June 8, 1954 H. F. OLSON ET AL 2,680,787

UNIAXIAL MICROPHONE

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Fig.1.

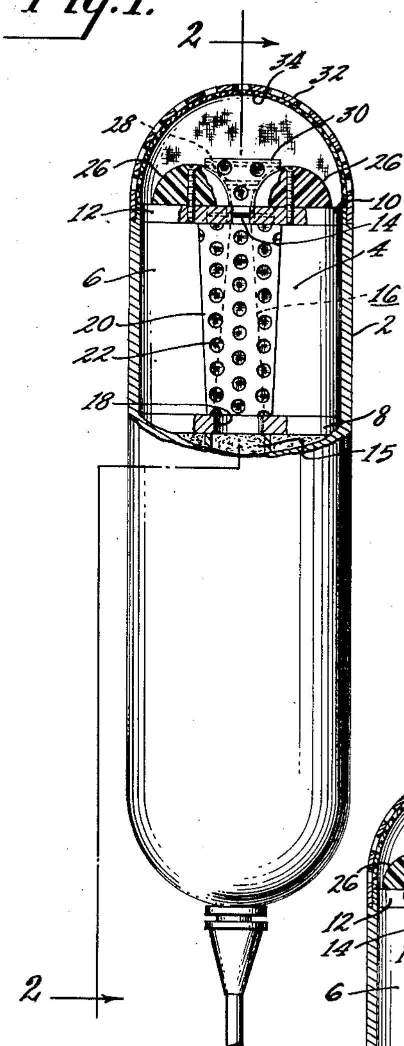
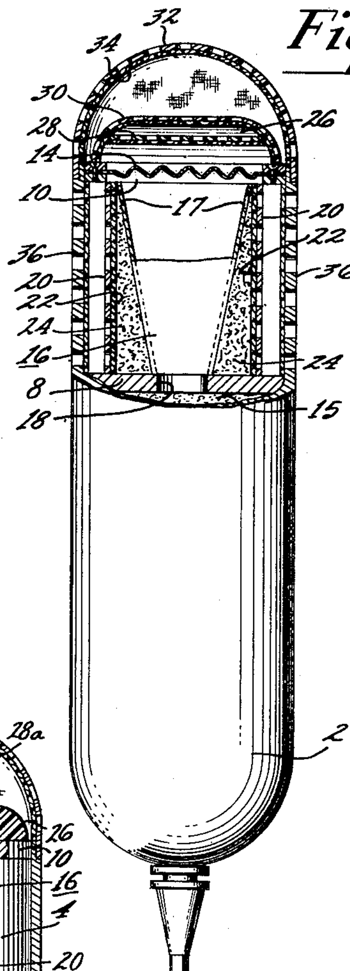


Fig.2.



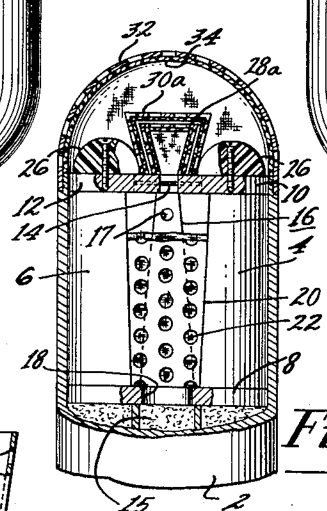
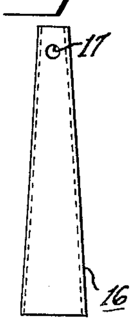


Fig. 7.

Fig. 3.



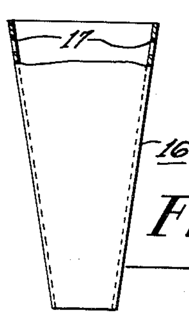


Fig. 4.

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*Fig. 5.*

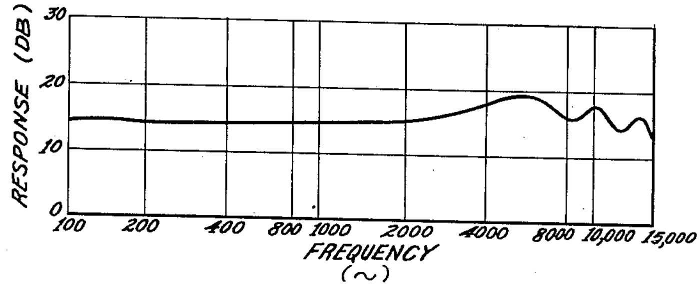
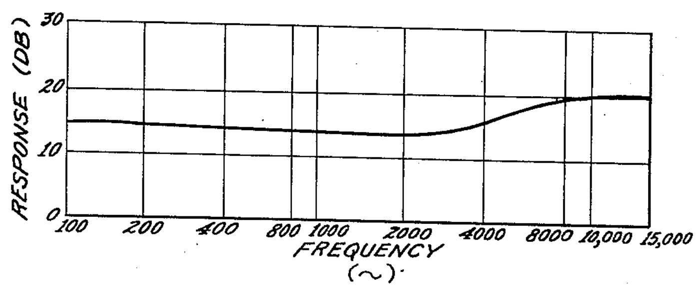



*Fig. 6.*



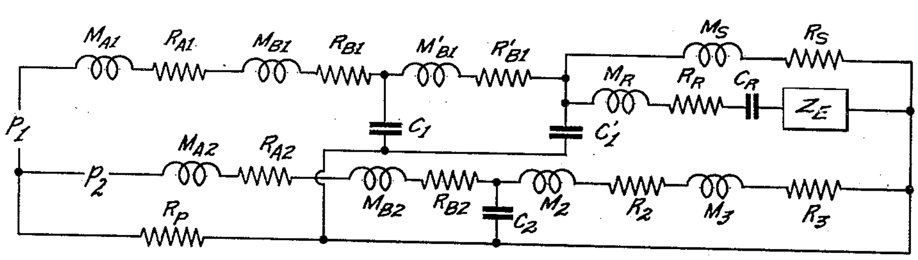




*Fig. 8.*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2,680,787

## UNIAXIAL MICROPHONE

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Application November 30, 1951, Serial No. 259,138

11 Claims. (Cl. 179—115.5)

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The present invention relates to microphones, and more particularly to ribbon type unidirectional microphones.

With the advent of television, efforts have been made to make microphones smaller, less obtrusive, without reducing the quality of the performance of the unit to a degree substantially below that of the larger, more conventional microphones. In the class of microphones wherein the sound source is relatively close, such as hand-held microphones, considerable advancement has been made. A microphone of that type is shown in Olson et al. Patent Number 2,566,094. That microphone is characterized, however, in that it is a pressure responsive unit and, hence, has a non-directional response characteristic.

For sound pick-up from a more remote position, as from a boom, wherein the microphone is at a considerable distance from the sound source, it has been found desirable to use a microphone having a unidirectional characteristic. The microphones which have heretofore been used for boom operation have been rather large because of the structure thought necessary to produce a pressure gradient responsive type microphone having the desired characteristics.

Since the hand-held type microphones are primarily used to pick up a speaking or singing voice, the structure may be quite simple. However, the remote or boom microphone may be used to pick up dramatic productions, including numerous sound effects. Among the various sound effects, many are accompanied by the generation of an initial high-amplitude, low frequency pressure wave. Such a pressure wave accompanies a blast from a firearm. If the microphone is relatively close to the source of the pressure wave, the ribbon of the microphone may be permanently damaged.

It is accordingly an object of the present invention to provide an improved pressure gradient responsive ribbon type microphone characterized in that a smaller sized unit is obtained without sacrificing quality of performance.

It is another object of the present invention to provide a small, pressure gradient responsive, ribbon type microphone wherein means are provided for protecting the ribbon from damage by the initial pressure wave such as would accompany the firing of a .45 caliber pistol at close range.

Still another object of the present invention is to provide a microphone as set forth wherein means are provided for dissipating the energy of the initial pressure wave before it impinges on the ribbon.

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In the development of a small microphone as set forth, a motor mechanism was chosen which is substantially similar to that employed in the microphone disclosed in the aforesaid patent, 2,566,094. However, the microphone of the present invention does not include a sound transmitting tube on the sound input side of the ribbon as does the pressure responsive microphone. Consequently a relatively large flat surface is presented to the impinging sound waves in the vicinity of the ribbon. Such a finite flat surface, broken by an air gap in which the ribbon is supported, produces a diffraction interference in the righer frequency sound waves. The interference, thus produced, distorts the response of the microphone to the sound waves impinging on the ribbon.

It is, therefore, a further object of the present invention to provide a microphone as set forth wherein means are provided to prevent the development of diffraction interference in the sound waves impinging on the ribbon.

In accomplishing these and other objects, there has been provided, in accordance with the present invention, an improved pressure gradient responsive, ribbon type microphone. The microphone is characterized in that the motor element is arranged with the ribbon supported in an air gap in one end of a magnetic structure. Thus, a relatively wide flat surface would be presented, in the vicinity of the ribbon, to the impinging sound waves. Anti-diffraction lobes are secured to the flat surface of the end of the magnetic structure on each side of the air gap to prevent the diffraction of the sound waves by the surfaces adjacent to the air gap. In addition, a plurality of baffle screens are interposed between the sound source and the ribbon to absorb or dissipate an initial high amplitude low frequency pressure wave, such as would accompany the firing of a .45 caliber pistol, to protect the ribbon against damage by such a pressure wave.

A better understanding of the present invention may be had from the following detailed description when read in connection with the accompanying drawings in which,

Figure 1 is an elevational view partly in crosssection of a microphone embodying the present invention,

Figure 2 is a view taken along the line 2—2 of Figure 1 and looking in the direction of the appended arrows,

Figures 3 and 4 are views showing the labyrinth connector,

Figures 5 and 6 are graphs indicating the frequency response characteristic, respectively, with and without the use of the anti-diffraction lobes,

Figure 7 is a fragmentary view partly in section similar to Figure 1 but incorporating a modification of the invention, and,

Figure 8 is a diagram of an electrical circuit analogous to the acoustical circuit of the microphone of the present invention.

Referring now to the drawings in more particularity, there is shown in Figures 1, 2 and 7 an outer casing **2** within which a microphone is housed. The microphone motor assembly includes a pair of magnetic members **4** and **6** which are secured, at one end, to a magnetically permeable base member **8**. A pair of soft iron pole pieces **10** and **12** are secured to the magnetic members at the end opposite from the base member **8**. The magnetic members are approximately semi-cylindrical in shape and are mounted upon the base member with their flat surfaces facing each other in spaced apart relation. Similarly the pole pieces **10** and **12** are flat and approximately semi-cylindrical. These pole pieces are secured to one end of the magnetic members respectively and are also arranged with their straight side in spaced apart relation facing each other. Thus, the pole pieces define an air gap. A conductive vibratile member or ribbon **14** is supported for vibratory movement in the air gap. A motor unit of this type is selected because it presents several advantages, among them being simplicity and magnetic efficiency. Simplicity is accomplished by the use of a small number of easily machined parts. High magnetic efficiency is obtained due to the small flux leakage inherent in magnetic designs of this type.

Adjacent to the end of the motor assembly opposite from the air gap, there is an acoustical labyrinth **15** substantially as defined in Olson Patent Number 2,271,988. In the space between the magnetic members **4** and **6** there is positioned a conduit or connector **16** which connects one side of the air gap through an aperture **18** in the base member **8** to the acoustical labyrinth **15**. The construction of the connector **16** is substantially the same as that described in the aforesaid Patent 2,566,094, with the exception that there is provided one or more orifices **17** (two being shown) near the end of the conductor adjacent to the air gap as shown in Figures 3 and 4.

Bridging the space between the magnetic members along the peripheral edges there is positioned a perforated metal screen **20**. A layer of closely woven fabric such as silk **22** is secured to the back of the metal screen. A similar piece of fabric covers the orifices **17** in the connector **16**. The space between the connector and the metal screens is filled with an acoustical damping material such as felt or fiber glass **24**.

Secured to each of the pole pieces **10** and **12** on the flat surfaces thereof opposite from the magnetic members, there is an anti-diffraction lobe **26**. These lobes may be made from any suitable material. However, a non-magnetic material is preferred. In cross-section, the lobes are substantially semi-circular in shape and are positioned on the pole pieces closely adjacent to the air gap. Between these lobes there is positioned a plurality of successively spaced baffles **28—30** which includes a perforated metal support with a backing of a closely woven fabric. The spacing of the baffles is such that sounds impinging on the ribbon **14** must first pass through one of the baffles and then the other baffle before arriving at the ribbon. The end closure of the outer casing is formed of a perforated metal support screen **32** and having a fabric backing **34**. However, here the dimensions of the perforations and the fabric of the backing are such that they are substantially transparent to the sound waves.

In Figures 1 and 2 the baffles **28—30** bridge the space between the anti-diffraction lobes. The perforated metal screen constituting the end closure of the casing has portions **36** which extend longitudinally of the casing. These extended portions are arranged to be aligned with the orifices **17** in the connector **16**. The fabric backing also extends along the extended portions. The perforated metal screens **20** are substantially parallel to the extended portions of the end closure and are spaced therefrom. In Figure 7 the construction of the baffle is somewhat modified in that the baffles are in the form of boxes **28*a***, **30*a***, one within the other, which are substantially pyramidal in shape. The inner box **28*a*** is spaced from the outer box **30*a*** as are the baffles **28—30** of Figures 1 and 2.

A microphone thus constituted may be termed a uniaxial microphone because the axis of maximum sensitivity corresponds to the axis of the assembly. The orifices **17** in the labyrinth connector **16** permit variations in sound pressure to impinge on the back side of the ribbon **14**. However, the structure of the microphone is such that the sound waves impinging on the back side of the ribbon are delayed and shifted in phase with respect to the sound waves falling on front of the ribbon. So long as the sound source is disposed along the axis of the microphone on the front side of the ribbon, a maximum phase difference between the sound waves falling on the front and back of the ribbon occurs, resulting in a maximum output. However, deviations from the axis are accompanied by a corresponding reduction in the phase difference and a lower output, with maximum cancellation occurring when the sound source is disposed along the axis of the microphone and on the back side of the ribbon. If the microphone as described were to be employed without the use of the anti-diffraction lobes, the flat surfaces of the pole pieces would produce a diffraction in the sound waves which would in turn cause an irregularity in the response characteristic of the microphone substantially as shown in the chart of Figure 5. There it may be seen that as the frequency of the incident sound waves increases, an irregularity in the response of the microphone is produced in the upper portion of the audible frequency range. It has been determined that this irregularity is a result of the diffraction of the sound waves as they impinge on the flat surfaces of the pole pieces. When the anti-diffraction lobes are positioned on the pole pieces, the response characteristic is substantially as shown in Figure 6. There it may be seen the irregularities have been smoothed out and substantially eliminated. In addition, the contour of the lobes is such that they effectively constitute a small horn, thereby increasing the sensitivity of the microphone.

When the microphone is used to pick up such sounds as the discharge of firearms, the ribbon may be permanently injured by the initial low frequency, high amplitude pressure wave which accompanies the blast of such firearms. This initial pressure wave, of course, varies in time duration with the type of instrument producing the wave. For example, the time might vary from a 20th of a second for a .45 caliber pistol to a 40th of a second for a .22 caliber pistol. These low frequency pressure waves are not reproduced through the complex chain of elements which constitute the sound channel of recording and broadcasting equipment. However, it is the low frequency component in the blast pulse that produces the large deflection in the ribbon and stresses it beyond the elastic limit and thereby introduces a permanent deformation in the ribbon. Since the initial pressure wave forms no part of the reproduced sound it may readily be dispensed with, without materially affecting the desired sound effect. In accordance with the present invention this initial pressure wave is dissipated before it impinges upon the vibratory member. The system of successively spaced baffles provides means for so dissipating the energy of the blast. Consider such a sound wave as emanating from a point beyond the perforated end closure of the microphone. The pressure wave will first encounter baffle **30** or **30***a* where it is attenuated by the acoustical resistance and the inertance thereof. From thence it falls upon the inner baffle **28** or **28***a* where, again, it is attenuated. By this time the pressure wave has been attenuated to the extent that it will no longer have a deleterious effect upon the ribbon. Similarly the sound wave impinges upon the opposite side of the ribbon after having passed the perforated metal screen **20**, the acoustical damping material **24**, and the orifices **17**, thus attenuating the energy of the pressure wave impinging upon the reverse side of the ribbon. Although the acoustical impedance of the baffle structure is substantially constant for all frequencies, effectively, it constitutes a low frequency acoustical impedance. This is true because the impedance of the baffle structure must be compared with the acoustical impedance of the ribbon itself. For low frequencies, the acoustical impedance of the ribbon is very small in comparison with the impedance of the baffles. Hence, for low frequencies the dominant impedance is that of the baffles. On the other hand, for higher frequencies, the acoustical impedance of the ribbon dominates that of the baffles.

The acoustical network shown in Figure 8 is representative of the conditions prevailing in the microphone herein set forth and may prove helpful to a better understanding of the principles involved herein.

In that network,

$P_1$ is the sound pressure on the front of the microphone,

$M_{A1}$ and $R_{A1}$ are the inertance and acoustical resistance respectively of the air load on the front of the microphone,

$M_{B1}$ and $R_{B1}$ are the inertance and acoustical resistance respectively of the first baffle **30**, while $M'_{B1}$ and $R'_{B1}$ are inertance and acoustical resistance respectively of the inner baffle **28**,

$C_1$ is the acoustical capacitance of the volume between the baffles **28** and **30** or **28***a* and **30***a*,

$C'_1$ is the acoustical capacitance of the volume between the inner baffle and the ribbon,

$M_S$ and $R_S$ are inertance and acoustical resistance of the slit between the edge of the ribbon **14** and the pole pieces **10** and **12**,

$M_R$, $R_R$ and $C_R$ are respectively inertance, acoustical resistance and acoustical capacitance of the ribbon,

$Z_E$ is the acoustical impedance due to the electrical circuit associated with the ribbon,

$P_2$ is the sound pressure on the back side of the vibrating system,

$M_{A2}$ and $R_{A2}$ are respectively the inertance and acoustical resistance of the air load of the back side of the vibrating system,

$M_{B2}$ and $R_{B2}$ are respectively inertance and acoustical resistance of the baffles **20** on the side of the microphone,

$C_2$ is the acoustical capacitance of the volume behind the baffles **20**,

$M_2$ and $R_2$ are the inertance and acoustical resistance respectively of the screen covering the orifices **17** in the labyrinth connector **16**,

$M_3$ and $R_3$ are the inertance of acoustical resistance respectively of the orifices in the labyrinth connector,

$R_P$ is the acoustical resistance of the labyrinth **15**.

In the event that the acoustical damping material is used in the space between the baffles **20** and the labyrinth connector **16**, the acoustical network would be modified to the extent of having the acoustical resistance of the damping material connected in shunt across the acoustical capacitance $C_{C2}$.

Similarly, acoustical damping material may be inserted between the front baffles **28** and **30** or **28***a* and **30***a*. This would, in effect, modify the acoustical network by the inclusion of the acoustical resistance of the material connected in shunt with the acoustical capacitance $C_1$ of the volume between the baffles.

Thus it may be seen that, by controlling the values of the elements of the network, through the control of the dimensions of the components represented thereby, the very low frequency pressure waves may be effectively filtered out, without materially affecting the microphone's response to the desired sound waves.

From the foregoing, it may be seen that there has been provided an improved small-size pressure gradient responsive microphone wherein the ribbon is protected from damage by high amplitude, low frequency pressure waves, and wherein means are provided for preventing the formation of diffraction patterns which would distort the microphone's frequency response characteristic.

What is claimed is:

1. A pressure gradient responsive ribbon type microphone comprising a magnetic field structure generally cylindrical in shape having substantially flat circular ends, said field structure defining an elongated air gap in one of said circular ends, a conductive vibratile member supported in and substantially coextensive with said air gap, a plurality of successively spaced baffles effectively constituting a low frequency acoustical impedance interposed between said vibratile member and the ambient, and a pair of anti-diffraction lobes mounted on said end adjacent to said air gap.

2. The invention as set forth in claim 1 wherein said anti-diffraction lobes are substantially semi-circular in cross section.

3. The invention as set forth in claim 2 wherein said lobes are secured to said end on opposite sides of said air gap.

4. The invention as set forth in claim 3 characterized in that at least two of said baffles are disposed between said lobes bridging the space therebetween.

5. The invention as set forth in claim 1 wherein said baffles comprise perforated metal supports and a layer of closely woven fabric secured to one surface of each of said supports.

6. A pressure gradient responsive microphone comprising a magnetic field structure having an air gap in one end thereof, a conductive vibratile member supported in and substantially coextensive with said air gap, said magnetic structure being disposed substantially all on one side of said air gap, a plurality of successively spaced baffles effectively constituting a low frequency acoustical impedance interposed between said vibratile member and the ambient, and a pair of anti-diffraction lobes secured to said structure adjacent to said air gap.

7. A pressure gradient responsive microphone comprising a magnetic field structure having an air gap in one end thereof, a conductive vibratile member supported in said air gap, said magnetic structure being disposed substantially all on one side of said air gap, and a pair of anti-diffraction lobes secured to said structure adjacent to said air gap.

8. The invention as set forth in claim 7 wherein said magnetic structure is generally cylindrical in shape having substantially flat circular ends, one of said ends being divided thereby defining said air gap.

9. The invention as set forth in claim 8 wherein one of said lobes is secured to each portion of said divided end.

10. The invention as set forth in claim 9 where-



in said lobes are substantially semi-circular in cross section.

11. A pressure gradient responsive ribbon type microphone comprising a magnetic field structure generally cylindrical in shape and including a spaced pair of substantially semi-cylindrical magnetic members and a pair of flat semi-cylindrical pole pieces positioned on one end of said magnetic members, said pole pieces defining an elongated air gap, a conductive vibratile member supported in said air gap, an acoustic labyrinth adjacent the end of said magnetic structure opposite from said air gap, a connector member of substantially constant cross sectional area connected between said air gap and said labyrinth, said connector member having a sound admitting aperture adjacent to the end thereof nearest said air gap, a plurality of successively spaced baffles effectively constituting a low frequency acoustical impedance interposed between said vibratile member and the ambient, and a pair of anti-diffraction lobes respectively mounted on said pole pieces.


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