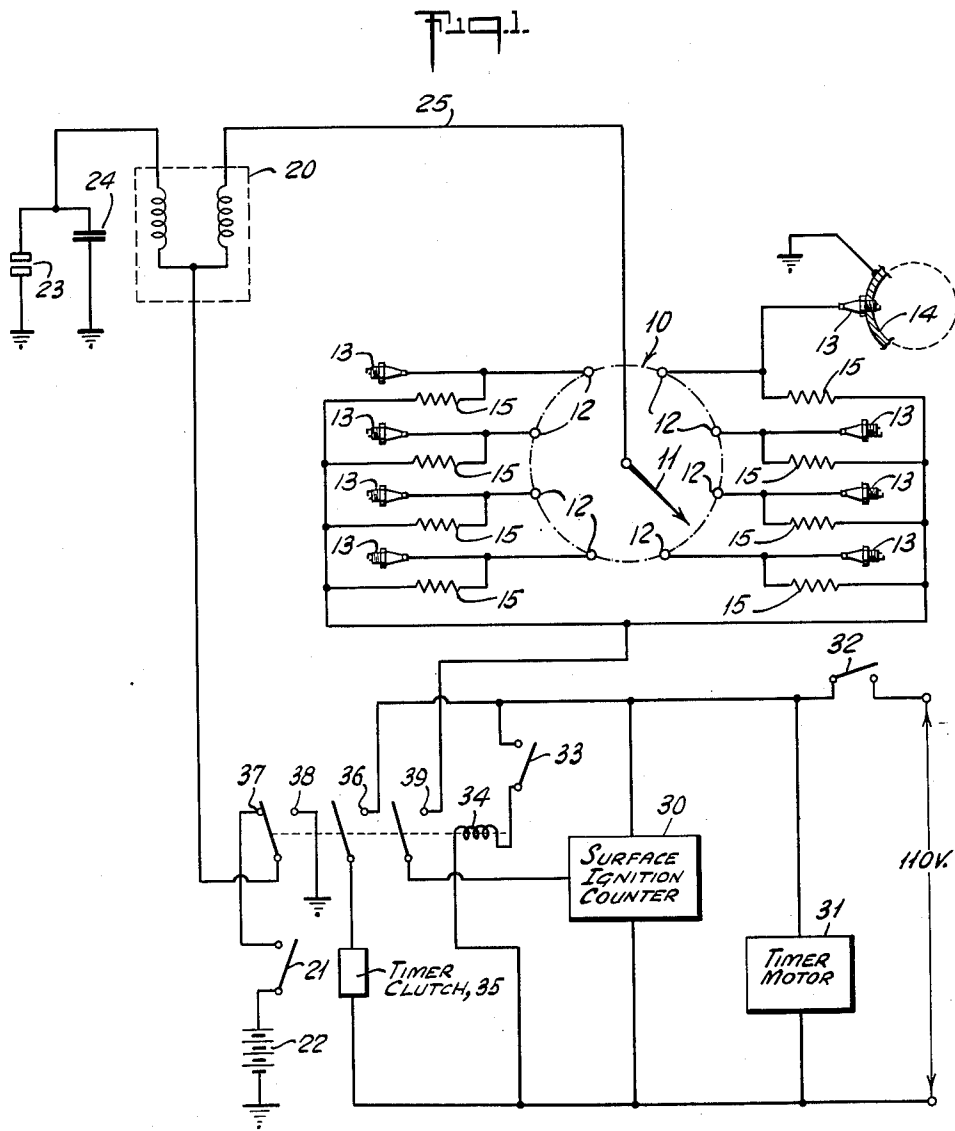


3,030,799

2 Sheets-Sheet 1



April 24, 1962

S. HOPKINS

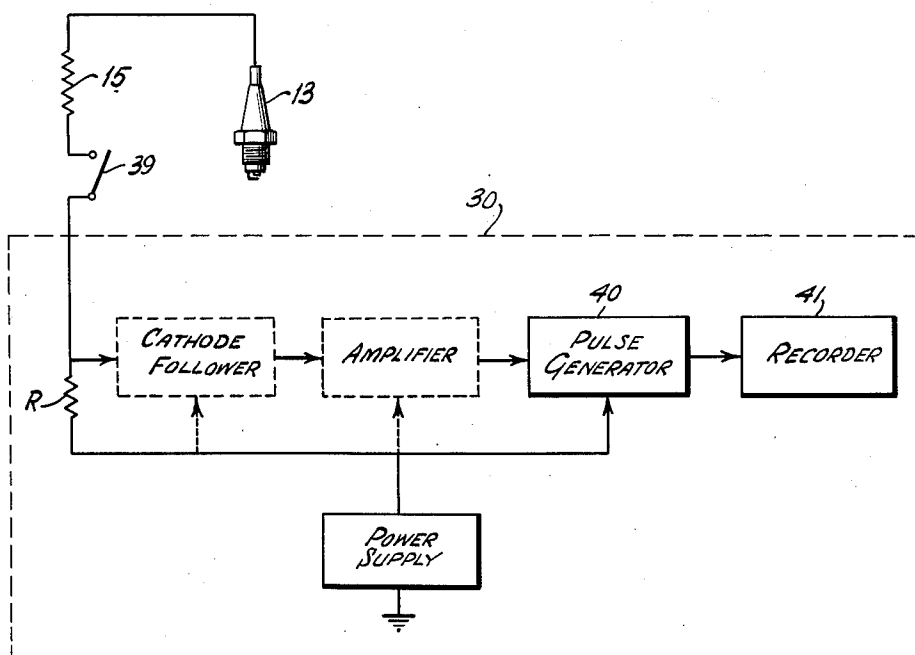
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APPARATUS AND TECHNIQUE FOR SURFACE IGNITION TEST

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2 Sheets-Sheet 2

Fig. 2.



1

3,030,799

APPARATUS AND TECHNIQUE FOR SURFACE IGNITION TEST

Stephen Hopkins, Fishkill, N.Y., assignor to Texaco Inc.,
a corporation of Delaware
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This invention relates generally to the operation of an internal combustion engine and specifically to the instrumentation and technique for measuring surface ignition encountered during such operation.

With the advent of higher compression ratio, internal combustion engines, the problem of surface ignition has become increasingly important. Automobile manufacturers, in the interest of more power per unit weight of engine and increased economy in the same package, have a definite interest in the further increase of compression ratios of their engines. Combustion chamber deposits are one of the limiting factors in the employment of higher compression ratios, because of their erratic ignition of the fuel-air mixture causing uncontrolled combustion which may produce engine roughness or combustion noise, knock and rumble. Surface ignition, therefore, is of primary importance to both the automobile and petroleum industry.

Surface ignition is defined as the occurrence of abnormal flame fronts initiated by any hot surface in the combustion chamber either before, during or after the occurrence of the normal spark induced flame front. The abnormal flame fronts, e.g. combustion, which occur either before the normal spark flame front or immediately thereafter usually accompanied with audible engine noise, knock or rumble, are the most troublesome.

Surface ignition can be inaudible also, and random or recurrent and manifests itself often as engine run-on, which is a continuation of engine firing after the electrical ignition is cut-off.

The effect of surface ignition on engine performance is resultant power loss, inefficient fuel utilization, and knock.

The role of petroleum products with regard to the surface ignition problem involves (1) the formation of combustion chamber deposits which are potential hot spots and which will ignite the charge independently of the normal ignition, and (2) the relative tendency of fuels to be ignited by such spots of glowing deposits. Fuel and lubricant performance is judged primarily on the basis of the average number of surface ignitions which occur per unit time while operating a specified engine on a specified cycle, obtained by plotting the accumulated number of "counts" against the total elapsed time. The slope of the best straight line drawn through these points is the average surface ignition rate.

A known technique for evaluating the surface ignition characteristics of fuel and lubricants involves the utilization of an ionization gap, e.g. an extra spark plug, as the surface ignition pick-up, the gap being mounted in a port in a cylinder head normally used for a knockmeter pickup. Flame fronts passing through the gap provide a conducting path for the voltage impressed across the two electrodes. The resulting current flow signals the passage of the flame front and activates an electro-mechanical recording counter. In the prior art practice, the counter would record the passage of both normal and abnormal combustion flame fronts through the ionization gap. Differentiation between the two is accomplished by making the counter operative only during a selected portion of the engine cycle before the normal spark initiated flame front arrives at the ionization gap.

Accordingly, it is an object of the invention to provide an improved apparatus for measuring surface ignition.

Another object of the invention is to provide for in-

2

strumentation for measuring surface ignition, which does not require deformation of the engine construction.

Still another object of the invention is to provide a simple yet accurate circuit for the measurement of surface ignition.

Another object of the invention is to provide for an improved technique for measuring surface ignition during run-on.

These and other objects, features and advantages of the invention will become apparent from the following description when read in conjunction with the accompanying drawings in which:

FIG. 1 is a diagrammatic showing of a surface ignition counter circuit interconnected with a spark ignition system; and

FIG. 2 is a block diagram of electrical circuits for a typical surface ignition counter.

The objects of the disclosed invention are achieved by the combination of a spark ignition system used in an internal combustion engine with a circuit for measuring surface ignition utilizing conventional spark plugs as the ionization gap transducers, with the determination of surface ignition during a given period being obtained with the ignition system turned off.

Referring to FIG. 1 of the drawing, there is disclosed in diagrammatic form, a distributor 10, interconnected with the high voltage side of an ignition coil, with a rotor at 11 which revolves past the individual terminals indicated at 12, connected by leads to the individual spark plugs at 13, the electrodes of which extend into the combustion chamber of an engine cylinder indicated in dotted outline at 14, shown in a single instance for purposes of clarity.

The primary winding of a transformer or ignition coil 20, an ignition switch 21 and a battery 22 are connected in series with a pair of breaker contacts at 23, with condenser 24 connected across the breaker contacts or points, in accordance with conventional ignition system techniques.

The transformer 20 is of conventional type, having a low voltage primary winding and a secondary winding which provides a high voltage current when the circuit through the primary winding is interrupted. The output of the secondary winding is connected to the distributor through the lead 25. A high voltage current is produced across the electrodes of each of the spark plugs in turn, each time that the breaker contacts 23 therein are caused to open, due to the action of the ignition coil 20, and battery 22 and the condenser 24.

The surface ignition counter circuit includes the surface ignition counter at 30, disclosed in further detail in FIG. 2, a timer motor at 31, a power switch at 32 and a start-stop switch at 33, for activation of the relay at 34 controlling the timer clutch 35 through the contact terminal at 36, the cutting-off of the spark ignition system by breaking contact at the terminal 37 and making contact with ground at terminal 38, the cutting in of the counting circuit by making contact at terminal 39 to connect the circuit to the individual spark plugs through a high impedance 15, e.g. a 10 megohm resistance, the spark plugs being connected in parallel.

Referring to FIG. 2, there is disclosed in block diagram form, the electrical circuits in a typical surface ignition counter. A positive potential of 300 volts is applied through an impedance such as a 5 megohm resistor, indicated at R, to the central electrode of the spark plug which serves as the ionization gap. As the conductivity of the gap changes with the presence of free ions in the flame from the combustion resulting from the surface ignition, the voltage change at the impedance (resistor) signals the arrival of the flame front. This voltage change is shown to be transmitted through the cathode follower to

the amplifier which provides amplification of the signal. The amplified signal resulting from the changes in conductivity of the ionization gap then passes to the pulse generator 40, which in turn provides a shaped voltage pulse to actuate the electro-mechanical recorder, 41. The purpose for and function of the resistance, the impedance matching and amplifying means in the input circuit to the pulse generator 40 are well known in the art and these elements may be omitted when not required for the operation of the pulse generator.

The technique in the operation of the surface ignition counting circuit during ignition-off, engine run-on, is as follows:

(1) The start-stop switch at 33 is closed to energize the relay 34.

(2) The normally closed contact at 37 breaks, i.e. opens, to cut-off the engine ignition.

(3) The normally open contacts at 36, 38 and 39 are closed to respectively, energize the timer clutch, discharge the ignition system condenser 24 to ground, and connect the counter to the transducers, viz, the spark plugs.

(4) After a specified time of ignition-off engine run-on (e.g. 0.1-0.2 minutes), the start-stop switch at 33 is opened to de-energize the relay at 34. This reverses the sequence of events of steps 2 and 3 above, the counter is disconnected from the transducers, the clock is stopped and normal ignition is re-established.

It should be noted that when the power switch at 32 is closed, both the surface ignition counter 30 and the timer motor at 31 are energized.

The resistors at 15 permit parallel connection of all spark plugs to the counter without interfering with or shorting the high tension voltage discharge to the adjacent cylinders. These resistors also prevent the breakdown of the contact gap at 39 between the counter and the spark plugs during normal engine operation. The value of this resistance should be of sufficient size so that the ignition voltage does not break down to ground along the exterior surface of the resistor.

Thus there has been shown and described an apparatus and technique for the study of surface ignition occurring during engine run-on after electrical ignition has been cut-off by eliminating extensive ionization gap transducer installations through the use of normally installed spark plugs for both spark ignition and surface ignition pickups, which is particularly attractive for surface ignition evaluations in engines in which, for simplicity or other reasons, deformation of the engine for the installation of instrumentation is not practical.

Obviously, many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. Means for determining the surface ignition characteristics of fuel and lubricants by counting the frequency of such ignition in a cylinder of an internal combustion engine having a spark ignition system, said system including a spark plug with electrodes extending into the combustion chamber of said cylinder and defining a spark gap therebetween, an ignition coil, breaker contacts, a condenser and a source of energy, for causing an ignition spark to occur between said electrodes of said spark plug when said contacts are caused to open, and means joined to said spark plug for indicating the frequency of surface ignition when the circuit of said spark ignition system is disconnected including timing and counting means, the spark gap between said electrodes of said spark plug serving as an ionization gap in an electrical circuit involving said last mentioned means, the conductivity of said gap changing with the presence of a flame, said engine and ignition system being in normal operation prior to the disconnecting of the circuit of said ignition system and the actuating of said timing and counting means.

2. In the means for indicating the frequency of surface ignition as defined in claim 1, the electrical circuit including a power supply for imposing an electrical potential across the electrodes of said spark plug and means interconnected with a source of power for energizing said counting means and for disconnecting said source of energy to said spark ignition system and for connecting said spark plug to the surface ignition indicating means.

3. In an apparatus of the class described, an internal combustion engine with a power cylinder and an ignition system therefor including a source of energy and a spark plug having a pair of spaced electrodes defining a spark gap extending into the combustion chamber of said power cylinder and counting means responsive to impedance changes between said electrodes interconnected with said ignition system and having means for disconnecting said source of energy from said ignition system when said counting means is actuated, said engine and said ignition system being in normal operation prior to the disconnecting of said ignition system and the actuating of said counting means.

4. In the apparatus as defined in claim 3, one of said pair of spaced electrodes being at a high potential and the other of said pair being at ground potential, said counting means being coupled to the high potential electrode of said spark plug.

5. In the apparatus as defined in claim 4, said counting means being coupled to an impedance in series with said spark plug and including signal amplifying means connected across said impedance.

6. The apparatus as defined in claim 5, wherein said signal amplifying means includes a cathode follower.

7. In the apparatus as defined in claim 6, said counting means including a pulse generator for receiving a signal resulting from the change in conductivity across said spark gap to provide in turn a shaped voltage pulse for actuating recording means.

8. The combination of an ignition system including a spark plug and a source of energy in an internal combustion engine having a cylinder with a combustion chamber wherein the spark plug of said system extends with a surface ignition counter circuit connected to said spark plug, said surface ignition counter circuit having means for recording the incidences of surface ignition with changes of impedance of the ionization gap defined by the spark plug electrodes in said combustion chamber upon disconnecting said source of energy from said ignition system, said circuit including signal amplification means and timing means, said engine and its ignition system being in normal operation prior to the disconnecting of the source of energy and the actuating of said surface ignition counter circuit.

9. In the combination as defined in claim 8, said surface ignition counter circuit including relay means for disconnecting the source of energy from said spark ignition system and connecting said spark plug to said surface ignition counter circuit.

10. In combination, an ignition system for an internal combustion engine having a source of energy and a spark plug with electrodes and a circuit for counting the incidences of surface ignition in a cylinder of said internal combustion engine wherein the spark plug thereof extends into said cylinder and the spark gap between said electrodes of said plug defines an ionization gap, said circuit comprising a surface ignition counting means, timing means, and an energy source therefor interconnected with a high impedance to said spark plug, and means for disconnecting said source of energy from said ignition circuit during the operation of said counting means, said engine and its ignition system being in normal operation prior to the disconnection of said ignition system and actuation of said counting means.

11. In the combination as defined in claim 10, the circuit wherein said counting means comprises signal amplification means and recording means, said means for dis-

5

connecting said source of energy from said ignition system comprising relays for breaking the circuit of the spark ignition system and making a circuit between said spark plug and the surface ignition incidence counting circuit.

12. In the combination as defined in claim 11, the circuit wherein said counting means includes a pulse generator interconnected with said recording means, said pulse generator receiving an amplified signal to provide a shaped pulse for actuating said recording means.

13. In the combination as defined in claim 12, the circuit wherein said counting means includes a pulse generator interconnected with said recording means, said pulse generator receiving an amplified signal to provide a shaped pulse for actuating said recording means.

14. A surface ignition counting circuit in combination with a spark ignition system in an internal combustion engine having a cylinder with a combustion chamber therein, said ignition system including interconnected breaker contacts, ignition coil, spark plug having spaced electrodes and a source of energy for causing a spark to occur across the spark gap defined between said electrodes of said spark plug extending into said combustion chamber when said breaker contacts are caused to open, said ignition counting circuit being interconnected with said spark plug through a high impedance and including relay means for breaking the circuit of the ignition system with said spark plug when surface ignition counting is desired, said counting circuit including an ignition counter having an impedance matching and signal amplifying means, pulse generating means and recording means interconnected together thereacross, said signal amplifying

6

means including a cathode follower and an amplifier coupled thereto, said pulse generating means providing a shaped voltage pulse to actuate said recording means and a power supply for imposing a high potential at one of the spaced electrodes of said spark plug, said pulse arising from a voltage change occurring with a change in conductivity of the spark gap due to the presence of ions resulting from a flame front in said combustion chamber, said engine and said ignition system being in normal operation prior to the breaking of the circuit of said ignition system and the actuating of said ignition counting circuit.

15. In the apparatus as defined in claim 3, said counting means being in communication with a plurality of spark plugs connected in parallel.

16. In the combination as defined in claim 14, said ignition counting circuit being interconnected with a plurality of spark plugs through a high impedance, said spark plugs being connected in parallel.

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