

Sept. 20, 1932.

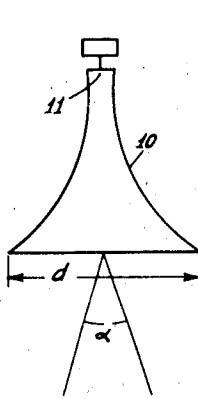
C. ZWIKKER

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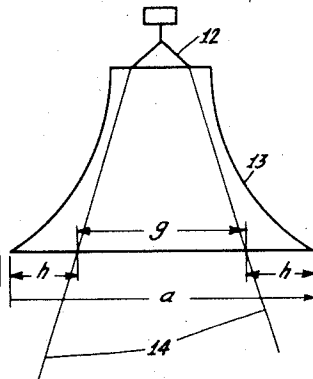
ACOUSTIC APPARATUS

Filed Nov. 1, 1929

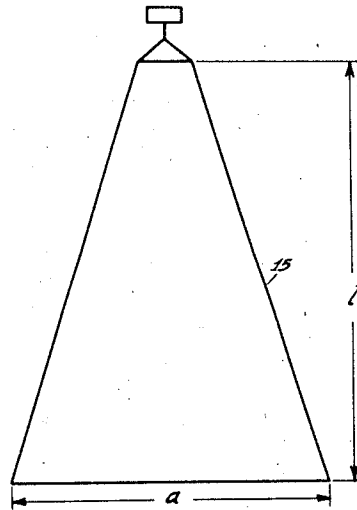
*Fig. 1*



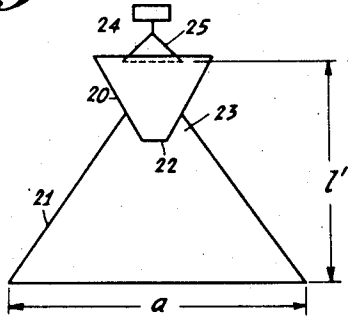
*Fig. 2*



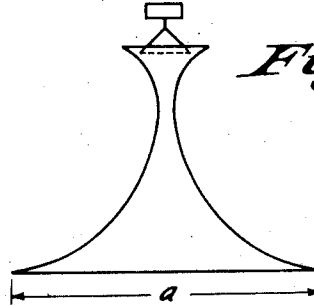
*Fig. 3*



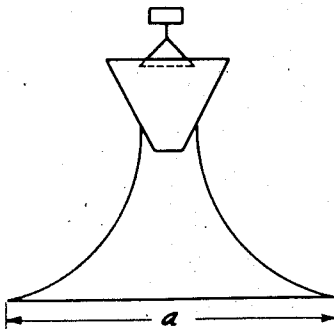
*Fig. 4*



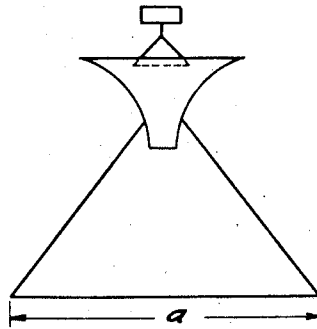
*Fig. 5*



*Fig. 6*



*Fig. 7*



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## ACOUSTIC APPARATUS

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It is known to direct sound waves by means of a horn or trumpet into a definite direction. It has been found that a vertical angle of a sound beam which is thus directed and radiated is inversely proportional to the cross sectional area of the mouth opening of the trumpet. The larger the said mouth opening is the smaller is the angle of the radiated beam and the more strongly directed is the sound. It has been stated, that this relation only holds good when the trumpet matches the sound source to such an extent that all the air particles in the mouth of the trumpet vibrate with the same amplitude.

When use is made for example of a diaphragm whose diameter is small in comparison with the length of the trumpet and with the diameter of its mouth opening, it may be assumed that all of air particles in the mouth opening of the horn really vibrate with the same amplitude. When using, however, a diaphragm whose diameter is large in comparison with the dimensions of the trumpet, the said diaphragm is liable to exert a certain directional effect and to radiate a divergent sound beam. When a trumpet badly matches this diaphragm the air particles in the mouth of the trumpet which are located within the beam radiated by the diaphragm will vibrate more strongly than the particles located outside the said beam. In this case only part of the mouth opening comes into consideration for the angle of the beam emitted by the trumpet and the diaphragm.

The said angle will consequently be larger than would be expected from the trumpet opening and the sound will consequently be directed less strongly. Consequently, if one wants to direct the sound waves issuing from a diaphragm which as to its diameter can no longer be said to be small relatively to the horn or trumpet opening one wishes to use, one is obliged to take horns, or trumpets of great length. These horns are very expensive and extremely unsightly. The invention has for its object to suggest a method which allows of directing sound waves strongly without necessitating abnormal dimensions of the trumpet or horn required to obtain the directional effect.

According to the invention, first the sound radiating area is reduced and then the sound is directed by means of a trumpet or horn which surrounds the said reduced area. The sound radiated by the reduced area can be directed with the aid of a short and strongly diverging horn without any risk that air particles in the mouth opening of the horn vibrate unequally. In fact, the small sound radiating area may be considered as a vibrating point which radiates in every direction the same quantity of sound. The sound radiating area can be reduced by means of a trumpet or horn whose concave side is turned towards the sound source.

In the device according to the invention the sound radiating area is first reduced and then the sound waves are directed by means of a trumpet or horn which surrounds the reduced area. According to the invention this device may consist of two funnel shaped parts whose throats open into each other. Either or both of the two funnel shaped parts may be formed as a horn.

The invention will be more clearly understood by referring to the accompanying drawing which represents by way of example some embodiments of the invention. In the drawing:

Figure 1 represents a horn shaped loudspeaker;

Figure 2 shows a loudspeaker comprising a horn and a diaphragm which relatively to the said horn has large dimensions;

Figure 3 represents a loudspeaker whose diaphragm has the same dimensions as that of Figure 2 but whose sound trumpet is longer than the horn represented in Figure 2;

Figure 4 shows a sound trumpet according to the invention used in conjunction with a diaphragm and a magnet system.

Figures 5, 6 and 7 are modes of realization of sound trumpets according to the invention.

Referring to Figure 1 the sound issuing from a diaphragm 11 is directed by a horn 10 into a beam whose vertical angle  $\alpha$  depends on the diameter of the mouth opening of the horn 10. As above observed, this relation only holds good, when all the air particles located in the mouth opening vibrate with

the same amplitude. This will usually be the case when the diameter of the diaphragm 11 is small in comparison with the dimensions of the trumpet.

- 5 Figure 2 represents a combination of a diaphragm 12 with a horn 13 in which the diaphragm has larger dimensions owing to which it has already a certain directional effect which is indicated by the diverging beam 14.
- 10 If the horn 13 badly matches the diaphragm 12, as is shown in Figure 2 the air particles in the mouth of the trumpet which are located in the zone *g* will vibrate more strongly than the particles located outside the said zone i. e.
- 15 in the zone *h*. In this case, only the portion *g* of the mouth opening will principally come into consideration for the angle of the beam radiated by the trumpet and the diaphragm. In order to avoid this, one must use a trumpet or horn which is better suited to the diaphragm 12, for example the trumpet 15 represented in Figure 3. When comparing Figures 2 and 3, one will observe that the mouth openings of the horn 13 and of the trumpet 15
- 20 have the same diameters but that the trumpet 15 is much longer than the horn 13.

- Figure 4 represents a sound trumpet which consists of two funnel shaped parts 20 and 21 whose throats 22 and 23 open into each
- 30 other. The concave side of the funnel shaped part 20 is turned towards the sound source 24. The sound radiating area of the said sound source may be considered the surface of the diaphragm 25. This sound radiating
- 35 area is reduced by the trumpet 20 to the area of the throat opening 23 of the funnel shaped part 21. The sound radiated by the area 22 is directed by means of the short, strongly diverging trumpet 21. All the air particles
- 40 in the mouth opening of this trumpet will vibrate with the same amplitude so that a strongly directed beam will be radiated. When comparing the Figures 3 and 4, one observes that the mouth opening of the trumpets 15 and 21 are equal but that the length *l* of the trumpet 15 is much greater than the length *l'* of the sound trumpet according to the invention.

- Figure 5 represents a mode of realization
- 50 in which the two funnel shaped parts are formed as a horn.

In Figure 6 only the directing funnel shaped part and in Figure 7 the reducing funnel shaped part, are formed as horns.

- 55 These sound trumpets are eminently suited to exert a strongly directional effect on the sound issuing from a loudspeaker having a large diaphragm, such for example as loudspeakers with diaphragms having diameter
- 60 of 10 centimeters and more.

I claim:

- A loudspeaker comprising a conical diaphragm having a large surface, a sound amplifying body having an opening which is
- 65 smaller than the said diaphragm and com-

parable in size with the other dimensions of the body to make a good amplifier of sound, and a sound directing body interposed between said diaphragm and said sound amplifying body, said sound directing body having a shape such that its end which is associated with the diaphragm has an opening that is larger than the diaphragm and its end which is associated with said sound amplifying body has an opening that is smaller than the opening in said sound amplifying body whereby the larger end of said sound directing body is out of contact with said diaphragm and the smaller end of said sound directing body is out of contact with the sound amplifying body.

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