May 15, 1951 A. M. WIGGINS 2,552,878

SECOND ORDER DIFFERENTIAL MICROPHONE

Filed Sept. 24, 1947 3 Sheets-Sheet 1

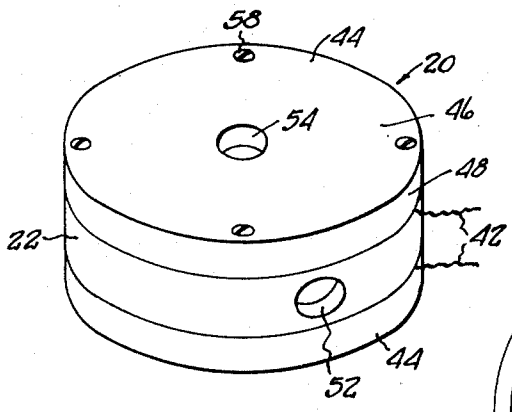


FIG. 1

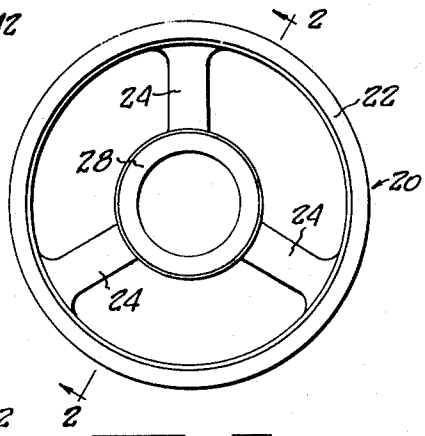


FIG. 3

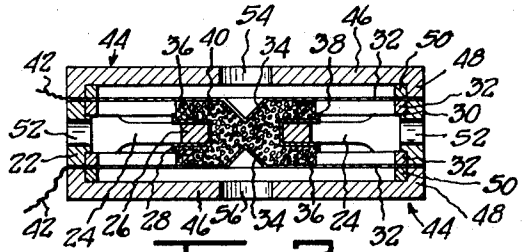


FIG. 2

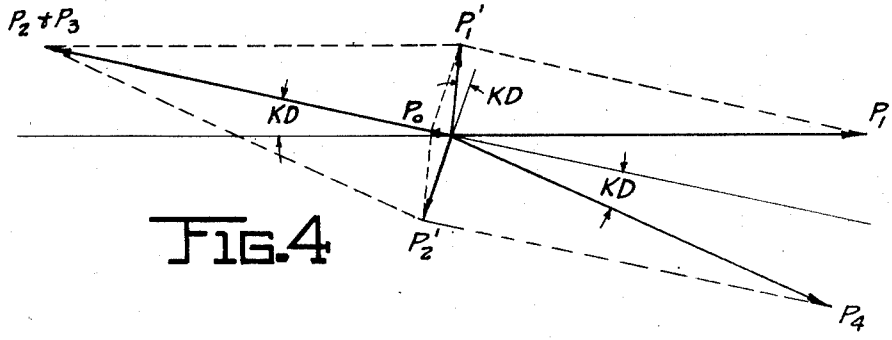


FIG. 4

INVENTOR.
ALPHA M. WIGGINS
BY
Attach & Knoblock
ATTORNEYS

May 15, 1951 A. M. WIGGINS 2,552,878

SECOND ORDER DIFFERENTIAL MICROPHONE

Filed Sept. 24, 1947 3 Sheets-Sheet 2

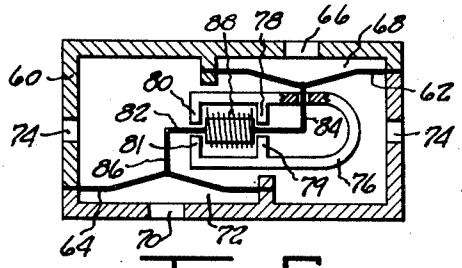


FIG. 5

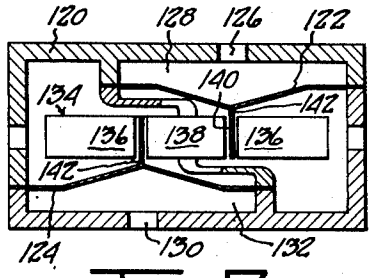


FIG. 7

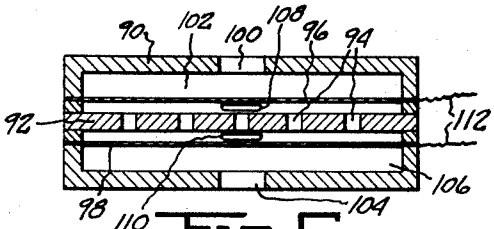


FIG. 6

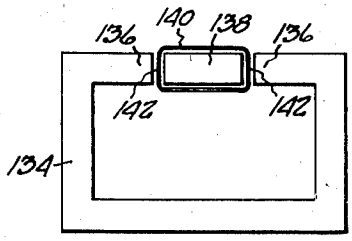


FIG. 8

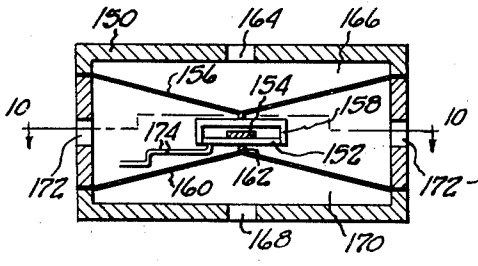


FIG. 9

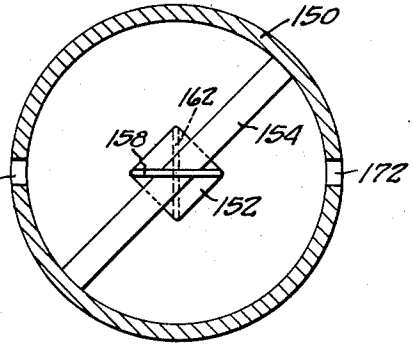


FIG. 10

INVENTOR.
ALPHA M. WIGGINS
BY
Altsch & Knoblock
ATTORNEYS

May 15, 1951 A. M. WIGGINS 2,552,878

SECOND ORDER DIFFERENTIAL MICROPHONE

Filed Sept. 24, 1947 3 Sheets-Sheet 3

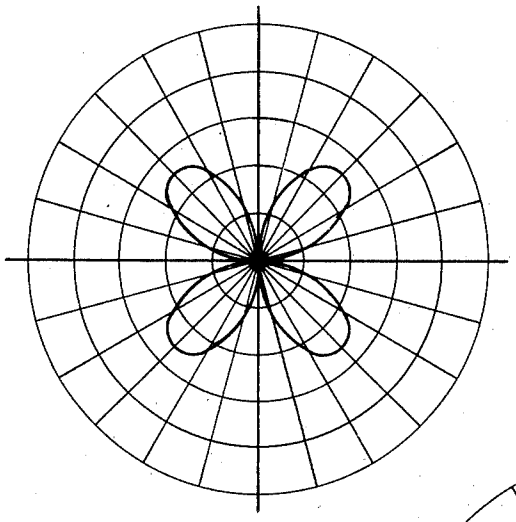


FIG. 11

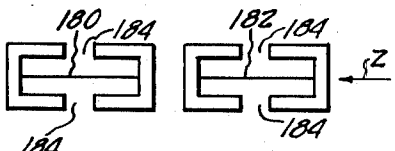


FIG. 12

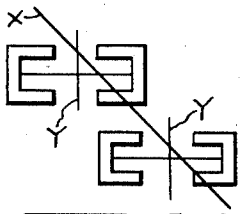


FIG. 14

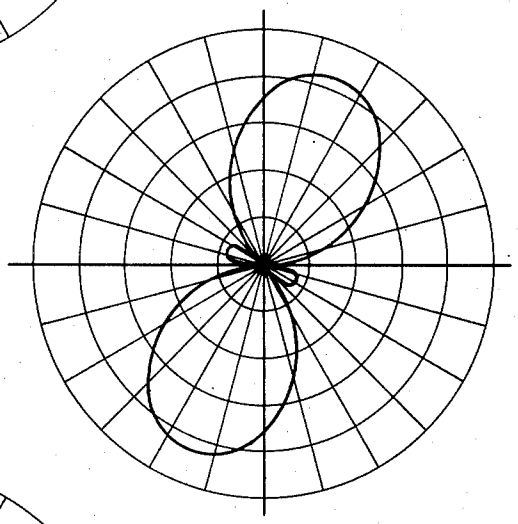


FIG. 13

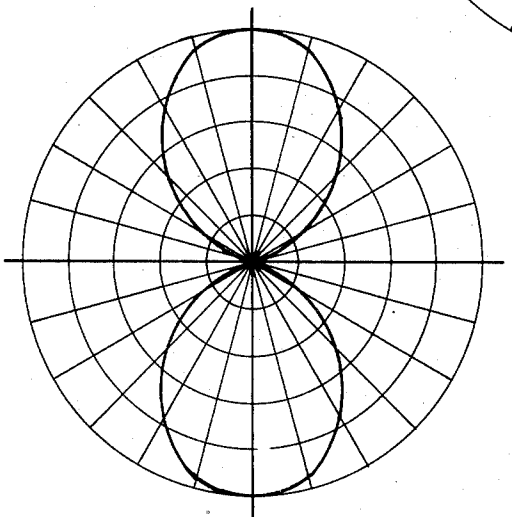


FIG. 15

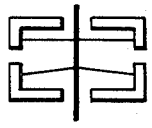


FIG. 16

INVENTOR.
ALPHA M. WIGGINS
BY
Oltsch & Knoblock
ATTORNEYS

Patented May 15, 1951

2,552,878

UNITED STATES PATENT OFFICE

2,552,878

SECOND ORDER DIFFERENTIAL MICROPHONE

Alpha M. Wiggins, Clay Township, St. Joseph County, Ind., assignor to Electro Voice, Inc., Buchanan, Mich., a corporation of Indiana

Application September 24, 1947, Serial No. 775,869

17 Claims. (Cl. 179—135)

1

This invention relates to improvements in differential microphones.

Differential microphones as here considered are of the general type illustrated in and disclosed in the Patent No. 2,350,010 granted May 30, 1944, to F. C. Beekley. A microphone of this type may be defined as a pressure gradient microphone which has two or more sound entrances spaced by an acoustic distance which is small compared to the wave lengths of sound which may pass through said entrances to impinge upon sound responsive generating means incorporated in the microphone whereby the resultant of the forces acting on the generating means in response to random sounds of distant origin are attenuated while the resultant of the forces acting on the generating means in response to sounds of close origin is preponderantly that resulting from the sound pressure at the entrance nearest to the sound source. In other words, a differential microphone is one having a proximity effect rendering the microphone highly sensitive to sounds of close origin directed preponderantly at one sound entrance and much less sensitive to random sounds of distant origin so that sounds of close origin are transmitted intelligibly and random sounds of distant origin are substantially ineffective upon the generating means or have such diminished effect thereon as not to detract materially from the intelligibility of the translation of the sounds of close origin by the microphone.

The primary object of this invention is to provide a novel, simple and inexpensive microphone of this character which has a very high discrimination against random sounds of distant origin and which is responsive only to the difference between two differential resultant forces of pressure gradients.

A further object is to provide a differential microphone having a discrimination of the second order which requires only one sound responsive generating element therein.

A further object is to provide a microphone of this type having two sound sensitive elements, each having two surfaces exposed to sounds traveling through different paths wherein said elements are spaced apart and each has one surface accessible to sounds having a common path between said elements whereby sounds of close origin traveling through said common path and impinging on said elements produce an output substantially double the output of the microphone compared to that of a microphone having a similar single sound sensitive element.

2

A further object is to provide a microphone having at least two similar vibrating elements whose axes are parallel and which are so arranged and related to a generating element that movements of said elements which are of equal amplitude and in phase produce or generate substantially zero voltage in the generating element. The axis of a vibrating element of a microphone is considered to be a line representing the vectorial sum of all lines connecting the centers of the sound access openings of the microphone at opposite sides of said element.

Other objects will be apparent from the following specification.

In the drawing:

Fig. 1 is a perspective view illustrating one embodiment of the invention.

Fig. 2 is a sectional view taken on line 2—2 of Fig. 3.

Fig. 3 is a face view of the central portion of the housing of the microphone shown in Fig. 2.

Fig. 4 is a vector diagram illustrating the resolution of the forces in the microphone.

Fig. 5 is a sectional view similar to Fig. 2 and illustrating the embodiment of the invention in a sound power type of microphone.

Fig. 6 is a sectional view similar to Fig. 2 and illustrating the embodiment of the invention in a condenser type of microphone.

Fig. 7 is a sectional view similar to Fig. 2 and illustrating the embodiment of the invention in a dynamic or moving coil type of microphone.

Fig. 8 is a schematic view illustrating the arrangement of the moving coil with respect to the magnet of a magnetic type of microphone.

Fig. 9 is a sectional view similar to Fig. 2, illustrating the embodiment of the invention in a microphone having a piezo electric crystal type of generating element.

Fig. 10 is a sectional view taken on line 10—10 of Fig. 9.

Fig. 11 illustrates the response characteristics of one embodiment of this invention.

Fig. 12 is a schematic view illustrating the arrangement of a pair of vibrating elements in a device of this character to produce the response pattern illustrated in Fig. 11.

Fig. 13 is a response pattern of another embodiment of this invention.

Fig. 14 is a diagrammatic view illustrating the relation of the vibrating elements to produce the response pattern shown in Fig. 13.

Fig. 15 is a response pattern of another embodiment of this invention.

Fig. 16 is a diagrammatic view illustrating the

arrangement of the vibrating elements to produce the response pattern shown in Fig. 15.

Referring to the drawings, and particularly to Figs. 1 to 3 wherein a microphone of the carbon granule type is shown, the numeral 20 designates a housing which preferably includes an annular center portion 22 which preferably has a spider formed therein in the nature of inwardly projecting arms 24 terminating in a concentric annular portion 26. The annular portion 26 is of a thickness small compared to the axial dimension of the portion 22 and is positioned centrally with respect to the longitudinal dimension of the housing portion 22. The annular member 26 is preferably provided with a metal sheath or ring 28 of channel shape in cross-section, which fits around said ring 26 as illustrated in Fig. 2. The interior wall surface of the housing portion 22 is preferably of stepped form, as illustrated at 30, to provide similar seats at its opposite margin for the reception of gaskets 32 which are adapted to engage diaphragms or other sound sensitive elements 32. Each of the diaphragms in this embodiment of the invention preferably has a central conical portion or button 34 projecting inwardly as shown and is similar to or balanced with respect to the other. A pair of gasket rings 36 which are preferably positioned by flanges 38 on the metal ring 28 span the space between central housing ring 26 and the diaphragms 32 to cooperate with the member 28 and the diaphragms 32 for the purpose of enclosing a space centrally of the microphone within which carbon granules 40 may be retained. An electrical lead 42 is connected with each of the two diaphragms 32.

The casing is completed by two similar end members 44 which are of substantial cup-shape form and each of which has an end wall 46 and a marginal flange 48. A gasket 50 fits in each of the end members 44 and bears against the outer surface of the adjacent diaphragm 32. The central housing portion 22 has one or more sound access openings 52 formed therein centrally between the two diaphragms 32, and each of the end portions 44 of the housing has one of the openings 54 and 56 formed therein preferably at the center thereof. The various parts of the casing are secured together by suitable securing means such as the screws 58 shown in Fig. 1.

The housing may be formed of any suitable material such as metal or plastic and is preferably molded from plastic material. The size of the housing is small so that the spacing between the openings 52, 54, 56 is small compared to the wave length of the sound of highest frequency which is intended to be transmitted. In the preferred embodiment, the spacing between the openings 52, 54 and 56 will preferably be in the order of three-eighths of one inch when the device is designed for use under conditions where random sound will include sounds having frequencies as high as 10,000 cycles. It will be understood, however, that random sounds in noisy and reverberatory locations, such as military tanks, airplanes, ships, machine shops, or other locations where the device may be used, seldom include sounds of frequencies as high as 10,000 cycles, and such random sounds are commonly of much lower frequency. Consequently, a dimension of three-eighths of an inch spacing between openings represents substantially the optimum condition for cancellation of random sounds. Practical constructions of the microphone may include units where the spacing between the openings is increased above three-eighths of an inch as long as the spacing dimension remains small compared to the wave length of the highest frequency likely to be encountered in the random sound intended to be cancelled by the device. In cases where sound components at the location for which the microphone is designed are known to have a certain maximum frequency, the microphone may be designed for effective use in that location by holding the spacing between the openings or sound passages to a dimension not substantially exceeding one-sixth of the wave length of random sound of the highest frequency being encountered.

It will be understood that, while the invention shown in Fig. 2 illustrates two diametrically opposed central sound openings and centrally positioned end sound openings 52 and 56, only three sound openings need be employed, namely, one opening 52 and one each of the openings 54 and 56. Also these openings may be positioned close together by arranging the openings 54 and 56 eccentrically with respect to the casing walls 46 as long as the requirement of a similar relation of each of said openings 54 and 56 with respect to the chamber or cavity into which the same leads is maintained. It will be understood further that the two diaphragms 32 should be of balanced construction and that the cavities or chambers whose inner walls constitute said diaphragms are of similar size, shape and volume.

It will be observed that both of the diaphragms 32 in this device are open at both the front and the back thereof. Each of these diaphragms is responsive to a difference in pressure between the front and the back thereof. In other words, sound pressures acting upon opposite faces of either of the diaphragms and which are of equal amplitude and in phase will not energize the diaphragm. The sound pressures at the sound entrances due to random sound are of equal amplitude due to the source of the sound being at a distance. There will be a phase difference, however, due to a shift in phase as the sound travels the distances between the sound entrances. The instantaneous difference between the sound pressure at one opening to a diaphragm and the sound pressure at the other opening is the pressure gradient. For sounds originating very close to one sound opening, the pressure at one opening is of greater amplitude than the sound pressure at the other. The pressure gradient is therefore greater for sounds of close origin than for sounds of distant origin causing a diaphragm which is open to the atmosphere on both sides to be more responsive to close sounds than to distant sounds. By virtue of the distance the requirement of equal amplitude will automatically be met. In order to energize either diaphragm there must be a pressure gradient between the actions upon the opposite faces of the diaphragm. It might be mentioned in this connection that where the spacing between the openings is in the order of three-eighths of an inch, the sound source should be very close. A microphone of this type is the U. S. Army T-45 microphone which is positioned directly against the face of the user with one of the sound openings directly in front of the lips of the user. In instances where the spacing is greater than this minimum spacing of three-eighths of an inch, the sound source may be located at somewhat greater dis-

tance from the microphone and still produce the pressure gradient necessary to energize the device.

In the instant device the combination of the two diaphragms arranged as shown, each of which is responsive to the gradient of pressure as explained above, produces a response which is the gradient of the gradients of pressure of the two component diaphragm units. In other words, the response of the microphone is of the second order. The response characteristics are illustrated graphically in Fig. 4, wherein P1 will represent the pressure of the sound passing through one of the openings, for instance opening **54**, P2 and P3 represent the pressure of sound acting upon the two diaphragms at the inner faces thereof and entering the microphone through the opening or openings **52**, and P4 represents the pressure acting upon the microphone and entering through the passage **56**. For distant sounds the pressures are all of equal magnitude and the vectors P1, P2, P3 and P4 are thus illustrated as of equal length. These distant sounds are, however, displaced in phase by an angle kD where k is

$$\frac{2\pi}{\lambda}$$

λ is the wave length of sound, and D is the acoustic distance between the sound openings **52**, **54** and **56**. The pressure available for actuating one of the diaphragms, for instance the upper diaphragm in Fig. 2, is designated P1′ and is the vector difference between the two pressures acting on the upper diaphragm as shown in Fig. 4. Similarly, the pressure available for actuating the other of the two diaphragms, which is designated P2′, is the vector difference between the two pressures acting on the lower diaphragm as shown in Fig. 2. The pressure P0 which is available for actuating the carbon element **54** is the vector difference between these two available pressures (P1′—P2′). It will be observed that P0 is very small by comparison to the pressures P1, P2, P3 and P4, and also is very small in comparison with the pressure gradients P1′ and P2′, hence the vector P0, which represents the sensitivity of the microphone or its response to sounds of distant origin, is very small and represents the very low transmission of random sound by the microphone. This represents a very high discrimination against random sounds and reduces the transmission of such sounds to a factor negligible compared to that existing in such previous differential microphones as the Army T–45 microphone mentioned above.

Transmission of sounds or signals by the microphone is limited to sounds originating at close origin. For this purpose the microphone may be operated by talking into any one of the openings **52**, **54** or **56**. Preferably, the microphone will be actuated by talking into the opening **52** between two diaphragms, thereby actuating the diaphragms in opposite directions and securing a greater output of the sounds intended to be transmitted. The sounds of close origin are translated with high fidelity and their intelligibility is very high because of the greatly diminished force P0 which represents the translation of the random sound. Thus it is possible by using a microphone of this type in the noisiest locations, which in a military tank often rise to a level of intensity of random or background sounds which can be described as an intensity at the threshold of pain, to be assured of high fidelity and high intelligible performance. In other words, when a transmitter is located in a tank, the speech of the operator will be intelligible at a receiving station, and the random or background noise within the tank which is at the high level mentioned above will be negligible insofar as its transmission by the microphone and insofar as the signal at the receiver is concerned. It will be understood that the condition of use within a military tank represents an extreme condition, and further that reference to use in a miltary tank are illustrative only. Comparable results of high intelligibility of transmission of intended signals will obviously result when the microphone is operated in other noisy locations, as in factories, noisy public buildings such as railroad stations, and the like.

In addition to the diagrammatic or vectorial illustration of the operation of the microphone, the response pattern of the microphone has been illustrated in Figs. 15 and 16. Fig. 16 represents the arrangement of the acoustical axes of the two diaphragms as coincident, a condition which is satisfied in the embodiment of the invention shown in Figs. 1, 2 and 3, it being understood that the axes of the diaphragms are determined as mentioned hereinabove. Fig. 15 illustrates the polar response pattern of the microphone, which in this instance is shown as $\cos^2\theta$, where θ is the angle of incidence.

The same principle may be provided in a microphone of the sound power type as illustrated in Fig. 5. In this construction a housing **60** has two diaphragms **62** and **64** mounted therein in offset relation but with their axes parallel. The housing **60** has an opening **66** leading to a chamber **68** defined in part by one face of the diaphragm **62**. A similar opening **70** is formed in the housing **60** leading into a chamber **72** defined in part by the diaphragm **64**. The two chambers **68** and **72** are similar. One or more openings **74** in the casing lead into the cavity defined in part by the inner faces or surfaces of the diaphragms **62** and **64**.

A permanent magnet **76** is suitably mounted in the housing **60** and has two sets of poles, which pole sets are spaced apart as illustrated. The poles, namely an inner set of poles **78**, **79** and an outer set of poles **80**, **81**, are so arranged that the two poles on the same leg of the permanent magnet, here shown as of U-shape, are of the same polarity. In other words, pole pieces **78** and **80** are of one given polarity and pole pieces **79** and **81** are of opposite polarity. A steel armature **82** of elongated form, as shown, passes through the magnetic fields of the two sets of pole pieces **78**, **79** and **80**, **81** as shown, and preferably is positioned centrally with respect to both sets of pole pieces. A link **84** connects one end of the armature **82** with the diaphragm **62**, and a link **86** connects the other end of the armature **82** with the diaphragm **64**. A voice coil **88** is wound upon the armature between the two sets of pole pieces.

It will be apparent that the same response of the microphone of Fig. 5 to distant sounds, as has been illustrated by the vector diagram in Fig. 4, will result from the operation of this construction of microphone, so that the very low P0 output of this sound power embodiment in response to distant sounds will substantially reduce the transmission value of such sounds. This form of microphone, like the preferred form, is rendered operative to transmit a desired signal by talking close to one of the openings **66**, **70**, **74** to secure a large pressure gradient action due to the difference in pressure resulting from application of the signal preponderantly through one of said openings. As in the embodiment previously

discussed, maximum output of the signal desired to be transmitted is obtained by speech through the opening 74 between the diaphragms which doubles the output as compared to other microphones having similar components and as compared to speech directed at one of the openings 66 or 70 of this embodiment.

The microphone shown in Fig. 5 has a polar response pattern as illustrated in Fig. 13 by reason of the offset relation of the acoustical axes of the diaphragms 62 and 64 as shown in Fig. 14. Notice in this instance that the axis of the microphone, considered as a whole and indicated at X in Fig. 14, is disposed at an angle to the axes Y of the individual diaphragms 62 and 64. The polar response of this microphone is cos (θ) cos (θ+X), where X is the angle of displacement of the axis X of the microphone as a whole compared to the axis Y of the individual microphones. It is essential for satisfactory operation of this device where the X and Y axes are angularly disposed, that the Y axes of the individual diaphragms shall be parallel to each other as illustrated.

The application of the invention to a microphone of the condenser type is illustrated in Fig. 6, wherein the casing 90 has a centrally positioned condenser plate 92 which is provided with openings 94 therein. Two diaphragms 96 and 98 are mounted in the casing in close spaced capacitative relation to the element 92. The casing 90 has an opening 100 leading into the chamber 102 defined in part by the outer face of the diaphragm 98, and also has a similar opening 104 leading into a chamber 106 defined in part by the outer face of the diaphragm 96. The chambers 102 and 106 are similar and the openings 100 and 104 are similar and similarly located. An opening 108 is formed in the housing and communicates with the space between the diaphragm 96 and condenser element 92, and a similar opening 110 is formed in the housing and communicates with the space between the diaphragm 98 and the condenser element 92. It will be understood that the spacing between the two diaphragms and the condenser element 92 is the same.

The response of this microphone to sound of distant origin is the same as that illustrated diagrammatically in Fig. 4, and the polar response pattern of this microphone is the same as that illustrated in Figs. 15 and 16 by virtue of the coincidence of the acoustical axes of the individual microphones with the axis of the microphone considered as a whole. In this case electric leads 112 will extend from the two diaphragms 96 and 98.

Fig. 7 illustrates the embodiment of the invention in a dynamic microphone. A casing 120 mounts diaphragms 122 and 124 in offset relation. An opening 126 leads into a chamber 128 defined in part by the outer face of the diaphragm 122, and a similar opening 130 leads into a chamber 132 defined in part by the other face of the diaphragm 124. Chambers 128 and 132 are similar, and the openings 126 and 130 are similar and are located in the same relation to said chambers.

A magnet 134 having pole pieces 136 terminating in spaced confronting relation and also having a pole piece 138 positioned between the poles 136, is suitably mounted in the center of the housing 120. A coil 140 of a shape to extend freely around the pole piece 138 and between the poles 136 and the pole piece 138 is mounted at opposite ends thereof as at 142 to the diaphragms 122 and 124.

If the voice coil 140 moves equally and similarly relative to the poles 136 and pole pieces 138, the voltage between one pole 136 and pole piece 138 cancels the voltage between the other pole 136 and pole piece 138. The voltage output of this microphone will be proportional to the vectorial difference between the velocities of the two diaphragms 122 and 124, as illustrated in the vector diagram in Fig. 4. The polar response pattern of this form of microphone will be a response as illustrated in Fig. 13, by reason of the location of the acoustical axes of the two constituent diaphragms in offset relation as illustrated diagrammatically in Fig. 14. In this instance it will be understood that it is necessary for the axes of the two constituent diaphragms to be parallel.

Fig. 8 illustrates the application of the principle of this invention to a magnetic microphone, wherein it will be understood that the same arrangement of diaphragms, chambers and openings as illustrated in Fig. 7 will be employed and wherein similar parts bear the reference numerals as Fig. 7.

A crystal microphone may be constructed in accordance with this invention as illustrated in Figs. 9 and 10. In these figures a casing 150 encases a crystal piezoelectric element 152. The crystal 152 is preferably mounted at its mid point as by the mounting member 154. A diaphragm 156 is mounted in the housing and is connected at its center to two diagonally opposed corners of the crystal 152 by a bridge member 158. A second diaphragm 160 is mounted in the housing and is connected to the crystal by means of a bridge member 162 which spans the crystal to connect diagonally opposed portions thereof and which is positioned at an angle to the bridge 158, as best shown in Fig. 10. An opening 164 in the housing communicates with a chamber 166 defined in part by the diaphragm 156, and a similar opening 168 in the housing leads to a chamber 170 defined in part by the diaphragm 160. The chambers 166 and 170 are similar, and the openings 164 and 168 are similar and similarly arranged. One or more openings 172 are formed in the housing to communicate with the space therein between the two diaphragms and leads 174 extend from the piezoelectric element 152. The response of this microphone to sounds of distant origin is the same as illustrated in the vector diagram in Fig. 4. The polar response pattern of this microphone corresponds to that illustrated in Fig. 15 by virtue of the coincidence of the acoustic axis of the microphone as a whole with the acoustic axes of the two constituent diaphragms 166 and 160, as illustrated in Fig. 15.

While the microphones shown herein are all arranged with the acoustic axes thereof in one of the two relations with respect to the acoustic axes of the constituent diaphragms which are illustrated in Figs. 14 and 16, such arrangements are not critical in the device, and an arrangement of the diaphragms 180 and 182 in a common plane, as illustrated in Fig. 12, is possible. Where such an arrangement is utilized, the acoustic axes of the two diaphragms 180 and 182 must be parallel to each other. The axis of the second order result or vector secured by a microphone of this character, where the openings 184 leading to the two diaphragms 180 and 182 are arranged as illustrated diagrammatically in Fig. 12, is at right angles to the axes of the two dia-

phragms themselves as is illustrated at Z in Fig. 12. The openings 184, will, of course, be arranged so that the space therebetween is small compared to the wave length of the sound of highest frequency occurring in random sound in order to secure the differential action explained above and an action which corresponds with or is represented by the vector diagram shown in Fig. 4. The polar response of a microphone whose elements are arranged as illustrated in Fig. 12 is shown in Fig. 11. This polar response is cos θ sin θ.

While the preferred embodiments of the invention have been illustrated and described herein, it will be understood that changes may be made therein within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A microphone comprising two vibrating elements each element having an inside and outside surface, means whereby a pair of acoustic networks are associated with each element to render each element responsive to the difference in pressure acting on its inside and outside surface, and means for attaching a common transducer element subtractively to both vibratory elements whereby no voltage is generated therein when said vibratory elements move with the same amplitude and in phase.

2. A microphone comprising two vibratory elements, a pair of acoustic networks associated with each element, means whereby each element is responsive to the difference in pressure acting on opposite surfaces thereof, and means whereby a common electric generating element is subtractively attached to both vibratory elements whereby no voltage is generated therein when said vibratory elements move with the same amplitude and in phase, said networks having inlets spaced apart a distance which is small compared to the wave length of sound of the highest frequency desired to be attenuated whereby random sounds originating at a distance and passing through said networks for impingement on the surfaces of said vibratory elements with equal amplitude is only displaced in phase at said surfaces.

3. A differential microphone comprising a housing, a pair of vibratory elements dividing said housing into at least three chambers, an opening means leading into each chamber whereby each element is responsive to the difference in sound pressure at its opposite faces, and means whereby an electric generating element is connected to said vibratory elements in subtractive relation for response to the difference between the resultant differential forces acting on the two vibratory elements, said openings being spaced apart a distance small compared to the wave length of sound of the highest frequency to which said elements respond.

4. A differential microphone as defined in claim 3, wherein said opening means are so oriented relative to said vibratory elements that the acoustic axes of said vibratory elements are parallel.

5. In a transducer, a pair of similar spaced diaphragms, each having an inside and outside face, means whereby each diaphragm is exposed to atmosphere at each of said inside and outside faces, and means whereby a single electric generating element is subtractively connected to and positioned between said diaphragms whereby no voltage is developed in said element when said diaphragms move with equal amplitude and in phase.

6. A differential microphone comprising a housing, a single sound responsive electrical generating means in said housing, and two similar vibratory sound responsive members, said generating means being positioned between said vibratory members, and means rendering said generating means oppositely responsive to said vibratory members, said housing having a plurality of opening means located to render all surfaces of both vibratory members substantially equally responsive to random sounds of distant origin and to define the acoustic axes of said vibratory members in parallel relation.

7. A differential microphone comprising a housing, a pair of vibratory members mounted in said housing and each having two sound sensitive surfaces, and a single sound responsive generating element connected for actuation by said members in opposition, said housing having a plurality of openings each accommodating passage of sound therethrough for impingement upon one of the sound sensitive surfaces of one of said members to render said members responsive to the difference in sound at opposite faces thereof, said members providing two sound responsive systems each having said generating element as a part thereof, wherein said openings are located to define parallel acoustic axes for said systems.

8. A differential microphone comprising a housing, an electric generating element in said housing, a pair of diaphragms mounted in said housing in offset relation and connected to said element to energize the same oppositely, and openings in said housing for passage of sound into the housing between said diaphragms and outwardly of said diaphragms respectively, and means whereby said openings are arranged relative to each other and to said diaphragms so as to admit sound of distant origin in equal amplitude and substantially in phase and to provide an acoustic axis for each diaphragm parallel to the acoustic axis of the other diaphragm.

9. A differential microphone comprising a housing, a pair of spaced diaphragms mounted in said housing, each of said diaphragms having two faces, a retainer carried by said housing between said diaphragms, confining rings carried by opposite sides of said retainer and each engaging the adjacent diaphragm, carbon granules confined between and engaging said diaphragms in the space defined by said retainer and confining rings, said housing having opening means therein for passage of sound from a distant origin to impinge upon each of the faces of said diaphragms with equal amplitude and only slightly displaced in phase with respect to sounds of the highest frequency effective to actuate the diaphragms and carbon granules including opening means leading to the space between said diaphragms.

10. A differential microphone comprising a housing, a magnet having two spaced sets of confronting pole pieces separated by a gap, the pole pieces on one side of said gap being of the same polarity, an armature positioned in said gap, a stationary voice coil encircling said armature, and a pair of diaphragms having inner and outer surfaces and connected to opposite ends of said armature, said housing having a plurality of openings each directing sound to one of the surfaces of a diaphragm, some of the openings

leading to the inner diaphragm surfaces and other leading to the outer diaphragm surfaces.

11. A differential microphone comprising a housing, a magnet having two spaced sets of confronting pole pieces separated by a gap, the pole pieces on one side of said gap being of the same polarity, an armature positioned in said gap, a stationary voice coil encircling said armature, and a pair of diaphragms having inner and outer surfaces and connected to opposite ends of said armature, said housing having a plurality of openings each directing sound to one of the surfaces of a diaphragm some of said openings leading to the inner diaphragm surfaces and others leading to the outer diaphragm surfaces, and means whereby said diaphragms are positioned in offset relation in said housing and so related to the openings for directing sounds to the opposite faces thereof that the acoustic axes of said diaphragms are parallel.

12. A microphone comprising a housing, a pair of diaphragms mounted in said housing, a single generating element interposed between said diaphragms and having an actuating connection with each diaphragm, a plurality of openings in said housing, means whereby one surface of each diaphragm is responsive only to sound entering a selected passage correlated therewith, means whereby said openings position the acoustic axes of said diaphragms in parallel relation and means connecting said diaphragms to said generating element in such a manner that the voltage generated by said element upon movement of said diaphragms of equal amplitude and in phase is substantially zero.

13. A transducer as defined in claim 5, wherein said electric generating element constitutes a mass of carbon granules interposed between and contacting said diaphragms, and means for retaining said carbon granules between said diaphragms.

14. A transducer as defined in claim 5, wherein said electric generating element constitutes a magnet having two spaced sets of spaced poles, an armature positioned within and passing through the magnetic field of the two sets of poles, means connecting the ends of said armature to the opposite diaphragms, and a voice coil wound upon said armature.

15. A transducer as defined in claim 5, wherein said electric generating element constitutes an apertured condenser plate mounted midway between and in close spaced capacitative relation to said diaphragms, said diaphragms constituting condenser plates.

16. A transducer as defined in claim 5, wherein said electric generating element constitutes a magnet having a pair of spaced confronting pole pieces, a third pole piece interposed between the first pole pieces, a coil extending freely around the third pole piece and between the first named pole pieces and the third pole piece, and means connecting said coil to both diaphragms.

17. A transducer as defined in claim 5, wherein said electric generating element constitutes a piezoelectric element, means mounting said piezo-electric element, means connecting said piezoelectric element at diagonally opposed portions thereof to one diaphragm, and means connecting said piezoelectric element to the other diaphragm at two diagonally opposed portions spaced from said first named diagonal portions.

ALPHA M. WIGGINS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,117,231	Palmer	Nov. 17, 1914
1,496,919	Bellus	June 10, 1924
1,546,749	Roberts	July 21, 1925
1,753,137	Seibt	Apr. 1, 1930
1,930,186	Swallow	Oct. 10, 1933
2,164,157	Kennedy	June 27, 1939
2,184,247	Baumzweiger	Dec. 19, 1939
2,196,342	Ruttenberg	Apr. 4, 1940
2,198,424	Baumzweiger	Apr. 23, 1940
2,233,886	Cowley	Mar. 4, 1941
2,293,258	Harry	Aug. 18, 1942
2,295,376	Anderson	Sept. 8, 1942
2,301,744	Olson	Nov. 10, 1942
2,476,396	Anderson	July 19, 1949

FOREIGN PATENTS

Number	Country	Date
212,857	Great Britain	Mar. 14, 1924