April 24, 1928. 1,667,149

E. GERLACH

ACOUSTIC DEVICE

Filed Nov. 5. 1926

Fig. 5

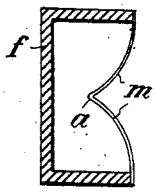



Fig. 6

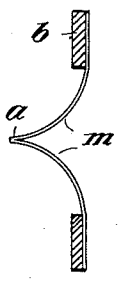



Fig. 1

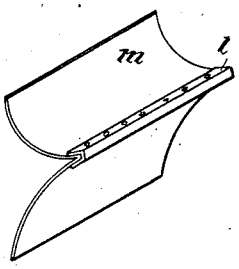
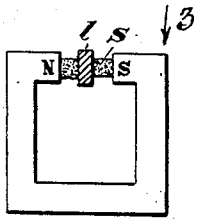



Fig. 2



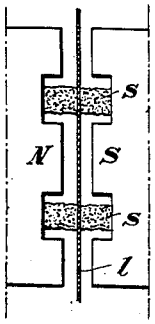




Fig. 3

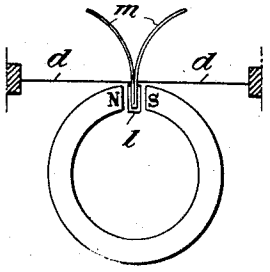



Fig. 4

Fig. 7

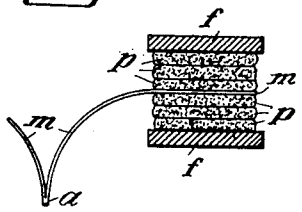
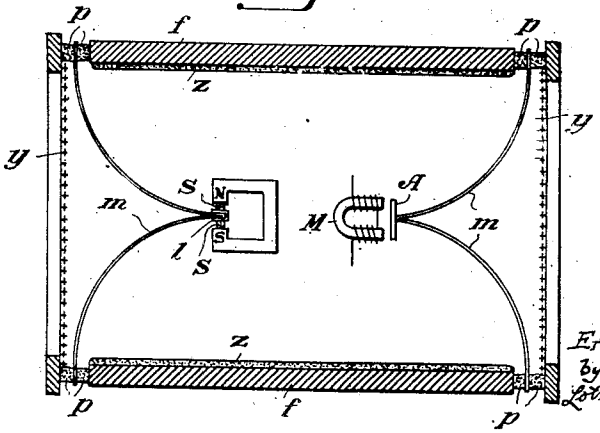



Fig. 9



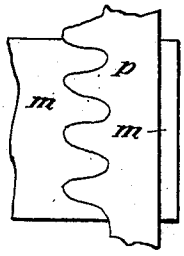




Fig. 8

Inventor:
Erwin GERLACH
by
Lowe, Kehlenbeck & Farley
Attorneys

Patented Apr. 24, 1928. 1,667,149

# UNITED STATES PATENT OFFICE.

ERWIN GERLACH, OF BERLIN-SIEMENSSTADT, GERMANY, ASSIGNOR TO SIEMENS & HALSKE, AKTIENGESELLSCHAFT, OF SIEMENNSSTADT, NEAR BERLIN, GERMANY, A CORPORATION OF GERMANY.

## ACOUSTIC DEVICE.

Application filed November 5, 1926, Serial No. 146,333, and in Germany August 11, 1925.

My invention relates to improvements in acoustic devices, particularly to a special diaphragm arrangement for acoustic devices such as electric loud-speaking or microphone apparatus. It is the principal object of my invention to secure an especially pure transmission and a good reproduction of the sound waves or oscillations.

According to this invention the diaphragm is constructed with a surface which may be produced by simply folding a smooth or flat plate of suitable material, the individual portions of which are bent in an outward direction parallel to the edge of the fold. Preferably, an electrodynamic system is employed for producing the oscillations of the diaphragm. For this purpose, the oscillating edge at the junction of the two portions of the plate is disposed in an electromagnetic field and carries a metallic rib which is fed with the alternating or fluctuating electric currents corresponding to speech, music, or other sounds, or in other words, telephonic currents. Of course the diaphragm may be constructed of two bent plates connected at one side. Through the electrically transmitted sound energy the common edge of the two plates is moved in such a manner that the oscillations pass uniformly longitudinal into the halves of the diaphragm whilst, by suitable selection of the curvature of the diaphragm surfaces, provision is made for the oscillations being converted into transverse diaphragm oscillations. The diaphragm may suitably be made of especially light metal or insulating material such as common or hard paper (pertinax) and the like.

In the accompanying drawings several embodiments of my invention are illustrated diagrammatically. The drawings represent the invention as follows:

Fig. 1 is a perspective view of one form of diaphragm embodying my invention; Fig. 2 is a face view of magnet with parts of the diaphragm and damping means interposed between the magnet poles and the rib carried by the diaphragm; Fig. 3 is a fragmentary view, looking in the direction of the arrow 3 in Fig. 2, with parts in section, and showing another arrangement of the damping means; Fig. 4 is a diagrammatic end view, with parts in section, illustrating still another form of my invention.

Fig. 5 is a vertical cross-section through a sound box, which may be used in connection with my invention,

Fig. 6 shows a special manner of supporting the diaphragm,

Fig. 7 is a partial cross-section through a suitable means for supporting the diaphragm,

Fig. 8 shows upon an enlarged scale, some of the parts represented in Fig. 7; and

Fig. 9 is a vertical cross-section of an apparatus effective towards both sides.

Referring to Fig. 1, the oscillating edge of the diaphragm $m$ carries as a reinforcing rib 1, a U-shaped sheet for instance of aluminium, embracing the stiff edge or bold $a$ at the junction of the two curved diaphragm portions and riveted thereon.

Such reinforcing metallic ribs increase the stability of the diaphragms and besides afford the essential advantage of enabling me to use an electrodynamic system for driving the diaphragms. In this case the metallic rib is disposed in a magnetic field and fed with current corresponding to speech or other sounds. Another advantage of this arrangement consists in enabling the forces for exciting the diaphragm to attack, not at a single point, but uniformily along the stiff edge of the diaphragm. A bendng of this edge which otherwise may sometimes happen when actuating the diaphragm, is made impossible because of the rib, and an apparatus with such a diaphragm affords an excellent reproduction of sound and a very high acoustic power without any disturbing noises.

The device comprises an electromagnet preferably of an extension equal to that of the metallic rib, the latter being arranged in a gap as narrow as possible between the poles of the magnet (see Figs. 2, 3 and 9). Care must be taken, however, that the rib can not touch the magnet poles. For this reason, according to Figs. 2 and 3, cushions or bolsters of felt, velvet or other suitable material may be interposed between the rib and the magnet poles, the bolsters thus giving an additional damping effect and increasing the purity in the reproduction of sound waves. Referring to these figures, $l$ is the conducting rib, $s$ is the bolster and N, S are the magnet poles. The manner of attaching the ends of the diaphragm is

shown in Fig. 4 by the way of example. Resilient ribbons, strips, wires $d$ or the like are provided for holding the conductor $l$ laterally, the individual frequency of the total magnet system is preferably below the limits of audibility.

If the air at both sides of the diaphragm has a common connecting path through which the differences of air pressure produced by the oscillating diaphragm will be compensated, the efficiency of the diaphragm is liable to decrease.

In Fig. 5 a means for avoiding the air pressure compensation is illustrated in a vertical longitudinal section. This means is a sound-proof box $f$, one side of which is closed by means of the diaphragm $m$, which with its ends is attached to the edges of the box.

Oscillations of the diaphragm $m$ are produced by mechanism operating the stiff edge $a$ of the diaphragm. The inner surface of the box is preferably lined with sound absorbing or damping material such as felt or the like, in order to prevent the occurrence of undesired oscillations.

Referring to Fig. 6, it will be seen that, instead of a box closed at one side by the diaphragm, I may employ a structure in which the free longitudinal edges of the diaphragm $m$ are secured to additional bars of flange $b$ which prevent the pressure differences from compensating each other. The construction of the means $b$ may be such as to hinder air compensation from the highest just to the lowest audible frequencies. For frequencies below this limit the compensation causes no disturbances.

It will be understood that a rib $l$ such as shown in Figs. 1, 4 and 9 may be also provided in Figs. 5, 6 and 7.

In the embodiments of the invention, the outer, stationary edges of the diaphragm are fixed either to the box $f$ (Fig. 5) or to marginal pieces or bars $b$ (Fig. 6). In order to avoid disturbing vibrations at the material's own rate, the diaphragm is preferably secured with the aid of intermediate bolsters of felt, velvet or the like, as shown in Fig. 7. Referring to this figure, $p$ are the bolsters, $f$ is the box or a marginal piece for securing the ends of the diaphragm $m$, the folded edge of which is indicated at $a$. Projecting teeth at those edges of the bolsters $p$ which touch the diaphragm prevent the diaphragm from having a distinct line of clamping which might favour the tendency of the structure to oscillate according to its own rate. This constructional form is represented in Fig. 8.

Referring to Fig. 9 it will be seen that two diaphragms $m$ effective towards two opposite sides are provided in an apparatus of the type described. This figure is a cross-section through the apparatus. The folded diaphragms $m$ are attached to the sound-proof box $f$. Between the box $f$ and the ends of the diaphragms $m$ bolsters $p$ are disposed in the manner described with reference to Fig. 7, the ends of the bolsters $p$ being preferably formed as shown in Fig. 8. The oscillations of the diaphragm shown at the left of Fig. 9 are produced by electrodynamically effective means, while the diaphragm shown at the right is electromagnetically operated. The first-named diaphragm $m$ has the U-shaped metallic rib $l$ of the type shown in Figs. 1 and 4. The rib is arranged in the field of the electromagnet N, S (see Figs. 4 and 9) and is supplied with the alternating currents for sound reproduction. Between the conducting rib $l$ and the poles of the magnet N, S, damping bolsters $s$, $s$ are clamped (see Figs. 2, 3 and 9). The stiff edge of the other diaphragm $m$ (Fig. 9) is attached to the armature A of an electromagnet M, the winding of which is energized by the electric currents which correspond to the sound to be reproduced. The inner surface of the sound box $f$ is lined with a sound damping or absorbing material $z$, for instance felt.

It will be understood that in Fig. 9 the two diaphragms can also be disposed to be actuated by two similar driving systems or by means of a single driving system. Besides, any number of folded diaphragms of the type described may be used in a single apparatus without departing from the spirit of the present invention. For instance, a plurality of diaphragms may be telescoped into each other with the stiff edges or folds adjacent to each other. It is also possible to connect the free ends of several diaphragms for obtaining a cylindrical acoustic surface.

In order to protect the rather delicate diaphragm against mechanical injury, it is advisable to arrange a screen or network $y$, Fig. 9, or the like of gauze or other suitable material in front of the outer side of the diaphragm, either directly in contact therewith or spaced therefrom.

It will be obvious to anyone skilled in the art that the devices described and shown herein may serve for the conversion of electrical energy into sound energy as well as for converting sound energy into electrical energy without changing the constructional form of the device. In other words, any one of the devices shown may serve either as a telephone receiver or as a transmitter, though in the specification in general the apparatus is assumed to be a "loud speaker". If the device is used as a transmitter the oscillations of the stiff edge will act upon an electric circuit electromagnetically, electrodynamically or by regulating a resistance.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an acoustic device for converting

electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a common folded edge, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, and an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of the rib and symmetrically to the said surfaces of the diaphragm.

2. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a common edge, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a U-shaped rib, connected to and embracing the said common edge of the diaphragm, and an electromagnet system, the said U-shaped rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of the rib and symmetrically to the individual surfaces of the said diaphragm.

3. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm consisting of two curved plate members with a common edge, these plate members being bent outwardly in a fanlike manner, a U-shaped edge rib of light metal riveted on and embracing the common edge of the diaphragm, and an electromagnet system, the said edge rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of the rib and symmetrically to the individual plate members of the said diaphragm.

4. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a common edge, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to said common edge, a magnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said magnet system in such manner as to oscillate transversely to the length of the rib and symmetrically to the individual surfaces of the said diaphragm, and resilient means interposed between the said rib and the poles of the said magnet system.

5. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a folded edge in common, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such a manner as to oscillate transversely to the length of said rib and symmetrically to the individual surfaces of the said diaphragm, and stiff walls for carrying the free ends of the said diaphragm, said walls having such an extension that the air on both sides of the said diaphragm is prevented from compensating air pressure differences at least within the range of the audible frequencies.

6. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a folded edge in common, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the individual surfaces of the said diaphragm, and a sound proof box, to the edges of which the free ends of the said diaphragm are attached to close said box on one side.

7. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a folded edge in common, the individual parts of said diaphragm being bent outwardly in a fan-like manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symetrically to the individual surfaces of the said diaphragm, a sound proof box, to one side of which the free ends of the said diaphragm are attached to close said box on that side, and bolsters interposed between the free ends of the said diaphragm and the wall of the said box.

8. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a folded edge in common, the

individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the individual surfaces of the said diaphragm, a sound proof box, to one side of which the free ends of the said diaphragm are attached to close said box on that side, and a sound damping lining on the inner surface of the said box.

9. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a folded edge in common, the individual parts of said diaphragm being bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the folded edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the individual surfaces of the said diaphragm, a sound proof box to one side of which the free ends of the said diaphragm are attached to close said box on that side, bolsters interposed between the free ends of the said diaphragm and the edges of the said box, and sound damping means disposed on the inner surface of the said box.

10. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm consisting of two curved plate members with a folded edge in common, said members being bent outwardly in a fanlike manner, a sound proof box to one side of which the free ends of the said members are attached to close said box on that side, bolsters interposed between the free ends of the said diaphragm and the walls of the said box, a U-shaped rib connected to and embracing the common edge of the said members, and an electromagnet system, the said U-shaped rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of the rib and symmetrically to the individual members of the said diaphragm.

11. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm consisting of two curved plate members with a folded edge in common, said members being bent outwardly in a fanlike manner, a sound proof box to one side of which the free ends of the said members are attached to close said box on that side, bolsters interposed between the free ends of the said diaphragm and the walls of the said box, a U-shaped rib connected to and embracing the folded edge of the said diaphragm, an electromagnet system, the said U-shaped rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the plates, and resilient means interposed between the said rib and the poles of the said electromagnet system.

12. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm including two curved surfaces with a common edge, the individual parts of the said diaphragm being bent outwardly in a fanlike manner, a sound proof box to one side of which the free ends of the said diaphragm are attached to close said box on that side, bolsters interposed between the free ends of the said diaphragm and the edges of the said box, the bolsters having toothed edges in contact with the edges of the diaphragm, a reinforcing metallic rib fixed to the common edge of the said diaphragm, and a magnet system, the said rib being disposed between the poles of the said magnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the individual surfaces of the said diaphragm.

13. In an acoustic device for converting electrical energy into sound energy or sound energy into electrical energy, the combination of a diaphragm consisting of two curved plate members connected at one edge, and bent outwardly in a fanlike manner, a reinforcing metallic rib fixed to the common edge of the said diaphragm, an electromagnet system, the said rib being adapted to carry telephonic currents and disposed between the poles of the said electromagnet system in such manner as to oscillate transversely to the length of said rib and symmetrically to the individual members of the said diaphragm, and a protecting network arranged on the outside of the said diaphragm.

14. In a device of the character described, a diaphragm consisting of two curved portions, a U-shaped rib into which extend the adjacent edges of said diaphragm portions, said rib being free to vibrate in a direction transverse to its length, and electrical means associated with said rib.

15. In a device of the character described, a diaphragm consisting of two curved portions, a U-shaped rib into which extend the adjacent edges of said diaphragm portions,

said rib being free to vibrate in a direction transverse to its length, and a magnet in the field of which said rib is located.

16. In a device of the character described, a diaphragm consisting of adjoining curved portions, a grooved vibratory rib embracing the adjacent edges of said diaphragm portions, and means for securing the other edges of said diaphragm portions.

17. In a device of the character described, a diaphragm consisting of two curved sections having contiguous conducting edge portions, a magnet in the field of which said edge portions are located, and an electric circuit in which said edge portions are included.

18. In a device of the character described, a diaphragm consisting of two curved sections, a vibratory conducting rib secured to said sections and forming contiguous edge portions therefor, a magnet in the field of which said rib is located, and an electric circuit in which said rib is included.

In testimony whereof I affix my signature.

ERWIN GERLACH.