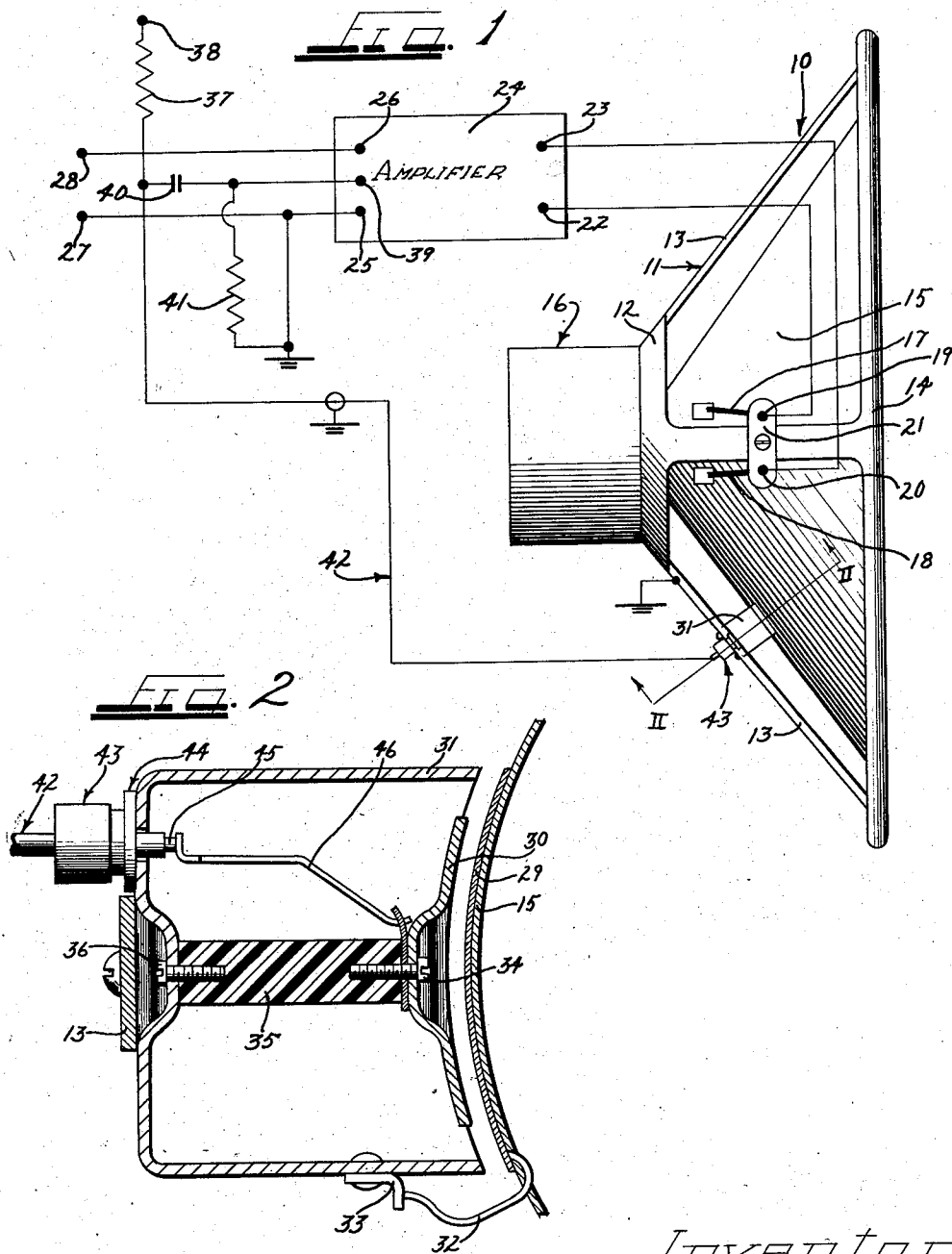


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G. H. BRODIE
SPEAKER DIAPHRAGM CONTROLLED CAPACITOR
FOR NEGATIVE FEEDBACK CONTROL
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SPEAKER DIAPHRAGM CONTROLLED CAPACITOR FOR NEGATIVE FEEDBACK CONTROL

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This invention relates to a speaker diaphragm controlled capacitor for negative feedback control by which greatly improved fidelity of sound reproduction is achieved.

Inverse or negative feedback has been extensively applied with respect to audio amplifiers to achieve an amplified output corresponding very accurately to the input signal. Such systems have been so good that the limiting factor on sound reproduction has been the electro-acoustical means or speaker utilized to transform the electrical output signal into a sound wave, and considerable difficulty has been encountered in attempting to design a speaker which will produce a sound wave accurately corresponding to the electrical signal applied thereto.

According to this invention, means are provided for developing an electrical signal in response to movement of the speaker diaphragm and such electrical signal is applied to the amplifier in phase opposition to the input signal to the amplifier, so as to provide a negative or inverse feedback which not only compensates for distortions produced in the amplifier but also compensates for distortions produced in the means for driving the amplifier from the electrical signal at the output of the amplifier.

Any form of electro-acoustical device may be utilized to develop a signal in response to movement of the speaker diaphragm but preferably, and in accordance with a specific feature of the invention, such means may comprise a plate of conductive material carried by the speaker diaphragm so as to be movable therewith and a fixed plate of conductive material in spaced registering relation to the movable plate. With this arrangement, the capacitance between such plates varies in accordance with movement of the diaphragm.

To develop an electrical signal in response to the varying capacitance between such plates, one of the plates may be connected to one end of an impedance and the other end of the impedance and the other plate may be connected to a voltage source. With this arrangement, variations in the capacitance between the plates will produce variations in the voltage across the plates, or the voltage across the impedance. One of such voltages, preferably the voltage across the capacitance defined by the plates, may be connected in the input circuit of the amplifier in a phase relation such as to produce inverse or negative feedback.

In a preferred embodiment of the invention, the speaker may be of conventional construction including a metallic frame with a conical diaphragm of a felted material mounted in such frame, the diaphragm carrying a voice coil connected through the amplifier output and movable in a constant magnetic field. A thin plate of conductive material such as a metallic foil may be disposed on such diaphragm and may be connected through a flexible lead to the frame of the speaker, which may be at ground potential. Another plate may be supported in fixed insulated relation from the frame in spaced op-

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posed relation to the plate on the diaphragm and may be connected through a resistor to a point at a relatively high potential relative to ground. The fixed plate may be coupled to the amplifier input, preferably through a capacitor-resistor coupling circuit.

It will be appreciated that this invention provides a negative feedback system which compensates for distortions not only in an amplifier but also in the speaker to provide greatly improved reproduction of sound, and the system, at the same time, is very simple and readily applied to speakers of conventional construction.

An object of this invention, accordingly, is to provide an improved inverse feedback system which compensates not only for distortions in an amplifier but also for distortions in a speaker.

Another object of this invention is to provide an improved negative feedback system utilizing a speaker diaphragm-controlled capacitor.

A further object of this invention is to provide an improved speaker diaphragm controlled capacitor which is particularly advantageous when used for negative feedback control.

This invention contemplates other objects, features and advantages which will become more fully apparent from the following detailed description taken in conjunction with the accompanying drawing which illustrates a preferred embodiment and in which:

Figure 1 illustrates in side elevation a speaker incorporating a diaphragm controlled capacitor in accordance with this invention, and also illustrates diagrammatically a preferred circuit arrangement for achieving the negative feedback control of this invention; and

Figure 2 is a sectional view, on an enlarged scale, taken substantially along line II—II of Figure 1 and illustrating in detail one preferred construction of the speaker diaphragm controlled capacitor.

Reference numeral 10 designates a speaker which may be of conventional construction and may comprise a frame 11, usually of metal, including a central portion 12 and spoke-like arms extending radially and axially from the central portion 12 to a rim portion 14. A conical diaphragm 15, usually of a felted material may be supported for vibratory movement in the frame 11 by having its periphery flexibly supported from the rim 14 of the frame 11. The diaphragm 15 may carry a voice coil movable in a fixed magnetic field produced by a magnetic structure 16 on the central portion 12 of the frame 11, the ends of the voice coil being connected through flexible leads 17 and 18 to terminals 19 and 20 on an insulator plate 21 secured to one of the arms 13 of the frame 11.

The voice coil terminals 19 and 20 may be connected to output terminals 22 and 23 of an amplifier 24 having a pair of input terminals 25 and 26 connected to terminals 27 and 28 which may be connected to any desired signal source. Signals applied to the terminals 27 and 28 will, of course, be amplified by the amplifier 24 and applied to the voice coil of the speaker 10 to produce vibratory movements of the speaker diaphragm 15.

According to this invention, means are provided for producing an electrical signal varying in accordance with vibratory movement of the diaphragm 15, and such signal is differentially compared with the input signal and the resultant signal is then applied to the amplifier 24 in phase opposition to the input signal applied to the terminals 27 and 28 in a manner such as to produce an inverse or negative feedback so as to compensate for inherent distortions produced in both the amplifier 24 and the speaker 10.

The means for producing an electrical signal in accordance with vibratory movement of the diaphragm 15

may preferably comprise a plate 29 of conductive material carried by the diaphragm 15, and a plate 30 fixedly carried from the frame 11 of the speaker 10 and disposed in spaced opposed relation to the plate 29, the plate 30 being also of a conductive material. It will be appreciated that the plates 29 and 30 define a parallel plate capacitor in which the spacing between plates and hence the capacitance varies with vibratory movement of the diaphragm 15.

The plate 29 may be an integral part of the diaphragm 15, but the diaphragm 15 will usually be of a felted or similar material having insulating properties so that the plate 29 may be non-integral with the diaphragm 15. The plate 29 may, for example, be of a very thin metallic foil or a layer of flexible conducting metallic paint, should be so located as to avoid nodes or anti-nodes at critical frequencies, and is preferably of such a material so as to have minimum effect on movement of the diaphragm 15. The plate 30 may also be of a metallic material, but may be substantially thicker than the plate 29, since it is not movable. Since the plate 30 should be in relatively closely spaced relation to the plate 29 to obtain maximum capacitance, there is a possibility that the plates may define a non-compliant acoustical reactance opposing movement of the diaphragm 15. To minimize this effect, the plate 30 may preferably be apertured, or it may of a screen material.

The variable capacitor defined by the plates 29 and 30 may be coupled in the input circuit of the amplifier 24, as will be described in detail hereinafter, and any voltages induced across the plates 29 and 30 by stray fields may be amplified by the amplification factor of the amplifier 24 to produce undesirable hums and noises. To minimize such effects, the plates 29 and 30 may be effectively shielded from stray fields. For this purpose, a generally cup-shaped member of a conductive material, preferably metal, may enclose the plate 30 with the rim of the member 31 being spaced outwardly from the peripheral edge of the plate 30 in closely spaced relation to the peripheral portion of the plate 29. The cup-shaped member 31 may be secured to one of the arms 13 of the speaker frame 11, which may be grounded as diagrammatically illustrated in Figure 1 and the plate 29 may be electrically connected to the member 31 by means of a flexible lead 32 having one end connected to the plate 29 with its other end connected to a lug 33 on the outside of the member 31. With this arrangement, the plate 30 may, except for the small opening between the peripheral edge portion of the plate 29 and the rim of the member 31, be completely enclosed by the plate 29 and member 31, both being at ground potential, so that an effective shield is provided.

To support the plate 30, the central portion thereof may be secured by a screw 34 to one end of a post 35 of insulating material, the other end of the post 35 being secured by a screw 36 to the bottom portion of the cup-shaped member 31.

To develop an electrical signal in response to variations in the capacitance between the plates 29 and 30, the plate 30 may, as diagrammatically illustrated in Figure 1, be connected through an impedance in the form of a resistor 37 to a circuit point 38, which may be at a relatively high positive potential with respect to ground, the plate 29 being connected to ground as previously indicated. With this arrangement, variations in the capacitance between the plates 29 and 30 caused by vibratory movement of the diaphragm 15 will cause corresponding variations in the voltage across the plates 29 and 30.

The signal developed at the junction between the plate 30 and the resistor 37 may be coupled to the input terminal 26 of the amplifier 24, but is preferably coupled to a separate input terminal 39 as illustrated and differentially composed with the input signal with the resultant signal acting to compensate for distortions in the ampli-

fier and speaker. A direct connection might be used but since the average potential of the plate 30 will be equal to the potential of the point 38 and hence at a relatively high potential with respect to ground, the connection may be made through a coupling capacitor 40 with a resistor 41 being connected between the input terminal 39 and the input terminal 25, or ground.

To shield the connection between the plate 30 and the amplifier 24 from stray fields, a shielded cable 42 may be utilized with a plug 43 at one end of the cable 42 being connected to a jack 44 mounted on the cup-shaped housing member 31, the outer conductor, or shield, of the cable 42 being connected to the housing member 31 and hence to ground, and the inner conductor of the cable 42 being electrically connected to a lug 45 on the jack 44. The lug 45 may be connected through a wire 46 to a lug 47 secured between the plate 30 and the post 35 in both mechanical and electrical contact with the plate 30.

Any capacitance in parallel with the capacitance defined by the plates 29 and 30 will lower the proportional change in capacitance caused by vibratory movement of the diaphragm 15, so as to lower the electrical output. It could happen that the capacitance between the inner conductor of the cable 42 and the outer conductor or shield may be so high as to lower the electrical output below the desired value. In such event, the amplifier 24 may include a vacuum tube or the like located closely adjacent the plate 30 with a short direct connection between the plate 30 and the grid of such vacuum tube. The tube might, if desired, be located within the cup-shaped housing member 31. Such tubes may preferably act as a cathode follower having a low output impedance so that the shunt capacitance of the connecting cable will have negligible effect.

From the foregoing, it will be appreciated that this invention provides an inverse feedback system which compensates not only for distortions within an amplifier but also for distortions in a speaker, the system being very simple, efficient and reliable and being readily constructed from a minimum number of component parts.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. In a sound reproduction system, a diaphragm, first electro-acoustical means for driving said diaphragm in response to an electrical signal, and second electro-acoustical means for developing an electrical signal in response to movement of said diaphragm, comprising: a movable plate of conductive material on said diaphragm, a fixed plate of conductive material in spaced registering relation to said movable plate to define therewith a capacitance varying in accordance with movement of said diaphragm, means connecting said movable plate to ground, resistance means connecting said fixed plate to a point at a relatively high positive potential with respect to ground, and amplifier means having an input connected between said fixed plate and ground and having an output connected to said first electro-acoustical means.

2. In a sound reproduction system, a diaphragm, first electro-acoustical means for driving said diaphragm in response to an electrical signal, and second electro-acoustical means for developing an electrical signal in response to movement of said diaphragm, comprising: a movable plate of conductive material on said diaphragm, a fixed plate of conductive material in spaced registering relation to said movable plate to define therewith a capacitance varying in accordance with movement of said diaphragm, means connecting said movable plate to ground, resistance means connecting said fixed plate to a point at a relatively high positive potential with respect to ground, amplifier means having an input connected between said fixed plate and ground and having an output

connected to said first electro-acoustical means, and means
for shielding said plates from stray fields.

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