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SHUT-OFF APPARATUS FOR ELECTROSTATIC IGNITION SYSTEM

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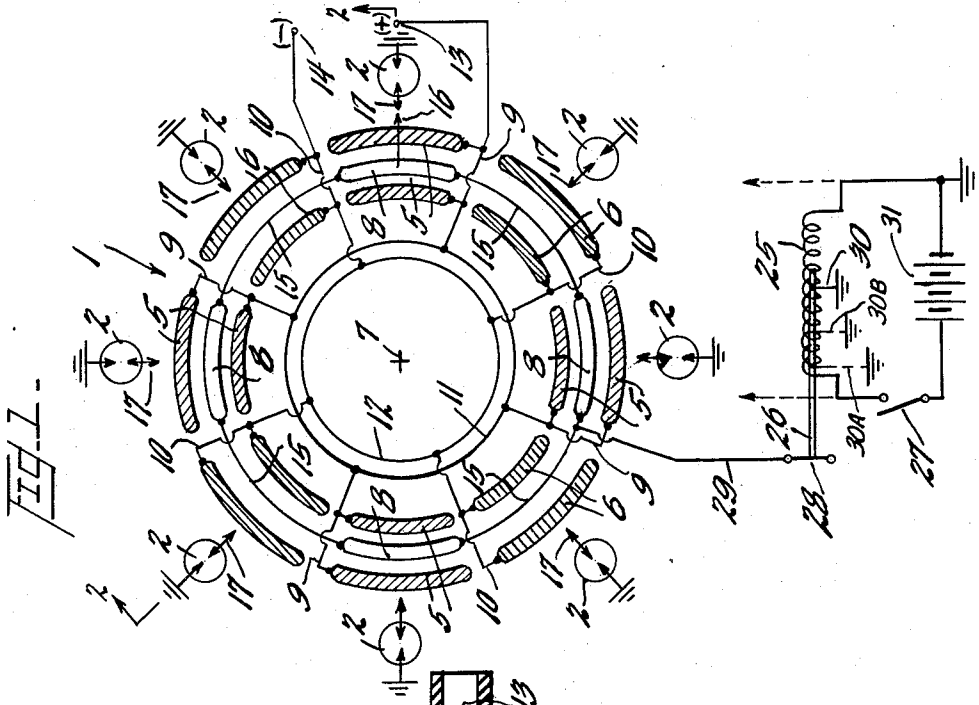


FIG. 1.

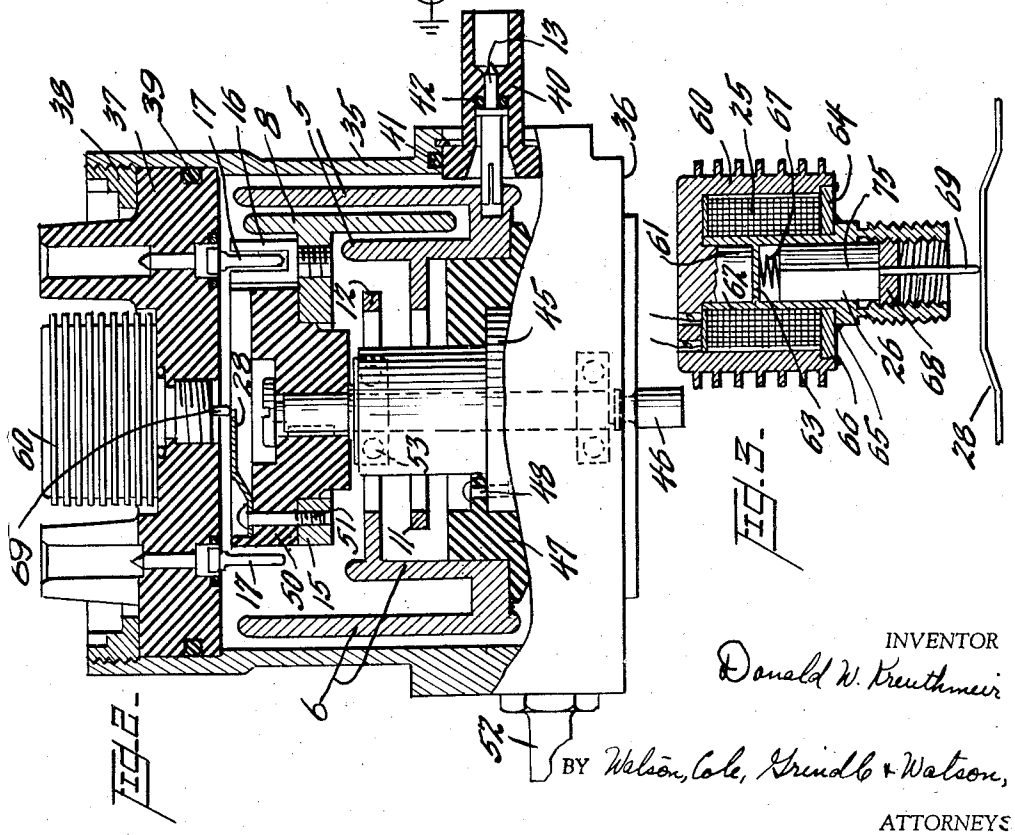


FIG. 2.

FIG. 3.

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SHUT-OFF APPARATUS FOR ELECTROSTATIC IGNITION SYSTEM

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12 Claims. (Cl. 315—55)

This invention relates to ignition systems which employ an electrostatic generator as the source of energy for activating the spark plugs of an engine, and in particular to apparatus for immediately terminating the flow of this energy in response to the de-energization of the ignition system.

Within recent years, the substantial improvements in automotive and aircraft engines have resulted in considerable demand for improved ignition systems so that the optimum theoretical performance of these engines may be more nearly approached. Considerable recent activity has been directed to the development of improved ignition systems employing electrostatic generators as the source of the high voltages required for producing ignition sparks.

Broadly speaking, electrostatic generators suitable for ignition purposes are classifiable in two categories. Namely, those in which electrostatic charges are transported on a conveyor of conductive material with respect to associated inductors, and those in which the electrostatic charges are transported on an insulating conveyor with respect to associated inductors and ionizers. Generators belonging to each of the foregoing classifications possess different electrical characteristics and are also capable of varied and unique mechanical constructions.

In order to attain voltage and current characteristics suitable for ignition purposes, most prior art systems have resorted to a plurality of electrostatic generators connected in cascade. Various arrangements have been proposed in which electrostatic generators of both types have been operatively associated with respect to one another. For example, the copending application of Noel Felici, Roger Morel and Marcel Point, Serial No. 492,496, filed March 7, 1955, for "Quick Starting Electrostatic Generator" discloses a system in which three electrostatic generators are connected in cascade with respect to one another. The individual generator units of this arrangement are aptly termed primer, exciter, and main generators in view of the functions performed. More particularly, the main generator supplies directly the energy required for establishing the ignition sparks, and the exciter generator supplies an exciting potential to the main generator inasmuch as the main generator is not self-exciting. The primer generator primes the exciter generator momentarily so that thereafter the exciter generator is self-exciting.

In view of the limited space available for ignition components within the engine compartments of most modern automobiles and aircraft, the primer, exciter and main generator cascade combination of the prior art has been characterized by a mechanical construction which compactly integrates the various components of all of the generators within a single housing. As a result of the compact construction of the relatively large number of components connected to the input or exciter terminals for the main generator, these terminals present considerable capacitive reactance to the main generator which effectively stores electrical energy. Sufficient energy is

stored, for example, to permit the main generator to operate without output energy from the exciter generator for a considerable period. Accordingly, the opening of the ignition or control switch for the system is ineffective to immediately deactivate the spark plugs for the engine, and therefore the engine continues to operate during an undesired period. It may be readily appreciated that satisfactory ignition demands system shut-down shortly after the ignition switch is opened.

Accordingly, a principal object of this invention is to provide improved apparatus for immediately terminating the flow of output energy from an electrostatic generator in response to the opening of a control switch or the like.

Another object of this invention is to provide improved apparatus for immediately terminating a flow of energy to the spark plugs of an ignition system in response to the commanded shut-down of the system.

Another object of this invention is to provide apparatus which is reliably operative to prevent the flow of output energy from an electrostatic generator and adaptable for a mechanical construction which is easily and economically integrated with an electrostatic generator in a compact arrangement.

In a preferred embodiment of this invention, the novel apparatus herein for effecting immediate shut-off in an electrostatic ignition system features a solenoid actuating a plunger inserted with the bore of the solenoid. Both the solenoid and the plunger are housed within a metallic housing which is adapted for ready coupling to the housing encasing the electrostatic generator which energizes the spark plugs of an engine. A spring is positioned within the bore of the solenoid so as to normally force the plunger away from the solenoid.

In a preferred installation, the electristatic generator is of the conductive-conveyor type which is operative in response to the relative movement of a set of metallic conveyor plates with respect to closely associated inductors. The conveyor plates are movably driven by a rotor supported on a drive shaft for the generator. One surface of this rotor carries a conducting ring which electrically connects and mechanically supports all of the conveyors with respect to one another. The other surface of the rotor contains a relatively rigid contact bar which is electrically connected to the ring of conveyors.

In the normal de-energized condition of the electrostatic ignition system, the plunger contacts the contact bar in response to the spring force applied into, and as a result thereof the conveyors are electrically connected to ground through the contact bar, the plunger and the metallic housing for the solenoid. This particular connection short circuits the output of the generator to ground and prevents the application of generator output to the distributor which otherwise sequentially energizes the spark plugs of the engine.

The solenoid is energized in response to the closure of the ignition switch, thereby causing the plunger to be drawn into the bore of the solenoid and removing the plunger from contact with the contact bar. This operation removes ground from the ring of conveyors and enables the generator to deliver energy to the spark plugs.

The subsequent opening of the ignition switch immediately de-energizes the solenoid causing the plunger to be forced outwardly by the force of the spring. As previously set forth, this operation grounds the conveyors and immediately de-activates the spark plugs notwithstanding the electrical storage of the internal capacities of the electrostatic main generator and the apparatus driving the main generator.

In order that all of the structural features for attaining the objects of this invention may be readily under-

stood, reference is herein made to the accompanying drawings wherein:

Figure 1 is a schematic diagram of an electrostatic ignition system incorporating the shut-off apparatus of this invention, and showing also the electrical connection and significance of the structural generator components shown in Figure 2 and the solenoid assembly shown in Figure 3,

Figure 2 is a longitudinal sectional view of a conductive-conveyor generator construction taken along lines 2—2 of Figure 1, and adapted for a connection of components in accordance with the diagram of Figure 1, and

Figure 3 is a sectional view of the solenoid assembly comprising the shut-off apparatus of this invention.

The schematic diagram of Figure 1 discloses in simplified form the electrical connection of the principal components of a conductive-conveyor generator 1 in an ignition application for sequentially energizing a plurality of spark plugs 2. The particular schematic shown for the generator is merely typical of a satisfactory arrangement for incorporating the solenoid shut-off apparatus of this invention. It should be clearly understood, however, that the principles of this invention are readily adaptable to other generator connections.

In Figure 1, two sets of arcuate inductors are disposed in an interspersed space relationship about an axis of rotation. A first set comprising inductors 5 is disposed on a first diameter through the axis 7, and the interspersed set comprising inductors 6 is disposed on a diameter forming a 45° angle to the diameter of the adjacent inductors of set 5. The individual inductors 5 and 6 of the respective sets each comprise two spaced parts which define therebetween the path of rotation for a plurality of conveyors 8. The arcuate extent and spacing of the conveyors from each other are such that there is one conveyor 8 provided for a pair of inductors 5, 6. In particular, with the relative positioning of the conveyors and inductors shown in the drawing, the parts of every other inductor sandwich an individual conveyor therebetween, with the conveyor path between the other inductors being vacant. Inasmuch as the conveyors 8 are mechanically ganged to one another, each of the conveyors pass between the adjacent parts of all of the inductors for every revolution of the conveyors about the axis of rotation 7.

The mating inner and outer parts of each inductor 5 are electrically connected together by conductors 9, and the mating inner and outer parts of each inductor 6 are electrically connected together by conductors 10. Accordingly, the two parts of each inductor assume the same polarity and potential. The inductors of set 5 are electrically connected together in multiple by ring conductor 11, and the inductors of set 6 are electrically connected together in multiple by ring conductor 12. The input potentials for operatively exciting generator 1 are applied to ring conductors 11 and 12 at high voltage input terminals 13 and 14.

Conveyors 8 are directly connected one to the other by means of conductors 15. It should be noted that conveyors 8 and conductors 15 are not connected to any of the other generator components, and therefore the conveyors may be considered to float potentialwise with respect to the associated components.

A conducting finger 16 is directly connected to the ring comprising conveyors 8 and conductors 15. As will be hereinafter outlined in detail, conducting finger 16 is mechanically coupled to conveyors 8 in such a manner that the finger rotates synchronously with the set of conveyors. A plurality of circularly disposed charge transfer elements 17, one for each inductor 5 or 6, is positioned in spark gap relationship with respect to finger 16 in such a manner that finger 16 becomes sequentially associated with each of the transfer elements 17. Each transfer element 17 is directly connected to ground through a different spark plug 2.

The output of the generator appears at conducting finger 16 in the form of a relatively high voltage. As the finger 16 becomes closely associated with each charge transfer element 17, a current surge to ground is developed which produces a suitable ignition spark between the electrodes of the associated spark plug 2.

The operation of the foregoing generator structure to activate spark plugs 2 is briefly as follows. In response to the closure of the ignition and starter switch of an automobile or the like, positive and negative high voltages are applied between terminals 13 and 14 and ground by the source of excitation (not shown). The positive high voltage applied to terminal 13 causes inductors 5 to assume a relatively high positive potential, and the negative high voltage applied to terminal 14 causes inductors 6 to assume a relatively high negative potential. Assuming the relative positioning of conveyors 8 shown in Figure 1, a relatively intense negative charge is induced thereon inasmuch as each conveyor is sandwiched between parts of a positively charged inductor.

As the conveyors 8 advance in their path of rotation to a position between the adjacent parts of each inductor 6, the negative charge of the conveyors is now subjected to the repulsive negative field existing between the parts of each inductor 6. This field causes the negative charge on the conveyors 8 to break down the gap existing between conducting finger 16 and the associated charge transfer element 17, thereby energizing the spark plug 2 connected thereto. This operation creates a substantial current flow which ultimately causes the conveyors to assume a positive charge.

As the now positively charged conveyors advance to the inductors 5, the repulsive positive field established therebetween, causes a breakdown in the spark gap between conducting finger 16 and the next charge transfer element 17 in the sequence and also the associated spark plug 2. The resulting current surge through these gaps ultimately causes the conveyors to assume a negative charge. It should be noted that alternate spark plugs are subjected to a sparking potential of one polarity, and the intermediate spark plugs are subjected to a sparking potential of the opposite polarity.

The foregoing circuit connection of inductors and conveyors for generator 1 is not self-priming, and therefore the generator must be continuously excited at terminals 13 and 14. While the inductors and conveyors of a conductive-conveyor type generator may be appropriately connected to constitute a self-priming generator, such a connection is undesirable for the reason that the resulting generator output is not adequate to supply the energy impulses required for sparking. This condition exists generally because the conveyors in such an arrangement are reduced to a relatively low potential through the ignition sparks and also because a potential build-up on the conveyors cannot occur thereafter within the relatively short time in which the conveyors are coupled to the next set of inductors in the path of rotation. It may be readily appreciated that the close coupling of the conveyors 8 to an associated set of inductors, substantially increases the capacitance to ground of the inductors which action must be counteracted in order to maintain a constant field between the inductors and conveyors necessary to deliver impulse energy adequate for ignition sparks.

The potential source for exciting generator 1 at terminals 13 and 14 usually presents sufficient capacity to the input of generator 1, whereby the opening of an ignition switch positioned in the low-voltage stages of the circuitry is ineffective to immediately shut off output from generator 1. Solenoid 25 which actuates plunger type armature 26 is mechanically coupled with the housing containing the components of generator 1. This soleniod assembly causes the immediate cessation of output energy from generator 1 in response to the opening of ignition switch 27. In particular, when solenoid 25 is in a de-

energized condition, armature 26 assumes the position shown in the drawing thereby contacting contact bar 28 and connecting the ring of conveyors 8 and conductors 15 to ground through conductor 29, bar 28, armature 26 and conductor 30. This action shorts out spark plugs 2 and prevents further ignition. Conductor 30 is connected to the car body, while alternative connections 30A and 30B are connected to the frame and the engine, respectively, to effect the grounded condition.

The closure of ignition switch 27 on the other hand energizes solenoid 25 by current flow from battery 31 thereby drawing armature 26 within the solenoid and removing the ground from the rings of conveyors 8. This circuit operation enables the conveyors to deliver sparking potentials to the set of plugs 2.

A detailed structural arrangement showing the form and disposition of certain component parts of a practical generator construction following the schematic of Figure 1 is disclosed in the longitudinal sectional view of Figure 2. It should be noted, as is shown in Figure 1, that the sectional view is taken at a 135° angle formed between the lines 2–2 which join at the axis of rotation 7 for the generator.

Most of the components for generator 1 are enclosed within the body of a generally cylindrical metallic housing 35 which is formed with an end wall 36 closing the bottom end of the housing cylinder. A cap 37 fabricated of insulating material closes the upper end of the hollow cylinder of housing 35. Inside ring nut 38 fixedly locks cap 37 to housing 35, and sealing ring 39 establishes a fluid tight seal between the edge surface of cap 37 and the inside wall of the cylinder of housing 35.

Insulator 40 supporting high-voltage input terminal 13 passes through a hole formed in the wall of the cylinder of housing 35. Sealing ring 41 establishes a fluid tight seal between the housing and insulator 40, and sealing ring 42 establishes a fluid tight seal between terminal 13 and insulator 40. The sectional view shows only a single input terminal 13 which is connected to the set of inductors 5. An identical second input terminal and insulator support corresponding with the terminal 14 of Figure 1 is supported by housing 35 in a position not shown in the particular sectional view taken.

A metallic bearing mount 45 is supported on end wall 36 of housing 35. This mount is generally cylindrical and is formed with a hollow bore through which drive shaft 46 extends. Inductor mount 47 which is fabricated of insulating material is fixedly coupled to bearing mount 45 by a plurality of circularly disposed screws 48.

Inductors 5 and 6 are fabricated in individual sets which are both supported by the shoulder formed in inductor mount 47. The cross-sectional form of each of the inductors of both sets assumes a generally U-shape as is shown in Figure 2 with respect to inductor 5. The inductors 5 are circularly disposed and are mechanically attached to a center ring 11 which gangs the individual inductors one to the other. Center ring 11 in a preferred embodiment is fabricated of metal or other conductive material, and therefore the ring also electrically connects the inductors one to the other as is required for generator operation.

The set of inductors 6 assumes a mechanical configuration identical with the construction of the set of inductors 5, with the exception that ring 12 which mechanically supports and electrically connects the individual inductors 6 to one another is disposed above ring 11 as is shown in Figure 2. This relative positioning of rings 11 and 12 is required in order that the individual inductors of one set may be positioned so as to mesh with the individual inductors of the other set.

Rotor 50 which is fabricated of insulating material is coupled to the upper portion of drive shaft 46 and rotates in correspondence with the shaft. Conveyors 8, which are mechanically coupled to one another by a conductive ring 15, are fastened to rotor 50 by a plurality of circularly disposed screws 51. In the sectional view of Figure 2, a conveyor plate 8 is shown disposed between the adjacent parts of inductor 5, whereas the space between the adjacent parts of inductor 6 is vacant inasmuch as the sectional view is taken at a 135° angle.

In view of the relatively compact construction of the generator, housing 35 is preferably charged with a pressurized dielectric gas supplied through valve 52. This dielectric gas effectively suppresses the sparking which would otherwise occur due to the relatively small spacing between components of the generator. It is obvious, of course, that the generator housing must contain this gas without loss of substantial pressure in order to provide satisfactory generator performance over a relatively long period.

Bearing mount 45 supports a set of ball bearings 53 which are mounted immediately below rotor 50, thereby assuring close alignment of the rotating conveyors 8 with respect to the stationary inductors 5 and 6. This arrangement also permits close alignment between the single connecting pin or finger 16 which is in a spark gap relationship with eight circularly disposed charge transfer elements 17 mounted on cap 37. The elements 16 and 17 of Figure 2 correspond in function with the conducting finger 16 and charge transfer elements 17 of the schematic of Figure 1.

Referring now to Figure 3, solenoid 25 corresponding to the solenoid shown in the schematic of Figure 1, is contained within metallic housing 60. The combination thereof is mounted on the central portion of end cap 37 as is shown in Figure 2. Housing 60 is formed with a central core projection 61 which is fabricated of the same magnetic material as is the housing, and also a plurality of fins for radiating heat energy. The upper portion of solenoid bobbin 62 envelopes core 61 and the lower portion thereof receives plunger type armature 26. Web 63 which is integrally formed with bobbin 62 defines the upper and lower portions of the solenoid bore which receive core 61 and plunger 26, respectively. Bobbin 62 is fabricated of a non-magnetic material such as brass, whereas the plunger is fabricated of magnetic material.

Solenoid end plate 64 which is also fabricated of magnetic material locks bobbin 62 to solenoid housing 60. Bobbin 62 is soldered to end plate 64 at 65, and end plate 65 is soldered to solenoid housing 60 at 66 so as to provide a fluid tight seal at these points. A spring 67 is locked between the upper surface of plunger armature 26 and the lower surface of center web 63. The resulting spring force drives plunger 26 against plunger stop 68 as is shown in Figure 3. Plunger 26 is formed with a pair of surface grooves 75 which enable the plunger to move freely inasmuch as the grooves permit the easy passage of gas from one end of the plunger to the other. Plunger stop 68 is formed with a central passage through which an elongated pin 68 movably carried by plunger 26 passes. Finger 69 normally contacts contact bar 28 which is fixedly positioned upon the upper surface of rotor 50 as is shown in Figure 2. This positioning of the plunger assembly electrically connects the conveyors 8 to generator housing 35 through a circuit which includes rotor conducting ring 15, screws 51, contact bar 28, pin 69, plunger 26, bobbin 62 and solenoid housing 60 to housing 35. This particular connection shorts out conducting finger 16 thereby preventing the application of sparking potentals to plugs 2.

The energization of solenoid 25 in response to the closure of ignition switch 27, forcibly attracts plunger 6 upwardly and into the bore of the solenoid in opposition to spring 67. This action opens the circuit previously set forth for connecting conveyors 8 to housing 35 by removing finger 69 from contact with bar 28. This operation enables the conveyors 8 to deliver output to the set of spark plugs 2 through rotating conducting finger 16 and the set of circularly disposed charge transfer elements 17.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Other arrangements may be devised without departing from the scope of the invention.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising a conductive-conveyor type electrostatic generator including a plurality of circularly disposed inductors and a plurality of circularly disposed conductive conveyors electrostatically coupled to said inductors, alternate inductors in said circular disposition being connected one to the other and disconnected from the intervening inductors whereby two separate inductor sets are formed, said conveyors being electrically connected together and disconnected from said inductors, an insulating rotor moving said conveyors relative said inductors, a housing enveloping the foregoing generator components including an insulating end cap mounted adjacent said rotor, a plurality of charge transfer elements each individually connected to a different one of said spark plugs and circularly disposed on said end cap, and a conducting finger connected to said conveyors and mounted on said rotor and movable therewith to sequentially assume a spark-gap relationship with each of said spark plugs; a magnetic solenoid housing including a circular core projection therein mounted on said end cap; a hollow non-magnetic bobbin positioned partially within said housing and including a central web dividing the internal volume of the bobbin into two portions one of which contains said core projection; a magnetic plunger positioned within the other portion of said bobbin; a plunger stop loosely confining said plunger within said other bobbin portion; a spring confined between said web and the end of the plunger adjacent thereto thereby forcing said plunger against said stop; a conductive contact bar positioned on said rotor and connected to said conveyors; a conducting pin carried by said plunger and projecting through said pluger stop and out of said bobbin into contact with said bar; and a solenoid positioned over said bobbin and within said housing and when energized retracting said plunger and separating said pin from contact with said bar, said solenoid in the de-energized condition permitting the shorting of said conveyors to said housing in a circuit path which includes said bar, pin, plunger, bobbin and solenoid housing.

2. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising a conductive-conveyor type electrostatic generator including a plurality of circularly disposed inductors and a pluraility of circularly disposed conductive conveyors electrostatically coupled to said inductors, a rotor moving said conveyors relative said inductors, a housing enveloping the foregoing generator components including an insulating end cap, a plurality of charge transfer elements each adapted for connection to a different one of said spark plugs and mounted on said end cap, and a conducting finger connected to said conveyors and movable therewith to sequentially assume a spark-gap relationship with each of said spark plugs; a magnetic solenoid housing including a core projection therein mounted on said end cap; a hollow non-magnetic bobbin positioned partially within said housing and including a central web dividing the internal volume of the bobbin into two portions one of which contains said core projection; a magnetic plunger positioned within the other portion of said bobbin, a plunger stop loosely confining said plunger within said other bobbin portion; a spring confined between said web and the end of the plunger adjacent thereto thereby forcing said plunger against said stop; a conductive contact carried by said rotor and connected to said conveyors; a conducting pin carried by said plunger and projecting through said pluger stop into contact with said bar; and a solenoid positioned over said bobbin and when energized retracting said plunger and separating said pin from contact with said bar.

3. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising a conductive-conveyor type electrostatic generator including a plurality of circularly disposed inductors and a plurality of circularly disposed conductive conveyors electrostatically coupled to said inductors, means moving said conveyors relative said inductors, a support, a plurality of circularly disposed transfer elements mounted on said support and each adapted for connection to a different one of said spark plugs, and a conducting finger connected to said conveyors and movable therewith to sequentially assume a spark-gap relationship with each of said spark plugs; a solenoid positioned on said support; a magnetic plunger positioned at least partially within the bore of said solenoid; a conductive contact bar movable with and connected to said conveyors; a conducting pin carried by said plunger and positioned into contact with said bar when said solenoid is de-energized; and means for shorting said spark plugs including the contact established by said bar and pin when said solenoid is de-energized.

4. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising an electrostatic generator, a distributor applying the output energy of said electrostatic generator to said spark plugs, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, a solenoid energized by a circuit including said ignition switch, a plunger magnetically coupled to said solenoid, and a contact actuated by said plunger and connected across the output of said generator in response to the de-energized condition of said solenoid.

5. In an electrostatic ignition system for an engine activated by one or more spark plugs, the combination comprising an electrostatic generator, a distributor applying the output energy of said electrostatic generator to said spark plugs, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, and means including said ignition switch shorting the output of said generator in response to the opening of said switch.

6. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising an electrostatic generator including a plurality of conveyors and inductors, a distributor including a conducting finger connected to said conveyors and a plurality of charge transfer elements each individually connected to a different one of said spark plugs, said distributor applying the output energy of said electrostatic generator to said spark plugs in sequence, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, and means actuated by said ignition switch shorting said conducting finger to ground in response to the opening of said switch.

7. In an electrostatic ignition system for an engine activated by a plurality of spark plugs, the combination comprising an electrostatic generator including a plurality of inductors and conveyors, a distributor including a conducting finger connected to said conveyors and a plurality of charge transfer elements each individually connected to a different one of said spark plugs, said distributor applying the output energy of said electrostatic generator to said spark plugs in sequence, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, a solenoid energized by a circuit including said ignition switch, an armature magnetically coupled to said solenoid, and a contact actuated by said plunger and short circuiting said spark plugs in response to the de-energized condition of said solenoid.

8. In an electrostatic ignition system for an engine activated by one or more spark plugs, the combination comprising an electrostatic generator, means including a spark gap applying the output energy of said electrostatic generator to said spark plugs, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, and means including said ignition switch shorting the output of said generator in response to the opening of said switch.

9. The combination of claim 8 in which the output of said generator is shorted to the engine.

10. The combination of claim 8 in which said engine is supported by a frame and in which the output of said generator is shorted to the frame.

11. The combination of claim 8 in which said engine is supported by a frame at least partially enclosed by a body and in which the output of said generator is shorted to the body.

12. In an electrostatic ignition system for an engine activated by one or more spark plugs, the combination comprising an electrostatic generator including a plurality of inductors and conveyors, means including a spark gap one terminal of which is connected to said conveyors and the other to a different spark plug, said means applying the output energy of said electrostatic generator to said spark plugs, a power supply including an ignition switch for exciting said electrostatic generator thereby energizing said spark plugs, and means including said ignition switch shorting the output of said generator in response to the opening of said switch.

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