United States Patent

[11] 3,560,668

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[33] **Germany**
[31] **100188**

[54] MICROPHONE HAVING COUPLED ACOUSTIC CIRCUITS

16 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **179/138,** 179/115.5, 179/121, 181/31
[51] **Int. Cl.** **H04r 1/28**
[50] **Field of Search** 179/1DIR, 115DVC, 121, 138, 139, 116, 1.3A; 181/31.1, 31A, 33, 34

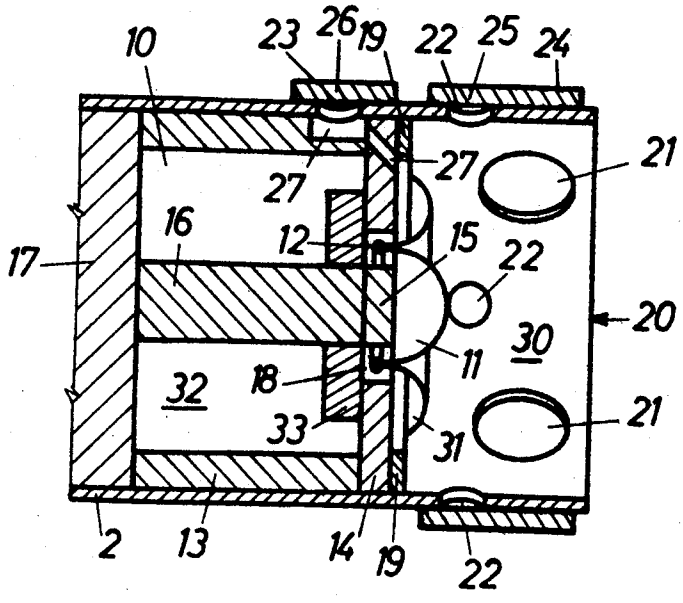
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Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: A microphone having a response characteristic in a set frequency range and a reinforced response at the upper limit of this range and comprising a housing containing an electroacoustic transducer with at least one diaphragm for producing output signals as a function of the sound striking the diaphragm and a substantially cylindrical acoustic resonance chamber coupled to the diaphragm. The opening to the acoustic resonance chamber forms the main sound inlet opening, and at least one group of subsidiary sound inlet openings are formed in the chamber walls.



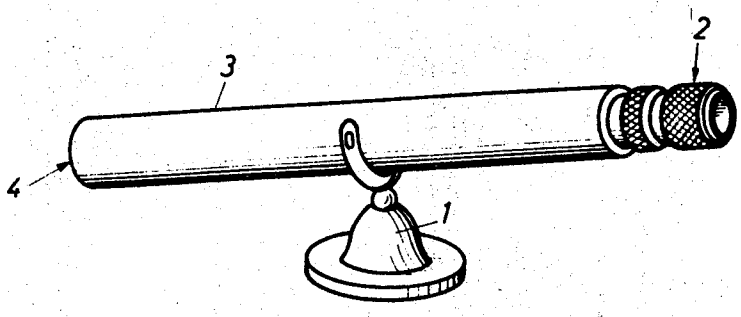


FIG. 1

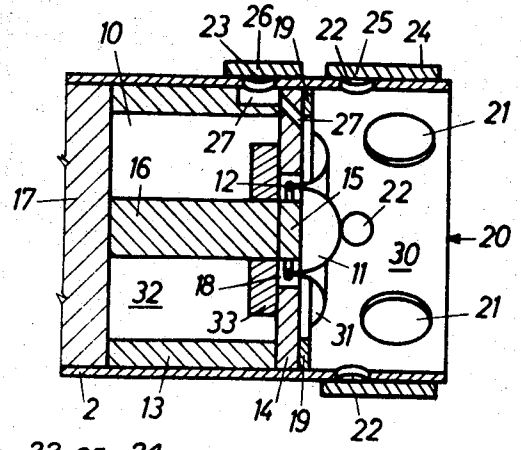


FIG. 2

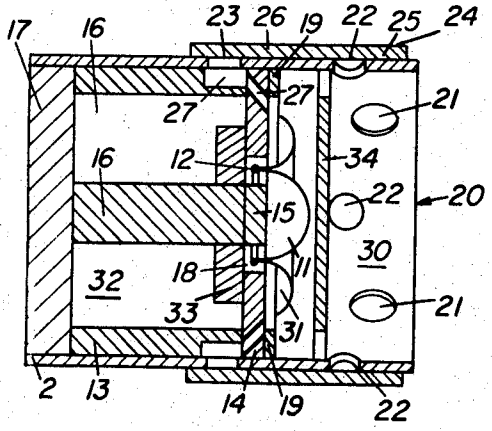


FIG. 5

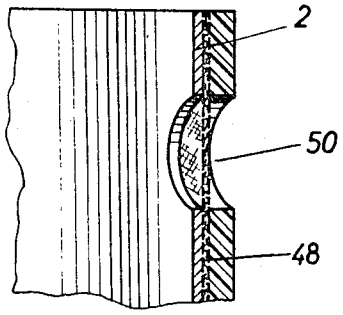


FIG. 3

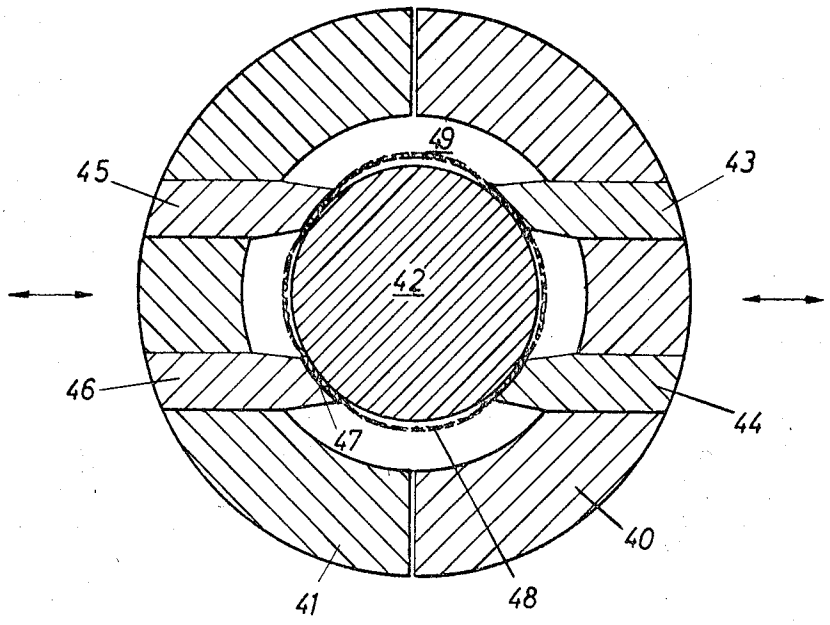


FIG. 4

MICROPHONE HAVING COUPLED ACOUSTIC CIRCUITS

The invention is a microphone responsive to a frequency range the upper limit of which lies above 5 kilocycles.

German Auslegeschriften 1,144,343 and 1,175,277 show that high frequencies may be raised by placing a preferably circular sound chamber before the diaphragm of an electroacoustical transducer. These sound chambers employed to raise the high frequencies present the disadvantage of being adjustable more or less exactly to only one single frequency so that the range influenced by the resonance is extremely limited.

It is therefore an object of the present invention to produce a microphone with a sound chamber whose resonance properties, derived from at least two acoustic circuits coupled together, effect a rise in the high frequencies within a given frequency range.

A further object of the invention is to produce a microphone with a sound chamber whose individual resonance curves are flattened by inserting acoustic resistances.

A further object is to produce a microphone with a sound chamber in which the acoustic resistances are so arranged that they lie in a protected position and do not increase the size of the microphone in relation to the outer diameter of the microphone and the inner diameter of the sound chamber.

Preferred embodiments of the microphone according to the invention are discussed in connection with the drawing.

FIG. 1 shows the microphone in perspective;

FIG. 2 a cross section of the front part of the microphone as shown in FIG. 1;

FIG. 3 a cross section of the shell of the microphone through an auxiliary sound opening;

FIG. 4 a mould for the manufacture of the shell of the microphone according to FIG. 3;

FIG. 5 a variation of the microphone shown in FIG. 1.

FIG. 1 shows a microphone attached to a stand **1**. The microphone consists of a shell **2** that is attached by springs to the inside of a casing **3**. The shell **2** and the casing **3** are tubular or cylindrical so that the microphone looks like a rod. The circuit clamps of the electroacoustical transducer or transducers are housed in the back part **4** of the microphone. Where two electroacoustical transducers are used, the one located in the front part of the shell **2** of the microphone is adjusted to a frequency range above 5 kilocycles, while the electroacoustical transducer in the back part of the shell **2** covered by the casing **3** is adjusted to lower sound frequencies.

As FIG. 2 shows, the microphone, which responds mainly to pressure gradients, contains an electroacoustical transducer which in turn consists of a closed magnetic circuit **10**, a diaphragm **11** and a voice coil **12**. The closed magnetic circuit **10** in turn contains a ring-shaped magnet **13**, a ring-shaped pole piece **14**, a pole field **15**, a ferromagnetic part **16** lying in the axis of the ring-shaped magnet **13**, a yoke **17** connecting parts **13** and **16** and an air slit **18** located between the pole piece **14** and pole field **15**. The diaphragm is attached to the pole piece **14** by the customary fastening means. In the air slit **18** the voice coil **12** oscillates and produces an electric signal, corresponding to the movements of the diaphragm **11**.

The shell **2** has main sound inlet means, auxiliary sound inlet means and back sound inlet means. The main sound inlet means consists of a main sound inlet opening **20** and may have a cover as well. The auxiliary sound inlet means consist of a group or row of four auxiliary sound inlet openings **21** and, if required, corresponding acoustical resistances **24**, as well as a second plurality of four auxiliary sound inlet openings **22** and, if required, corresponding acoustical resistances **25**. The back sound inlet means consist of eight back sound inlet openings **23** corresponding acoustical resistances **26** and sound conduits **27**.

The acoustical resistances **24** to **26** corresponding to the auxiliary sound inlet openings **21** to **23** may be of covers of varying thickness and/or density. It is also possible to place a closed resistance sheet of uniform thickness and density in or around the front part of the shell **2** so that resistances **24** to **26** are determined by the size of openings **21** to **23**. The resistance sheet may be an integral part of the shell **2**, as shown in FIGS. **3** and **4**. It is also possible to do away with resistances **24** to **26** so that the auxiliary sound inlet means consist merely of the auxiliary sound inlet openings **21** and **22**.

Between the main sound inlet opening **20** and the diaphragm **11**, the shell **2** delimits a cylindrical sound chamber **30**. The main sound inlet opening **20** constitutes one base, the walls of the shell **2** the walls, and the diaphragm together with the fastening means **19** the other base of the cylinder. The diameter of the sound chamber **30** measured parallel to the diaphragm is greater than the diameter of the diaphragm and in general greater than the length of the cylinder perpendicular to the diaphragm. As a result, the cross section of the sound chamber **30** has a greater area than the cross section of the diaphragm. Between the diaphragm **11** and the pole pieces **14** there is a chamber **31** and a chamber **32** between the ring-shaped magnet **13** and the ferromagnetic part **16**. The sound chamber **30** communicates with the surrounding sound field through the main sound inlet means and the auxiliary sound inlet means. The chamber **31** communicates through the back sound inlet means whereas the chamber **32** communicates through air slit **18** with chamber **31**. This acoustical communication between chambers **31** and **32** is modified by an additional acoustical resistance **33**.

When the RC combination constituted by chamber **32** and resistance **33** is not needed, the resistance **33** may be eliminated and the conduit **27** is led into the chamber **32** through opening **23**. If the high frequency chamber is to be used with pressure sensors the back inlets **23** and conduits **27** are not employed.

In one model, the inner diameter of the sound chamber **30** was 22 mm., the diameter of the diaphragm **11** was 18 mm., the diameter of the main sound inlet opening **20** was 22 mm., the corresponding distance to the fastening means **19** respectively to the diaphragm **11** was 18 mm., the diameter of the first auxiliary sound inlet opening **21** was 8 mm., the corresponding distance to the fastenings means **15** respectively to the diaphragm **11** was 14 mm., the diameter of the second auxiliary sound inlet opening **22** was 4 mm., the corresponding distance to the diaphragm was 7.5 mm., the back sound inlet opening **23** was 2 mm. parallel to the axis of the cylinder times 7.6 in the direction of the cylinder wall, the corresponding distance to the fastening means **19** was 9 mm. (the distances are measures from the middle of the corresponding surface to the fastening means of the diaphragm). If the acoustical resistances **24** and **25** left out and the sound allowed to pass successively through the auxiliary sound openings beginning with the main sound opening, resonance frequencies of 3.8, 4.5 and 7 kilocycles can be measured. If all sound openings **20**, **21** and **22** are open, the resonance frequencies are not sharply defined but cause a uniform rise in frequencies. It seems likely that simultaneously an effective resonance is set up as an $\lambda/2$ resonance between the walls of the sound chamber.

The operational frequency of the microphone can further be influenced by using acoustical resistances **24** and **25**. If the second auxiliary sound inlet openings **22** are made as large as the first auxiliary sound inlet openings **21**, a resonance frequency limited for all practical purposes to 7 kilocycles would be set up; in order to allow the 4.5 kilocycles resonance frequency to act the second auxiliary sound inlet openings **22** are damped by means of acoustical resistances **25** larger than acoustical resistances **24** of the first auxiliary sound inlet openings **21**.

The same consideration holds for the first group of auxiliary sound inlet openings **21** and main sound inlet opening **20**. When auxiliary sound inlet openings **21** are a certain size it is useful to dampen the openings by resistances **24** so that a 3.8 as well as a 4.5 kilocycle resonance frequency can be established. This means that the resistance of the sound openings should decrease as the distance from the diaphragm **11** increases. This requirement is met by the relative size of

the auxiliary sound inlets to each other and to the main sound inlet **20**; the first group of auxiliary sound inlet openings **21** is made larger than the second group of auxiliary sound inlet openings **22** so that resistance material of the same substance, thickness and density gives rise to a lesser acoustical resistance in the first group of auxiliary sound inlet openings **21** than in the second group of auxiliary sound inlet openings **22**. Whereas the resonance frequencies are thus determined by the distances of the second inlet openings from the diaphragm **11**, the intensity of the resonance frequencies is regulated by the size of the openings and thereby the size of the resistances with which these openings are provided. In this manner it is possible to obtain an approximation of the characteristics desired in the microphone. In practice, acoustical resistances **24** and **25** were made of material having 100 mechanical ohms per square meter and back inlets of material having 200 mechanical ohms per square meter.

It follows that ideally the ratio of distance of the main sound inlet openings **20** from the fastening means **19** or to the diaphragm **11** to the distance of the first group of auxiliary sound inlet openings **21** from the fastening means or diaphragm **11**, as well as the ratio of the distance of the first group of auxiliary sound inlet openings from the fastening means or diaphragm **11** to the distance of the second group of auxiliary sound inlet openings from the fastening means or diaphragm **11** should be selected in the range from 1:1.2 to 1:1.6.

Instead of two auxiliary sound inlet openings **21** and **22** leading to the sound chamber a single row of auxiliary sound inlet openings or possibly a single auxiliary sound inlet opening may be made. If characteristics similar to those obtained with both groups of auxiliary sound inlet openings are desired, the cross section of the individual openings is made wedge-shaped or trapezoidal.

The sound chamber **30** and the auxiliary sound inlet means can also be used in a variation of the model shown in FIG. **2** with a pressure sensor for which no back inlet **23** is provided.

FIGS. **3** and **4** show a process for making auxiliary sound inlet means. The shell **2** of the microphone is sprayed synthetic material. The mould employed consists of two or more outer parts **40**, **41** and an inner part **42**. The outer part **40** has projections **43** and **44** and outer part **41** projections **45** and **46**. These projections **43** to **46** are slightly conical in shape and each have a front surface **47** which lies parallel to the opposite surface of the inner part **42**. A loose acoustical resistance sheet **48** which may be made of silk is pressed against this inner part **42**. When the outer part **40**, **41** is closed, the branches **43** to **46** lie against the resistance sheet **48** and press it against the inner part **42**. A space **49** filled with synthetic material remains between the outer part **40**, **41** and the inner part **42**. In the filling process the resistance sheet **48** is impregnated with and surrounded by the synthetic material. The resistance sheet **48** remains free from synthetic material only where the projections **43** to **46** are located. After the synthetic material has hardened the outer parts **40**, **41** are loosened and sound openings **50** with acoustical resistance material remain where projections **43** to **46** were located.

The cross section of these sound openings need not be round; it is possible to use other shapes particularly trapezoids. In the event the openings are trapezoidal, the base of the trapezoid should lie nearest the main sound inlet openings and the short side nearest the diaphragm.

The process illustrated in FIGS. **3** and **4** makes it possible to manufacture shells **2** with relatively thin walls, and resistance material protecting against damage. This manufacturing process falls in with the trend toward narrow, rod-shaped microphones.

FIG. **5** shows a further modification of a sound chamber. It contains as a supplement to the items in FIG. **2** a so-called radial funnel. This radial funnel consists of a volume that lies nearer the diaphragm **11** than the volumes of the auxiliary sound inlet openings and is limited in the simplest case by the diaphragm and by a plate **34** fastened to the shell walls and porous to sound in the vicinity of the fastening. Sound therefore reaches the diaphragm **11** from outside and is compressed in the decreasingly available space in front of the diaphragm **11**. In this manner a rise in frequencies higher than the frequency range obtained with auxiliary sound inlet openings **21** and **22** is brought about. In addition to the illustrated model of the radial funnel **34** other variations are possible, particularly those with a central sound passage (parallel to the axis of the microphone).

I claim:

1. A microphone having a response characteristic in a frequency range and a reinforced response at the upper limit of this frequency range, consisting of a housing, an electroacoustic transducer having at least one diaphragm which produces electric output signals as a function of the sound impinging upon the diaphragm, a substantially cylindrical acoustic resonance chamber in the housing directly in front of and coupled to the diaphragm, an opening to said acoustic resonance chamber providing a main sound inlet opening, at least one group of subsidiary sound inlet openings formed in the cylindrical walls of the acoustic resonance chamber and acoustic resistances provided for the subsidiary sound inlet openings.

2. A microphone according to claim **1**, in which two groups of subsidiary sound inlet openings are provided at different distances from the diaphragm, each subsidiary sound inlet opening of one group being at a constant distance from the diaphragm.

3. A microphone according to claim **2**, in which the ratio of the distance of the main sound inlet opening from the diaphragm to the distance of the first group os subsidiary sound inlet openings from the diaphragm has a value of between 1:1.2 and 1:1.6.

4. A microphone according to claim **2**, in which the ratio of the distance of the first group of the subsidiary sound inlet openings from the diaphragm to the distance of the second group of subsidiary sound inlet openings from the diaphragm has a value within the range of between 1:1.2 and 11:1.6.

5. A microphone according to claim **1**, in which the diameter of said acoustic resonance chamber is greater than its length.

6. A microphone according to claim **1**, in which the size of the cross-sectional area of the acoustic resonance chamber is at least equal to the size of the surface of the diaphragm.

7. A microphone according to claim **1**, in which the distance of the main sound inlet opening of the acoustic resonance chamber from the diaphragm is less than the diameter of the diaphragm.

8. A microphone according to claim **2**, further comprising acoustic resistances provided for the subsidiary sound inlet openings, the size of the acoustic resistances being selected so as to decrease with an increase in the distance of the groups of subsidiary sound inlet openings from the diaphragm.

9. A microphone according to claim **1**, in which the housing is formed of a plastic material and the acoustic resistance associated with the subsidiary sound inlet openings are located in the walls of the housing.

10. A microphone according to claim **1**, in which the acoustic resistances associated with the subsidiary sound inlet openings are fastened to the outside of the housing.

11. A microphone according to claim **1**, in which the subsidiary sound inlet openings are of circular cross section.

12. A microphone according to claim **1**, in which the length of the acoustic resonance chamber is at most 20 mm. and the distance of the subsidiary sound inlet openings from the diaphragm is at most 15 mm.

13. A microphone according to claim **1**, further comprising reverse sound inlet openings provided behind the diaphragm.

14. A microphone according to claim **13** further comprising phase-reversing members provided in said reverse sound inlet openings.

15. A microphone having a response characteristic within a frequency range and increased response at the upper limit of

said frequency range, comprising a housing, an electroacoustic transducer having a diaphragm which produces electric output signals in response to sound impinging upon the diaphragm, an acoustic resonance chamber in the housing in front of the diaphragm having the form of a substantially cylindrical pot, a radial horn directly in front of the diaphragm which extends over the entire cross-sectional area of the acoustic resonance chamber and is fastened to the cylindrical walls of the latter, said horn being permeable to sound in the vicinity of the place of attachment, the opening of the acoustic resonance chamber forming a main sound inlet opening, and at least one group of subsidiary sound inlet openings formed in the cylindrical walls of said chamber, the distance of which from the diaphragm is greater than the distance of the radial horn from the diaphragm.

16. A microphone according to claim **15**, in which the radial horn consists of a circular plate which is clamped in the housing and is permeable to sound in the vicinity of its place of clamping.