THE FLUID PUMP

by T. Townsend Brown

For the Whitehall-Rand Group, Washington, D.C.

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In the past, numerous types of devices have been employed to pump fluid. However, these prior devices are characterized by moving parts. I have discovered that fluids, and particularly dielectric fluids, may be pumped by a device which does not require ... that 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 are brought to bear 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 manner of their orientation. Further shaping of the electric field may be implemented by means of the particular mode of energization of the electrodes.

Fluid pumps, in accordance with this invention, may be used for electrohydrodynamic pumping of oil or other dielectric fluids. They may be used to produce steady and noiseless propulsion or pumping of air or other gases. They may also be used for rapid pulsing or pumping of residual gas in ultra-high vacuum systems. The use of electrical fields to produce a pumping action is peculiarly adapted to vacuum pumping. Electrical breakdown rarely occurs in a vacuum and no important limitation exists as to electrode spacing. Accordingly, very intense electric fields may be utilized, which fields, when properly "shaped," cause the molecules of the residual gas to be accelerated to very high velocities. Electrode structures employed to pump or propel fluids may be serially positioned to be produce a high measure of vacuum. For example, these electrodes might be positioned in a manner to produce pressures of the order of 10^{-9} to 10^{-13} mm of mercury, all without use of moving points.

Figure 1:

The pump consists of two basic parts, a ball electrode 1 and an annular ring electrode 2. Ball electrode 1 is located on the axis of the ring electrode and to one side of the plane of the ring electrode. Electrodes 1 and 2 are maintained at different electrical potentials by means of conductors 3 and 4 connected to a source of high voltage 5. Reversal of polarity makes little difference upon the magnitude or direction of forces 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 ball or point electrode 1 is negatively charged with respect to ring electrode 2 for the reason that the breakdown potential is higher; hence, higher voltages may be used continuously. When electrodes 1 and 2 are differently charged, the dielectric fluid medium near the axis between the electrodes is set in motion and flows through the ring electrode, creating a steady stream in a direction indicated by the arrows.

Figure 2:

A sectional view in elevation of Figure 1, showing the configuration, in dotted lines, of the electrostatic lines of force and the way in which they diverge from the ball toward the ring. Such divergence is believed to give rise to a resultant pressure on the dielectric medium in the region principally along the axis between the electrodes generally in the direction of the divergence. This pressure causes the medium to move axially through the ring electrode as indicated by the arrows.

Figure 3:

Electrode 1 is replaced by a tube or annular electrode 6 where a fluid medium is free to move into the tube from the left, and out of the tube to the right. For the reasons already set forth, a field exists in the region between the two electrodes, pulling the surrounding medium through the electrode 6 along the axis and through the ring electrode 2 and outwardly, as shown.

Figure 4:

The annular electrode is in the form of a truncated conic or frusto-conical electrode 7 having aperture 8 of slightly larger diameter than tube electrode 6. As in the other structures, flow is initiated in the region between the electrodes and is projected through the aperture of the conic electrode. The advantage of the conically-shaped electrode over that of the ring is an increased concentration of electrostatic field between the electrodes while at the same time preserving the necessary divergence of the lines of force.

Figure 5:

A series of annular frusto-conical electrodes 7a, 7b, 7c...7n is serially connected to the source 5, by means of voltage dividers. Here, as in the previous structures, the electric field between successive conic electrodes is divergent. Hence, a resultant force exists upon the dielectric medium generally in the vicinity of the axis of the electrodes tending to drive the medium through the conic electrodes from the larger to the smaller apertures, as shown.

When the system of conic electrodes is tightly enclosed in an insulated tube there is a notable difference in hydrostatic pressure between the inlet and outlet ends of the system, it will also exhibit a force in the same direction as the fluid flow. Small chunks of matter and even powdered materials suspended in a dielectric fluid are similarly driven through the system at high velocity so that, especially in a vacuum, the structure serves as a linear accelerator.

Figure 6:

The electrode structure here is the same as in the preceding figure, except that the electrical connections are in parallel groups rather than in series. in this structure, successive conic electrodes are of opposite polarity. It has been found that the desired pumping action can be achieved with either series or parallel connection but that the parallel connection offers one advantage, namely, operation of the electrode system at a much lower voltage.

In Figures 5 and 6 four electrodes are shown. However, it is understood that any desired number may be employed depending on the amount of pressure to be produced.

In any of the embodiments shown, magnetic collimation may be achieved by connecting a solenoid 9 shown in Figure 6, to the source 5a and orienting solenoid adjacent the last of the electrodes (7d in Figure 6 or 7n in Figure 5) with the solenoid axis coincident with the electrode axis.

Figure 7:

A pump for use in obtaining ultra-high vacuum. For the sake of convenience, the conic electrodes 7a - 7n are arranged in vertical assembly by means of insulating cylinder 10 within an insulating tube, 14, which is supported on base 16. An ionization gauge 18 is connected through tube 20 to the interior of tube 14 and a pressure indicator 22 is operatively connected to gauge 18.

An oil diffusion pump 24 of the type well known in the art is connected to the interior of tube 14 by means of a pipe 26 connected to base plate 16 at an aperture 28. A mechanical pump 30 is connected to the pump 24 by means of pipe and exhausts to the atmosphere through pipe 34. Pumps 24 and 30 merely perform the initial pump-down and the electrohydrodynamic pump is employed to produce the very high vacuum. Gas molecules are ejected directly into the oil diffusion pump and exhausted into the atmosphere as shown.

Since very high voltage can be applied to the electrodes in vacuum without danger of breakdown, and since the pumping action is roughly proportional to the square of the applied voltage, the operation of the system at high voltage for the removal of residual gas is particularly rapid.

While I have shown and described various embodiments of my invention, it is understood that the principles thereof may be extended to many and varied types of machines and apparatus. The invention, therefore, is not to be limited to the details illustrated and described herein.