April 29, 1941. W. H. BENNETT 2,239,694

ELECTRIC DISCHARGE ELECTRODES AND CIRCUIT ARRANGEMENTS THEREFOR

Filed Feb. 4, 1939 3 Sheets-Sheet 1

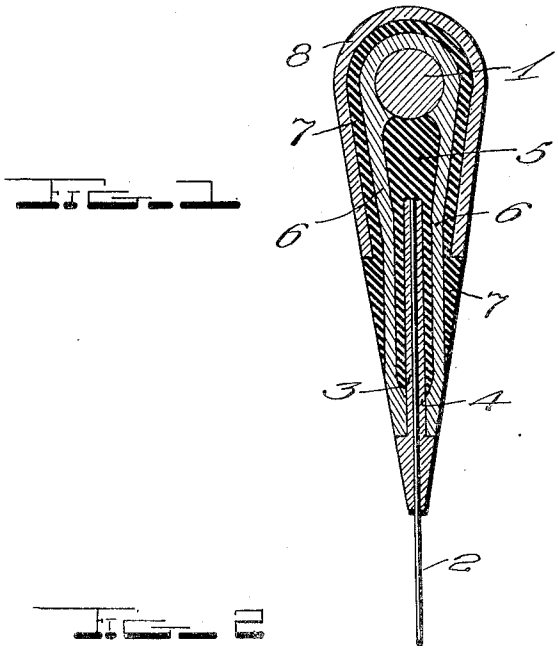
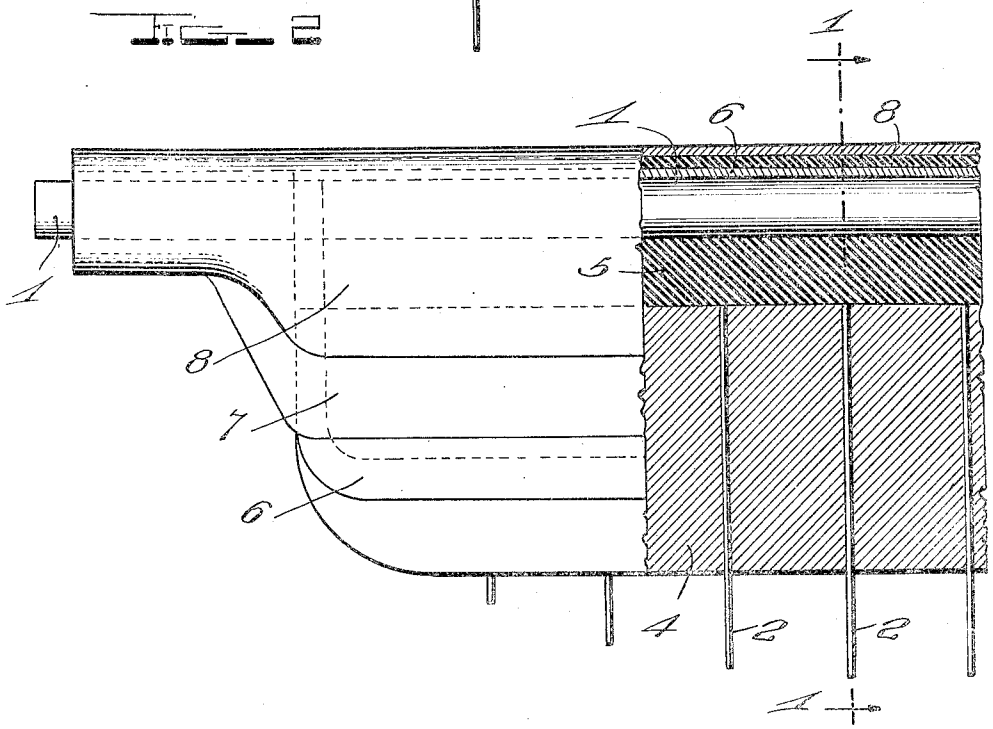


Fig. 1

Fig. 2



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Fig. 3

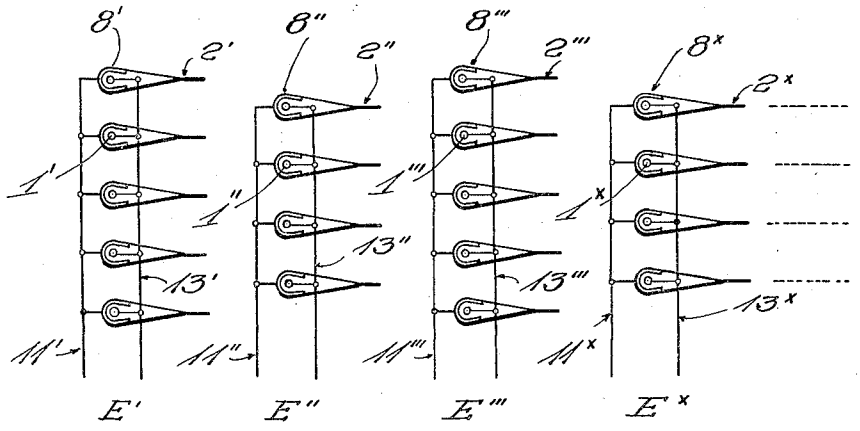
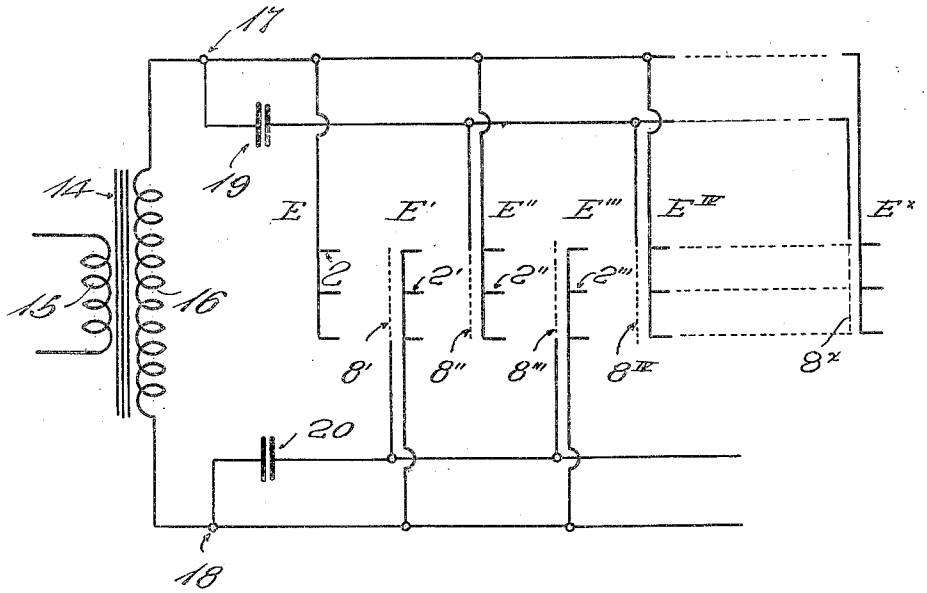


Fig. 4



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FIG. 5

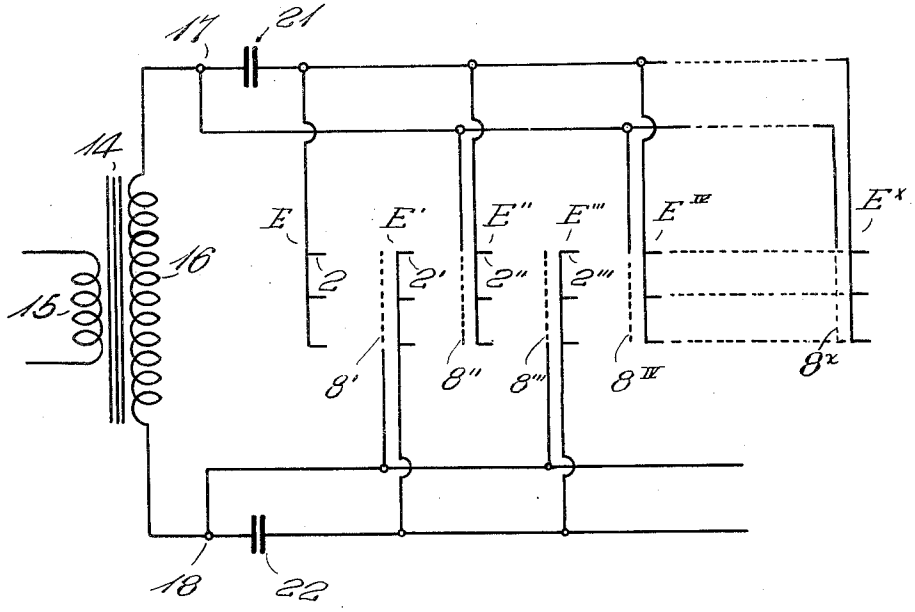
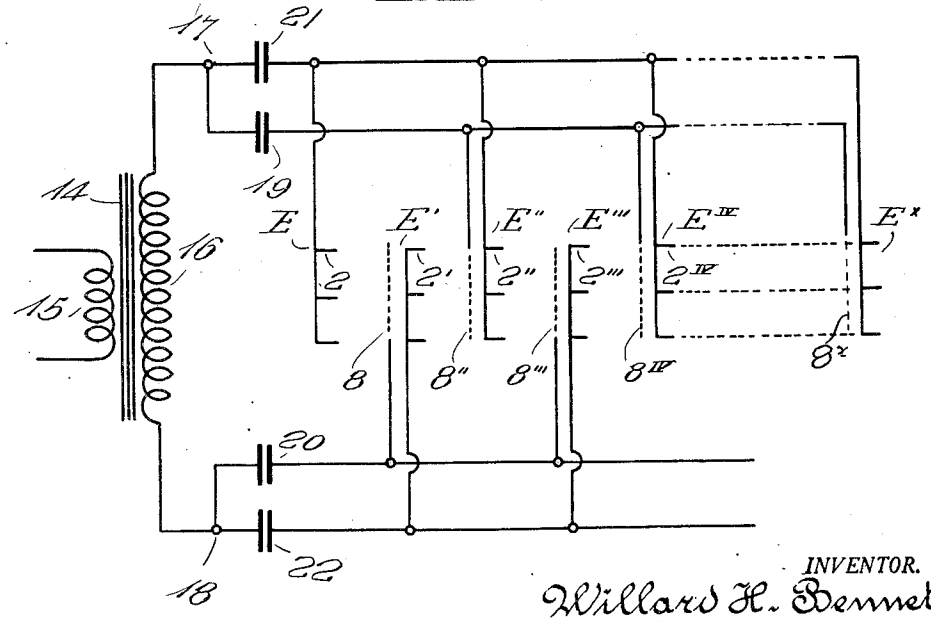


FIG. 6



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UNITED STATES PATENT OFFICE

2,239,694

ELECTRIC DISCHARGE ELECTRODES AND CIRCUIT ARRANGEMENTS THEREFOR

Willard H. Bennett, Newark, Ohio, assignor to Electronic Research Corporation, Newark, Ohio, a corporation of Ohio

Application February 4, 1939, Serial No. 254,727

20 Claims. (Cl. 230—69)

My invention relates broadly to fans and more particularly to an electrical circuit arrangement and construction of electrodes for fans of the electric discharge type.

One of the objects of my invention is to provide a circuit arrangement for fans of the electric discharge type by which improved efficiency in the mass movement of fluid may be obtained.

Another object of my invention is to provide an improved construction of electric discharge electrode for fans.

Still another object of my invention is to provide a construction of combined target and electric discharge electrode for fans in which capacity and resistance are directly incorporated into the structure of the electrode.

A further object of my invention is to provide a combined target and discharge electrode for fans which is composite in character and includes a body structure of semi-conducting material and a capacitive connection thereto extending to the control circuit of the fan.

Other and further objects of my invention reside in an improved circuit arrangement for a fan of the electric discharge type and an improved construction of combined target and discharge electrode for such fans as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a cross sectional view on an enlarged scale taken through one form of target and emitter or discharge electrode embodying my invention on line 1—1 of Fig. 2; Fig. 2 is an elevational plan view partially in section showing the construction of target and emitter or discharge electrode embodying the principles of my invention; Fig. 3 illustrates an arrangement of a multiplicity of banks of such electrodes arranged in a fan assembly in accordance wtih my invention; Fig. 4 is a schematic circuit arrangement showing the electrical connections to the banks of target and discharge electrodes in the fan system of my invention; Fig. 5 shows a modified circuit arrangement with condenser blocked emitter buses as distinguished from the condenser blocked target buses shown in Fig. 4; and Fig. 6 shows a circuit arrangement in which both the emitter buses and the target buses are condenser blocked.

My invention is directed to systems for cascading electrode assemblies in fans of the electric discharge type and contemplates the construction of electrodes from composite semi-conducting material having the required resistivity for a predetermined potential which is impressed thereon, insulation material and conductive material, and incorporating a condenser element therein by which a capacity coupling may be established between a target element and a multiplicity of discharge points or emitters carried by the electrode. The emitters consist of sections of wire held by semi-conducting tapes and uniformly spaced along the tapes. The tapes constitute ballasting strips. The bus that supports the electrode and distributes energy to the emitters has a semi-conducting layer of material which passes around the bus and establishes connection with the semi-conducting tapes at a position adjacent substantially the midsection thereof. A layer of insulation material encases the base ends of the emitting wires and insulatingly separates the base ends of the emitting wires from the bus. This insulation material effectively prevents the internal failure of the electrode by puncture of the high potential directly from the bus to the base ends of the emitters without traversing the semi-conducting layer which electrically connects the emitters with the bus.

I provide a layer of insulation material extending over the semi-conductive transmission layer and over this I provide a metallic shell which performs a number of different functions. The metallic shell serves as a mechanical support and stiffener for the electrode; it performs the function of a target when a multiplicity of similar units are operated in cascade and it coacts as a capacity area with respect to the bus with the layer of insulation material therebetween serving as a dielectric. The special relation of the metallic shell with respect to the bus enables a biasing voltage to be established by which the operation of the electrode is regulated according to the applied alternating current potential. Electrical connection is established from the bus bar to one side of the high potential source. Electrical connection is established from the capacity area or target to the same side of the high potential source. The applied potential is alternating current which may be obtained from a step-up transformer. The potential is impressed across the capacity areas of one bank of emitters and the emitters of the adjacent bank of the emitters, whereby the capacity areas coact as targets in one bank of emitters with respect to the emitting portions of the electrodes of the adjacent bank of emitters. The capacity area serves as a collector and collects more negative charges than posiitve charges at first until ex-

ternal condensers in the circuit to the fan acquire sufficient potential so that the emitters discharge as much positive charge on their positive swing as they discharge negative charge on their negative swing. In this way the operation is self regulating and makes full use of both cycles of the applied alternating current. In lieu of the condenser blocking arrangement for the targets, shown in Fig. 4, I may provide a condenser blocking circuit for the emitting electrodes as shown in Fig. 5, or in some instances, as indicated in Fig. 6, I provide circuit arrangements for blocking both the buses leading to the emitters as well as the buses leading to the targets.

Referring to the drawings in detail, reference character 1 designates the metallic bus which extends longitudinally through the electrode and which is supported at opposite ends in a suitable insulated frame for mounting the electrode in position and establishing electrical connection thereto. The emitters are constituted by sections of wire shown at 2 which are supported in uniform spaced relation between semi-conductive tapes 3 and 4. These tapes may be woven fiber glass material impregnated with a substantially resinous insulation mixed with carbon black. The semi-conductive character of tapes 3 and 4 enables these tapes to serve as ballasting strips in the distribution of current from bus 1 to the emitters 2. The base ends of emitter wires 2 are insulatingly protected from bus 1 by means of insulation material 5 which encases the base ends of emitter wires 2 and is disposed as a separator between the said base ends of emitters 2 and the bus 1. The insulation material 5 may be empire cloth or other material of high insulation properties. The insulation material 5 extends substantially midway of the width of the tapes 3 and 4. To provide for the distribution of potential to the emitter wires 2, I provide a layer of semi-conductive material 6 passing around bus 1 and electrically connecting therewith and extending to positions adjacent substantially the midsections of the tapes 3 and 4. The semi-conductive material 6 establishes electrical connection with the tapes 3 and 4 and is pressed into intimate union therewith for building up the stream-lined contour of the discharge electrode. The semi-conductive material 6 may be woven fiber glass material impregnated with a substantially resinous insulation mixed with carbon black. The semi-conductive layer 6 is substantially covered by a layer of insulation material 7 and pressed into the stream-lined contour of the structure of the electrode. Layer 7 may be empire cloth or other insulation material of high dielectric properties. A backing plate or metallic target 8 is rolled over the rear of the insulation layer 7 forming a substantial mechanical binder for the laminated layers of the electrode and constituting a target with respect to wire-like emitters of adjacent electrodes in cascaded systems. Target 8 provides a capacity area separated by dielectric 7 with respect to bus 1. In this way the discharge electrode includes a condenser formed integrally with the structure thereof. The discharge electrode also includes a resistance established by the path through layer 6 and tapes 3—4 to the emitters 2 between metallic bus 1 and the emitters 2 of the electrode.

In Fig. 3 I have shown a multiplicity of banks of electric discharge electrodes constructed and arranged in accordance with my invention. I have illustrated the banks of electrode assemblies at E', E'', E'''—E$^{\times}$. The banks of electrodes have their individual electric discharge members connected in parallel. That is to say, the metallic strips 8' forming the rear edges of the stream-lined electrodes are connected in parallel and the buses 1' which extend through the electric discharge electrodes are connected together. Conductor 11' is represented connected to each of the strips 8' while conductor 13' is represented as connected with each of the bus bars 1'. The emitters of the discharge electrodes of bank E', shown generally at 2', are directed toward the metallic strips 8'' of the bank of discharge electrodes E''. The metallic strips 8'' of the electrodes in bank E'' are connected together through conductor 11''. The semi-conductive portions of the discharge electrodes convey energy to the emitters 2'' from the bus bars 1'', energized through bus bar connector 13'' which interconnects each of the bars 1''. The emitting portions of the emitters 2'' of the discharge electrodes in bank E'' coact with the metallic strip portions 8''' of the bank of electrodes E'''. Conductor 11''' connects metallic strips 8''' together in parallel. The semi-conductive portions of the discharge electrodes in bank E''' supply the points 2''' with energy from conductor 13''' which connects with bus bars 1'''. Similarly, the emitters 2''' of the group of electrodes E''' coact with the targets or rear strips of the next adjacent group of electrodes and so on in cascade through the group of electrodes E$^{\times}$. Conductor 11$^{\times}$ interconnects the metallic target strips 8$^{\times}$ of the several electrodes and conductor 13$^{\times}$ interconnects bus bars 1$^{\times}$ which connect with the emitters 2$^{\times}$ of the several electrodes in the electrode assembly E$^{\times}$. Each bank of electrodes has two connecting leads as shown and these leads connect to the high potential source as illustrated diagrammatically in Fig. 4.

The power transformer for the fan is indicated generaly at 14 having primary winding 15 adapted to be connected with a suitable source of alternating current and secondary winding 16 having terminals 17 and 18. The electrode assemblies are connected in alternate arrangement with the terminals 17 and 18 of the power transformer as shown. That is to say, banks of electrodes, E, E'', E^{iv}—E$^{\times}$ are connected with the end of secondary winding 16, represented by terminal 17, while group of electrodes E', E''', etc. intermediate the aforesaid groups of electrodes are connected to the end of secondary winding 16, represented by terminal 18. Condensers 19 and 20 are disposed between the power terminals and the collectors or targets or metal strips of the respective groups of electrodes. That is to say, condenser 19 is interposed between metallic strip 8'' of group of electrodes E'' and metallic strip 8^{iv} of group of electrodes E^{iv} and power terminal 17. Similarly the collectors, targets or metallic strips represented at 8' and the collectors, targets or metallic strips 8''' are connected in parallel and through condenser 20 with terminal 18 of secondary winding 16 of power transformer 14. The groups of electrodes are alternately arranged so that one group of electrodes is subjected to maximum voltage of one polarity while the adjacent group of electrodes is being subjected to maximum voltage of an opposite polarity for effecting a discharge therebetween.

The metallic strips, targets or collectors 8', 8'', 8''', 8^{iv}, serve as collectors and collect more negative charge than positive charge at first until the condensers 19 and 20 acquire sufficient poten-

tial so that the emitters emit as much positive charge on their positive swing as negative charge on their negative swing. In this way the operation is self regulating and full use is made of both half cycles of the applied alternating current. The emitters 2' of group of electrodes E' coact with metal strip 8'' of group of electrodes E'' as targets. Similarly, emitters 2'' of group of electrodes E'' coact with metal strips 8''' of group of electrodes E''' as targets. Discharge portions 2''' of group of electrodes E''' coact with metal strips 8^{iv} of group of electrodes E^{iv} serving as targets and so on for the remainder of the assemblies of the several groups of electrodes.

The banks of electrodes are alternately arranged and connected to opposite sides of the alternating current source. The emitters of each bank are directly connected to the source and the target of that bank connected to the same side of the source but blocked with respect to D. C. potential through a condenser.

In Fig. 4 I have shown a circuit arrangement in which the buses leading to the target electrodes are condenser blocked but it will be understood that I may utilize a circuit in which the buses leading to the emitters are condenser blocked as shown in Fig. 5, or in which both the buses leading to the emitters as well as the buses leading to the target electrodes are condenser blocked as shown in Fig. 6.

In the circuit arrangement of Fig. 5, the electrodes are arranged in a manner identical to the arrangement described in connection with Fig. 4 except that the condensers 19 and 20 are omitted in the leads which connect with the target electrodes. In lieu of these connections I provide direct connections from the opposite ends of secondary winding 16 to the alternately arranged target electrodes from terminals 17 and 18. The emitting electrodes 2, 2', 2'', 2''', 2^{iv} are alternately connected to buses which connect through condenser blocks 21 and 22 as shown to opposite terminals 17 and 18 of secondary winding 16 as shown.

In Fig. 6 I have shown the electrode assemblies with the alternately arranged emitting electrodes condenser blocked through condensers 21 and 22, respectively, and the alternately arranged target electrodes condenser blocked through condensers 19 and 20.

In describing the structure of the laminated electrode, I have referred to the use of particular types of insulation material but I desire that it be understood that various kinds of insulation may be used and that my invention is not limited to the selection of the materials specified. In addition to the fiber glass or empire cloth referred to I may use treated rayon, cotton, silk, cloth, fibrous resinous materials and other types of insulation materials. Various mixtures may be used for impregnating any of the insulation materials which may be selected for rendering such materials semi-conductive.

The arrangement of electrodes set forth herein has been found highly desirable in cascade arrangements in fans for developing wind pressures by electric discharge. However, I realize that other modifications in structure and arrangements of electrodes may be made and I intend no limitations upon my invention 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. A fan of the electric discharge type comprising a multiplicity of groups of electric discharge electrodes arranged in cascade, each electrode of each group of discharge electrodes including a charge collecting portion and a charge emitting portion, and insulation means between said charge collecting portion and said charge emitting portion, the charge emitting portion of each electrode of one group of electrodes coacting with the charge collecting portion of an electrode of the adjacent group of electrodes.

2. A fan of the electric discharge type comprising a multiplicity of groups of electric discharge electrodes arranged in cascade, each electrode of each group of discharge electrodes including a charge collecting portion and a charge emitting portion, and insulation means between said charge collecting portion and said charge emitting portion, the charge emitting portion of each electrode of one group of electrodes coacting with the charge collecting portion of an electrode of the adjacent group of electrodes, and each of said electrodes including said insulation means being stream-lined in contour for offering minimum obstruction to the flow of fluid around the electrodes.

3. An electric discharge electrode for fans comprising a stream-lined structure having a charge collecting portion and a charge emitting portion, and means for capacitively relating the charge collecting portion to the charge emitting portion.

4. An electric discharge electrode for fans comprising a stream-lined member having a charge collecting portion and a charge emitting portion, and a dielectric portion separating said charge collecting portion from said charge emitting portion.

5. An electric discharge electrode for fans comprising a stream-lined member constituted by a longitudinally extending bus bar, a semi-conducting body extending around one side of said bus bar, a dielectric body extending over said semi-conducting body, and a capacity area carried by said dielectric body and shaped to conform with the stream-lined structure of said discharge electrode.

6. An electric discharge electrode for fans comprising a stream-lined member constituted by a longitudinally extending bus bar and shaped layers of semi-conducting material and dielectric material surrounding said bus bar, emitters supported by said semi-conductive material, and a charge collecting plate carried by said dielectric body.

7. An electric discharge electrode for fans comprising a stream-lined member constituted by a longitudinally extending bus bar and laminated layers of semi-conducting material and dielectric material surrounding said bus bar, electric emitters supported by said semi-conductive material and a curved plate carried by said dielectric body and conforming with the contour of said stream-lined member.

8. Electric discharge means for fans comprising a multiplicity of groups of electrodes, each electrode having a charge emitting portion and a charge collecting portion with the emitting portion of the electrodes of one group coacting with the charge collecting portion of the electrodes of an adjacent group, means insulating the charge collecting portion from the charge emitting portion, and means for impressing a source of potential between the charge emitting portion of said electrode of one group of electrodes and the charge collecting

portion of each electrode of an adjacent group of electrodes.

9. Electric discharge means for fans comprising a stream-lined member including a charge collecting portion and a charge emitting portion, insulating means separating said portions, a source of potential, a capacitive connection between one side of said source of potential and said charge collecting portion, and a direct electrical connection between the same side of said source of potential and said charge emitting portion.

10. A fan comprising a multiplicity of groups of electrodes, each electrode of each group of electrodes including a charge collecting portion and a charge emitting portion with the charge emitting portions of the electrodes in one group coacting with the charge collecting portions of the electrodes in the adjacent group, a source of alternating current, electrical connections from opposite ends of said source to the emitting portions of adjacent groups of electrodes, and connections from the collecting portions of said groups of electrodes respectively to the corresponding terminal of said source of potential, said last mentioned connections each including a condenser.

11. Discharge electrodes for fans comprising in combination a supporting bus, a semi-conductive tape-like member, wire-like emitters mounted in spaced relation with their axes normal to the longitudinal axis of said tapelike member, insulation means embracing the ends of said wire-like members adjacent the supporting bus and insulatingly separating the said wire-like emitters from said bus, a semi-conductive member embracing said bus and the aforesaid insulation means electrically and mechanically connected to said semi-conductive tape-like member, a dielectric member substantially enveloping said semi-conductive member, and a metallic member embracing said dielectric member.

12. Discharge electrodes for fans comprising in combination a supporting bus, a semi-conductive tape-like member, wire-like emitters mounted in spaced relation with their axes normal to the longitudinal axis of said tape-like member, insulation means embracing the ends of said wire-like members adjacent the supporting bus and insulatingly separating the said wire-like emitters from said bus, a semi-conductive member embracing said bus and the aforesaid insulation means electrically and mechanically connected to said semi-conductive tape-like member, a dielectric member substantially enveloping said semi-conductive member, a metallic member embracing said dielectric members, said metallic member being stream-lined and said dielectric and semi-conductive member and insulation means conforming in contour therewith and tapering to an edge portion constituted by said tape-like member through which said wire-like emitters extend.

13. An electric discharge electrode comprising in combination with a supporting bus, a layer of semi-conductive material surrounding said bus, a multiplicity of emitters, semi-conductive material supporting said emitters, and means bonding said last mentioned semi-conductive material to the semi-conductive layer.

14. A discharge electrode comprising in combination a bus, superimposed layers of semi-conductive, dielectric and conductive material embracing said bus, a plurality of emitters, semi-conductive material supporting said emitters, and a mechanical and electrical connection between the aforesaid semi-conductive layer and said last mentioned semi-conductive material for establishing an electrical path between said bus and said emitters.

15. A discharge electrode comprising in combination a bus, superimposed layers of semi-conductive, dielectric and conductive material embracing said bus, a plurality of emitters, semi-conductive material supporting said emitters, a mechanical and electrical connection between the aforesaid semi-conductive layer and said last mentioned semi-conductive material for establishing an electrical path between said bus and said emitters, and insulation means disposed between said bus and the ends of said emitters carried by said semi-conductive material.

16. A fan comprising a multiplicity of groups of electrodes, each electrode of each group of electrodes including a charge collecting portion and a charge emitting portion with the charge emitting portions of the electrodes in one group coacting with the charge collecting portions of the electrodes in the adjacent group, a source of alternating current, electrical connections from opposite ends of said source to the emitting portions of adjacent groups of electrodes, and connections from the collecting portions of said groups of electrodes respectively to the corresponding terminal of said source of potential, said first mentioned connections each including a condenser.

17. A fan comprising a multiplicity of groups of electrodes, each electrode of each group of electrodes including a charge collecting portion and a charge emitting portion with the charge emitting portions of the electrodes in one group coacting with the charge collecting portions of the electrodes in the adjacent group, a source of alternating current, electrical connections from opposite ends of said source to the emitting portions of adjacent groups of electrodes, and connections from the collecting portions of said groups of electrodes respectively to the corresponding terminal of said source of potential, each of said electrical connections including an electrical condenser.

18. Electric discharge means for fans comprising a stream-lined member including a charge collecting portion and a charge emitting portion, insulating means separating said portions, a source of potential, a direct electrical connection between one side of said source of potential and said charge collecting portion, and a capacitive electrical connection between the same side of said source of potential and said charge emitting portion.

19. Electric discharge means for fans comprising a stream-lined member including a charge collecting portion and a charge emitting portion, insulating means separating said portions, a source of potential, a capacitive electrical connection between one side of said source of potential and said charge collecting portion, and a separate capacitive electrical connection between the same side of said source of potential and said charge emitting portion.

20. An electric discharge system comprising a multiplicity of groups of electrodes, each electrode of each group of electrodes including a charge emitting portion and a charge collecting portion, the charge collecting portions of one group of electrodes coacting with the charge emitting portions of an adjacent group of elec-

trodes, a source of alternating current, electrical connections from opposite ends of said source to the emitting portions of adjacent groups of electrodes, and connections from the respective ends of said source to the charge collecting portions of said adjacent groups of electrodes, and blocking condensers disposed in series with the individual connections between said source and the respective charge emitting portions and charge collecting portions of said electrodes.

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