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B. H. SHORT

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IGNITION SYSTEM

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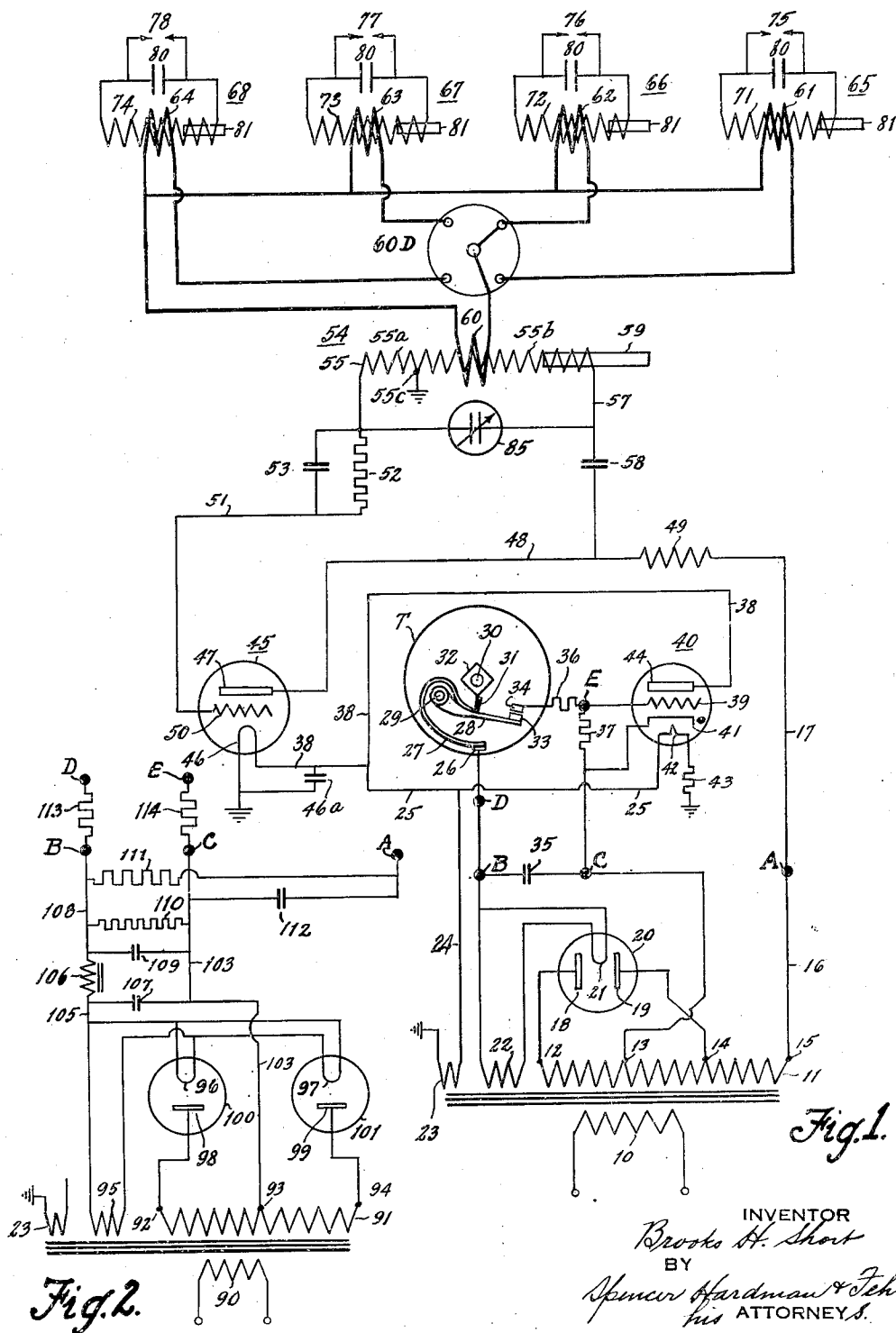


Fig. 1.

Fig. 2.

INVENTOR
Brooks H. Short
BY
Spencer Hardman & Fehr
his ATTORNEYS.

UNITED STATES PATENT OFFICE

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IGNITION SYSTEM

Brooks H. Short, Anderson, Ind., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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This invention relates to high frequency ignition systems for internal combustion engines.

An object of the present invention is to obtain a rapid succession or shower of sparks during the period of closure of the engine operated timer contacts. This object is accomplished by the combination of a resonator connected with the spark plug, an oscillator inductively connected with the resonator and having a tube, a thyatron, a condenser which is charged while the timer contacts are separated and is discharged while the contacts are engaged, a connection between the condenser discharge circuit and the thyatron grid such that the grid is positively biased and the thyatron is ionized during the period of contact closure, a circuit which includes in series the plate of the oscillator tube, the cathode of the oscillator tube and the plate of the thyatron both at ground or zero potential and the cathode of the thyatron, and means for intermittently impressing positive potential on the plate of the oscillator tube while the cathode of the thyatron is negative with respect to ground whereby pulses of current flow through the oscillator tube. In one form of the invention, the means is a source of alternating current of high frequency. In another form the means is a second condenser which discharges intermittently at high frequency, said second condenser being charged through a resistance in series therewith, the R. C. relation of the second condenser and series resistance being such that frequency of charge and discharge of the second condenser is relatively high.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein preferred embodiments of the present invention are clearly shown.

In the drawing:

Fig. 1 is a wiring diagram of an embodiment of the present invention.

Fig. 2 shows a modification of the diagram of Fig. 1.

Referring to Fig. 1, a transformer primary 10 is connected with an alternating current source S1 of high frequency. For an engine operating at 2500 R. P. M., the frequency of the source S1 should be at least 3750 cycles per second in order to obtain 4% accuracy of timing. This frequency could be generated by a high power audio oscillator or by a rotary machine. Secondary windings 11, 22 and 23 are associated with the primary winding 10. A rectifier tube 20 has its cathode 21 connected with the winding 22 and its

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plates 18 and 19 connected respectively with terminal 12 and tap 14 of the winding 11. The tap 13 is connected with a terminal C. The cathode 21 is connected with a terminal B. The condenser 35 is connected with the terminals B and C. Terminal 15 of secondary 11 is connected by wire 16 with a terminal A.

Terminal B is connected with terminal D of a timer T driven by the engine. The timer comprises a support 26 connected with timer terminal D and connected by a leaf spring conductor 27 with a circuit breaker lever 28 pivoted at 29 and carrying a rubbing block or cam follower 31 for engaging a cam 32 rotated by an engine driven shaft 30. Lever 28 carries a contact 33 for engaging a contact 34. A resistance 36, preferably 3000 ohms, is connected between the contact 34 and a terminal E. A resistance 37, preferably 30,000 ohms, is connected between terminal E and terminal C.

A thyatron tube 48 has a plate 44 connected with wire 38, a grid 39 connected with terminal E, a cathode 41 connected with terminal C and a cathode heater 42 connected with a grounded resistance 43 and with wire 25 connected with wire 38 and with wire 24 connected with secondary winding 23.

An oscillator tube 45 has a cathode 46 which is grounded and which is connected with wire 38 and which is in parallel with a condenser 46a. Tube 45 has a plate 47 connected with wire 48, connected with choke 49 connected by wire 17 with terminal A. Tube 45 has a grid 50 connected by wire 51 with a resistance 52 in parallel with a condenser 53, both together being connected with one end of the primary 55 of an oscillator coil 54, the other end of which is connected by wire 57 with a condenser 58 connected with wire 48. An adjustable condenser 85 is connected across the terminals of the primary 55 of the coil 54. The primary 55 is divided into two sections 55a and 55b by a tap 55c which is grounded.

The oscillator coil 54 has a secondary 60 connected selectively by distributor 60D with primary windings 61, 62, 63 and 64 of resonators 65, 66, 67 and 68, respectively, having secondary coils 71, 72, 73 and 74, respectively connected with spark gaps 75, 76, 77 and 78, respectively. Each spark gap is paralleled by condenser 80. The frequency of the oscillator can be adjusted by varying the capacity of the condenser 95 and by endwise movement of a magnetizable rod 59 which is surrounded by a portion of the coil 55. The frequencies of the resonators can be adjusted by endwise movements of magnetizable rods 81 sur-

rounded by portions of the resonator secondaries. In this way, the frequencies of the resonators and the oscillator can be equalized.

The operation of the system shown in Fig. 1 is as follows. While the contacts 33, 34 are separated, condenser 35 is charged. Current flows to cathode 21 of rectifier 20 alternately from its plates 18 and 19. Condenser terminal B is positive. When the contacts 33, 34 engage, condenser 35 discharges through these contacts and resistances 36 and 37 which retard discharge so that thyatron grid 39 will be positively biased and the thyatron 40 will be ionized as long as possible during the period of contact closure. During the period of ionization of thyatron 40, it is in condition to pass current from its plate 44 which is at ground potential to its cathode C when the latter is at negative potential with respect to ground. Terminals or points A and C are connected with the points 15 and 13 of the transformer secondary 11 which is inductively connected with an A. C. source of relatively high frequency. When A is positive, C is negative, and vice versa. During half of the A. C. wave when C is negative and A is positive, current will pass through the following circuit: terminal A, wire 17, choke 49, wire 48, grid 47 of oscillator tube 45, cathode 46 of tube 45 and plate 44 of tube 40 (both at ground or zero potential) cathode 41 and terminal C. When C is positive and A is negative no current will pass through this circuit. Therefore the oscillator is intermittently operative and sparks will occur at a plug at the frequency of the A. C. source connected with transformer primary 10.

Instead of using a power supply or power pack requiring high frequency input for obtaining high frequency plate supply, the same effect can be obtained by the use of an R. C. circuit in the power pack where the time constant of R. C. is the required value, for example, 250 (ohms, resistance) $\times$ 1 (microfarad, capacity), the equivalent of 4000 cycles per second alternating current plate supply.

Fig. 2 shows the modification of Fig. 1 in order to use an R. C. circuit. The source 52 connected to the transformer primary 90 may be at the usual frequency. The transformer secondary 23 is connected as in Fig. 1. The transformer secondary 91 has end terminals 92 and 94 and a center tap 93. The secondary winding 95 is connected with the cathode filaments 96 and 97 of rectifier tubes 100 and 101 having their plates 98 and 99, respectively, connected with terminals 92 and 94, respectively. Terminal 93 is connected with wire 103, connected with terminal C. Wire 105 connects the cathode filaments 96 and 97 with a choke 106, connected by wire 108 with terminal B. Filter condenser 107 is connected between the wires 105 and 103. Filter condenser 109 and a parallel resistance 110 are connected between wires 108 and 103. A resistance 111, preferably 250 ohms, is connected between terminals B and A. A condenser 112, preferably one microfarad, is connected between terminals C and A. A resistance 113, preferably 75,000 ohms, is connected between terminals B and D. A resistance 114, preferably 25,000 ohms, is connected between terminals C and E. The terminals D, E and A are connected with the timer T, thyatron 40 and the wire 17 as shown in Fig. 1, but there is no resistance between timer contact 34 and terminal E.

The operation of the system as modified ac-

ording to Fig. 2 is as follows. While contacts 33, 34 are open condensers 109 and 112 are charged, wire 108 being positive and wire 110 negative. Terminal A is connected with the positive terminal of condenser 112 and terminal C with its negative terminal. During engagement of contacts 33, 34, condenser 109 discharges through resistance 113, contacts 33 and 34 and resistance 114. These resistances retard discharge of condenser 109 so that thyatron grid 39 will remain positively biased and thyatron 40 will remain ionized as long as possible during the period of contact closure. When the thyatron is ionized, condenser 112 discharges through the circuit A to C described with reference to Fig. 1 and the oscillator becomes operative. When the potential of the terminal A falls so low that current flow from A to C ceases, the condenser 112 is recharged until the potential of A is such that current flow from A to C is resumed. Therefore current flows from A to C intermittently at the rate determined by the R. C. relation of resistance 111 and condenser 112. If resistance of 111 is 250 ohms and the capacity of 112 is one microfarad, the timer constant of the combination (resistance 111 and condenser 112) is $250 \times 1 \times 10^{-6}$ which is the equivalent of 4000 cycles per second. The discharging of the condenser 112 can take place because, concurrently, the plate 47 of tube 45 is more positive than ground (potential of its cathode 46 and of plate 44 of thyatron 40) while potential of C is more negative than ground.

The operation of the oscillator is the same in both circuits. Whenever a sufficient voltage is impressed on the plate 47 of tube 45, the oscillator tube 45 permits current to flow to charge the condenser 35. The condenser charging circuit includes secondary terminal 15, wires 16 and 17, choke 49, condenser 35, condenser 35, resistance 52, wire 51, grid 50, cathode 46, wire 33, plate 44, cathode 41, wire 21, terminal C and secondary tap 13. During the charge of condenser 35, the voltage impressed on the grid 50 becomes increasingly positive. As grid 50 becomes more positive, tube 45 passes more current and the voltage drop across the tube decreases. As the voltage drop decreases across tube 45, the condenser 35 starts discharging and produces a negative voltage on the grid 50 due to the operation of two inductively related circuits. One of these circuits is condenser 35, wire 57, all of the oscillator primary coil 55. The other circuit includes the grounded tap 55c of primary 55, the primary section 55a, resistance 52, wire 51, grid 50, cathode 46 and ground connection back to 55c. The negative voltage impressed on grid 50 causes less current to flow from the plate 47, thereby raising the voltage drop across the tube 45 and allowing the condenser 35 to be charged again. In this way, an oscillation through the primary 55 is sustained. This oscillation increases rapidly in amplitude until the maximum amplitude is reached; and the oscillation is sustained so long as sufficient voltage is impressed on the plate 47 of oscillator tube 45. In other words, the oscillator tube 45 operates in a manner analogous to a variable resistance in shunt with the condenser 35. As condenser charge increases the variable resistance decreases automatically; and, when the decrease of resistance is such that the condenser is robbed of charging current, the condenser discharges. The discharge of the condenser automatically causes the variable resistance to increase whereby the condenser is permitted to receive a charging current; and

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the cycle is repeated so long as sufficient voltage is being impressed on the plate 47 of tube 45.

As the current oscillation through the oscillator primary coil 55 increases in magnitude, the resonator then connected with the oscillator by the distributor 60D while the timer contacts are closed, will have, in its condenser-coil circuit, a corresponding oscillation increasing in magnitude until voltage impressed upon the spark plug is sufficient to cause the current to jump the gap. Because positive potential is being intermittently impressed on terminal A while the potential of C is negative with respect to ground during the period of contact closure, the oscillator operates intermittently through the resonator then connected by distributor 60D to produce a shower of sparks at the plug connected with the resonator.

From the foregoing description of two embodiments thereof, it is apparent that the present invention resides in the combination with a resonator connected with a spark plug of an oscillator inductively associated therewith having a tube, a series circuit which includes a terminal A, the plate of the oscillator tube, the cathode of the oscillator tube and the plate of a thyatron both at ground or zero potential, the cathode of the thyatron and a terminal C, means controlled by the engine timer for effecting ionization of the thyatron during the sparking period, and means for intermittently impressing upon terminal A a positive potential while the potential of the terminal C is more negative than ground.

While the embodiments of the present invention as herein disclosed, constitute preferred forms, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. An ignition system comprising a spark plug, a resonator connected with the plug, an oscillator inductively connected with the resonator and having a tube including a plate and a cathode, a thyatron having a plate, grid and cathode, an engine operated timer having contacts, a condenser, a D. C. source for charging the condenser, a circuit including the condenser and the timer contacts, when closed, for effecting condenser discharge and including resistances for retarding condenser discharge, a connection between the condenser discharge circuit and the grid of the thyatron such that the grid is positively biased and the thyatron is ionized during the period of contact closure, a circuit including in series a first terminal, the plate of the oscillator tube, the cathode of the oscillator tube and the plate of the thyatron at ground or zero

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potential, the cathode of the thyatron and a second terminal at the same potential, and means for intermittently impressing on the first terminal a positive potential while the potential of second terminal is negative with respect to ground, whereby current passes through said circuit intermittently to effect through the oscillator and resonator a rapid succession of sparks at the plug during the contact closing period.

2. An ignition system according to claim 1 in which the first and second terminals are connected with an A. C. source of relatively high frequency.

3. An ignition system according to claim 1 in which the first and second terminals are respectively connected with the positive and negative terminals of a second condenser which is charged by the D. C. source, and in which the charging circuit of the second condenser includes a resistance in series with the second condenser, the time constant of the second condenser and series resistance being such that the condenser discharges and recharges at relatively high frequency during the period of contact closure.

4. An ignition system comprising a spark plug, a resonator connected with the plug, an oscillator inductively connected with the resonator and having a tube including a plate and a cathode, a thyatron having a plate, grid and cathode, an engine operated timer, means under control by the timer for effecting ionization of the thyatron during the period required for ignition, a circuit including in series a first terminal, the plate of the oscillator tube, the cathode of the oscillator tube and the plate of the thyatron at ground or zero potential, the cathode of the thyatron and a second terminal at the same potential, and means for intermittently impressing on the first terminal a positive potential while the potential of the second terminal is negative with respect to ground, whereby current passes through said circuit intermittently to effect through the oscillator and resonator a rapid succession of sparks at the plug during the contact closing period.

BROOKS H. SHORT.

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