March 14, 1933. I. WOLFF 1,901,388

METHOD AND APPARATUS FOR ELIMINATING THE EFFECT OF CABINET RESONANCE

Filed April 18, 1930

Fig. 1.

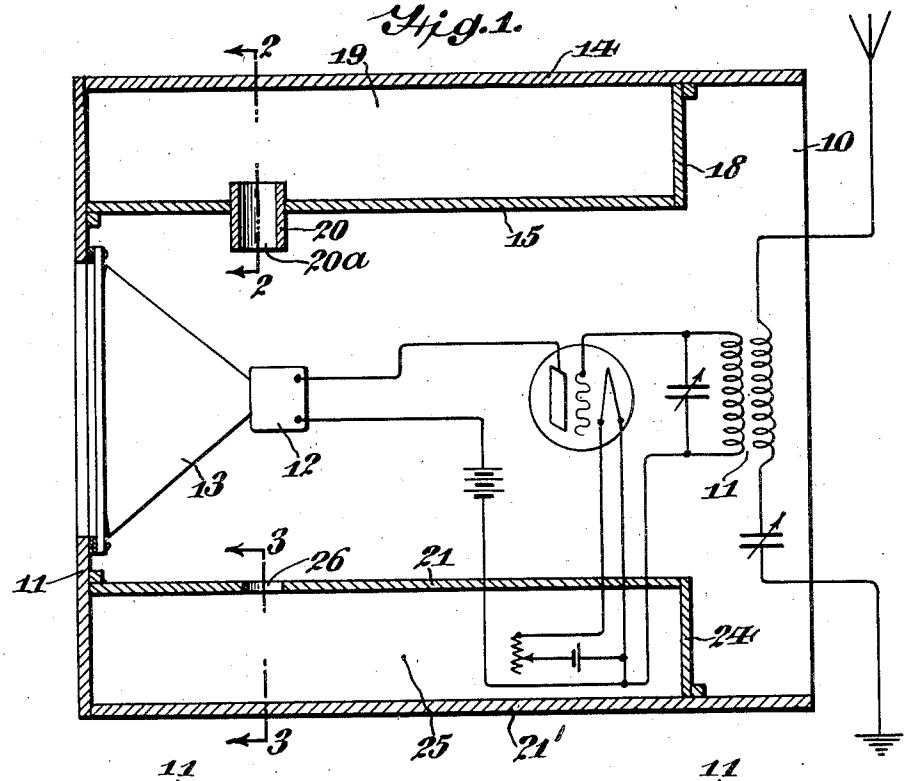


Fig. 3.

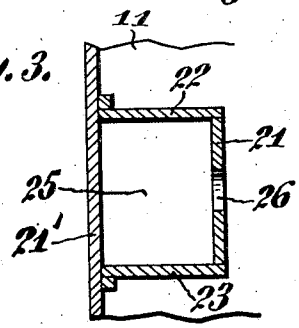


Fig. 2.

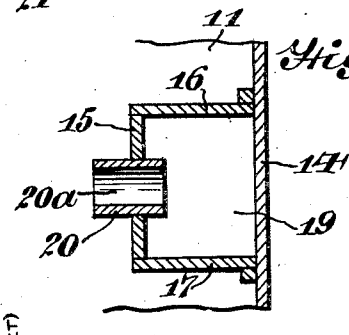


Fig. 4.

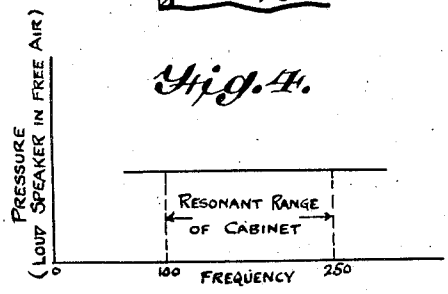
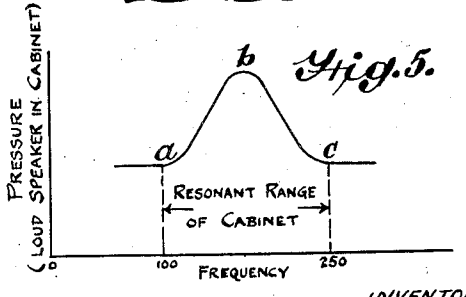


Fig. 5.



INVENTOR

Irving Wolff

BY

O. P. Stafford

ATTORNEY

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1,901,388

UNITED STATES PATENT OFFICE

IRVING WOLFF, OF MERCHANTVILLE, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

METHOD AND APPARATUS FOR ELIMINATING THE EFFECT OF CABINET RESONANCE

Application filed April 18, 1930. Serial No. 445,448.

My invention relates to method and apparatus for eliminating the effect of cabinet resonance.

In sound-producing apparatus constructed heretofore and comprising generally a suitable cabinet and radio, phonographic or other system embodied in the cabinet, the sound reproduction is sometimes distorted and imperfect, due to the natural resonance of the cabinet at certain frequencies or at frequencies within a given range.

It is well known that a diaphragm or vibratory member disposed in a cabinet develops a relatively high pressure region in the same, and that this pressure is increased substantially by the joint effects of the cabinet and the diaphragm when the latter vibrates at a frequency within the natural resonant frequency range of the cabinet.

Since the energy output or intensity of the sound emitted by the diaphragm depends largely on the force against which the diaphragm acts when vibrating, this force depending directly on the pressure in the region around the diaphragm, it has been proposed to eliminate the undesirable acoustic effects referred to by providing the cabinet with openings or passages whereby the region in the cabinet near the diaphragm is in direct communication with the outside air.

While the acoustic impedance of these openings or passages has been sufficiently low to relieve the pressure effectively, the advantage thus obtained has been offset by the fact that free circulation of air through the openings or passages is permitted in such degree to appreciably reduce response of the apparatus to low frequencies.

One of the objects of my invention is to provide improved apparatus of the character referred to wherein the acoustic effect of the cabinet, due to its natural resonant frequency, is eliminated, the action being such that a certain part of the energy at the diaphragm is absorbed or dissipated to prevent development of vibrations in the cabinet at the normal resonant frequency thereof without interfering with response of the apparatus to relatively low frequencies.

In accordance with my invention, undesirable acoustic action in sound-producing apparatus comprising a cabinet resonant within a given frequency range and a vibratory member associated with said cabinet, is avoided or eliminated by developing within the cabinet during operating of the apparatus within said frequency range a relatively low pressure region at a region within said cabinet where a relatively high pressure region would otherwise develop, so that the excess energy in the form of sound waves emitted from the vibrating diaphragm is absorbed or dissipated before it can have any influence in the way of permitting the vibrations of the cabinet structure to develop at the natural resonant frequency thereof, in which case the cabinet would operate as a Helmholtz resonator.

Further in accordance with my invention, means are disposed in the cabinet and supported independently of and in spaced relation with respect to the associated diaphragm or vibratory member, such means providing a resonator tuned to resonate within the natural resonant frequency range of the cabinet and to develop a relatively low pressure region in the cabinet where a relatively high pressure region would otherwise develop.

Further in accordance with my invention, a partition is disposed within and forms with the wall structure of the cabinet an auxiliary resonator tuned to resonate within the natural resonant frequency range of the cabinet, and which has an opening disposed substantially in the region in the cabinet and in proximity to the vibratory member where a relatively high pressure region would otherwise develop upon vibration of the member at frequencies within said range.

More particularly in accordance with my invention, apparatus of the character referred to is provided which comprises a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, means such as a radio, phonographic or other system operable to impart vibratory movement to the member at frequencies within said range, means disposed in the cabinet and providing a resonator chamber operable to compensate for

acoustic action of the cabinet with respect to the member during vibration of the latter within said frequency range, and apparatus which is disposed within the chamber of the resonator and contained thereby, and which forms part of the radio, phonographic or other system.

My invention resides in the method and apparatus of the character hereinafter described and claimed.

For the purpose of illustrating my invention, one embodiment thereof is shown in the drawing, in which

Fig. 1 is a central sectional plan view, partly diagrammatic, of apparatus embodying my invention;

Fig. 2 is a section taken on line 2—2 in Fig. 1;

Fig. 3 is a section taken on line 3—3 in Fig. 1; and

Figs. 4 and 5 constitute a graphical showing of the acoustic action or effects which are eliminated in the present improved apparatus.

In Fig. 1, the cabinet 10 contains the radio, phonographic or other system designated generally by reference numeral 11, and has a natural resonant frequency range which may be, for example, between 100 and 250 cycles.

Disposed within the cabinet and secured to the front panel 11 thereof is the loud speaker unit 12 comprising the cone-shaped diaphragm or vibratory member 13 connected in the usual manner in the radio system, as shown. Secured to the front panel 11 and side panel 14 of the cabinet are the partitions 15, 16, 17 and 18, which form with these panels a resonator having the chamber 19 and the tubular member 20 providing communication between this chamber and the interior of the cabinet through opening 20*a*.

Secured to the front panel 11 and side panel 21′ are the partitions 21, 22, 23 and 24 forming with these panels a second resonator having the chamber 25 and the opening 26 providing communication between the chamber and the interior of the cabinet. The dimensions of the resonators are determined by the formula:

$$f=\frac{C}{2\pi}\sqrt{\frac{K}{V}},$$

where f is the natural resonant frequency of the cabinet, C the velocity of sound, K the conductivity of the opening 20*a* or 26, and V the volume of chamber 19 or 25.

When a tube such as the tube 20 in the first resonator is used, the conductivity K of the opening 20*a* is determined by the formula:

$$K=\frac{S}{l},$$

where S is the cross sectional area of the tube and l the length of the tube.

When a plain opening is used, such as opening 26 in the second resonator, the conductivity K of the opening is determined by the formula:

$$K=2\sqrt{\frac{S}{\pi}},$$

where S is the area of the opening.

Assuming that the loud speaker or other vibratory member is in free air, that is, outside of the cabinet and in no way influenced thereby, and the radio or other system 11 imparts vibratory movement to diaphragm 13 at a frequency within the natural resonance frequency range of the cabinet, that is, between 100 and 250 cycles, the pressure in the region about the diaphragm would be substantially constant, as indicated by the graph in Fig. 4.

With the loud speaker or vibratory member disposed in operative position within the cabinet, however, and without employment of the resonators, the pressure in the region about the diaphragm will increase substantially upon vibration of the same at frequencies within the natural resonant frequency range of the cabinet. This is illustrated by the graph in Fig. 5. As explained, it is this condition of high pressure about the diaphragm which causes the same to work against a greater force, and accordingly generate more sound energy than is desirable for the proper and natural acoustic effect.

In the present improved apparatus, this relatively high pressure which tends to develop about the diaphragm during operation of the apparatus within the natural resonant frequency range of the cabinet, is reduced or kept down by relatively low pressure regions developed by the resonators within the regions where the high pressure would otherwise occur. Development of these low pressure regions are explained by the fact that when the resonators are resonating, there is air-flow alternately in opposite directions at the resonant frequency in openings 20*a* and 26 at high velocity. The velocity head at these points or regions being high, the pressure head is accordingly low. The action of the resonators may be explained in another way by saying that the same compensate for the acoustic action of the cabinet with respect to the diaphragm during vibration of the latter within the natural resonant frequency range of the cabinet, or substantially absorb the energy inside the cabinet represented by the area *a b c* of the peak of the graph in Fig. 5.

Satisfactory results can be obtained by the use of only one resonator, which may have the tube 20 providing the opening 20*a*, or the plain opening such as opening 26. A greater number of resonators than those shown in Fig. 1 can be used with satisfactory results,

in which case the same may be positioned and supported symmetrically in the cabinet about diaphragm 13 or other vibratory member with their respective openings disposed in the region about the diaphragm where the high pressure would otherwise develop.

The resonator or resonators should be placed in the cabinet so that the same do not change the geometry of the cabinet cavity in such wise as to cause the cabinet to resonate at a frequency outside of the normal range.

Conditions may be such that in using a particular resonator tuned to a certain frequency, only a part of the abnormal peak *a b c* in Fig. 5 is removed, in which case one or more other resonators, tuned to other frequencies, may be used to remove the remaining portion or portions of the peak.

The design or arrangement of the resonator or resonators is such that the same do not interfere with or vary the normal amplitude and frequency of vibration of the diaphragm outside of the resonant frequency range of the cabinet.

It is contemplated to make the partitions forming the resonators of metal or other suitable material suitably stiff or of such gauge to preclude excessive vibration at the resonant frequency.

Certain parts of the radio or other system 11 may be disposed within the chamber of one or more of the resonators without interfering with the resonating action thereof. In Fig. 1 the filament battery and control resistance are indicated as being disposed within the chamber 25 of the second resonator.

While but one embodiment of my invention has been shown and described, it will be understood that various changes may be made, such as in the size, shape and arrangement of the parts without departing from the spirit of the invention or the scope of the claims.

I claim as my invention:

1. In the art of avoiding undesired acoustic action in sound-producing apparatus comprising a cabinet resonant within a given frequency range and a sound producer diaphragm associated with said cabinet, the method which comprises developing during operation of said apparatus within said frequency range, a relatively low pressure region at a region about the diaphragm within said cabinet where a relatively high pressure region would otherwise develop.

2. The combination with apparatus of the character described including a cabinet normally resonant within a given frequency range and a relatively large sound producing diaphragm within the cabinet, of means disposed within said cabinet providing a resonator tuned to resonate within said frequency range and operable when resonating to develop a relatively low pressure region within said cabinet, said resonator having an orifice disposed adjacent to the sound producing diaphragm.

3. The combination with apparatus of the character described comprising a cabinet normally resonant within a given frequency range, and a vibratory member associated with said cabinet, said cabinet and member being jointly effective upon vibration of said member within said frequency range to develop a relatively high pressure region within said cabinet, of means disposed within said cabinet and providing a resonator tuned to resonate within said frequency range and operable when resonating to develop a relatively low pressure region substantially within said high pressure region.

4. The combination with apparatus of the character described comprising a cabinet normally resonant within a given frequency range, and a vibratory member associated with said cabinet, said cabinet and member being jointly effective upon vibration of said member within said frequency range to develop a relatively high pressure region within said cabinet, of a partition disposed within and forming with the wall structure of said cabinet an auxiliary resonator tuned to resonate within said frequency range and having an opening disposed substantially within said high pressure region.

5. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, and means disposed within said cabinet and providing a resonator operable to compensate for acoustic action of said cabinet with respect to said member during vibration of the latter within said frequency range.

6. In apparatus of the character described, a cabinet normally resonant at a given frequency, a vibratory member associated with said cabinet, said cabinet and member being jointly effective upon vibration of said member at said frequency to develop a relatively high pressure region in proximity to said member, and means disposed within said cabinet and providing a resonator chamber having an opening disposed within said region, said means dimensioned substantially in accordance with the formula:

$$f = \frac{C}{2\pi}\sqrt{\frac{K}{V}}$$

where f is the normal resonant frequency of said cabinet, C the velocity of sound, K the conductivity of said opening, and V the volume of said chamber.

7. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, means for imparting vibratory movement to said member within said range, means disposed within said cabi-

net and providing a resonator chamber operable to compensate for acoustic action of said cabinet with respect to said member during vibration of the latter within said frequency range, and apparatus disposed within said chamber and forming part of said first-named means.

8. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, means for imparting vibratory movement to said member at frequencies within said range, and means disposed in said cabinet and supported independently of and in spaced relation with respect to said member and providing a resonator tuned to resonate at frequencies within said range and operable to absorb energy in the form of sound waves emitted from said member during vibratory movement of the latter at frequencies within said range.

9. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory diaphragm member for a loud speaker associated with said cabinet, means for imparting vibratory movement to said member at frequencies within said range, and means disposed in said cabinet and supported independently of and in spaced relation with respect to said member providing a resonator chamber tuned to resonate within said range, said chamber having an opening disposed in the region in proximity to said diaphragm member.

10. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, said cabinet and member being jointly effective upon vibration of said member within said frequency range to develop a relatively high pressure region within said cabinet, means for imparting vibratory movement to said member at frequencies within said range, and means disposed in said cabinet and supported independently of and in spaced relation with respect to said member and providing a resonator tuned to resonate within said range and having a chamber provided with an opening disposed within said region.

11. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, means for imparting vibratory movement to said member at frequencies within said range, and a resonator disposed in said cabinet and supported independently of and in spaced relation with respect to said member, said resonator tuned to resonate at frequencies within said range and operable to absorb energy in the form of sound waves emitted from said member during vibratory movement of the latter at frequencies within said range, said resonator being non-effective to absorb such energy during vibratory movement of said member at frequencies outside of said range.

12. In combination, a cabinet normally resonant within a given frequency range and means disposed within said cabinet providing a resonator tuned to resonate within said frequency range and functioning when so resonating to develop a relatively low pressure region within said cabinet, said means and the interior of said cabinet being interconnected through means the acoustic conductivity of which is determined by the formula:

$$K=\frac{S}{1}$$

wherein S is the cross-sectional area of the connecting means and 1 is the length thereof.

13. In combination, a cabinet normally resonant within a given frequency range and means disposed within said cabinet providing a resonator tuned to resonate within said frequency range and functioning when so resonating to develop a relatively low pressure region within said cabinet, said means and the interior of said cabinet being interconnected through means the acoustic conductivity of which is determined by the formula:

$$K=2\sqrt{\frac{S}{\pi}}.$$

14. The combination of an apparatus cabinet and a loud speaker unit having a vibratory diaphragm of relatively large size mounted in said cabinet to direct sounds therefrom, means providing a resonator chamber within the cabinet, and at least one tubular member providing communication between the said chamber and the interior of the cabinet adjacent to said diaphragm.

15. In apparatus of the character described, a cabinet normally resonant within a given frequency range, a vibratory member associated with said cabinet, and resonator means disposed within said cabinet operable to compensate for acoustic action of said cabinet with respect to said member during vibration of the latter within said frequency range, said resonator means including a plurality of chambers communicating with the interior of the cabinet and being resonant at frequencies within said frequency range of cabinet resonance.

16. In combination, a cabinet normally resonant within a given frequency range and means disposed within said cabinet providing a resonator tuned to resonate within said frequency range and functioning when so resonating to develop a relatively low pressure region within said cabinet, said means and the interior of said cabinet being interconnected through means the acoustic con-

ductivity of which is determined by the formula:

$$K=\frac{S}{l}$$

wherein S is the cross-sectional area of the connecting means and l is the length thereof, and K is of a value such that it satisfies the formula:

$$f=\frac{C}{2\pi}\sqrt{\frac{K}{V}}$$

wherein f is the natural resonant frequency of the cabinet, C is the velocity of sound, K is the conductivity of the inter-connecting means and V is the volume of the resonator means.

17. In combination, a cabinet normally resonant within a given frequency range and means disposed within said cabinet providing a resonator tuned to resonate within said frequency range and functioning when so resonating to develop a relatively low pressure region within said cabinet, said means and the interior of said cabinet being interconnected through means the acoustic conductivity of which is determined by the formula:

$$K=2\sqrt{\frac{S}{\pi}}$$

wherein S is the cross-sectional area of the connecting means and l is the length thereof, and K is of a value such that it satisfies the formula:

$$f=\frac{C}{2\pi}\sqrt{\frac{K}{V}}$$

wherein f is the natural resonant frequency of the cabinet, C is the velocity of sound, K is the conductivity of the inter-connecting means, and V is the volume of the resonator means.

In testimony whereof I have signed this specification.

IRVING WOLFF.