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ELECTROHYDRODYNAMIC FLUID PUMP

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5 Claims. (Cl. 103—1)

This invention relates to fluid pumps and more particularly to fluid pumps for pumping dielectric fluids. This is a continuation-in-part of my application Serial No. 793,893, filed February 17, 1959.

In my above-mentioned application, I disclosed a pump for dielectric fluids which does not require moving parts. I have discovered an improved device by which electrical energy may be converted directly into kinetic energy in the form of moving dielectric fluids. Accordingly, this device may be employed to pump dielectric fluids such as air, oil, gases or dielectric solids suspended in a gas through the system. These propulsive forces act upon the dielectric fluid due to the unique geometry of the electric fields. These electric fields may be shaped in a manner to produce a propulsive force on the fluid dielectric by the geometry of the electrodes and by the use of a rod electrode extending from the smaller end of a frusto-conical electrode toward the larger end of the next adjacent frusto-conical electrode. Preferably, a rod electrode extends from each conical electrode and is positioned axially of the conical electrodes. The electrodes are immersed in the dielectric fluid and different electrical potentials are applied to the electrodes from a source of high voltage. Reversal of the polarity of the voltage applied to these electrodes makes little difference upon the magnitude or direction of the force developed in the surrounding fluid medium. One or the other of the electrodes may be grounded if convenient. It has been found that generally better results are obtained if the rod electrodes are positioned axially of the conical electrodes and extend at least to the plane containing the larger aperture of the next adjacent electrode. When the electrodes are differentially charged, the dielectric fluid medium near the axis of the annular electrodes is set in motion and flows through the conical electrodes and around the rod electrodes or extensions of the conical electrodes.

In accordance with aspects of this invention, a number of annular frusto-conical electrodes, each but the last having a rod-like axial extension, are positioned with their axes coincident and these electrodes are connected to a source of potential which applies increasingly higher potentials from one end of the series of electrodes. With this arrangement, a propulsive force is produced on the immersing dielectric fluid in a direction axially of the frusto-conical electrodes.

In accordance with other aspects of this invention, a number of annular frusto-conical electrodes, each but the last having a rod-like axial extension, are mounted with their axes coincident and these electrodes are charged in alternate groups to different potentials. When so charged, a propulsive force is produced on the dielectric fluid surrounding the electrodes to produce a pumping action or flow of fluid through the frusto-conical electrodes and around the rod-like extensions in a direction along the axes of the electrodes.

In accordance with yet other aspects of this invention, the extension is constructed with an insulating rod formed of material such as plastic or ceramic, coated with a resistive material such as carbon, and the coating is electrically connected to the electrode supporting the projection. Preferably, the resistance between the electrical connection to the electrode and the opposite end of the coating is of the order of ten to twenty megohms. If an arc occurs between the extension and the next electrode, the resistive coating will act as a voltage limiter and arc suppressor.

Accordingly, it is a feature of this invention to employ as an electrohydrodynamic pump a series of annular frusto-conical electrodes, each but the last having a rod electrode extending from its smaller aperture toward the next electrode, and positioned with their axes coincident in sealed relationship to the inner surface of a dielectric tube in a dielectric fluid and charged in a serial fashion by a high voltage source to produce flow of the dielectric through the electrodes and around the rod electrode.

It is another feature of this invention to employ as a dielectric material pump, a plurality of annular frusto-conical electrodes positioned in sealed relationship to the interior of a dielectric tube with their axes coincident and each but the last having an axial extension thereon, and to connect alternate ones of these electrodes to different terminals of a high voltage source such that the dielectric material flows along the axis of the tube in response to the shaped electric field produced by the electrodes.

It is still another feature of this invention to employ, as a dielectric material pump, a plurality of frusto-conical electrodes positioned in fluid sealing relationship to the interior of a dielectric tube with their axes coincident, with each but the last having a resistive projection thereon and extending along the axes to enhance the pump efficiency and act as an arc suppressor when a high voltage direct current potential difference is applied between the electrodes.

These and various other objects and features of this invention will be more clearly understood from a reading of the detailed description of this invention in conjunction with the drawing in which:

FIGURE 1 is a combined schematic and perspective view, partly in section, of one illustrative embodiment of this invention;

FIGURE 2 is a combined schematic and perspective view, partly in section, of another illustrative embodiment of this invention;

FIGURE 3 is an end view of one electrode of the type shown in FIGURES 1 and 2, as viewed from its left-hand end in FIGURES 1 or 2;

FIGURE 4 is a side elevational view of the electrode of FIGURE 3;

FIGURE 5 is an end view of an alternative embodiment of electrode corresponding to the view of FIGURE 3; and

FIGURE 6 is a side elevational view of the electrode of FIGURE 5.

Referring now to FIGURE 1, there is depicted a combination perspective and schematic view, partly in section, of one illustrative embodiment of this invention. A pump device **10** for moving dielectric material includes a series of conical conducting surfaces, or electrodes, **12**, **14**, **16** and **18**, each having its outer surface engaging the inner surface of a tube **20** in fluid sealing relationship. A serially ascending direct current potential is applied to these electrodes from a high voltage source **22** connected to a voltage divider including resistors **24**, **26** and **28** through conductors **25**, **27**, **29** and **31**. The dotted line **30** indicates that an infinite number of stages or series of electrodes may be employed and that they will each be connected to a point on the voltage divider coresponding to their position in the tube **20**. The source **22** supplies a potential of the order of at least 8 to 50 kv. to the series of electrodes **12**, **14**, **16** and **18** and the rate of movement of a dielectric axially along the tube varies with the applied potential, as long as the breakdown or arcing potential is not exceeded.

Advantageously, each electrode of the series except the last has a rod-like conducting extension thereon extending toward the electrode having the adjacent larger opening (i.e., to the right as viewed in FIGURE 1) to produce an annular electric field which improves the electro-kinetic force on the dielectric material as compared to electrodes without extensions. For example, electrode **12** has a rod-like metallic extension **32** mounted on a tripod including members **33**, **34** and **35**, which position the rod **32** axially relative to the electrode **12** and to the tube **20**. Preferably, the rod **32** extends to a position within the electrode **14** and the preferred embodiment extends substantially the entire length of the next conical surface. The electrodes **14** and **16** and any electrodes added within the series have axial extensions thereon, such as extension **36** and **38**, supported by suitable tripods on electrodes **14** and **16**, respectively.

FIGURE 2 shows an alternative connection of the electrodes **12**, **14**, **16** and **18** in which electrodes **12** and **16** are connected to one terminal of source **22** and electrodes **14** and **18** are connected to the other terminal. If additional electrodes are added, first alternate ones are connected to the left-hand terminal of source **22** and second alternates ones are connected to the right-hand terminal. Here, again, the rod-like conducting extensions aid in the production of electro-kinetic force and increase the flow of material through the tube **20**, as compared to my earlier device disclosed in my above-mentioned application. FIGURES 3 and 4 are end and side views, respectively, of a single electrode **12** showing the tripod mounting and axial position of the extension **32**. Each of the electrode extensions is formed of conducting material such as copper and is similarly oriented.

FIGURES 5 and 6 are views corresponding to the views of FIGURES 3 and 4, respectively, and showing an alternative embodiment and arrangement of electrode extension **50** in which the extension is formed of a single member having a curved portion **51** extending from the conical portion and a straight portion **52** of sufficient length to project to a position within the next electrode of the device. In this particular embodiment, the straight portion **52** is formed of an insulating rod **54** of plastic or ceramic material and coated with a suitable resistive coating **56**, such as carbon or manganin. The coating is connected through curved portion **51** to the electrode **12**. When a high direct current potential is applied to the electrodes **12**, **14**, **16** and **18** and the electrodes **12**, **14** and **16** have resistive type extensions, an annular field will be produced around the resistive extensions which aids the pumping action. If an arc occurs, it will occur between the end of the extension closest the next electrode and the current to this arc must flow through the resistive coating **56**. Because the resistance of the coating is high (preferably at least ten megohms) the voltage drop across the extension will reduce the voltage between the extension and the next electrode below the arc-sustaining potential. Thus, this embodiment of extension acts as an arc suppressor and permits the application of higher potentials between electrodes than the embodiment of FIGURES 1–4.

While I have shown and described various embodiments of my invention, it is understood that the concepts and features thereof may be incorporated in other embodiments without departing from the spirit and scope of this invention.

What is claimed is:

1. A pump for dielectric fluids comprising an insulated tube through which said fluids may pass, an equispaced series of baffles in the form of electrically conducting annular truncated cones, each having an outer surface engaging said tube, said cones being axially aligned within said tube and all but one of said electrodes including an axially extending rod and means for maintaining different electrical potentials upon the successive cones of said series.

2. An electro-kinetic device for moving dielectric material comprising a series of annular conical electrodes encased in a dielectric conduit and each having a rod extending axially therefrom toward the larger opening in the next electrode and means for applying electrical potentials to the electrodes.

3. An electro-kinetic device for moving dielectric material through a dielectric tube comprising a spaced series of annular conical electrodes, each having an outer surface engaging the inner surface of said dielectric tube, certain of said electrodes having a conducting extension electrically connected thereto and axially aligned with the electrode to which the extension is connected and means for applying a direct current potential between adjacent ones of said electrodes.

4. An electro-kinetic device for moving dielectric material comprising a spaced series of annular conical electrodes encased in a dielectric tube, certain of said electrodes having a resistive extension electrically connected thereto and axially aligned with the electrode to which the extension is connected and means for applying a direct current potential between adjacent ones of said electrodes.

5. A device according to claim **4** wherein said resistive extensions include an insulating rod with a resistive coating thereon, said coating being electrically connected to the respective electrode on which the extension is mounted.

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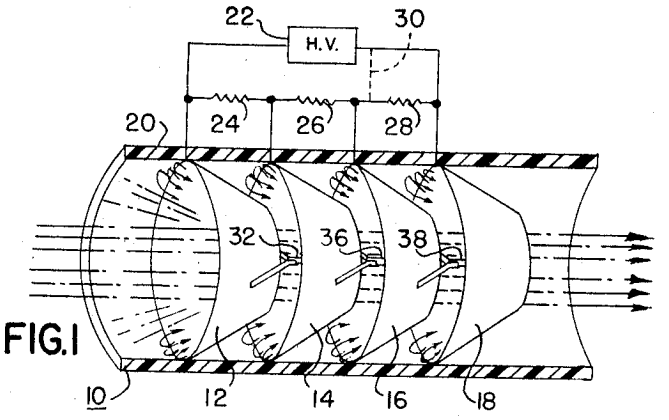

FIG.1

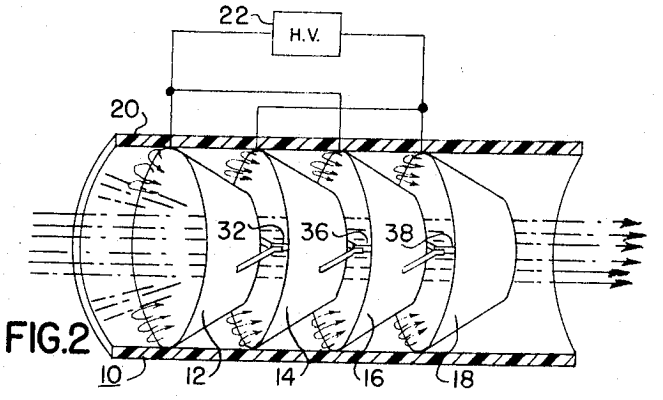

FIG.2

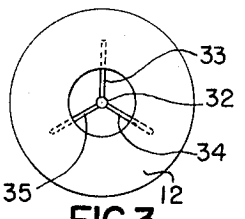

FIG.3

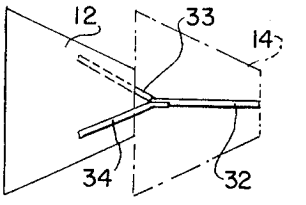

FIG.4

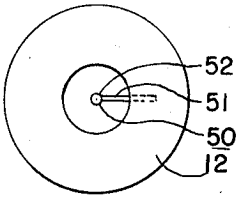

FIG.5

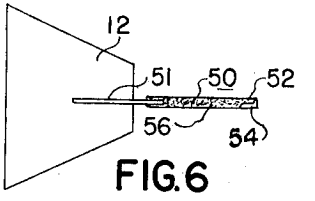

FIG.6

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