March 31, 1942. W. H. OTTO 2,277,712

ELECTRIC DISCHARGE ELECTRODE

Filed Feb. 4, 1939

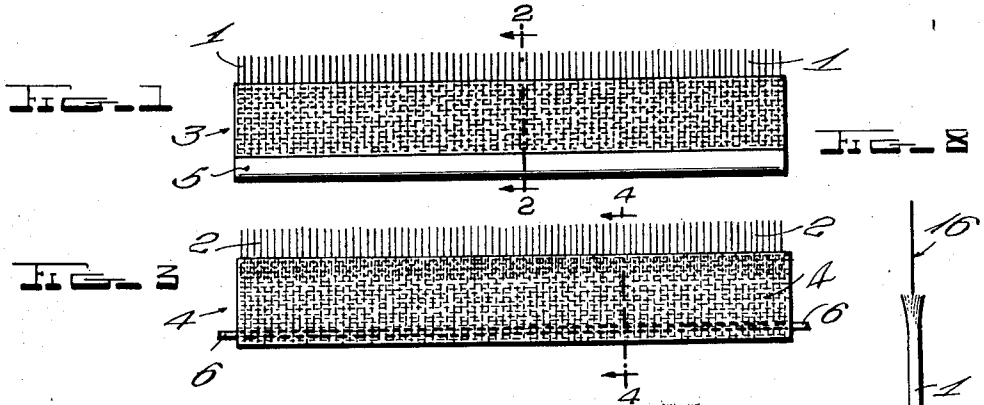


Fig. 1

Fig. 8

Fig. 3

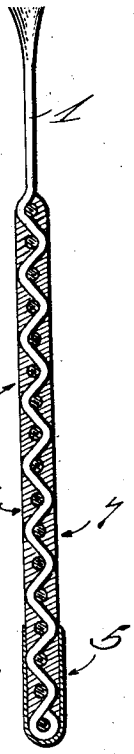


Fig. 2

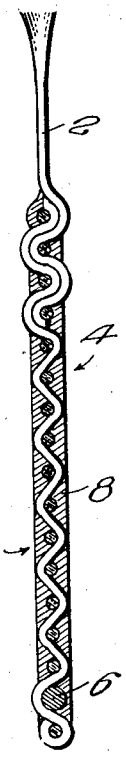


Fig. 4

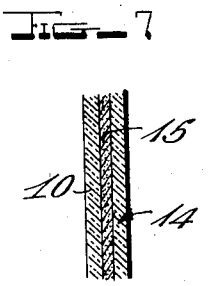


Fig. 7

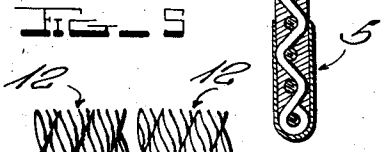
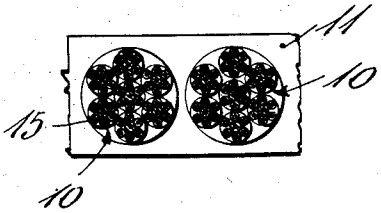


Fig. 5



Fig. 6



INVENTOR.

William H. Otto,

BY John B. Brady

ATTORNEY.

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ELECTRIC DISCHARGE ELECTRODE

William H. Otto, Newark, Ohio, assignor to Slayter Electronic Corporation, a corporation of Ohio

Application February 4, 1939, Serial No. 254,723

12 Claims. (Cl. 230—69)

My invention relates broadly to electric discharge systems and more particularly to an improved construction of multipoint discharge electrode.

One of the objects of my invention is to devise a multipoint high potential discharge electrode produced by impregnating electrically non-conducting or semi-conducting materials with colloidal suspensions of electrically conducting materials.

A further object of my invention is to provide a multipoint discharge electrode formed from fine fibers and having a predetermined degree of ballast resistance for insuring the operation of the fibers as emitters in a high potential system without arcing or sparking under conditions of high potential operation.

Another object of my invention is to provide arrangements of electrically emitting points formed from thread-like members having hollow cores filled with a semi-conducting material.

A further object of my invention is to provide a construction of emitter formed from thread-like organic material suitably treated or in which materials have been incorporated to impart required electrical conductivity to the fibers.

A still further object of my invention is to provide a construction of fibrous electrode as an emitter for coaction with a target electrode in a high potential discharge system in which the fibers are woven in the nature of cloth or tape with the ends directed toward the target electrode and constituting a multiplicity of emitting points.

A further object of my invention is to provide a construction of high potential multipoint emitter formed from impregnated glass fibers incorporating ballast resistance in intimate association with the glass fibers and in which the glass fibers constitute emitters which are substantially uniform in diameter having an average diameter of not more than .0004 inch.

Other and further objects of my invention will be understood more fully from the specification hereinafter following by reference to the accompanying drawing, in which:

Figure 1 is a plan view of one form of discharge electrode embodying my invention; Fig. 2 is an enlarged transverse sectional view taken on line 2—2 of Fig. 1; Fig. 3 is a plan view showing a modified form of discharge electrode embodying my invention; Fig. 4 is an enlarged cross sectional view taken on line 4—4 of Fig. 3; Fig. 5 is an elevational view on a greatly enlarged scale partially broken away and shown in section illustrating an emitting electrode formed from woven strands of thread-like members each having a hollow core filled with a conducting material; Fig. 6 is a transverse section through the thread-like strands on line 6—6 of Fig. 5; Fig. 7 is a longitudinal section of a thread-like strand treated in accordance with my invention; and Fig. 8 shows a form of my invention in which a row of single fibers formed from multiple fiber strands distributed along the tape constitutes the emitter.

My invention provides a construction of multipoint high potential discharge electrode which is capable of rapid production on a quantity basis at relatively low cost. I employ in the manufacture of the high potential emitters, textile threads, cotton, rayon, celanese, resinoids or glass fibers which are of substantially uniform diameter and have an average diameter of not more than .0004 inch. When the electrodes are formed from glass fibers, the glass from which the fibers are drawn has an electrically conducting material incorporated therein while the glass is in the molten state; or the glass fibers may be subsequently treated with a bonding or fixating agent which provides a mono-molecular film over the fiber through which a direct and strong wetting of the fiber surface may be effected by either the colloidal material or a dispersion medium or both. The fibers may thus be impregnated with a colloidal suspension of electrically conducting material such as graphite, carbon black, etc., which introduces required ballast resistance in the fibers when functioning as emitters for reducing surges and eliminating arcing and sparking under high potential conditions. The fibers may be woven into a tape with their projecting ends exposed forming the emitters with respect to a target electrode. The woven tape of the extremely fine thread-like fibers is subjected to treatment at high temperatures and under the action of chemical baths in effecting the required colloidal suspensions for providing the required ballast resistance with respect to the emitters.

The discharge electrodes of my invention may be used in association with target electrodes which are perforate in character or formed for example by a grid-work of metal rods where the discharge electrode is connected to one side of a high voltage source and the target electrode is connected to the opposite side of the high voltage source. The ends of the fibers constituting the emitters are sheared and directed toward the target electrode. Voltages of from 10,000 to 20,000 volts are employed but the spacial rela-

tion of the discharge electrode with respect to the target and the potential gradient along the discharge electrode is so controlled that arcing or sparking or detrimental surges are prevented. The electric stress which is established in the area between the emitters and the target creates differences in pressure in the air, causing mass movement of air from the sheared fiber ends of the emitters through the coacting perforate target. Among the advantages of this type of emitter in point-discharge devices are the availability of thousands of points in a compact arrangement and the fact that in operation of the device the fibers tend to fan out, thereby exposing each fiber end to the electric field.

In the production of the fibers constituting the emitters in the system of my invention, the fibers may be coated with a substance immediately when they are drawn or before they are spooled. If the fibers are sprayed with a colloidal suspension of an electrically conducting material, such as colloidal graphite, or are drawn across a wiper which applies colloidal suspension of an electrically conducting material, such as colloidal graphite, to the fiber then each fiber is made electrically conducting to any degree depending on the concentration of the applied conducting material. These fibers may then be bound together as, for example, being woven into a tape as hereinbefore described and the fiber ends used as points in point-discharge devices such as fans, rectifiers, inverters, precipitators, catalytic means in chemical reactions, and other devices where stabilized electric discharge is a factor. An electrically conducting material may be incorporated into glass or other mineral non-conductors or incorporated into any material which may be drawn into fibers, this process making the fibers electrically conducting to a degree dependent upon the concentration of the electrically conducting material in the final product. These fibers may be bound together, the fiber ends serving as points in point-discharge devices.

By the technique of vacuum sputtering, the fibers of an electrically non-conducting material or the fiber ends of an electrically non-conducting or semi-conducting material may be coated such as to give the fibers any desirable degree of conductivity. As in the instances heretofore described, these fibers may be bound together and the fiber ends serve as points in point-discharge devices. Any electrically non-conducting material, fibrous by nature or which may be drawn into fibers, may be made electrically conducting to any desired degree by impregnating the fibers with a colloidal suspension of a conducting material or incorporating an electrically conducting material into the product before the fibers are drawn. These fibers may then be bound together or woven into a tape, one edge of which may then be sheared in any desired manner to expose the fiber ends and these fiber ends will serve as points for use in point-discharge devices such as fans, rectifiers, etc. The tape, while initially flexible, is rendered substantially rigid upon impregnation and serves as a support for the fibers constituting the discharge points. The tape may be readily supported in insulated relation to the target. An electrically non-conducting material which has been made electrically conducting by incorporating into it an electrically conducting material, or, if it be fibrous, by impregnating it with a colloidal suspension of an electrically conducting material, or by coating it (painting or dipping or spraying) with a colloidal suspension of an electrically conducting material, may then be used as a ballast resistance for the thread-like discharge points in point-discharge devices such as fans, rectifiers, etc.

An example of this type of emitter is one in which the thread-like members such as 1 and 2 in Figs. 1–2 and Figs. 3–4 extend from one edge of a fiber tape 3, in Figs. 1–2 or from 4 in Figs. 3–4. The tape is formed from woven fibers of thread-like members and may then be painted with or dipped into a colloidal suspension of carbon black in cellulose acetate, the solvent used being acetone. The solvent is evaporated and a degree of electrical conductivity is obtained between each of the thread-like points and the metallic channel-like member 5 shown in Figs. 1 and 2 or the bus 6 shown in Figs. 3 and 4, the degree of conductivity being dependent upon the concentration of the carbon black in the cellulose acetate.

In Fig. 1 of the drawing, the discharge electrode is shown formed from a tape of woven fibers indicated at 3, and in cross section in Fig. 2 taken on line 2—2 of Fig. 1. The tape 3 may be impregnated with a colloidal suspension of an electrically conducting material which I have indicated generally at 7. Fig. 2 is an enlarged cross sectional view on line 2—2 of Fig. 1 which more clearly illustrates my invention. The electrically conducting material fixes the resistance of the discharge electrode so that the potential gradient thereof is established for any applied potential at the same time that substantial rigidity is imparted to the electrode. One longitudinally extending edge of the tape 3 is clamped by metallic channel-like strip 5 providing means for establishing electrical connection with the tape. The opposite edge of the tape is sheared, thus exposing the fiber ends which serve as the discharge points in point-discharge devices such as fans, rectifiers, etc.

In Fig. 3 I have shown a form of my invention in which the fiber tape 4 has emitting thread-like members 2 sewed or woven directly into one edge of the tape 4 for forming the emitting points. Fig. 4 is taken on section line 4—4 of Fig. 3 and shows in exaggerated form the structure of the emitters in the arrangement of Fig. 3. The weaving of the fibers forming the tape is relatively fine and close and the thread-like members 2 are correspondingly close together and form hundreds of emitting points along the edge of the tape. The fiber tape 4 has a bus bar 6 of substantially rigid section extending longitudinally of the tape providing a rigid support and electrical connection for the electrode. A coating 8 of semi-conducting material extends over tape 4 between bus bar 6 and the emitting thread-like members 2.

In the forms of my invention employing glass fibers as the thread-like discharge points, the tape is formed from glass fibers which have average diameters of not more than .0004 inch. The glass fibers are woven as shown in Figs. 3–4 to form a tape which is baked at a temperature of 400° to 500° C. in order to volatilize such substances as waxes or oils from the surface of the fibers. This material is then cleaned in a solution of chromic acid in an evacuated vessel, heat being applied to assist in the penetration of the acid to each fiber. The material is next washed thoroughly with water, one wash being conducted in an evacuated vessel. The fiber cloth is then

treated with aluminum stearate in petroleum spirits. The fiber glass cloth is then dried in an oven at 100° C. to 150° C. The clean dry material is impregnated in an evacuated vessel with a colloidal suspension of graphite in water (Aquadag of Acheson colloids), heat being used to assist the impregnation. The product is dried in an oven where the temperature is gradually raised to 125° C. and finally is subjected to a heat treatment at 400° C. One edge of the cloth or tape may be sheared either before or after impregnation thereby exposing the fiber ends to produce the form of my invention set forth in Figs. 1 and 2.

For predetermined spacial relations between emitters and the target elements for predetermined potentials, the quantity and resistivity of the impregnated material may be selected for securing operation of the emitters without surging and without sparking or arcing.

The cross sectional views taken through the tapes are each greatly exaggerated in size in order to more adequately explain my invention. The fibers **1** in Figs. 1 and 2 and the fibers **2** in Figs. 3 and 4 have not been shown in exact proportions or relative numbers but have been illustrated sufficiently to make the principles of my invention clear. For example, in the arrangement shown in Figs. 1 and 2 hundreds of fibers are fanned out to form the emitters of my invention.

It should be understood that my invention is not limited to the use of glass fibers. I may employ virgin cotton tapes in which the cotton has never been treated and from which the natural cotton oils have been leached. Cotton tapes have a peculiar advantage in that impregnating such fibers with colloidal graphite suspended in various liquid media leads to the loading of the hollow core of the cotton fibers with microscopic graphite pencils. Such an impregnation protects against the source of failure which most other fibers are subject to, namely, the scaling off of the graphite and consequent disruption of the channels of conduction along the fibers.

In Fig. 5, I have shown in greatly enlarged scale an electrode formed from thread-like members as heretofore explained. The thread-like members are indicated generally at **10** projecting beyond the edge of the woven body of the said members indicated at **11**. Thousands of discharge points are presented by the thread-like members extending from the tape as the strands of thread are twisted with respect to each other forming a compact bundle of discharge points as illustrated in Figs. 5 and 6. The projecting ends of the thread-like members are sheared as indicated at **12**. The bundles of thread-like members are uniformly spaced along the edge of the woven body **11**, forming a multiplicity of emitting points. Each strand of the thread-like members **10**, as shown in Fig. 7, has a hollow core **14** which is filled with a semi-conducting material **15**, providing the required ballast resistance for the emitting point. The advantage of the thread-like emitters of the type illustrated in Figs. 5, 6 and 7 is that the semi-conducting material **15** is retained interiorly of the thread-like members and does not chip or shear off as is the case with emitting points having the electrically conducting material impregnated over the surface thereof. The resistance of the discharge points is thus permanently fixed. The thread-like members and the woven tape from which the thread-like members extend is suitably impregnated so that the ends of the thread-like members are rendered rigid and extend toward the target for discharge at high potential with respect thereto without arcing or sparking.

Electrostatic stress may develop between adjacent fibers detrimental to the firing of the fibers with respect to the target. By cutting off all of the fibers except a single strand in the group of fibers, as shown in Fig. 8, I provide a single firing point which is not subjected to electric strain from the fields established about adjacent fibers.

Referring to Fig. 8 I have shown a view of a form of my invention in which the strands of fibers **1** have been trimmed so that only one fiber **16** protrudes and acts as the emitting member for that group of strands. The drawing shows only one group of strands trimmed in this manner, but an emitter constructed in accordance with this modification of my invention consists of a row of strands each trimmed so that there will be a row of isolated fibers. It has been found that if the single fibers are located too close to each other, that is approximately one tenth of a millimeter to one millimeter, the emission characteristic is not that of single fine fibers but more nearly approaches the characteristic of a much coarser fiber structure. In order to attain the performance possible with this degree of fineness of fiber, the single fibers are separated from each other.

I have heretofore explained that the fibrous emitters may be formed from material where the colloidal conductive content is embodied in the fibrous substances before the drawing of fibers. Many substances other than glass may be employed from which to form the fibers constituting the emitters. Such substances as rayon, celanese and resinoids, such as polystyrene may be utilized. The advantage of employing such substances with the colloidal conducting materials incorporated therein previous to the drawing of the fibers is that most of the conducting material is in the interior of such fibers and therefore is not subject to scaling.

While I have referred to fibers of certain diameters I desire that it be understood that in general the finer the fiber the more smoothly the fiber functions as an electric emitter. No limitations as to size are intended to be placed upon the fibers employed in the system of my invention.

I have described my invention in certain preferred embodiments, but 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 electrode comprising a tape of non-conductive woven material, emitting points carried by said tape and projecting from an edge thereof at spaced intervals, and a coating of conducting material on said tape for imparting mechanical rigidity and electrical conductivity to said tape.

2. An electric discharge electrode comprising an impregnated semi-conductive tape of woven material, emitting points carried by said tape along one edge thereof, and a metallic member extending along the opposite edge thereof and forming an electrical connection for impressing

high electric potential on the emitting points through said tape.

3. An electric discharge electrode comprising an impregnated semi-conductive tape of woven material, emitting points coextensive with one edge of said tape, and an electrical conductor extending longitudinally of the other edge of said tape for providing an electrical connection for impressing high electric potential upon said emitting points.

4. An electric discharge electrode comprising an impregnated semi-conductive woven tape, a multiplicity of emitting points mounted at spaced intervals along one edge of said tape, and means for establishing an electrical connection with said tape for impressing high electric potential on said emitting points with the semi-conductive tape providing a ballast resistance for said emitting points.

5. An electric discharge electrode comprising a tape of semi-conductive woven threads, a multiplicity of emitting points woven at spaced intervals into one edge of said tape, and means for establishing an electrical connection adjacent the opposite edge of said tape for impressing a high electric potential on said emitting points.

6. An electric discharge electrode comprising a tape of impregnated semi-conductive thread-like members, a multiplicity of electric discharge points extending at spaced intervals along one edge of said tape, and means for establishing an electrical connection with the opposite edge of said tape.

7. An electric discharge electrode comprising an impregnated semi-conductive woven tape, a plurality of emitting points coextensive with one edge of said tape, and an electrical connecting member coextensive with the opposite edge of said tape for establishing connection with a source of high electric potential for effecting emission of energy from said emitting points.

8. An electric discharge electrode comprising a tape, a multiplicity of emitting points coextensive with one edge of said tape, an electrical connecting member coextensive with the opposite edge of said tape, and a coating of semi-conducting material on said tape for determining the effective resistance of the tape between the electrical connection thereto and the emitting points.

9. An electric discharge electrode comprising an impregnated semi-conductive tape formed from woven members with the ends of said members fanned outwardly along one edge of the tape, and a metallic member extending longitudinally of the opposite edge of the tape and providing a connection to a source of high potential, the outwardly flared ends of said members constituting emitting points.

10. An electric discharge electrode comprising a tape of woven material, electric discharge points mounted in one edge of said tape, and a metallic member mounted along the other edge of said tape, and a coating of electrically conducting material on said tape extending between said metallic member and said electric discharge points.

11. An electric discharge electrode comprising a strip of material formed by interwoven thread-like members, said thread-like members projecting from one edge of said tape and forming electric emitting points, a metallic member forming an electrical connection with the opposite edge of said tape, and a coating of conducting material on the surface of said tape between said metallic member and the electrically emitting points formed by said thread-like members.

12. An electric discharge electrode comprising a multiplicity of strands of interwoven fiber members, groups of fiber members projecting from one edge of said interwoven fiber members, certain of the fibers in each of said groups being trimmed in length with a strand of the group projecting beyond the limits of the associated fibers of the group and constituting an electric emitter.

WILLIAM H. OTTO.