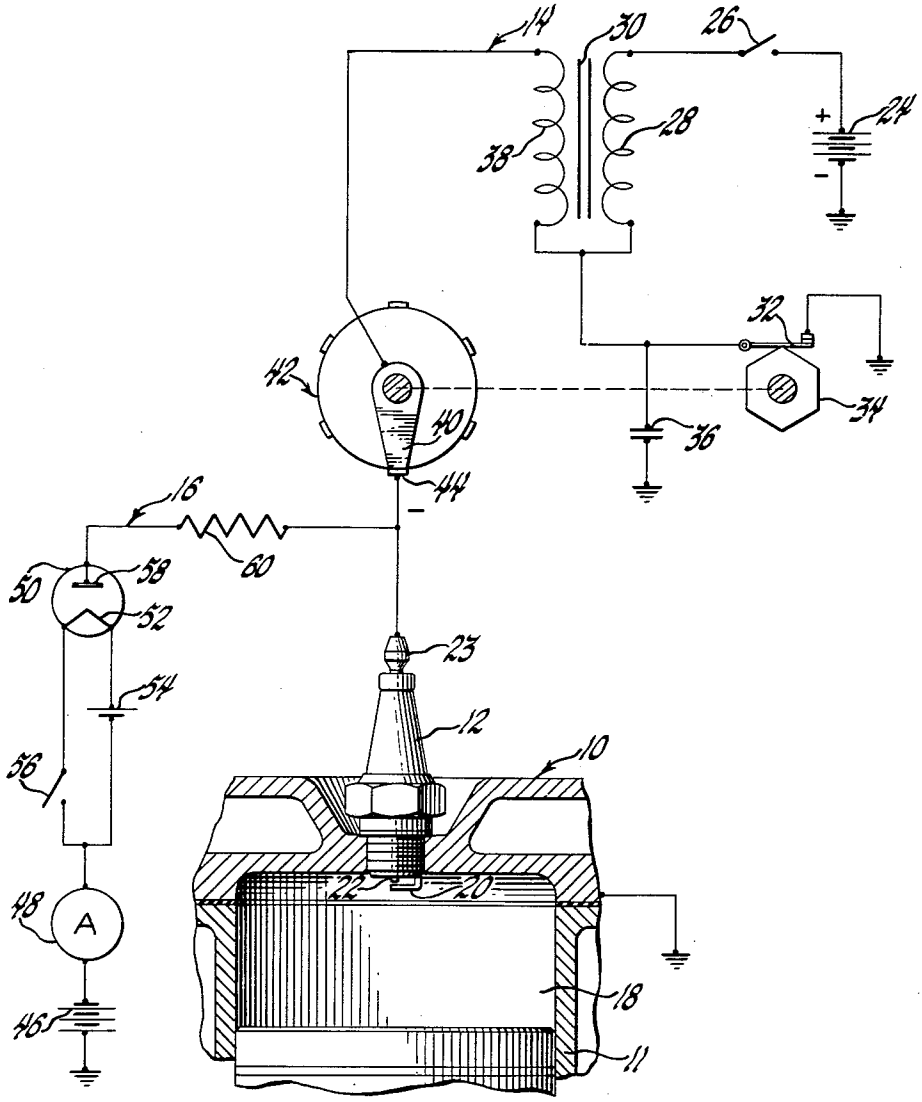
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SPARK PLUG TESTER

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# SPARK PLUG TESTER

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1 Claim. (Cl. 324—16)

This invention relates to apparatus for ascertaining conditions of a spark plug in a combustion chamber and more particularly for testing spark plugs of internal combustion engines for pre-ignition, spark plug fouling, and the like.

In studies of the operation of internal combustion engines, for servicing or evaluation, the duration or time period of the combustion in the operating cycle is a characteristic of particular conditions in the combustion chamber. For example, in operation under conditions of normal ignition combustion occurs late in the compression stroke as determined by the timing of the spark ignition. Under abnormal ignition conditions such as pre-ignition, combustion is caused to occur earlier in the compression stroke and the duration of combustion is correspondingly increased. There are, of course, other abnormal conditions in the combustion chamber, such as spark plug fouling, which are induced by various causes and result in disturbance or change of the combustion duration.

It has been found that the electrical resistance between spaced points in a combustion chamber is related, not only to the condition of the spark plug but also, to conditions attendant with combustion which cause a marked decrease of resistance. In accordance with this invention a measure of combustion duration is obtained by sensing the time average value of electrical resistance between spaced points in the combustion chamber. Thus, a change of ignition conditions may be detected by the change of resistance. This is accomplished during engine operation by a meter circuit connected across spaced electrodes, suitably the spark plug electrodes, which develop an indication of the time average value of resistance therebetween. The meter circuit, including a source of voltage, preferably comprises means for blocking the ignition voltage from the meter circuit.

A more complete understanding of the invention may be had from the detailed description which follows taken with the accompanying drawing in which the single FIGURE is a schematic diagram of the inventive system.

Referring now to the drawing, there is shown an illustrative embodiment of the invention in a pre-ignition meter for a spark ignited internal combustion engine. The system, in general, comprises an engine **10** including a cylinder **11** provided with a conventional spark plug **12** to which is connected the usual ignition circuit **14** and the meter circuit **16**.

The engine cylinder defines a combustion chamber **18** into which extends the spark plug **12** for developing the igniting spark in the usual manner. The spark plug **12** has an electrode **20** connected through the spark plug shell to ground and a center electrode **22** insulated from the shell and extending to the terminal **23**. The ignition circuit **14** is suitably of conventional design and includes the vehicle battery **24** having one terminal connected to ground and the other terminal extending through the ignition switch **26** to the ignition coil or transformer **30**. The ignition circuit extends through the primary winding **28** of the coil **30** to the movable contact of the periodic switch or breaker points **32**, the other contact of which is connected to ground. The breaker points **32** are opened and closed periodically by the cam **34** which is driven synchronously with the engine. A condenser **36** is connected across and affords protection for the breaker points **32** in the usual manner. The secondary winding **38** of the



ignition coil **30** has one terminal connected to a terminal of the primary winding and its other terminal connected to the rotor contact **40** of a distributor **42**. The fixed contact **44** of the distributor corresponding to the cylinder **11** is connected to the terminal **23** of spark plug **12**. The distributor rotor contact **40** is driven in timed relation with the cam **34**.

The meter circuit **16** is connected across the spark plug electrodes **20** and **22** and comprises in series connection a voltage source or battery **46**, a meter **48**, a blocking diode **50** and a current limiting resistor **60**. The meter **48** is suitably a conventional moving coil type micro-ammeter. The diode **50** is suitably of the high vacuum type and includes a plate electrode **58** and a thermally emissive cathode **52** provided with a heater circuit including a voltage source **54** and a switch **56**. The battery **46** has one terminal connected to ground and its other terminal connected through the meter **48** to the cathode **52** of the diode and the plate of the diode is connected through the resistor **60** to the terminal **23** of the spark plug. It is to be noted that the orientation of the diode **50** in the meter circuit is such that it will conduct meter circuit current from the battery **46** but will block any current flow in the meter circuit due to the ignition voltage. For this purpose the polarities of the diode **50** and the battery **46** are of the same sense and are in a sense opposite that of the ignition voltage appearing across the spark plug electrodes **20** and **22**. In the illustrative example, the battery **24** has its negative terminal connected to ground and the ignition coil **30** is arranged to develop an ignition voltage which is negative with respect to ground. Accordingly, the diode **50** is oriented with its plate receiving the negative ignition voltage and the battery **46** has its positive terminal connected to ground to apply a negative voltage to the cathode of the diode.

In operation of the inventive system, with the ignition switch **26** closed and the engine running, the ignition voltage is applied to the spark plug **12** once each cycle late in the compression stroke of the piston in cylinder **10**. This is accomplished in the usual manner by the alternate closing and opening of the breaker points **32** which energizes and de-energizes the primary winding **28** to cause a high voltage to be induced in the secondary winding **36** and applied through the distributor **42** to the terminal **23** of the spark plug **12** by the synchronized rotation of the cam **34** and the distributor rotor **40** by the engine. This ignition voltage, of negative polarity, is also applied through the resistor **60** to the plate **58** of the blocking diode **50**. Due to the relative polarity of the ignition voltage and the diode **50**, no current is caused to flow in the meter circuit **16**.

When the engine is operating under normal ignition conditions, the meter circuit **16** is conditioned for operation by closing the switch **56** in the heater circuit to render the cathode **52** emissive. Accordingly, the battery **46** will cause a current to flow in the meter circuit from the positive terminal of the battery through ground to the electrode **20** and thence across the spark plug gap to the electrode **22**. The circuit is completed from the spark plug terminal **23** through the resistor **60**, the diode **50**, and the meter **48** to the negative terminal of the battery. The spark plug gap between electrodes **20** and **22**, in air or a gaseous dielectric at low temperature, presents a very high electrical resistance. However when combustion occurs, accompanied by a flame front and very high temperatures, the resistance of the gap is substantially reduced. Accordingly, an appreciable amount of current may flow in the meter circuit under the influence of the battery **46**. Under normal conditions of ignition; that is, when combustion does not precede the occurrence of the ignition voltage, the meter circuit current has a value dependent upon the magnitude of the voltage in the meter

circuit and the resistance presented by the spark plug gap. As a typical value, the voltage of battery **46** may be 270 volts. The meter **48** responds to a time average value of the current flow in the meter circuit and averages the high value of current during combustion with the low value of current during the remainder of the cycle. A typical range of values which have been found to correspond to normal ignition conditions is of the order of 10 to 25 micro-amperes.

When the combustion conditions change in the cylinder, as by the occurrence of pre-ignition, the flame front and high temperature occurs earlier in the compression stroke. Accordingly, the resistance of the spark plug gap assumes a low value for a longer interval during each operating cycle. Thus the period of high current flow in the meter circuit is increased and the time average value, as indicated by the meter **48**, is abruptly increased. A typical range of current values in the meter circuit corresponding to pre-ignition conditions is of the order of 50 to 100 micro-amperes. Thus, the occurrence of pre-ignition or the increased duration of combustion during the engine cycle may be readily detected by the abrupt change of the average value of current flow in the meter circuit.

Although the description of this invention has been given with respect to a particular embodiment, it is not to be construed in a limiting sense. Many variations and modifications within the spirit and scope of the invention will now occur to those skilled in the art. For a definition of the invention reference is made to the appended claim.

We claim:

Apparatus for detecting preignition and like conditions in operation of a spark ignited combustion engine comprising, an internal combustion engine with a spark plug having a pair of electrodes disposed in a combustion chamber, an engine ignition circuit connected across the electrodes of the spark plug to apply a sparking voltage of a given polarity across the electrodes, a measuring circuit comprising a first direct voltage source, an average current indicating device, a current limiting resistor and



a unidirectional conductive device connected in series across the electrodes of the spark plug, the unidirectional conductive device being connected with a polarity opposite the sparking voltage to block current flow from the ignition system through the current indicating device, the unidirectional conductive device being connected with the same polarity as said first direct voltage source whereby said first direct voltage source causes a low value of current flow between the spark plug electrodes when the resistance therebetween is of high value prior to combustion in the chamber and causes a high value of current flow between the spark plug electrodes during combustion in the chamber when the resistance therebetween is of low value so that the time average value of the currents, as indicated by the current indicating device, increases when the resistance between the electrodes is decreased, by preignition or like conditions, prior to the occurrence of the sparking voltage from the ignition circuit.

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