May 17, 1949. J. G. WOODWARD 2,470,597

ACOUSTIC ATTENUATOR

Filed Jan. 31, 1946 2 Sheets-Sheet 1

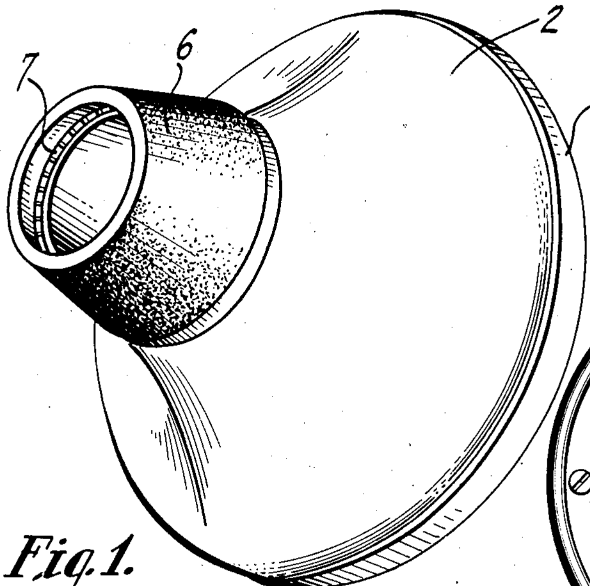
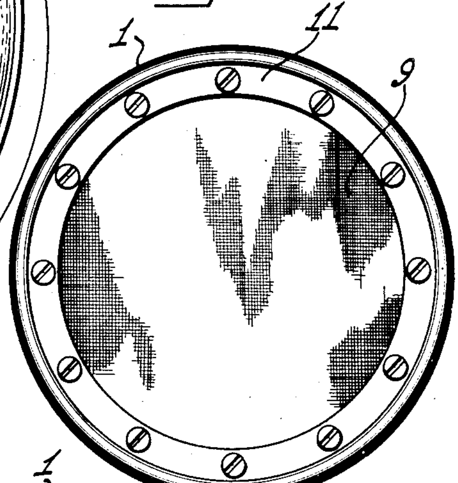


Fig. 1.

Fig. 2.



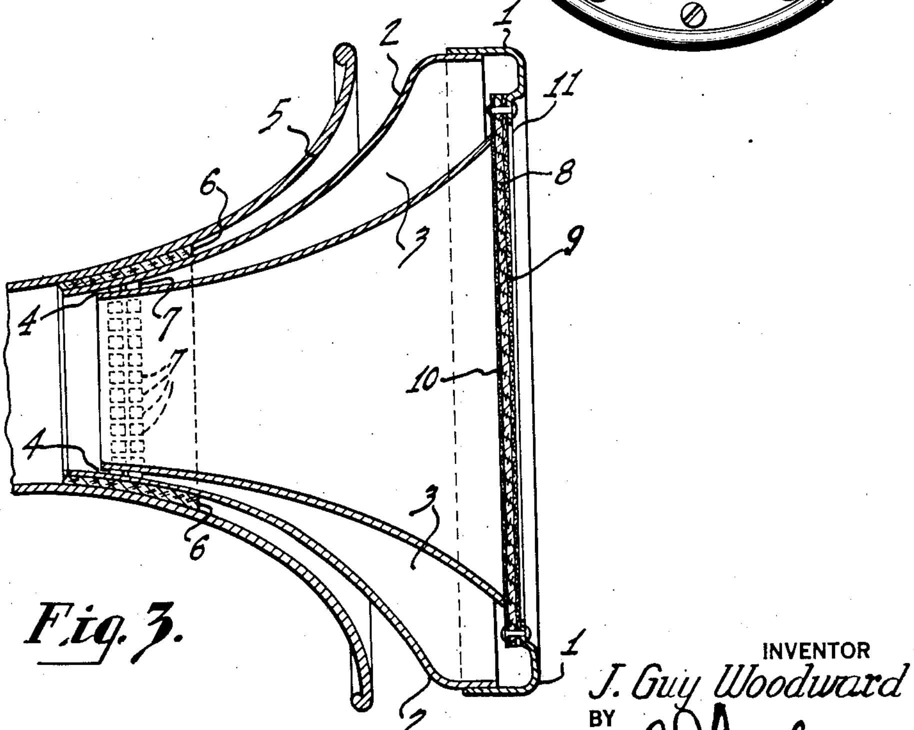


Fig. 3.

INVENTOR
J. Guy Woodward
BY
C. D. Tuska
ATTORNEY

May 17, 1949. J. G. WOODWARD 2,470,597

ACOUSTIC ATTENUATOR

Filed Jan. 31, 1946 2 Sheets-Sheet 2

Fig. 4.

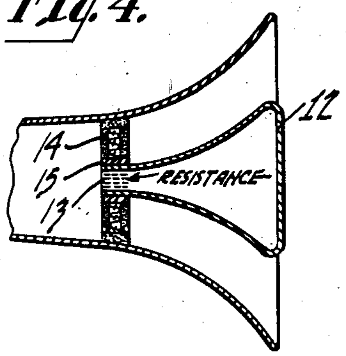


Fig. 5.

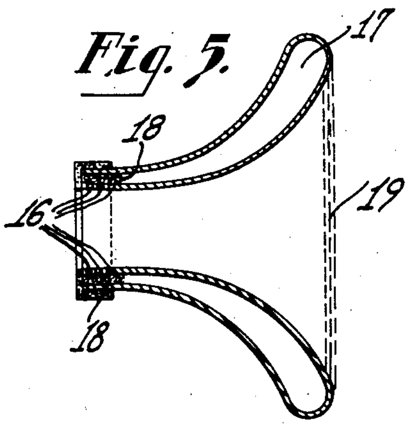


Fig. 6.

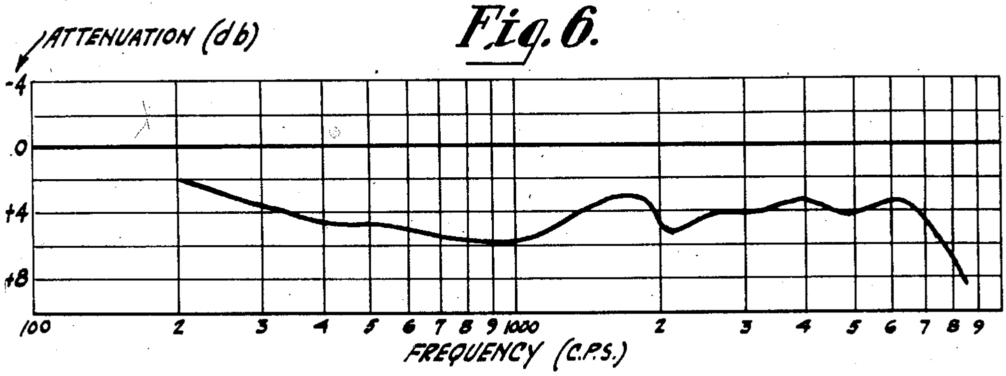
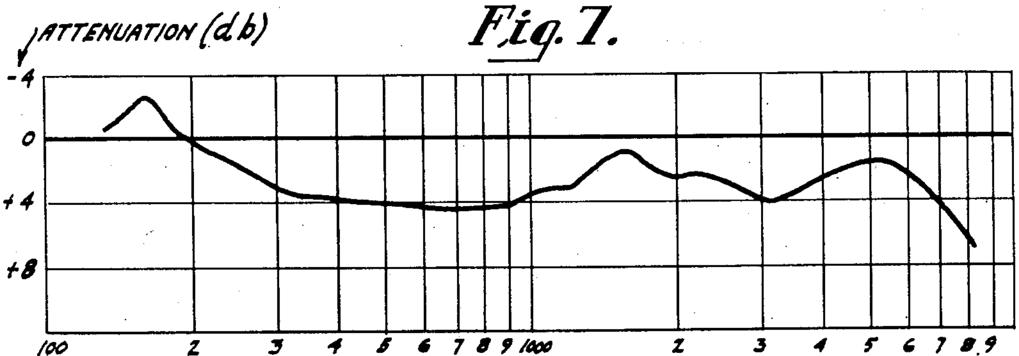


Fig. 7.



INVENTOR
J. Guy Woodward
BY
C. D. Tuska
ATTORNEY

Patented May 17, 1949 2,470,597

UNITED STATES PATENT OFFICE

2,470,597

ACOUSTIC ATTENUATOR

J. Guy Woodward, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application January 31, 1946, Serial No. 644,525

7 Claims. (Cl. 84—400)

1

This invention relates to improvements in acoustic attenuators used with wind instruments. More specifically, it relates to an improved attenuator or mute to be used with cornets or trumpets although the device could be used with other wind instruments such as the trombone.

In general, the idea of using a mute to either distort the tone or cut down the intensity of sound output of a trumpet is old. Hundreds of varied shaped mutes have been constructed, most of them to give some unusual distortion effect to the sound output of the instrument. Almost none of the mutes commercially obtainable has been constructed on any scientific design.

The preferred type of mute embodying the present invention is not the distortion type but rather one which attenuates the sound as uniformly as possible over a wide range of frequencies. This type of mute is useful for achieving proper balance between the various instruments and sections of an orchestra, especially when playing before microphones. The problem of balance in this connection has been one of major concern to program producers, musicians, and broadcast engineers alike due to the high level of sound produced by the brass instruments, particularly the trumpets, compared with the rest of the orchestra. The problem cannot be solved by merely having the trumpets play softly since, in the first place, the trumpet loses much of its characteristic quality when played softly and, second, the musician finds it more difficult to control tone and pitch.

It is an object of the present invention to provide an attenuator for wind instruments which has been designed on scientific acoustic principles.

Another object is to provide a mute for instruments such as the cornet and trumpet which attenuates the sound output uniformly over a wide range of frequencies.

Another object is to provide an acoustic attenuator for wind instruments which is especially adapted to attenuate a certain band of frequencies.

A further object is to provide an acoustic attenuator which cuts down the sound output uniformly without distorting the tone to any appreciable extent.

A still further object is to provide an attenuator which, although being designed in accordance with scientific acoustic principles, is still of simple construction and light weight.

Other objects and advantages of the invention will become apparent from a further description of the invention including the drawings in which:

2

Fig. 1 is a rear perspective view of a preferred embodiment of the attenuator.

Fig. 2 is a front view of the attenuator shown in Fig. 1.

Fig. 3 is a cross-sectional view of the attenuator shown in Fig. 1.

Fig. 4 is a cross-sectional view of another modification of the attenuator.

Fig. 5 is a cross-sectional view of still another modification of the attenuator.

Fig. 6 is a typical attenuation curve compiled from data resulting from operation of the attenuator similar to the one illustrated in Figs. 1 and 2.

Fig. 7 is another attenuation curve.

The device is preferably made of aluminum spinnings in two sections **1** and **2** forming a cavity **3** between them. The volume (acoustic capacitance) of the cavity combined with the narrow opening (acoustic inertance) at **4** provides a system which is resonant at a desired, convenient frequency. When the attenuator is inserted in the bell **5** of an instrument, the sound leaving the instrument and passing through the mute is partially absorbed by the resonant cavity, the absorption being greatest at the resonant frequency. A band of cork **6**, or other material having a high coefficient of friction, aids in holding the attenuator in the bell of the horn. In the instance of an attenuator designed for trumpets or cornets, it is preferred to have a system which resonates at a comparatively low frequency such as 300 cycles per second. This may be obtained by using a cavity having a volume of 12.4 cubic inches and a separation of approximately $\frac{1}{16}$ inch between the flaring walls at their small ends. By varying the volume of the cavity in relation to the size of the opening, this resonant frequency can be changed as desired. For cornets and trumpets, the low resonant frequency is desired so that the attenuation may be obtained for the low frequency range of notes.

In the design as illustrated, the resonant cavity has gradually flaring walls. This causes the acoustic constants, capacitance and inertance, to be distributed rather than lumped and results in a resonant system which will allow absorption of sound by the cavity to occur over a fairly wide band of frequencies.

It is also possible to have an attenuator of conic shape although this form does not have as desirable distribution of the acoustic constants as the form which has flared walls.

In the design of the attenuator shown in Figs.

1–3 and which will now be described by way of example, the attenuation of frequencies below 300 C. P. S. becomes increasingly less, the lower the frequency. However, the lowest note ordinarily played on a trumpet has a frequency of 165 C. P. S. and notes below 350 C. P. S. cannot usually be played so loudly as to require attenuation. To make the band of absorption at low frequencies still broader and less dependent on frequency, additional acoustic resistance can be inserted in the narrow opening of the cavity at 4. One form which this resistance may take is a number of small aluminum blocks 7 inserted side by side in the narrow opening with small open spaces between blocks. For example, in the resonant system shown, the blocks may have dimensions of ⅜ inch long by $\frac{3}{32}$ inch wide by 0.03 inch thick. Thus, the sound must enter the cavity through a number of slots which give the desired resistance, resistance being varied by varying the spacing between blocks. Another way of accomplishing the same result is to wrap several layers of cloth about the inner section of the attenuator at the narrow opening.

The effect of the resonant cavity in attenuating the sound is restricted almost entirely to frequencies below 1,000 C. P. S. To get attenuation at higher frequencies, additional acoustic resistance 8 in the form of several layers of cloth is placed at the large end of the attenuator. The cloth used may be silk, nylon or similar material and the layers are mounted between two fine-mesh metal screens 9 and 10 supported around the edge by a metal ring 11 and screws or rivets. The effect of the cloth layers, in attenuating the sound, increases with the frequency and is almost negligible below 1,000 C. P. S. compared to its effect at higher frequencies and to the effect of the cavity. Hence, by securing the proper relation between the two types of absorption, attenuation can be achieved which is quite independent of frequency over nearly the whole range of frequencies present in the tone of the trumpet.

Typical attenuation curves are shown in Figs. 6 and 7. These curves are the result of plotting the differences between frequency response curves of a trumpet without and with the mute inserted in its bell. In taking the data from which the response curves were drawn, the trumpet was driven by a magnetic loud speaker unit coupled to it at the mouthpiece end of the horn. The remainder of the test procedure and equipment is the same as that commonly used for loudspeakers.

As shown in the curves, the attenuation decreases markedly below 300 C. P. S. and, as shown particularly in Fig. 7, may actually become negative below 200 C. P. S. This situation could be remedied by using a cavity having a larger volume since the resonant frequency of the cavity decreases as the cavity is increased in size. It is undesirable, however, to make the dimensions of the attenuator any larger than necessary. Furthermore, as pointed out previously, the notes below 350 C. P. S. cannot ordinarily be played loudly enough to require attenuation. Hence, modifications for attenuating these frequencies may be omitted if desired.

It may also be noted from the curves that the degree of attenuation varies considerably at frequencies above 1,000 C. P. S. This can be eliminated by mounting within the attenuator small resonators (not shown) tuned to the frequencies of the peaks in the response curve. But listening tests indicate this additional precaution to be unnecessary for most purposes since variations of ±2 decibels in the attenuation curve above 1,000 C. P. S. do not seriously alter the quality of the trumpet tone providing the variation does not include too wide a range of frequencies.

From the foregoing description, it will be seen that the uniformity of attenuation depends upon the relative values of the acoustic capacitance and inertance as well as upon the amount of acoustic resistance used in the attenuator. Acoustic capacitance is analogous to electrical capacitance in electrical circuits. Acoustic inertance is analogous to electrical inductance while acoustic resistance is akin to electrical resistance. By properly adjuting the relative values of resistance, capacitance and inertance, there is obtained a system which attenuates a wide band of frequencies including most of the range normally played on the instrument. The preferred attenuation design is found, for any particular wind instrument, by selecting a chamber having the proper ratio between size of cavity and size of opening, and the use of gradually flaring walls enclosing the cavity and its opening helps to provide more uniform response over a usable band of frequencies.

There has thus far been described and emphasized a form of mute which attenuates a wide band of frequencies with a high degree of uniformity. Without departing from the basic concept of the invention, there may also be designed mutes which will attenuate some special range of frequencies such as those in the higher or lower region. The desired attenuation may be obtained by balancing the capacitance, inertance and resistance so as to obtain the desired result. For example, by making the capacitance higher or lower, which is to say, making the volume of the cavity greater or less, the principal resonant frequency of the system can be made lower or higher. The greater the volume of the cavity, the lower is the resonant frequency and therefore the lower the frequency of greatest attenuation. As previously pointed out, the size of the openings into the cavity determines the inertance. If it is desired to keep the size of the cavity constant, the resonant frequency may be varied by changing the size of the openings. By increasing the size of the openings, the resonant frequency is made higher and vice versa.

No general rule can be stated concerning the use of resistance in the attenuating system. Usually those materials which are the best sound absorbers such as cloth, Celotex, etc., are also the best attenuators of the higher frequencies. The use of very small openings into the resonating cavity can be made to supply resistance which will attenuate the lowest frequencies since, in the case of narrow openings, their resistance value is more important than their inertance value.

Modifications in the design of the attenuator may also be made as illustrated in Figs. 4 and 5. In the form shown in Fig. 4, the cavity 12 has a capacitance depending on volume. Obstructions 13 such as aluminium blocks may be placed in the narrow opening of the cavity to provide both some desired resistance and inertance. Additional resistance in the form of layers of cloth 14 may be placed in a frame 15 to attenuate higher frequencies.

Fig. 5 illustrates a modification similar to Fig. 3 but having the openings 16 into the cavity 17 located along the flared walls instead of at the end. Resistance 18 may be inserted within the cavity and additional resistance 19 such as layers of cloth may be placed over the mouth of the attenuator opening. In this type of design, it is preferable to have openings 16 consist of a number of perforations to provide the desired inertance.

I claim as my invention:

1. An acoustic attenuator for a wind instrument comprising a resonant cavity having one end insertable within the bell of said instrument, an opening adjacent said insertable end and means having relatively high acoustic resistance positioned within said cavity adjacent said opening.

2. An attenuator, according to claim 1, in which said means having acoustic resistance comprises a plurality of small metallic blocks uniformly spaced around said opening so as to form a number of narrow slots.

3. An attenuator according to claim 1 in which said cavity has a gradually increasing diameter in a direction away from said opening.

4. An attenuator, according to claim 3, in which said resistance comprises a plurality of small aluminum blocks evenly spaced around said opening so as to form a number of narrow slots.

5. An acoustic attenuator for a wind instrument comprising, in combination, a resonant cavity having a resonant frequency below 1,000 cycles per second adapted to be inserted within the bell of said instrument, means having relatively high acoustic resistance positioned within

said cavity and sound absorbing means for attenuating audible frequencies above 1,000 cycles per second adapted to be positioned in acoustic relationship with said bell.

6. An attenuator, according to claim 5, in which said sound absorbing means comprises a plurality of layers of cloth.

7. An acoustic attentuator for a wind instrument comprising a resonant cavity of annular configuration surrounding a central air passage, said cavity having a narrow tapered end and a flared end, said narrow end being adapted to fit within the bell of said instrument and having an opening adjacent thereto, means for attenuating audible frequencies below 1,000 cycles per second positioned within said cavity adjacent said opening, and means for attenuating audible frequencies above 1,000 cycles per second positioned across said air passage.

J. GUY WOODWARD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,338,108	Sordillo	Apr. 27, 1920
1,342,846	Emma	June 8, 1920
1,697,707	Berg	Jan. 1, 1929
1,702,561	Emma	Feb. 19, 1929
2,244,205	Koeder	June 3, 1941
2,318,535	Spivak	May 4, 1943