

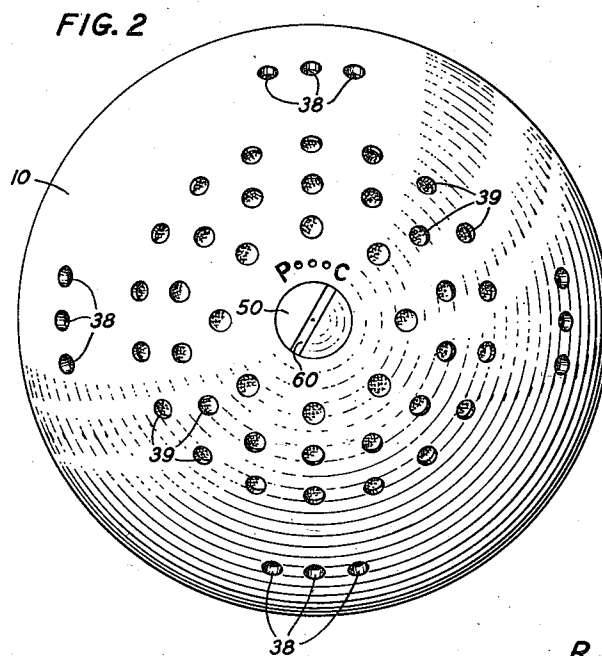
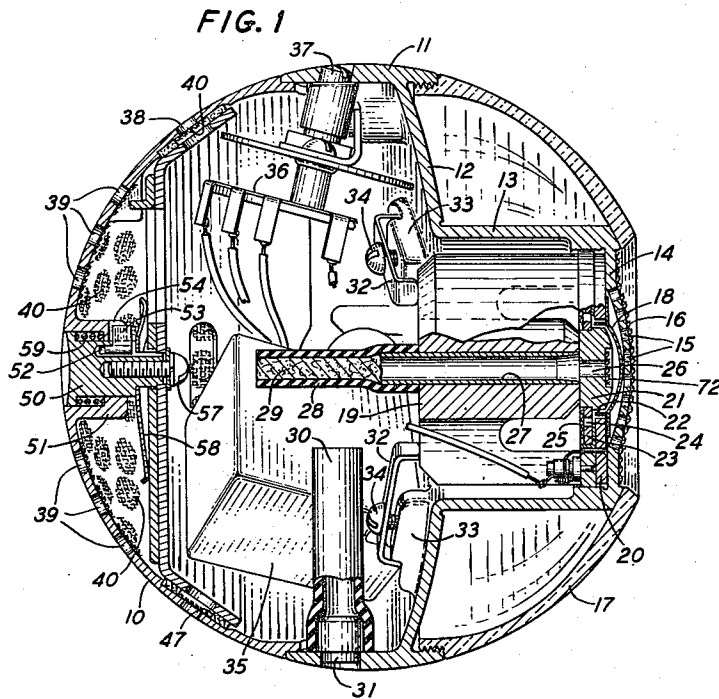
July 11, 1950

R. BLACK, JR.
MICROPHONE HAVING CONTROLLABLE
DIRECTIONAL RESPONSE PATTERN

2,515,031

Filed March 31, 1948

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

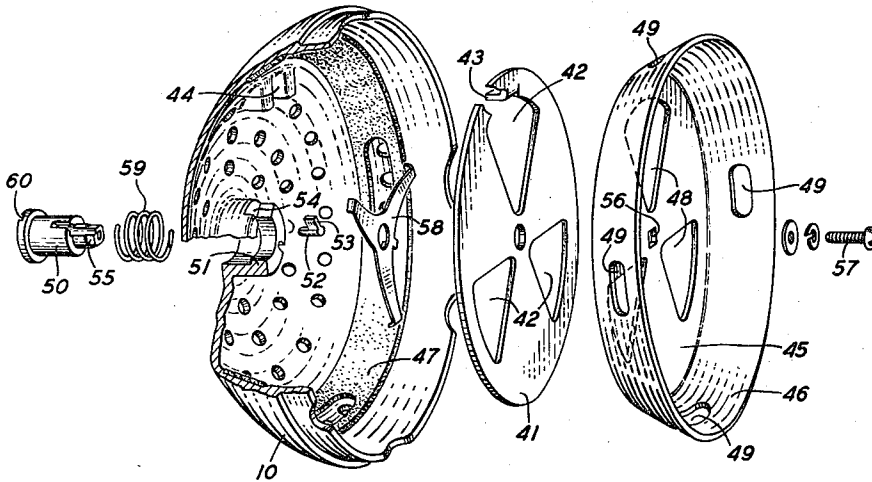


FIG. 4A

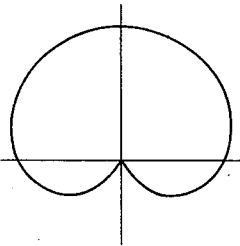


FIG. 4B

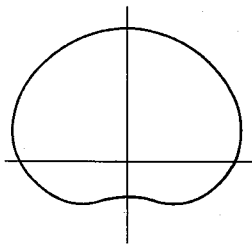


FIG. 4C

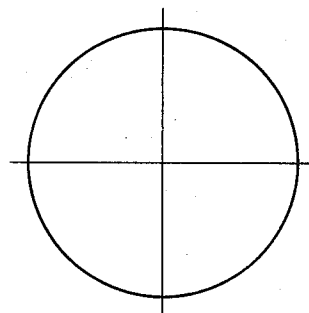
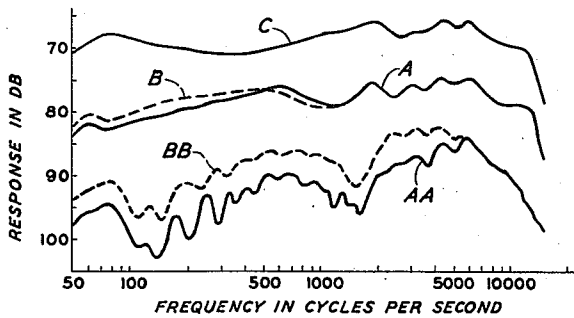


FIG. 5



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MICROPHONE HAVING CONTROLLABLE
DIRECTIONAL RESPONSE PATTERNRobert Black, Jr., South Orange, N. J., assignor
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This invention relates to telephone transmitters and more particularly to microphones having a controllable directional response pattern.

In one known type of microphone, such as that disclosed in Patent 2,401,328, granted June 4, 1946, to Robert Black, Jr., the vibrating member or diaphragm has one face in direct communication with the atmosphere and the opposite face coupled to the atmosphere through an acoustic network. This network is defined by a chamber within the microphone housing and connected to the atmosphere by way of apertures in the housing wall and having acoustic impedance material, such as acoustic silk, extending thereacross. The directional characteristics of the microphone are dependent upon the parameters of this network. Also, as set forth in detail in the patent above identified, substantially uniform directional discrimination over a wide range of frequencies may be attained by providing a plurality of paths of different lengths between the two diaphragm faces, each path including the chamber and one of the apertures comprised in the network above noted.

One object of this invention is to enable ready selective adjustment of the directional pattern of such a microphone. More specifically, one object of this invention is to attain any one of several different directional patterns concomitantly with uniform response over a wide frequency range for each pattern.

Another object of this invention is to facilitate and assure positive control of the acoustic network associated with the diaphragm to effect accurately, selective adjustment of the directional pattern of the microphone.

In accordance with one feature of this invention, in a microphone of the general construction heretofore described, and wherein a plurality of air paths of different lengths obtain between the two faces of the diaphragm, means are provided for simultaneously adjusting the impedances included in the several paths in such manner that the directional pattern of the microphone is altered without substantial variation or degradation in the uniformity of the response over a wide frequency range. Specifically, in one illustrative construction, a shutter is mounted in the housing for simultaneously adjusting the effective areas, and hence impedances, of the plurality of silk-covered apertures defining parts of the acoustic network.

In accordance with another feature of this invention, the shutter is mounted to be readily controllable from the exterior of the microphone

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housing and positively retained in any adjusted position.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a side sectional view of a microphone illustrative of one embodiment of this invention;

Fig. 2 is a rear view of the microphone shown in Fig. 1;

Fig. 3 is an exploded perspective view showing details of the shutter included in the microphone;

Figs. 4A, 4B and 4C are diagrams illustrating several directional patterns for different positions of the shutter; and

Fig. 5 is a graph illustrating the frequency response of the microphone for the several shutter positions corresponding to the patterns shown in Figs. 4A, 4B and 4C.

Referring now to the drawing, the microphone illustrated in Figs. 1 and 2 comprises a generally spherical casing including a rear portion 10 joined to an intermediate portion having an annular part 11, a front wall part 12 and a cylindrical part 13 extending forwardly from the wall 12, the part 13 having an integral front cover 14 provided with a multiplicity of apertures 15 over which a protective screen 16 extends. Joined to the intermediate portion adjacent the annular part 12 and bearing against the front end of the cylindrical part 13 is a dome-shaped member 17. The rear and intermediate housing portions may be of a suitable metal, such as aluminum; the domed member 17 may be of a transparent plastic.

Mounted within the cylindrical part 13 is a microphone unit which may be of the moving coil type and comprises a diaphragm 18 in juxtaposition to the cover 14. The microphone unit shown comprises also a permanent magnet 19 and a pair of pole-pieces 20 and 21 which are spaced to form an annular air-gap in which a signal coil 22 connected to the diaphragm 18 is positioned. Below the air-gap is an annular plate 23 having therein a plurality of apertures 24 over which acoustic silk 25 extends, the plate 23 and silk 25 serving to damp the diaphragm motion in a manner to suppress the response peak associated with diaphragm resonance.

The pole-piece 21 is provided with an aperture 26 having acoustic silk 27 extending thereacross and leading to a tube 27 in the magnet 19. The tube 27 in turn leads to a second tube 28, for example of soft rubber, having cotton wool 29, or other acoustic energy dissipative material,

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therein. The tubes 27 and 28, together with the bore or aperture 26 and elements 72 and 29, define an acoustic impedance so correlated with the damping system associated with the diaphragm, as disclosed in the patent hereinabove identified, as to enhance the low frequency response of the microphone.

The low frequency response may be enhanced further, as in the manner disclosed, for example, in Patent 1,869,178, granted July 26, 1932, to Albert L. Thuras, by an equalizer tube 30, for example of soft rubber, extending inwardly from a port 31 in the housing part 11.

The microphone unit is held securely within the cylindrical part 13 by a plurality of clamps 32 which bear against the magnet 19 and are affixed to protuberances 33 on the wall 12 by screws 34.

Also mounted within the housing is a transformer 35, connected in circuit with the microphone unit and having a plurality of taps, not shown, connected to a selector switch 36. The switch is operable by a screw 37, having its head in a recess in the housing part 11, to effect selective connection of the transformer with the microphone unit and thereby to set the impedance of the microphone at any one of a number of prescribed values.

The rear housing part 10 is provided with two groups of apertures 38 and 39, one group of apertures, 38, being divided into four equally spaced sets of three each, and the apertures 39 of the other group being substantially equally spaced and arranged in circular rows adjacent the control portion of the housing part 10. All of the apertures have extending thereacross acoustic impedance material 40, such as acoustic silk.

The front face of the diaphragm 18 is in direct communication with the atmosphere through the apertures 15 in the cover 14; the rear face of the diaphragm is coupled to the atmosphere by way of the acoustic network defined in part by the chamber bounded by the housing portions 10 and 11 and the silk-covered apertures 38 and 39. As described in the patent hereinabove identified, because of the acoustic network and the substantial length of air paths between the two diaphragm faces, the relative phase of the forces effective upon the opposite faces of the diaphragm, due to sound waves, is a function of the angle of the sound source relative to the diaphragm. The phase shift due to the path lengths is a function of the spacing of the apertures 38 and 39 relative to the diaphragm. Specifically, the apertures 38, being closer to the diaphragm than the apertures 39, provide relatively short path lengths which are of greatest significance, from the standpoint of cancellation effect, at the higher speech frequencies. Conversely, the apertures 39, being relatively remote from the diaphragm, provide relatively long paths which are of greatest significance, from the standpoint of cancellation effect, at the lower and intermediate frequencies. The parameters involved are correlated so that with all of the apertures 38 and 39 open, the directional pattern of the microphone is cardioid, i. e., of the form illustrated in Fig. 4A, the direction of maximum response being for sound waves incident substantially normal to the front face of the diaphragm, i. e., for zero angle between direction of the waves and the horizontal axis of the device in Fig. 1.

In some fields of use it is eminently desirable that the microphone have a directional pattern of other than cardioid form and more par-

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ticularly that it be capable of providing any one of several different patterns, readily selectable. In general, the directional pattern of a microphone of the type heretofore described can be altered by operating upon the acoustic network between the rear face of the diaphragm, e. g. by varying the extent of the openings in the housing. However, although the directional pattern can be thus altered, in prior devices the changes in pattern have been accompanied by alterations or degradation in the uniformity of the response of the microphone over substantial portions of the operating frequency range. As has been indicated hereinabove, such degradation is substantially prevented in accordance with one feature of this invention. More specifically, in accordance with one feature of this invention, the areas of both groups of openings are altered controllably to vary the directional pattern without substantial variation in the form of the frequency response characteristic of the device. Details of the mechanism involved are shown in Figs. 1 and 3.

Mounted within the housing portion 10 and extending transversely thereof is a plate 41, for example, of metal, having sectoral apertures 42, for example, three, therein by way of which the rear face of the diaphragm has access to the apertures 39. The plate is provided with an ear 43 which fits into a keyway 44 on the housing portion 10 and functions to prevent rotation of the plate 41. Held against the plate 41 in a manner to be described presently, and rotatable with respect thereto is a dished member, also for example of metal, having a base 45 and a circular frusto-conical wall 46 contoured to conform substantially to the inner wall of the housing portion 10 and bearing against an annular, frusto-conical seat 47 thereon. The base 45 has therein apertures 48 substantially identical with and in the same relation as the apertures 42. The frusto-conical wall 46 has therein four apertures 49 in the same relation as the four sets of apertures 38. The construction is such that when the apertures 48 are aligned with the apertures 42, each of the apertures 49 is opposite the respective set of apertures 38 and the latter are fully exposed.

The members 41 and 45, 46 are aligned upon a shaft or stud 50 which extends through a guide or bearing 51 on the housing portion 10 and is rotatable through a preassigned arc determined by a key 52 locked to the shaft or stud and having an arm 53 extending into a cut-out 54 in the guide or bearing 51. As shown clearly in Fig. 3, the stud is freely rotatable relative to the plate 41 whereas the stud and member 45, 46 rotate together by virtue of the fitting of the rectangular section 55 of the stud in the central opening 56 of the same shape in the member 45, 46. The member 45, 46 is affixed to the stud or shaft by a screw 57 and is held against the plate 41 by the action of a tri-armed spring 58 only.

The head of the stud or shaft 50 is provided with a slot 60 to facilitate manipulation thereof as by a key or screwdriver. When it is desired to operate the stud and with it the member 45, 46, the stud is pressed inwardly to reduce the pressure between the member 45, 46, and the seat 47, is turned through a desired arc and is then released. The spring 58 holds the member 45, 46 firmly against the plate 41 to prevent accidental alteration in the relative angular positions thereof.

The maximum arc through which the stud

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may be rotated may be set, by design of the key 52, 53 and cut-out 54, to any desired value. Conveniently, the two extreme positions of the stud and, hence, of the member 45, 46 may be those corresponding to indicia C and P in Fig. 2 for which the apertures 42 and 38 are entirely open and for which these apertures are fully closed. The former position results in a cardioid directional pattern, as has been indicated heretofore. For the fully closed position, the pattern of the microphone is of the form shown in Fig. 4C, that is the microphone has a non-directional pick-up pattern.

For a shutter position intermediate the two extremes, the pattern for the microphone is a modified cardioid, for example, of the form shown in Fig. 4B which corresponds to a position for which the apertures 38 and 42 are half open. For other shutter positions, the directional pattern will lie between the forms illustrated in Figs. 4A and 4C. The changes in effective areas of openings 38 and 39 with rotation of the shutter are of equal proportions.

It will be noted that as the member 45, 46 is rotated, the effective area of the apertures 38 and 39 is varied in like sense, the former by virtue of the direct increase or decrease of the exposed area thereof and the latter by virtue of the alteration of the size of the openings through the apertures 42. Thus, concurrent changes in the paths through the openings 38 and 39, which paths are significant primarily at different respective frequencies as has been pointed out heretofore, are effected. The result is that changes in the directional pattern are effected without degradation in the uniformity of the response of the microphone.

Response characteristics for a typical device of the construction illustrated in Fig. 1 are shown in Fig. 5. In this figure—

Curve A is the response for sound incident upon the diaphragm at zero angle, the apertures 38 and 42 being wide open;

Curve AA is the response for sound incident at an angle of 180°, the apertures being wide open;

Curves B and BB show the responses for 0 and 180 degrees incidence angles respectively, with the apertures 38 and 42 half open; and

Curve C shows the response for the shutter position for which the apertures 38 and 42 are fully closed.

The directional pattern of Fig. 4A corresponds to curves A and AA in Fig. 5; Fig. 4B corresponds to curves B and BB in Fig. 5; and Fig. 4C corresponds to curve C of Fig. 5.

It is evident from Fig. 5 that the response curves corresponding to the several illustrative directional patterns for the microphone, particularly the cardioid and non-directional patterns, are of essentially the same form and that, for practical purposes, over the frequency range from about 50 to 10,000 cycles, the response is substantially uniform for the three directional patterns.

Although a specific embodiment of this invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A microphone comprising a diaphragm having one face exposed directly to the atmosphere, means defining an acoustic phase shifting network for coupling the other face of said dia-

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phragm to the atmosphere, said means including a casing having therein a chamber in communication with said other face and having also two groups of apertures therein coupling said chamber to the atmosphere, the two groups of apertures being spaced unequal distances from said diaphragm, and acoustic impedance means extending across said apertures, and means for selectively varying the effective area of both said groups of apertures simultaneously and in the same sense.

2. A microphone comprising a housing having an apertured wall portion, an electroacoustic translating unit in said housing and including a diaphragm one face of which is exposed directly to the atmosphere through said wall portion and the other face of which is in communication with the chamber within said housing, said housing having also a first group of apertures opposite said wall portion through which said chamber is coupled to the atmosphere and a second group of apertures for coupling said chamber to the atmosphere and positioned intermediate said first group and said wall portion, acoustic impedance means extending across the apertures of both said groups, and means for selectively varying the directional pattern of the microphone without substantially altering the form of the frequency response characteristic of the microphone, said pattern varying means comprising a shutter member and means for adjusting said shutter member to vary the effective area of both said groups of apertures simultaneously and in the same sense.

3. A microphone comprising a diaphragm having one face in substantially direct communication with the atmosphere, phase shifting means for coupling the other face of said diaphragm to the atmosphere, said phase shifting means comprising a chamber providing two groups of paths between said other diaphragm face and the atmosphere, the paths of the two groups being of different lengths and including acoustic resistance, and means for selectively varying the directional pattern of the microphone including means for altering the resistance in the paths of both groups simultaneously in the same sense and in substantially equal proportion.

4. A microphone comprising a diaphragm having one face in substantially direct communication with the atmosphere, a housing bounding a chamber coupled to the other face of said diaphragm and having therein two groups of apertures spaced different distances from said other face, acoustic resistance material extending across said apertures, a plate member within said housing and having openings therein, said plate member dividing said chamber into two parts each connected to a respective group of apertures and coupled to each other through said openings, one group of apertures being exposed to said other face of said diaphragm only through said openings and the other group of apertures being exposed to said other face independently of said openings, and means for simultaneously varying the area of said openings and said other group of apertures.

5. A microphone comprising a diaphragm one face of which is exposed directly to the atmosphere, means defining an acoustic network between the other face of said diaphragm and the atmosphere, said means including a housing bounding a chamber in communication with said other face, said housing having therein a first group and a second group of apertures spaced at different distances from said

other face, and acoustic resistance material extending over said apertures, a plate within said chamber and dividing it into two compartments each in communication with a respective group of apertures, said plate having an opening therein opposite said first group of apertures, and means for selectively adjusting the impedance of said network comprising a shutter having a first portion adjacent said plate for controlling the size of the opening therein and a second portion adjacent said second group of apertures for controlling the size thereof, and means operable from the exterior of said housing for actuating said shutter.

6. A microphone comprising a diaphragm having one face in substantially direct communication with the atmosphere, means defining an acoustic phase shifting network for coupling the other face of said diaphragm to the atmosphere, said means including a housing bounding a chamber in communication with said other face and having communication with the atmosphere through apertures in said housing spaced a preassigned distance from said diaphragm, said means comprising also a member within said housing and defining therewith a compartment having communication with the atmosphere through other apertures in said housing spaced a second preassigned distance from said diaphragm, said member having openings therein through which said other apertures are exposed to said other diaphragm face, acoustic resistance means extending across said first and other apertures, shutter means for simultaneously varying the effective area of said first and other apertures in like sense and substantially equal proportions, said shutter means comprising a rotatable member having a first apertured portion overlying said openings and a second apertured portion overlying said first apertures, and means operable from the exterior of said housing for actuating said rotatable member.

7. A microphone comprising a housing bounding a chamber and having an apertured wall portion, said housing having a first group of aper-

tures therein opposite said wall portion and a second group of apertures intermediate said first group and said wall portion, a microphone unit in said housing including a diaphragm having one face in juxtaposition to said wall portion and its other face coupled to said chamber, acoustic resistance material extending across the apertures of both said groups, a plate member within said housing dividing said chamber into two parts each of which is associated with a respective group of apertures, said plate member having openings therein, a rotatable member having a first portion in juxtaposition to said plate member and provided with openings positioned to correspond to the openings in said plate member, said rotatable member having also a second portion in juxtaposition to said second group of apertures for controlling the extent of opening of said second group of apertures in accordance with rotation of said rotatable member, and means operable from the exterior of said housing for rotating said rotatable member.

8. A microphone in accordance with claim 7 wherein said last-mentioned means comprises a longitudinally reciprocable shaft extending through a wall of said housing and affixed to rotatable member, the microphone comprising also spring means coupled to said shaft and rotatable member for holding said rotatable member in firm face-to-face engagement with said plate member.

ROBERT BLACK, JR.

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