July 12, 1949. M. T. WINTSCH 2,476,128

IGNITION SYSTEM

Filed Sept. 11, 1945

4 Sheets-Sheet 1

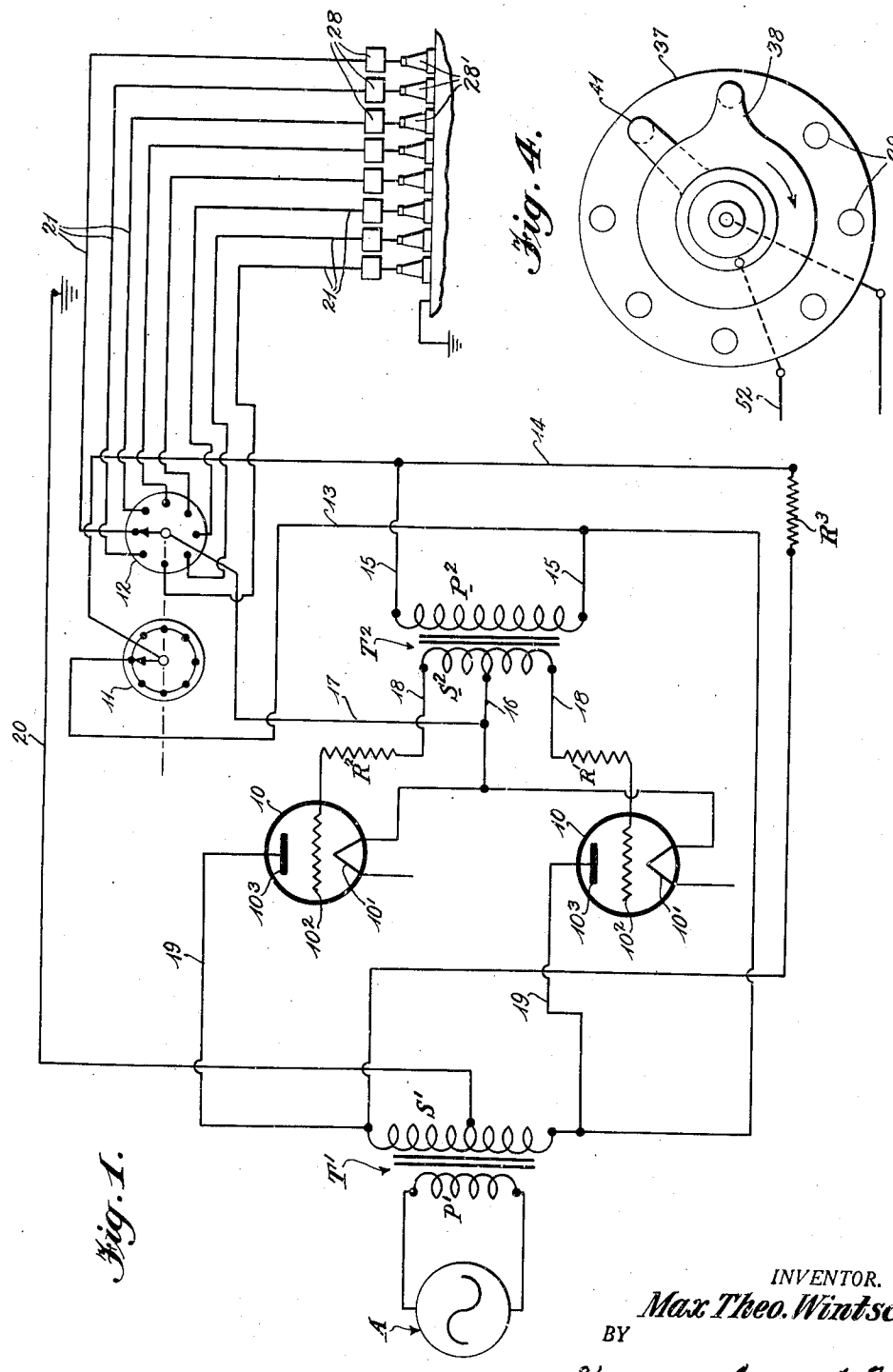


Fig. 1.

Fig. 4.

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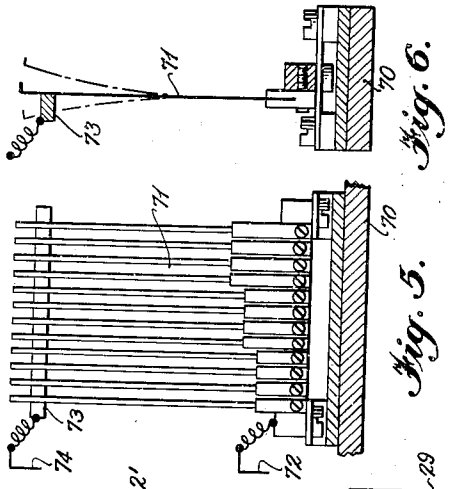


Fig. 6.

Fig. 5.

Fig. 2.

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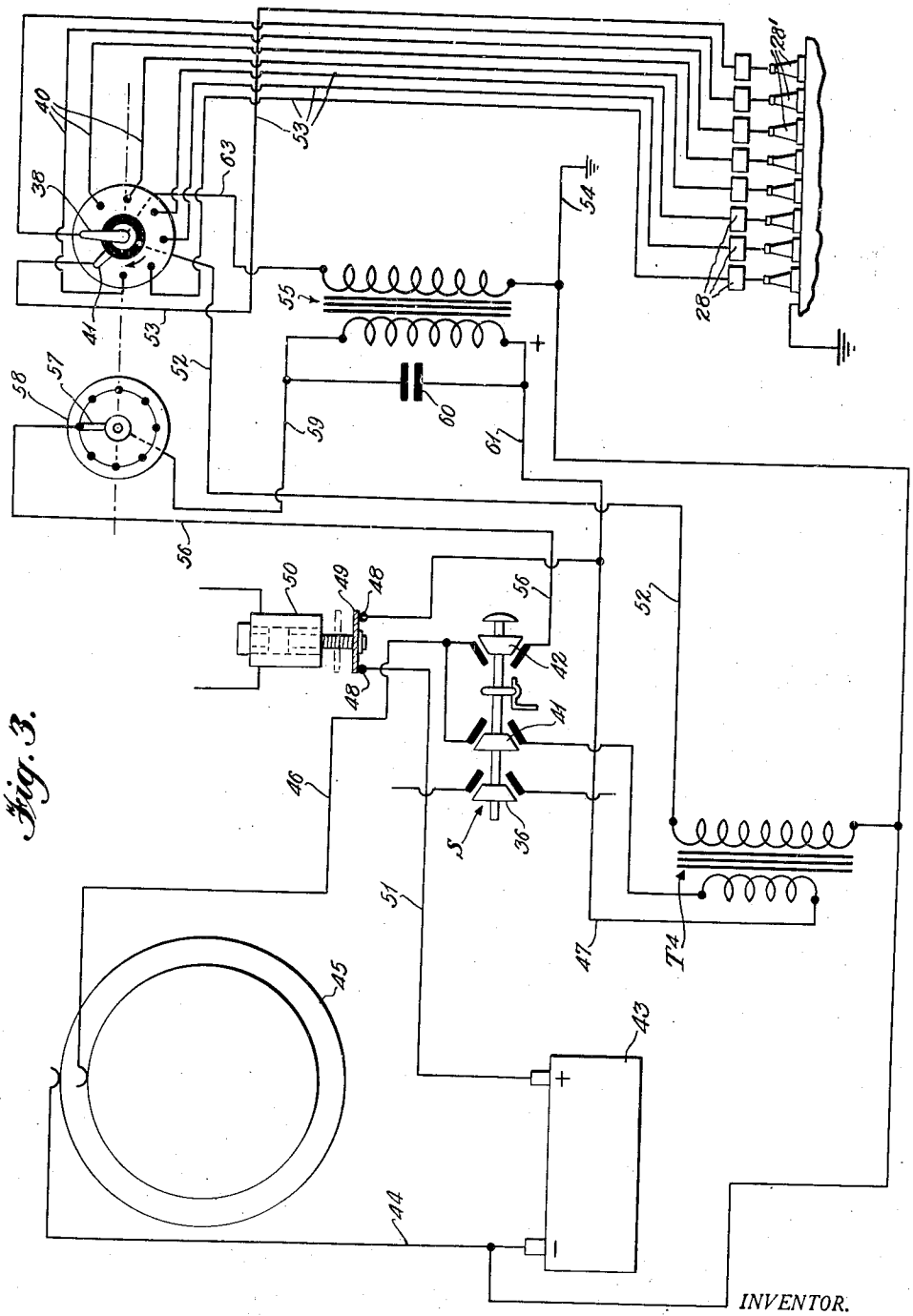


Fig. 3.

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IGNITION SYSTEM

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4 Sheets-Sheet 4

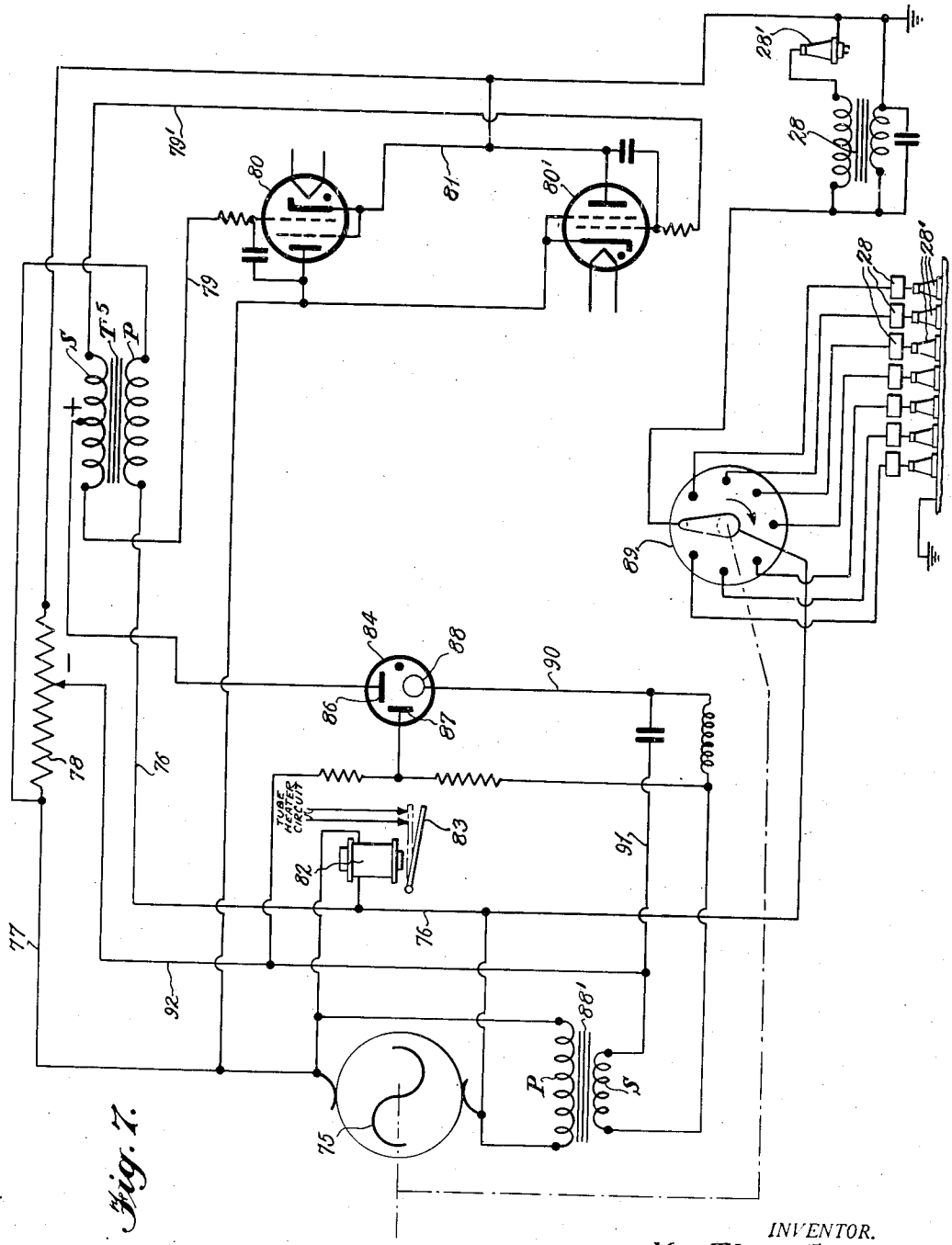


Fig. 7.

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UNITED STATES PATENT OFFICE

2,476,128

IGNITION SYSTEM

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Application September 11, 1945, Serial No. 615,665

7 Claims. (Cl. 315—213)

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This invention relates to ignition systems for high speed internal combustion engines, and is a continuation-in-part of my application Serial No. 496,337, filed July 27, 1943 now abandoned.

In high speed internal combustion engines close timing of the spark is a very important feature, and as the speed of such engines is stepped up it becomes more and more necessary that the timing be made more nearly instantaneous in order that the engine may operate at highest efficiency. Such nearly instantaneous timing is not possible with the present day systems employing high potential current and rotary interrupters because of the burning of the interrupter points and corrosion of terminals which set up high resistance in the ignition circuit and, also, because of the current losses in high potential systems due to insulation breakdown and other failures characteristic of high potential use.

An important object of the present invention is to provide novel forms of low potential ignition systems which shall be especially adapted for use with airplane engines.

Another object of the invention is the provision of a novel ignition circuit arrangement whereby the use of breaker points is avoided and the sparking is substantially instantaneous, being timed to within $^{10}/_{1,000,000}$ of a second, as contrasted with present systems in which the spark is timed to about $^{10}/_{10,000}$ of a second.

Another object of the present invention is to provide an ignition system of relatively simple design in which thermionic tubes are employed in association with a rotary timing device actuated synchronously with a distributor for delivering rectified current from an alternator or other source of current to individual ignition coils associated with the spark plugs.

A further object is to provide an ignition system using a low potential current up to the spark plugs of the engine with individual voltage step-up means at each spark plug, whereby there is eliminated all possibility of burned contacts, which are a source of much trouble in present systems, and to avoid complete engine failure by failure of the ignition coil where a single coil is used for all plugs.

A further object is to provide in an ignition system of the character designated, a novel battery operated voltage booster system which furnishes the necessary current to the engine spark plugs when the engine crank shaft is rotating too slowly to turn the alternator rotor at a speed which will induce sufficient voltage to fire the plugs.

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Another object is to provide an ignition system in which all rotary contacts, with the exception of the distributor, are replaced by electron tubes, thus substantially eliminating all moving parts from the system.

These and other objects of the present invention will become evident from the following description taken in connection with the accompanying drawings, it being understood that minor changes are contemplated and may be made in the invention as described and illustrated so long as such changes are within the scope of the appended claims.

In the drawings:

Figure 1 illustrates one embodiment of the present invention in which full wave rectified ignition current is supplied to the engine spark plugs.

Figure 2 illustrates an application of the invention in which combined alternating and direct current control is had of the full wave alternating current supplied to the engine ignition circuits.

Figure 3 illustrates a battery operated "booster" system which may be coupled with the system of Figure 2 for supplying necessary current until the supply alternator is running at proper current supplying speed, and to "take-over" in case of failure of the alternator system.

Figure 4 is a detail view of the combined distributor and booster contactor used in the system of Figure 3.

Figure 5 shows in front elevation, and

Figure 6 in side elevation, a vibrating reed type of converter for alternative use in the system of Figure 3.

Figure 7 is a diagram of a system in which the mechanical timing device of Figures 1, 2 and 3 is replaced by a thermionic tube.

Referring now more particularly to the drawings and, first, to Figure 1 thereof, there is illustrated as the preferred current source a variable reluctance current supply alternator "A" such as shown in my prior Patent No. 2,255,092, granted September 9, 1941, coupled, as shown, with a transformer T'. Preferably the alternator A is driven at constant speed by the internal combustion engine to be supplied with ignition, the drive being accomplished by the use of any suitable type of transmission. Connected with this alternating current supply means are two thermionic tubes 10 which, under the control of a timing device 11, take the place of the mechanically operated interrupter ordinarily used in present engine ignition systems.

While any suitable type of thermionic tube may be used, preference is had for the "Westinghouse Thyratron" tube, of the inert gas type or a Thyratron mercury vapor type tube. Due to the presence of gas in the tubes positive ions are formed when the discharge occurs. The ions neutralize the negative space charge of electrons around the cathode with the result that comparatively large currents flow readily through the anode circuit. The positive ions in the vicinity of the grid prevent its regaining control until the anode potential becomes zero or is specifically controlled. Thus the tube affords a high speed lock-in control device with a relatively low voltage drop and hence a low power loss.

In this circuit tubes 10—10 are connected, as before stated, directly to the alternating current supply means and under this arrangement the grid can regain control with each negative half cycle on the anode, and the plate current may be started at any point on the positive voltage wave during the next half cycle. Definite control of the magnitude and duration of the anode current is obtained by using suitable grid voltages.

In the present improved system medium-high voltage and relatively low amperage are supplied by the alternator to the spark plugs. Circuits with these voltage and current values can readily be insulated effectively.

The timing device 11 is of a mechanical design similar to that of the standard distributor in presently used ignition systems. The timing device and the distributor 12 may both be in the same housing and are mounted on the distributor shaft. The timing device contains as many stationary contacts as there are spark plugs and in the present illustration eight plugs are employed. The stationary contacts are raised about one-eight of an inch above the body of the device and these contacts are all electrically connected as indicated in the drawing. As a consequence of this arrangement the rotating contact finger engages only one of the stationary contacts at a time and there is a timed break while the finger is moving from one contact to another. If the rotating contactor 12 is mechanically connected to the distributor shaft and the plane's engine in correct relation, it functions while rotating to make direct contact with one of the stationary contacts of the timing device at the exact moment when the respective spark plug is to be fired. Since the voltage and amperage of the grid circuit are low (about 50 volts A. C. and 0.5 milliampere), there will be no burning of the contact points.

The timing device 11 is connected across the secondary S^1 of the plate transformer T' by conductors 13 and 14, and across the primary winding P^2 of the grid transformer T^2, by the conductors 15. From the center of the secondary S^2 of the grid transformer T^2 a conductor 16 connects with the tube cathodes 10'—10' and a conductor 17 leads to the center terminal of the distributor 12. The ends of the secondary S^2 of the transformer T^2 are connected by conductors 18, and suitable resistance R' and R^2 with the tube grids 10^2—10^2 while the plates 10^3—10^3 of the tubes are connected by conductors 19—19 each with an end of the secondary S^1 of the plate transformer T'. The center of the secondary S^1 is connected to the ground side of the engine spark plugs by a conductor 20. The conductors 21 each lead from a stationary contact of the distributor 12 to a spark plug 28' through an individual ignition coil 28 indicated diagrammatically and hereinafter referred to in the description of Figure 2, and shown in detail therein.

The operation of the circuit of Figure 1 is as follows:

With the engine turning over so as to drive the timing device 11 and the distributor 12, and with the alternator A being driven, the closing of a timing device contact shunts the primary P^2 of transformer T^2, bringing the grids 10^2 of the tubes 10 to positive cathode potential. This renders the tubes conducting until the contact is opened. The resistor R^3 in circuit with the rotor of the timing device prevents the short circuiting of the transformer T^2. In an alternative connection the contacts of the timing device 11 can take the place of the resistor R^3 so that the tubes will be conducting when these contacts are open and will not pass current when they are closed.

With the tubes in conducting condition ignition current will flow through the spark plugs which are in circuit as determined by the distributor 12 which functions in the usual manner. The timing device 11 therefore serves only to render these tubes 10 alternately conducting and non-conducting at proper intervals to supply ignition current to the spark plugs at those intervals. The usual mechanical timer is thus eliminated and instantaneous and invariable results attained by simple means.

In Figure 2, which shows a modified form of the invention, better control is had of the Thyratron tubes by combining alternating and direct current for application to their grids and in controlling only the direct current. This may be properly designated voltage amplitude control of the rectifiers and results in greater stability, accuracy and speed of control. Furthermore, a novel arrangement of two tubes to pass the entire alternating current wave is illustrated, and it eliminates the need for a transformer between the source and the tubes.

Referring now to Figure 2 of the drawings, the source of supply of alternating current is again preferred to be the variable reluctance device A' and this is connected through conductors 22 and 22' to a pair of suitable Thyratrons 23 and 23' connected plate to filament as shown. The sources of filament excitation are not illustrated, but it will be appreciated that they can be of any desired type with the requisite that they be independent because of the manner of connection. The conductor 22 connects directly to conductor 24 between the plate of tube 23 and the filament of tube 23' but the conductor 22' leads to the rotor of the distributor 12' and the various leads 21' from the distributor contacts each extend to a separate spark coil 28 including a primary 28P, shunted by a condenser 28C, and a secondary 28S. Preferably these coils have a step-up ratio of about 45 to 1, and each secondary is connected in series with a spark plug 28' in the usual manner.

Attention should be directed to the special form of ignition coil 28 which actuates the spark plug 28'. The primary 28P of this coil is shunted by a condenser 28C, as shown, in order to change the characteristics of the sparks at the plug. They are converted from the usual succession of one-way sparks to a stream of alternately reversibly directed sparks to insure even wear of the plug electrodes. Furthermore the condenser size may be selected to resonate with the primary current to thus give hotter sparks.

It will be seen from this arrangement that current will be supplied to the proper ignition coil 28 in accordance with the position of the distrib-

utor rotor. Timing of the spark to each coil is effected by starting and stopping the full wave A. C. conduction effected by the Thyratrons, by control of the potential on the grids of these tubes from the timing device which may include a sensitive speed responsive governor of known type.

The grids are continuously energized with alternating current, preferably 90° out of phase with that supplied to the anodes of the tubes, by means of grid transformer **30**, the primary P of which is connected by conductors **31** and **31'** directly across the source A'. Each end of the split secondary S of transformer **30** is connected by a conductor **32—32'**, through an appropriate resistance to one of the grids of the two rectifier tubes. As shown, a shunt condenser is arranged between each grid and its anode. This alternating current applied to the grids is such that it prevents operation of the tubes but maintains them in a threshold condition so that they can be triggered into action by a slight increase of the grid voltage resulting from superimposing direct current onto the alternating being applied to them. This triggering times the initiation of the rectification under the action of the timing device **11'** constructed as described in connection with Figure 1 and in control of current from battery **33** of about 5 volts. It will be understood, of course, that the source A', the timing device **11'** and the distributor **12'** are driven in unison from the engine. Current from the positive side of the battery flows through conductor **33'** to the center of a resistor **34** one end of which is connected to conductor **31** leading between conductor **22**, from the source A', and the right hand end of the primary P of transformer **30**. The opposite end of resistor **34** is connected by wire **35** to wire **29**. The negative side of the battery is connected by wire **36** to the rotor of the timing device **11'**. The several contacts of the timing device which are all electrically connected together are connected by wire **36'** to the center tap on the secondary S of transformer **30**.

This connection just described places the resistor **34** across the Thyratrons to provide, by means of its center tap, a floating ground for the positive side of the battery, the opposite or negative terminal of which is applied to the center tap of the secondary of the grid transformer each time a contact is engaged by the rotor of the timing device, thus applying the proper negative bias to the grid of the Thyratron when its plate is positive, at the exact time when a spark is to be fired, thus rendering the tube conductive to the anode-cathode current. By having two Thyratrons connected as shown, firing is instantaneous, in spite of the direction of flow of alternating current from the source, at the exact instant of closing the circuit at the timing device. Furthermore, a full cycle of current is delivered to each individual spark coil since the grid of each tube will be energized permitting it to operate at least for one cycle or as long as the grid remains properly biased. As soon as the proper bias is removed from the grid the tubes are quenched but remain in active threshold condition for the next spark.

In an experimental form of the apparatus the anode-cathode current was delivered at a potential of 350 volts at 0.3 amperes and at a frequency of 360 cycles. This current flowing through the primary winding of the spark coil **28** was stepped up to about 16,000 volts, sufficient to ignite the gas in the engine cylinder.

In the system just described ignition sparks cannot be produced until the rotor of alternator A' rotates at a predetermined speed, at which speed the change in flux linkage is sufficiently high to induce the required primary current and the resultant high tension output. Conditions at times make it impossible to rotate the engine crank-shaft fast enough to produce the "coming-in" speed of the alternator. This condition is taken care of in the present invention by the provision of a battery operated "booster" system which is illustrated in Figures 3 and 4.

In this "booster" system, which is also designed to provide an emergency ignition system in case of failure, for any cause, of the system of Figure 2, with which it is designed to operate, there is employed in the place of the single contact distributor of Figure 3; a distributor **37**, Figure 4, having a standard rotor finger **38** and spark plug contacts **39** connected each with an individual ignition coil of a spark plug and a "booster" rotor finger **41** which trails the standard rotor **38**.

In the operation of the system of Figure 3, when the rotational speed of the engine is too low to provide for sufficient "come-in" voltage by the supply alternator, as A' of Figure 2, the system of Figure 3 is put into operation by the operator by actuation of the control switch unit S (Figure 3).

This switch unit comprises the three switches designated **36**, **41** and **42**. The switch **36** controls the cathode circuits of the tubes **23** of the system of Figure 2. Switch **41** is the voltage booster switch, and **42** is the "emergency" switch.

In actuating the unit S, the voltage booster switch **41** is closed along with switch **36** when the handle is moved to the right. Thus the unit S is set in "booster position." With switch **41** closed pulsating direct current, supplied by the battery **43**, or by the generator, will flow through the primary circuit of the step-up transformer T^4 by way of the positive pole of the source; through conductor **51**, contacts **48** and armature of relay **50** in de-energized position; line **47**; primary of transformer T^4; contacts of switch **41**; conductor **46**; windings of converter **45**, and conductor **44** to the negative side of the source.

The secondary side of the booster circuit includes one side of the secondary winding of the transformer T^4; wire **52**; the rotating "booster" finger **41**; conductor **53**; the primary and secondary windings of the respective individual spark plug ignition coil and the condenser and spark plug shown in Figure 2, and indicated by reference character **28**. Return flow of current is by way of conductor **54**. Sparking will occur at the respective spark plugs by current flowing thereto through conductors **53**, as the respective contacts are closed by the booster finger **41**, in the distributor. As soon as the regular ignition system provides sufficiently high voltage with increasing engine speed, and conditions are right, the armature **49** of the relay **50** will be picked up and the primary booster circuit will be interrupted.

The relay **50** forms a part of the system of Figure 2, as shown.

The relay **50** has a time delay feature in its pick-up action. That is, after the relay coil becomes energized from the current of full voltage from the Thyratron standard ignition system, the armature **49** will not be picked-up to full "up" position immediately, but about twelve seconds will elapse before the contacts **48** are

opened. The cathodes of the tubes must always reach proper temperature before current is drawn from them. Accordingly while the switch unit S is in "booster" position, in which switch 41 is closed, the switch 36 will also be closed to complete the operating circuit for the tube filaments, and thereby current is supplied to the filaments by the booster system for at least ten seconds, before full voltage is supplied to the anode-cathode circuit of the tubes, by the Thyratron system. Current to heat the filaments may be obtained from the pulsating direct current supply by tapping the secondary winding of the step-up transformer and use of the proper resistors for the 2.5 volts required for the purpose.

In the event of failure of the standard ignition system of Figure 2, during flight of the plane in which it is used, the emergency system may be put into operation as follows.

The operator will actuate the switch unit S to the left to close the "emergency" switch 42. This will close the supply circuit for the primary of the high tension ignition coil 55. This circuit leads from the positive pole of battery 43; conductor 51; contacts 48 and armature 49 of relay 50; conductor 61; primary winding of coil 55; wire 59; contact finger 57 of emergency system timer 58; wire 56; contacts 42 of switch S; wire 46; windings of converter 45; and wire 44 to the negative pole of the source.

The high voltage secondary circuit includes the secondary winding of the coil 55; wire 63; the contact finger 38; and respective contacts of distributor 37; the respective conductors 53 running to the primary windings of the respective individual ignition coils of the plugs; conductor 54, and the secondary of coil 55.

In the operation of the "booster-emergency system" the booster rotor finger always trails the main distributor finger to provide for a retarded spark time for starting the engine. When the distributor main finger is in position to fire No. 1 cylinder, for example, the booster rotor finger is in position to fire the preceding cylinder of the firing order of the engine, whose piston has already started down on its power stroke.

Instead of having a cam operated interrupter as is customary in conventional ignition systems, the present systems use a variable reluctance converter and rotating timing devices to change the straight direct current into pulsating direct current and the timing of the sparks is done by such rotating devices.

Figures 5 and 6 illustrate a substitute for the converter 45 of Figure 3. This converter changes the direct current from the battery 43 to alternating whereas the device of Figures 5 and 6 converts it to pulsating direct current which is equally as effective in the operation of the system. The device is constructed substantially like the Frahm vibrating reed tachometer in that it includes a base 50 which may be mounted on the engine body to partake of its vibrations. This base supports a plurality of reeds 71 of varying lengths each capable of vibrating violently when in substantial resonance with the speed of the engine.

All of the reeds are connected, at the base, to a conductor 72, and near the upper ends of the reeds, where the vibration amplitude is greatest, a conductor bar 73 is spaced behind them and connected to a conductor 74. The conductors 72 and 74 are adapted to place the instrument in position in the circuit of Figure 3 in lieu of the converter device 45 therein. It will be seen that the reeds which are vibrating in resonance will periodically engage the bar 73 to close the circuit as many times a second as the frequency of vibration. A number of reeds for each frequency are illustrated to insure ability to handle an adequate current. It is believed that but three sets of reeds will be necessary, one to take care of low engine speeds, one medium and one set for high speeds. In substituting the vibrating reed device for the converter 45, the terminals 72 and 74 merely connect to the line wires 44 and 46 of Figure 3 with the converter 45 removed. With this substitution the operation will be similar to that just described with respect to the circuit of Figure 3. The sole difference from a functional standpoint will be that the current supply to the system will be pulsating instead of alternating.

The embodiments of the invention so far described include in addition to the usual distributor a rotary timing device. Figure 7 shows a preferred system in which the rotary timing device is wholly replaced by electronic means in the form of a single timing tube which reduces still further the moving parts required in systems embodying the invention.

The simplified construction shown in Figure 7 of the drawing in general corresponds to the circuit shown in Figure 2, but with the mechanical timing device and the battery 33 replaced by the tube 84. In the system of Figure 7 a rotary alternator is preferably used as before as a source of alternating current, and it is employed in conjunction with two reversely connected tetrodes and the usual rotary distributor which supplies current to the engine spark plugs through the individual transformers as described above.

The thermionic tube which is used to replace the timing device 11 and battery 33 of Figure 2 is a triode of the Thyratron type. The tube is gas filled and includes a starter anode for initiating the anode-cathode current flow. The triode is supplied with the necessary operating current from a step-down transformer fed directly from the alternator while the tetrodes are connected directly to the alternating current sources as in Figure 2.

In examining the circuit in detail, reference may be had to Figure 7 where the modified circuit is shown.

In Figure 7 the alternator which supplies current for the system is designated 75, and it supplies current through line wires 76 and 77 to the primary P of transformer T5. The secondary S of this transformer supplies biasing potential to the grids of the two tetrodes 80 and 80' through connections 79 and 79', one at each end of said secondary. The connections 79 and 79' includes suitable current limiting resistances. The heater circuits of the tubes are controlled by a relay 82 connected across the output terminals of the alternator 75. When the armature 83 of the relay is moved to the dotted line position, that is, when the alternator is started and has built up sufficient voltage to operate this relay, it closes the heater circuit of the two tubes 80 and 80', thus putting the system in condition for operation. When the alternator stops or its generated voltage drops too low, the relay opens to de-energize the heaters of tubes 80 and 80'.

The triode 84 is of the cold cathode type and, therefore, need not be energized in this manner. The mid-point in the secondary winding S of transformer T5 is connected to the anode 86 of

the triode 84. The triode 84 has a cathode 88 and a starting anode 87. All of its current is supplied from the alternator 75 through the secondary S of a transformer 88', the primary of which is directly connected across the output terminals of the alternator. The anode-cathode circuit of the tube 84 leads from a center tap in the secondary S, transformer T5 to the anode 86 of the tube, cathode 88 of that tube, and wires 90, 91, and 92 to the negative tap on resistor 78. This resistor 78 corresponds to the resistor 34 shown in Figure 2.

It will be understood that the gas triode 84 is so constructed that a glow discharge can be initiated with a very small amount of energy supplied to the starter anode circuit to close the anode-cathode circuit through the tube. The tube ceases to discharge immediately when the starting potential is disconnected. In one installation the starter anode voltage had a minimum peak value of 55 volts. Due to its manner of connection the current in the anode-cathode circuit of tube 84 flows in synchronism with the current supplied by the alternator, and since the alternator is synchronized with the engine, being driven by it, it supplies correctly timed current impulses having a frequency which corresponds to the number of sparks required to fire the engine. The anode-cathode current flow through the timing tube is, therefore, controlled by the action of the starter anode. Every time that the starter anode 87 of tube 84 is positive, and the anode of one of the tubes 80 and 80' is also positive, the circuit through that tube from anode to cathode is closed, and the discharge in the particular tube is initiated. As in the system already described in Figure 2, tubes 80 and 80' are maintained in a threshold condition by alternating current being applied to their grids from the secondary of transformer T5. However, they are triggered into action by a slight increase of voltage resulting from superimposing upon them current from the tube 84.

It will be evident from the description which has just been given that the delivery of firing voltages to the various spark plugs is determined by the position of the distributor arm associated with the distributor 89. As the alternator rotates in synchronism with the engine which drives it, the tubes 80 and 80' are periodically triggered into action and the tube 84 determines by its firing impulses when firing voltages are to be applied to the circuits of the motor under control. Consequently, the tube 84 serves purely a timing function and operates as a timing device in the same manner as the devices 11 and 11'. It is, however, the triggering of tubes 80 and 80' which actually furnishes the firing voltages supplied to the individual transformers associated with the various spark plugs on the engine, as timed by the tube 84. In the drawing the tubes 80, 80' and 84 are shown, each as a separate unit, but it is possible to combine these units and place them all in a single envelope, and such a procedure is contemplated when practicable, that is, the showing herein is exemplary and illustrates the functional elements of the circuit without limitation to the specific location of the mechanical parts where the location shown is not critical.

It will be clear from the above description that the present invention not only provides means for greatly increasing the firing rate of high speed engines, but at the same time provides safeguards at present unknown. It not only reduces

the mechanical parts required, but eliminates failures due to coil-breakdown, to burning of spark plug electrodes and other failures which are incidental to systems employing many mechanical parts.

While only a few embodiments are herein shown and described, it is to be understood that the invention is not limited in its scope to these embodiments except where such limitations are found in the appended claims.

I claim:

1. An internal combustion engine ignition system including a plurality of spark ignitors, a separate ignition coil connected with each ignitor, a primary circuit including a source of electric potential, and a circuit including a cyclically operating distributor for transmitting power from the primary circuit under low potential at timed intervals to the ignition coils to be stepped-up to high potential at the respective ignitors, said primary circuit including reversely connected thyratrons connected for rectification and circuits including a timing device connected to an electrode of each of said thyratrons for maintaining them in condition to be triggered in response to the timing effect of said timing device.

2. In an internal combustion engine ignition system, a source of electric potential, a distributor including a plurality of terminals and a rotary contactor for progressive electrical connection therewith, a pair of thermionic tubes connected to said source so as to be maintained in threshold condition by current from said source, the anode-cathode circuits of said tubes being connected in series relation to said source and said distributor, and a thermionic timing tube supplied with current from said source and arranged to trigger one of said pair of tubes into conducting condition simultaneously with each engagement of the distributor contactor with a terminal.

3. An ignition system for high speed internal combustion engine systems comprising a source of alternating current, a plurality of spark plugs and ignition coils, a rotary distributor to progressively associate each coil with said source, rectifying means interposed between said source and a selected coil and comprising a plurality of thermionic rectifier tubes, each having a grid the potential of which controls the operation of the tube, and thermionic timing means rendered effective synchronously with said distributor for controlling the potential applied to said grid.

4. In an internal combustion engine ignition system, a source of alternating current, a pair of reversely connected thermionic rectifier tubes connected to said source to provide for full-wave rectification, each of said tubes having a control grid, and being arranged to be maintained in threshold condition, a distributor comprising a plurality of terminals and a rotary contactor for progressive electrical connection therewith, means for connecting said distributor in series relation with said thyratrons and said source, and a thyratron timing tube supplied with current from said source and arranged to trigger one of said rectifier tubes into conducting condition simultaneously with each engagement of the distributor contactor with a terminal.

5. In an internal combustion engine ignition system, a source of alternating current, a pair of thyratron tubes connected to said source so as to be maintained in threshold condition and to become alternately conducting and non-conducting in response to changes in the polarity of the current from the source, a distributor comprising

a plurality of terminals and a rotary contactor for progressive electrical connection therewith, said distributor being connected in series relation with said thyratrons and said source, and a thermionic timing tube energized from said source and arranged to trigger said thyratron alternately into conducting condition each time the distributon contactor engages one of its terminals.

6. In an internal combustion engine ignition system, a source of alternating current, a pair of reversely connected thyratron tubes connected to said source so as to be maintained in threshold condition and to become alternately conducting and non-conducting in response to changes in the polarity of the current from the source, relay controlled means responsive to the output voltage of said source for supplying the heaters of said thyratron tubes, a distributor comprising a plurality of terminals and a rotary contactor for progressive electrical connection therewith, said distributor being connected in series relation with said thyratrons and said source, and a thermionic timing tube energized from said source and arranged to trigger said thyratrons alternately into conducting condition each time the distributor contactor engages one of its terminals.

7. In an ignition system for high speed internal combustion engines, a source of alternating current, a distributor including a plurality of terminals and a rotary contactor for progressive electrical connection therewith, an individual spark plug transformer connected to each of said terminals, electronic means for rectifying current from said source and supplying it to said transformers under control of said distributor, and electronic timing means for timing the impulses supplied to said distributor through said electronic means.

MAX THEODORE WINTSCH.

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