No 1.

"Flow Control Device"

Docket No. 8308

Thomas Townsend Brown

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No 1.

"FLOW CONTROL SYSTEM"

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COMMENTS:

Reference: A) U.S. Patent No. 2,949,550 - "Electrokinetic Apparatus"
B) U.S. Patent No. 3,018,394 - "Electrokinetic Transducer"

1) In (A), a two-element (2 electrode) structure is shown whereby electrical energy is converted directly into fluid flow without the aid of moving parts. The device has immediate commercial application as a noiseless fan.

2) In (B) the same basic two-electrode structure shown in (A) is electrically modulated to serve as an electro-sonic transducer. An alternating current (signal) is superimposed upon the direct current bias to produce pulses of air or sound waves. The device operates either as a loudspeaker or the converse, as a microphone. The disadvantage of the system is that, especially with a large loudspeaker, the entire supply current must be modulated by the signal. This requires an excessive amount of signal energy and expensive amplifiers.

3) In the present application, a third element is included as a "control grid" in much the same manner (and for the same reason) as the grid of a triode. In this case however, the grid controls the shape of the electric field and hence the emission of ions from the fine-wire anode in the direction of the plates (cathodes). The transfer of momentum from ions to the host medium (air) and the electrostrictive gasdynamic effect upon the fluid dielectric cause the dielectric fluid (air) to move in the direction of the divergence of the electric field. The polarity is not specific. The polarity may be reversed without changing the direction of the air flow. The volume of flow with reversed polarity is approximately the same, but reversed polarity results in undesirable side effects. When the fine wire is negative, a "beaded" type of corona (quite different from the smoothly-luminous positive corona) surrounds the wire. The "beads" are regions of excessively high (local) field gradients and produce large quantities of ozone and a hissing sound. Positive corona, therefore, is preferred.

4) In general, the invention represented in the present flow control system, reminds one of the advantage gained, in the history of the vacuum tube, by the addition of the control grid (DeForest et al) to the earlier diode rectifiers (Edison effect). The grid placed between the filament and plate controlled the flow of electrons from the cathode to the anode. This resulted in the concept of the electronic "valve" and, hence, the power amplifier by which relatively large plate current could be controlled by almost insignificant grid current. The application of the control grid to the vacuum tube diode was a major breakthru in early radio technology.

The situation is much the same in the present invention except that the flow is now composed of air ions or fluid ions, usually (tho not necessarily) at atmospheric pressure. In the present instance, the grid controls the flow of the fluid, gaseous or liquid, thru the electrode assembly. But it also operates as an amplifier, either to control the relatively large energy of fluid flow or to control current in the "plate circuit" similar to a 3-element vacuum tube.

Undoubtedly there may be special applications where controlled flow of a fluid medium is not necessarily the objective and a current amplifying device, based on the above effect, may be more useful. If so, there should be claims directed toward this possibility.

5) The flow-control described herein would appear to have its principal field of usefulness as an electro-acoustic transducer or loudspeaker. The electro-acoustical efficiency, because of the amplifying action, appears to be at least one order of magnitude higher than that of conventional electromagnetic or electrostatic loudspeakers which have no amplifying capability. This increase in efficiency is intrinsic in the control grid. The small signal current applied to the grid produces relatively large acoustic output, with the additional energy being supplied by the relatively inexpensive DC bias. The device operates concurrently as an amplifier and transducer. It is important to repeat that this is not the case with any other type of loudspeaker on the market today.

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SUGGESTED SPECIFICATIONS:

1) This invention relates to fluid flow-control devices whereby a varying electric input is made to control or regulate output pressure or flow of an ionizable dielectric fluid.

2) This invention relates to electro-acoustic transducers, loudspeakers or the like, whereby an electric signal produces sound without the aid of a diaphragm or other moving part.

3) This invention relates to amplifying devices whereby relatively small input energy triggers, controls and generates a relatively large output energy.

1) This invention features a fluid control system which has no moving mechanical parts, the response of which is practically instantaneous.

2) This invention features a system which is noiseless in operation.

3) This invention features a loudspeaker which operates with unusually high signal efficiency by reason of the fact that it is an electro-acoustic amplifier. This loudspeaker has no diaphragm or other moving element and has virtually no inertial or Doppler distortion.

4) This invention features a loudspeaker which has a full-range frequency response (believed to extend from a few cycles per second to beyond 250 KC per second in air at atmospheric pressure) free from resonance peaks or mechanical distortion.

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Referring to the attached drawings:

Fig. 1 is a diagram of an electrical circuit with associated electrodes by which a flow of a medium is controlled.

Fig. 2 is a diagram of a circuit with associated electrodes by which flow pulses or sound waves are produced.

Fig. 3 is a diagram, partly in perspective, showing the physical structure of electrodes set forth in Fig. 1

Fig. 4 is an electrical circuit producing results similar to that in Fig. 2 but using a vacuum tube for producing the modulated signal rather than a transformer.

Fig. 5 is a perspective diagram similar to Fig. 3 showing a two-sided electrode structure to produce a "push-pull" action for the generation of sound waves.

Fig. 6 is a circuit diagram showing the application of vacuum tubes for "push-pull" operation as in Fig. 5.

Referring in more detail to the attached drawings:

Fig. 1 illustrates the simplest form of the invention and sets forth the circuit by which the control principle is applied to the flow of a dielectric fluid. The diagram illustrates basically three electrodes. Filaform electrode 1 consists of a fine wire or grid of fine wires. These wires are usually less than .003" in diameter and may be formed of any conducting material, stainless steel, tungsten or the like, which is both mechanically strong and resistant to corrosion. In practice, stainless steel wires approximately .0015" to .0025" diameter have been found to be satisfactory.

High voltage is provided by power supply 5. In most applications the requirements call for 7,500 to 25,000 volt with current demands proportional to the size of the systems. Current requirements usually range from 1 milliampere up to several hundred milliamperes for the larger installations. A convenient form of power supply includes a 60 cycle step-up transformer and a voltage-tripler rectifier circuit with ripple less than 1%. Depending upon the system requirements, either the positive or negative output side of the power supply may be grounded, or the entire power supply may be floating with respect to the ground. The ground connection in no way affects the rate of flow or controllability of the flow.

When energized, electrode 1 is surrounded by a coronal envelope which is smooth, silent and slightly luminous. The air in the region of the envelope is intensely ionized, generating both positive and negative ions. The negative ions are pulled into the positive electrode and discharged. The positive ions are repelled by the fine-wire electrode and travel outward in the general direction of electrode(s) 3. The arrangement and spacing of these electrodes is such as to provide a divergent electric field from electrodes 1 outward toward electrodes 3. Positive ions falling thru this electric field tend to accelerate in the direction of 1 to 3 and transfer their momentum to the host medium (air) in doing so. Air is then driven thru the electrode structure by "ion momentum transfer".

Concurrently, electrostrictive gasdynamic forces are created in the divergent electric field which tends to drive the entire volume of dielectric fluid in the space between the electrodes in the direction of the divergence of the electrostatic field. Gasdynamic pressure is initiated in the coronal envelope (so-called corona pressure) and this extends outward in the direction of the divergent electrostatic field, i.e., towards electrode(s) 3. This pressure is constant when the field is constant.

If, however, the field varies this pressure varies instantly. Control electrode 2, placed in the divergent field is capable of altering the field according to the charge it carries. Hence, a variation in the potential of electrode 2 causes a change in the shape of the steady electrostatic field created between electrodes 1 and 3 so as to affect the corona pressure and the augmentation of corona pressure produced by electrostriction. The sudden change in pressure produces sound waves.

Electrostrictive gasdynamic pressure augments the flow produced by ion momentum transfer. Both of the above pressure components, tending to cause flow of the dielectric medium, are governed by the shape and intensity of the electrostatic field between electrodes 1 and 3. Electrostrictive gasdynamic pressure is virtually instantaneous with the applied electric field whereas pressure resulting from ion-momentum transfer is relatively slow in building up. (This is because of the "time-of-flight" of the slow-moving positive ions).

Electrode 2, in the form of a wire grid or screen, is placed in the electrostatic field between electrodes 1 and 3. A variation in the electrical potential of electrode 2 readily affects the shape and intensity of this field and, hence, affects the resultant flow of dielectric medium thru the field.

In Fig. 1, for purposes of describing the basic aspects of the invention, the electrical potential applied to electrode 2 is varied by rheostat 4. When the slider of this rheostat is in position "A" the potential of control grid 2 is the same as that of electrode 1. This virtually eliminates the field around electrode 1, extinguishes the corona around electrode 1, stops the generation of ions and minimizes the resulting flow of dielectric fluid.

When the slider of rheostat 4 is in position "B", the electrostatic field around electrode 1 is increased and the coronal envelope and ion emission is intensified. This results in increased flow of dielectric fluid thru the system of electrodes so that when rheostat 4 is in position "B" this flow is maximum. The rate of flow can be varied or modulated by changing the potential of electrode 2 by shifting the rheostat between positions "A" and "B".

Fig. 2 illustrates a basic structure similar to that of Fig. 1 except that the potential of control grid 2 is shifted rapidly (modulated) by transformer 6 from a signal input.

Fig. 2 shows high voltage power supply 5 with mid-point connected to one side of transformer 6, which mid-point may also be grounded if such grounding is desirable. Rapid fluctuations in the potential applied to control grid 2 cause virtually instantaneous flow pulses to be emitted by the system (as shown by the arrows). This results mainly from electrostrictive gasdynamic pulsesrather than ion-momentum transfer. When the potential of the control grid is constant the resulting flow of dielectric media is constant.

Fig. 3 is a diagram similar to Fig. 1 with electrodes 1, 2 and 3 shown in perspective. Electrode 1 is a grid of fine wires, control electrode 2 is a grid or screen of coarse wires (with wire diameter exceeding .025"). Electrode(s) 3 is an edgewise array of plates made of conducting or partially-conducting material. Metallic plates are satisfactory in most cases. Even a screen may be used in place of the edgewise array of plates, but screen is found to be less satisfactory.

Where very high voltages are used or when inter-electrode spacing is small, it is found desirable in some cases to use plates of poorly-conducting material. The reason for this is to prevent damaging electrical break-down across the air gap between the electrodes. When plates 3 are fabricated of a material (such as a plastic loaded with carbon powder) so as to have a resistivity in the range from 10^6 to 10^{10} ohms per cubic centimeter, the possibility of damaging spark breakdown to the edge of the plates is virtually eliminated. The low conductivity prevents the localization of an intense electric field which must precede spark breakdown.

It is also helpful to provide the leading edges (edges nearest the anodes) of electrodes 3 with a substantial radius so as to eliminate sharp edges facing the highly-charged grids. It is found that well-rounded edges improve not only the flow but the quality of the sound produced by the device when operating as a loudspeaker. Troublesome hissing is almost completely eliminated by rounding all cathodic edges.

In an electrode system where it is of primary importance, as in the present invention, to create a divergent electrostatic field and where the operating efficiency depends primarily on the degree of divergence, the electrode shape and field geometry are important if not critical. The fine-wire electrodes must have minimum surface area and the plate electrodes must have a surface area several orders of magnitude larger. The operability depends upon area differential. The effectiveness also depends on the emissivity of the electrodes, i.e., the anodes for the emission of positive ions and the cathodes for the emission of electrons and the establishment of a negative space charge. Toward this end, it is desirable to coat the electrodes with materials to increase their emissivity.

In certain special cases, operation is improved by heating the electrodes to provide thermal ionization and the emission of thermions. Toward this end, the fine-wire anode may be heated by including the same in a resistance-heating electrical circuit. Since this is an obvious arrangement it is not shown specifically in the drawings. Coating the electrodes with such materials as cesium or barium chloride, thorium oxide or certain radioactive materials may be resorted to whenever indicated.

Fig. 4 is a diagram of an acoustic pulse-forming system similar to that shown in Fig. 2 but using a vacuum tube (6A) instead of a transformer for energizing the control grid 2 from a signal input. Resistor 7 is a current-limiting protective device to prevent a breakdown in the air space between electrodes 1 and 2 during excessive voltage peaks. Resistor 8 conducts plate current to triode (6A), permitting the control grid 2 to engage in voltage swings fromthat represented by the limit of the power supply 5 to almost ground potential, depending upon the signal applied to the grid of the triode.

In short, the energy of the input signal is amplified once in the triode and again in the flow-control system. A relatively small input signal results in the generation of heavy flow pulses or sound waves.

Fig. 5 is a diagram, along with a perspective view, of the screens and plates of a sound generating system for "push-pull" operation. Due to the fact that the electrode structure is electrically balanced there is no net flow of air as in structures previously illustrated. Sound waves are produced by the electrical action upon the air column between the electrodes, first in one direction and then in the other. It is to be noted that electrodes 9 and 9A are connected together to the negative side of the power supply 13. The positive side of the power supply is connected to the fine-wire grid 12. Coarse-wire grids 10 and 11 are connected to opposite ends of the secondary of transformer 14, the midpoint of which connects to that of the power supply 13 and to the ground (if a ground is desirable). Signal input to the primary of transformer 14 is stepped up to produce relatively high opposing potentials between control grids 10 and 11 so that pressures are directed first one way, then the other, (left or right as indicated) causing a push-pull generation of sound waves in the air column.

Fig. 6 is a diagram including vacuum tubes to produce essentially the same result as that shown in Fig. 5 but free from the distortion introduced by a high voltage transformer (with its frequency limitations caused by its inter-winding capacitance,etc.). The system set forth in Fig. 6 is desirable because of its high fidelity capability.

Electrodes 15 and 19 are connected to the negative side of the high voltage power supply 25 and can be grounded if convenient. From a practical standpoint, it is desirable to use electrodes 15 and 19 as protective grids at the sides of the commercial-type loudspeakers and to electrically ground these protective grids. The fine-wire anode 17 is conveniently protected against damage in the center of the structure and is maintained at a high DC positive potential from power supply 25.

Resistor 22 serves as a current-limiting device to prevent damage due to accidental wire breakage or electrical breakdown within or near electrode 17.

Resistors 23 and 24 convey the plate potential to triodes 20 and 21 and, at the same time, permit the plates to engage in voltage swings which are conducted to control grids 16 and 18 respectively. Signal input is applied to the primary of modulation transformer 26 feeding "push-pull"to the grids of the two triodes. A suitable bias supply 27 is shown in connection.

In this form of the invention, as an electro-acoustic transducer as shown also in Fig. 4, There are, in reality, two stages of amplification resulting from the use of 1) a vacuum tube triode, and 2) a control grid in the transducer itself. Because of such double amplification, the purity of signal-input(in a range less than 1 volt) can be maintained. This is especially desirable in super high-fidelity systems.

It is to be understood in the interpretation of the foregoing drawings that control devices or loudspeakers operating in accordance with the principles described herein are in no way limited in size. The smallest units may be suitable for portable loudspeakers. The largest units, built by assembling modules to sizes measuring several hundred square feet in radiating area, are for theatre or auditorium use.

There may be many variations in the form of the control electrode or the circuit by which it is linked into the system without departing from the spirit of the invention as set forth in the following claims:

SUGGESTED CLAIMS:

1) Method for producing and controlling flow of a dielectric medium consisting in establishing a non-linear electric field between a system of three or more electrodes immersed in said medium, utilizing one of said electrodes as a control grid and applying electrical potential to said control grid for the purpose of increasing or reducing said flow.

2) Method for generating pressure pulses in a dielectric fluid in accordance with an electrical signal consisting in utilizing at least three electrodes immersed in said fluid, charging two of said electrodes to produce an electric field therebetween and utilizing a third electrode as a control grid to which said electrical signal is conducted.

3) In a system of three or more electrodes which may be differently charged, said electrodes being capable of producing a non-linear electric field therebetween, the use of at least one electrode to serve as a control grid to vary the flow of a dielectric medium through and between said system of electrodes.

4) A current amplifying device consisting of two or more electrodes immersed in an ionizable dielectric fluid, means for supplying a DC charging current to said electrodes, a control grid located in the field of said electrodes, means for supplying a varying current to said control grid and means for utilizing the corresponding amplified variations in the charging current to said electrodes.

5) In a system according to claim 3, the use of coatings applied to the electrodes thereof to improve the emissivity of said electrodes.

6) In a system according to claim 3, the use of partially-conducting materials in the electrodes thereof to prevent electrical breakdown between said electrodes.

7) In a system according to claim 3, the use of vacuum tubes in combination therewith to modulate the electrical potential applied to the control grid.

8) Two systems according to claim 3, combined in contra-acting arrangement to provide reversible or push-pull forces on the fluid dielectric.

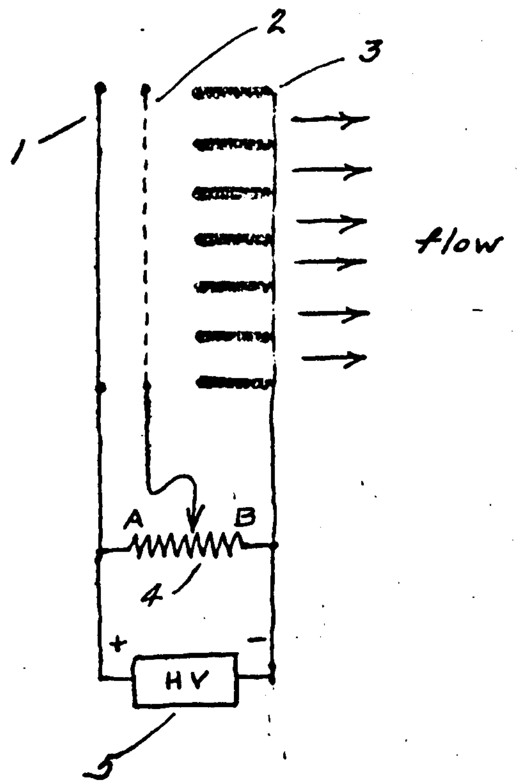

Fig. 1.

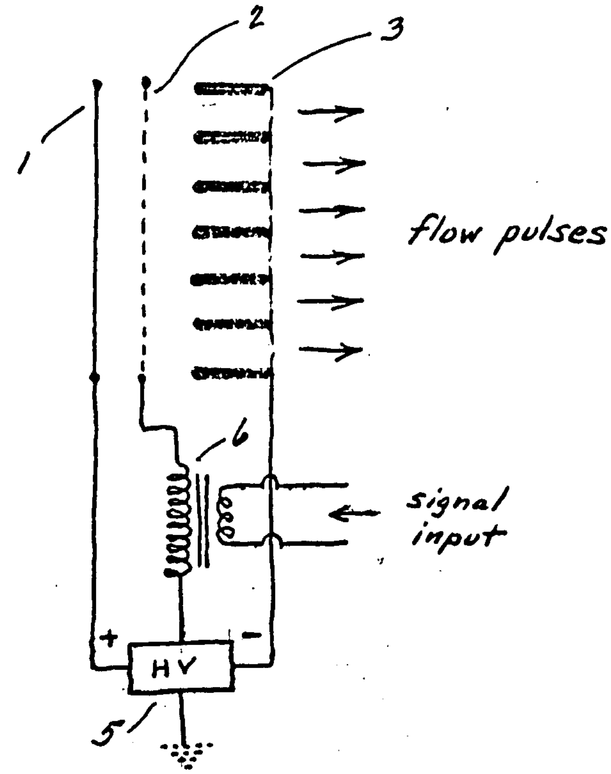

Fig. 2

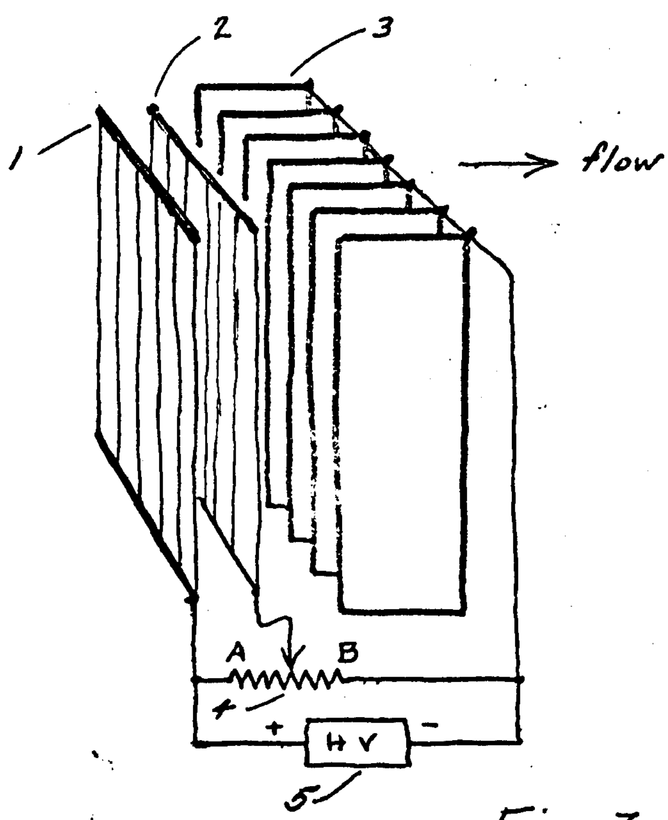

Fig 3.

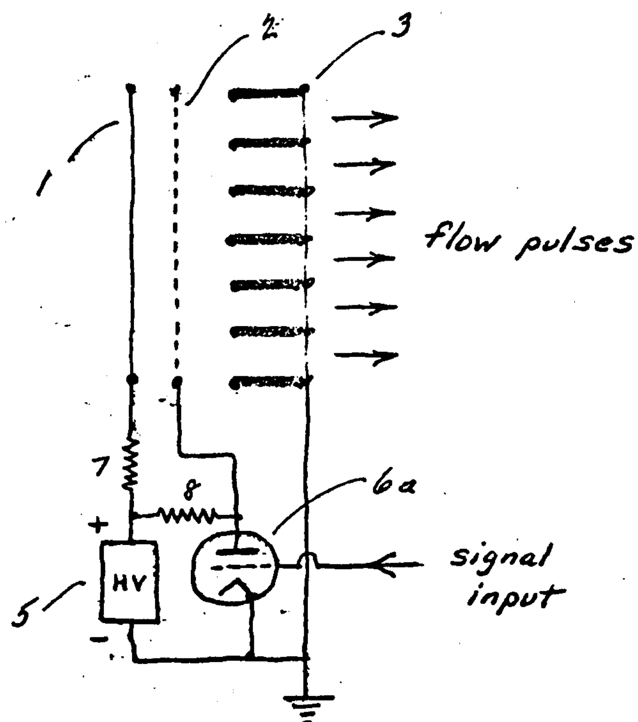

Fig 4.

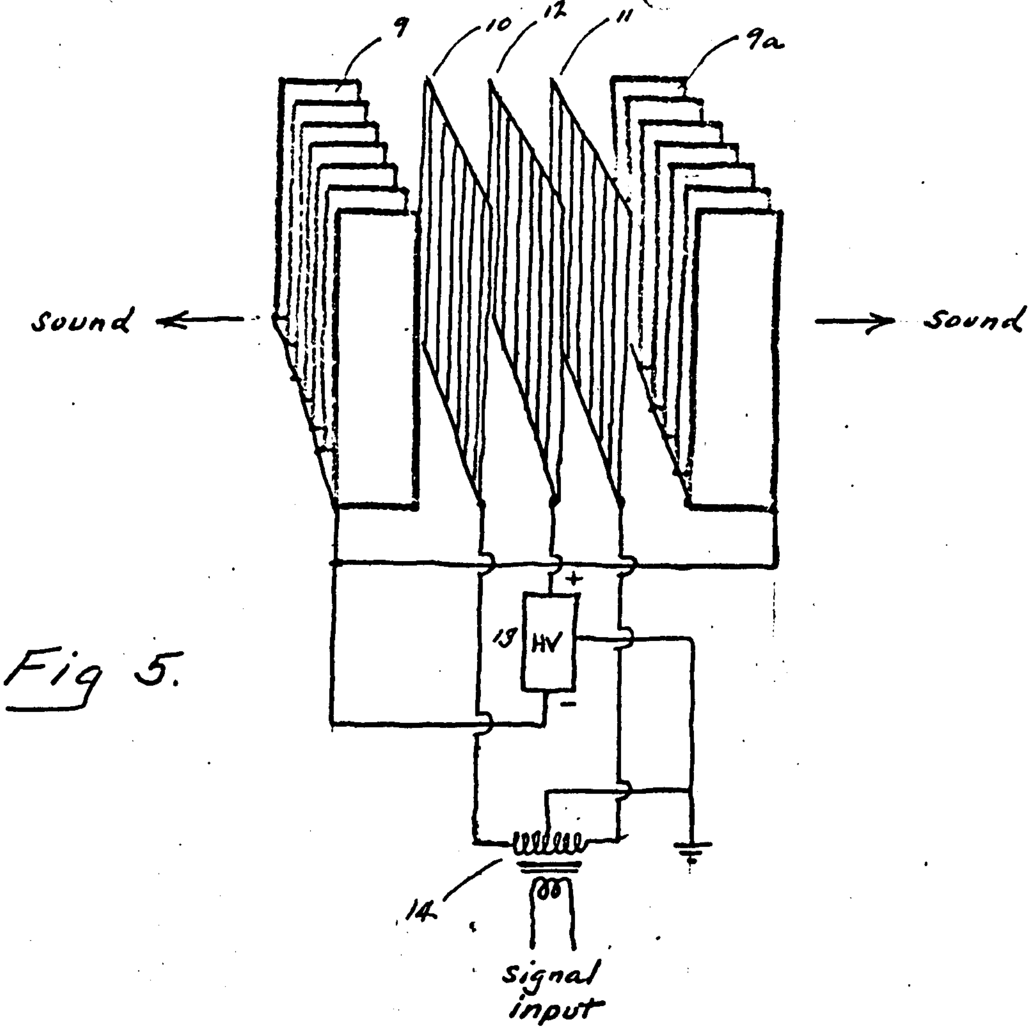
9
10
12
11
9a
sound
sound
HV
13
14
signal input

Fig 5.

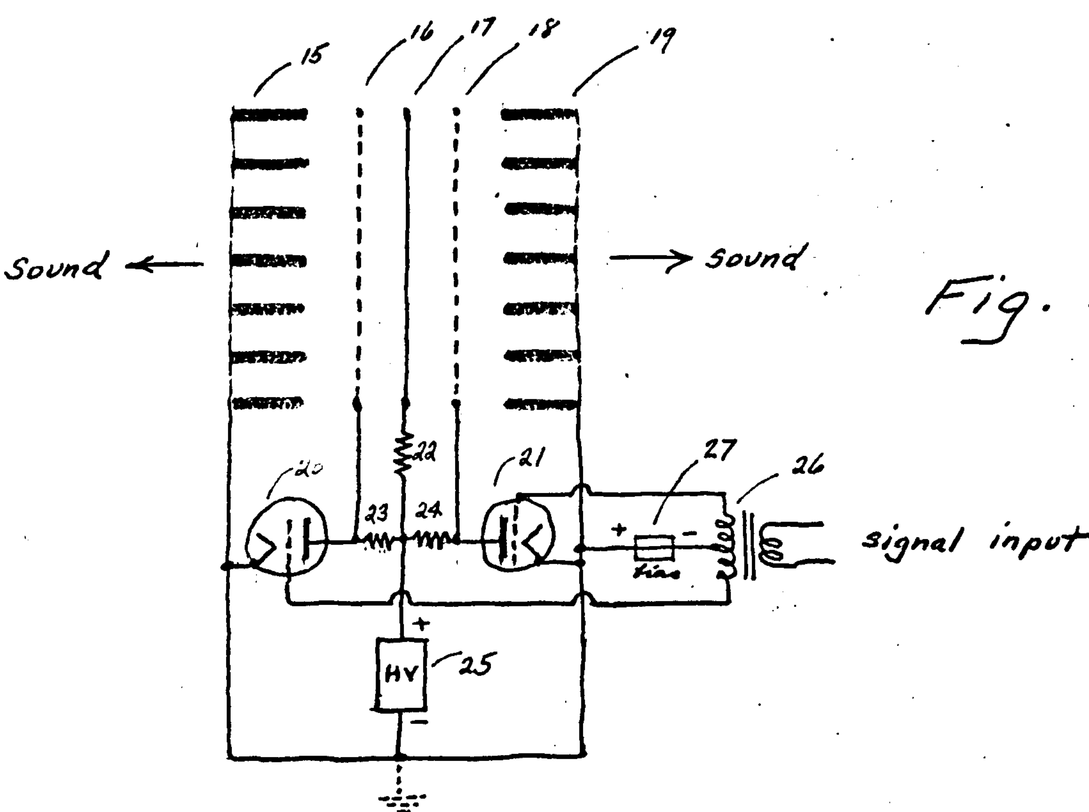
15
16
17
18
19
Sound
sound
22
20
21
27
26
23
24
signal input
HV
25

Fig. 6.