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ELECTROSTATIC ACOUSTIC DEVICE

Filed March 24, 1930

FIG. 1

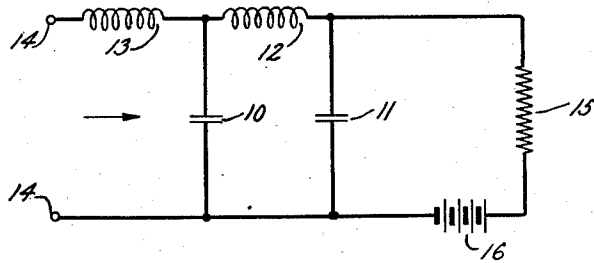


FIG. 2

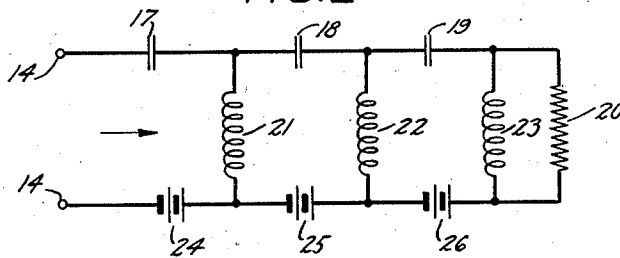


FIG. 3

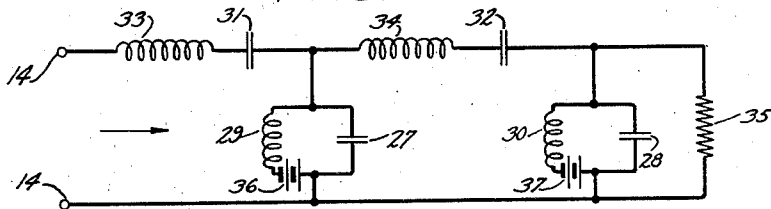
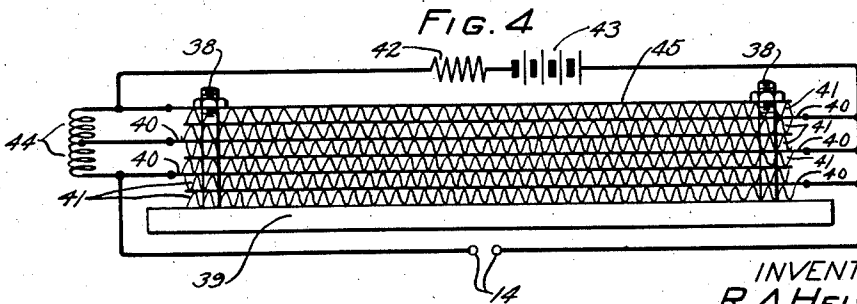


FIG. 4



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ELECTROSTATIC ACOUSTIC DEVICE

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3 Claims. (Cl. 179—111)

This invention relates to acoustic devices and more particularly to electrostatically operated loud speakers.

The usual type of multiplate electrostatic or condenser loud speaker consists essentially of a plurality of thin conducting plates mounted parallel to and in spaced relation with one another, alternate plates being connected electrically into two groups, one of which is fixed and the other movable, and a polarizing D. C. potential applied between the plates of the two groups. When a varying potential, such as may be obtained from the plate-filament circuit or an electron discharge device used as an amplifier, is applied across the plates of the multiplate condenser thus formed, the movable elements respond and vibrate with a frequency determined by that of the impressed voltage. A loud speaker of this design, because of the inherent mass, inertia, and elasticity of the movable elements, and the natural electrical properties of the condenser, when connected in an electrical circuit has a frequency response characteristic which is irregular and is, furthermore, more resonant to one frequency or limited band of frequencies than to others. The distortion of reproduced sound due to the mechanical and physical properties of the movable elements, as is known, may be decreased by making these elements as light as possible and the elasticity thereof a minimum. The distortion due to the electrical characteristics, however, will still be present. A loud speaker of the type heretofore described has, furthermore, a low operating efficiency, the greater part of the input energy being consumed in charging the condenser, while a small part is utilized in the propagation of sound.

An object of this invention is to decrease the distortion due to the innate electrical properties of the condenser and thereby improve the response characteristics of electrostatically operated acoustic devices.

A further object of this invention is to improve the operating efficiency of such devices.

In accordance with this invention the electrostatically operated loud speaker is built as an electrical filter and in one embodiment comprises a plurality of plate condensers, each having a fixed plate and a movable plate, connected in parallel with the usual polarizing D. C. potential applied across the plates. The condensers may be built side by side, each by itself and disposed as desired. An inductance of suitable constants is connected between the corresponding plates of successive condensers to form

a plurality of electrical meshes corresponding to a low pass filter and to provide a speaker which will be substantially equally resonant to all frequencies below the cut-off of the filter and which will have a very nearly flat-topped frequency response characteristic up to this cut-off point. The cut-off point will, of course, be determined by the constants of the capacities and inductances employed.

In this arrangement when an E. M. F. corresponding to the input signal is applied across the plates of the condensers a successive transfer of a portion of the input energy takes place between the individual condensers and each of the movable plates will dissipate a portion of the input as sound energy as this transfer occurs. In this manner the percentage of input energy expended as sound is increased and a loud speaker having a higher efficiency is obtained.

The unit may also be constructed as a high pass filter, that is, with the individual two plate condensers interposed between inductance units connected in parallel. The point of cut-off will as before be determined by the constants of the capacities and inductances employed.

In a specific structural embodiment of this invention the device may be built in one compact unit with all the plates movable and loosely stacked, and electrically connected into two groups with inductance elements inserted between the plates of either group or both groups. In this arrangement only the end plate is exposed directly to the air and propagates sound energy, the remainder of the plates responding to the input signal and accentuating the motion of the end plate.

The design of the electrostatically operated loud speaker of this invention will be more clearly understood from the accompanying drawing in which several of the many electrical filter constructions which may be employed in loud speakers in accordance with this invention are illustrated. Figs. 1, 2, and 3 show diagrammatically a condenser speaker built as a low pass, high pass, and band pass filter respectively and Fig. 4 illustrates the arrangement of the elements in a specific structural embodiment of this invention.

In one embodiment of this invention as shown in Fig. 1, the loud speaker comprises condensers 10 and 11 each having a fixed plate and a movable plate parallel to the fixed plate and separated therefrom by air or some suitable flexible di-

electric, as for example a rubber membrane. Although but two condensers are shown in this figure it is to be understood that any number may be employed. An inductance element 12 is connected between corresponding plates of successive condensers and another inductance element 13 is connected between the first condenser, in this case 10, and one of the input terminals 14, which may be connected to any suitable source (not shown) of an E. M. F. corresponding to the sounds to be reproduced, as for example, to the output terminals of an audio amplifier. A resistance 15 may be shunted across the last condenser, in this case 11, in series with a polarizing battery 16 or some other unit for establishing the desired D. C. potential across the plates of the condensers if there are not enough sections to absorb most of the speech frequency energy.

By proper selection of the constants of the capacities 10 and 11, and the inductances 12 and 13 and the number thereof, the speaker of this arrangement may be made substantially resonant electrically to all frequencies normally in the speech band and which it is desirable to reproduce. The condenser 10, for example, may have a capacity of C farads with the polarizing potential applied and the coil 12 an inductance of L henries. The end condenser 11 should then be of such dimensions as to have a capacity C/2 and the end coil 13 of such dimensions as to have an inductance of L/2 henries. The cut-off frequency will then be given by

$$\frac{1}{\pi\sqrt{LC}}$$

and the speaker will have a substantially uniform impedance to all frequencies in the audio range between zero and the highest which it is desired to reproduce.

In the operation of a speaker thus designed and constructed the wattless component of the input energy is passed from one condenser to the other until it is dissipated, each of the individual condensers emitting sound as this transfer takes place. Since, as previously pointed out, the electrical impedance of the speaker is substantially uniform for all those frequencies within the limits of the audio range which it is desired to reproduce, the unit will have a more uniform efficiency-frequency characteristic than electrostatically operated loud speakers of designs heretofore known; furthermore, since the arrangement provides a system whereby a large portion of the input energy is dissipated as sound, the condenser speaker of this invention will have a higher efficiency than has heretofore been attained for electrostatically operated sound reproducing devices.

Another form of the loud speaker of this invention is shown in Fig. 2 is built as a high pass filter and comprises a plurality of loosely constructed condensers 17, 18 and 19, each having a fixed plate and a movable plate, connected in series with a resistance 20, with each condenser connected between two of the inductance elements 21, 22, 23. In this arrangement individual sources of polarizing potential, such as batteries 24, 25 and 26 are required and may be inserted in the electrical circuit as shown. A speaker of this construction will be substantially resonant electrically to all frequencies above the cut-off of the filter which will, of course, be determined by the constants of the condensers and inductances employed.

Still another form which the sound reproducer of this invention may take is illustrated in Fig. 3 wherein condensers 27 and 28 are connected in parallel with an inductance 29 and 30 respectively, and the combination of an inductance and capacity is inserted, as shown, in a series circuit comprising the condensers 31 and 32, inductance coils 33 and 34, and resistance 35. In this arrangement the condensers 27 and 28 are loosely constructed, each having a movable plate adapted to act as a diaphragm and propagate sound waves, and the condensers 31 and 32 are preferably fixed, although they also may be loosely constructed and adapted to emit sound. Individual sources of polarizing D. C. potential as, for example, batteries 36 and 37, are provided and connected as shown. This combination forms a band pass filter which will be substantially resonant electrically to all frequencies between the upper and lower cut-off points of the filter, the cut-off points being determined, as before, by the constants of the condensers and inductances used.

In a specific embodiment and structure shown in Fig. 4, the loud speaker comprises a plurality of condensers arranged in one pile and loosely clamped by bolts 38 or other suitable means to an insulating plate 39, the condensers consisting of loosely disposed metal foil sheets 40, alternate sheets being electrically connected, separated by resilient spacers 41 of rubber, paper or the like. A resistance 42 and source of polarizing potential 43 are connected across the plates as shown, and inductance elements 44 are interposed between corresponding plates of successive condensers. It is preferable that the mutual inductance between the coils be very small. The condenser speaker thus formed has the electrical characteristics of a low pass filter and differs from the form shown in Fig. 1 in that only the end plate 45 radiates sound, the remainder of the movable plates serving to accentuate the movement of the plate 45.

It is to be understood that the forms of the invention shown in the accompanying drawing are merely illustrative of the various principles involved and that any suitable filter circuit may be employed. Many variations in the details of structure and relative arrangement may occur to persons skilled in the art and still fall within the broad scope of this invention as defined in the appended claims.

What is claimed is:

1. An electrostatic sound translating device comprising electrically conductive plate members forming electrodes of a plurality of condensers electrically in parallel, certain of said plate members being vibratile in accordance with audio-frequency impulses, an inductance and a source of potential in shunt with each of said condensers, reactance means connected between corresponding electrodes of said condensers, and a terminating impedance in shunt with said condensers, said inductances and reactance means neutralizing the capacity of said condensers, whereby said device is adapted to translate sound energy with substantially negligible attenuation over a wide range of audio-frequencies.

2. An electrostatic sound translating device comprising members forming a plurality of condensers, certain of said members being vibratile in accordance with audio-frequency impulses applied thereto, means connecting said condensers in series, reactance means for neutralizing the capacity of said condensers, and a terminating impedance in circuit with said condensers, said

condensers, reactance means and terminating impedance defining an electro-acoustic system adapted to translate energy with substantially negligible attenuation over a wide range of audio frequencies.

5 3. An electrostatic sound translating device comprising members forming a plurality of condensers, certain of said members being vibratile in accordance with audio-frequency impulses applied thereto, means including inductance members connecting certain of said condensers in

series, means connecting other of said condensers in parallel with each other and in circuit with said first condensers, an inductance and a source of potential in shunt with each of said other condensers, and a terminating impedance in shunt with said other condensers, said condensers, inductance members, and inductances defining an electro-acoustic system adapted to translate energy with substantially negligible attenuation over a wide range of audio-frequencies.

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