No 7.

"Electrokinetic Apparatus"

Docket No. 8780

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ELECTROKINETIC APPARATUS

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COMMENTS:

In all of the applicant's former patent disclosures for " producing relative movement between an electrode structure and the ambient fluid medium, " metal electrodes are specified either directly or indirectly. In most cases, the electrodes have been referred to as "electrically conducting". Sometimes these electrodes are coated with various materials such as cesium, thorium oxide or the like, to improve emissivity. In one instance, (Patent 793,893, EHD Fluid Pump) the smaller of the two "principal" electrodes is made electrically-resistive, but this resistivity is indicated only for the smaller of the two electrodes (the pointed emitter).

The first reference to electrically-resistive material for the larger electrode appears in Patent Application 662,105, "Fluid Flow Control System", filed August 21, 1967.

Recent experiments covering the use of electrically-resistive materials for the large electrodes (the array of vanes) has revealed surprising results. This change has made it possible to obtain air velocities and sound densities several times that obtained from the use of bare-metal electrodes. These improved results are obtained for two reasons:

1. Increased electric density across the air gap without the danger of spark breakdown, hence the use of increased voltage gradients, and

2. Increased divergence of the electric field and the extension of the field (between the vanes) to the far edges of said vanes.

In application 662,105, these advantages were known and the specification and claims included the use of resistive materials in the fabrication of the larger electrodes, but that patent application referred specifically to a three-electrode (triode) structure rather than a two-electrode (diode) structure. It is the purpose of the present application to cover specifically the use of electrically-resistive materials in the fabrication of the vanes in the diode.

EARLIER PATENT COVERAGE:

In Bennett Patent No. 2,327,588 the use of an elongated (filiform) electrode is taught. This disclosure (now in public domain) may tend to compromise certain of the applicant's coverage in Patent 2,949,550 (currently assigned to Decker). If, upon careful investigation, this is found to be the case, that part of the Decker-held patent may also be considered to be in the public domain. The purpose of the present application, therefore, is to provide independent patent coverage by specifying the electrically-resistive materials.

OBJECTS OF THE INVENTION:

1. To provide relative movement between an electrode structure and the ambient fluid medium so as
   a) to impart a propulsive force to a vehicle (to which the structure is attached), or
   b) to cause flow of the ambient medium (in the opposite direction).

2. To provide an electrode structure capable of creating an intense electrical field without the possibility of electrical breakdown across the fluid gap.

3. To serve as an improved flow-control device comparatively free from the danger of electrical breakdown.

4. To serve as an electrogasdynamic loudspeaker wherein extreme voltage peaks would not cause sparking.

5. To provide an electrogasdynamic loudspeaker with improved acoustical volume and frequency response.

6. To provide a fan or pump for combustible fluids which is relatively free from explosion hazards.

7. To provide an electrogasdynamic fan having increased velocity and improved electrical efficiency.

8. To serve as an electrostatic precipitator whereby suspended matter in the fluid medium is deposited upon and held by the vanes with increased retentivity.

9. To provide an electrostatic precipitator with disposable vanes which are relatively inexpensive.

10. To provide such electrokinetic devices with an electrode structure which is free from electrical hazards and is not dangerous to touch.

SPECIFICATIONS:

The electrokinetic device described herein is believed to operate by virtue of two contributing forces:

1. Electrophoresis - ion momentum transfer from the region of the fine wire to the large vanes.

2. Electrostrictive fluid dynamics - that force which exists in a fluid dielectric generally in the direction of the divergence of the electric field.

The above forces cause a flow of any ionizable dielectric fluid medium generally in the direction from the fine wire toward the vanes and thru the region between the vanes. This flow is a function of the voltage applied between the fine wire and the vanes. In the present instance, where the electric gradient across the air gap exceeds the normal breakdown value, the gas in this region is intensely ionized. There is a visible glow-discharge around the fine wire and this glow increases with the electric gradient and the degree of ionization.

Referring to the attached drawings, Fig. 1 is a diagrammatic view of the simplest form of the invention. Fig. 1a is a chart indicating the electric potential profile between the electrodes of Fig. 1. Fig. 2 is a diagrammatic view, partly in perspective, of a plurality of electrodes as set forth in Fig. 1. Fig. 3 is an alternate arrangement of electrode vanes providing increased insulation and protection against accidental shock, together with a modulating circuit for producing sound waves. Fig. 4 is a similar device with a bare third electrode (control grid) for producing sound waves. Fig. 5 is a device similar to that shown in Fig. 4 with the third electrode encased in partially-conducting dielectric material.

Referring in more detail to the attached drawings, Fig. 1 is a typical cross-section showing ionizing wire 1 associated with two partially-conducting vanes 2 and 2a, terminated by metal strips 4 and 4a. Electrical potential difference is supplied by direct current high voltage power supply 3. Electrode 1 is a fine wire equi-spaced between the leading edges of vanes 2 and 2a and extending longitudinally along and near the (leading) edges of said vanes. It has been empirically determined that the location of electrode 1, together with the leading edges of electrodes 2 and 2a, should form an equilateral triangle, the size of which depends upon the voltage used. For normal operation, as an air fan, the sides of the equilateral triangle may range from 1/4" for 10 KV to 1/2" for 20 KV. This spacing is about one-half of the normal electric breakdown distance between metal points in air at atmospheric pressure.

Because of the extremely high electric gradients developed, the ionizing envelope around electrode 1 is intensified far beyond that which would be possible with naked metal electrodes. It is this intensified ionization and electric gradient which results in increased air velocity and sound pressure (when modulated). It is the principal feature of this invention. It apparently is not covered in the prior art.

Fig. 1a is a graph showing the typical potential gradient found in the electrode structure of Fig. 1. If electrode 1 is considered to have zero potential at point A (this electrode may actually be grounded in service without affecting the operation), the potential rises as B is approached and then ranges still higher throughout the distance between B and C. The electric gradient between A and C is therefore not uniform but is stepped, so that there actually exists an electrical balancing action in the current passed between step A to B and step B to C. Any excessive current in step A to B instantly results in increased voltage in step B to C, so that the current across the gap A to B is always balanced and limited. This limitation effectively prevents breakdown.

In Fig. 2, a plurality of partially-conducting vanes 2a, 2b, 2c, 2d, and 2e are terminated with metal electrodes 4a, 4b, 4c, 4d, and 4e, which are connected to the negative side of power supply 3. Fine-wire grid 1, with wires positioned intermediate and forward of the vanes, is connected to the positive side of power supply 3.

It is to be noted that, whereas in Fig. 2 the fine-wire grid is made positive and the vanes negative, the polarity may be reversed without reversing the airflow or affecting the sound density. The reverse polarity does, however, produce an increase in ozone emission because of the nature of the negative corona around the fine wires. Such corona is "beaded", with more or less regularly spaced bright spots with high electrical gradient. These spots emit large quantities of ozone. This characteristic has its advantage, however, in that when a larger content of ozone is desired (in the effluent of the fan), the polarity may be reversed.

Fig. 3 is similar to Fig. 1 except that the apparatus is utilized to produce sound rather than merely the flow of air. Additionally, a shock-protective feature is included by having the bare metal electrodes 4a and 4b completely encased in partially-conducting material forming vanes 2a and 2b. This makes it possible to touch the vanes at any point on their surface without being shocked. Fine wire electrode 1 is not so insulated but carries only the signal voltage from modulation transformer 5 which is not dangerous to touch and is normally at ground potential in the absence of a signal. Variations in the potential of emitter 1 causes pressure waves which travel largely in the direction of the vanes, passing between the vanes and outward as indicated.

Fig. 4 is similar to Fig. 3 except that the field between the emitter 1 and vanes 2a and 2b is altered by means of a control grid 6 according to the output of modulation transformer 5. This electrode structure is similar to that disclosed in the applicant's co-pending Patent Application 662,105 , except that, in the present instance, the partially-conducting vanes 2a and 2b completely enclose metal electrodes 4a and 4b and provide breakdown resistance and protection against shock.

In Fig. 5, equivalent to Fig. 4, further breakdown protection is accomplished by encasing bare control electrode 7 within its own partially-conducting sheath 6. Due to the fact that electrode 1 must have minimum surface area in order to produce maximum voltage gradient in the surrounding envelope of air, it cannot be covered with insulating or semi-conducting material. Such covering would reduce the ion emission from the region around electrode 1 and make the system virtually inoperative. For protection against shock, however, such covering is not necessary inasmuch as electrode 1 may be optionally grounded (as indicated). Grounding may be actually desirable in order to minimize the insulation required in modulation transformer 5.

The advantage to be gained by the use of partially-conducting material in the manner specifically set forth in Figs. 4 and 5 constitute a basic improvement over the teachings of Patent Application 662,105. In this respect, the present patent application may have to provide this additional coverage as a "Continuation-In-Part" of Application 662,105.

The partially-conducting material referred to in this specification can be fabricated in several ways. It may consist of phenolic plastic (or the like) loaded with carbon powder or metallic oxides. It may take the form of glass or plastic sheets with thin metallic films deposited thereon. In certain cases where the precipitation vanes must be made inexpensively such as for disposable precipitator sections, the vanes may be made of metalized paper or a molded plastic covered with a thin film of stannous tetrachloride, to provide a limited amount of electrical conductivity. Where the partially-conducting material is homogenous, as in molded electrode, it is found that volume conductivity should be in the range from 10^7 to 10^{10} ohms/cc.

It is important to distinguish in this patent application between the term "electrode" and the term "partially-conducting vane". In the applicant's former patents, claims are made covering the use of electrodes or sets of electrodes producing electrical fields between them. Breakdown always occurred to limit the operating capability and it was never satisfactory to operate the units even up to 70% of breakdown. The electrodes described in the applicant's issued patents and forming the basis for those claims are now considered to be limiting. No device constructed according to these earlier patents is free from the threat of damaging breakdown. The novelty of the present application lies in

1. the elimination of the threat of breakdown, and
2. the ability to operate with electric field densities far in excess of anything heretofore possible. Air velocities and sound densities are 3 to 4 times greater than before.

It is important, therefore, to stress in both the specifications and the claims of the present invention the distinguising feature which makes the present invention novel and useful over and beyond the prior art. This distinguishing feature probably must be expressed as the "partially-conducting vane" rather than the "electrode". It would seem that, by definition, an electrode is a surface of uniform electrical potential. If that surface is not uniformly conducting, the member ceases to be (strictly speaking) an electrode and becomes an element of the electrical circuit, especially if its poor conductivity serves a useful purpose. Such "elements" were not foreseen or taught in the earlier patented art. They provide the essential feature of the present invention.

The use of partially-conducting vanes serves still another purpose by increasing the retentivity of electrostatically precipitated particles. Ordinarily, particles precipitated upon (dry) metal electrodes suffer a certain amount of "bounce-off". Particles acquire the same polarity as the electrode and are immediately repelled electrostatically.

When partially-conducting vanes are used, the electric gradient along the surface of the vanes projects a divergent field outward from the sides of the vanes which reduces "bounce off" and tends to trap and retain precipitates by dielectrophoretic attraction.

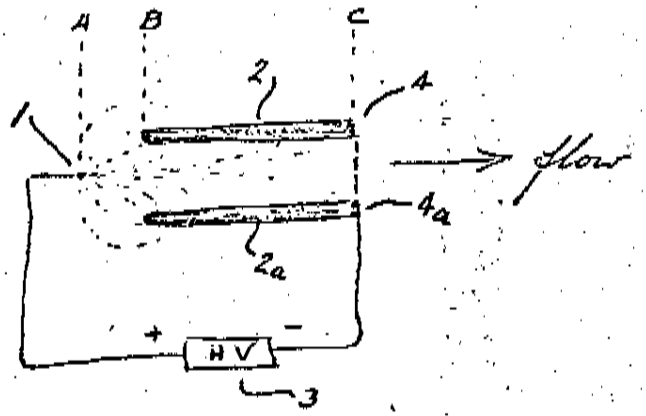

Fig. 1.

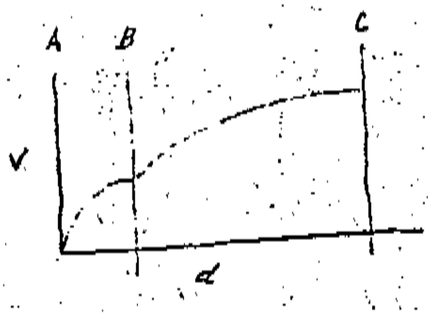

Fig. 1a

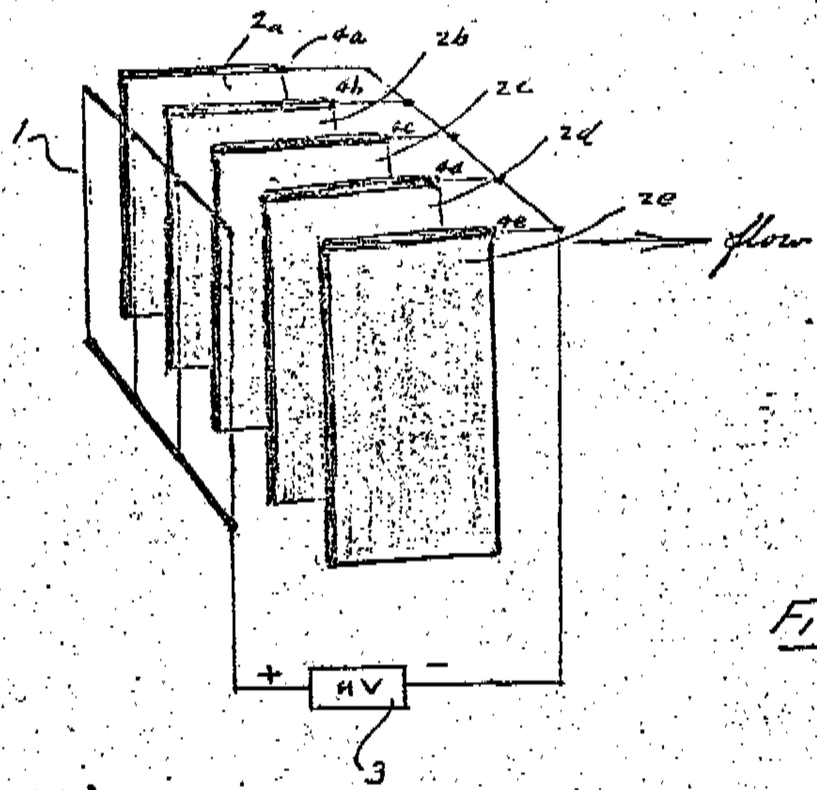

Fig. 2.

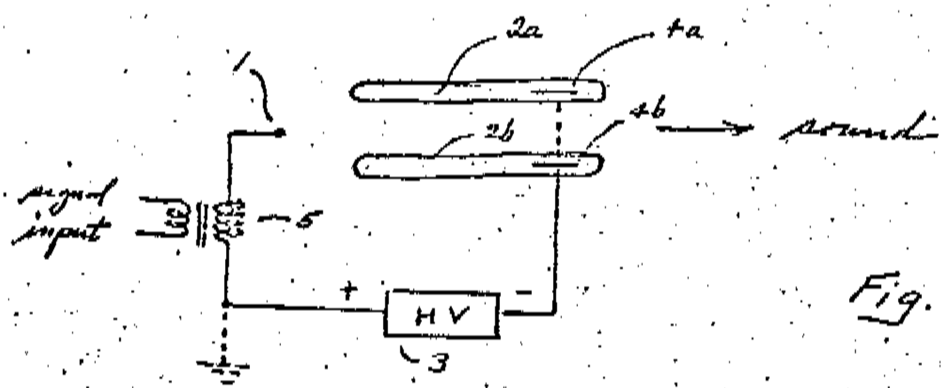

Fig. 3

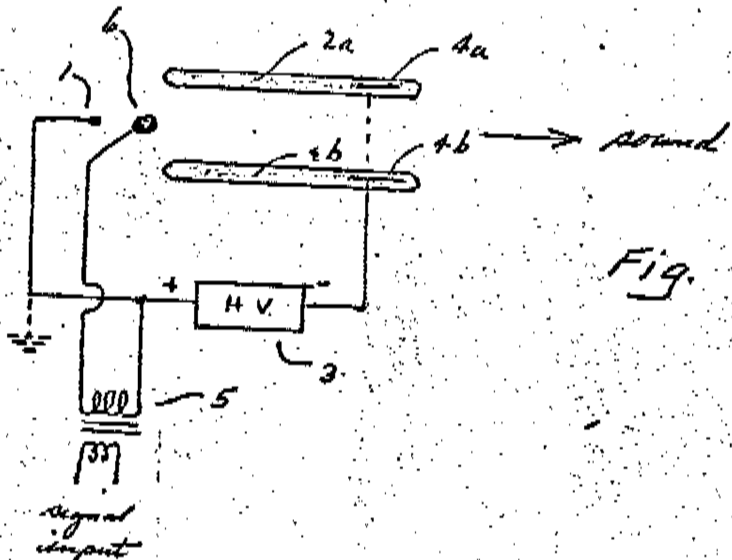

Fig. 4

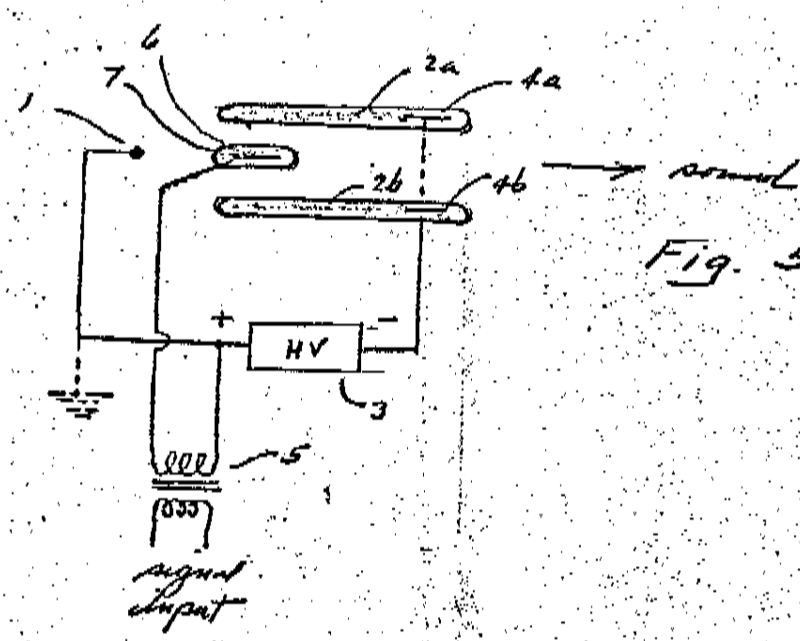

Fig. 5.