METHOD FOR MAKING AN ACOUSTIC TRANSDUCER

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ABSTRACT

An acoustic transducer having the general form of a condenser microphone in which the natural resonant frequency of an edge-supported diaphragm is increased by connecting the diaphragm and backplate at places removed from the edge of the diaphragm with a liquid which is relatively immovable in response to high frequency impulses. The liquid is not resilient, but is dissipative of energy transferred thereto from the diaphragm at frequencies as low as only a few Hertz; at higher frequencies, it is functionally equivalent to a rigid connection.

4 Claims, 7 Drawing Figures
METHOD FOR MAKING AN ACOUSTIC TRANSUDER

This disclosure repeats, in part, subject matter which was disclosed in application Ser. No. 650,324 filed June 30, 1967, and now abandoned.

This invention relates generally to acoustic transducers and more particularly to an electrostatic transducer such as a microphone having a diaphragm which is primarily supported at its edges.

In a condenser microphone, also sometimes called an electrostatic or capacitor microphone, the sound waves to be converted to electrical signals are received by a diaphragm which is usually supported at its edges. It will be understood that when the diaphragm is circular in shape, the plural term edges is still conventionally used even though a circular diaphragm may be said to have only one edge. The construction of the microphone is such that its useful frequency-pass band lies below the natural resonant frequency of the edge-supported diaphragm; therefore, to extend the useful band so as to encompass high frequencies, the natural resonant frequency must be increased. It is known that the resonant frequency may be raised by decreasing the diameter of the diaphragm, but such a decrease has a deleterious effect on the sensitivity, low-frequency response, and noise characteristics of the microphone. The resonant frequency can also be increased by connecting additional support to the diaphragm at its center or at another point removed from the edges. The deficiency which has heretofore characterized this second technique arises from the fact that a condenser microphone diaphragm must be placed adjacent and parallel to an electrically insulated backplate, with the separation of the diaphragm and backplate being critical to the operation of the microphone. Typical separation distances are on the order of 0.001 inch. Therefore, a solid connection to the diaphragm away from its edge requires precise fabrication and assembly, which naturally contributes to high cost. Thus, there has existed a need to have a microphone exhibiting a relatively high resonant frequency for the size of its diaphragm, but which is capable of being fabricated with simple manufacturing techniques.

Another demand sometimes placed upon the operating range of a condenser microphone is that it operate at low ambient pressures, such as the pressures characteristic of high altitudes. Condenser microphones typically depend on a quantity of air between the backplate and diaphragm to provide some mechanical resistance to the motion of the diaphragm. The mechanical resistance of air at normal atmospheric density maintains the frequency response of the microphone fairly flat, even at frequencies close to the natural resonant frequency. If the air density is reduced much below normal atmospheric density, however, the response of the microphone tends to peak near the resonant frequency, thus disrupting flatness of response at the high end of the useful frequency band. Therefore, at low pressures, the high-frequency operation of the ordinary condenser microphone is not completely satisfactory.

Accordingly, it is a major object of the invention to provide improved high-frequency response in a microphone having a diaphragm primarily supported at its edges.

Another object of the invention is to provide a relatively high natural resonant frequency for an acoustic transducer with an edge-supported diaphragm while employing simple manufacturing techniques.

A further object is to provide operation of an acoustic transducer with satisfactory high-frequency response at low ambient pressures.

A still further object is to provide a condenser microphone having a diaphragm which is at least partially supported by a liquid medium.

Another object is to provide an economical method of manufacturing a condenser microphone.

Other objects and numerous advantages will be apparent from the specification and claims and from the accompanying drawing illustrative of the invention.

In accordance with the invention, there is provided a microphone having a diaphragm primarily supported at its edges by a housing, a member called a backplate electrically insulated from and fixed interiorly of the housing near the diaphragm, and a quantity of viscous, non-resilient matter disposed in connecting relation between the member and the diaphragm at one or more places removed from the diaphragm's edges.

In the drawing:

FIG. 1 is a perspective view of a microphone according to the invention;

FIG. 2 is a vertical, sectional view of the microphone shown in FIG. 1, taken in the plane established by line 11—11 of FIG. 1, and enlarged for clarity;

FIG. 3 is a sectional view like a portion of a backplate (corresponding to the center portion of the backplate shown in FIG. 2) during an intermediate stage of manufacture of a microphone;

FIG. 4 is a sectional view like FIG. 3 showing a diaphragm after it has been installed adjacent the backplate;

FIG. 5 is a sectional view similar to FIG. 4 wherein a liquid wets both the diaphragm and a portion of the backplate;

FIG. 6 is a plan view of a diaphragm showing locations for a plurality of connections between a diaphragm and a backplate; and

FIG. 7 is a sectional view similar to FIG. 5 showing an alternate manner of segregating a cap from the rest of the backplate.

Referring now to the drawing, there will be described a preferred embodiment of the invention. The acoustic transducer shown in FIGS. 1 and 2 and referred to by the numeral 10 will be generally described as a condenser microphone. Microphone 10 has a circular diaphragm 11 which is firmly attached, as by cementing or the like, to an internally threaded ring 12 at the periphery of the diaphragm. The protective cover normally used with such a microphone 10 has not been shown, in order to better show diaphragm 11. The diaphragm 11 is preferably of stainless steel and is typically very thin, for example, approximately 0.0001 inch thick. The ring 12 forms a movable part of a housing 13, and is threadedly engaged with a fixed portion 12A of said housing. The housing portion 12A has an opening or cavity which intersects the top side of the housing so that the diaphragm 11 is supported at the edge 15 of the opening 14 when the housing portions 12, 12A are fully engaged. The opening 14 is shown as being circular, but those skilled in the art will recognize that this is not critical. It will be apparent that the portion of diaphragm 11 which is active in microphone operation is appropriately described as edge-supported since the edge of the operative diaphragm is located...
where it contacts housing 13 only at the edge of opening 14. It is also possible, however, to provide alternate constrictions wherein the edge of the operative diaphragm is supported only by the ring portion 12, etc.

As is normal in condenser microphones, microphone 10 has ring 15 fixedly behind the diaphragm 11 with a flat, front surface of the backplate adjacent the diaphragm. Backplate 15, housing 13, and ring 12 are preferably made of the same material, e.g., stainless steel. By making all of the structural elements out of the same material (or at least materials having almost identical coefficients of thermal expansion), the performance of the microphone is not affected to any noticeable extent by increases in temperature measured even in hundreds of degrees celsius. Supporting the backplate 15 and electrically insulating it from the housing 13 is an annular insulator 16, typically made of quartz. Circular spacer 18 supports the quartz insulator 16 and in turn is supported by an annular ring 19 threadedly engaged with the housing 13. Threaded section 20 serves as a nut holding backplate 15 in place while making electrical contact therewith. The plaste surface of backplate 15 adjacent diaphragm 11 has a shape generally corresponding to the shape of diaphragm 11, i.e., circular, and is located concentrically with the opening 14 in housing 13. The edge 17 of the backplate is separated from the edge of opening 14 by an appreciable gap so that the backplate is completely insulated from the housing. Thus, the insulator 16 and the air gap between backplate edge 17 and housing 13 serve individually and collectively as means for maintaining an electrical potential between the diaphragm and the backplate when such a potential is established in accordance with conventional practice in electrostatic microphones.

The separation of diaphragm 11 and the surface of backplate 15 adjacent thereto is of necessity very small, for example, approximately 0.001 inch. For purposes of clarity, the separation is shown somewhat out of proportion in the drawing. Holes in backplate 15, such as the representative hole 21, are not essential but serve a beneficial purpose in reducing what is commonly denominated as stiffness in the vibration of diaphragm 11 caused by entrapped air between the diaphragm and the backplate. A porous material such as sintered bronze could be readily substituted for solid material in the backplate 15, however, rendering the holes 21 unnecessary. The preferred embodiment has a recess in the surface of backplate 15 adjacent diaphragm 11, and in the recess there is fixed (as with cement or the like) an electrical insulating mount 22. Insulating mount 22 is preferably formed from one of the fluorocarbon resins sold under the trademark Teflon but it may be suitably fashioned of any other solid material which can be finished to satisfactory tolerances. The use of the insulating mount allows a wide variety of viscous support media to be used; however, it will be seen to be unnecessary for certain media, e.g., certain silicone compounds.

In the embodiment of the invention shown in FIG. 2, an annular groove 23 is formed in the top surface of mount 22 leaving a raised, central portion in the center of the mount. A cap 25 is rigidly fixed to the top of this center portion, as by cementing or the like, the cap having a thickness such that the top of the cap is flush with the top surface of backplate 15. The cap 25 is preferably made of stainless steel, but can be made of any material which is capable of being readily ground or otherwise finished to close tolerances; it is also preferred that the cap be capable of being wet by certain liquids to be described hereinafter. Of course, it is not necessary that the cap be made from material originally wettable by the liquids to be described, since it is possible to apply a suitable coating which will render a material wettable which was not originally. The shape of the groove 23 is not critical, and it is only necessary that there be some space alongside the cap 25 - as will be apparent in the description of FIG. 4. For example, a groove shaped like that shown in FIG. 7 would be entirely satisfactory.

Placed between the diaphragm 11 and the top of cap 25 (and constituting the essence of this invention) is a quantity of liquid 24. Unlike a solid, the liquid 24 continuously yields under slowly applied stress, so that the liquid 24 connects the diaphragm 11 and the cap 25 regardless of any slow changes that may occur in the size of the gap separating the two solid pieces. The liquid 24 has sufficient inertia, however, to remain substantially static under stress that is applied very rapidly. Another property of the liquid 24 that gives it advantages over previously known solid connections (especially during fabrication of a microphone) is its viscosity. It has been found that highly viscous liquids are more advantageous than those with low viscosities; individual media having a viscosity lower than water (1.0 centipoise at 20°C) are not deemed to be satisfactory, while those with a viscosity greater than water are satisfactory. Any liquid that is employed as the connecting liquid 24 will also have a measurable surface tension, but those having a high surface tension are more satisfactory than those with low surface tension. Accordingly, it is preferred that the liquid 24 have a surface tension at least as great as that of ethyl alcohol at 20°C, i.e., about 20 dynes/cm. Included within the group of satisfactory media are condensed fluids, e.g., liquids such as water and alcohols, as well as materials such as silicone grease, uncured silicone rubbers, common gels and petroleum oils, and mercury. A preferred material is a silicone grease such as that available from the Dow Corning Corporation under the label Dow Corning 44 grease, which is made from a stable silicone oil thickened with a lithium soap. The most common use for this grease is lubrication of ball bearings of electric motors. Besides its particularly advantageous viscosity, the Dow Corning 44 grease has a low vapor pressure; it is very stable and has no propensity to creep. Of particular importance is the characteristic of the liquid 24 that it does not possess sufficient resilience to pose any structural obstacle to the diaphragm 11 when the microphone 10 is being assembled. If the mount 22 is an electric insulator, the liquid 24 need not necessarily be an insulator also. The quantity of liquid 24 that is provided at any one mount 22 is usually a function of the surface area of cap 25 and the thickness of a non-conductive spacer 26 which is employed to establish the size of the gap between the diaphragm 11 and the backplate 15. It will be recalled that this gap is usually on the order of 0.001 inch, so the quantity of liquid 24 is always very small. Furthermore, each quantity of liquid 24 may be a mixture of chemicals selected for their individual properties.

A method of fabricating the microphone 10 consists of initially assembling all of the housing members except the diaphragm 11 (and its attached ring 12) and
the spacing washer 26. A plane surface is then established across the mouth of opening 14 by grinding or lapping the assembled members. A locating pin 27 serves to locate the backplate 15 radially with respect to the housing portion 12A so that the pieces can be separated after grinding and later reassembled without disturbing the spatial relationship which has once been established. A plane is thus initially defined which includes the mouth of opening 14, the top surface of the backplate 15, and the top surface of all of the caps 25. The assembled members are then separated and subsequently reassembled with the spacing washer 26 in its proper position between the quartz insulator 16 and the shoulder of housing 13.

Since the top of the backplate -6 and the mouth of opening 14 were in the same plane during grinding, they will be in exactly parallel planes if the spacer 26 has exactly parallel faces. Thus, the degree of parallelism between the mouth of opening 14 (and ultimately the diaphragm 11) and the backplate 15 is a direct function of the degree of parallelism between opposite faces of a washer 26. Since the faces of the washer 26 can be easily finished to any desired degree of accuracy with chemical milling techniques or the like, and readily inspected before installation with such devices as optical flats, it is relatively economical and easy to fabricate a complete microphone to any desired degree of accuracy.

The next step in fabricating a microphone in accordance with this invention is to place a quantity of viscous liquid 24 on top of each cap 25. Great precision in the placement of the liquid 24 is usually not required, since it will tend to center itself on top of the cap 25 when it wets the cap but does not wet the Teflon support 22. The placement of a quantity of liquid 24 on top of a cap 25 is shown in FIG. 3, with the quantity being slightly exaggerated for clarity. Furthermore the quantity of liquid 24 that is placed on a cap 25 is not too critical, since the size of the cap sets a practical limit on the size of the area of the diaphragm that is contacted by liquid 24. As can best be seen in FIG. 4, if an excessive amount of liquid 24 is present on top of a cap 25, the excess will expand in the groove 23 when the diaphragm 11 is placed adjacent to the backplate 15. If the support 22 is not made of solid Teflon, it is advantageously coated with Teflon or some other material which the liquid matter 24 will not wet so that the matter will remain in place atop the cap 25 and not be lost in the groove 23. It is perhaps appropriate here to point out that for preciseness the cap 25 has been described as being structurally distinct from the backplate 15, but in describing the function of liquid 24 it is nevertheless appropriate for simplicity to refer to said liquid as connecting the diaphragm and backplate.

It should now be apparent that the functions of the groove 23 are two-fold, namely, to define with accuracy the location of the various quantities of liquid matter 24 with respect to the diaphragm 11 and, secondly, to accommodate any excess of said liquid that may be spilled or leaked 24 or that might result from expansion of the original quantity of liquid due to increased temperatures.

After the liquid 24 is in place on top of the caps 25 the backplate assembly is installed into the microphone body 13 which has the diaphragm 11 already attached to ring 12 and properly tensioned. Since the mouth of opening 14 is parallel to the backplate 15, the dia-

phragm 11 will be similarly parallel to the backplate when the backplate is advanced far enough during installation to bring the backplate close to the diaphragm 11. As each quantity of liquid medium 24 (as illustrated in FIG. 3) is contacted by the diaphragm 11 during installation thereof, it will yield without storing any energy and, depending on the quantity of liquid present and the surface properties of the diaphragm, take on a configuration like that shown in FIG. 4 or FIG. 5. If the liquid matter 24 does not wet the diaphragm 11, it will appear like that shown in FIG. 4; if the matter does wet the diaphragm, it will appear like that shown in FIG. 5.

Also forming a part of this invention are materials that are molten at fabrication and operation temperatures but perhaps solid at an intermediate temperature, say, room temperature. Such materials would include, for example, ordinary soldering materials. Thus, if the matter 24 is in a liquid state at the time the diaphragm 11 is placed adjacent to backplate 15, then the two elements will be exactly parallel. As long as there is no change in the size of matter 24 as it changes from a liquid to a solid state, and as long as the matter did wet both the diaphragm and backplate while it was liquid, there might not even be any inaccuracy introduced even if the microphone were operated after the matter has solidified - as long as the connection to both the diaphragm and backplate remained firm. An attempt to operate an electrostatic microphone with a solid connection, however, does introduce the possibility of a solid connection tearing loose; such a severe connection would almost certainly introduce unacceptable noise into the acoustic system as the diaphragm alternately made and broke contact with the backplate during its excursions. Accordingly, it will be understood why it is preferable to have planned, liquid connections between the diaphragm and backplate during operation of the microphone. It should be merely noted, then, that the teachings herein can be employed to provide a temporary solid connection between a diaphragm and a backplate at, say, room temperature, and a desired, liquid connection at another, e.g., operating, temperature. Such solid connections naturally would be very advantageous in absolutely precluding loss of the matter 24 from its intended position atop a cap 25 during some step in a manufacturing process, or during transportation, storage, etc.

In the operation of the microphone 10, diaphragm 11 and the adjacent surface of backplate 15 form a parallel-plate condenser having a capacitance which varies with vibratory changes in the position of diaphragm 11 relative to the backplate. According to principles well known in the microphone art, the variable condenser thus formed is connectable to external electronic circuitry to produce electrical signals directly related to the sound waves causing diaphragm 11 to vibrate. When the device 10 is used as a loudspeaker, an alternating voltage applied between the diaphragm 11 and the backplate 15 causes the diaphragm to be alternately attracted to and withdrawn from the backplate, i.e., vibrate. Electrical contact with diaphragm 11 is made by connecting housing 13, while contact with backplate 15 is made through section 20.

The fundamental natural resonant frequency of an edge-supported diaphragm is the frequency of that oscillatory mode in which the center of a diaphragm moves up and down (as the microphone is oriented in FIG. 2) and the remainder of the diaphragm surface
moves in the same direction as the center. If a diaphragm has a support connected at the center as well as at the edges, the fundamental, natural resonant frequency will be raised. The theory of such an increase in fundamental resonant frequency is reasonably well established, but it is somewhat complex. The reason for the increase may perhaps be best explained by simply pointing out that the insertion of the center support decreases the length of the longest standing wave which can be established between any two points on the diaphragm.

For acoustical waves having a frequency above just a few Hertz, liquid matter 24 acts substantially the same as a fixed support connected to diaphragm 11. In its preferred embodiment, liquid 24 adheres to both the surface of the diaphragm 11 and to mount 22. The mere presence of the matter 24 prevents the acoustical waves from freely moving the diaphragm in the direction toward backplane 15, and, during the last half of a cycle when the diaphragm would normally be freely moving away from the backplate 15, the surface tension of the matter 24 causes the matter to remain in contact with the diaphragm so that the contacted portions of the diaphragm are essentially held fixed. It should perhaps be emphasized here that the excursions of a diaphragm at the center of its unsupported area are very small. That is, the unsupported portions of the diaphragm 11 will likely never move by more than approximately 5 percent of the initial separating distance between the diaphragm and the backplane. Thus, it will be seen that the surface tension of liquid 24 need not be exceedingly high in order to permit the liquid 24 to follow whatever - if any - diaphragm motion that might occur at the point of contact. Furthermore, even if the liquid matter 24 wets the cap 25 and does not wet the diaphragm 11, the distance that the diaphragm tends to move away from matter 24 during an outwardly excursion is so small that it is actually very hard for air to quickly flow into the space between the diaphragm and the top of matter 24, especially, when the surface tension of the liquid is acting to convert the shape of the liquid from a relatively flat ellipsoid to a relatively tall spheroid. Too, as may be understood by viewing FIG. 4, the top surface of matter 24 approaches the bottom surface of the diaphragm 11 asymptotically. It can be anticipated, then, that air attempting to rush in from the groove 23 behind an outwardly moving diaphragm at high speeds will likely experience considerable turbulence, especially as the distance between the matter 24 and the diaphragm 11 becomes infinitely small. The difficulty with which air moves into the gap tends to establish a vacuum between separated portions of the matter 24 and the outwardly moving diaphragm. Normal air pressure acting on the outer surface of the thin diaphragm 11 will oppose any tendency to create a vacuum internally of the diaphragm, so those portions of the diaphragm opposite the liquid 24 remain locally restrained against outward movement. Hence, in the presence of atmospheric air or its equivalent, it is preferred - but not absolutely necessary - that the liquid matter 24 wet both the diaphragm and backplane.

Assurance of linearity in the operations of the diaphragm is, of course, increased if portions of the diaphragm 11 opposite the support 22 are treated such that they will be wet by the matter 24. It is advisable that the entire diaphragm 11 not be wettable by the matter 24, however, since this might increase the chance of the matter 24 being forced from its intended location if accelerating forces were somehow to be applied parallel to the diaphragm. Any tendency of liquid matter 24 which is a dielectric to be accidently removed from its intended location atop a cap 25 as a result of vibrations or the like is also resisted by the electric field between the diaphragm 11 and the backplate 15 in an operating microphone.

It is also possible to achieve variable sensitivity with a microphone as described herein if a plurality of connections between the diaphragm 11 and backplate 15 consist of dissimilar matter. For example, in FIG. 6, let it be assumed that the matter designated as 24a is mercury and the matter designated as 24b is water. The response of the microphone while matter 24a and 24b is present will be predictable, and the response of the same microphone at atmospheric pressure and temperatures above 100° Celsius (when only the mercury will still be connecting the diaphragm and backplate) will be different but similarly predictable. Various other combinations of liquid media connecting the diaphragm and backplate will no doubt occur to those skilled in the art so as to make the diaphragm especially sensitive at predicted conditions of temperature, pressure, etc.

If it is desired to make the diaphragm 11 out of very thin Teflon film, with an electrical conductor placed thereon by vapor deposition or the like, the use of liquid matter 24 to support it uniformly over its surface will likely be the only way to successfully guarantee the structural integrity of the diaphragm. That is, since it is particularly difficult to stretch Teflon, only by placing a large quantity of contact points or caps 25 (e.g., 100) with matter 24 under the diaphragm is it likely that the diaphragm could be reasonably supported so as to preclude tearing.

At atmospheric pressures, a condenser microphone such as microphone 10 typically relies on a mechanical resistance provided by viscous airflow in the gap between the diaphragm and backplate during vibration to reduce peaking of the microphone response near the resonant frequency of the diaphragm. At low ambient pressures, as for example 4mm Hg, the mechanical resistance provided by the thin air-filmm between the diaphragm and backplate is significantly reduced. However, liquid medium 24 which wets both the diaphragm 11 and backplate 15 may be characterized as lossy in the same sense that air at atmospheric pressure is lossy, since it will inherently absorb some energy from diaphragm 11 by its slight pulling and pushing on the vibrating diaphragm. Thus, the liquid 24 provides at least some mechanical resistance to the motion of the unsupported portion of diaphragm 11 between its center and edges. This mechanical resistance is not of a size to be particularly significant while the normal air film is present between the diaphragm and backplate, but it becomes increasingly significant as air pressure is reduced. Thus, the support matter 24 provides improved high-frequency response at low ambient pressures.

Another embodiment of the invention lossy - but perhaps somewhat resilient - material in place of at least some quantities of the liquid 24 on some of a plurality of caps 25. A piece of material which is slightly resilient, such as Teflon "wool," will serve to enhance the low-pressure performance of a capacitance microphone as long as it does not tend to store and release
energy in the manner of a spring (but rather absorbs energy by virtue of friction) when flexed by the motion of the diaphragm. Such a dissipative material will provide at least some of the desired mechanical resistance needed to flatten the microphone frequency response at low pressures. In the event Teflon wool is to be placed between the diaphragm 11 and backplate 15, special care must be taken to insure that the desired flat configuration of a static diaphragm is not interfered with by putting too much wool on top of a cap 25. A person giving thought to the difficulties of sizing a solid or fibrous support like Teflon wool, when dimensions involved are on the order of small fractions of a mil, will no doubt recognize and appreciate the advantages of using a liquid support as described herein.

While only a preferred embodiment of the invention, together with some modifications thereof, has been described in detail herein and shown in the accompanying drawing, it will be evident that various further modifications are possible in the arrangement and construction of its components without departing from the scope of the invention.

What is claimed is:

1. The method of supporting a diaphragm in a condenser microphone, comprising:
   establishing a plane in a microphone housing which encompasses the mouth of a cavity in the housing;
   locating a backplate adjacent and parallel to the plane of the cavity mouth;
   providing a quantity of liquid matter on top of the backplate at one or more locations removed from the edge of the cavity mouth, so that the matter initially extends through the plane of the cavity mouth;
   stretching a diaphragm across the mouth of the cavity, whereby the diaphragm contacts and is supported by both the mouth and the liquid matter.

2. The method of supporting a diaphragm as claimed in claim 1 wherein the quantity of liquid matter is provided on top of the backplate by:
   establishing certain points on top of the backplate that are wettable by the liquid matter, with said points being surrounded by areas that are not wettable;
   covering the entire surface of the backplate with the liquid matter; and permitting those portion of the liquid matter that do not wet the backplate to flow from the backplate.

3. The method of achieving a variation in the sensitivity of a condenser microphone, comprising:
   connecting the microphone diaphragm to the backplate at two or more locations removed from the edge of the diaphragm with two liquids having different boiling points, with the area of the connections being appreciably less than the surface area of the diaphragm; and
   subsequently causing at least one of the two liquids to vaporize.

4. The method of making an acoustic transducer, comprising:
   establishing a plane in a housing, said plane encompassing the mouth of a cavity in the housing and the top surface of a backplate which is mounted internally of the housing;
   removing the backplate to a plane which is parallel to and near the plane of the cavity mouth;
   providing a quantity of liquid matter on top of the backplate at one or more locations removed from the edge of the cavity mouth so that the liquid matter initially extends through the plane of the cavity mouth;
   stretching a diaphragm across the mouth of the cavity, whereby the diaphragm contacts both the mouth and the liquid matter; and
   providing means for establishing an electrical potential between the diaphragm and the backplate.