United States Patent

[11] 3,585,317

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[54] **CARDIOID MICROPHONE**
7 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** ..... **179/121D,** 179/115.5 R
[51] **Int. Cl.** **H04r 1/38**
[50] **Field of Search** ..... 179/1 DM, 121 D, 180, 146, 178, 179; 181/31

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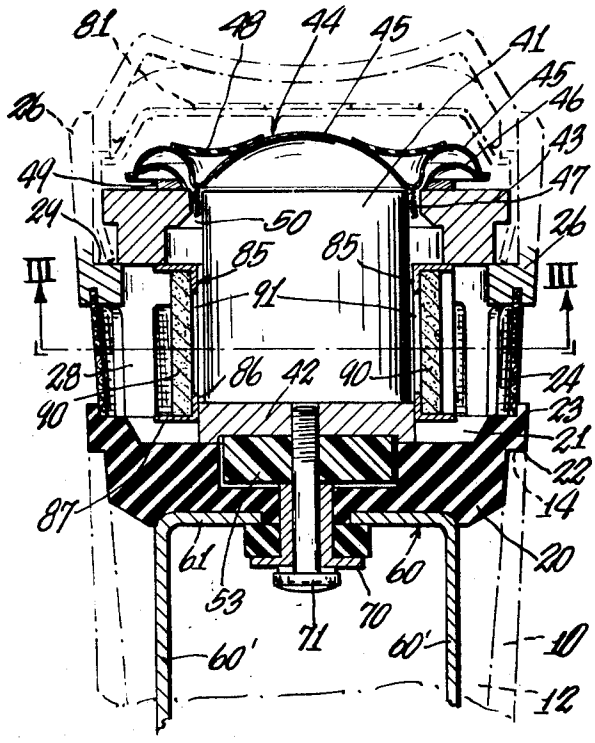
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ABSTRACT: Directional (cardioid) response is achieved by acoustical phase shift through porous plates and slots which are adjustable. Rubber vibration isolator means adjustably secures the transducer in the housing. A multipath acoustical system, combined with a high-compliance diaphragm, insures improved response and greater discrimination over a wide frequency range.



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SHEET 1 OF 2

FIG. 1.

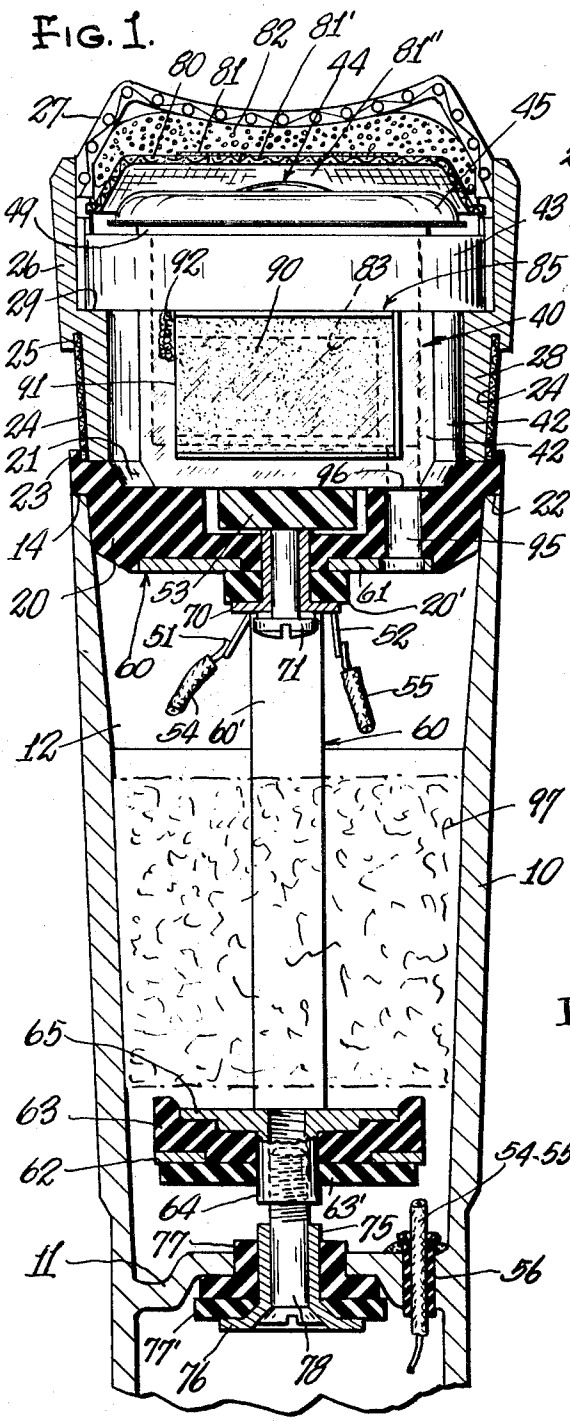
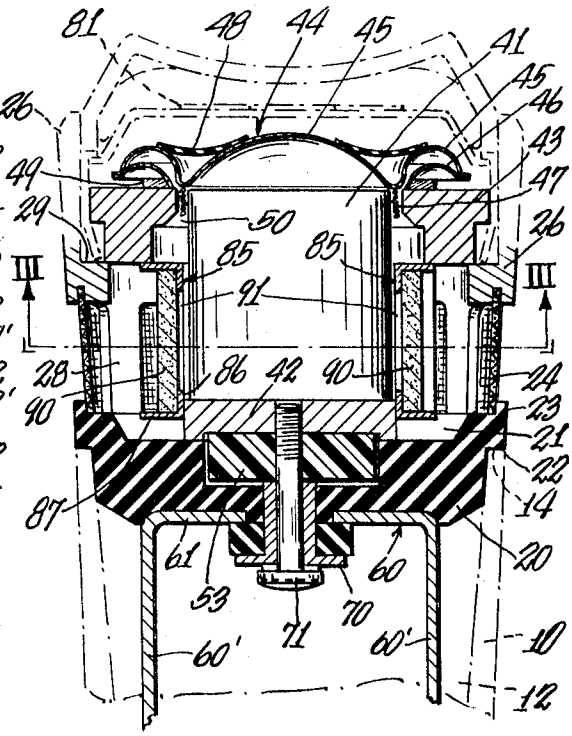


FIG. 2.



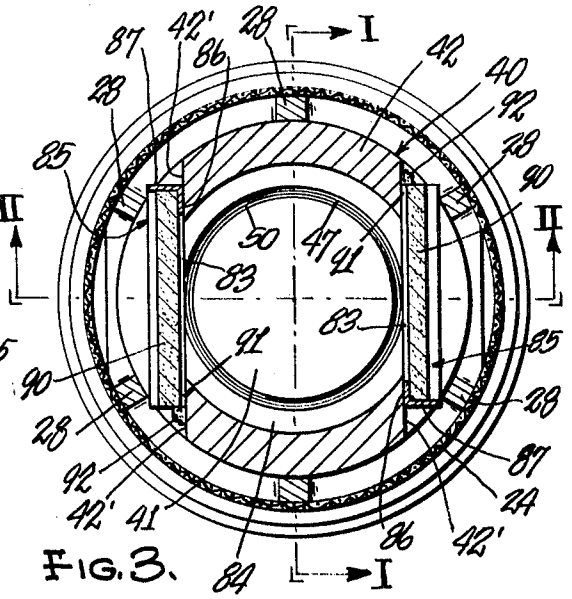


FIG. 3.

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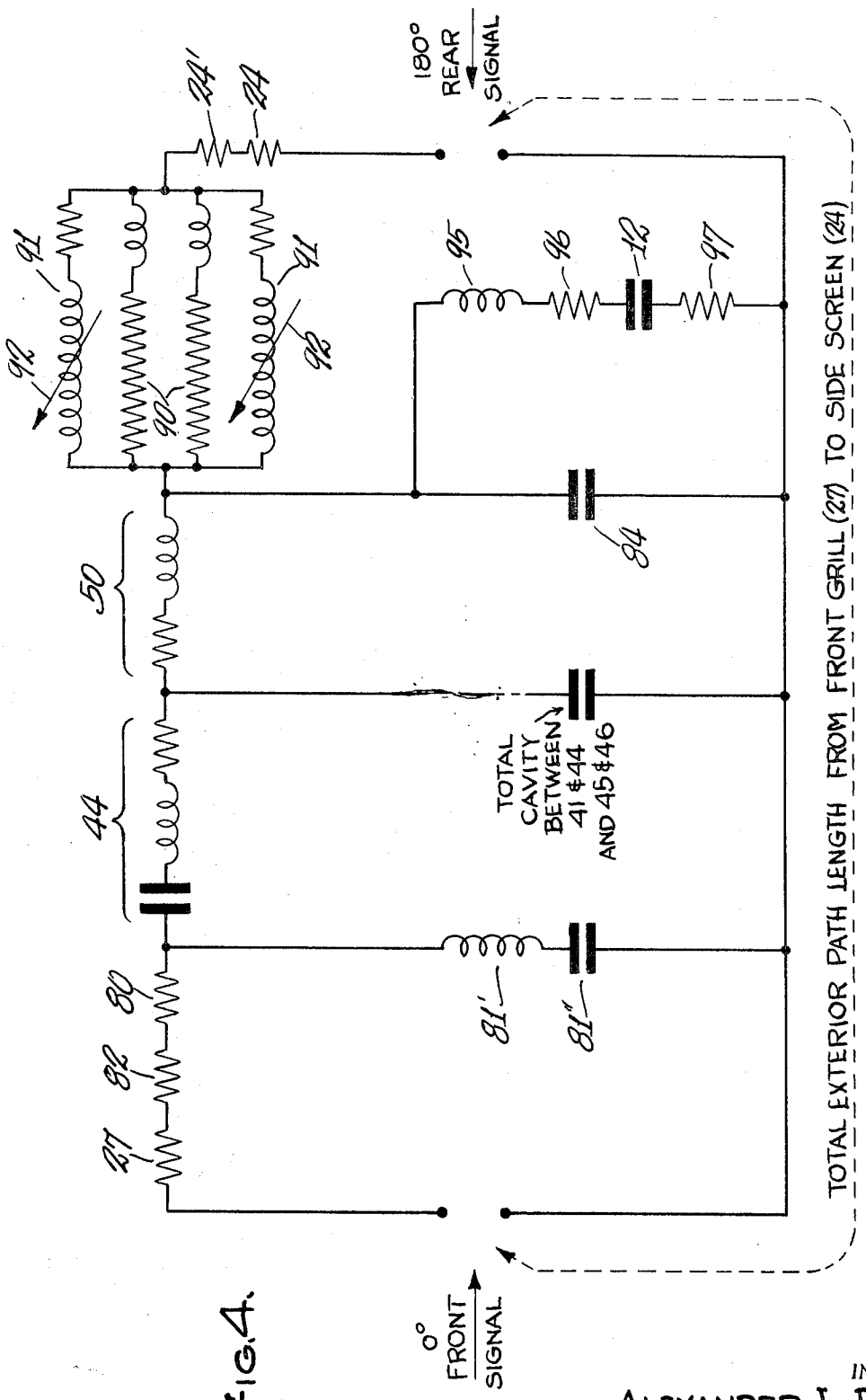


FIG. 4.

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CARDIOID MICROPHONE

This invention concerns the structure of acoustic microphones generally, and in particular those microphones which display directional pickup sensitivity. For use in areas where ambient noise levels are quite high, or where extraneous sounds would tend to become confused with principal voices or music, it is desirable to provide a microphone which can be aimed at a chosen source of sound with its back to unwanted noise. Microphones having a cardioid pattern of response are well known for use under these conditions. A vardioid microphone acceptable in today's market will display a front sensitivity approximately 10 to 15 decibels higher than the back sensitivity, over a substantial portion of its frequency range. Some few microphones can, at modest cost, achieve a front-to-back rejection ratio as high as 20 decibels, but in limited selected portions only, of their frequency range. Only the relatively costly condenser microphones generally can demonstrate rejection ratios of 25 decibels or more, over any reasonably wide range.

The microphone of the present invention demonstrates a higher front-to-back ratio, over a wider portion of the useful frequency spectrum, than any comparable unit know to exist. This superiority partly derives from the use of an extremely compliant diaphragm assembly, which is the subject of my copending Pat. application Ser. No. 671,185, filed Sept. 15, 1967, and assigned to the assignee of the present invention. The diaphragm assembly of the above identified application is utilized to extend the operational range of my microphone over a controlled wider portion of the frequency spectrum. The device of the present invention is utilized to controllably adjust the front-to-back response ratio of any suitable microphone using the improved diaphragm identified above.

In addition to affording means to control the directional response pattern of a microphone, the present invention discloses improved means for securing the internal operating parts of a microphone within its outer casing. It is essential that the operating acoustical parts be securely held and protected to prevent their being damaged by normal usage. It is also essential, for good quality operation, that the operating parts be isolated from mechanical shocks occurring in the floor, the supporting stand, or the outer casing. Secure mechanical anchoring is seldom compatible with insensitivity to mechanical shock in the known devices of prior art.

The primary object of the present invention is the provision of novel means for achieving cardioid directional response in a microphone.

A further object is the provision of means for adjusting the directional response of a microphone, within broad limits prior to assembly, and within fine limits after assembly.

Still a further object is the provision of means to secure a microphone within its protective casing in a manner to make it insensitive to mechanical shock excitation.

Yet another object is the provision of microphone shock-isolation means which is adjustable at assembly.

These and other objects and advantages will be apparent upon consideration of the following description wherein there is disclosed a preferred embodiment of the invention.

DESCRIPTION OF DRAWINGS

FIG. 1 is a longitudinal sectional view of the microphone of the invention taken in the direction of the arrows I–I of FIG. 3, and with certain parts in elevation,

FIG. 2 is a longitudinal sectional view of the top portion of the microphone of FIG. 1, taken in the direction of the arrows II–II of FIG. 3, with parts in broken lines to simplify the drawing,

FIG. 3 is a cross section of the top portion of the microphone of FIG. 2, taken at the line III–III of FIG. 2, and

FIG. 4 is an electrical analogy of the acoustical parameters encountered in the microphone of the present invention.

DETAILED DESCRIPTION

Referring to the drawings more in detail, the reference numeral **10** indicates the outer body of the microphone. Body **10** is a tubular member, preferably of metal, and has a transverse wall **11** extending across its inner diameter to form a generally cylindrical inner cavity **12**. Body **10**, shown broken off at its lower end, may conveniently be extended downwardly to accommodate a suitable terminal plug, not shown.

A rubber isolation cup **20** rests on the upper open end **14** of body **10**. Cup **20** has a cavity **21** formed in its upper face to receive a microphone cartridge **40**, and has a peripheral flange **22** to bear on the upper end of body **10**. A small upwardly extending circular lip **23** embraces the lower edge of a tubular screen **24**.

The upper end of screen **24** is received in an annular groove **25** formed in the lower edge of a ferrule **26**. Ferrule **26** supports, at its upper end, a protective grille **27** formed of relatively heavy wire mesh. Extending downwardly from ferrule **26**, and inside the screen **24**, a plurality of legs **28** are provided to bear against the upper flat annular surface of cup **20**. In the inside of the ferrule **26**, immediately above and inside the groove **25**, an annular stop **29** is provided upon which a part of the cartridge **40** bears, as will be described presently.

The microphone cartridge **40** is the operating transducer unit of my microphone assembly. In the illustrated embodiment, the cartridge **40** is shown as being of the "dynamic" or "moving-coil" type, although other types of microphone cartridges (such as crystal, ceramic or condenser, for example) are considered to be within the purview of this invention.

The microphone cartridge **40** comprises a centrally located cylindrical permanent magnet **41**, a cuplike outer shell **42** of magnetically permeable metal, a face plate **43**, also of permeable material, and a diaphragm assembly indicated generally at **44**. The diaphragm assembly **44** may ideally be that of my copending Pat. application Ser. No. 671,185 mentioned above, and it comprises a main diaphragm **45**, an edge support corrugation **46**, a voice coil **47** and a topper **48**. The edge support corrugation **46** is held centrally located on the upper surface of face plate **43** by a mounting ring **49**. The outer edge of corrugation **46** is adhered to the outer edge of the diaphragm **45** and the voice coil **47**, which is supported on the diaphragm **45**, is thus positioned in the gap **50** which exists between the top edge of magnet **41** and the inner edge of face plate **43**. When supported in the indicated position, the voice coil **47** is free to move in the gap **50** under the urging of acoustical waves which may impinge upon the major surfaces of the diaphragm **45**. Motion of coil **47**, in the field of magnetic flux existing across the gap **50**, induces in the former a voltage change which is characteristic of such "dynamic" devices. The two ends of coil **47** are connected by lead wires, not shown, to the terminals **51** and **52** supported in a terminal block **53** attached to the bottom of outer shell **42**. Conductors **54** and **55** are attached to terminals **51** and **52** respectively, and are extended through a port **56** in the transverse wall **11**, and thence to suitable amplifying equipment, not shown, where the conducted voltage changes are converted into acoustic signals in well-known manner.

To secure the microphone cartridge **40**, the ferrule **26**, the screen **24** and the isolation cup **20** all in assembled relation, I employ a metal framelike yoke **60**. Yoke **60** comprises two elongated side legs **60'** bent downwardly from a disc portion **61** to lie parallel to each other. The disc portion **61** is adhered securely to the under side of isolation cup **20**.

A hole in the center of cup **20** accommodates a shouldered metal bushing **70** which, in turn, surrounds a machine screw **71**. A rubber washer **20'** is held under the enlarged shoulder of bushing **70**. Screw **71** extends upwardly through bushing **70**, through a hole in terminal block **53**, and into a tapped hole in the under side of outer shell **42**. The length of bushing **70** is accurately controlled to establish the amount of compression which can be applied by the screw **71** to the interface contact between cup **20** and shell **42**.

The lower ends 62 of legs 60' are turned inwardly toward each other and are securely cemented to the under side of a rubber washer 63. An internally threaded bushing 64, having an enlarged flat head 65, is disposed in the center of washer 63. A metal bushing 75 having an enlarged flange 76 and surrounded by a rubber grommet 77 is received in a hole provided in the center of the transverse wall 11.

A machine screw 78 is passed upwardly through bushing 76 and threaded into bushing 64. After thus assembling the entire microphone in its body 10, final adjustment of tension on screw 78 will be seen to controllably adjust the shear force occurring between the upper end 14 of body 10 and the outwardly extending flange 22 of the isolation cup 20, to achieve one of the objects of the present invention. This adjustment fixes the degree of resilient restraint applied between the microphone cartridge 40 and its surrounding hardware, in relation to the outer body 10. The resilience of the rubber components can be adjusted by the amount of compressive restraint applied and the damping or energy-absorbing characteristics thus controlled. Further control is afforded by providing means to interpose additional masses of damping rubber in the form of backup washers 20', 63' and 77'. Any or all of these washers may be used as required, and the rubber used to form the cup 20 and other rubber components is preferably medium soft having good aging and good dampening properties, such as butyl rubber.

In addition to the mechanical components thus far described, the following acoustical-mechanical elements are incorporated in the microphone assembly of the present invention.

Immediately forward of the diaphragm assembly 44, and spanning the inside diameter of ferrule 26, I provide a dished wire screen cap 80. Screen cap 80 serves to exclude any magnetic foreign particles from being attracted by the flux area which exists just back of the diaphragm 44. Screen cap 80 also supports, on its upper flat face, a nonmagnetic metal washer 81, with a hole 81' in its center, which washer serves to define one wall of a partially enclosed cavity 81'' confronting the diaphragm. This cavity is considered as an acoustical capacity in controlling the response of my microphone.

Over the top face of cap 80 and immediately inside the grille 27, a disc 82 of very soft open-cell foam sponge is placed. Disc 82 is held in place under very slight compression and serves as a blast guard to exclude the effects of wind puffs and/or excitation by the "plosive" components of speech. It is effective principally against low frequency ambients and is almost completely transparent to normal acoustic waves, except in the very high frequency range where it exhibits a slight resistive aspect.

As described above, and as shown in the drawing, the tubular screen 24 is positioned at the lower edge of ferrule 26 where it affords ingress for sound waves to the microphone cartridge 40. Screen 24 is quite strong physically, but is almost totally transparent to acoustic waves. Further, it faces no internal obstruction except the six legs 28, which are evenly spaced about the diameter of the unit. Screen 24 may be lined with an inner ply of cloth mesh 24' to exclude dust, providing the cloth mesh is also essentially transparent acoustically. The vertical length of ferrule 26 is acoustically chosen to perform a significant acoustical function, as will be described presently.

Located on the sidewall of outer shell 42, a pair of flat areas 42' are formed. They remove two sections of the entire wall of shell 42 and effectively provide a pair of window openings 83 opening into the interior cavity 84 of the shell 42, which cavity contains the magnet 41. Window openings 83 are disposed diametrically opposite each other on shell 42.

Affixed securely, by a suitable adhesive for example, to each of the flat areas 42', I provide three-sided metal frames 85. Frames 85 each comprise an inner face flange 86 extending around three sides only of windows 83. At right angles to face flange 86, I provide edge flanges 87 which combine to form walls around three sides only of frames 85. Cemented into the frames 85 are porous phase-shifting plates 90. Plates 90 may be sintered bronze and comprise a very significant part of the present invention and exhibit all of the desirable properties ascribed to plates of sintered material in my U.S. Letters Pat. 2,702,318. Plates 90 are carefully selected as to thickness and porosity so as to exhibit prescribed resistance to the ingress of acoustic waves. They may differ from each other as to density or acoustic capacity. When assembled on the frames 85, in the manner illustrated, the plates 90 will be seen to completely cover the window openings 83, except for a narrow slot 91 which occurs at one edge of each plate where it is not embraced by any flange of its supporting frame 85. The thickness of the slots 91 are controlled by the gauge of the metal from which the frames 85 are constructed.

The relative open areas of the slots 91 are finally controlled and adjusted by the application of a small fillet 92 of hardenable wax to a selected length of slots 91. Prior to hardening, the fillets 92 may be partially removed to effectively "open" up the net inductive value of each half of the system. Although wax is presently preferred, any other suitable hardenable plastic may be used, such as plastic cement or solder.

As further acoustically significance elements of the present microphone, I provide a port 95 which connects the cavity 84, inside the cartridge shell 42, to the inner cavity 12 of the body 10. Port 95 is formed by axially aligning properly positioned holes formed respectively in the shell 42, the isolation cup 20 and the disc portion 61 of yoke 60. The acoustic properties of port 95 can be altered further by positioning a disc 96 of finely woven fabric transversely of the port. Disc 96 is held dampened and cemented between the shell 42 and the cup 20. The inner cavity 12 accommodates a volume of spun glass fiber 97 which partially fills it.

The mechanical members of the microphone assembly thus far described as component parts, combine and interact to achieve the acoustic functions required for a complete realization of the objects of the present invention. It is seldom possible to assign to each mechanical component a discrete or exclusive function in an acoustical system, since much interaction is known to occur. Analysis is hampered further by the obvious fact that fixed mechanical members are being called upon to control acoustic waves of widely differing frequencies, having widely varying wavelengths.

The acoustic behavior of my microphone will be understood from the following description and by reference to the analogy of FIG. 4.

Any good quality microphone is required to display, for signals incident to its "front," a substantially constant electrical output over the entire frequency range of interest. This should extend from 50 Hz. to 15,000 Hz, within which range a maximum total deviation of 10 db. may be tolerated. A good cardioid microphone should maintain the above stated level of front-side performance, while rejecting all signals incident to its "back" side by at least 7 or 8 db. at the lowest frequency, and by an average of about 15 db. over the entire range.

Attention is directed first to a consideration of the performance of the microphone of the present invention, under applied signals from a source in "front" of the unit. As a sound wave enters the front of grille 27, it meets little or no resistance. It normally meets very little resistance in the sponge disc 82 or in the screen cap 80, unless it is a very high frequency wave having very short wavelength. It thus meets the diaphragm 44 and exerts its pressure thereupon causing rearward motion thereof. A portion of the same sound wave travels past the side of the microphone toward the side screen 24 where it enters, passes through the porous plates 90 and slots 91 into the interior cavity 84 where it acts upon the rear surface of the diaphragm 44. However, it has been delayed in its path, both by the distance it has travelled from the front surface to the back surface of the diaphragm 44, and by the combined inductive and resistive character of the plates 90 and slots 91, and it meets the backside of diaphragm 44 approximately 180 acoustic degrees "out-of-phase" with the next oncoming pressure wave front which is striking the front of the diaphragm 44. The two waves thus reinforce each other

since a "null" at the back of the diaphragm coincides with a pressure peak at the front side, and the output of the unit is thus maximum.

In treating a sound wave originating from a source at the "rear" of the microphone, the precise opposite effect occurs. A pressure front in a sound wave approaching from the rear, first enters the side screen **24**, is delayed in the plates **90** and the slots **91** and proceeds through the air gap **50** to the rear side of diaphragm **44**. The same pressure front travelling forwardly to the front of the diaphragm **44**, via open air and the front grille **27** meets no substantial delay other than that of distance, and it meets the front side of the diaphragm at the same time the delayed component meets the rear side thereof. The two opposite and equal pressures cancel and the output of the microphone is zero.

The above-described directional property is observed at its maximum, i.e., 180 degree phase-shift, only on the axis of the assembly. For signals originating at an angle off axis to the rear of the microphone, cancellation is somewhat less than perfect and the polar response pattern is thus heart-shaped (cardioid). Further, it must be recognized that, since phase-shift caused by a physically fixed delay path is effective only in a very narrow band of frequencies, it is essential to provide a number of different delays operating in parallel to accomplish the wide-range directional performance of the present invention. The required multiple delay paths are identified as follows with relation to their general areas of effectiveness in the frequency spectrum.

The delay afforded by porous plates **90** is effective in the midportion of the range, from about 500 Hz to about 8,000 Hz. This range can be broadened some amount by making the two plates **90** each of different porosity or thickness or both. The slots **91** are effective at the lower end of the range, from 50 Hz to about 700 Hz, their effect overlapping that of plates **90** to a degree. Slots **91** further may be adjusted by the application of more or less of the wax fillets **92**.

From the range of about 4,000 or 5,000 Hz upward, the length of the path from front to back sides of diaphragm **44** is controlling. This length is established physically by the depth at which diaphragm **44** lies below the upper edge of ferrule **26**, the length of the ferrule **26** and the distance inwardly through the porous plates **90** and the slots **91**. Further, the metal washer **81** appears opaque, and its hole **81'** appears transparent, to short waves (above 9,000 to 10,000 Hz) and hole **81'** thus establishes a different path length for shorter waves than for longer waves which might be expected to act mainly upon the outer edges of the diaphragm **44**. The space volume between washer **81** and the diaphragm **44** is utilized as a damped resonance cavity to extend the front side response in the range above about 12,000 Hz, and in this range the minimal resistivity inherent in the screen cap **80** and the sponge disc **82** becomes more effective, to both resonate the diaphragm and to increase the acoustic length of the delay path. A change in the length of side screen **24** will obviously change the relationship of both the "front" signal path and the "rear" signal path with respect to any sound source.

The inner cavity **12**, connected through the port **95** and its fabric disc **96** to the cavity **84** and thence through the gap **50** to the backside of diaphragm **44**, is a damped resonator which is doubly effective. It improves the front-side response below about 1,500 Hz and overcomes a tendency for the bass response to droop, and it also improves back-side rejection in this same frequency range by virtue of its "damped" return of energy to the backside of the diaphragm, some of which energy is delayed in the glass fiber filling **97** and some in the port **95** and the disc **96**.

There has thus been provided a microphone assembly which accomplishes the objects initially set forth. Cardioid directional response is achieved by the use of porous phase-shifting plates **90**, coupled with the use of slots **91** and the adjustment thereof by the wax fillets **92**. The limits of adjustment in directional response are chosen broadly in the selection of density grades in the plates **90**, in the size of the openings in the frame **85** and in the thickness of the slots **91**. Fine adjustment is accomplished after assembly by the application of the wax fillets **92**, both as to their extent and location. The entire active microphone assembly is held in isolated security in its outer case **10** by the interposition of massive amounts of dissipative rubber in the form of isolation cup **20**; rubber washer **63** and rubber grommet **77**. These rubber elements afford insulation from direct mechanical contact yet they hold the parts mechanically secured and capable of adjustment through the screw **78** and its effect upon the juncture between the flange **22** of cup **20** and the upper open end **14** of body **10**.

In view of the foregoing it will be apparent to those skilled in the art that I have accomplished at least the principal object of my invention and it will also be apparent to those skilled in the art that the embodiment herein described may be variously changed and modified, without departing from the spirit of the invention, and that the invention is capable of uses and has advantages not herein specifically described; hence it will be appreciated that the herein disclosed embodiment is illustrative only, and that my invention is not limited thereto.

I claim:

1. A directional microphone of the cardioid type, having one side of its diaphragm exposed directly to sound waves in air, and having the other side of the diaphragm closed off from direct contact with said sound waves by an acoustic delay path leading partly through a controlled distance in porous material and partly through an open slot at an edge of said porous material, said delay path being divided into parallel courses and said porous material and said slot are both made plural so that at least one portion of said material and one of said slots exist in each of said parallel courses, the portions of porous material in said parallel courses being of different density.

2. A directional microphone of the cardioid type, having one side of its acoustic diaphragm exposed directly to sound waves in air, and having the other side of its diaphragm closed off from direct contact with said sound waves by an acoustic delay path which is divided into parallel courses, each course leading partly through a controlled distance in porous material and partly through an open slot at an edge of said porous material, said slot providing a partial bypass around said porous material.

3. The microphone of claim **2**, further characterized in that each said delay path is branched after leading through said porous material and said slot, with a first branch communicating with said other diaphragm side and with a second branch communicating with a damped resonance cavity.

4. The microphone of claim **3**, in which said first branch includes a restriction through which sound waves pass before communicating with said other diaphragm side, and said second branch includes a restriction through which sound waves pass before communicating with said resonance cavity.

5. A microphone comprising a tubular body, a wall formed of medium soft rubber overlying an opening into said tubular body and resiliently supporting a transducer unit, said body having an inner ledge spaced from its opening, and a link member having opposite ends respectively connected to said rubber wall and said ledge, the connection between said link member and said ledge being adjustable and disposed so that a pulling force may be applied to said link member to seat said rubber wall in the surface defining said body opening with a selected force.

6. The construction of claim **5**, wherein said transducer unit is supported on that surface of the rubber wall which is directed outwardly of said tubular body, means mounting an acoustic diaphragm adjacent to said transducer unit, and a passage effecting acoustic communication between the rear surface of the diaphragm and the interior of said tubular body.

7. A resilient mounting for securing a transducer in its protective casing, comprising a cuplike resilient body of substantial volume having a recess on one side for receiving said transducer, a radial flange integral with said body and resting on an edge of said casing, means to adjustably urge said transducer into said body without compressing said body, said means to urge also applying shear stress between said flange and said edge.