

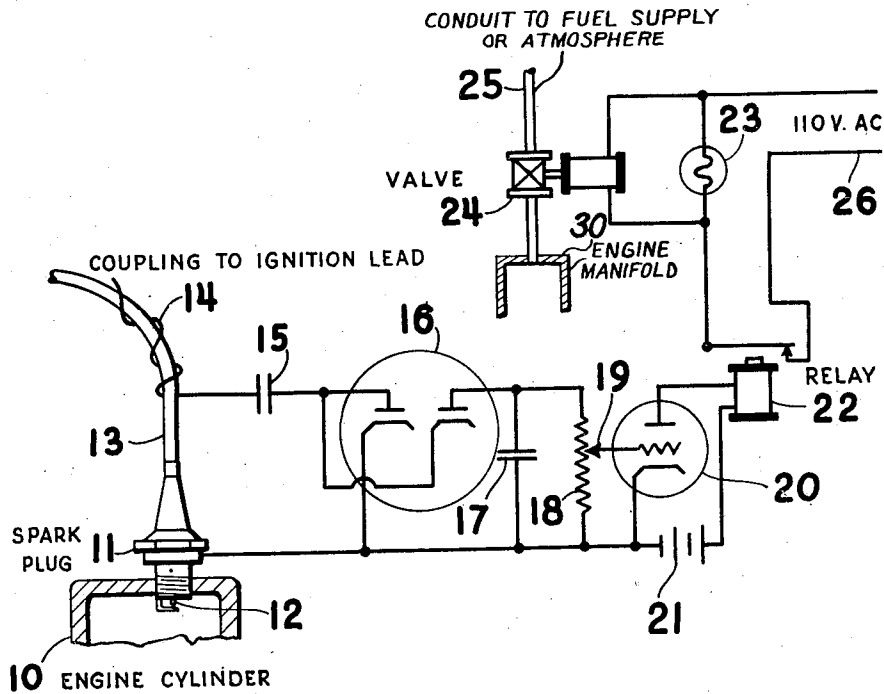
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PREIGNITION DETECTION AND CONTROL

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PREIGNITION DETECTION AND CONTROL

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This invention relates to a method and apparatus for the detection and control of preignition in internal combustion engines having spark ignition, and particularly refers to a method and apparatus which is responsive to the potential rise of one electrode of the spark plug for indicating preignition and, if desired, for controlling manifold pressure, fluid flow or some other phase of engine operation to control said preignition.

In the course of investigating the phenomena of detonation and preignition in internal combustion engines, particularly those of the type used in aircraft, it has been found that, although detonation has been blamed for engine failure, the effects of preignition may be even more serious and destructive.

With normal engine operation, an electrical potential is impressed across the spark plug electrodes once every cycle, and when this potential is high enough to ionize the gap between the spark plug electrodes, a spark forms across the gap, and the fuel is ignited. Under these circumstances, the voltage is impressed across a gap filled preponderantly with air and gasoline molecules, and the concentration of free ions is very low. Therefore, a relatively high electrical potential is required to initiate the ionization process which allows the spark to form. If a highly ionized gas is present in the spark gap, however, the potential required to initiate a spark or current flow across the gap is greatly decreased. A flame front constitutes such a highly ionized gas, this ionization persisting so long as combustion is being effected. Therefore, if a flame front is present at the spark plug electrodes, when the high ignition voltage impulse from the magneto, distributor, etc. arrives, as is the case when preignition occurs, the voltage-time pattern in the spark plug lead and at the electrode will be appreciably different from that which obtains during normal engine operation. This difference in the voltage-time pattern in the ignition lead between normal and preigniting operation is used to activate the circuit described below.

It is an object of this invention to provide a method and apparatus for indicating the presence of preignition in a cylinder of an internal combustion engine utilizing the usual spark plug found in such a cylinder.

Another object is to provide a method and apparatus for determining and, if desired, controlling preignition in an engine cylinder by providing means responsive to the rise of potential of a spark plug electrode on which the igni-

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tion voltage is impressed and modifying the flow of air, fuel, or the like, to the intake manifold of said engine to control the operation of said engine to prevent further preignition.

These and other objects and advantages of this invention will be further apparent from the following description and from the attached drawing which forms a part of this specification and illustrates diagrammatically an apparatus suitable for practicing the invention.

In the drawing, reference number 10 designates a cylinder of an internal combustion engine to which fuel, air and the like are periodically admitted by means not shown. Mounted in the wall of the cylinder is a spark plug 11 provided with an electrically insulated center electrode 12 on which a high voltage impulse is impressed through lead 13 from a conventional magneto, distributor and the like (not shown).

In order to detect the potential rise in lead 13, due to the high voltage impulse from the ignition system, pick-up means such as a coupling wire 14 is provided, in this case consisting merely of a few turns wrapped about the insulated lead 13. If the lead should be metallically shielded, as is customary with internal combustion engines used on aircraft and in other locations to prevent radio interference, the electrostatic coupling means may be placed inside of the shielding so that the potential rise of the wire core of lead 13 will be proportionally impressed upon coupling means 14.

High voltage impulses from lead 14 are conducted to a coupling condenser 15 and thence to a rectifier 16 which may be a conventional double diode where these impulses are rectified to proportioned negative pulses of direct current. The output of double diode 16 is connected to a time delay circuit, in this case, capacitor 17 in parallel with a resistor 18, the movable contact 19 of resistor 18 leading to the grid of a conventional amplifier triode 20. Battery 21 is connected in series with relay 22 and the anode and cathode of triode 20. When there is no preignition in the engine cylinder 10, the high potential voltage impulses, which are rectified by tube 16 to negative direct current pulses, are impressed through the time delay circuit 17—18 onto the grid of triode 19 and bias the latter beyond cutoff substantially continuously so that insufficient current flows from battery 21 through the winding of relay 22 to close the contacts of the latter. If preignition does occur in engine cylinder 10 the potential to which center electrode 12 will rise is reduced by the ionization of the gases

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in the cylinder which in turn reduces the magnitude of the negative potential impressed upon the grille of triode 20, permitting the latter to become conducting and causing the contacts of relay 22 to close.

In this example an indicator, which may be lamp 23 connected in series with the contacts of relay 22 and a source of current 26, may be used to indicate the presence of preignition. If it is desired further to modify the operation of engine cylinder 10 when preignition exists therein, a solenoid or other type of electrically controlled valve 24, also in series with the contacts of relay 22 and current source 26, may be placed in conduit 25, the latter of which communicates with the intake manifold 30 of engine cylinder 10 to modify the pressure therein or to change the flow of air or fuel thereto. Desirably, the time constant of the circuit, which includes capacitor 17 and resistor 18, is adjusted so that as long as the gap of spark plug 10 between the center electrode 12 and the grounded electrode remains non-ionized as in normal or known non-preigniting operation, contacts of relay 22 will remain open and the indicating means 23 and flow control means 24 will remain unenergized.

It will be appreciated from the foregoing description that there has been provided a means responsive to the potential to which a spark plug electrode will rise when the normal ignition voltage impulse is impressed thereon, that potential being dependent upon the presence or absence of ionization in the cylinder due to preignition. Electrical means, including a rectifier and an amplifier, are so connected and biased that the decreased electrode potential which accompanies preignition in the engine cylinder will cause the amplifier to become conducting and actuate indicating and control means, the latter optionally adapted to modify the conditions existing in the engine cylinder to prevent continuance of preignition therein.

Although a single example is given of an apparatus suitable to practice this invention, it is to be understood that numerous modifications and changes could be made in the apparatus concerned and in the procedure followed without departing from the invention and all such modifications and changes that come within the scope of the appended claims are embraced thereby.

I claim:

1. The method of detecting preignition in an internal combustion engine cylinder having a spark plug provided with a high potential electrode for igniting an explosive charge in said cylinder, comprising the steps of cyclically impressing a high voltage ignition impulse on said electrode and continuously inducing potentials proportional to the voltage rise of said electrode in a circuit isolated from said electrode, rectifying said last named potentials, impressing said rectified potentials upon the grid circuit of a triode to control the flow of current therethrough, and adjusting the time constant of said grid circuit

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whereby the magnitude of said last named current indicates preignition in said cylinder.

2. The method of detecting preignition in an internal combustion engine cylinder having a spark plug provided with a high potential electrode for igniting an explosive charge in said cylinder, comprising the steps of impressing a high voltage ignition impulse on said electrode and utilizing the potential to which said electrode rises under the conditions of gaseous conductivity in said cylinder to modify the operation of said engine cylinder to prevent preignition therein.

3. Apparatus for detecting preignition in an internal combustion engine cylinder having a spark plug provided with an insulated electrode for igniting an explosive charge in said cylinder, comprising a source of high potential for said electrode and means responsive to the rise of potential of said electrode to modify the operation of said engine cylinder to prevent preignition therein.

4. Apparatus for detecting preignition in an internal combustion engine cylinder having a spark plug provided with an insulated electrode for igniting an explosive charge in said cylinder, comprising a source of high potential for said electrode and means responsive to the rise of potential of said electrode to modify the operation of said engine cylinder to prevent preignition therein, said last named means comprising fluid flow control means communicating with said engine cylinder.

5. Apparatus for detecting preignition in an internal combustion engine cylinder having a spark plug provided with an insulated electrode for igniting explosive charges in said cylinder when high potentials are cyclically impressed thereon through a conductor, comprising a rectifier, means for continuously coupling said rectifier to said conductor, a triode, time delay means connecting the output of said rectifier to the grid of said triode, said grid being normally biased beyond cut-off, and current responsive means in the output of said triode, so constructed and arranged that preignition of explosive charge surrounding said electrode prior to the application of a high potential thereto will reduce the potential attained by said electrode and modify the grid bias of said triode to render it conductive.

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