Oct. 14, 1930. C. E. SEMPLE, JR 1,778,693

LOUD SPEAKER

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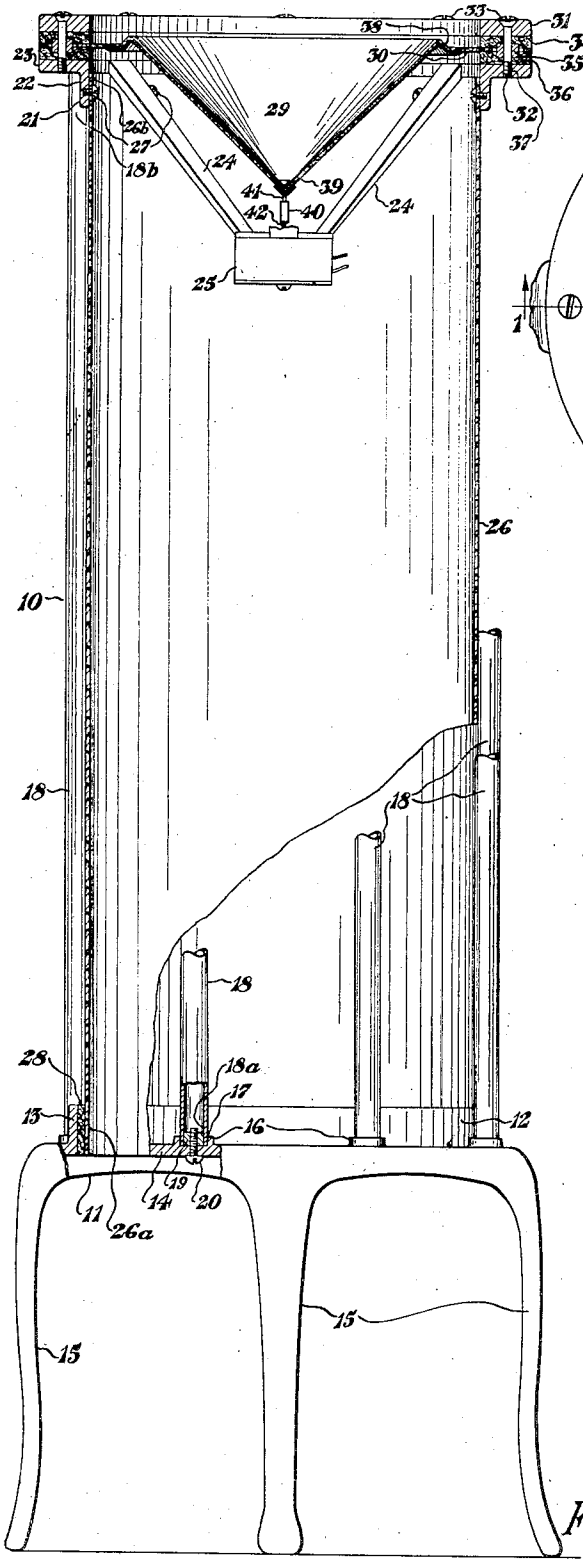



Fig. 1

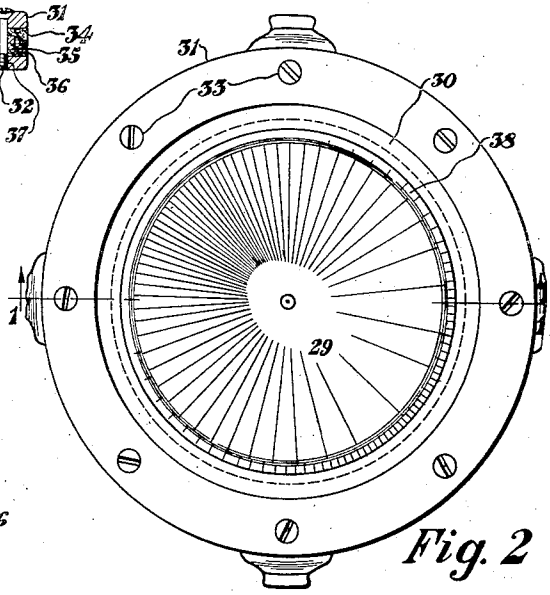



Fig. 2

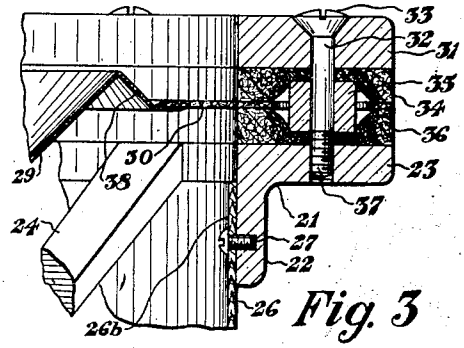



Fig. 3

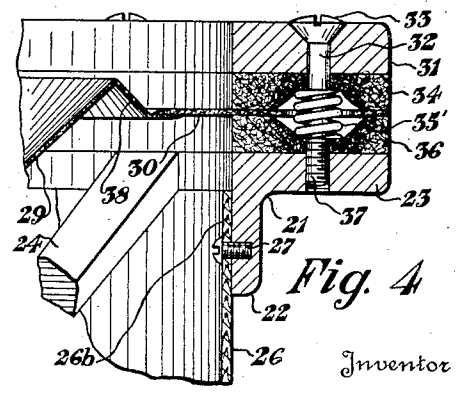



Fig. 4

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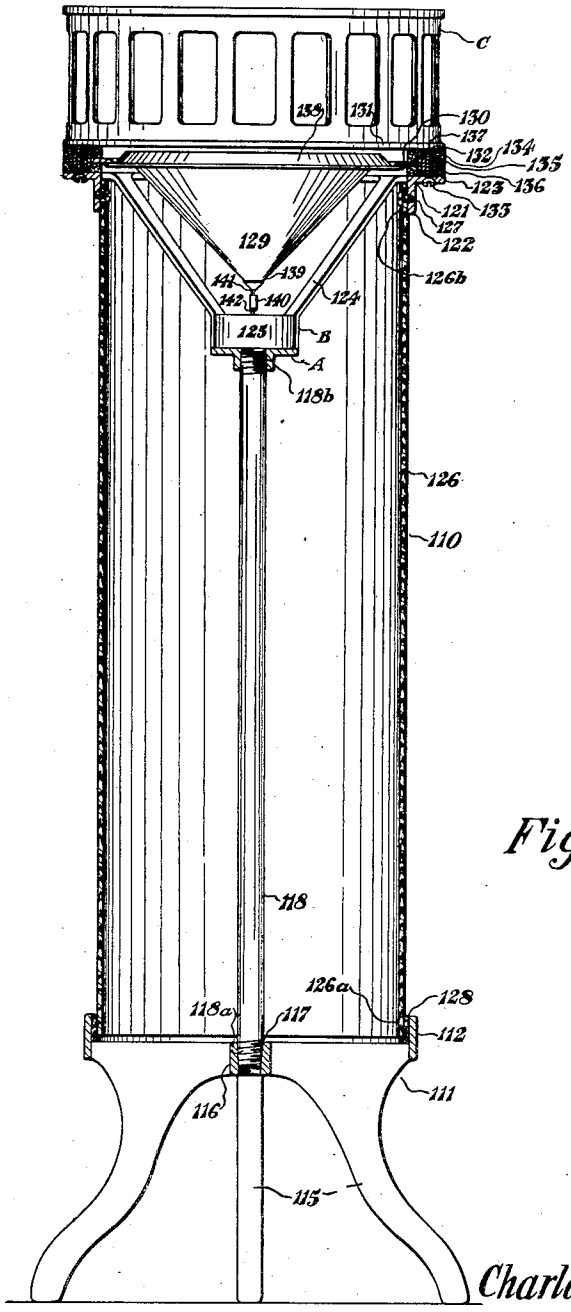



Fig. 5

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# UNITED STATES PATENT OFFICE

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## LOUD-SPEAKER

Application filed February 24, 1928. Serial No. 256,549.

My invention relates to loud speakers for use in the radio, telephone, telegraph, and other allied arts; and more particularly to a loud speaker including a diaphragm connected to the armature of an electro-magnetic sound reproducing unit which may be actuated by relatively weak fluctuating currents.

If the diaphragm of a loud speaker has a relatively small area, as for example a circular diaphragm whose diameter is two inches, more or less, it may be in the form of a flat disc. The waves emitted by such a small diaphragm are not usually sufficiently audible, and a horn is usually associated therewith for amplifying to sufficient audibility the sound waves emitted thereby.

If the diaphragm of a loud speaker is larger in area, it is usually in the form of a cone which itself emits sufficiently audible waves, and does not require a horn merely for the purpose of increasing audibility.

For amplifying and facilitating the emission of sound waves applied to large conical diaphragms by electro-magnetic units, some diaphragms have been made which have been rigidly supported at their peripheries, and which have had a free area equal to that of a circle exceeding 9 inches in diameter. Other diaphragms have been subject to radial tensioning. The peripheries of other diaphragms have been yieldingly restrained, without particularly adjusting the force and character of the restraining means. Finally, the peripheries of other diaphragms have been entirely free.

Obviously, the above limitations are mutually contradictory, and loud speakers constructed according to any of them have not been uniformly satisfactory in their reproduction over the full range of audible waves, nor in the quality of such reproduction, the reproduced waves frequently being harsh and unpleasant, and there frequently being emitted cracking noises, in addition to the desired waves, even though the diaphragm be made of non-metallic material such as paper.

Another important objection to cone type loud speakers constructed according to the foregoing limitations is the fact that in a diaphragm meeting any of the limitations, a portion of the diaphragm area is doing work other than its intended work of amplifying the vibration applied thereto by the sound reproducing unit. In other words these diaphragms are all inefficient.

In a diaphragm rigidly supported at its periphery or to which a radial tension is applied a certain proportion of the energy transmitted from the diaphragm to the sound reproducing unit is absorbed in bending the diaphragm adjacent its periphery, and this bending energy is accordingly not available for amplifying purposes.

In cone diaphragms provided with the usual form of yielding restraint at its periphery, because each diaphragm is slightly different than others of the same series, and because the restraining means employed have no means of adjustment whatever, and because in their actual embodiment such restraining means are in fact forms of rigid peripheral supports for the diaphragms, bending energy is absorbed in a similar manner.

In the case of diaphragms having entirely free peripheries the air displaced at the periphery tends to swirl from one side of the cone to the other, thereby causing the peripheral area of the diaphragm to work against itself, and energy is wasted because the peripheral portions are thus of no avail for amplifying purposes.

The horn type loud speakers employing relatively small diaphragms emphasize the higher or treble frequencies, while the cone type loud speakers emphasize the lower or base frequencies. It is desirable that a loud speaker should emit the lower frequencies, but only in a volume permitting audibility of the detail of the higher frequencies. Neither the horn type, nor the cone type loud speakers are satisfactory for this purpose.

In general, the larger the diaphragm the more readily it will respond to lower frequencies, and the objects of the present improvements include the provision of a loud speaker employing a cone diaphragm larger than the usual horn type loud speaker diaphragm and

smaller than the usual free air cone type loud speaker diaphragm.

Such a diaphragm of intermediate area responds more readily to the higher frequencies, and it is a further object of the present improvements to associate a diaphragm of intermediate area with other elements in such a manner that the lower frequencies will be emitted therefrom in addition to the higher frequencies which it will emit independently, without any material reduction in the higher frequencies, all the frequencies being emitted in proper balance with each other, and their quality being soft and pleasing and relatively free from cracking noises and the like.

A further object of the present improvements is to provide a loud speaker including a diaphragm and diaphragm mounting means permitting substantially all of the diaphragm area to be used for amplifying purposes, thereby increasing the efficiency of the diaphragm.

These and ancillary objects are attained in the loud speaker of the present invention hereinafter set forth in detail, and which may be stated in general terms as including a sound reproducing unit, a conical diaphragm of novel construction and preferably of intermediate area, and a diaphragm loading chamber, the sound reproducing unit being connected with the diaphragm for applying vibrations thereon, and the diaphragm being mounted at its periphery by novel means adapted to provide a highly efficient diaphragm by applying a yielding variable pressure on opposite faces of its periphery, and the loading chamber being adapted for applying an air column load on the diaphragm more particularly for amplifying the lower frequency vibrations applied on the diaphragm by the unit, the diaphragm itself being preferably adequate to sufficiently amplify the upper frequency vibrations applied thereon by the unit, so that the higher and lower frequencies will be emitted by the loud speaker in proper balance with each other.

A preferred embodiment of the present improvements is illustrated in the accompanying drawings forming part hereof, in which

Figure 1 is an elevation view of the improved loud speaker of the present invention, portions being illustrated in section as on line 1—1, Fig. 2;

Fig. 2, a top plan view thereof;

Fig. 3, an enlarged fragmentary sectional view illustrating the details of the variable yielding mounting for the cone diaphragm periphery;

Fig. 4, a view similar to Fig. 3, illustrating a modified arrangement for the variable yielding mounting; and

Fig. 5, a view similar to Fig. 1, of a modified embodiment of the improved loud speaker of the present invention.

Similar numerals refer to similar parts throughout the several views.

The improved loud speaker indicated generally at 10 in Figs. 1, 2, and 3, includes a base 11 which may be in the form of a ring 12 having an upwardly extending band 13 from the lower edge of which a flange 14 extends outwardly. Legs 15 may support the ring 12 at a suitable distance above the floor, as will hereinafter be specified.

The flange 14 is preferably provided with a plurality of bosses 16, in each of which a socket 17 is formed for receiving one end $18^a$ of a strut 18 which is preferably in the form of a hollow tube, a plug 19 being sweated or otherwise secured in the end $18^a$ of each tube and provided with a suitable threaded aperture, whereby screws 20 passing through suitable apertures in the flange 14 may be utilized to secure and position the tube struts 18.

The other ends $18^b$ of the tube struts 18 are secured to and support a diaphragm mounting angle ring 21, which includes a longitudinally extending band 22 from one end of which a ring flange 23 extends outwardly.

A plurality of unit supporting members 24 extend from the ring 21 preferably inwardly and downwardly, and at their lower ends suspend an electro-magnetic sound reproducing unit 25 which may be of any desired construction.

The upper end $26^b$ of a loading chamber tube 26, preferably made of paper or plywood, fits within and is secured to the band 22 as by means of screws 27.

The lower end $26^a$ of the tube 26 depends from the band 22 and extends preferably freely through the band 13, a yielding band 28 of felt or the like being preferably interposed between the outer face of the lower end $26^a$ of the tube 26 and the inner face of the band 13.

A novel conical diaphragm 29 is provided with a laterally extending peripheral flange ring 30, and is associated with the loading chamber tube 26, and the unit 25 preferably by the following novel means:

An outer pressure ring 31 is provided with apertures through which the shanks of headed screws 32 extend, the upper heads 33 of the screws 32 abutting against the upper surface of the ring 31, and the shanks of the screws first passing through apertures in an upper yielding pressure ring 34 of felt or the like, then each through the aperture of a collar 35, then through apertures in a lower yielding pressure ring 36 of felt or the like, and the lower threaded ends 37 of the screws then being screwed into suitable apertures in the flange 23 of the angle ring 21.

The diaphragm peripheral flange 30 is provided with enlarged apertures through which the collars 35 extend without contact-

ing, and the flange 30 is interposed between the yielding pressure rings 34 and 36 whereby any desired yielding pressure may be applied on the diaphragm peripheral flange 30 by adjustment of the screws 32.

The diaphragm flange 30 is preferably made of a suitable fibrous material, which may be leather or the like, and which is itself rigid enough to support the conical diaphragm 29, which may be made of paper, and may be provided with a frusto-conical reversely extending base flange 38 secured at its outer peripheral edge as by gluing or the like to the inner peripheral edge of the diaphragm flange ring 30.

The apex 39 of the cone diaphragm 29 is connected as by means of a link 40 with the armature of the electro-magnetic unit 25 for being actuated thereby.

The link 40 is preferably rigid in its central portions and flexible at its end connection 41 with the cone, and at its end connection 42 with the unit.

The free area of the diaphragm is preferably less than the area of a circle 9 inches in diameter and the length of the loading chamber tube 26 is preferably over 5 inches, the lower end of the loading chamber tube 26 being preferably supported by the legs 15 above the floor a distance substantially equal to the diameter of the tube 26.

As is clearly illustrated in the drawings, the tube 26 forms a loading chamber for the diaphragm 29 without obstructing either face of the diaphragm.

By the foregoing construction and arrangement of the improved loud speaker the periphery of the diaphragm is neither rigidly secured, nor radially tensioned, but the opposite faces of its peripheral flange may be subject to just the proper amount of yielding pressure to distribute over the entire area of the diaphragm the work of amplifying the vibrations applied thereto by the electro-magnetic unit 25. The proper amount of yielding pressure is determined for each particular loud speaker, by a test operator, who has skill similar to that of a piano tuner, and adjusts the yielding pressure until the audible vibrations emitted by the loud speaker are satisfactory to the trained ear of the test operator.

Such distribution of the amplification load is possible neither with a rigidly secured diaphragm periphery, a radially tensioned diaphragm, a free diaphragm periphery, nor a yieldingly secured diaphargm periphery in which the yielding securing means is not exactly adjustable on opposite faces of the diaphragm periphery.

The modified arrangement for the variable yielding mounting illustrated in Fig. 4 is identical with the construction illustrated in Figs. 1, 2, and 3, with the exception that the collar 35′ of the modified form consists of a coiled compression spring in the place of the solid collar 35.

The improved loud speaker of the foregoing construction including the yielding variable pressure applied upon both faces of the diaphragm periphery, and the loading chamber for the diaphragm formed by the tube 26, emits sound waves, in which the higher and lower frequencies are in proper balance, of sufficient volume in the lower frequencies and sufficient detail in the higher frequencies.

The modified embodiment of the improved loud speaker indicated generally at 110 in Fig. 5 includes a base 111 which may be in the form of a ring 112 supported by legs 115 at a suitable distance above the floor, as will hereinafter be specified.

The legs 115 preferably intersect at the center of the ring 112, and a boss 116 is formed at the intersection in which a threaded socket 117 is provided for receiving one threaded end $118^a$ of a strut 118 which is preferably in the form of a length of standard pipe.

The other threaded end $118^b$ of the pipe strut 118 is screwed into a threaded aperture in the base A of a diaphragm and unit mounting bracket B which includes a diaphragm mounting angle ring 121, which includes a longitudinally extending band 122 from one end of which a ring flange 123 extends outwardly.

A plurality of supporting members 124 extend from the ring 121 preferably inwardly and downwardly, and at their lower ends are joined to the base A on which is carried an electro-magnetic sound reproducing unit 125 of any desired construction.

The upper end $126^b$ of a loading chamber tube 126, preferably made of paper or plywood, fits within and is secured to the band 122 as by means of screws 127.

The lower end $126^a$ of the tube 126 depends from the band 122 and extends preferably freely through the ring 112, a yielding band 128 of felt or the like being preferably interposed between the outer face of the lower end $126^a$ of the tube 126 and the inner face of the ring 112.

A novel conical diaphragm 129 similar to the diaphragm 29 is provided with a laterally extending peripheral flange ring 130, and is associated with a loading chamber tube 126 and the unit 125 preferably by the following means, similar to the mounting means of the loud speaker 10.

The ring flange 123 is provided with apertures through which the shanks of headed screws 132 extend, the lower heads 133 of the screws 132 abutting against the lower surface of the flange 123, and the shanks of the screws first passing through apertures in a lower yielding pressure ring 136 of felt or the like, then each through the aperture of

a collar 135, then through apertures in an upper yielding pressure ring 134 of felt or the like, and the upper threaded ends 137 of the screws then being screwed into suitable threaded apertures in the flange 131 of an ornamental top cover C for the loud speaker.

The diaphragm peripheral flange 130 is provided with enlarged apertures through which the collars 135 extend without contacting, and the flange 130 is interposed between the yielding pressure rings 134 and 136 whereby any desired yielding pressure may be applied on the diaphragm peripheral flange 130 by adjustment of the screws 132.

The diaphragm flange 130 is preferably made of a suitable fibrous material, which may be leather or the like, and which is itself rigid enough to support the conical diaphragm 129, which may be made of paper, and may be provided with a frusto-conical reversely extending base flange 138 secured at its outer peripheral edge as by gluing or the like to the inner peripheral edge of the diaphragm flange ring 130.

The apex 139 of the cone diaphragm 129 is connected as by means of a link 140 with the armature of the electro-magnetic unit 125 for being actuated thereby.

The link 140 is preferably rigid in its central portions and flexible at its end connection 141 with the cone, and at its end connection 142 with the unit.

The free area of the diaphragm is preferably under 9 inches and the length of the loading chamber tube 126 is preferably over 5 inches, the lower end of the loading chamber tube 126 being preferably supported by the legs 115 above the floor a distance substantially equal to the diameter of the tube 126.

When the loading chamber tube is made of the preferred material, paper or ply-wood, this material being vibratile is itself vibrated during operation of the loud speaker, and sets in motion the air on the outside of the tube as well as on the inside of the tube.

The most desirable results are obtained, when the length of the straight loading chamber tube is greater than the diameter of the diaphragm, and preferably the length of the loading chamber tube, as illustrated in Figs. 1 and 5, should be several times as long as the diameter of the diaphragm, or longer.

I claim:

1. A loud speaker including a sound reproducing unit, a diaphragm, means mounting the diaphragm at its periphery by applying a yielding variable pressure upon opposite faces thereof, and the unit being connected with the diaphragm for applying vibrations thereon, and means forming a loading chamber for applying an air column load on the diaphragm without obstructing either face of the diaphragm.

2. A loud speaker including a sound reproducing unit, a diaphragm of an area equal to that of a circle less than nine inches in diameter, means mounting the diaphragm at its periphery by applying a yielding variable pressure upon opposite faces thereof, and the unit being connected with the diaphragm for applying vibrations thereon, and means forming a loading chamber for applying an air column load on the diaphragm without obstructing either face of the diaphragm.

3. A loud speaker including a base, a strut extending from the base, a diaphragm mounting means supported by the strut, a diaphragm mounted on the mounting means, and a sound reproducing unit connected to the diaphragm for applying vibrations thereon and means forming a loading chamber for applying an air column load on the diaphragm.

4. A loud speaker including a sound reproducing unit, a diaphragm, means mounting the diaphragm at its periphery by applying a yielding variable pressure upon opposite faces thereof, and the unit being connected with the diaphragm for applying vibrations thereon, and a tube connected with the diaphragm periphery for applying an air column load on the diaphragm.

5. A loud speaker including a sound reproducing unit, a diaphragm of an area equal to that of a circle less than nine inches in diameter, means mounting the diaphragm at its perpihery by applying a yielding variable pressure upon opposite faces thereof, and the unit being connected with the diaphragm for applying vibrations thereon, and a tube connected with the diaphragm periphery for applying an air column load on the diaphragm.

6. A loud speaker including a base, a strut extending from the base, a diaphragm of an area equal to that of a circle less than nine inches in diameter mounted on the mounting means, and a sound reproducing unit connected to the diaphragm for applying vibrations thereon, and means forming a loading chamber for applying an air column load on the diaphragm.

7. A loud speaker including a sound reproducing unit, a diaphragm, the unit being connected with the diaphragm for applying vibrations thereon, a straight tube associated with the diaphragm for applying an air column load on the diaphragm, one end of the tube being connected with the diaphragm and the other end of the tube being open, and the length of the tube being greater than the diameter of the diaphragm.

8. A loud speaker including a sound reproducing unit, a diaphragm, the unit being connected with the diaphragm for applying vibrations thereon, a tube connected at one end with the diaphragm periphery for applying an air column load on the diaphragm, the other end of the tube being open, and the

length of the tube being greater than the diameter of the diaphragm.

9. A loud speaker including a sound reproducing unit, a diaphragm, the unit being connected with the diaphragm for applying vibrations thereon, a straight tube of vibratile material associated with the diaphragm for applying an air column load on the diaphragm, one end of the tube being connected with the diaphragm and the other end of the tube being open, and the length of the tube being greater than the diameter of the diaphragm.

10. A loud speaker including a sound reproducing unit, a diaphragm, the unit being connected with the diaphragm for applying vibrations thereon, a tube of vibratile material connected with the diaphragm periphery for applying an air column load on the diaphragm, one end of the tube being connected with the diaphragm and the other end of the tube being open, and the length of the tube being greater than the diameter of the diaphragm.

11. A loud speaker including a sound reproducing unit, a diaphragm of an area equal to that of a circle less than nine inches in diameter, the unit being connected with the diaphragm for applying vibrations thereon, a tube associated with the diaphragm for applying an air column load on the diaphragm, one end of the tube being connected with the diaphragm and the other end of the tube being open, and the length of the tube being greater than the diameter of the diaphragm.

In testimony that I claim the above, I have hereunto subscribed my name.

CHARLES E. SEMPLE, JR.