

June 22 , 1926.

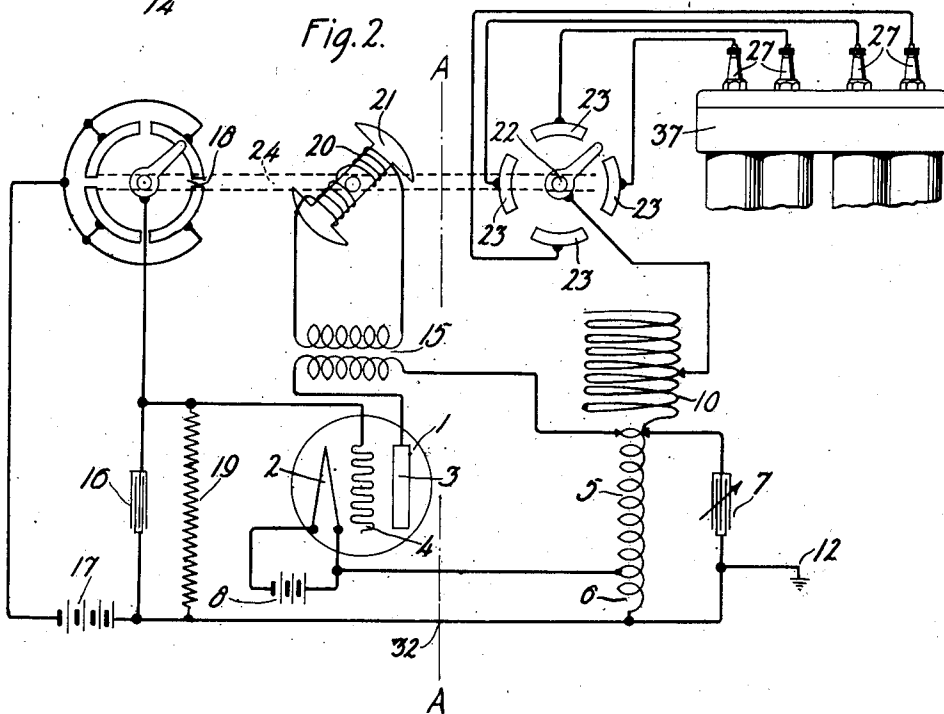
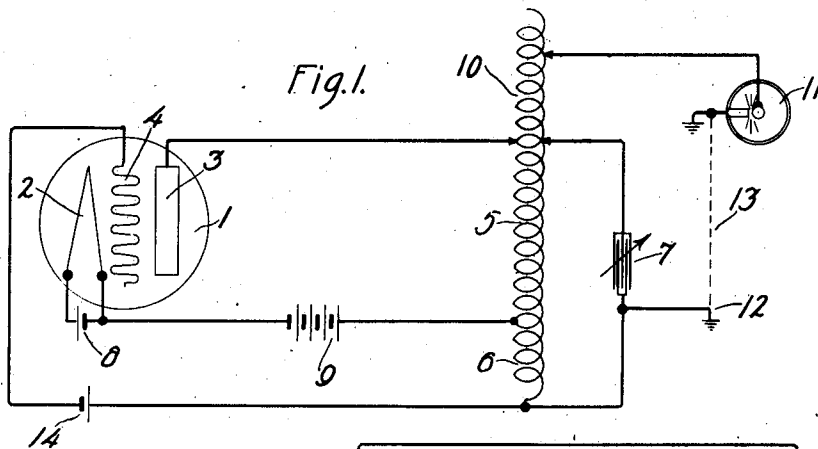
1,589,489

H. C. SNOOK

ELECTRIC IGNITION SYSTEM

Filed Oct. 15, 1920

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

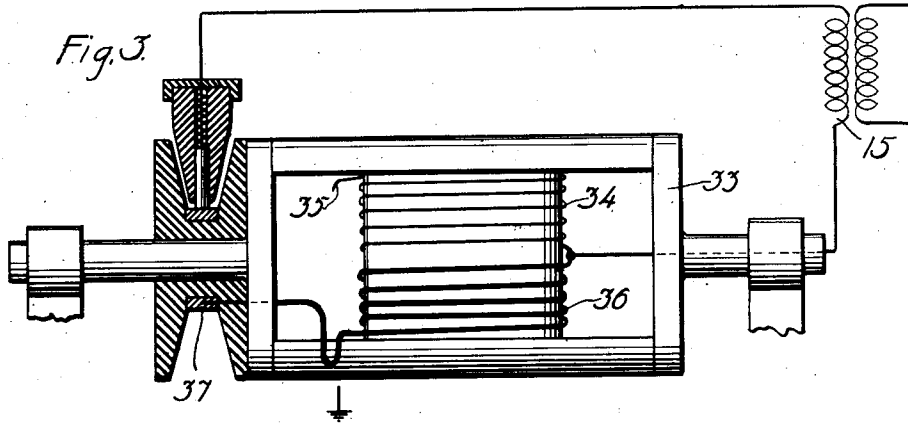
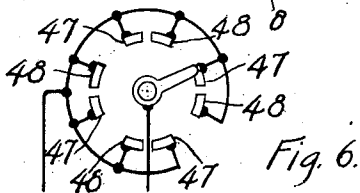
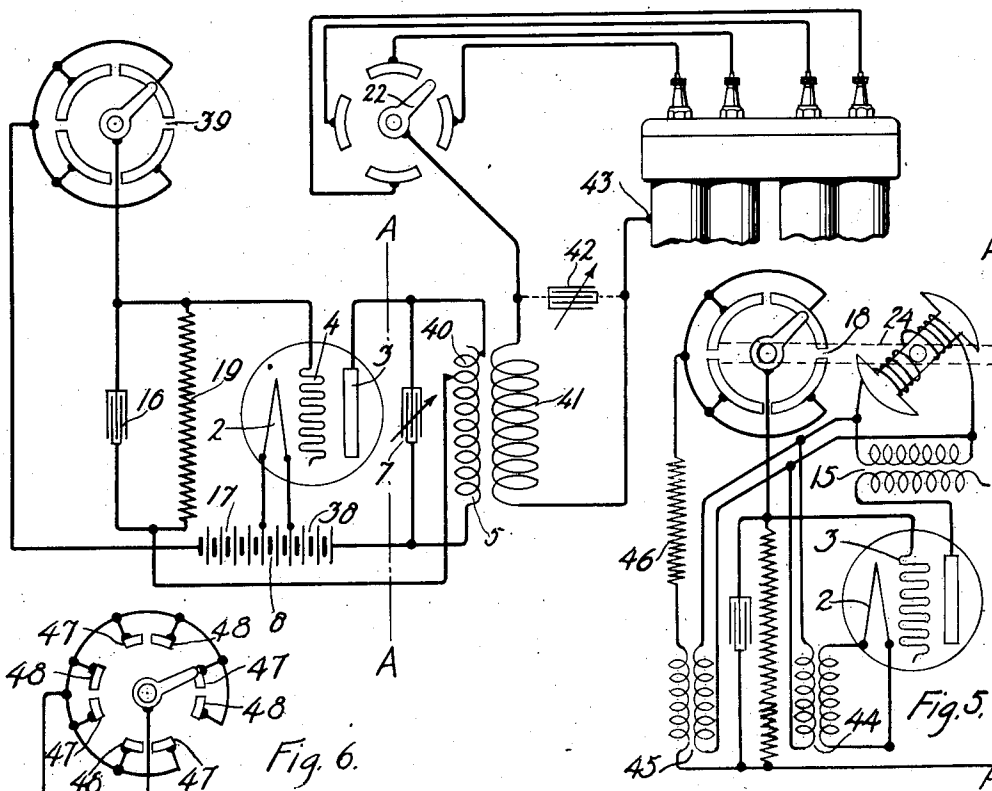


Fig. 4.



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UNITED STATES PATENT OFFICE.

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ELECTRIC IGNITION SYSTEM.

Application filed October 15, 1920. Serial No. 417,208.

This invention relates to an electric ignition system using high frequency current to ignite explosive charges and is especially adapted for use with internal combustion engines, though not limited to such use, as it may be utilized for blasting and similar purposes. More particularly, it relates to a system of this type wherein a low tension current source may be used to supply energy to the high frequency current generating means.

The fact that a high frequency current discharge across the ignition gap of a spark plug possesses the peculiar property of not being materially affected by defects in the insulation of the plug and that a plug may be fouled, even to the extent of being short circuited by a loop of conductive material, without stopping the spark was, perhaps, first pointed out by Sir Oliver Lodge.

Ignition systems utilizing high frequency current have been devised but they generally involve the use of an induction coil, the secondary winding of which is associated with a capacity to constitute an oscillatory circuit having a spark gap in air as a discharge element for said circuit; the terminals of the spark plug operating as a secondary discharger therefor. The disadvantage of such systems is that the high frequency current source is of low electric efficiency, unreliable and non-controllable, and hence, while demanding considerable care and attention on the part of the operator, are found to be of no practical value.

The primary object of this invention is to devise an ignition system employing high frequency current which is free from these defects and eminently satisfactory from a practical point of view.

Another object is the production of high tension high frequency current from a low voltage source of current.

A further object is the provision of a source of high frequency current which does not involve discharge elements in air, whereby contact terminals of highly infusible material such platinum, tungsten, etc. which are essential to the induction coil ignition systems of today, are eliminated.

Still another object is to provide a variable

frequency source of high frequency current for ignition purposes.

A still further object is the provision of means whereby a low voltage source of vibratory or alternating current may be controlled to supply selected portions of the positive current wave to the plate circuit of an electronic tube.

These objects and others which will appear as the description of the invention proceeds may be obtained by the arrangement herein set forth which discloses one method of accomplishing this result.

Briefly, this invention comprises a space discharge device as a source of high frequency current adapted to be energized by a low tension current source, and a circuit for transmitting the high frequency impulses to the ignition device or devices, this circuit being in resonance with the tuned circuit which, as is well known, is associated with the oscillator to determine the frequency of the oscillations produced.

When used to supply ignition current to a multiple cylinder engine, the operation of the oscillator is controlled by a make and break device or interrupter to supply high frequency current when the spark circuit is completed and to prevent the generation of oscillations when this circuit is opened; a distributor being used to connect the spark plugs in proper sequence and at the proper time periods, relatively to the interrupter, to make and break said spark circuit.

Like reference characters indicate like parts in all the figures of the drawings in which Fig. 1 illustrates a simple form of the invention; Fig. 2 shows an ignition system for a multiple cylinder engine involving the invention; Fig. 3 shows the adaptation of a Bosch high tension magneto for use in the system of Fig. 2; Fig. 4 is a different circuit arrangement embodying the system shown in Fig. 2; Fig. 5 shows another arrangement of the tube energizing and control circuits for use with an ignition system of the type shown in Figs. 2 and 4, and Fig. 6 shows a modified form of the interrupter or make and break device.

In the arrangement shown in Fig. 1, an oscillation generator of the type disclosed

in United States Patent No. 1,356,763, issued to R. V. L. Hartley, October 26, 1920, is used as a source of high frequency current, by way of example. This oscillation generator comprises a space discharge device 1 having an input circuit extending from a hot filament 2, to and through an adjustable inductance coil 6 to an impedance controlling element 4. An output circuit 10 connected between said filament and an anode 3 has an adjustable inductance coil 5 included therein. The coils 5 and 6 having the adjustable condenser 7 connected across their terminals constitute a closed oscillatory circuit. The natural period of the oscillatory circuit may be varied to control the frequency of the oscillations produced therein. Increments of oscillating energy are fed back to the input circuit. The battery 8 supplies heating current to the filament 2 and the battery 9 supplies plate current to the discharge device.

As described in the above mentioned patent, oscillations are set up in the tuned circuit, by means of the coil 10, designed and associated with the oscillatory circuit 5, 6 and 7 in a manner similar to the secondary of an Oudin resonator. By means of this arrangement high potential impulses of predetermined frequency are transmitted to the spark device 11 to which its outer terminal is connected, the other terminal of the spark device being grounded. The oscillatory circuit is connected to the frame of the engine and is thus grounded at 12 to provide a return path for the high frequency current. Instead of grounding the secondary terminal of the spark device, a conductor, indicated by the dotted line 13, may be used to connect it to the oscillatory circuit. A polarizing battery 14 may be used to supply a negative potential to the grid 4, thereby maintaining said grid negative relatively to the cathode. The spark device may be mounted in the head of a single cylinder engine to ignite the charge, therein, may be used to ignite a mine, a blasting charge or for any other similar purpose.

Referring to Fig. 2, there is shown an electric system for an automobile in which current, generated in a low tension winding 20 mounted on the rotor 21 of a magneto or motor starting and lighting dynamo of the system, flows through the primary of the transformer 15 thereby setting up current in the secondary of said transformer, which secondary is connected in the output circuit of the discharge device to supply plate current thereto. Thus, the low voltage winding is used in this arrangement as a substitute for the battery 9 of Fig. 1.

Plate current flows from one terminal of the secondary winding of the transformer 15 through the coil 5 to the filament 2, thence to the plate 3 and back to the other

terminal of said winding. The flow of this current sets up oscillatory current in the tuned circuit 5, 6 and 7, increments of which, as is fully set forth in the above mentioned patent, are fed back to the grid to control the operation of the discharge device. These oscillations traverse the conductor 32 and the connection including the condenser 16, which constitutes a low impedance path for the high frequency impulses.

The flow of current in the plate circuit of the discharge device may be suppressed by negatively polarizing the plate relatively to the cathode or by applying to the grid element a negative potential of sufficient value to prevent the flow of space current within the device. This operating feature of the discharge device is utilized to determine or select the intervals during which energy is applied to the oscillatory circuit and, as a consequence, high frequency impulses are transmitted to the spark circuit.

Connected in parallel to the condenser 16 is a circuit containing a battery 17 and a make and break device 18. The battery is designed to apply a negative potential to the grid 4, when the circuit is completed by the make and break device, of sufficient magnitude to suppress or so reduce the plate current that the tube is inoperative. Thus, when the battery circuit 17—18 is completed no current is supplied to the oscillatory circuit, but when it is open the discharge device operates to supply impulses to the oscillatory circuit.

In parallel with the condenser 16 is a second path including a high resistance 19 which serves as a leakage path to prevent the tendency of a negative charge to accumulate on the grid 4 which, if not dissipated, would ultimately "block" the discharge device. The resistance 19 is so large that it does not conduct appreciable current from the battery 17 when the interrupter 18 is closed or interfere with the flow of the oscillations through the parallel condenser path when the interrupter is open.

A coil 10, cooperating with the oscillatory circuit, as described with reference to Fig. 1, has its outer terminal connected to the movable arm 22 of a rotary distributor which by successive engagement with the contacts 23 completes the circuit of the spark plugs 27 associated with the engine 31, whereby high frequency impulses are transmitted in proper sequence to the cylinders of said engine, to ignite the explosive charges. One terminal of each spark plug is grounded to the engine head, and a connection to the primary of the resonator is grounded to the frame at 12 to provide a return path for the high frequency current.

The spark circuit including the coil 10, the high tension distributor 22—23, the leads to the spark plugs 27 and the return path to

the tuned circuit 5, 6 and 7 constitutes the circuit for transmitting the high frequency impulses to the ignition device or devices which, as is hereinbefore stated is in resonance with the tuned circuit 5, 6 and 7.

The make or break device merely involves a fixed contact periodically engaged for a definite interval by a movable contact whose motion may be controlled by the crank shaft of the engine and may therefore be of any suitable design.

Ignition sparking will occur at the proper time at the proper spark plug when the magneto, the make and break device, and distributor arm are driven by a common driving mechanism designed to maintain such time relation between them, in the performance of their functions, that a positive impulse of sufficient voltage value is supplied by the magneto to the plate circuit of the discharge device to set up oscillations, the interrupter is in open circuit position, and the distributor is in engagement with a selected one of its stationary contacts.

The common driving mechanism for the make and break device, magneto and movable contact of the distributor is shown in the drawings as a shaft, represented by the dotted lines 24, and maybe an extension of the crank shaft or a separate shaft geared to the crank shaft. Immediately preceding the opening of the contacts of the make and break device 18, the movable arm 22 engages one of the contacts 23 to complete the spark circuit to one of the plugs and, upon closure of the interrupter contacts, the arm 22 disengages said contacts. Hence for an interval of time, slightly greater than the oscillation producing period, the spark circuit is completed, and consequently disruptive discharges across the distributor contacts is avoided.

That the Bosch high tension magneto may be readily modified to adapt it to use with an oscillator including an electron discharge device, is shown in Fig. 3, wherein the rotor 33 of such a magneto is illustrated. The high tension winding 34 is open circuited as indicated at 35. One terminal of the low tension winding 36 is disconnected from ground and connected to the slip ring 37, a brush in engagement with said ring being connected to the primary of the transformer 15, the other terminal of said primary being directly connected to the other end of the low tension winding. The secondary of the transformer is adapted to be connected to the oscillator shown in Fig. 2 with which arrangement this adaptation is designed to be used.

Another arrangement of the ignition system is shown in Fig. 4. In this system, a divided battery is utilized as a source of power. One portion 17 supplies the blocking potential to the grid 4 through an in-

terrupter 39, a second portion 8 supplies heating current to the filament 2, while a third portion 38 is connected to the plate circuit which extends from the cathode 2 to one terminal of the battery subdivision 38 and from its other terminal through a tuned circuit consisting of an adjustable winding 5 and an adjustable condenser 7 to the plate 3. Oscillations of a definite frequency, determined by the constants of the tuned circuit, are thereby produced in this latter circuit; increments of which, derived from a portion 40 of the coil 5, are fed back to the impedance control element 4 through a low impedance path including the condenser 16. As in Fig. 2, a high resistance 19 is connected in shunt to the condenser for the purpose hereinbefore set forth with reference to said last-mentioned figure.

Inductively related to the winding 5 is a secondary winding 41 which may be designed to have sufficient distributed capacity to permit of its being tuned by adjustment to the frequency of the oscillatory circuit associated with the tube, or it may be the secondary of an oscillation transformer having an adjustable capacity to effect tuning, as indicated by the dotted line connection 42 shown in this figure. In this modification one terminal of the secondary winding is connected to the high tension distributor arm 22, the other end of said secondary being connected to the engine frame at 43 to constitute a return path for the high frequency current. The stationary contacts of the distributor are connected to the spark plugs in proper order.

The method of operation of this system is similar to that of the construction shown in Fig. 2. Any other form of oscillation generator, as for example that described in U. S. Patent 1,472,470, October 30, 1923, to R. V. L. Hartley, may also be used as a source of high frequency current.

In the system shown in Fig. 5, energy is supplied to heat the filament 2 by means of the transformer 44 and to the grid 3 through the transformer 45, whose primary is reversely connected to the magneto, and also to the plate 4 by the transformer 15. The transformers 44 and 45 are designed respectively to maintain the filament heated to the desired temperature and to apply potential of the desired magnitude to the grid at the desired intervals in the cycle of operation of the magneto.

In this showing, the discharge device is blocked during the negative wave period of the magneto by the application of a negative potential to the plate of the discharge device and during desired portions of the positive wave period of said magneto by the application of a negative voltage, through the transformer 45 to the grid 3, under the control of the make and break device 18.

The reversal of connections to the primary winding of the transformer 45 serves to reverse the phase of the potential supplied to the grid circuit of the discharge device relative to that supplied to the plate circuit and the resistance 46 included in the grid circuit is adapted to limit the current flow therein to a negligible quantity when the grid is positive relative to the filament.

The resistance 46 may be dispensed with if the grid circuit is open during the positive wave period of the magneto. In order to effect this, there is illustrated in Fig. 6 a make and break device provided with a pair of short segmental contacts 47 and 48 in place of the longer single contacts shown in the preceding figures. Thus, during the time when a positive wave is being supplied to the plate circuit of the discharge device, first the grid circuit is completed through one of these contacts 47 after which this circuit is opened for an interval, during which oscillations are produced and high frequency current is supplied to the spark circuit. This interval is then followed by another contact interval, the contact arm 18 being in engagement with 48 to impress a negative potential upon the grid and prevent oscillation production. A non-contact period then follows, but, as a negative potential is supplied to the plate element of the discharge device, the flow of space current is suppressed and generation of oscillations is thereby prevented. This cycle of operations is continuously repeated.

Under certain conditions an arrangement of the type shown in Figure 5, with or without the interrupter of Figure 6 to control oscillation production, will be preferable to those illustrated in Figures 2 and 4. In this arrangement the magneto, interrupter and distributor arms will be driven in proper time relation by a common driving mechanism similar to that heretofore described and the discharge device and its related circuits, just described, will be associated with either the Oudin resonator of Figure 2, or the transformer of Fig. 4 and their related spark circuits. The dotted line A—A serves to indicate the fact that said additional elements must be used to complete the system and the plane of connection in these figures.

While separate transformers have been shown to supply the grid, filament and plate circuits, it is obvious that other methods of deriving the desired energy may be used. For instance, a plurality of secondary windings associated with, or a tapped secondary inductively related to, the primary winding of the transformer 15 may be used.

In Figs. 2, 4, 5 and 6, no attempt has been made to indicate accurately the open and closed circuit periods of the interrupter and distributor, since in said figures the showing is merely schematic of one of the well-

known forms of switching devices which may be used for the purpose desired. It will be sufficient to state that, in the case of the former, the circuit from the source of blocking potential should be open for brief intervals relatively to the time period of one complete generating cycle of the magneto and cyclically with the sparking periods, and, in the case of the latter, the spark circuit should be closed for substantially similar periods. By using the well-known bayonet socket a spare electron tube may be substituted for one that is worn out, hence the matter of renewals becomes simpler and less troublesome than the renewal of contacts employed in ignition systems heretofore known.

As stated above, the discharge device may be rendered inoperative or blocked by the application to its grid or plate of an electrostatic charge of definite voltage negative to the filament. The current flow in the grid circuit will be negligible under the conditions hereinbefore described. Moreover, as the circuit connecting the grid and the source of potential used for blocking purposes is practically a short-circuit, hence without inductance, there will be uniform potential conditions throughout this circuit when the discharge device is inoperative. Under the most adverse potential conditions, during its operating periods, the voltage applied to the grid will not be materially different from that supplied by the blocking source. Therefore, since the control of the grid does not involve energy or current, the circuit connecting the blocking source to the grid being without inductance and a practically uniform potential condition existing between source and grid, it will be evident that the grid circuit may be made and broken by the interrupter without arcing at its terminals.

Again, as the spark circuit is adapted to be completed just prior to the time when the discharge becomes operative and is maintained in a closed circuit condition for a brief interval after the termination of the oscillation production period, no destructive discharges will take place across the terminals of the distributor.

By changing the adjustment of the condenser, windings of the resonator, or both, the periodicity of the oscillations generated may be varied. This is important since by this simple adjustment a hot spark is always assured regardless of the conditions at the terminals of the spark plug or plugs, due either to differences in design, imperfections in manufacture or to continued use.

A particular use and specific means have been shown and described, merely with the object of illustrating one practical application of the invention and the principles involved; consequently it is to be understood

that this invention is not to be construed as limited either to such use or the means herein set forth, but includes all such modifications and uses as fall within the scope of the appended claims.

What is claimed is:

1. An ignition system comprising an oscillation generator including an electron discharge device and means to determine the frequency of the oscillations produced, a source of low tension alternating current supply for said generator, means to render the generator inoperative at selected intervals and a spark circuit in resonance with said frequency determining means.

2. A system comprising an oscillation generator including an electron discharge device and means to determine the frequency of the oscillations generated, a source of low voltage alternating current supply for the generator, means to prevent energization of the device for time intervals greater than, but including the time during which negative waves are supplied by said source, and a circuit in resonance with said frequency determining means.

3. An ignition system comprising an oscillation generator including an electron discharge device and means to determine the frequency of the oscillations produced, a source of low voltage alternating current supply for the generator, means controlling the device to render it inoperative when the low voltage source supplies negative current waves, and a spark circuit tuned to the frequency of said frequency determining means.

4. An ignition system comprising an oscillation generator including an electron discharge device and the primary of a resonator as a means to determine the frequency of the oscillations generated, sparking means, the resonator secondary including the sparking means, a source of low voltage alternating current supplying the device, and means to confine the flow of impulses from said source to the device to selected intervals.

5. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electron discharge device, an impedance control element for the device, means intermittently to apply a blocking potential to the impedance control element, a spark circuit coupled to the generator, and means to connect said circuit to the spark plugs in proper sequence and to each plug substantially during a non-blocked period of the device.

6. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electron discharge device, an impedance control element for the device, a source of negative potential adapted to be connected intermittently to the con-

trol element to block the device, a spark circuit coupled to the generator and means to connect the circuit to the spark plugs in proper sequence, and to each plug substantially during a non-blocked period of the device.

7. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electron discharge device and means to determine the frequency of the oscillations produced, an impedance control element for the device, a source of negative potential adapted to be connected cyclically to the control element during definite time intervals, a spark circuit in resonance with said frequency determining means, and means to connect the circuit to the spark plugs in proper sequence and to each plug substantially during an interval when the source of negative potential is disconnected from the impedance control element.

8. An ignition system comprising a spark gap, an oscillation generator including an electron discharge device, and an Oudin resonator, the primary circuit of the resonator operating as a means to determine the frequency of the oscillations produced, and the spark gap being included in the secondary circuit of the resonator.

9. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electron discharge device and frequency determining means which also functions as the primary of an Oudin resonator, an impedance control element for the device, a potential source adapted to be connected to the impedance control element to block the device, and a spark circuit, the secondary of said resonator constituting said spark circuit and having means to connect the circuit to the spark plugs in proper sequence and to each plug during a non-blocked period of the device.

10. A method of operating an electric discharge device having input and output circuits associated therewith comprising supplying an alternating current to the output circuit of the device, and applying a potential to the input circuit to render the device inoperative at selected intervals.

11. A method of operating an electric discharge device having a cathode, an anode and an impedance control element which comprises supplying a low voltage alternating current to the plate circuit thereof, and applying a potential to the impedance control element to render the device inoperative at predetermined intervals.

12. A method of operating a thermionic device having a cathode, an anode and an impedance control element which comprises supplying a low voltage alternating current to the anode circuit thereof and recurrently applying a blocking potential to the im-

pedance control element for a period greater than a half cycle of said low voltage alternating current.

13. Means for operating an electron discharge device comprising means to supply alternating current to the output circuit of the device, and means to supply the input circuit of the device with a potential adapted to render the device inoperative at selected intervals.

14. Means for operating an electron discharge device having a cathode, an anode and an impedance control element comprising a low tension alternating current source connected to the cathode and anode, and means to apply a potential to the impedance control element to render the device inoperative at selected intervals.

15. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electron discharge device and means to determine the frequency of the oscillations produced, an impedance control element for the device, means to apply intermittently a blocking potential to the impedance control element, a spark circuit in resonance with the frequency determining means, and means to connect said circuit to the spark plugs in proper sequence and to each plug substantially during a non-blocked period of the device.

16. Means for operating an oscillator comprising an electron discharge device having an input circuit, an output circuit, a coupling connecting said circuits, a low voltage alternating current source of supply for the output circuit, and means for neutralizing the regenerative effect due to said coupling during predetermined intervals.

17. An ignition system for a multiple cylinder engine comprising a generator of sustained oscillations including means selectively to determine the frequency of the oscillations produced, means to render the generator inoperative at selected intervals, a spark circuit connected to and in resonance with the frequency determining means, and means to connect the spark circuit to the spark plugs in proper sequence and to each plug during an operative period of the generator.

18. An ignition system for a multiple cylinder engine comprising an oscillation generator, means to cyclically limit the generation of oscillations to definite time intervals, a spark circuit, and means to connect said circuit to the spark plugs in succession substantially in synchronism with the generating intervals.

19. An ignition system for a multiple cylinder engine comprising an oscillation generator including means to determine selectively the frequency of the oscillations produced, means to limit cyclically the gen-

eration of oscillations to definite time intervals, a spark circuit in resonance with the frequency determining means, and means to connect said circuit to the spark plugs in succession substantially in synchronism with the generating intervals.

20. An ignition system for internal combustion engines, comprising a plurality of spark plug circuits forming part of the ignition circuit, electric discharge means associated with said spark plug circuits, said discharge means having a plurality of electrodes, and means for controlling the flow of electrical energy between the electrodes of said device and to a plug circuit for practically the duration of the ignition interval.

21. An ignition system for internal combustion engines, comprising a plurality of spark plug circuits forming part of the ignition circuits, electric discharge means associated with said spark plug circuits, said discharge means having a plurality of electrodes, means for controlling the flow of electrical energy between the electrodes of said discharge means and to a plug circuit for practically the duration of the ignition interval, and connections between spark plug circuit and the circuit of the discharge means whereby the ignition current is caused to flow through the plug circuit.

22. An ignition distributing system for internal combustion engines comprising a plurality of spark plug circuits forming part of the ignition system, electric discharge means associated with said plug circuits, said discharge means having a plurality of electrodes, and means for controlling the flow of space current between the electrodes of said discharge means so that ignition current is supplied to a plug circuit for practically the duration of the ignition interval.

23. An ignition distributing system for internal combustion engines, comprising a plurality of spark plug circuits, electric discharge means provided with a plurality of electrodes and associated with said plug circuits, means associated with each plug circuit and the circuits of the discharge means for controlling the flow of space current through the discharge means whereby ignition current is supplied to a plug circuit during practically the duration of an ignition interval.

24. An ignition distributing system for internal combustion engines, comprising a plurality of spark plug circuits, electric discharge means provided with a plurality of electrodes and associated with said plug circuits, means associated with the plug circuits and the circuits of the discharge means for controlling the flow of space current through the discharge means whereby ignition current is supplied to the plug circuits

in proper sequence and to each plug circuit for practically the duration of an ignition interval.

25. An ignition distributing system for internal combustion engines, comprising a plurality of spark plug circuits, electric discharge means provided with a plurality of electrodes and associated with said plug circuits, means associated with each plug circuit and the circuits of the discharge means for preventing and permitting the flow of space current through the discharge means to control the discharge of a spark.

26. An ignition distributing system for internal combustion engines, comprising a plurality of spark plug circuits, each including a spark gap, electric discharge means provided with a plurality of electrodes and associated with said spark circuits, means associated with said spark circuits and the circuits of said discharge means for preventing and permitting the flow of space current through the discharge means to control the discharge of sparks across said gaps in proper sequence and across each gap during the proper interval.

27. In an ignition distributing system for internal combustion engines, spark circuits including plugs each having sparking electrodes, electric discharge means provided with a plurality of electrodes associated with said plug circuits, means associated with the circuits of the discharge means and each plug circuit for permitting and preventing the flow of space current between the electrodes of said discharge means to control the passage of current across the sparking electrodes.

28. In an ignition distributing system for internal combustion engines, spark circuits including plugs each having sparking electrodes, electric discharge means provided with a plurality of electrodes associated with said plug circuits, means associated with the circuits of the discharge means and each plug circuit for permitting and preventing the flow of space current between the electrodes of said discharge means to control the passage of current through the plug circuits in proper sequence and across the sparking electrodes of each plug at selected intervals.

29. An ignition distributing system for internal combustion engines comprising a plurality of spark plug circuits forming part of the ignition circuits, electric discharge means having an anode, a cathode and a grid, circuits including said discharge means, means for associating the circuits of said discharge means with said plug circuits, and means for rendering the discharge means operative during selected intervals.

30. An ignition distributing system for internal combustion engines comprising a plurality of spark plug circuits, forming part

of the ignition circuits, electric discharge means having an anode, a cathode and a grid, circuits including said discharge means, means for associating the circuits of said discharge means with said plug circuits, and means for controlling the action of said grid to prevent and permit the flow of space current between the anode and cathode at selected intervals.

31. An ignition distributing system for internal combustion engines comprising a plurality of spark plug circuits, electric discharge means having control means between anode and cathode means, circuits including said discharge means as well as plug circuits and means adapted to control the action of said control means.

32. An ignition distributing system for internal combustion engines comprising a plurality of spark plug circuits, electric discharge means and circuits containing said discharge means, connections between said plug circuits and the circuits of said discharge means, said discharge means having control means between anode and cathode means, and means for controlling the time of ignition by differing variations of potentials applied to the control means.

33. In an ignition distributing system for internal combustion engines, an ignition circuit, a thermionic tube for controlling said ignition circuit and a control circuit for said thermionic tube independent of said ignition circuit.

34. In an ignition distributing system for internal combustion engines, a plurality of ignition devices, energizing circuits for said ignition devices and distribution control means for said energizing circuits exclusive of said energizing circuits.

35. An ignition distributing system for internal combustion engines comprising a plurality of ignition devices and circuits therefor, thermionic discharge means for said ignition circuits and control means including a controller for said discharge means and distributing circuits.

36. An ignition distributing system for internal combustion engines comprising a plurality of ignition circuits, a source of energy therefor, thermionic discharge means for controlling said ignition circuits, control means for said discharge means, a source of potential for charging said control means, and means interposed between said source of potential and said control means for regulating the potential supplied thereto.

37. An ignition system for a multiple cylinder engine comprising an oscillation generator including an electric discharge device, an impedance control element for said device, an ignition circuit including spark plugs coupled to said generator, means independent of the ignition circuit for intermittently applying a blocking potential to

the impedance control element of said device, and means to connect said circuit to the spark plugs in proper sequence and to each plug substantially during a non-blocked period of the device.

38. An ignition system for internal combustion engines comprising an ignition circuit, an oscillator comprising an electric discharge device having an input circuit, an output circuit, a coupling connecting said circuits, and a control circuit independent of said ignition circuit for neutralizing the regenerative effect due to said coupling during predetermined intervals.

39. An ignition system for internal combustion engines comprising in combination, a sparking plug, a thermionic tube adapted to generate electric oscillations, means for so controlling said tube that its oscillations are available practically only during the ignition interval and means utilizing said oscillations for producing the necessary sparking voltage.

40. An ignition system for internal combustion engines, comprising in combination, a sparking plug, a thermionic triode tube adapted to generate electric oscillations, means for so controlling the potential of the tube control element that the thermionic current is allowed to pass only during the ignition interval and means utilizing said oscillations for producing the necessary sparking voltage.

41. An ignition system for internal combustion engines, comprising in combination, a sparking plug, a thermionic triode tube and generator circuit therefor arranged to generate electric oscillations, a commutator comprising a wipe contact and a series of complementary contacts connected to the tube control element and to the generator circuit in such a way that only during the ignition interval a potential is applied to the control element of the tube allowing the thermionic current to pass, and means utilizing said oscillations for producing the necessary sparking voltage substantially as described.

42. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic tube adapted to generate electric oscillations, means for so controlling said tube that its oscillations are available practically only during the ignition intervals, means utilizing said oscillations for producing the necessary sparking voltage, and a distributor adapted to transmit the sparking voltage to said sparking plug or plugs.

43. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic triode tube and generator circuit therefor arranged to generate electric oscillations, means for so controlling the potential of the tube con-

trol element that the thermionic current is allowed to pass only during the ignition intervals, means utilizing said oscillations for producing the necessary sparking voltage, and a distributor adapted to transmit the sparking voltage to said sparking plug or plugs.

44. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic triode tube and generator circuit therefor arranged to generate electric oscillations, a commutator comprising a wipe contact and a system of complementary contacts connected to the tube control element and to the generator circuit in such a way that only during the ignition intervals a potential is applied to the control element allowing the thermionic current to pass, means utilizing said oscillations for producing the necessary sparking voltage, and a distributor adapted to transmit the sparking voltage to said sparking plug or plugs, substantially as described.

45. An ignition system comprising ignition spark terminals, an air tight vessel containing electrodes associated with suitable circuits for controlling the generation of oscillatory current, means connecting said vessel and said terminals for providing sparks under the influence of said current, and a single source of energy supply for the system, said source supplying energizing potentials to said electrodes.

46. An ignition system comprising spark terminals, an air tight vessel enclosing a space discharge path associated with suitable circuits, means connecting said circuits to said spark terminals, and a source for supplying energy to said path for controlling the energy in said path to cause the generation of oscillatory current and for controlling the supply of oscillatory current to said spark terminals.

47. An ignition system comprising spark terminals, an air tight vessel enclosing a space discharge path associated with suitable circuits, means for connecting said circuits to said spark terminals, and a source for supplying energy to said path for controlling the energy in said path to cause the production of oscillatory current and for determining a definite interval during which oscillatory current is supplied to said spark terminals.

48. An ignition system comprising a plurality of ignition devices, an air tight vessel enclosing a space discharge path associated with suitable circuits, means for connecting said circuits to said ignition devices successively, and a source for supplying energy to said space path, for controlling the energy in said path to cause the generation of oscillatory current, and for controlling the distribution of oscillatory current to said ignition devices in sequence.

49. An ignition system comprising a plurality of spark plugs, an air tight vessel containing electrodes associated with suitable circuits for controlling the generation
5 of oscillatory current, means for cyclically connecting said circuits to said spark plugs, and a single source of energy for the system, said source supplying energizing potentials to said electrodes whereby oscillatory current is produced only during the
10 intervals when said circuits are connected to said plugs.

50. Means for producing high voltage electric impulses comprising a three electrode space discharge device, a large inductance and a source of current connected in series with the space path of said device, and means for impressing a high negative
15 potential upon the control element of said device.

51. An ignition system comprising spark terminals, a space discharge oscillator, means for connecting said oscillator to said
20 terminals, and a single source for supplying energy to said oscillator.

52. An ignition system comprising a plurality of ignition devices, a space discharge oscillator, means for connecting said oscillator to said devices in succession, and a single
25 source for energizing and controlling said oscillator to generate oscillatory current only when said oscillator is connected to said devices.

53. An ignition system comprising ignition spark terminals, and air tight vessel containing electrodes supplied with energy and associated with suitable circuits to control the generation of oscillatory current, and means for connecting said circuits and
30 said terminals for providing sparks under the influence of said current.

54. In an ignition distributing system for internal combustion engines, an ignition circuit, a tube including an electron emitter
35 and a circuit associated with said tube to control the supply of current to said ignition circuit.

55. An ignition system comprising spark terminals, an air tight vessel enclosing a
40 space discharge path supplied with energy and associated with suitable circuits, means

for connecting said circuits to said spark terminals, and means for limiting the flow of energy in said path to substantially the period when said circuits and said terminals
45 are connected.

56. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic tube adapted to generate electric oscillations, and
50 means utilizing said oscillations for producing the necessary sparking voltage.

57. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic tube adapted to generate electric sustained oscillations, means utilizing said oscillations for
55 producing the necessary sparking voltage, and a distributor adapted to transmit the sparking voltage to said sparking plug or plugs at the proper ignition intervals, as set forth.

58. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, a thermionic triode tube and generator circuit therefor arranged to generate electric oscillations, a commutator connected to the tube control
60 element and to the generator circuit in such a way that only during the ignition intervals a potential is applied to the control element allowing the thermionic current to pass, means utilizing said oscillations for producing the necessary sparking voltage, and a distributor adapted to transmit the
65 sparking voltage to said sparking plug or plugs and having contact members, the duration of engagement of which is longer than that between said wipe contact and the fixed contact of said control commutator, substantially as described.

59. An ignition system for internal combustion engines, comprising in combination, a sparking plug or plugs, means for generating sustained high frequency electric
70 oscillations, and means utilizing said oscillations for producing the necessary sparking voltage.

In witness whereof, I hereunto subscribe my name this 9th day of October A. D.,
75 1920.

H. CLYDE SNOOK.