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C. B. SPENCER

2,364,485

ACOUSTICAL DEVICE

Filed July 10, 1939

Fig. 1.

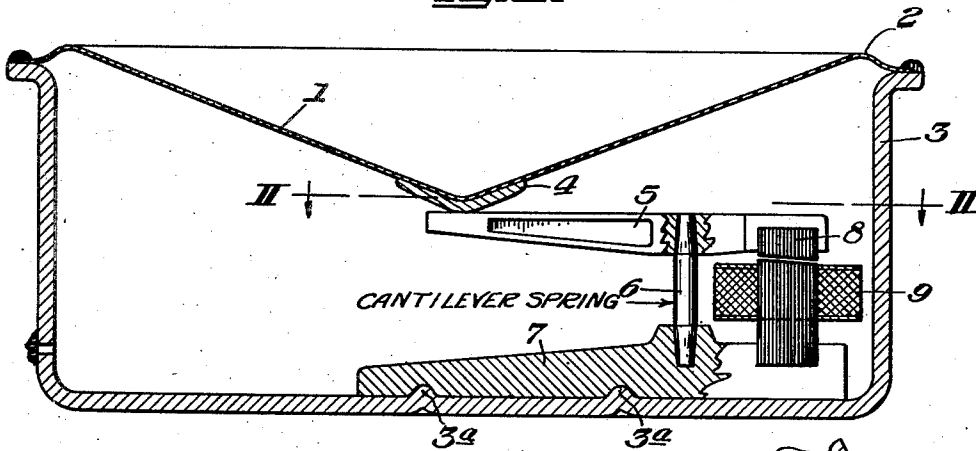


Fig. 4.

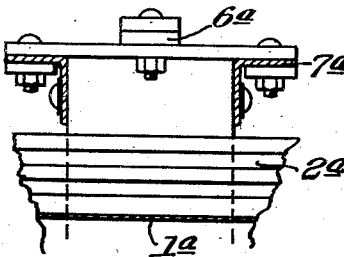


Fig. 2.

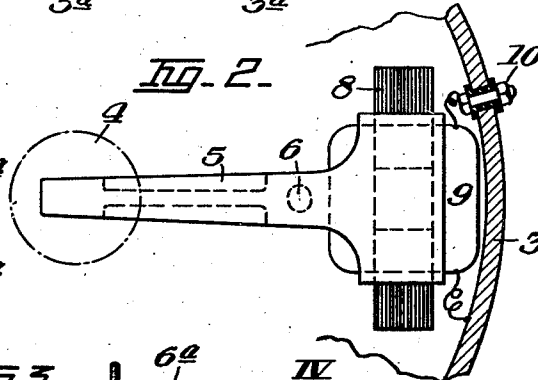


Fig. 3.

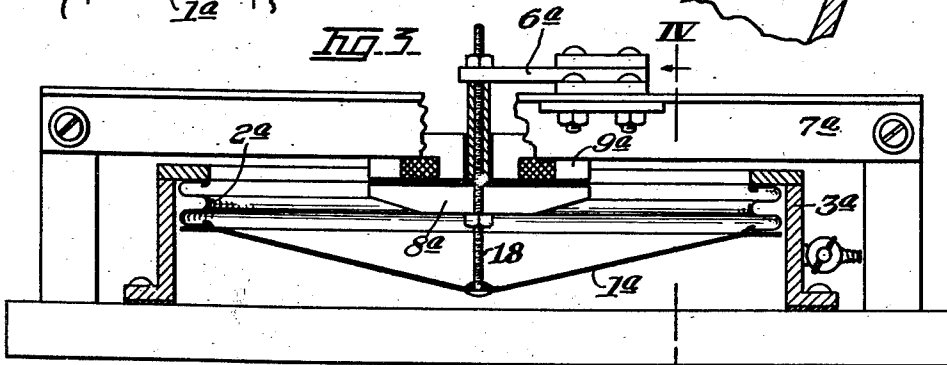
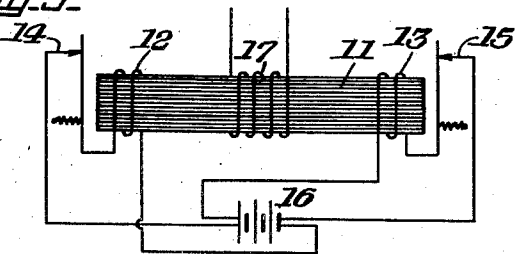


Fig. 5.



INVENTOR.

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UNITED STATES PATENT OFFICE

2,364,485

ACOUSTICAL DEVICE

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Application July 10, 1939, Serial No. 283,631

8 Claims. (Cl. 177-7)

My invention relates to acoustical devices, automobile horns and radio loud speakers, for instance; my object being to increase the efficiency of such devices and to reduce the acoustical distortion generally involved in their operation.

This application is a continuation in part of my copending application of the same title, bearing Serial No. 37,225, and filed August 21, 1935.

The accompanying drawing illustrates specific examples of my invention, Figure 1 being a section of a first example; Figure 2 a section of this first example taken on the line II-II in Figure 1; Figure 3 a section of the second example; Figure 4 a section of this second example taken on the line IV-IV in Figure 3; and Figure 5 a diagram of an arrangement for powering either example when it is to be used for signaling purposes, such as in the case of an automobile horn.

More specifically, in the case of the first example, a conical, metal diaphragm 1 is integrally provided with a flexible peripheral mounting 2 that is peripherally welded to a suitable rigid metal enclosure 3 for the back of the diaphragm. The apex of the diaphragm has a reenforcement 4 bearing on the end of a two-armed lever 5 mounted on the end of a cantilever spring 6, the other end of the spring 6 being fixedly mounted on a support 7 bearing on the end of the enclosure 3.

Since the diaphragm 1 is conical, it is inherently structurally rigid to a considerable extent. In other words, the diaphragm 1 is of a rigid or piston type as contrasted to being of the membrane type which is peripherally mounted in a rigid manner and operates by reason of its inherent flexibility.

The enclosure 3 is evacuated to a high degree, the atmospheric pressure on the outside of the diaphragm 1 being balanced by the spring 6 working through the arm of the lever 5 between this spring and the reenforcement 4 at the apex of the diaphragm. This places this arm of the lever, it functioning as a cantilever beam, under a very heavy stress, the diaphragm exerting a pressure at the end of this lever of several hundred pounds in the case of a diaphragm of average diameter when a reasonably good vacuum exists in the enclosure 3. Since the peripheral mounting 2 is a continuation of the diaphragm 1 which is made of metal, this mounting is elastic, and it is formed so that it has at least a slight tendency to urge the diaphragm 1 away from the enclosure 3.

The diaphragm 1 is stressed by the atmosphere

to a high degree in a direction tending to spread its conical shape, whereby the application of a forward force to the apex of the diaphragm with the quickness necessary to produce sound cannot produce material further spreading of the diaphragm. In other words, the diaphragm is stressed to a greater rigidity than it possesses when unstressed.

If this forward force is applied by a suitably directed force exerted on the other or free arm of the lever 5, substantially none of the force is lost, the cantilever spring 6 being rigid to longitudinal compression and its bending being in the direction its resilience, due to its strain, is tending to move it, while the arm of the lever 5 between the spring 6 and the reenforcement 4 at the apex of the diaphragm 1, is already highly stressed so that the transmission of the relatively small force through this arm required to produce sound, cannot cause its further deflection to any appreciable extent.

No force is lost in the diaphragm because as previously explained, it also is stressed to a degree where the application of the relatively slight force required to produce sound cannot further deform it, the diaphragm, therefore, moving as a unit from its apex to its periphery. The mounting 2 cannot absorb the force because it is elastically urging the diaphragm forwardly to such a degree that movement of the diaphragm results in a release of strain in the mounting, whereby the latter cannot dissipate any of the force.

Such a force may be exerted on the free arm of the lever 5 by an armature 8 fixed to this arm and associated with the pole pieces of an electromagnet 9, one end of the coil of this magnet being grounded to the enclosure 3 and its other end insulatively extending through the enclosure, as at 10, in an air-tight manner.

The support 7 is shown as mounting the magnet 9, this support 7 being a die casting cast around the metal laminations of the magnet. The lever 5 may also be a die casting and connect with the armature 8 in a similar fashion. The support 7 and the lever 5 are shown as provided with tapered sockets, the spring 6 having tapered ends fitting in these sockets. Since the stresses are largely compressive, no other mode of fastening is needed. For the same reason the end of the lever 5 need not be fixed to the diaphragm nor need the reenforcement 4 be rigidly fixed in place. Similarly, the support 7 may rest directly on the end of the enclosure 3 without being fixedly fastened, the enclosure being shown as provided with projections 3a which extend into

recesses in the support, solely to position the support against shifting in the event the device is roughly treated.

As a means for energizing the magnet 9 when the device is used as an automobile horn, for example, Figure 5 shows a core 11 having primary coils 12 and 13, respectively, energized through vibrators 14 and 15, by a battery 16. The core 11 carries a single secondary coil 17 which connects with the leads of the coil of the magnet 9. With this arrangement, the vibrators 14 and 15 may be tuned to different frequencies so that the coil of the magnet 9 is energized with two frequencies.

When the coil of the magnet 9 is energized by the arrangement described above, the armature 8 applies a double frequency or complex vibratory movement to the free arm of the lever 5 which is in turn transmitted to the diaphragm 1. By making the two arms of the lever 5 of unequal lengths, the diaphragm 1 may be moved through large amplitudes upon small movement of the armature 8. This enables the armature to be nicely spaced respecting the pole pieces of the magnet 9 and still accommodate the double frequency vibratory movement without being required to move with an amplitude causing chattering on the pole pieces.

When the spring 6 is made with a large cross section as compared with its length, it need be strained but a very slight amount to provide the resilience necessary to properly position the diaphragm 1. In such a case, very slight movement of the spring 6, due to movement of the diaphragm 1, will produce large changes in the force it exerts, whereby the acoustical system as a whole will be extremely stiff to vibratory coasting and will, therefore, have a very high natural vibratory frequency. Proper design of the spring can place this frequency above the audible range, thus avoiding undue accentuation of any frequencies during the movement of the diaphragm at a double frequency in the manner described, since it is not tuned to any audible frequency.

One of the troubles with using motors of the type disclosed in connection with an acoustical device, such as a loud speaker, is that distortion results from the fact that the power exerted on the armature by the electromagnet varies as the square of the movement of the armature. In the case of the device illustrated, this distortion is diminished by reason of the leverage arrangement wherein the armature moves with a small amplitude as compared to the amplitude with which the diaphragm is operated. Distortion is further reduced by the fact that the aid provided by the spring 6 decreases in proportion to the removal of strain from the spring, this removal occurring as the armature approaches the pole pieces of the magnet and partially, or wholly, counteracting the increasing pull on the armature.

One big reason for the ability of the device to utilize the principles mentioned is because its operation does not at any time involve stress reversals. The stress is applied in the same direction to all of the parts all of the time during the operation of the device. Even though variations in its performance are obtained by varying the degree of evacuation in the enclosure, or by varying the dimensions of the spring 6, or its degree of strain, the parts are always stressed in the same direction.

It is to be understood that, even though the enclosure 3 is evacuated to theoretical perfection, the operation of the device is based on the principle that the creation of sound is caused by

compressing the atmosphere, this being possible because of the weight of the atmosphere which resists movement and provides a reaction permitting elastic compression. In other words, the energy required to produce sound is that required to compress the air locally rather than to move a volume of air bodily. Therefore, the power required to move the diaphragm 1 in a forward direction is only that required to compress the atmosphere locally, rather than that required to lift a column of air represented by the area of the diaphragm.

Since there is no air behind the diaphragm, there is no reaction to oppose its return movement when it has once been displaced so as to locally compress the atmosphere in front of it, whereby the diaphragm is returned by the elasticity of the air itself rather than by power-consuming spring arrangements or by yanking it back as is done by the motor of the so-called dynamic radio loud speaker, both of these expedients involving extreme stress reversals in the system they power. Furthermore, since the diaphragm is working against the atmosphere on only one of its sides, it does not waste any power working the atmosphere on its back side nor does it require elaborate baffling chambers or baffle boards to carry a large range of frequencies.

In some instances, it may be desirable to provide the diaphragm 1 with a very low inherent vibratory frequency, and this can be done by the use of a suitably dimensioned, highly strained spring. The movement of the working end of such a highly strained spring will not produce substantial changes in the force it exerts, whereby the diaphragm 1 will tend to float easily back and forth, particularly if the enclosure 3 is evacuated to a very high degree. In case an arrangement of this sort is provided, the diaphragm 1 may not inherently return with the same degree of facility, but the arrangement may be useful for some purposes.

The other example, illustrated by Figures 3 and 4, is illustrative of how the principles disclosed may be experimentally applied. Since the parts are substantially the equivalents of similar parts that have already been described in connection with the first example, they are similarly numbered and identified by the letter *a* wherever possible.

It will be noted that the lever 5 is not used, the spring 6a being directly fixed to a tension rod 18. The arrangement is such that the support 7a is in the form of a beam passing over the front of the diaphragm 1a and mounting the spring 6a, the armature 8a and the magnet 9a outside of the enclosure 3a, so that the various parts may be adjusted.

A further difference is that the diaphragm mounting 2a is in the form of a metallic bellows of the type known commercially as a Sylphon. This type of mounting may be desirable where more flexibility is desired.

Both examples are shown as provided with armatures and magnets which are sufficiently heavy to carry large currents. In case the devices are to be used as radio loud speakers, the coils of the magnets may be designed with consideration of the set which is to power them. Furthermore, it may prove expedient to redesign the armature and the magnet core and pole pieces. In some instances, it may even be desirable to substitute radio loud speaker motors of the so-called dynamic type or, in other words,

of the moving conductor type, for the electromagnetic type disclosed herein.

It is to be noted that in the first example all of the moving parts work in a vacuum so that their operation is not impeded by the atmosphere as is usually the case. As previously explained, the vacuum contemplated may be as nearly perfect as is commercially possible to obtain in the manufacture of the device. This vacuum is permanently maintained during the use of the device.

I claim:

1. An acoustical device including the combination of a rigid type diaphragm, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure.

2. An acoustical device including the combination of a rigid type diaphragm, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure, said diaphragm being in the form of a cone facing outwardly from said enclosure and said spring working against the apex of said cone so that the latter is stressed by the atmospheric pressure to a greater rigidity than it possesses when unstressed.

3. An acoustical device including the combination of a rigid type diaphragm, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure, said annulus being made of elastic material and strained when said diaphragm is at rest in such a direction that its resulting resiliency tends to urge said diaphragm forwardly.

4. An acoustical device including the combination of a rigid type conical diaphragm, a rigid enclosure for the convex back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure by reacting thereagainst at the location of the apex of said diaphragm so that said diaphragm is stressed by the atmospheric pressure to a greater degree of rigidity to forward movement than it inherently possesses when unstressed.

5. An acoustical device including the combination of a rigid type diaphragm, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure, said diaphragm being

in the form of a cone facing outwardly from said enclosure and said spring working against the apex of said cone so that the latter is stressed by the atmospheric pressure to a greater rigidity than it possesses when unstressed, said combination including means working through said apex for vibrating said diaphragm.

6. An acoustical device including the combination of a rigid type conical diaphragm, a rigid enclosure for the convex back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, said enclosure being evacuated, and a spring balancing said diaphragm against the atmospheric pressure by reacting thereagainst at the location of the apex of said diaphragm so that said diaphragm is stressed by the atmospheric pressure to a greater degree of rigidity to forward movement than it inherently possesses when unstressed, said combination including means for vibrating said diaphragm working through the location said spring applies the reaction balancing said diaphragm against the atmosphere, said means comprising an electromagnet and an armature attracted by said electromagnet when the latter is energized and connected to said location of said diaphragm so as to force the latter forwardly when so attracted, the evacuation in said enclosure being sufficient to permit compression of the atmosphere by forward movement of said diaphragm to reversely move said diaphragm.

7. An acoustical device including the combination of a conical diaphragm of the rigid type, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, a lever inside said enclosure working against the apex of said diaphragm, a cantilever spring inside said enclosure with its free or moving end mounting said lever for rocking movement of the latter, said enclosure being evacuated and said spring balancing said diaphragm through said lever against the atmospheric pressure, and means for vibrating said lever.

8. An acoustical device including the combination of a conical diaphragm of the rigid type, a rigid enclosure for the back of said diaphragm, a flexible annulus peripherally interconnecting said diaphragm and said enclosure, a lever inside said enclosure working against the apex of said diaphragm, a cantilever spring inside said enclosure with its free or moving end mounting said lever for rocking movement of the latter, said enclosure being evacuated and said spring balancing said diaphragm through said lever against the atmospheric pressure, a shorter lever extending from said lever on the opposite side of said spring inside said enclosure, an armature connecting with said shorter lever and an electromagnet for actuating said armature.

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