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IGNITION TESTER COMPRISING CATHODE RAY TUBE AND MEANS
RESPONSIVE TO SPARK PLUG LEAKAGE CURRENT TO
VARY BEAM INTENSITY

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2 Sheets-Sheet 1

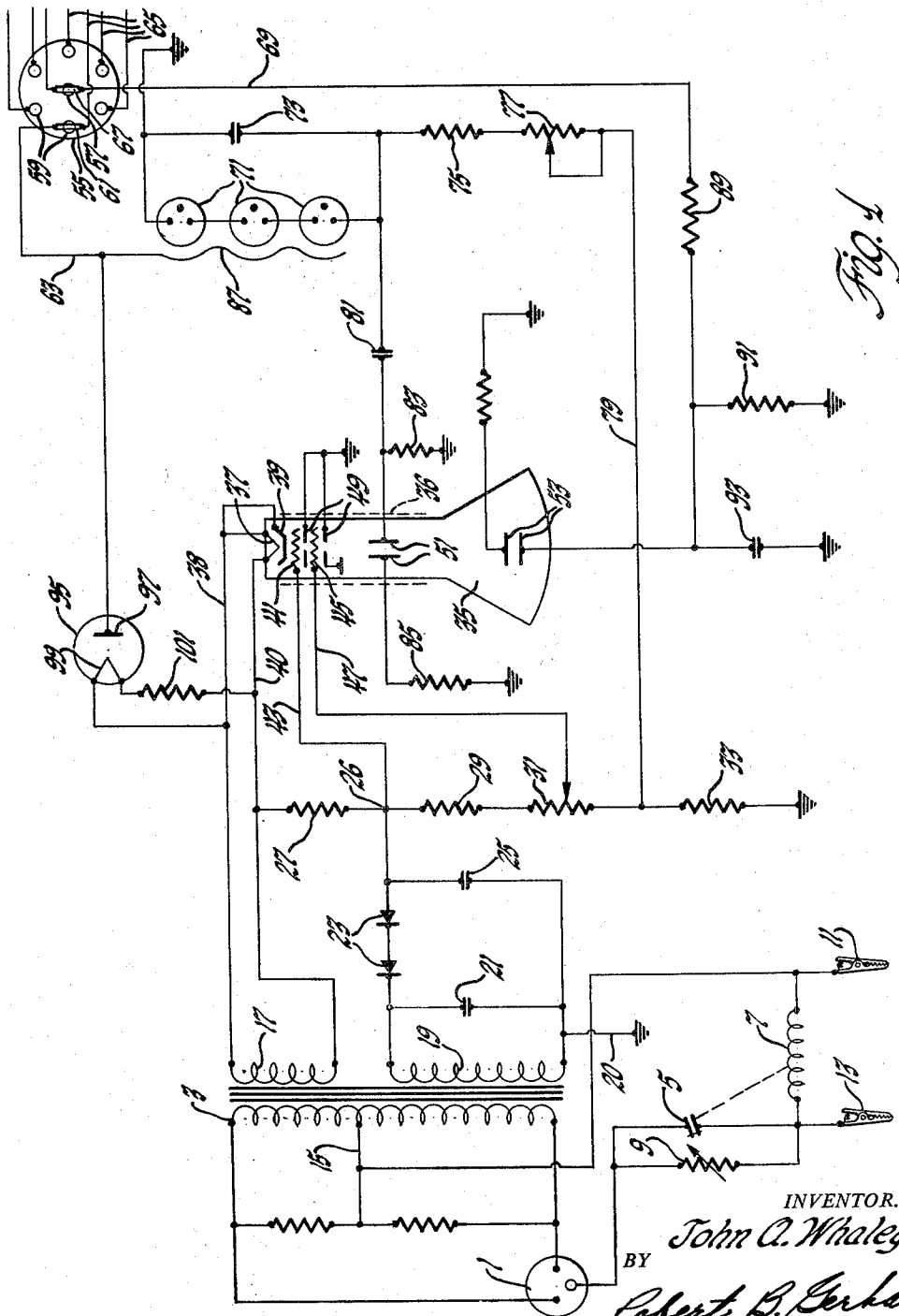


Fig. 1

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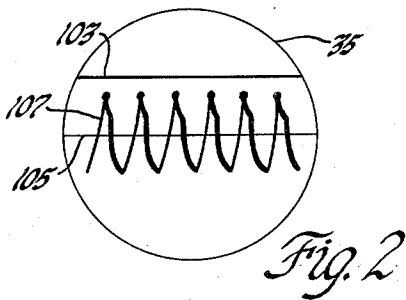
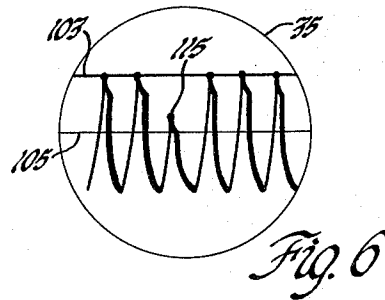
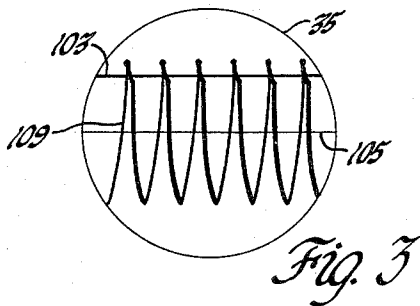
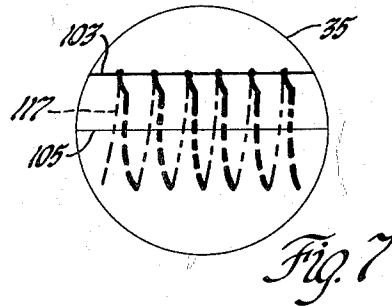
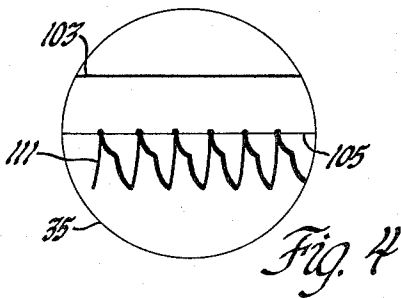
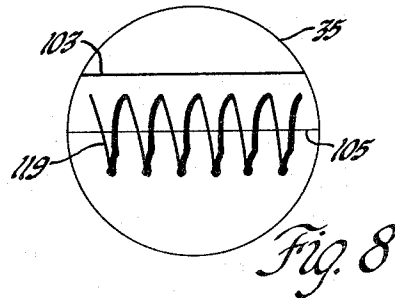
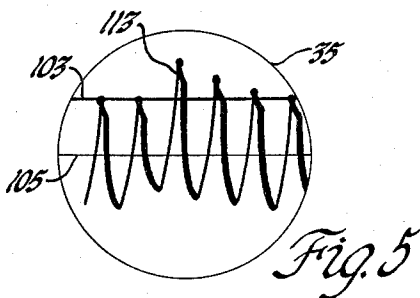
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IGNITION TESTER COMPRISING CATHODE RAY TUBE AND MEANS RESPONSIVE TO SPARK PLUG LEAKAGE CURRENT TO VARY BEAM INTENSITY

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This invention relates to a spark plug and ignition testing apparatus for an internal combustion engine and more particularly to an oscilloscope apparatus for visually indicating the condition of the spark plugs and ignition system while the engine is in normal operation.

Here before most spark plug testers have required removal of the plugs from the engine and insertion of the plugs in a special pressure bomb to simulate actual operating conditions. Each plug must be tested separately and reinserted into the engine. Such a test method reveals nothing about the condition of the engine ignition system.

Other types of spark plug testers that can test the plugs in the engine as in a motor vehicle, require a relatively complicated apparatus that requires an expert to operate and interpret the results therefrom. These apparatus require considerable time to set up and operate and are usually quite expensive. Furthermore since they require expert interpretation their use is quite limited. These devices fail to disclose certain conditions in the engine, such as lead deposits on the plugs.

The present invention has for its object an apparatus that will simultaneously test all the spark plugs and ignition of an internal combustion engine.

A further object is to provide such an apparatus that is relatively simple in construction, is practically fool-proof in operation, and can be operated by anyone without experience.

Another object is to provide a cathode ray tube indicator that has relatively few components, operates on low voltages and yet is highly reliable in use.

Still another object is to provide an apparatus that will indicate formation of deposits on the spark plugs and will instantly indicate whether the ignition system for the engine is properly polarized.

Briefly the invention comprises a cathode ray tube oscilloscope having a power supply that can be connected to either a 6 volt or 12 volt electrical system in a motor vehicle without regard for voltage or polarity. The cathode ray tube is of the electrostatic focus and deflection type and is operated at lower than normal voltages, but because of certain novel circuit features, provides a relatively bright pattern on the face of the tube. A horizontal or X axis sweep circuit for the cathode ray tube is triggered by a so-called gimmick lead connected to any of the engine spark plugs. No direct connection is made between the horizontal sweep circuit and the plug so that actual sparking voltages do not appear in the sweep system. Simple neon gas discharge tubes in a RC saw-tooth oscillator circuit are synchronized or triggered by the gimmick wire located adjacent to the neon tubes.

The vertical or Y axis deflection of the scanning beam in the cathode ray tube is energized by a pulse forming network connected to the center or input distributor wire that is connected to the secondary winding of the ignition coil. The voltages existing in this wire during firing of the plugs have a sharp initial spike shape followed by a series of reducing height spikes. These spikes are of such short duration that even with very high voltage on the cathode ray tube, the beam pattern on the face of the scope is normally dim and is especially difficult to see if viewed under day-light conditions. The movement of the

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scanning beam under these conditions is so rapid that the phosphors on the tube face are not sufficiently energized to glow bright. The present invention utilizes an integration or pulse forming network that produces a relatively slow moving pulse proportional to the average voltage value of the sparking voltage during ignition of one plug. By utilizing this pulse forming network, a relatively low accelerating voltage can be utilized to provide an easily visible beam pattern. With the use of low accelerating voltages for the electronic beam, it is possible to utilize low deflecting voltages such as that obtained from the simple neon saw-tooth generator referred to above and used in the horizontal sweep circuit.

The invention further utilizes a high voltage diode having its anode connected to the spark plug used to trigger the sweep oscillator and its heater-cathode connected to the cathode ray tube cathode. The cathode ray tube cathode is supplied by electrons from the power supply through a resistor. When this spark plug is fouled by deposits such as lead oxide and these deposits are heated, they will shunt the plug electrodes and the diode will draw a relatively heavy current through the cathode ray tube cathode resistor. By utilizing the increased voltage drop across this resistor during this current flow to change the bias on the cathode ray tube control grid, the electron beam will be reduced or eventually completely cut off.

Further advantages and applications will be apparent to those skilled in the art from the following detailed description and accompanying drawings in which:

FIG. 1 illustrates a representative form of the invention in schematic form;

FIG. 2 illustrates an oscilloscope beam pattern for normal spark plug and ignition operation;

FIG. 3 illustrates a similar beam pattern wherein the sparking voltage on all the plugs is high;

FIG. 4 illustrates a similar beam pattern wherein the sparking voltage on all the plugs is low;

FIG. 5 illustrates a beam pattern wherein the sparking voltage for one plug is high;

FIG. 6 shows a beam pattern wherein the sparking voltage for one plug is low;

FIG. 7 illustrates the beam pattern present that indicates lead fouling of the spark plugs; and

FIG. 8 shows a beam pattern obtained when the ignition polarity is reversed.

Referring now to the drawings and first to the schematic showing of FIG. 1, it will be seen that the test apparatus has its own power supply including a vibrator 1 and a transformer 3. An input relay switch has normally closed contacts 5 which are opened by a solenoid 7 that is connected across a pair of power input lead clips 11 and 13. An adjustable resistor 9 is shunted across the contacts 5. The input lead clip 13 is connected through resistor 9 or contacts 5 to the input of the vibrator and the lead clip 11 is connected to a center tap 15 on the transformer primary winding. With proper adjustment of the variable resistor 9 and the proper selection of coil 7 the voltage applied through the vibrator 1 to the ends of the primary winding on the transformer 3 will be the same when the leads 11 and 13 are connected to either a six volt electrical system or to a twelve volt system. Thus connection of leads 11 and 13 to six volts will be directly through the normally closed contacts 5, while connection of the leads to a twelve volt system will be through the voltage dropping resistor 9, contacts 5 being at this time opened by coil 7 with twelve volts applied thereto.

A low voltage secondary winding 17 provides heater voltage such as 5.5 volts, for the two electron tubes, while a high voltage winding 19 applies approximately 550 volts across a buffer condenser 21. Diodes 23 rectify this voltage from winding 19 and filter condenser 25 smooths out

the ripple in the output in conventional manner. Note that the diodes 23 are arranged to produce a negative voltage at 26 with the system ground at 20 being positive. Resistors 27, 29, 31, and 33 provide a voltage divider to supply various potentials to elements of the cathode ray tube circuit to be described below.

The cathode ray tube 35, which may be of any suitable type such as type 3RP1, has an electromagnetic shield 36 surrounding its neck. This shield, which is not electrically connected to any of the tube elements, prevents external radiation from affecting the relatively low speed electron beam. The tube 35 includes a cathode heater 37 connected to the low voltage leads 38 and 40. The cathode electrode 39 is connected to lead 38 and receives electrons from the high voltage source point 26 by way of a cathode bias resistor 27. A first control electrode or grid 41 is directly connected to the high negative voltage point 26 by lead 43.

The tube ultor 49 comprising conventional accelerating anodes is connected directly to the system electrical ground. This grounding of the ultor is not conventional and has a major advantage in connection with the indication of lead deposits as will be described later. A focus grid 45 is connected to a focus control variable resistor 31 by lead 47. Conventional electrostatic horizontal deflection plates 51 and vertical deflection plates 53 provide for beam deflection and scanning.

The horizontal and vertical beam deflecting plates 51 and 53 are energized by circuits synchronized with the engine ignition system. This is conveniently accomplished as shown by direct connection of test leads to terminals on the ignition distributor cap such as the six cylinder distributor 55. The conventional high voltage from the ignition coil, not shown, to the distributor is through a center socket terminal 57, while sockets 59 receive the individual spark plug wires 65. A T connector 61 allows connection of a first test lead 63 directly to any of the spark plug wires. A second T connector 67 allows connection of a second test lead 69 to the input center terminal 57.

The horizontal beam deflection is controlled by a neon tube saw-tooth generator including series connected neon tubes 71. A condenser 73 across the neon tubes is charged through fixed resistor 75, variable resistor 77, and lead 79 from the power supply voltage divider. The three neon tubes which may be of any suitable type, such as the type NE 2, serve as a discharge device when the voltage across capacitor 73 reaches a specific amount, such as 120 volts, or a high tension voltage appears on a gimmick wire 87 located adjacent to the tubes 71. The gimmick wire 87 is directly connected to the test lead 63 and will have a high voltage therein whenever the spark plug connected to the T connector 61 is fired. By proper positioning of the neon tubes with respect to the lead 63, the gimmick wire can be dispensed with. This high voltage ionizes the gas in the neon tubes making them serve as a trigger for synchronization. The RC time for capacitor 73 can be predetermined by the value of resistors 75 and 77. The discharge of capacitor 73 into the neon tubes produces a backward saw-tooth voltage which is applied to the deflection plates 51 through the coupling capacitor 81. The initial discharge of capacitor 73 causes the electron beam to snap towards one side from its normal center position (left side as viewed in the figure), while the discharge of capacitor 81 through resistor 83 to ground causes a slow return sweep of the beam towards the other side of the tube. Resistor 85 serves to limit the charging of the deflection plates to prevent the same from drawing electrons from the electron beam.

The vertical deflection of the electron beam is controlled by a pulse forming network comprising resistors 89 and 91 and capacitor 93. Test lead 69 receives sparking voltage impulses with each spark ignition. Capacitor 93 charges slowly through resistor 89 and subsequently discharges slowly to ground through resistor 91 to cause the

voltage on the vertical deflection plates 53 to gradually rise and fall to and from a value that is in proportion to the average sparking voltage in lead 69 during firing of a plug. As pointed out above, this pulse forming feature is important since the direct use of the sparking voltages on the deflection plates is difficult or impossible since the ignition spikes are very sharp and would be difficult to observe on the face of the tube unless very high accelerating beam voltages are used.

The test lead 63 is connected to the anode 97 of a high voltage rectifier tube 95 such as a type 1B3. The heater-cathode 99 receives heater voltage through voltage dropping resistor 101 from the secondary winding 17 of the transformer 3. When the anode 97 is connected to a high voltage positive with respect to the cathode 99, the tube 95 will draw current through the grid bias resistor 27. This will occur when the spark plug has lead deposits thereon that are heated to the point where they conduct from the negative electrode to the ground. Since the system ground is positive with respect to the electron ray tube cathode there will be a current flow through tube 95 under these conditions. Increased current flow through the resistor 27 results in a greater voltage drop across the same and causes the oscilloscope cathode 39 to become more positive with respect to control grid 41. In effect this is the same as driving the grid 41 negative. This will reduce the intensity of the electron beam and if the voltage drop across 27 becomes sufficiently high, the cathode ray beam is completely cut off.

The operation and use of the tester illustrated will now be discussed. The complete apparatus would be enclosed in a portable case, not shown, and thus could easily be carried by the operator directly to an engine to be tested, such as that in a motor vehicle. The power supply input leads 11 and 13 are connected to the vehicle battery positive terminal and any convenient electrical ground point. As pointed out above, the power supply automatically adjusts itself to both 6 and 12 volt systems and the polarity of connections is unimportant. Any spark plug lead wire is then removed from its terminal on the distributor cap 53 and the T connector 61 on lead 63 is inserted. The removed spark plug wire is then inserted in the T connector. Similarly the center input wire leading to the distributor is removed, the T connector 67 inserted in the terminal and the center wire inserted in connector 67. With the power supply connected it will then produce the necessary voltage for warming up the cathode ray tube 35 and diode 95.

The engine is then started. Each time that the spark plug connected to the lead 63 is fired, high voltage in the gimmick wire 87 will cause the neon tubes 71 to fire resulting in a horizontal sweep of the beam across the face of the cathode ray tube. The horizontal sweep is now synchronized with the engine and will remain synchronized over the full range of engine speeds. This synchronization is especially easy since the voltages across the neon tubes is relatively low.

With the firing of each spark plug the lead 69 will carry a voltage which is applied across the voltage divider 89-91. As explained above the capacitor 93 in combination with the resistors 89-91 produces a formed voltage pulse on the deflection plates 53 which is proportional to the average value of the sparking voltage for each plug.

Referring now to FIGS. 2 to 8 which illustrate representative wave forms produced by the electron beam on the face of tube 35, it will be seen that there are two reference lines 103 and 105 marked on the tube face. These lines may be omitted if desired. The wave form indicates both the absolute and relative sparking voltage of each individual spark plug. The first or left most pip or wave shape represents the spark plug connected to the test trigger lead 63. The remainder of the pips indicate the sparking voltages on the other plugs in the firing order of the engine. Thus a six cylinder engine may have a firing order of 1-5-3-6-2-4. When the trigger lead 63

is attached to the plug in the number six cylinder, the pips on the pattern would be reading from left to right: first pip, cylinder 6; second pip, cylinder 2; third pip, cylinder 4; etc.

The sparking voltage is the amount of voltage required to fire the spark plug. New and reconditioned spark plugs require less sparking voltage than spark plugs that have been in an engine for some time. Spark plugs that are in a running engine are influenced by rotor gap, plug lead from distributor, improper connection (at distributor or spark plug), spark plug gap, air-fuel mixture, compression pressure, engine speed and/or load. At any constant engine speed, the spark plugs in an engine should require a uniform voltage to fire the same.

The height of the individual pips shows the voltage required to fire that spark plug, thus shorter pips indicate low voltage, longer pips indicate high voltage. No pips should extend above line 103 as this indicates an excessive voltage, or below line 105, as this indicates a low voltage.

FIG. 2 shows a pattern 107 that indicates that all plugs have the same sparking voltages and are within the limits of lines 103 and 105. FIG. 3 pattern 109 indicates a uniform high voltage which results from too wide a spark plug gap, lean fuel mixture, excessive rotor gap or a gap in the lead from ignition coil to distributor. Under these conditions removal, observation, and gap measurement of one plug will usually show whether the plugs are at fault or whether the distributor leads or coil should be checked. FIG. 4 shows the pattern 111 obtained from uniformly low sparking voltages resulting from too small a gap in each plug, fouling of the plugs by engine deposits, low compression or rich fuel mixture. Examination of one plug and cleaning or replacement will indicate whether the spark plugs are the cause of the low voltage or other engine or ignition malfunctions are the cause.

FIGS. 5 and 6 illustrate patterns 113 and 115 each showing a defect in one spark plug or its lead or contact in the distributor cap. FIG. 5 indicates a wide spark plug gap or bad connection while FIG. 6 indicates a narrow gap or deposit fouling the plug.

FIG. 7 represents the special pattern seen when there are lead deposits in the plugs. The dashed wave form 117 indicates a dim beam. After the engine has run a minute or so any hot lead deposits will conduct current from the diode tube 95 to ground and thereby increase the voltage drop across resistor 27 to change the relative grid voltage and lower the beam intensity. Under extreme lead deposit conditions the tube 35 will be totally cut off and no pattern will be seen. Since this condition only indicates lead deposits on the plug connected to the trigger lead 63, the lead 63 should be connected to other plugs to check for lead fouling on the same.

FIG. 8 shows the pattern obtained if the ignition polarity is reversed from the normal wherein the spark plug terminal is negative. If the system has been reversed the pattern will appear upside down as in FIG. 8.

Polarity is important to efficient ignition operation. Manufacturers of ignition components agree that all satisfactory ignition systems are those that are negative at the spark plug terminal. Should polarity be reversed at battery, coil or the wrong coil for that particular ignition system used, the sparking voltage may be increased 10 to 30 percent. When polarity is reversed, hard starting, rough idling, misfiring during acceleration, and misfiring at high speeds will occur. The tester provided by the invention gives an immediate indication of wrong polarity.

By accelerating the engine during the test, the operation of the plugs during extreme conditions can be observed and thus give a better idea of the condition of the plugs. The whole procedure including making the four connections, starting and accelerating the engine and observ-

ing the pattern of the tube face can be accomplished in a matter of several minutes. Since the tester has a minimum of parts resulting from the simplified and yet highly efficient circuits, a tester incorporating the invention can be readily utilized at many locations such as at gasoline pump islands in service stations. Furthermore, since there are no adjustments except for the pattern width, the tester can be used by anyone without experience.

Modifications and other applications will be readily apparent to those skilled in the art and such modifications and applications are within the scope of the invention which is limited only by the following claims.

I claim:

1. In an apparatus for testing spark plugs in an engine having an ignition system with a high voltage secondary circuit connected to a plurality of individual spark plugs having spark gap electrodes, the combination including a cathode ray tube having a cathode electrode, a control electrode and an accelerating ultor, power supply means connected with the cathode and ultor for developing a scanning beam in said tube, bias means connected with the power supply means and with one of said electrodes for controlling the intensity of said scanning beam, first means for deflecting said beam in one direction in response to the voltages in said secondary circuit required to fire each spark plug, second means for deflecting said beam in another direction perpendicular to the first direction, said second means responsive to high voltage in said secondary circuit directed to one of said plugs, a rectifier and said bias means connected in series with said one spark plug, said rectifier allowing current to flow to said one plug when the same leaks current to the ignition electrical ground, whereby a voltage change on said bias means causes said one electrode to reduce the intensity of said beam.

2. In an apparatus for analyzing spark plugs in an engine having an ignition system producing a first high negative voltage with respect to an electrical ground, said ignition system including a distributor for connecting said high negative voltage successively to a first electrode on each of a plurality of individual spark plugs each having a second grounded electrode, the combination including a power supply for providing a medium value negative voltage with respect to the electrical ground, a cathode ray tube having a heated cathode, control grids and an accelerating ultor, means connecting said medium negative voltage to said cathode and connecting said ultor to ground for developing a scanning beam in said tube, a bias resistor connected with the power supply and with one of said grid means for controlling the intensity of said scanning beam, means for deflecting said beam in one direction in response to the voltage in said ignition system required to fire each spark plug, means for deflecting said beam in another direction in response to high voltage distribution to the first electrode of one of said plugs, a rectifier and said bias resistor connected in series with said one spark plug, said rectifier allowing current to flow to said one plug when the first and second electrodes are shunted whereby a voltage change on said bias resistor causes said one grid to reduce the intensity of said beam.

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