Aug. 19, 1941. W. H. BENNETT 2,252,694

ELECTRIC DISCHARGE ELECTRODE

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FIG. 1

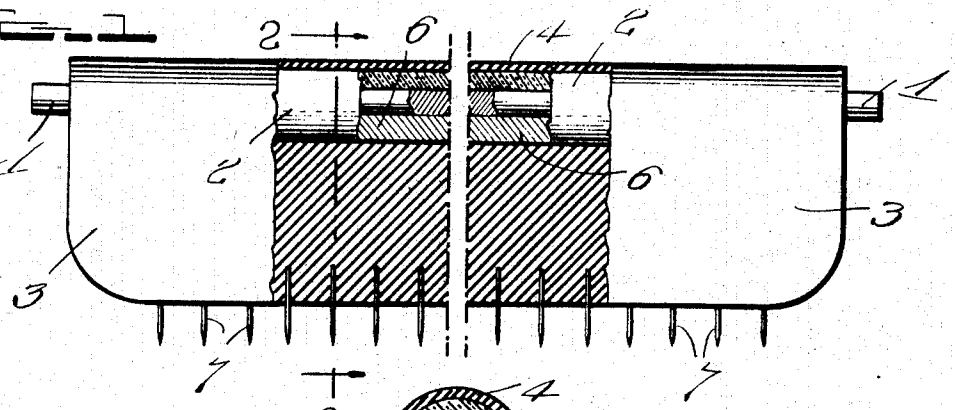


FIG. 2

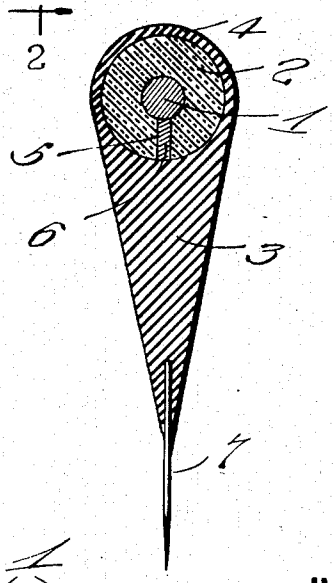
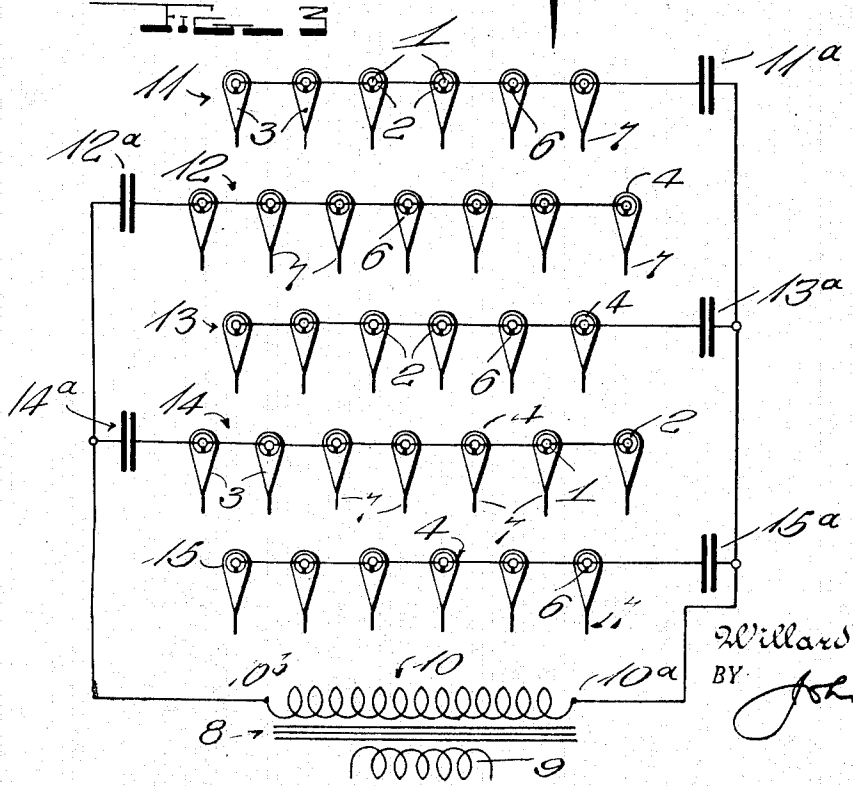


FIG. 3



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FIG. 4

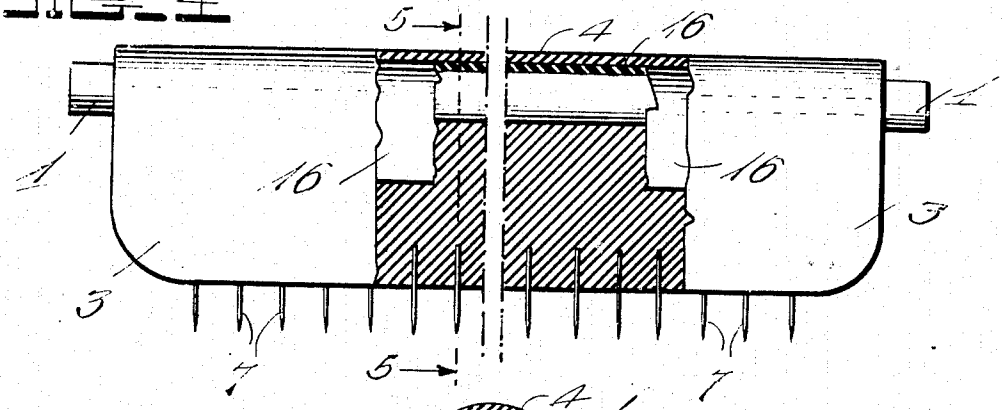


FIG. 5

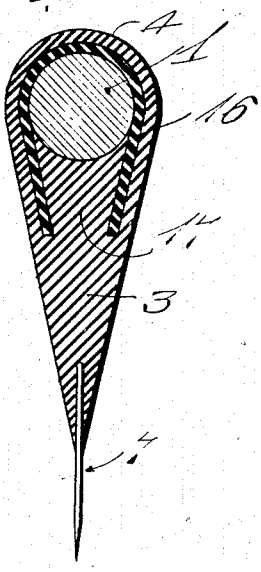
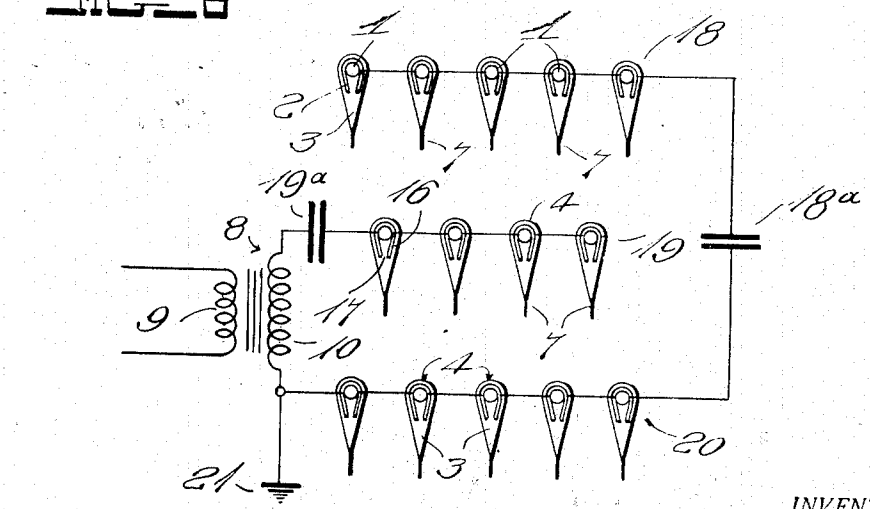


FIG. 6



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UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE ELECTRODE

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Application June 17, 1939, Serial No. 279,769

16 Claims. (Cl. 230—69)

My invention relates broadly to electric discharge electrodes and more particularly to a construction of electric discharge electrode particularly adapted for use in fans, blowers, electrical precipitators and the like.

One of the objects of my invention is to provide a construction of electrode for use at high potentials which provides a high resistance leak path through the insulating sheath of a capacitive type electrode which will eliminate the D. C. bias from being applied across the insulating sheath in such a manner that this D. C. bias will entirely appear across external blocking condensers in circuit with the electrode.

Another object of my invention is to provide a construction of relaxation type of capacitive electrode for high potential discharge systems.

Still another object of my invention is to provide a capacitive construction of electric discharge electrode having means for maintaining a regulated silent electric discharge in a cascade system of electrodes and determining proper operating bias potentials in circuits associated with the electrode.

A further object of my invention is to provide a construction of electric discharge electrode hava charge receiving portion and a discharge portion with a high potential bus extending through the electrode and having means built into the electrode for enabling charges to be built up to a predetermined potential on the charge receiving portion and equalized on succeeding half cycles of the impressed energy.

A still further object of my invention is to provide a construction of discharge electrode of the capacitive type having a semi-conductive body portion and an emitting portion with an intermediate leak path for electric charges built internally into the electrode, said leak path having a higher resistance than the resistance of the semi-conducting body portion of the discharge electrode.

Another object of my invention is to provide a discharge electrode having a capacitive target surface and an emitting portion with a controlled leak path for electric charges built internally into the electrode for enabling charges to leak off for maintaining the total quantity of electric charge accumulated on the target surface on succeeding half cycles equal.

Other and further objects of my invention reside in the construction of a high potential electrode which avoids many of the defects inherent in prior constructions of high potential electrodes as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which;

Figure 1 is a plan view of a high potential electrode embodying my improved construction, the view being partially broken away and illustrated in section for more clearly showing the internal construction thereof; Fig. 2 is a transverse sectional view taken on line 2—2 of Fig. 1; Fig. 3 shows a schematic circuit arrangement for a cascade system of electrodes arranged according to my invention; Fig. 4 illustrates in plan view a modified form of electrode embodying my invention, the view being partially broken away and illustrated in section for showing the internal construction of the modified form of electrode; Fig. 5 is a transverse sectional view on line 5—5 of Fig. 4; and Fig. 6 is a schematic view showing the circuit arrangement for connecting the electrodes of the construction shown in Figs. 4 and 5 in a cascade system.

In cascade arrangements of electrodes in high potential discharge systems where the integral effect of a multiplicity of discharge electrodes is to be secured, the breakdown of certain of the electrodes in the cascade system by the establishment of incipient streamers, spark-over, and electric breakdown tends to destroy the efficiency of the entire system. I have developed constructions of electrodes by which a regulated and controlled high potential discharge may be effected by virtue of internal distributed capacity, and in which the excessive accumulation of charge due to the natural biased character of point discharges is arrested by providing a leak path for those excessive charges internally of the electrode. I so construct the electrodes of a cascade system that ionic currents arriving at the target surface of one electrode in one half cycle are just equal to the ionic currents of opposite polarity arriving in the following half cycle, and also that the potential difference between the bus and the target surface produced by the ionic charge arriving at the target surface of the electrode in one half cycle is just equal in magnitude and opposite in polarity to the potential difference due to the charge arriving in the following half cycle. The function of the internal leak path in the electrode is to maintain these magnitudes of potential difference the same on succeeding half cycles. This can be realized only if external blocking condensers are used. Thereafter excessive charges are carried off through an internal leak path in each electrode permitting a steady drain of accumulated charges above a predetermined operating potential supplied to the electric emitters

which discharge in regulated and controlled manner to associated target surfaces of adjacent electrodes and without incipient streamers, sparkover or disruptive discharge. By such arrangement of internal leak path within the electrode, highly efficient operation is obtained by use of such electrodes in cascade systems employed in blowers, fans and in other electric discharge systems.

Referring to the drawings in detail, reference character 1 indicates a high potential bus which mechanically supports the electrode and supplies high potential to the electrode. The bus 1 is enclosed in a tubular sheath of insulation material indicated at 2. The tubular sheath 2 is slotted at one side thereof to provide a gap 5 extending radially from the bus 1 to the surface of the tubular sheath 2. The tubular sheath 2 is wholly enclosed in the semi-conducting body 3 which is stream-lined in shape from the portion which surrounds the tubular sheath 2 to the discharge portion of the electrode. The discharge portion of the electrode carries a multiplicity of uniformly spaced discharge points 7 which may be in the form of conducting fibers, fine wires or metallic needle-like points. The gap 5 formed in the slotted side of the tubular sheath 2 is directly opposite the portion 4 of the semi-conducting body 3 which surrounds the insulated tubular sheath 2. The portion 4 of the semi-conducting body 3 forms a target surface against which charges from the discharge points of adjacent electrodes are discharged. The gap 5 extends longitudinally of the electrode and is filled by a conducting strip or piece of material 6 which has a predetermined resistance. The conductive strip 6 forms an electrical leak path between the semi-conductive body 3 and the high potential bus 1. The resistance of conductive strip 6 is so selected that the capacity between the bus 1 and the semi-conducting material 3 will relax in a time period which is long compared with the time of a half cycle of the impressed alternating current. The resistance value of the conductive strip or path 6 is higher than the resistance of semi-conductive body 3. A criterion of the value of the resistance leak would be that the relaxation of the charge thrown onto the target edge during any half cycle through that resistance leak should be slower than such as to decrease that charge by, say, 5% during the time of a half cycle. This may be computed by a simple direct measurement of the electrostatic capacity of the insulating sheath in the absence of the leak, or circuit methods may be used for measuring the equivalent capacity of the sheath in the presence of the leak.

The circuit arrangement for this type of electrode is shown generally in Fig. 3 which illustrates an input transformer 8 having primary winding 9 and secondary winding 10 arranged to deliver charging potential to coacting rows of discharge electrodes constructed in accordance with my invention. The electrodes are shown arranged in staggered relation in rows 11, 12, 13, 14 and 15. Connection is made from alternate rows 11, 13 and 15 through condensers 11*a*, 13*a* and 15*a* with terminal 10*a* of secondary winding 10. Connection is made to the other alternate rows of electrodes 12 and 14 through condensers 12*a* and 14*a* to the opposite end 10*b* of secondary winding 10. In each instance the connection to the electrodes in each row is made through the metallic buses 1 of the respective electrodes. This type of electrode reacts like a capacitive target without having to withstand the direct current biasing potential in addition to the alternating current potential which is required for the alternating current operation of this kind of electrode, and consequently this type of electrode assists in overcoming insulation difficulties inherent in the arrangement of the tubular sheath 2. Discharge from points 7 in one row is accumulated on target portions 4 of the electrodes in the adjacent row and the effects of the discharge integrated for producing a conjoint total effect of all of the disharges. Inasmuch as the structure of the electrodes is such that excessive accumulation of potential by each electrode is prevented by reason of the leak path through the high resistance strip 6, a silent, steady discharge is maintained resulting in the setting up of mass movement of air or other fluid in which the electrodes are arranged at relatively high velocity. The incipient discharges, streamers, spark-overs, breakdowns and disruptive discharges which are detrimental to the establishment of mass movement of air or fluid are eliminated so that the total effects of the silent, steady discharges may be effectively utilized.

In Figs. 4–6 I have illustrated a modified form of electrode embodying my invention. The high potential bus 1 is provided with a sheet-like layer of insulation material 16 which is folded around the bus 1 as shown. The bus 1 with the layer of insulation material 16 folded thereabout is embedded within the semi-conductive mass of material constituting body 3. The opposite ends of the insulation strip 16 terminate adjacent each other, separated by a gap 17. The semi-conductive material 3 within which the insulated strip 16 and bus 1 are completely embedded forms a target portion 4 which receives ionic currents. The emitters 7 are carried by the opposite edge of the semi-conducting body 3. The gap 17 in the semi-conducting body 3 extends longitudinally of the body 3 and provides a leak path through the semi-conducting material 3 from the target portion 4 to the bus 1. Ionic currents arriving at the target surface 4 can accumulate on surface 4 until a voltage through the insulation strip 16 has been built up. Excessive charges leak off from target surface 4 around the edge of insulation strip 16 and enter bus 1 at the side toward emitters 7 through gap 17. The resistivity of the semi-conducting material 3 is adjusted to the correct value so that the action of the capacitive sheath around the bus will still be effective in obstructing abrupt formation of streamers, disruptive discharge, sparkover, and/or incipient discharges. The sudden voltages that are built up across the layer of insulation 16 next adjacent the point of arrival of charges on target 4 are sufficient to oppose the momentarily applied voltage in the incipient streamer channel. Excessive voltages leak off from the electrode and are not passed to the emitters. Moreover, there is a tendency in this type of discharge electrode to redirect the charges coming from an adjacent bank so that they will tend to arrive more nearly uniformly and symmetrically at the surface of the target 4 around the positions opposite the edges of the insulating strip 16.

In Fig. 6 I have shown schematically the type of circuit in which the high resistance leak type of electrode shown in Figs. 4 and 5 may be connected. For purposes of explaining my invention I have shown coacting rows of electrodes 18, 19 and 20. The electrodes in row 18 are

connected through condenser 18a and together with the electrodes in row 20 to one side of secondary winding 10 of the transformer 8, while the other side of the secondary winding 10 is connected through condenser 19a with the electrodes in row 19. One side of the high potential circuit connected to secondary winding 10 may be grounded as indicated at 21. Power transformer 8 may have the primary winding 9 thereof connected to a suitable source of alternating current.

In both forms of electrodes of my invention, a continuous leak path is provided from the target portion of the electrode to the bus so that excessive potentials leak off internally in the electrode and are prevented from puncturing the insulation material constituting the dielectric in the capacitive electrode. Accordingly the pressure effects in air or fluid may be established and maintained through a steady, silent discharge from the electrodes of my invention, thereby insuring high efficiency in operation.

In both forms of my invention, the insulated sheath constitutes a dielectric between the high potential bus and the semi-conductive body for the capacitive transfer of energy from the high potential bus to the emitters through the resistance of the semi-conducting body. Interposed in the capacitive path thus provided a high resistance leak path is established in a narrow zone for the leakage of excessive potentials from the semi-conducting body to the bus. The value of the leak path is determined in the form of my invention shown in Figs. 1 and 2 by the conductivity imparted to strip 6 while in the form of my invention shown in Figs. 4 and 5 by the size of the gap between the ends of insulation strip 16 and the conductivity of the semi-conducting material 3 between gap 17 and bus 1. In both forms the conductivity of the leak path is readily controllable by the construction and treatment of the electrode. The insulation material is selected to provide dielectric strength in the transfer of high potential energy from the bus 1 to the emitters 7. The electrode of my invention is fundamentally of the capacity type with relaxation added to control the rate of leak of excessive potentials internally of the electrode.

While I have described my invention in certain of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An electric discharge high potential electrode including a high potential bus, a sheath of insulation material partially surrounding said bus and open at one side thereof, a mass of semi-conducting material surrounding said sheath, emitters carried by said mass of semi-conducting material, and a conductive leak path extending from said mass of semi-conducting material through the said open side of said sheath to said bus.

2. An electric discharge electrode comprising a body of semi-conducting material including a target portion and an emitting portion, a high potential bus, substantially U-shaped means for electrically shielding said high potential bus from said target portion, and an electrically conductive leak path extending intermediate the opposite side portions of said U-shaped means and between said semi-conducting material and said bus.

3. An electric discharge electrode comprising a body of semi-conducting material including a target portion and a discharge portion, a bus extending through said electrode, and means partially surrounding said bus and open at one side thereof and forming a capacitive connection with said semi-conducting material throughout the major portion of said bus and embracing a narrow portion of said body of semi-conducting material at the said open side for forming a conductive connection between said semi-conducting material and said bus throughout a minor area of said bus.

4. An electric discharge electrode including a bus, a strip of insulation material partially wrapped around said bus with the edges of said strip open at one side of said bus, semi-conducting material enclosing said strip of insulation material and said bus, and electric emitters carried by said semi-conducting material.

5. An electric discharge electrode including a bus, a strip of insulation material partially wrapped around said bus with the edges of said strip open at one side of said bus, semi-conducting material enclosing said strip of insulation material and said bus, and electric emitters carried by said semi-conducting material, said electric emitters being aligned with a path between adjacent ends of said strip of insulation material and said bus.

6. An electric discharge electrode comprising a bus, a strip of insulation material wrapped partially around said bus with the edges of said strip disposed in spaced longitudinal alignment, a mass of semi-conducting material surrounding said strip of insulation material and said bus and stream-lined from a target portion adjacent said strip of insulation material to an emitting portion remote from said bus, and a multiplicity of electric emitters carried by said semi-conducting material and aligned substantially with the opening between the adjacent longitudinally extending edges of said strip of insulation material.

7. An electric discharge electrode comprising a target portion and an emitting portion, means for capacitively impressing high potential upon the emitting portion of said electrode and a leak path of high electrical resistance extending between the target portion of said electrode and said means.

8. An electric discharge high potential electrode comprising a target portion and an emitting portion, a high potential bus, means for capacitively transferring electrical energy from the bus to the emitting portion of said electrode, and an internal electrically conducting leak path in said electrode interconnecting said bus with both said target portion and said emitting portion.

9. An electric discharge high potential electrode comprising a target portion and an emitting portion, a high potential bus, means for capacitively transferring electrical energy from the bus to the emitting portion of said electrode, and an electrically conductive leak path extending between said bus and the target portion of said electrode in a position remote from said target portion and directed toward said emitting portion.

10. An electric discharge electrode compris-

ing a target portion and an emitting portion, a bus, a sheath of insulation material surrounding said bus and longitudinally slotted along one side thereof, the longitudinally slotted side of said sheath being directed away from said target portion and toward said emitting portion, and a high resistance path extending through the slotted portion of said sheath.

11. An electric discharge electrode comprising a target portion and an emitting portion, a bus, a sheath of insulation material surrounding said bus and longitudinally slotted along one side thereof, the longitudinally slotted side of said sheath being directed away from said target portion and toward said emitting portion, and a strip of conductive material disposed in the longitudinally extending slot in said sheath, said strip interconnecting said bus and the target and emitting portions of said electrode and forming a high resistance leak path therebetween.

12. An electric discharge electrode of the capacitive type including a bus, a dielectric member partially surrounding said bus, a mass of semi-conducting material enclosing said dielectric member and stream-lined from a target portion adjacent said dielectric member to an electric emitting terminus, and a high resistance conductive path extending between said bus and between the side walls of said dielectric member to said mass of semi-conducting material and forming a leak path between the target portion of said mass of semi-conducting material and said bus.

13. An electric discharge electrode comprising a target portion and an emitting portion, a bus, means for capacitively transferring energy from said bus to the emitting portion of said electrode, and leak means for conductively transferring energy from the target portion of said electrode to said bus in shunt with the said capacitive means.

14. An electric discharge electrode comprising a target portion and a discharge portion, a bus, and a composite capacitive and resistive leak connection between said bus and the target and discharge portions of said electrode, the resistive leak connection extending in a path remote from said target portion and directed toward said emitting portion.

15. An electric discharge high potential electrode including a high potential bus, a sheath of insulation material partially surrounding said bus and open at one side thereof, a mass of semi-conducting material surrounding said sheath, emitters carried by said mass of semi-conducting material, and resistive material extending into the open side of said sheath and establishing electrical connection between said bus and said mass of semi-conducting material, said resistive material having a value of resistance which is greater than the resistance of said mass of semi-conducting material.

16. An electric discharge electrode of the capacitive type including a bus, a dielectric member partially surrounding said bus and forming a gap between the opposite edges of said member, a mass of semi-conducting material enclosing said dielectric member and stream-lined from a position adjacent said dielectric member to an electric emitting terminus, and a resistive leak path extending through the gap formed by said dielectric member and interconnecting said bus with said mass of semi-conducting material, said resistive leak path having a value of resistance which is greater than the resistance of said semi-conducting material.

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