pressure thereby permitting spring **142** to hold the diaphragm **116** and abutment or stop plate **124** in the position shown. Accordingly, it can be seen that spark or ignition advance is achieved by virtue of the manifold vacuum generated by the engine only when the throttle valve **40** begins to open.

However, as is also shown in FIG. **1**, when the throttle valve **40** is closed lever or actuating member **46** closes switch member **60** against contact **58** thereby completing a circuit from a source **146** of electric potential (grounded as at **148**) via a conductor **150** and through conductors **98** and **100** to solenoid winding or coil **82** and through conductor **102**, to, again, ground at **104**. Solenoid coil **82** is thusly energized causing core or armature **84** to move to the right, due to the air gap **151**, until it abut against metallic stop member **154**, which is disposed within the end **152** of the casing for the coil **82**, thereby creating a predetermined degree of spark retard in the ignition timing by causing control arm **92** to rotate the distributor breaker plate **24**, and breaker arm assembly **26** situated thereon, a predetermined distance clockwise as viewed in FIG. **1**. The U-shaped stop **154** is disposed centrally within the member **152**, and it is formed with a radial slot **153** to accommodate the free reception therethrough of said control arm **92**.

It should be apparent, in view of the above, that during vehicle deceleration with the throttle valve **40** closed, the identical results would be obtained with regard to ignition timing as achieved during engine idle operation.

When the throttle valve is rotated from its closed position to some other part throttle position, as shown for example at **40***a*, port **54** becomes exposed to the engine or manifold vacuum posterior to the throttle valve and such vacuum is communicated via conduit means **37** to chamber **118** of housing section **70**. Since chamber **120** is at atmospheric pressure, a pressure differential is thereby created across diaphragm **116**

causing the diaphragm **116**, abutment plate **124**, diaphragm plate **126**, and cap or housing **136** to move to the left against the resilient resistance of spring **142**. In so moving, spring **134** causes solenoid armature **84** to also move to the left carrying control arm **92** with it so as to rotate breaker plate **24** and breaker arm assembly **26** counterclockwise resulting in advancing the ignition timing. The degree of spark advance will of course depend on the calibrated force of spring **134** and the magnitude of the vacuum generated by the engine which, in turn, is also controlled by the position of the throttle valve both of which reflect engine load.

SECOND EMBODIMENT

FIG. **3** illustrates another embodiment of the invention; all elements of FIG. **3** which are like or similar to those of the elements of FIG. **1** are identified with like reference numbers.

In the embodiment of FIG. **3**, a pressure responsive electrical switch assembly **160** is provided to at times complete or break the circuit leading to the solenoid coil **82** of ignition control **12**. Switch assembly **160** is illustrated as being comprised of housing sections **162**, **164** which cooperate to peripherally retain therebetween a pressure responsive wall or diaphragm member **166** which serves to generally define two variable but distinct chambers **168**, **170** the first of which may be vented to the atmosphere as by means of suitable apertures formed through the housing section **162** as typically illustrated at **172**. Housing section **164** may be provided with a tubular extension, suitably secured within the wall of the engine intake manifold **16**, with a conduit **174** formed therethrough so as to place chamber **170** in continual communication with the induction passage or interior **38** of intake manifold **16**.

Chamber **168**, generally, contains a fixed contact terminal **176** connected as by a conductor **178** to terminal post **96** of the ignition spark control assembly **12**. A movable switch member **180** pivotally secured to a second electrical terminal **182**, connected to source **146** via conductor **189**, is normally biased toward engagement with fixed contact **176** as by means of a compression spring **184** situated between switch member **180** and housing section **162**. A switch member actuator **186** secured to diaphragm **166**, for movement therewith, is urged upwardly, by a spring **188** contained within chamber **170**, so as to engage and move switch member **180** upwardly out of engagement with contact **176** in order to open the circuit therethrough.

As can be seen, the operation of the advance mechanism of the control **12** is the same as described with reference to FIG. **1**. However, the operation of the retard mechanism of the control **12** is achieved through the opening and closing of the switch assembly **160**. That is, when a predetermined value of manifold vacuum is attained a pressure differential is attained across diaphragm **166** causing the diaphragm and actuator **186** carried thereby to move downwardly, against the resistance of spring **188**, so as to permit spring **184** to seat movable switch member **180** against fixed contact **176**. When this happens, solenoid coil **82** is, of course, energized causing armature **84** to move to the right rotating breaker plate **24** clockwise and retarding the ignition spark timing at discussed with reference to FIG. **1**. As stated before, the manifold vacuum at which switch member **180** will be closed is a predetermined value selected in order to be indicative of a particular attained engine operating condition. If this selected value were, for example, the value of manifold vacuum at idle engine operation it would, of course, follow that the switch member **180** would also be closed during vehicle deceleration with the vehicle driving the engine because the manifold vacuum attained at that time would exceed the value of idle engine operation.

THIRD EMBODIMENT

FIG. **4** illustrates a third embodiment of the invention. All elements in FIG. **4** which are like or similar to the elements of either FIGS. **1**, **2** or **3** are identified with like reference numbers.

In comparing the embodiments of FIGS. **1**, **3** and **4** it can be seen that the embodiment of FIG. **4** appears to be, generally, a combination of the embodiments of FIGS. **1** and **3** with the exception that switch assembly **160***a* differs from switch assembly **160** by having compression spring **184** normally urge pivotally mounted switch member **180** in a direction away from fixed contact **176** so as to thereby open the circuit therethrough. As can be seen, fixed contact terminal **176** is connected as by conductor **178** to post terminal **96** while terminal **182** is connected via a conductor **190** to fixed contact terminal **58** of switch assembly **52** (which is also illustrated in FIG. **2**).

The operation of the vacuum advance portion of the ignition control **12** of FIG. **4** is, as can be seen, like that of the vacuum advance portion of either FIGS. **1** or **3**. That is, engine generated vacuum is communicated to port **54**, conduit means **37** and chamber **118** only upon movement of the throttle valve **40** a distance sufficient to plate port **54** in communication with the pressure in the induction passage **36** on the engine side of the throttle valve **40**.

In the embodiment of FIG. **4**, it can be seen that when a predetermined value of manifold or engine vacuum is created, the pressure differential across diaphragm **166** causes actuator **186** to be moved downwardly, against the resistance of spring **188**, thereby enabling spring **184** to move switch member **180** away from contact **176** and opening the electrical circuit between conductors **190** and **178**.

Accordingly, it can be appreciated that if the force of spring **188** were such as to maintain switch member **180** closed for all vacuum values of manifold vacuum less than or equivalent to idle engine operation, the only time that the core **84** would move to its retard position would be at idle engine operation because: (1) during normal driving conditions throttle valve **40** will be in some partly opened positioned causing the electrical circuit through switch assembly **52** to be opened; and (2) during vehicle deceleration with the throttle valve **40** closed and the vehicle driving the engine the valve of the manifold vacuum will exceed the value of manifold vacuum generated at idle engine operation causing diaphragm **166** to move downwardly opening the electrical circuit through switch assembly **160***a*.

FOURTH EMBODIMENT

FIG. **5** illustrates another embodiment of the invention; all elements of FIG. **5** which are like or similar to the elements of either FIGS. **1**, **2**, **3** or **4** are identified with like reference numbers.

In the embodiment of FIG. **5** a temperature sensing electrical switch assembly **200** is situated so as to have a suitable temperature responsive element or means **202** within the coolant **204** of the engine coolant system, fragmentary illustrated at **206**. Switch assembly **200** may be further comprised of a housing **208** within which are situated a fixed contact terminal **210** and a cooperating movable switch member **212** pivotally secured to a second terminal **214**. Fixed contact terminal **210** is electrically connected to post terminal **96** via conductor **216** while terminal **214** is connected to fixed contact terminal **58** (see FIG. **2**) by means of a conductor **218**. A compression spring **220** may be employed normally maintain the electrical circuit through switch assembly **200** closed by urging switch member **212** toward engagement with fixed contact **210**. A suitable motion transmitting member or means **222** is provided in order to cause upward movement of switch member **212**, thereby opening the circuit through switch assembly **200**, whenever the temperature of the coolant **204** has attained a predetermined temperature.

As in FIG. **4**, it can be seen that in the embodiment of FIG. **5** the electrical actuating circuitry includes switch assemblies **52** and **200** in series with each other. Accordingly, both switch assemblies **52** and **200** must be closed in order to attain energization of the coil assembly **82** and thereby actuate core or armature **84** to effect to retard of ignition timing. If either the throttle valve **40** is moved toward an open position, as at **40***a*,

or the temperature of the coolant exceeds a predetermined temperature the circuit to solenoid coil **82** is opened and no retard of ignition timing via armature **84** can be achieved. This particular feature becomes very important in especially truck engine applications where engine temperature may increase because of heavy engine loads. In such instances a retard of the ignition timing could well increase such engine temperature above that considered acceptable for continued operation.

Fifth Embodiment

FIG. **6** illustrates what may be considered to be a further modification of any of the systems disclosed by FIGS. **1**, **3**, **4** and **5** as well as that of FIG. **7** yet to be described. All elements of FIG. **6** which are like or similar to those of either FIGS. **1**, **2**, **3**, **4** or **5** are identified with like reference numbers.

Basically, the modification resides in the provision of a remotely situated power switch assembly **224**, for completing or opening the power circuitry comprised of conductors **226** and **228**, and the employment of switch assembly **52** (which may be physically situated on the carburetor **14**) as a control switch thereby requiring control conductors **230** and **232** (respectively connected to terminals **58** and **64** of switch assembly **52**) to carry only a relatively low current and low voltage so as to minimize any possible incident of switch arcing as between movable contact **60** and fixed contact **58**. Of course, the arrangement would be one where, for example, closure of switch assembly **52** would cause the switch assembly **224** to complete the circuit to solenoid coil **82** through conductors **226** and **228**.

Sixth Embodiment

FIG. **7** illustrates another embodiment of the invention; all elements in FIG. **7** which are like those elements of FIGS. **1** and **2** are identified with like reference numbers.

In the embodiment of FIG. **7**, the ignition spark timing control assembly **12***a* also defines an electrical retard mechanism and a vacuum or pressure responsive advance section as does the structure specifically disclosed in FIG. **1**.

In the arrangement of FIG. **7**, the spark timing control assembly **12***a* is illustrated as being comprised of housing sections **370**, **372** and **374** which, in assembled relationship, are secured, as by welding, to a support bracket assembly **376** which is in turn secured to the distributor housing **18** as by means of screws **78** and **80**.

A solenoid coil assembly **382**, fixedly secured within housing **374** generally slidably receives a movable core or armature **384**, centrally thereof. One end of armature **384** is provided with a reduced portion **386** for receiving thereabout a bracketlike tab **388** of a control arm **392** having its other end pivotally connected as at **394** to the rotatable breaker plate **24**. Bracket **376** may carry an insulating grommet **396** for admitting therethrough conductor **98** leading from fixed contact **58**, of switch assembly **52**, to solenoid coil **382**. Coil or winding **382** may also be provided with a second electrical lead or conductor **402** which may be connected to and grounded through the distributor housing **18** as generally indicated at **104**.

Housing sections **370** and **372** cooperate with each other to peripherally retain therebetween, as by flange portions **412** and **414**, a flexible or pressure responsive diaphragm **416** which defines, at opposite sides thereof, two variable but distinct chambers **418** and **420**. Chamber **418** is in constant communication with conduit means **37** while chamber **420** may be vented directly to the atmosphere as by suitable ports or apertures indicated typically at **422**. Accordingly, it can be seen that, generally, housing sections **370**, **372** and diaphragm **416** cooperate to define a pressure responsive motor assembly and that such motor assembly is in turn fixedly secured, through any suitable fastening, joining or securing means, to housing section **374**.

Oppositely disposed diaphragm reinforcing members **424** and **426** may be retained as by a suitable fastener or rivet **428**. Reinforcing or plate member **424** is adapted to have one end of a spring **442**, contained within chamber **418**, seated thereagainst while reinforcing member **426** may take the form of a cup-shaped cage, with a radially inwardly directed flange portion **441**, for retaining therein a compression spring **434** continually urging the armature or core **384** to the left by engaging an enlarged head portion **431** thereof.

In view of the above it can be seen that, due to the air gap **381**, whenever the electrical circuit leading to solenoid coil or winding **382** is closed, armature or core **384** will move to the right against the resistance of compression spring **434** thereby causing control lever or arm **392** to rotate the breaker plate **24** clockwise as to retard the ignition spark timing. The degree of spark retard will be determined by the distance available for movement as exists between the surface **454** on armature head **431** and cooperating end abutment surface **456** provided by housing section **374**. When sufficient vacuum is admitted to chamber **418**, diaphragm **416** responds by moving to the left against spring **442**, carrying cage **426** and armature **384** with it. Since armature **384** is connected to control arm **392** the breaker plate **24** will be rotated counterclockwise advancing the ignition spark timing. The degree of ignition advance will, of course, depend on the degree or magnitude of the vacuum communicated to chamber **418** with the maximum advance being susceptible of determination by a threaded portion **450**, formed on or carried by armature **384**, and a cooperating threaded stop nut member **452** threadably adjustable therealong.

In view of the preceding it can be seen that the various embodiments and/or modifications of the invention provide a novel ignition distributor timing control which employs a pressure responsive motor section and an electrically energizeable section for effecting an advance and retard in the ignition spark timing. The respective sections are made respectively responsive to preselected indicia of engine operation so that optimum engine operating efficiencies are achieved regardless of the then conditions of engine operation.

The various linkages, levers and switches herein disclosed have been, for purposes of clarity, illustrated somewhat schematically. It will be readily apparent, especially to those skilled in the art, that the invention can be practiced employing, for example, switch assemblies of a multitude of differing configurations without the necessity of inventive faculties. Further, it should be apparent that the practice of the invention does not require, specifically, a lever or arm as disclosed at **46** and that a switch-actuating member may in fact be operatively connected to the throttle-actuating linkage but located physically remote with respect to the throttle shaft and carburetor structure. It is also contemplated that such an actuating member may, in fact, take the form of a suitable camlike member having provision for adjustment so as to vary its effectiveness with respect to the angular position of the throttle valve. Further, it is possible, if desired, to provide, in the switch assemblies, typically shown at **52**, variable electrical resistance means engageable by, for example, a movable wiper contact effectively positioned by the lever or arm **46** to vary the current flow to the solenoid coil assembly in accordance with the position of the throttle valve.

Although only a select number of embodiments and modifications of the invention have been disclosed and described, it is apparent that other embodiments and modifications of the invention are possible within the scope of the appended claims.

I claim:

1. An engine ignition-timing control arrangement for advancing and retarding the timing of an associated ignition distributor mounted in driven relationship to an internal combustion engine having an air induction passage controlled by a variably positioned throttle valve mounted therein, said timing arrangement comprising first pressure responsive means; second electrically responsive means; housing means contain-

ing said first pressure responsive means and said second electrically responsive means; said first means and said second means being operatively connected to said ignition distributor in order to effect both an advance and a retard of the timing of said ignition distributor; said first pressure responsive means being effective when exposed to vacuum generated in accordance with indicia of engine operating conditions for advancing said timing of said ignition distributor; said second electrically responsive means being effective to retard said timing of said ignition distributor upon the occurrence of certain predetermined engine operating conditions; said air induction passage comprising a carburetor, including a passageway formed in a wall of said carburetor so as to be in communication with said air induction passage and located so as to be in communication with said air induction passage at a point anterior to said throttle valve when said throttle valve is in its closed position, including conduit means communicating between said passageway and said first pressure responsive means within said housing means; said electrically responsive means comprising a solenoid coil, an armature movable with respect to said coil upon electrical energization of said coil, circuit means electrically interconnecting said solenoid coil to a source of electrical energy, first electrical switch means serially connected in said circuit means, second electrical switch means serially connected in said circuit means; said first and second switch means being collectively effective to close said circuit means whenever said first and second switch means are both in a closed condition in order to electrically energize said solenoid coil and thereby cause said armature to retard said timing of said ignition distributor; said first switch means being effectively closed upon the occurrence of a first predetermined indicium of engine operation; said second switch means being effectively opened upon the occurrence of a second predetermined indicium of engine operation; a condition of closed throttle engine operation comprising said first predetermined indicium of engine operation; and the attainment of a preselected value of engine temperature comprising said second predetermined indicium of engine operation.

2. An engine ignition-timing control arrangement for advancing and retarding the timing of an associated ignition distributor mounted in driven relationship to an internal combustion engine having an air induction passage controlled by a variably positioned throttle valve mounted therein, said timing arrangement comprising first pressure responsive means; second electrically responsive means; housing means containing said first pressure responsive means and said second electrically responsive means; said first means and said second means being operatively connected to said ignition distributor in order to effect both an advance and a retard of the timing of said ignition distributor; said first pressure responsive means being effective when exposed to vacuum generated in accordance with indicia of engine operating conditions for advancing said timing of said ignition distributor; said second electrically responsive means being effective to retard said timing of said ignition distributor upon the occurrence of certain predetermined engine operating condition; said housing means comprising at least a first housing section and a second housing section; said first pressure responsive means comprising a pressure responsive diaphragm peripherally retained in sealing relationship between said first and second housing sections; said first housing section and said diaphragm cooperating to define a first general chamber therebetween; said second housing section and said diaphragm cooperating to generally define a second chamber; said second electrically responsive means comprising a solenoid assembly carried within said second chamber; said solenoid means comprising a solenoid coil fixedly situated within said second chamber and an armature slidably received within said coil and movable with respect thereto and said second housing section, including first abutment means for limiting the movement of said armature upon energization of said coil; first spring means for urging said diaphragm in a direction toward said second chamber; resilient motion transmitting means interconnecting said diaphragm and armature so as to cause said diaphragm and said armature to move in unison with each other when vacuum of sufficient magnitude is admitted to said first chamber; and linkage means for operatively connecting said armature to said ignition distributor; said resilient motion transmitting means being effective to permit relative motion between said diaphragm and said armature upon electrical energization of said solenoid coil.

3. An engine ignition-timing control arrangement according the claim 1 including adjustable abutment means for positively limiting the maximum distance to which said diaphragm can move in the direction of said first chamber.

4. An engine ignition-timing control arrangement according to claim 1 wherein said solenoid armature includes an enlarged head end; and said resilient motion transmitting means comprises a cage portion carried by said diaphragm within said second chamber, said cage portion being formed as to generally loosely receive said head end therein, second spring means situated within and carried by said cage normally biasing said armature head end in the direction of said diaphragm; and abutment means carried by said armature for determining the maximum distance to which said diaphragm can move in the direction of said first chamber.

5. An engine ignition-timing control arrangement according to claim 1 wherein said solenoid armature includes a portion extending through said diaphragm in sliding relationship thereto; and said resilient motion-transmitting means comprises second spring means operatively connected to a free end of said armature portion and said diaphragm so as to normally resiliently urge said free end and said diaphragm in directions away from each other, and including second abutment means effective for determining the maximum distance to which said first spring means can move said diaphragm in the direction of said second chamber.