Nov. 10, 1964 A. J. BLACKWOOD 3,156,228

METHOD AND APPARATUS FOR RETARDING SPARK

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FIGURE 1

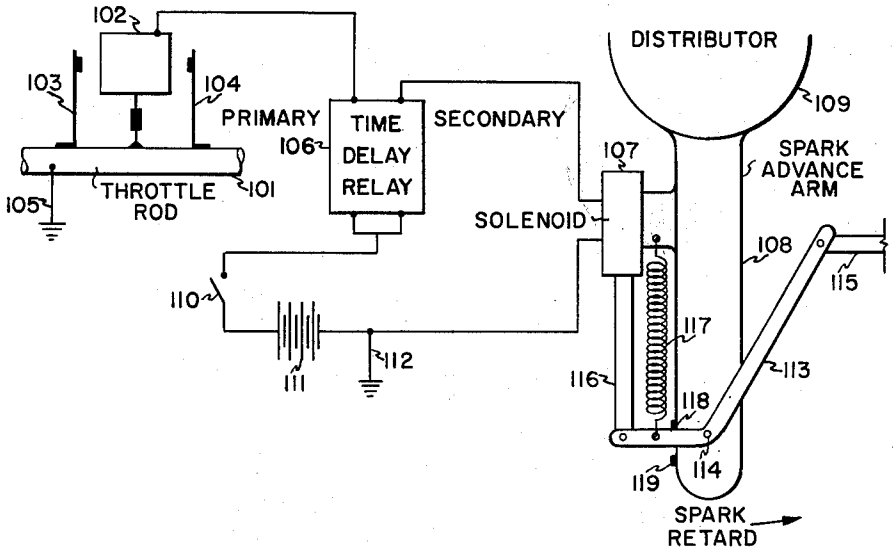
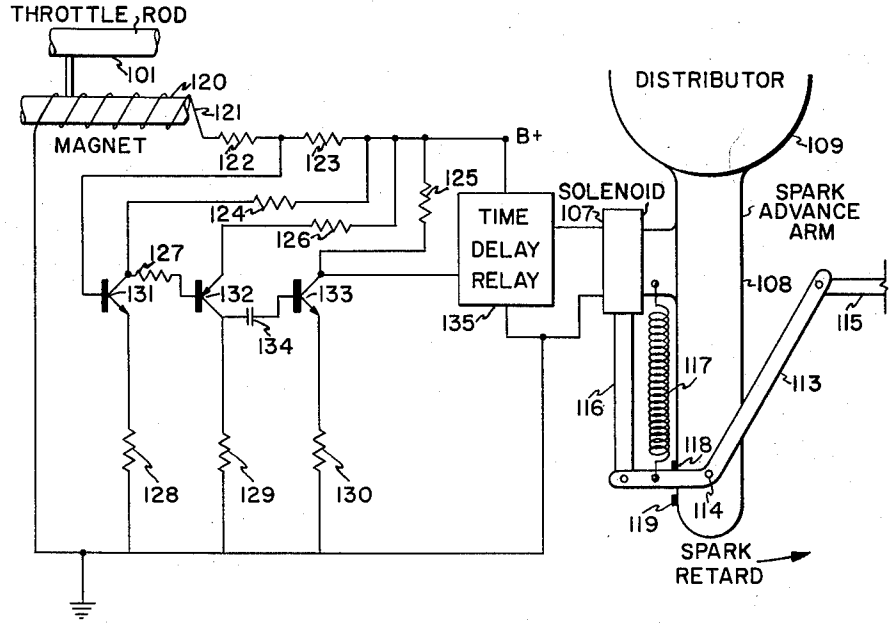


FIGURE 2



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METHOD AND APPARATUS FOR RETARDING SPARK

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This invention relates to a method and apparatus for retarding spark to reduce detonation in internal combustion engines. More specifically, this invention relates to a method and apparatus for reducing detonation in internal combustion engines by temporarily retarding the spark during changes in the throttle position (i.e., acceleration, deceleration and starting).

The method and apparatus of the present invention are described in connection with the ignition and fuel systems of an internal combustion engine of a motor vehicle, e.g., automobile.

Background

As manufacturers have increased the compression ratios of internal combustion engines, e.g., automobile engines, to compression ratios of, for example, 9.5:1 or 10:1 etc., certain combustion problems have developed when using commercially available gasolines. One of these problems is detonation which occurs during periods when the throttle position is changed, e.g., acceleration, start-up etc. This detonation is generally observed as an unpleasant noise and is both annoying to the driver and detrimental to the engine. Generally, the cause of such detonation can be traced to the fact that under conditions of changing throttle positions there is too great a spark advance for the fuel being used. It is thought that certain precombustion reactions within the fuel/air mixture cause the mixture to be oversensitive and cause an explosive pressure peak immediately upon spark ignition. In support of this theory, it has been observed that detonation is accompanied by a very rapid and unusual increase in cylinder pressure.

Detonation frequently occurs for a short period of time during the acceleration which follows a partial increase in throttle opening (usually referred to as part throttle knock) and also for a period of time during the acceleration which follows a complete opening of the throttle (usually referred to as full throttle knock). Detonation may also occur during the cranking period, i.e., start-up, of the engine (usually referred to as hot starting noise). This noise is usually associated with a start-up of a prewarmed engine although occasionally it will occur in a cold engine.

Discovery

It has now been discovered, and this discovery forms the basis of the present invention, that the detonation occurring during partial and complete openings of the throttle, as well as detonation occurring during start-up periods, may be substantially reduced or eliminated altogether by applying the method and apparatus of this invention which serve to temporarily retard the normal spark advance a predetermined number of degrees.

Brief Description

Briefly, the present invention can be described as follows:

Sensing means are positioned so as to be actuated by any change in the throttle position, e.g., an inertia device operating off the throttle linkage. Upon actuation, this sensing means causes a time delay means to go into operation. This time delay means, in turn, causes spark retarding means to temporarily retard or reduce the basic spark advance a few degrees, e.g., 0.1 to 10°, or more,

of angular rotation. This temporary retarding of the basic spark advance lasts for a short, predetermined period of time, e.g., up to 30 seconds, or until the acceleration, etc., is completed. Since it has been shown that exhaust gas air pollution is reduced if the spark is retarded during the period of deceleration, the particular method and apparatus of this invention takes on an added advantage over prior art systems.

It will be realized that the number of degrees of spark retard obtained by the present device could also be provided by a suitable change in the basic manual adjustment. This would, however, be an undesirable expedient since the power, economy and engine deposit accumulation characteristics of the engine under normal operation would be adversely affected. For example, the normal ignition system in an automobile is provided with means whereby the spark is automatically advanced a maximum number of degrees. Generally, this is about 23°. Thus, the maximum amount of spark advance from any arbitrary manual adjustment set point is fixed at a certain number of degrees. If this manual adjustment of the spark were varied to further retard the spark, it would correspondingly reduce the maximum spark advance which could be obtained by a similar number of degrees. To illustrate this phenomenon, assume that the basic manual adjustment of the spark were considered as 0° and the maximum advance provided by the automatic spark advance mechanism, either centrifugal or vacuum, is 23°. With the recommended basic setting, the spark could be advanced to +23° maximum and retarded to a minimum of 0°. If, however, the basic adjustment were changed to retard the spark an additional 10°, the initial setting would be −10° and the maximum spark advance would be to +13°. By utilizing the method and apparatus of the present invention, however, the basic setting of 0° can be retained, thus permitting a maximum spark advance to +23°. However, the total range of advance and retard of the spark is expanded since the apparatus of the invention can retard the spark an empirically selected number of degrees, e.g., 10. Thus, using the apparatus of the present invention, the total range as given in this example would be increased from the narrow range of 0° to +23°, to the broader range of from −10° to +23°. The spark retard of from 0° to −10° would be in effect only under conditions of changing the throttle position, i.e., acceleration, deceleration and starting.

As referred to herein "advancing the spark" refers to causing the spark to occur early in time and "retarding the spark" refers to causing the spark to occur later in time, all with respect to the normal position of a piston within a cylinder of the internal combustion engine.

Detailed Description

The present invention will be more clearly understood by reference to the following description and claims taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagrammatic view of the spark retard apparatus of the present invention.

FIGURE 2 is a diagrammatic view of an alternate embodiment of the present invention.

FIGURE 1 represents, in partly schematic form, an apparatus suitable for carrying out the method of the present invention. The apparatus is used in connection with the ignition and fuel systems of an internal combustion engine. The fuel system (not shown) includes a throttle control rod **101**. An inertia mass **102** is mounted above or below throttle control rod **101** and positioned between electrical contacts **103** and **104** which are affixed to throttle control rod **101**. Inertia mass **102** is electrically insulated from throttle control rod **101**. Throttle control rod **101** is electrically grounded

105. Inertia mass 102 is electrically connected to the primary circuit of time delay apparatus 106. The secondary circuit of time delay apparatus 106 is electrically connected to solenoid 107 which is firmly, but detachably, mounted on spark advance arm 108 of distributor 109. Time delay apparatus 106 is further connected electrically through the ignition switch 110 and battery 111 to solenoid 107. This electrical circuit is also grounded 112. A swinging arm or lever 113 is pivotally connected to spark advance arm 108 at point 114. One end of swinging arm 113 is pivotally connected to automatic spark advance control rod 115 (a normal feature of conventional internal combustion engines), while the other end of swinging arm 113 is pivotally connected to plunger 116 of solenoid 107. Spiral spring 117 is attached to the base of solenoid 107 and to swinging arm 113. Spiral spring 117 is in tension and exerts a pulling force upon swinging arm 113 to bias it in a normal position against stop 118. Movement of swinging arm 113 is limited by stops 118 and 119. For purposes of discussion, it is assumed that a rotation of the distributor 109 by spark advance arm 108 in a counterclockwise direction will cause the spark to be retarded as indicated by the arrow in FIGURE 1.

In operation (assuming the ignition switch is "on"), a demand for more or less power is met by movement of the throttle, and likewise a movement of the throttle control rod 101 to provide a corresponding increase or decrease in the throttle opening. Movement of the throttle control rod 101 (or linkage connected thereto) causes inertia mass 102 to make contact with electrical contact 103 or 104, thus completing an electrical circuit and causing current to flow in the primary circuit of time delay relay 106. When the primary circuit of the time delay relay 106 is activated, it closes the secondary circuit in the time delay relay 106, either by the use of thermal elements or other means such as transistors and condensers, for a short period of time, e.g., 0.5 to 30 seconds. The secondary circuit of time delay relay 106 is in series with solenoid 107 which, therefore, becomes energized for the same period of time, i.e., from 0.5 to 30 seconds. Energizing solenoid 107 causes plunger 116 of solenoid 107 to push downwardly against the biasing force of spiral spring 117, thus moving swinging arm 113 from stop 118 to stop 119 (which have been carefully placed so as to allow a predetermined amount of spark retardation, e.g., 10°). For any given position of the automatic advance control rod 115, this movement of swinging arm 113 will cause a temporary retardation of the spark by causing spark advance arm 108 to move in a counterclockwise direction. Thus, regardless of the engine operating conditions, a reduction in spark advance will occur when solenoid 107 is energized. This reduction in spark advance will be a predetermined amount below the usual position of the spark advance as set by the manufacturer, and will be determined by the relative positions of stops 118 and 119. While it is recognized that the reduction in spark advance (i.e., spark retard) may be accomplished over wide ranges, e.g., 15° to 30° or more, it will usually be found preferably to employ spark advance reduction of about 10° or less, e.g., from 0.5° to 10° for periods of time of from 0.5 to 30 seconds, e.g., 5 to 25 seconds.

In the above embodiment, it has been assumed that, to retard the spark, the distributor 109 must be rotated in a counterclockwise direction. It will be understood that not all distributor shafts rotate in the same direction. For this reason, in the case of distributor shaft rotations opposite to that shown in FIGURE 1, the direction rotation of the distributor housing would be reversed to obtain the desired affect.

FIGURE 2 illustrates in detail a slightly different, but preferred, device for practicing the present invention. A device such as this has been constructed and has been found to perform quite well.

The B+ power supply may be taken as that provided by the normal automobile battery, e.g., twelve volts. Resistors 122 to 130 are selected so as to provide the necessary voltage distribution. As magnet 120 is moved within coil 121 during periods of changing throttle position, i.e., acceleration, deceleration or start-up, a pulse is formed which is applied to the base of transistor 131. This signal is amplified by transistor 131 and the amplified signal is applied through resistor 127 to the base of transistor 132. Here the signal is again amplified. The output signal of transistor 132 is then separated into its A.C. and D.C. components by decoupling capacitor 134. The D.C. component is bled off through resistor 129 while the A.C. component (the amplified pulse) passes through capacitor 134 to transistor 133. Here, the A.C. signal is amplified and the amplified signal applied to time delay mechanism 135. Activation of time delay mechanism 135 energizes solenoid 107 for a predetermined length of time. When solenoid 107 is energized, plunger 116 is forced in a downward direction causing a counterclockwise movement of lever 113 and a corresponding movement of spark advance arm 108, thereby causing the spark to be temporarily retarded the desired number of degrees.

If desired, other sensing means may be employed in lieu of those already indicated, e.g., mercury capsules, pneumatic sensors, etc.

While the time delay mechanism 135 may be of the thermal type, it is greatly preferred to use a solid state time delay relay of the type manufactured by the Elastic Stop Nut Corporation of America, Elizabeth Division, Elizabeth, New Jersey (Model No. 2735). This relay is particularly desirable since it need not complete an energizing cycle for the predetermined time, e.g., 30 seconds, before it can be re-energized to give a continued delay for the same period of time. Still another alternate time delay means would be an electric spring winding clock of the type built by the Stewart-Warner Company of Indianapolis, Indiana. This electric clock device would energize the solenoid until it unwound. The use of transistors rather than vacuum tubes is preferred due to their smaller size and durability.

By employing the method and/or apparatus of the present invention, the unwanted detonation during accelerations will be avoided with but a slight and temporary loss of full throttle power and only a slight loss of overall economy of operation, with no loss of economy of operation under constant speed operating conditions. The present invention may be used to reduce the anti-knock (fuel octane) requirement of vehicles, and thereby permit a lowering of the octane rating of fuels being used. Alternately, use of the present invention will permit automobile engine manufacturers to increase the compression ratios of their engines while maintaining satisfactory anti-knock performance with existing fuels. This increase in compression will produce an increase in the efficiency of the engine with a concomitant reduction in fuel consumption.

Although the present invention has been described with a certain degree of particularity, it is to be understood that the present disclosure has been made only by way of example, and that numerous changes in the details of construction and of the combination and arrangement of the parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed. The headings used throughout this disclosure are not intended to be limiting, but are merely provided as a convenience to the reader.

What is claimed is:

1. A method for reducing detonation in an internal combustion engine having an ignition system including a distributor and a fuel system including a throttle which comprises:

(*a*) sensing changes in the position of said throttle, and

(*b*) temporarily retarding for a short predetermined

period of time the spark within said distributor in excess of the normal spark setting, said temporary spark retardation taking place in response to the sensed change in throttle position.

2. A method for reducing detonation in an internal combustion engine having an ignition system including a distributor and spark advance arm and a fuel system including a throttle which comprises:

(*a*) converting changes in throttle position to a first electrical signal,

(*b*) actuating a second signal of predetermined finite duration by means of said first signal, and

(*c*) using said second signal to temporarily move said spark advance arm, thereby temporarily retarding the spark within said distributor.

3. In an internal combustion engine assembly having a fuel system including throttle means and an ignition system including a distributor means and an automatic spark advance control means, an automatic spark delay apparatus to temporarily retard the spark within said distributor means below the normal spark setting under conditions of changing throttle position which comprises in combination:

(*a*) sensing means responsive to changes in the position of said throttle means,

(*b*) time delay means actuated by said sensing means,

(*c*) lever rotating means controlled by said time delay means,

(*d*) lever means rotated by said lever rotating means and acting in cooperation with said distributor means to retard the spark therein, said lever means also being connected to said automatic spark advance control means,

(*e*) travel limiting means positioned to limit the rotation of said lever means by said lever rotating means, and

(*f*) biasing means holding said lever means in a normal position of minimum rotation.

4. A combination as defined in claim 3, wherein:

(*a*) said sensing means comprises an inertia mass mounted on said throttle means,

(*b*) said time delay means is a time delay relay having an electrical energizing capacity of from 0.5 to 30 seconds,

(*c*) said lever rotating means is a solenoid, and

(*d*) said travel limiting means are mechanical stops, said stops being positioned to limit the maximum rotation of said lever means to that which will retard the spark a maximum of 10 angular degrees.

5. In an internal combustion engine assembly having a fuel system including a throttle control rod and an ignition system including a distributor, an automatic spark advance control rod and a spark advance arm, an automatic spark delay apparatus to temporarily retard the spark within said distributor below the normal spark setting under conditions of changing throttle position which comprises in combination:

(*a*) sensing means responsive to change in the position of said throttle control rod, said sensing means producing an electrical signal,

(*b*) amplification means for said electrical signal generated by said sensing means,

(*c*) time delay means actuated by said amplified signal,

(*d*) lever rotating means controlled by said time delay means,

(*e*) lever means rotated by said lever rotating means and acting in cooperation with said automatic spark advance control arm and said spark advance arm to temporarily retard the spark within said distributor when said lever rotating means are actuated,

(*f*) travel limiting means positioned to limit the movement of said lever means, and

(*g*) biasing means attached to said lever means and holding said lever means in a normal position of minimum rotation.

6. An automatic spark delay apparatus as defined in claim 5, wherein:

(*a*) said sensing means comprises a magnet and an electrical coil, said magnet being attached to said throttle control rod, and adapted to move within said electrical coil,

(*b*) said amplification means comprises a transistorized amplifier circuit,

(*c*) said time delay means comprises a solid state time delay means having a time delay electrical energizing capacity of from 0.5 to 30 seconds,

(*d*) said lever rotating means comprises a solenoid,

(*e*) said travel limiting means comprises mechanical stops, said stops being positioned to limit the maximum rotation of said lever means to that which will retard the spark within said distributor a maximum of 10 angular degrees, and

(*f*) said biasing means comprises a spring.

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