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N. FELICI

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ELECTROSTATIC MACHINE

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Fig. 1

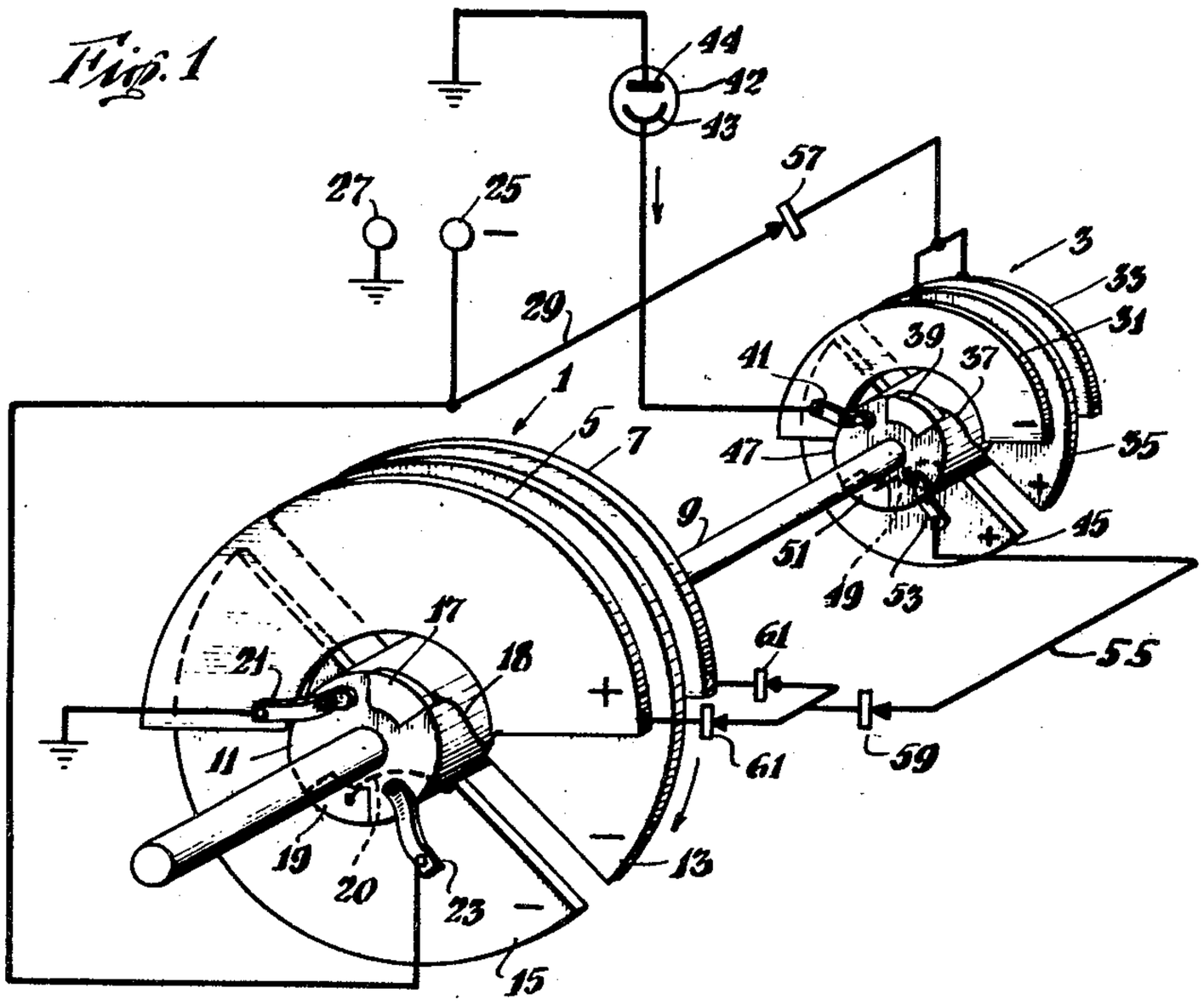

Fig. 2

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ELECTROSTATIC MACHINE

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13 Claims. (Cl. 171—329)

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The present invention relates to electrostatic machines with conductive inductor and conveyor members movable relative to each other and more particularly to means for imposing a given polarity to such machines when they are excited.

It is known to provide electrostatic machines having conductive relatively movable inductor and conveyor members with self exciting means which spontaneously excite the machine as soon as they are set in motion. This is the case for the Toepler machine provided with a regenerator, the Wimshurst machine, the "Replenisher" and the machines described in Patent Application No. 760,896 filed July 14, 1947. In all the said devices, the excitation is secured if the required conditions are met but the polarity taken by the machine is not always the same. This is a great disadvantage for numerous applications.

The object of the present invention is to remedy this disadvantage by making it possible to insure in the machine a previously chosen polarity which it always will take when excited.

According to the invention, a device having a substantially unidirectional conductivity, that is to say a device conducting the electricity substantially in one direction only, is inserted in one or more conductors through which the electric current is to pass on exciting of the machine and the severing of which conductor or conductors would make this excitation impossible. After many tests it has been found that spontaneous excitation may be secured because of the residual charge carried by the solid insulating bodies of the machine. The excitation takes place in the same positive manner but always with the polarity corresponding to the direction allowed by the inserted device or devices.

If the device employed is not rigorously insulating for the direction in which it should prevent the passage of the current but possesses in this direction only a finite resistance R its effectiveness is nevertheless total if an ohmic resistance R inserted in its place renders the excitation impossible, that is, if the voltage drop across the resistance is sufficient to prevent building up of the charge. If desired, it is possible to decrease the minimum value of R otherwise necessary by modifying the machine in order to render its excitation more difficult, for instance, by inserting leakage resistances of a suitable value between the conducting inductors and the ground.

The device having a unidirectional conductivity should of course be such that the current normally flowing through the conductor in which it is inserted may flow through said device without

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damaging it. One may choose, among a plurality of conductors in which it would be possible to insert such a device, that conductor through which flows the smallest current. On the other hand, at starting the device which is used is not required to withstand large potential differences in the reverse direction, the potential differences which usually exist in a machine at the moment when it begins to be excited being very small, of the order of one volt to ten volts.

However, it may be necessary to take steps in order that once the machine is excited any accidental condition which may occur, such as an internal discharge, may not reverse the polarity of an inductor by bringing it immediately to a very high reverse potential which would develop at the terminals of the device having a unidirectional conductivity a considerable potential difference which it could no longer oppose and the choking of which device, if it is thus effected, would suspend the normal working of the machine without it being possible, on the other hand, to compel it to take the desired polarity again.

It will always be possible to avoid such occurrences in the machines which are exposed to them by dividing the inductors, for example, into sections connected by high resistances, one only of said sections then incurring the risk of having its potential reversed after an internal discharge, or by connecting the inductors to sufficiently large capacities through high resistances, the capacity storing enough electricity for maintaining the potential of the inductor with the same sign even though it would receive a large quantity of electricity of the opposed sign.

Any device having a unidirectional conductivity may be used for practicing the invention provided its effective resistance in the direction in which it must prevent the passage of the current is sufficient for preventing the excitation of the machine as previously explained. Electronic devices in which the unidirectional conductivity results from the emission of electrons by a suitable cathode under the influence of heat, light or any other cause are particularly advantageous owing to their very high resistance in the direction in which the electrons are not accelerated, to their small bulk and to their ability to conduct large currents in the direction of the flow of electrons more particularly when they comprise a gaseous atmosphere the ionization of which reduces the space charge. Devices could also be used which comprise a semi-conductive substance such as silicon, germanium or the like.

The invention is more fully described hereafter,

by way of example, as applied to an electrostatic machine with stationary conductive inductor members and movable conductive conveyor members of the Toepler type, with reference to the appended drawings in which:

Fig. 1 shows diagrammatically an embodiment of the invention in connection with an electrostatic machine and an exciter of the type having conductive electrodes.

Fig. 2 shows a modification of the apparatus of the invention.

The machine shown in Fig. 1 comprises two sections, the main electrostatic machine 1, for example an electrostatic generator, and an electrostatic exciter generator 3 for providing the excitation of the main machine. The main machine 1 comprises conductive inductors 5 and 7 of generally semicircular segmental form arranged in parallel plane at one side of the axis of rotation of the shaft 9 of the machine and insulated therefrom. Upon this shaft 9 is carried a drum 11 of insulating material for rotation therewith. The drum 11 carries for rotation therewith two conductive conveyors 13 and 15 also of generally semicircular segmental form spaced apart and insulated from each other by the drum 11.

The conveyors 13 and 15 as shown in Fig. 1 are arranged in spaced parallel relation to and between inductor members 5 and 7 so that upon rotation of the shaft 9 the conveyors 13 are moved in succession into and out of face to face relation with these inductor members.

As shown in Fig. 1 in the insulating material of the drum 11 are inset two segmental contacts 17 and 19 which by means of conductors 18 and 20 respectively are electrically connected to conveyors 13 and 15. Brushes 21 and 23 are provided for engaging the segmental contacts 17 and 19 as the shaft 9 and the drum 11 are rotated. As will be understood from a consideration of Fig. 1 the brush 21 may be in engagement with the segmental contact 17 substantially when the conveyor 13 is in full face to face relation with the inductors 5 and 7. At that time also the brush 23 will engage the segmental contact 19. The brush 21 is connected to ground, the brush 23 being connected to the discharge terminal 25 of the machine which is in opposed relation to the terminal 27 which is connected to ground.

In the embodiment of Fig. 1 let it be assumed that it is desired to maintain the terminal 25 at a negative potential. When the conveyor 13 is in the full face to face position and is connected to ground through the brush 21 it will be at zero potential. The inductor members 5 and 7 may be assumed to have a small positive residual charge. This induces a negative charge on the conveyor 13. As the conveyor 13 rotates in the direction of the arrow from the position in full face to face relation to the inductors 5 and 7 through the position shown in Fig. 1 and continues this rotation the brush 21 first breaks engagement with the segmental contact 17. Since in such rotation of the conveyor 13 the capacity thereof with respect to the inductors 5, 7 decreases, the negative potential of this conveyor is increased until the forward edge of the segmental contact 17 comes into engagement with the brush 23, thereby delivering its negative charge to the terminal 25 until the conveyor 13 completely passes out from between the inductors 5 and 7.

During such rotation of the conveyor 13 the conveyor 15, having been connected to terminal 25 through the segmental contact 19 and brush 23, becomes disconnected from this brush and

terminal and rotates through the position shown in Fig. 1 toward and then fully into face to face relation with the inductors 5 and 7, thus increasing the capacity between itself and these inductors concomitantly with decrease in the potential of this conveyor. This action continues until the segmental contact 19 comes into engagement with the brush 21 at the moment when the potential of the conveyor 15 is substantially zero. The conveyor 15 thereby is connected to ground and its potential remains zero as the capacity between conveyor 15 and inductors 5, 7 increases. Due to the electric field developed by the inductors 5, 7 which are at positive potential, the conveyor 15 acquires a negative charge which flows through the connection to ground. When this conveyor has reached full face to face relation to the inductors 5, 7 and begins to leave this position as the capacity between this conveyor and the inductors 5, 7 begins to decrease, the segmental contact 19 breaks connection with the brush 21. The conveyor 15 then continues in its rotation through the part of the cycle which has been described in connection with the conveyor 13.

As shown in Fig. 1 the brush 23 and the terminal 25 are connected through the lead 29 to the inductor members 31 and 33 of the exciter 3 which are of similar form and arrangement to the inductors 5 and 7 of the main machine. Since, as above indicated, the terminal 25 and the brush 23 carry a negative potential the inductors 31, 33 may be considered also to have a residual negative charge capable of inducing a positive charge on the conveyor member 35 corresponding in the exciter 3 to the conveyor member 13 of the main machine. The conveyor 35 is connected through the lead 37 with segmental contact 39 adapted to be engaged by brush 41 which in this embodiment is connected to ground through the unidirectional conductivity device 42. Similarly, the exciter 3 is provided with a conveyor 45 oppositely carried on the drum 47 to the conveyor 35, the conveyor 45 being connected by the lead 49 to its segmental contact 51. The contacts 39 and 51 are adapted to engage in succession the brushes 41 and 53 positioned in relation thereto similarly to the brushes 21, 23 of the main machine. As shown in Fig. 1, the brush 53 is connected through the lead 55 to the inductor members 5 and 7 of the main machine.

In the same manner as described in connection with the main machine the conveyor 35 as it moves from full face to face relation with the inductors 31, 33 first breaks connection with the ground through the brush 41 and then the potential thereof increases until the segmental contact 39 engages the brush 53, whereupon the positive charge carried by the conveyor 35 is shared with the inductors 5 and 7. Similar action occurs when the conveyor 45 is moved from face to face relation with the inductors 31 after having become connected to ground by engagement of its segmental contact 51 with the brush 41, thereafter to continue the cycle as described for the conveyor 35.

As above stated the residual charge carried by the conveyors with respect to the insulating parts of the machine may be relied upon to produce the initial excitation, that is the initial charge of the inductor members 5, 7 and 31, 33 from which is built up the requisite charges upon these inductor members for operation of the machine. Whenever the segment 39 or the segment 51 of the exciter engages the brush 53 the charges car-

ried by the conveyors 35, 45 although weak are distributed to the inductors 5 and 7. The increase of the potential and the distribution of the charges carried by the conveyors 13 and 15 to the terminal 25 and to the inductors 31, 33 increases the charge of the inductors 31, 33 of the exciter with consequent increase of the charge upon the conveyors 35, 45 of the exciter resulting in further increase of the charge upon the inductors 5 and 7 of the main machine. This build up of charge and of potential continues until a state of equilibrium is attained as determined by discharge of the machine at the terminal 25. As will be apparent this auto-excitation is analogous to that of dynamo electric machines.

In order to prevent spontaneous reversal of the excitation of the main machine upon the occurrence, for example, of a condition in the machine provoking internal discharge therein it is possible to provide means for interrupting one or more of the connections between the exciter and the main machine or for interrupting the connection of either machine to ground. To this end it is possible, for instance, to provide a unidirectional conductivity device in the lead connecting from the brush 21 of the main machine, as shown in Fig. 2, or in the lead from the brush 41 of the exciter to ground, as provided by the photoelectric cell 42 of Fig. 1 having its cathode 43 connected to the brush 41 and its anode 44 connected to ground. It is further possible to introduce such a unidirectional conductivity device, for example, at 57 in the tie lead 29 connected between the terminal 25 and the inductor members 31, 33 of the exciter. Such a unidirectional device alternatively may be placed in the lead 55 as shown at 59. It is, of course, possible to substitute for the device 59 two such devices 61 placed in the branch connections of the lead 55 to the inductors 5, 7 as shown in Fig. 1.

As it is desired in the embodiment of Fig. 1 that the terminal 25 shall be at negative potential the photoelectric cell which is used in this embodiment is connected in the lead from the brush 41 to ground so that the cathode 43 thereof is connected to the brush 41 and the anode 44 is connected to ground. This photoelectric cell thus connected and provided with the requisite illumination compels the current to flow from the ground to the brush 41, this resulting in positive electrification of the conveyors 35, 45 of the exciter, and securing a positive electrification of the inductors 5 and 7 as described above. The main conveyors 13, 15, therefore, become negatively electrified by induction and the main terminal 25 becomes charged at a negative potential. The photoelectric cell 42 may, for example, be a caesium cell having a gaseous atmosphere.

In the embodiment of Fig. 2 it is assumed that the terminal 25 shall be at a positive potential. For this purpose the unidirectional device of Fig. 1 may be connected in the reverse direction. As shown in Fig. 2, however, a vacuum diode 65 provided with the conventional heating element 67 has the anode 69 thereof connected to the terminal 27 which is connected to ground, the cathode 71 of this diode being connected to the brush 21 of the main machine. The diode thus connected compels the current to flow from the ground to the brush 21 to produce positive electrification of the conveyors 13, 15 of the main machine. The inductors 5, 7 of this machine, therefore, must have a negative potential requiring that the conveyors 35, 45 of the exciter shall carry a negative charge which is distributed to the inductors 5 and 7 through the lead 55 upon engagement of the segmental contacts 39, 51 with the brush 53. The inductors, 31, 33 of the exciter 3, therefore, are required to be positively charged, these inductors being substantially at the same potential as the terminal 25 being connected thereto through the lead 29.

The cathode of the diode 65, of course, must be heated by a source sufficiently insulated from the ground in order to prevent the machine from being excited in the wrong direction by electrostatic action of the heating element 67 upon the cathode 71. It is possible, for instance, to use an insulated battery or a transformer the secondary winding of which is especially insulated or an alternator the armature of which is especially insulated while the inductor thereof may be electrically connected to the ground.

As above indicated, when a machine such as is described in connection with Figs. 1 and 2 is being operated conditions may be developed therein which produce an interior discharge which may provoke a reversal of polarity of the machine. If, for example, in the machine shown in Fig. 1 and with the conveyors 13, 15 and the other members occupying the position shown therein a spark flashes between the inductors 31, 33 of the exciter and the conveyor 35 this conveyor may be changed from a positive potential to a very high negative potential approximating that of the terminal 25 and the load connected thereto to which the inductors 31, 33 are connected. Such discharge neutralizes the positive charge normally carried by the conveyor 35 and the negative charge produced will not be able to discharge to the ground when the segmental contact 39 engages the brush 41 because the cathode 43 of the diode 42 will be brought to this high negative potential with respect to the anode 44. Meanwhile when, upon rotation of the conveyor 35 from the position shown, the segmental contact 39 engages the brush 53, the conveyor 35 will share its negative charge with the inductors 5 and 7 which may neutralize the positive charge on these inductors and may produce a negative charge thereon depending upon the relation of the capacities of the conveyor and the inductor electrodes. The conveyor member 13, therefore, may become positively charged and the polarity of the terminal 25 will be reversed when segmental contact 17 connected to the conveyor 13 engages the brush 23.

In order to avoid the development of such a condition in the machine as indicated above the inductors may be divided into sections connected by high resistances. As it is highly improbable that a spark will flash simultaneously between the conveyor and the several sections of the inductor only one of these inductors is affected by a discharge at a given instant and the charge which it acquires may be discharged very slowly and is insufficient with respect to the total charge of the inductors to build up a reversal of polarity. As shown in Fig. 1, for example, the inductors 5 and 7 constitute two sections which may be connected through the resistances which may be inserted at 61 in place of the unidirectional devices there shown.

It is further possible to avoid reversal of polarity by connecting the inductors 5 and 7, for example of Fig. 2, to ground through a condenser 73 having a high capacity. A high resistance 75 may be included in the connection. The capacity of the condenser may be sufficient to carry enough electricity to maintain the same sign as the poten-

tial of the inductors 5, 7 even when these inductors receive a large amount of electricity of the opposite sign, for example by the discharge of a spark between the conveyors and the inductors of the main machine or of the exciter in the manner above described. The capacity of the condenser further may be sufficient to carry a quantity of electricity more than is required to neutralize the combined charges carried by the electrodes 5, 7, 35, 45 when the polarity of these electrodes has been changed by the occurence of internal discharge or other disturbance.

As above generally stated a leakage resistance of suitable amount may be connected between the inductors, 5, 7, for example, and the ground which constitutes substantially a resistance in parallel with the resistance afforded by the insulation of the machine which resists flow of current between the ground and other conductive parts of the machine. If, as is generally the case, this insulating resistance for inductors or the conveyors is very high and, therefore, the leakage current which may flow through the resistance afforded by the unidirectional conductivity device produces a small voltage drop, in order to prevent building up of a charge the leakage current may be increased and consequently the voltage drop in the resistance of the unidirectional conductivity device may be increased by means of a resistance connected in parallel with the leakage resistance. Such a parallel resistance may be represented by a resistance connected between the inductors 5, 7 and the ground as is the resistance 75 of Fig. 2 but omitting the condenser.

Within the scope of the invention various combinations of the elements hereinabove described may be utilized to secure the excitation of the main electrostatic machine with the desired polarity and the maintenance of such polarity continuously during the operation of the machine. These combinations and the devices used are effective to prevent change of polarity which because of the development of electrostatic conditions within the machine or its exciter may produce or tend to produce the reversal of polarity.

I claim:

1. An electrostatic machine comprising a conductive inductor member, a conductive conveyor member, said members being supported for movement one relative to the other in inductive relation to each other, a terminal, means cooperating with said members and connected to said terminal for conducting thereto an electrostatic charge induced by said relative movement of said conductive members, an exciter adapted to produce an exciting electrostatic charge of given polarity and connected to said inductor member to deliver said exciting electrostatic charge thereto to determine the polarity of the charge delivered to said terminal, and a device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in a circuit of said machine which normally carries current in a given direction contributing to the producing and delivery of at least one of said charges with its given or determined polarity, said connection of said device in said circuit being made so as to prevent flow in the reverse direction in said circuit.

2. An electrostatic machine comprising a conductive inductor member, a conductive conveyor member, said members being supported for movement of one relative to the other in inductive relation to each other, a terminal, means cooperating with said members and connected to said terminal for conducting thereto an electrostatic charge induced by said relative movement of said conductive members, an exciter adapted to produce an exciting electrostatic charge and connected in a circuit with said inductor member normally to effect excitation thereof with a given polarity, and a device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in said circuit so as to carry current in said circuit in the direction contributing to said excitation of said inductor member with said given polarity.

3. An electrostatic machine comprising a conductive inductor member, a conductive conveyor member, said members being supported for movement of one relative to the other in inductive relation to each other, a terminal, a brush connected to said terminal, a second brush connected in a circuit connected to ground, means adapted intermittently to make contact in succession with said brushes and connected to said conveyor member to connect said conveyor member in succession to ground and to said terminal to deliver a charge to said terminal, an exciter adapted normally to produce a given electrostatic potential in a given direction and connected in an exciter circuit between ground and said inductor member to effect excitation thereof, and a device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in said exciter circuit so as to carry current in said circuit in the direction contributing to said normal excitation of said inductor member.

4. An electrostatic machine comprising a main conductive inductor member, a main conductor conveyor member, said members being supported for movement of one relative to the other in inductive relation to each other, a terminal, a main brush connected to said terminal, a second brush connected in a circuit connected to ground, means adapted intermittently to make contact in succession with said main and second brushes and connected to said main conveyor member to connect said main conveyor member in succession to ground and to said terminal to deliver a charge to said terminal, a conductive exciter inductor member, a conductive exciter conveyor member, said exciter members being movable one relative to the other in inductive relation to each other, a delivery brush associated with said exciter members and connected to said main inductor member, an auxiliary brush associated with said exciter members and connected in a circuit connected to ground, means cooperating with said exciter conveyor member and adapted to connect said exciter conveyor member in succession to said auxiliary and said delivery exciter brushes to deliver an excitation charge to said delivery brush and to said main inductor member, and at least one device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in one of said connections to said exciter brushes so as to carry current in said connection in the direction contributing to delivery of said excitation charge to said main inductor member with a given polarity.

5. An electrostatic machine comprising a main conductive inductor member, a main conductive

conveyor member, said members being supported for movement one relative to the other in inductive relation to each other, a terminal, means cooperating with said members and connected to said terminal for conducting thereto the electrostatic charge induced by said relative movement of said conductive members, a conductive exciter inductor member, a conductive exciter conveyor member, said exciter members being movable one relative to the other in inductive relation to each other, means connecting said exciter conveyor member to said main inductor member for conducting thereto an electrostatic charge induced by said relative movement of said exciter inductor and conveyor members, a tie connection between said terminal and said exciter inductor member, and a device adapted to carry a current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in said tie connection to carry current therein in a given direction contributing to maintaining said terminal at a given polarity.

6. An electrostatic machine comprising a conductive inductor member, a conductive conveyor member, said members being supported for movement of one relative to the other in inductive relation to each other, a terminal, a brush connected to said terminal, a second brush connected in a circuit connected to ground, means adapted intermittently to make contact in succession with said brushes and connected to said conveyor member to connect said conveyor member in succession to ground and to said terminal, an exciter normally adapted to produce an electrostatic potential of given polarity and connected in an exciter circuit between ground and said inductor member to effect excitation of said inductor member, and a device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction, said device being connected in said connection between said second brush and ground so as to carry current in the direction of flow normally produced by said electrostatic potential of said given polarity of said exciter.

7. An electrostatic machine as defined in claim 4 in which said device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction is connected in said connection between said exciter delivery brush and said main inductor member.

8. An electrostatic machine as defined in claim 1 in which said device adapted to carry current in one direction and substantially to prevent flow of the current therethrough in the reverse direction comprises an electronic device having a cathode capable of emitting electrons and an anode, said device being connected in said circuit so that current flows into the device at the anode and flows from the device at the cathode.

9. An electrostatic machine as defined in claim 8 in which said electronic device is an electronic tube having means for heating said cathode.

10. An electrostatic machine as defined in claim 1 in which said device adapted to carry current in one direction comprises a photoelectric cell.

11. An electrostatic machine as defined in claim 1 which comprises a leakage resistance connected between said inductor member and ground.

12. An electrostatic machine as defined in claim 1 which comprises a condenser connected to said inductor member, the capacity of said condenser exceeding the capacity of said inductor member sufficiently to maintain the polarity of said capacities upon delivery to said inductor member of a charge capable of effecting reversal of the polarity of said inductor member when disconnected from said condenser.

13. An electrostatic machine as defined in claim 12 in which said condenser in series with a resistance is connected between said inductor member and ground.

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No references cited.