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Sattler

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[54] **IGNITION SPARK VACUUM ADVANCE SYSTEM**

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[52] **U.S. Cl.** ..... **123/117 R,** 123/117 A

[51] **Int. Cl.** **F02p 5/04**

[58] **Field of Search** ..... 123/117 R, 117 A, 97 B

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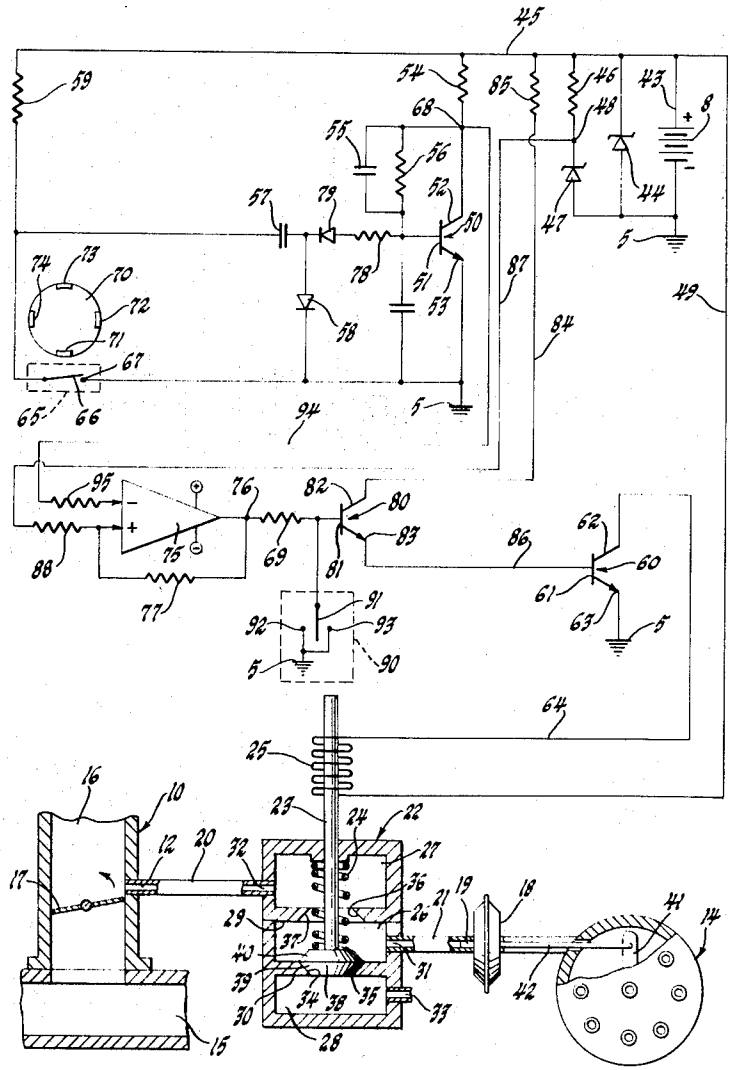
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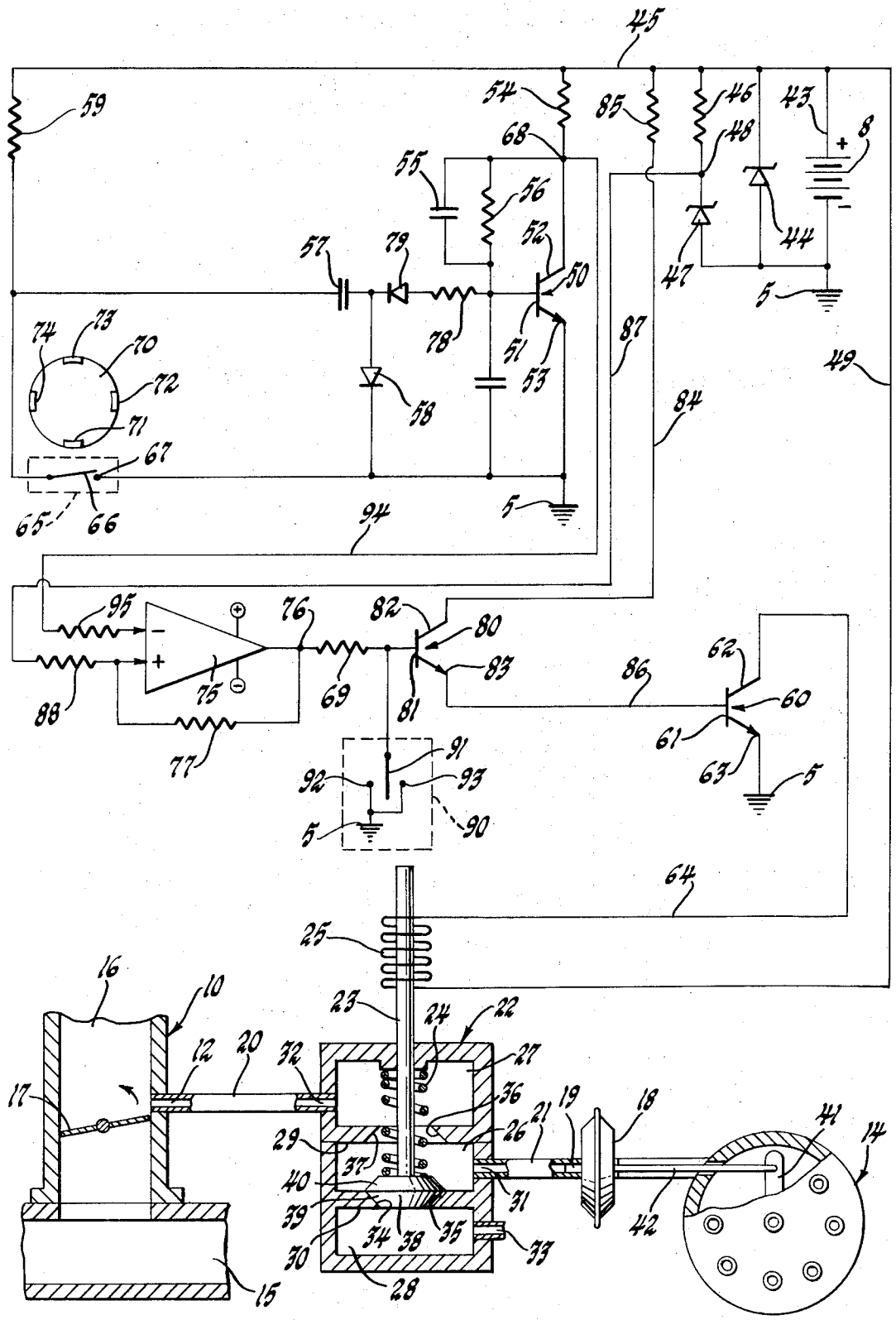
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[57] **ABSTRACT**

An ignition spark vacuum advance system for use with motor vehicle internal combustion engines. An operational amplifier responsive to a vehicle speed signal and a reference signal produces a control signal during acceleration to a speed of a selected magnitude and during deceleration at a speed less than the selected magnitude. The control signal triggers a switching transistor conductive to complete an energizing circuit for the operating coil of a two-way valve which normally establishes a vacuum connection between the carburetor vacuum spark advance port and the associated spark advance vacuum unit vacuum port and, upon the energization of the operating coil, vents the spark advance vacuum unit vacuum port to atmosphere. A temperature sensitive switch is operated to the circuit closed condition with engine temperatures less and greater than a selected engine temperature range to inhibit the switching transistor.

6 Claims, 1 Drawing Figure




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IGNITION SPARK VACUUM ADVANCE SYSTEM

This invention is directed to an ignition spark vacuum advance system and, more specifically, to an ignition spark vacuum advance system for use with motor vehicle internal combustion engines which provides ignition spark retard at vehicle or engine speeds less than a preselected magnitude with normal engine temperatures and normal ignition spark vacuum advance at any vehicle or engine speed with a cold or overheated engine.

In an effort to reduce the undesirable emissions of the exhaust of internal combustion engines employed to drive motor vehicles, various ignition spark control systems have been developed which prevent ignition spark vacuum advance during low vehicle speeds. One undesirable consequence of systems of this type is the difficulty of a cold engine to start properly in cold weather and drive the vehicle without stalling. Furthermore, since internal combustion engines heat more rapidly with a retarded spark, there is a tendency for the engine to overheat at low vehicle speeds, such as encountered in slow traffic or standing, with the spark retarded.

It is therefore, an object of this invention to provide an improved ignition spark vacuum advance system for use with motor vehicle internal combustion engines.

It is another object of this invention to provide an improved ignition spark vacuum advance system for use with motor vehicle internal combustion engines which, at low vehicle or engine speeds, disenables the ignition spark vacuum advance mechanism while the engine is at normal operating temperature and enables the ignition spark vacuum advance mechanism at any vehicle or engine speed while the engine is operating at temperatures less than and greater than a selected engine temperature range.

In accordance with this invention, a motor vehicle internal combustion engine ignition spark vacuum advance system which retards the ignition spark at low vehicle or engine speeds with engine temperatures within a selected range and provides normal ignition spark vacuum advance at any vehicle or engine speed with engine temperatures not within the selected range is provided wherein a switching transistor having the collector-emitter electrodes connected in series in the energization circuit of the operating coil of a two-way valve, the energization of which operates the valve to a condition which vents the vacuum port of an associated spark advance mechanism vacuum unit to atmosphere, is triggered conductive through the collector-emitter electrodes in response to a control signal produced during vehicle acceleration until the vehicle has accelerated to a speed of a selected magnitude and during vehicle deceleration after the vehicle has decelerated to a speed less than the selected magnitude and a temperature sensitive switch is operated to the electrical circuit closed condition in response to engine temperatures less than and greater than a selected engine temperature range to inhibit the switching transistor.

For a better understanding of the present invention, together with additional objects, advantages and features thereof, reference is made to the following description and accompanying single FIGURE drawing which sets forth the ignition spark vacuum advance system of this invention in schematic form.

The ignition spark vacuum advance system for use with motor vehicle internal combustion engines of this invention operates in combination with a conventional automotive type carburetor **10** having a vacuum spark advance port **12**; an ignition distributor **14,** shown in top plan view in the FIGURE, having an ignition spark advance mechanism operated by a spark advance vacuum unit **18** having a vacuum port **19** and a source of direct current potential, which may be a conventional automotive type battery **8.**

Carburetor **10** may be of conventional design having a vacuum spark advance port **12** which opens into the carburetor mixing conduit **16,** through which the air-fuel mixture is conducted to the intake manifold **15,** just above the throttle plate **17.** At idle or conditions of very low speed, throttle plate **17** is closed or nearly closed, consequently, carburetor vacuum spark advance port **12** is exposed to substantially atmospheric pressure, as shown in the FIGURE. As the throttle plate **17** is revolved to open in a counterclockwise direction, as viewing the FIGURE, carburetor vacuum spark advance port **12** becomes exposed to the engine intake manifold vacuum.

Ignition distributor **14** may be of conventional design having an ignition spark advance mechanism of conventional design operated by a spark advance vacuum unit **18** having a vacuum port **19.** As ignition spark vacuum advance mechanisms of this type are well known in the automotive art and, per se, form no part of this invention, it has not been illustrated in detail in the FIGURE. The operation will be explained in greater detail later in this specification.

Extending between the carburetor vacuum spark advance port **12** and the spark advance vacuum unit vacuum port **19** is a vacuum line which includes vacuum line segments **20** and **21** and a two-way valve **22,** having an operating member or rod **23,** which is operated to a first position by compression spring **24** to establish a vacuum connection between the carburetor vacuum spark advance port **12** and spark advance vacuum unit vacuum port **19** and is operable to a second position upon the energization of operating coil **25** to vent the spark advance vacuum unit vacuum port **19** to atmosphere. Two-way valve **22** is illustrated in the FIGURE as having a center chamber **26** and two outside chambers **27** and **28** separated by respective walls **29** and **30.** Each of chambers **26, 27** and **28** communicates externally of valve **22** through respective ports **31, 32** and **33.** Internally of valve **22,** center chamber **26** communicates with outside chamber **28** through an inside port **34** having an angularly disposed valve seat **35** and with the other outside chamber **27** through an inside port **36** having an angularly disposed valve seat **37.** Port **31** of two-way valve **22** is interconnected with the spark advance vacuum unit vacuum port **19** through vacuum line segment **21,** port **32** is interconnected with the carburetor vacuum spark advance port **12** through vacuum line segment **20** and port **33** is vented to atmosphere. Secured to the end of operating member **23** within valve **22** is a piston **38** having two angularly disposed faces **39** and **40** which are arranged to engage respective angularly disposed valve seats **35** and **37** in a tight complementary fit. Valve **22** is operated to the first condition by compression spring **24** and is operated to the second condition by energizing operating coil **25** which moves rod **23** linearly in an upward direction as viewing the FIGURE. In the first condition of

valve 22, face 39 of piston 38 is in tight complementary fit with valve seat 35 to provide an open passage therethrough between only ports 31 and 32 and in the second condition, face 40 of piston 38 is in a tight complementary fit with valve seat 37 to provide an open passage therethrough between only ports 31 and 33. It is to be specifically understood that two-way valve 22 of the FIGURE is only one example of many two-way valves which may be employed for this application.

With conventional ignition spark vacuum advance mechanism, the carburetor vacuum spark advance port is directly interconnected through a vacuum line with the spark advance vacuum unit vacuum port. The spark advance vacuum unit 18 may be any one of the many vacuum units well known in the automotive art.

Mounted within the distributor 14 is a movable breaker plate, upon which the ignition breaker contact points are mounted, which is rotatable in a plane normal to the axis of the distributor drive shaft to advance and retard the engine ignition spark. This movable breaker plate is revolved by an operating arm, such as that referenced by the numeral 41 in the FIGURE, which is attached to and moved by a diaphragm within the spark advance vacuum unit 18 through a push rod 42 in a manner well known in the automotive art.

As vehicle acceleration, deceleration and rate of speed is directly proportional to engine speed, the ignition spark vacuum advance system of this invention will be herein described in relation to engine speed.

At idle or conditions of low engine speed, with the carburetor throttle plate closed or nearly closed, the carburetor vacuum spark advance port 12 is exposed to atmospheric pressure, consequently, the diaphragm within the spark advance vacuum unit 18 is exposed to atmosphere on both sides. Under these conditions, the diaphragm and connected operating rod 42 are forced by a spring, also within the spark advance vacuum unit 18, in a direction which will rotate the movable breaker plate within distributor 14 in the direction which will retard the ignition spark. With the carburetor throttle plate 17 open during acceleration or cruising speed, the carburetor vacuum spark advance port 12 is exposed to engine intake manifold vacuum, the diaphragm with the spark advance vacuum unit 18 is exposed to manifold vacuum on the side of the vacuum port 19. Under these conditions, the diaphragm within the spark advance vacuum unit 18 and connected operating rod 42 are forced in the opposite direction by the greater pressure on the side of the diaphragm vented to atmosphere to rotate the movable breaker plate in the direction which will advance the ignition spark. From this description, it is apparent that with two-way valve 22 in the first condition of operation with face 39 of piston 38 in tight complementary fit with valve seat 35, the ignition spark vacuum advance mechanism illustrated in the FIGURE will operate in a normal manner.

In the FIGURE, the output potential of battery 8 is shown to be regulated by Zener diode 44. It is to be specifically understood that this potential regulating arrangement is not absolutely necessary for the practice of this invention.

As point of reference or ground potential is the same point electrically throughout the system, it has been illustrated in the FIGURE by the accepted schematic symbol and referenced by the numeral 5.

One method, and without intention or inference of a limitation thereto, for producing a direct current speed signal of a magnitude proportional to vehicle speed may be a type NPN transistor 50 operating as a class A amplifier having the collector electrode 52 and emitter electrode 53 thereof connected across the positive and negative polarity terminals, respectively, of battery 8 through collector resistor 54 and leads 45 and 43 and point of reference or ground potential 5, respectively; the parallel combination of capacitor 55 and resistor 56 connected across the collector electrode 52 and the base electrode 51 of transistor 50 and the parallel combination of capacitor 57 and diode 58 in series and the contacts 66 and 67 of a magnetically operated reed switch 65 connected across battery 8 through current limiting resistor 59 and leads 45 and 43 and point of reference or ground potential 5. Member 70 may be any member which may be conveniently rotated at a speed equal to or proportional to vehicle or engine speed which is arranged to carry a plurality of permanent magnets, four of which are illustrated in the FIGURE and referenced by the numerals 71, 72, 73, and 74. For example, member 70 may be a drum mounted upon the engine crankshaft, it may be a member mounted upon the engine flywheel or a member mounted upon any other vehicle part which is rotated at a speed equal to or proportional to vehicle or engine speed. It is only necessary that the permanent magnets rotated thereby are in operative relationship with the contacts 66 and 67 of reed switch 65 to operate these contacts to the electrical circuit open and closed conditions at a frequency proportional to vehicle or engine speed by passing in close proximity thereto in a manner well known in the art. While the contacts 66 and 67 of reed switch 65 are open, capacitor 57 charges through resistor 59 and diode 58 and while the contacts 66 and 67 of reed switch 65 are closed, a discharge circuit is established therethrough for capacitor 57.

Discharging capacitor 57 reduces the positive polarity potential upon the base electrode 51 of type NPN transistor 50 thereby decreasing the collector-emitter conduction therethrough as a class A amplifier. Capacitor 55 charges through the relatively low value resistances 54 and 78 and diodes 78 and 58 and discharges through high resistance 56 or much more rapidly through the collector-emitter electrodes of type NPN transistor 50, depending upon the degree of its conductivity. Consequently, the more frequently contacts 66 and 67 of reed switch 65 are operated to the electrical circuit closed condition by the magnets carried upon rotating member 70 with increases of vehicle or engine speed, the lower the degree of conduction through type NPN transistor 50. As capacitor 55 discharges more slowly with a decrease of conduction through transistor 50, the potential appearing across junction 68 and point of reference or ground potential 5, the speed signal which is of a positive polarity upon junction 68 with respect to point of reference or ground potential 5, increases in magnitude. Consequently, this speed signal potential is of a magnitude proportional to vehicle speed.

To produce a direct current reference signal of a predetermined substantially constant magnitude, the series combination of a resistor 46 and the Zener diode 47 may be connected across battery 8 through leads 45 and 43 and point of reference or ground potential 5. Zener diode 47 is selected to have an inverse breakdown potential of a magnitude equal to the selected predetermined magnitude. Consequently, the direct

current reference signal potential appearing across junction **48** and point of reference or ground potential **5** of a positive polarity upon junction **48** with respect to point of reference or ground potential **5** remains substantially constant at a magnitude equal to the inverse breakdown potential of the Zener diode selected as Zener diode **47.** In one specific embodiment of the internal combustion engine ignition spark advance system of this invention, the selected Zener diode corresponding to Zener diode **47** had an inverse breakdown potential of seven volts.

Circuitry responsive to the speed signal appearing across junction **68** and point of reference or ground potential **5** and the reference signal appearing across junction **48** and point of reference or ground potential **5** for producing a control signal during vehicle acceleration until the vehicle has accelerated to a speed of a selected magnitude and during vehicle deceleration after the vehicle has decelerated to a speed less than the selected magnitude may be a conventional operational amplifier **75** having an inverting input circuit, referenced in the FIGURE as a "minus" sign, and a non-inverting input circuit, referenced in the FIGURE as a "plus" sign, and an output circuit **76,** operating in the open loop mode. When operating in the open loop mode, operational amplifiers function as an extremely sensitive and rapidly operating electrical switch produces an output signal of a positive polarity upon the output terminal **76** thereof with respect to point of reference or ground potential **5** when a positive polarity potential is applied to the inverting input circuit of a magnitude less than the positive polarity potential applied to the non-inverting input circuit and produces an output signal of substantially ground potential when a positive polarity potential is applied to the inverting input circuit of a magnitude greater than the positive polarity potential applied to the non-inverting input circuit. To provide the hysteresis required for operational amplifier **75** to produce the control signal during vehicle acceleration until the vehicle has accelerated to a speed of a selected magnitude and during vehicle deceleration after the vehicle has decelerated to a speed less than the selected magnitude, a feedback resistor **77** is connected between output circuit **76** and the non-inverting input circuit thereof.

Circuitry responsive to the control signal produced by operational amplifier **75** for completing an energizing circuit for the operating coil **25** of two-way valve **22** across the source of direct current potential may be any electrical switching device having normally open current carrying elements, operable to an electrical circuit closed condition in response to an electrical signal such as the control signal, connected in series with the operating coil **25** of two-way valve **22** across the source of direct current potential. In the FIGURE, and without intention or inference of a limitation thereto, this electrical switching device is illustrated as a type NPN transistor **60** having the collector electrode **62** and emitter electrode **63** thereof connected in series with operating coil **25** of two-way valve **22** across battery **8** through a circuit which may be traced from the positive polarity terminal of battery **8** through lead **43,** lead **49,** operating coil **25** of two-way valve **22,** lead **64** and the collector-emitter electrodes of transistor **60** to point of reference or ground potential **5.** With some applications, the base electrode **61** of transistor **60** may be connected to output circuit **76** of operational amplifier **75** through current limiting resistor **69.** Alternatively, a type NPN driver transistor **80** having the collector electrode **82** thereof connected to the positive polarity terminal of battery **8** through lead **84,** collector resistor **85** and leads **45** and lead **43** and the emitter electrode **83** thereof connected to the negative polarity terminal of battery **8** through lead **86,** the base-emitter electrodes of transistor **60** and point of reference or ground potential **5** may be connected between output circuit **76** of operation amplifier **75** and switching transistor **60** and the base electrode **81** thereof connected to output circuit **76** of operational amplifier **75** through current limiting resistor **69.** With the first alternative, switching transistor **60** is responsive to the control signal for completing an energizing circuit for operating coil **25** of two-way valve **22** and with the second alternative, drive transistor **80** and switching transistor **60** are responsive to the control signal for completing an energizing circuit for operating coil **25** of two-way valve **22.**

The device responsive to engine temperatures less than and greater than a selected engine temperature range, for example, 140° to 160° F., for inhibiting the circuitry responsive to the control signal, either switching transistor **60** or driver transistor **80** and switching transistor **60,** may be a temperature sensitive switch **90** having a movable contact **91** and two stationary contacts **92** and **93.** This temperature sensitive switch may be connected across the base electrode **81** of driver transistor **80** and point of reference or ground potential **5,** as shown in the FIGURE, or, alternatively, it may be connected across the base electrode **61** of switching transistor **60** or across the non-inverting input circuit of operational amplifier **75** and point of reference or ground potential **5.** Switch **90** may be any one of the many temperature sensitive switches having a movable contact which is operated to an electrical circuit closed condition to one associated stationary contact with engine temperatures below a selected minimum and to an electrical circuit closed condition to the other associated stationary contact with engine temperatures greater than a selected minimum.

Assuming that the associated internal combustion engine, not shown, is operating the vehicle at idle or low engine speed within the selected engine temperature range, transistor **50** is operating as a class A amplifier and the contacts **66** and **67** of reed switch **65** are being slowly operated by the magnets upon rotating member **70** and capacitor **55** is charged through resistor **54,** resistor **78,** diode **79** and diode **58.** With these conditions, the reference potential appearing across junction **48** and point of reference or ground potential **5,** applied to the non-inverting input circuit of operational amplifier **75** through lead **87** and resistor **88** is of a magnitude greater than the speed signal appearing across junction **68** and point of reference or ground potential **5,** applied to the inverting input circuit of operational amplifier **75** through lead **94** and resistor **95.** As the positive polarity potential applied to the non-inverting inverting input circuit of operational amplifier **75** is of a magnitude greater than the positive polarity potential applied to the inverting input circuit thereof, operational amplifier **75** produces an output control signal upon output circuit **76** thereof of a positive polarity upon output circuit **76** with respect to point of reference or ground potential **5.** As this control signal is applied across the base-emitter electrodes of type NPN driver transistor **80** through resistor **69** in the proper polarity relation-

ship to produce base-emitter drive current through a type NPN transistor, driver transistor **80** is triggered conductive through the collector-emitter electrodes thereof to supply base drive current to switching transistor **60** through leads **43** and **45**, collector resistor **85**, lead **84**, the collector-emitter electrodes of transistor **80**, lead **86**, the base-emitter electrodes of type NPN switching **60** and point of reference or ground potential **5**. This base drive current supplied to switching transistor **60** triggers this device conductive through the collector-emitter electrodes thereof to complete an energizing circuit for operating coil **25** of two-way valve **22** which may be traced from the positive polarity terminal of battery **8**, through leads **43** and **49**, operating coil **25**, lead **64**, the collector-emitter electrodes of switching transistor **60** and point of reference or ground potential **5** to the negative polarity terminal of battery **8**. It may be noted that with applications in which driver transistor **80** is eliminated and the base electrode **61** of type NPN switching transistor **60** is connected to output circuit **76** of operational amplifier **75** through resistor **69**, the positive polarity control signal upon output circuit **76** of operational amplifier **75** is of the proper polarity relationship to produce base drive current through type NPN switching transistor **60** to trigger this device conductive through the collector-emitter electrodes to establish the same energizing circuit for operating coil **25** of two-way valve **22**. Upon the energization of operating coil **25**, two-way valve **22** is operated to the second condition in which the vacuum port **19** of spark advance vacuum unit **18** is vented to atmosphere through port **31** of valve **22**, center chamber **26**, internal port **34**, outside chamber **28** and port **33**. With vacuum port **19** of spark advance vacuum unit **18** vented to atmosphere, the ignition spark vacuum advance mechanism is disabled and the ignition spark is retarded at these low engine and, consequently, vehicle speeds.

As the speed of the engine is increased to accelerate the vehicle, the magnets carried by rotating member **70** operate contacts **66** and **67** of reed switch **65** more rapidly to the electrical circuit open and closed conditions to reduce the degree of conduction through transistor **50** for the reason previously set forth. A decreased degree of conduction through transistor **50** results in the retention of a charge of increased magnitude upon capacitor **55** as it is not as rapidly discharged through conducting transistor **50**. Consequently, as the engine continues to accelerate the vehicle, the speed signal appearing across junction **68** and point of reference or ground potential **5** continues to increase in magnitude with increases of engine and vehicle speed until the vehicle has been accelerated to a speed of a selected magnitude, for example **30** miles per hour, at which the magnitude of the speed signal appearing across junction **68** and point of reference or ground potential **5** is of a magnitude greater than the reference potential appearing across junction **48** and point of reference or ground potential **5**. With these conditions, the positive polarity speed signal potential applied to the inverting input circuit of operational amplifier **75** is of a magnitude greater than the reference signal potential applied to the non-inverting input circuit of operational amplifier **75**, consequently, the control signal is removed from output circuit **76** which is now of substantially ground potential. With output circuit **76** of operational amplifier **75** at ground potential, base drive current is no longer supplied to driver transistor **80**, consequently, this device extinguishes. With driver transistor **80** extinguished, the circuit through which base drive current is supplied to type NPN switching transistor **60** is interrupted, consequently, switching transistor **60** extinguishes to interrupt the energizing circuit of operating coil **25** of two-way valve **22**. Upon the deenergization of operating coil **25**, compression spring **24** operates piston **38** of two-way valve **22** into a tight complementary fit with valve seat **35** to place valve **42** in the first condition. With two-way valve **22** in the first condition, a vacuum connection is established between the carburetor spark advance port **12** and the spark advance vacuum unit **18** vacuum port **19** through vacuum line segment **20**, port **32** of valve **22**, outside chamber **27**, internal port **36**, center chamber **26**, port **31** and vacuum line segment **21**. With the establishment of this vacuum connection, the internal combustion engine ignition spark vacuum advance mechanism operates in a normal manner to provide ignition spark advance in accordance with engine vacuum. It may be noted that with applications in which driver transistor **80** is eliminated and the base electrode **61** of type NPN switching transistor **60** is connected to output circuit **76** of operational amplifier **75** through resistor **69**, a ground potential signal upon output circuit **76** of operational amplifier **75** will remove base drive current from switching transistor **60** to extinguish this device and interrupt the energizing circuit for operating coil **25** of two-way valve **22**.

During deceleration, the contacts **66** and **67** of reed switch **65** are operated at a proportionately lower rate, consequently, the degree of conduction through transistor **50** begins to increase proportionately, resulting in a proportionate decrease of the magnitude of the speed signal appearing across junction **68** and point of reference or ground potential **5**. However, the ground potential upon output circuit **76** of operational amplifier **75**, applied to the non-inverting input circuit thereof through feedback resistor **77**, effectively reduces the magnitude of the positive polarity reference potential also applied to the non-inverting input circuit. Consequently, the positive polarity speed signal applied to the inverting input circuit of operational amplifier **75** is of a relatively greater magnitude. Therefore, upon deceleration, the magnitude of the positive polarity reference signal potential applied to the non-inverting input circuit of operational amplifier **75** will not exceed the realtive magnitude of the positive polarity speed signal potential applied to the inverting input circuit thereof until the speed signal potential has reduced to a value lower than that corresponding to the speed of the selected magnitude, for example at 20 miles per hour. With this arrangement, a hysteresis is introduced into the system to provide increased stability and smoothness of vehicle operation. As the engine and vehicle continue to decelerate until a speed is reached at which the reference signal potential is of a magnitude greater than the relative speed signal potential operational amplifier **75** again produces the control signal upon the output circuit **76** thereof. Upon the appearance of this control signal, driver transistor **80** and switching transistor **60** or, alternatively, only switching transistor **60** in the event driver transistor **80** is not employed, again establishes the energizing circuit for operating coil **25** of two-way valve **22** to operate two-way valve **22** to the second condition which vents the vacuum port **19** of spark advance vacuum unit **18** to atmosphere. With

vacuum port **19** vented to atmosphere, the ignition spark is retarded at these low engine speeds.

Should the vehicle or engine be operating at any speed at a temperature less than the selected engine temperature range, movable contact **91** of temperature sensitive switch **90** is operated to the circuit closed condition to one of stationary contacts **92** or **93** and should the vehicle or engine be operating at any speed at a temperature greater than the selected engine temperature range, movable contact **96** of temperature sensitive switch **95** is operated to the electrical circuit closed condition to the other one of stationary contacts **97** or **98.** Upon the closure of movable contact **91** of temperature sensitive switch **90** to either one of stationary contacts **92** or **93,** base drive current is diverted from driver transistor **80** with the circuit connections in the FIGURE. With base drive current diverted from driver transistor **80,** this device does not conduct to supply base drive current to switching transistor **60,** consequently, an energizing circuit is not established for operating coil **25** of two-way valve **22.** Should temperature sensitive switch **90** be connected across the base electrode **61** of switching transistor **60** and point of reference or ground potential **5,** base drive current supplied by driver transistor **80** would be diverted from switching transistor **60,** a condition which prevents switching transistor **60** from conducting through the collector-emitter electrodes to establish the energizing circuit for operating coil **25** of two-way valve **22.** Should temperature sensitive switch **90** be connected across the non-inverting input circuit of operational amplifier **75** and point of reference or ground potential **5,** any speed signal potential magnitude would result in a ground potential signal upon output circuit **76** thereof, a condition which would trigger neither driver transistor **80** nor switching transistor **60** conductive through the collector-emitter electrodes, consequently, the energizing circuit for operating coil **25** of two-way valve **22** would not be established. Consequently, at any engine speed while the engine is operating at a temperature greater than or less than the selected engine temperature range, temperature sensitive switch **90** inhibits the circuitry through which the energizing circuit is established for operating coil **25** of two-way valve **22** and the ignition vacuum spark advance mechanism of the associated engine operates in a normal manner to advance the ignition spark in accordance with engine vacuum.

While a preferred embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is to be limited only within the scope of the appended claims.

What is claimed is:

1. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for producing a direct current reference signal of a predetermined substantially constant magnitude, means responsive to said speed signal and said reference signal for producing a control signal during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, and means responsive to said control signal for completing an energizing circuit for said operating coil of said two-way valve across said source of direct current potential.

2. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for producing a direct current reference signal of a predetermined substantially constant magnitude, means responsive to said speed signal and said reference signal for producing a control signal during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, means responsive to said control signal for completing an energizing circuit for said operating coil of said two-way valve across said source of direct current potential, and means responsive to engine temperatures less than and greater than a selected engine temperature range for inhibiting said means responsive to said control signal.

3. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for produc-

ing a direct current reference signal of a predetermined substantially constant magnitude, means responsive to said speed signal and said reference signal for producing a control signal during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, an electrical switching device having normally open current carrying elements operable to an electrical circuit closed condition in response to said control signal, and means for connecting said current carrying elements of said electrical switching device and said operating coil of said two-way valve in series across said source of direct current potential.

4. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for producing a direct current reference signal of a predetermined substantially constant magnitude, means responsive to said speed signal and said reference signal for producing a control signal during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, an electrical switching device having normally open current carrying elements operable to an electrical circuit closed condition in response to said control signal, means for connecting said current carrying elements of said electrical switching device and said operating coil of said two-way valve in series across said source of direct current potential, and means responsive to engine temperatures less than and greater than a selected engine temperature range for diverting said control signal from said electrical switching device.

5. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for producing a direct current reference signal of a predetermined substantially constant magnitude, an operational amplifier having an inverting input circuit, a non-inverting input circuit and an output circuit for producing a control signal upon said output circuit thereof during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, means for applying said direct current speed signal to said inverting input circuit of said operational amplifier, means for applying said direct current reference signal to said non-inverting input circuit of said operational amplifier, and means responsive to said control signal for completing an energizing circuit for said operating coil of said two-way valve across said source of direct current potential.

6. An ignition spark vacuum advance system for use with motor vehicle internal combustion engines comprising in combination with a carburetor having a spark advance port, an ignition distributor having an ignition spark advance mechanism operated by a spark advance vacuum unit having a vacuum port and a source of direct current potential, a vacuum line extending between said carburetor spark advance port and said spark advance vacuum unit vacuum port, a two-way valve having an operating coil included in said vacuum line which is normally in a first condition to establish a vacuum connection between said carburetor spark advance port and said spark advance vacuum unit vacuum port and operable, upon the energization of said operating coil, to a second condition to vent said vacuum advance unit vacuum port to atmoosphere, means for producing a direct current speed signal of a magnitude proportional to vehicle speed, means for producing a direct current reference signal of a predetermined substantially constant magnitude, an operational amplifier having an inverting input circuit, a non-inverting input circuit and an output circuit for producing a control signal upon said output circuit thereof during vehicle acceleration until said vehicle has accelerated to a speed of a selected magnitude and during deceleration after said vehicle has decelerated to a speed less than the selected magnitude, means for applying said direct current speed signal to said inverting input circuit of said operational amplifier, means for applying said direct current reference signal to said non-inverting input circuit of said operational amplifier, means responsive to said control signal for completing an energizing circuit for said operating coil of said two-way valve across said source of direct current potential, and means responsive to engine temperatures less than and greater than a selected engine temperature range for inhibiting said means responsive to said control signal.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,824,972 Dated July 23, 1974

Inventor(s) Walter J. Sattler

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 41, delete "minimum" and insert -- maximum --.

Signed and sealed this 15th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents