

March 15, 1966

C. E. SEELER

3,240,883

MICROPHONE

Filed May 25, 1961

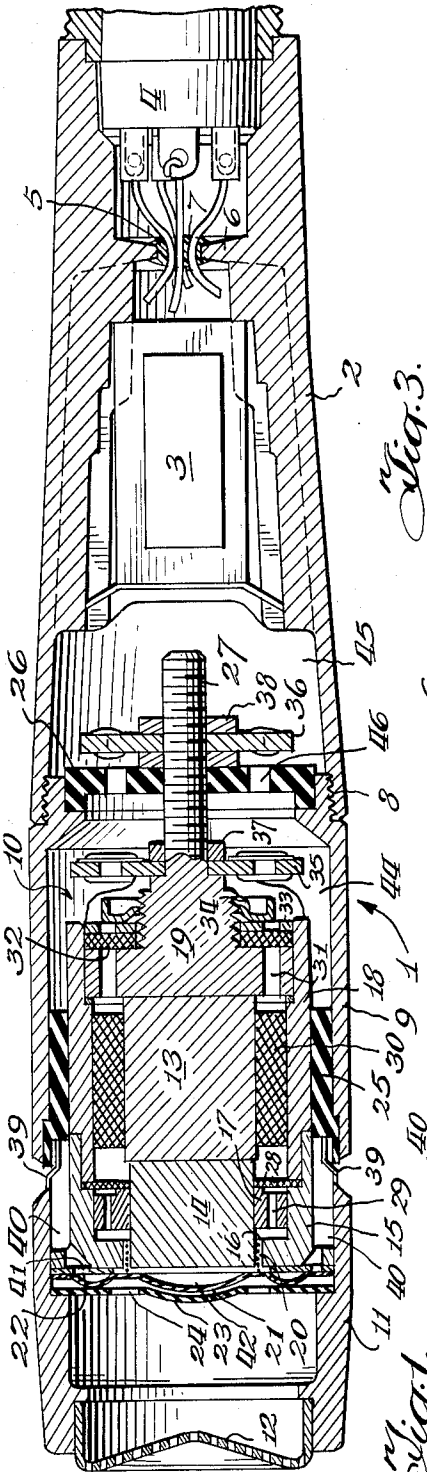
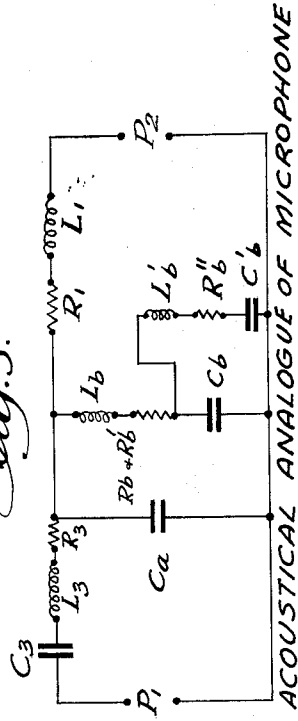


Fig. 3.



ACOUSTICAL ANALOGUE OF MICROPHONE

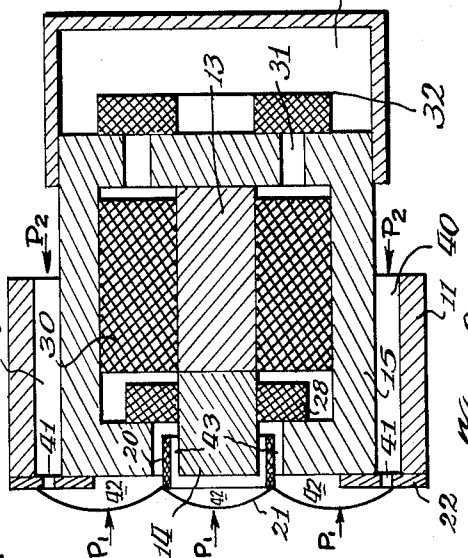
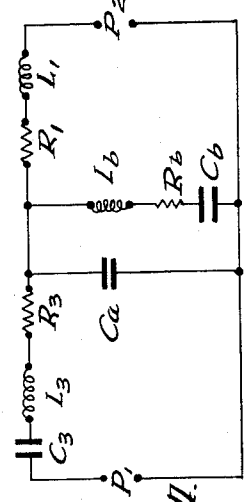


Fig. 2.



SIMPLIFIED ACOUSTICAL ANALOGUE

Inventor
 Charles E. Seeler
 By
 Schneider, Dresler, Goldsmith & Clement
 Attorneys

1

2

3,240,883

MICROPHONE

Charles E. Seeler, Evanston, Ill., assignor to Shure Brothers, Incorporated, a corporation of Illinois
 Filed May 25, 1961, Ser. No. 121,280
 6 Claims. (Cl. 179-115.5)

The present invention relates to a microphone structure and more particularly to a new and improved microphone having unidirectional properties.

There have been several types of microphones known in the art which have response characteristics such that they have been called unidirectional. By and large, these devices have generally cardioid response patterns at selected frequencies. A major difficulty with those devices, however, is that the response curves were not uniform in polar orientation with respect to the solid which would be generated by rotation of the response pattern of a selected plane and were not symmetrical with respect to the axis of the microphone or a line normal to the diaphragm.

Particular difficulty existed due to variations in frequency response characteristics and polar orientations.

Of the various types of unidirectional microphones, one of the most well-known is the type utilizing a phase shifting system and rear entry structure for effecting cancellation of behind-the-microphone signals, such as that described and illustrated in Baumzweiger Patent No. 2,237,298, issued April 8, 1941.

The present invention overcomes these difficulties and in accordance therewith there is provided a new unidirectional microphone utilizing phase shifting characteristics and which has a response pattern that is uniform in polar orientation. Microphones embodying this invention utilize an increased number of phase shifting and correcting networks in a simplified structure whereby more uniform frequency response is achieved and the acoustic circuit elements are so oriented that the response pattern is cardioid and symmetrical in revolution about the longitudinal axis of the microphone normal to the diaphragm.

Microphones embodying this invention utilize a system of coaxially arranged, longitudinally distributed elements providing localized and distributed acoustic capacitances, resistances and inductances, whereby the desired results discussed above are readily achieved in a structure which may be relatively small and convenient to handle. Structures embodying this invention utilize not only the parts which are generally considered to be the acoustic, magnetic and electrical components of a microphone, but also utilize the shell and case of the device to provide the coaxially arranged, longitudinally distributed acoustic phase shifting network.

There is shown in the drawings an illustrative embodiment of the instant invention in which the microphone cartridge, consisting generally of the magnets and diaphragm, are so arranged in a shell and case that the physical interrelation of the cartridge with the shell and the case provides the distribution and localized capacitance, resistance and inductance.

FIGURE 1 of the drawings which form a part of this specification is a cross-sectional illustration of the aforementioned illustrative embodiment of the present invention.

FIG. 2 is a simplified mechanical schematic illustration of the microphone of FIGURE 1.

FIG. 3 is an electrical equivalent schematic illustration of the acoustic analogue of the microphone of FIGURE 1, and

FIG. 4 is a further simplified electrical equivalent schematic illustration of the acoustical analogue.

The microphone 1 shown in FIG. 1 is a rotationally symmetrical device, mechanically, about the longitudinal

axis thereof. The outer structure of the microphone includes, in this particular embodiment, a slightly conical base 2 in which the microphone transformer 3 is housed and mounted. At the back end of the base there is secured a cable jack 4 which closes the end of the base and provides for electrical connection to the system that is to receive signals from the microphone. At an intermediate position between the transformer and the cable jack, the interior of the base is acoustically sealed from the cable jack by a grommet 5 that is mounted on an internal flange 6 in the base. An appropriate passage 7 in the grommet provides for the connecting wires for coupling the transformer to the cable jack. This passage is sealed with cement so that it does not destroy the acoustic sealing qualities of the grommet.

The front end of the base is threadably attached, as at 8, to an intermediate cylindrical shell and housing portion 9 within which the microphone cartridge assembly 10 is mounted.

The housing is completed at its front end by an acoustically permeable headpiece 11, also substantially cylindrical, which carries the perforated screen 12 for direct entry of the acoustic vibrations to the cartridge of the microphone.

The physical assembly of the microphone cartridge 10 includes a magnet 13 on the front end of which there is secured an inner, cylindrical pole piece 14. The cylindrical inner pole piece is coaxially arranged with a tube-like cylindrical outer pole piece 15 so disposed with respect to the inner pole piece that it is radially spaced therefrom. This provides an air gap 16 between the outer peripheral surface of the inner pole piece and the inner peripheral surface of the outer pole piece.

The spacing in coaxial arrangement of the inner and outer pole pieces is maintained by a non-magnetic, such as brass, spacing bushing 17 disposed therebetween rearwardly of the defined air gap. At its rearward end, the outer pole piece is carried on a pole piece ring 18 that is mounted on a yoke 19 affixed to the rearward end of the magnet 13. The pole piece ring 18 and yoke 19 are of magnetic material, such as iron, to provide a closed magnetic circuit between the outer pole piece and the rearward end of the magnet. With this arrangement, the entire magnetic circuit is closed except for the radially oriented air gap between the inner and outer pole pieces at the front end of the assembly of the cartridge.

This air gap provides a radially oriented field in which the voice coil 20 is disposed. The voice coil consists of a number of turns of fine wire cemented together to form a solid structure in the form of a short, thin-walled tube which is arranged in the air gap in such a manner that axial movement thereof will generate an E.M.F. to excite the primary winding of the transformer by appropriate electrical interconnection between these elements.

The voice coil is cemented to an appropriately configured diaphragm 21 of thin, flexible material which will vibrate in accordance with the acoustic undulation engaging the same. The diaphragm is carried on a resistance ring 22 secured in place on the outer pole piece 15. Ahead of the diaphragm, between its front surface and the inner surface of the screen 12, there is provided a protective, perforated resonator plate 23 mounted on the interior of the headpiece, substantially parallel to the diaphragm and radially of the microphone assembly. The resonator plate 23 is provided with a plurality of circularly arranged poles 24.

The microphone cartridge is held coaxially within the shell 9 by shock mount rings 25 and 26 disposed about the pole piece ring 18 and the adjusting screw 27 at the rearward end of the yoke 19, respectively, with the inner peripheries thereof in tight engagement with the outer

3

peripheries of the pole piece ring and the screw, and with the outer peripheries of the shock mounts in firm engagement with the inner peripheral surface of the shell 9.

Additional structure provided in the microphone assembly of FIG. 1 includes a cloth screen 28 disposed behind the non-magnetic spacer bushing 17 in line with the circularly arranged passages 29 in the bushing. In the same general area, the space between the magnet 13 and the outer pole piece ring 18 is substantially filled with felt or acoustically similar material, as indicated at 30.

Proceeding rearwardly, the yoke 19 has a plurality of circularly arranged apertures 31 therein, which are closed at their rearward ends by a felt or a cloth washer 32 and backed by a pressure plate 33 having apertures therein or being slightly smaller in diameter than the felt washer 32. The pressure on the plate 33, and thereby the compaction and acoustic qualities of the washer 32, is adjustably controlled by a nut 34 threadably engaged on the rearward end of the yoke and bearing against the back side of the pressure plate 33.

For electrical connections within the microphone, terminal plates 35 and 36, carrying solder lugs thereon, are mounted at the back end of the yoke 19 and behind the apertured shock mount 26, respectively, and secured in position by nuts 37 and 38 on the screw 27.

The microphone described in conjunction with the illustrative embodiment of FIG. 1 performs four significant functions. These are (1) magnetic, (2) mechanical vibratory, (3) electrical, and (4) acoustic vibratory.

The magnetic function of providing an appropriate field for electro-magnetic relation with the voice coil is provided by the magnet, the inner pole piece, the outer pole piece disposed with an airgap between it and the inner pole piece, and the magnetic circuit closing elements of the outer pole piece ring and the yoke, with the bushing providing a stable spacing relation between the inner and outer pole pieces to maintain a mechanically stable, and therefore a magnetically stable, airgap.

The mechanical vibratory functions are provided by the diaphragm to which the voice coil is mounted and which is itself mounted on the resistance ring so as to be effectively secured in proper radial position with the voice coil disposed within the airgap without engaging either of the pole pieces.

The electrical function is performed when the diaphragm is vibrated to axially move the voice coil in the airgap so as to generate an E.M.F. transmitted to the transformer by electrical connections therewith effected at the terminal plates.

Of salient significance in connection with the present invention are the acoustic functions provided by the circumferentially or peripherally symmetrical microphone structure herein described. As noted above, microphones embodying this invention have an essentially cardioid response pattern which is uniform and rotationally symmetrical about the major axis of the microphone. This characteristic is provided by the phase-shifting interrelation and rotationally symmetrical arrangement of the components of the microphone.

The phase-shifting effects of this microphone are obtained from the utilization of a plurality of isolated acoustic paths within the device itself. Thus, the acoustic vibratory functions of the device are performed by the interrelation of three distinctive acoustic paths, the first of which is wholly isolated from the other two, and the second and third of which are physically in series but acoustically arranged in accordance with the electrical symbol equivalent circuit arrangements shown in FIGS. 3 and 4 in conjunction with the simplified mechanical equivalent schematic illustration of FIG. 2.

The first path, and the primary one for generation of signals in response to acoustic undulations from a source such as a voice, proceeds through the perforate screen 12 and the acoustically permeable headpiece 11 at the

4

front of the microphone structure, through the chamber between the screen and the resonator plate, and through perforations in the resonator plate to the front face of the diaphragm.

The pressure on the diaphragm from the first air path is the primary signal source and is designated as P_1 in FIGS. 2, 3 and 4.

The second acoustic path is provided by a rear entry avenue progressing through a protective screen 39 underlying radial openings at the junction of the headpiece 11 with the shell 9 and at which the signal P_2 appears. The acoustic signals P_2 entering these apertures progress axially forwardly through a plurality of peripheral recesses 40 in the outer surface of the outer pole piece 15 and the inner surface of the headpiece 11. The rear entry signals progress from these recesses forwardly to the back surface of the diaphragm 21. The entry to the underside of the diaphragm and into the cavity 42 from the recesses 40 is provided by circularly arranged apertures 41 in the resistance ring 22. This cavity is effectively an acoustic capacitance designated as C_a in the acoustic analogues of FIGS. 3 and 4. Appropriate passages provided by proper configuration of the diaphragm in accordance with the principles of this invention provides for acoustic communication throughout the entire chamber 42.

The compliance of the diaphragm to the acoustic undulations presented to it is an acoustic capacitance designated as C_3 in the equivalent analogues of FIGS. 3 and 4 while the diaphragm-voice coil assembly provides an inductance designated by an equivalent L_3 and an acoustic resistance R_3 . The inductance and acoustic resistance of the slots or recess paths 40 and the apertures 41 are indicated by equivalent elements L_1 and R_1 in the equivalent analogues of FIGS. 3 and 4.

The remainder of the acoustic path system of the microphone, while acoustically complex, is physically in series with the above-described second path and initiates in the chamber 42. The path, herein described as the third path, progresses from the chamber 42 through the cylindrical passages 43 defined by the voice coil 20 in the airgap, through the apertures 29 in the brass bushing, and into the felt-filled chamber between the outerpole piece ring and the magnet. This felt-filled cavity provides an acoustic capacitance designated in the equivalent analogues as C_b while the passages defined by the voice coil in the airgap, the apertures in the bushing, and the acoustic action of the cloth washer, provide acoustic inductance and resistance designated as L_b and R_b . The acoustic resistance of the felt pad 30 is designated by the equivalent R'_b in the analogue of FIG. 3.

From the felt-filled chamber, the third path continues through the apertures 31 in the yoke 19 on the felt pad 32, the pressure and compression on which is controlled by the nut 34 and brass washer 33 to the chamber 44 between the outer pole piece and the shell 9, the forward end of which chamber is acoustically sealed by the shock mount 25. This chamber 44 is in acoustic connection with the microphone transformer chamber 45 by means of apertures 46 in the shock mount 26 at the back end of the shell 9. The total of the acoustic capacitances of the chambers 44 and 45 are lumped as an equivalent C'_b in FIG. 3 while the passages 31 and the compressed felt washer 32 provide acoustic inductance and resistance designated in the equivalent analogue of FIG. 3 as L'_b and R''_b .

Analysis of FIG. 3, which is the effective low frequency analogue and of the simplified equivalent schematic of FIG. 4, which is an effective schematic for medium frequency signals, readily shows that the phase-shifting capacities of the network for establishing a relation between the signals F_1 and P_2 is such that the desired cardioid polar pattern is provided by structures embodying this invention and is such that the polar pattern is uniform and provides for uniform discrimination through

5

the medium frequency range. The shape, dimensional proportions and arrangement of the headpiece, cavities, apertures, felt piece, felt and cloth washers, openings, screens and recesses are chosen so as to transform the lumped impedances shown in FIG. 3 into distributed impedances which will, at higher frequencies, interact in such a manner so as to provide unidirectional characteristics at higher frequencies. Thus, this invention provides for uniform polar response over substantially the entire audio spectrum while feedback at frequencies normally favored by the mechanical properties of a microphone are avoided and the pattern is rotationally symmetrical about the major axis of the microphone.

It will be seen also that in accordance with this invention there is provided a new and highly improved systematic arrangement of coaxially disposed, longitudinally arranged elemental interrelations providing effective inertances, acoustic capacitances and resistances for appropriate phase-shifting over wide frequency variation whereby a microphone is more uniformly controlled for unidirectional response in accordance with a predesired pattern. The principles of this invention are readily applicable to substantial modification and variation of embodiments thereof, such that additional equivalent circuit components may be piled in a structure for controlled response characteristics without substantially increasing the bulk of the microphone unit. For example, additional inertance and resistance elements may be provided at the openings 46 in the shock mount 26 to provide a separation of the capacitances of the chambers 44 and 45 in this embodiment of the invention, thereby creating an additional network in parallel with the capacitance C'_b of FIG. 3 or the lumped capacitance C_b of FIG. 4.

Thus, it is clear that numerous modifications and variations may be effected without departing from the spirit and scope of the novel concepts and principles of this invention.

I claim:

1. In a microphone having a housing, a diaphragm mounted in said housing and a voice coil mounted on one side of said diaphragm, an opening in said housing at the opposite side of said diaphragm from said voice coil to admit acoustic vibrations to said diaphragm from a source external of said housing, a second opening in said housing, a passageway in said housing defining an acoustic communication between said second opening and said one side of said diaphragm, a first chamber in said housing, an acoustic resistance defining a communication path between said first chamber and said one side of said diaphragm, a second chamber in said housing and a second acoustic resistance defining a communication path between the first chamber and the second chamber.

2. In a microphone having a housing, a diaphragm mounted in said housing and a voice coil mounted on one side of said diaphragm, an opening in said housing at the opposite side of said diaphragm from said voice coil to admit acoustic vibrations to said diaphragm from a source external of said housing, a second opening in said housing, a passage in said housing providing acoustic communication between said second opening and said one side of said diaphragm, a first chamber in said housing, an acoustic resistance providing a communication path between said first chamber and said one side of said diaphragm, a second chamber in said housing and a second acoustic resistance providing a communication path between the first chamber and the second chamber, said chambers and said resistances being axially arranged to provide a longitudinal major axis and being substantially symmetrical about the major axis of the microphone.

3. A microphone having unidirectional response, characteristics uniform in polar orientation with a polar response pattern symmetrical over substantially the entire audio spectrum, comprising a housing, a diaphragm mounted in said housing, a voice coil mounted on one side of said diaphragm, an opening in said housing pro-

6

viding an acoustic entry to said diaphragm and coaxial therewith at the side thereof opposite to said voice coil, a chamber in said housing at said one side of said diaphragm, said one side of said diaphragm serving to define a portion of said chamber, a plurality of circumferentially disposed and symmetrically arranged openings in said housing in communication with said chamber, a second chamber in said housing, an acoustic resistance providing a communication path between the first mentioned chamber and said second chamber, a third chamber in said housing, and a second acoustic resistance providing a communication between said second chamber and said third chamber.

4. A microphone having unidirectional response characteristics uniform in polar orientation with a polar response pattern symmetrical over substantially the entire audio spectrum, comprising a housing, a diaphragm mounted in said housing, a voice coil mounted on one side of said diaphragm, an opening in said housing providing an acoustic entry to said diaphragm and coaxial therewith at the side thereof opposite to said voice coil, a chamber in said housing at said one side of said diaphragm, said one side of said diaphragm serving to define a portion of said chamber, a plurality of circumferentially disposed and symmetrically arranged openings in said housing in communication with said chamber, a second chamber in said housing, an acoustic resistance providing a communication path between the first mentioned chamber and said second chamber, a third chamber in said housing, and a second acoustic resistance providing a communication between said second chamber and said third chamber, said chambers and said acoustic resistances being axially arranged to provide a longitudinal major axis and being substantially symmetrical about the major axis of the microphone.

5. A microphone having unidirectional response characteristics uniform in polar orientation with a polar response pattern symmetrical over substantially the entire audio spectrum, comprising a housing, a diaphragm mounted in said housing, a voice coil mounted on one side of said diaphragm, an opening in said housing providing an acoustic entry to said diaphragm and coaxial therewith at the side thereof opposite to said voice coil, a chamber in said housing at said one side of said diaphragm, said one side of said diaphragm serving to define a portion of said chamber, a plurality of circumferentially disposed and symmetrically arranged openings in said housing in communication with said chamber, a second chamber in said housing, an acoustic resistance providing a communication path between the first mentioned chamber and said second chamber, a third chamber in said housing, and an adjustable second acoustic resistance providing a communication between said second chamber and said third chamber.

6. A microphone having unidirectional response characteristics uniform in polar orientation with a polar response pattern symmetrical over substantially the entire audio spectrum, comprising a housing, a diaphragm mounted in said housing, a voice coil mounted on one side of said diaphragm, a first chamber in said housing at said one side of said diaphragm, said one side of said diaphragm serving to define a portion of said chamber, a second chamber in said housing disposed longitudinally of said housing with respect to said first chamber, an acoustic resistance providing a communication path between said first chamber and said second chamber, a third chamber in said housing disposed longitudinally of said housing with respect to said second chamber and located on the side of said second chamber opposite the side on which said first chamber is located, and a second acoustic resistance providing a communication path between said second chamber and said third chamber.

(References on following page)

References Cited by the Examiner

UNITED STATES PATENTS

2,252,846	8/1941	Giannini et al.	179—115.5
2,515,031	7/1950	Black	179—115.5
2,627,558	2/1953	Wiggins	179—115.5
2,699,473	1/1955	Kettler et al.	179—115.5
2,852,620	9/1958	Schoeps et al.	179—111
2,865,464	12/1958	Gorike	179—121

2,920,140	1/1960	Morgan	179—1
2,957,954	10/1960	Swinehart	179—180

FOREIGN PATENTS

164,714	12/1949	Austria.
186,689	9/1956	Austria.
190,988	7/1957	Austria.
599,289	7/1960	Canada.

ROBERT H. ROSE, *Primary Examiner.*