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VENTILATOR

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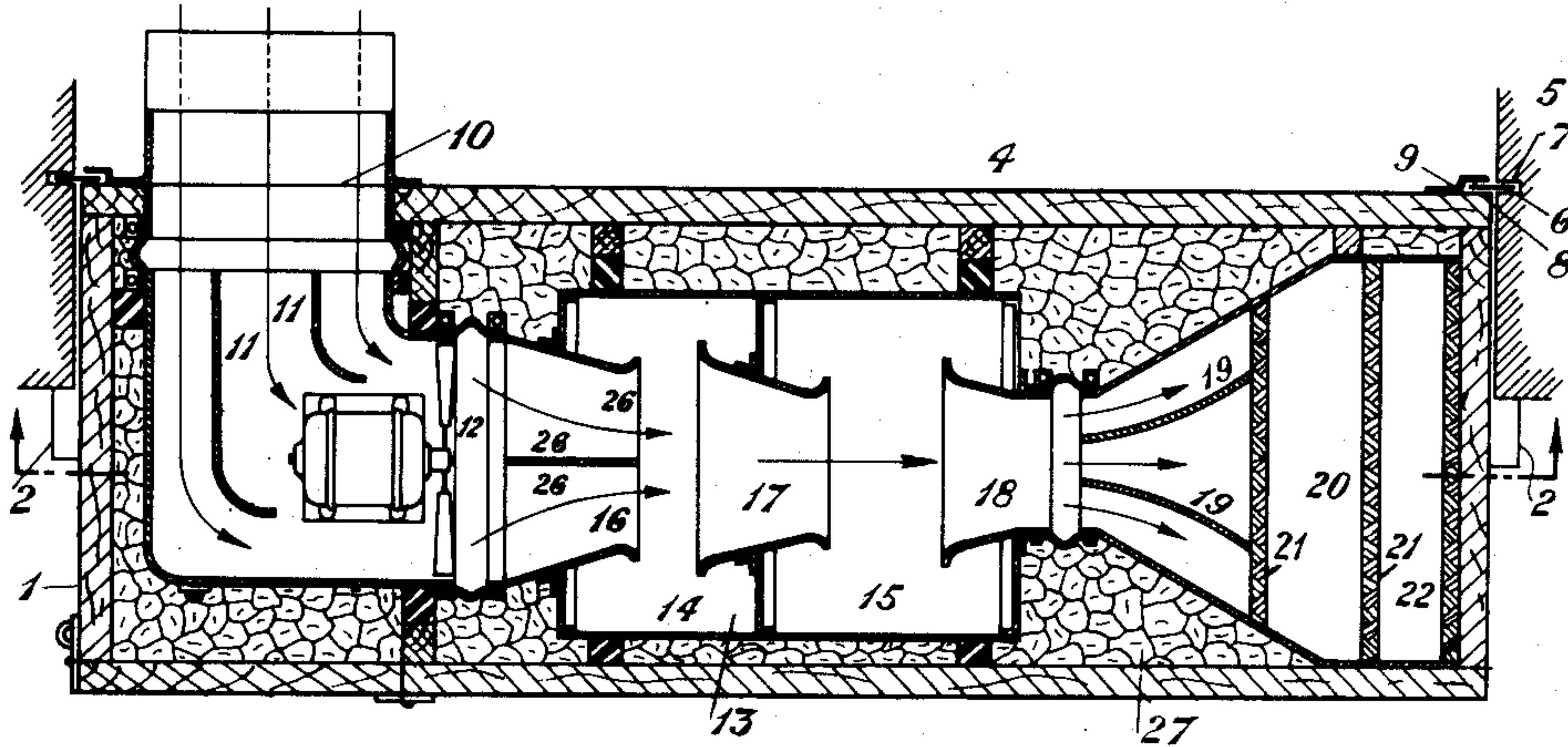


Fig. 1

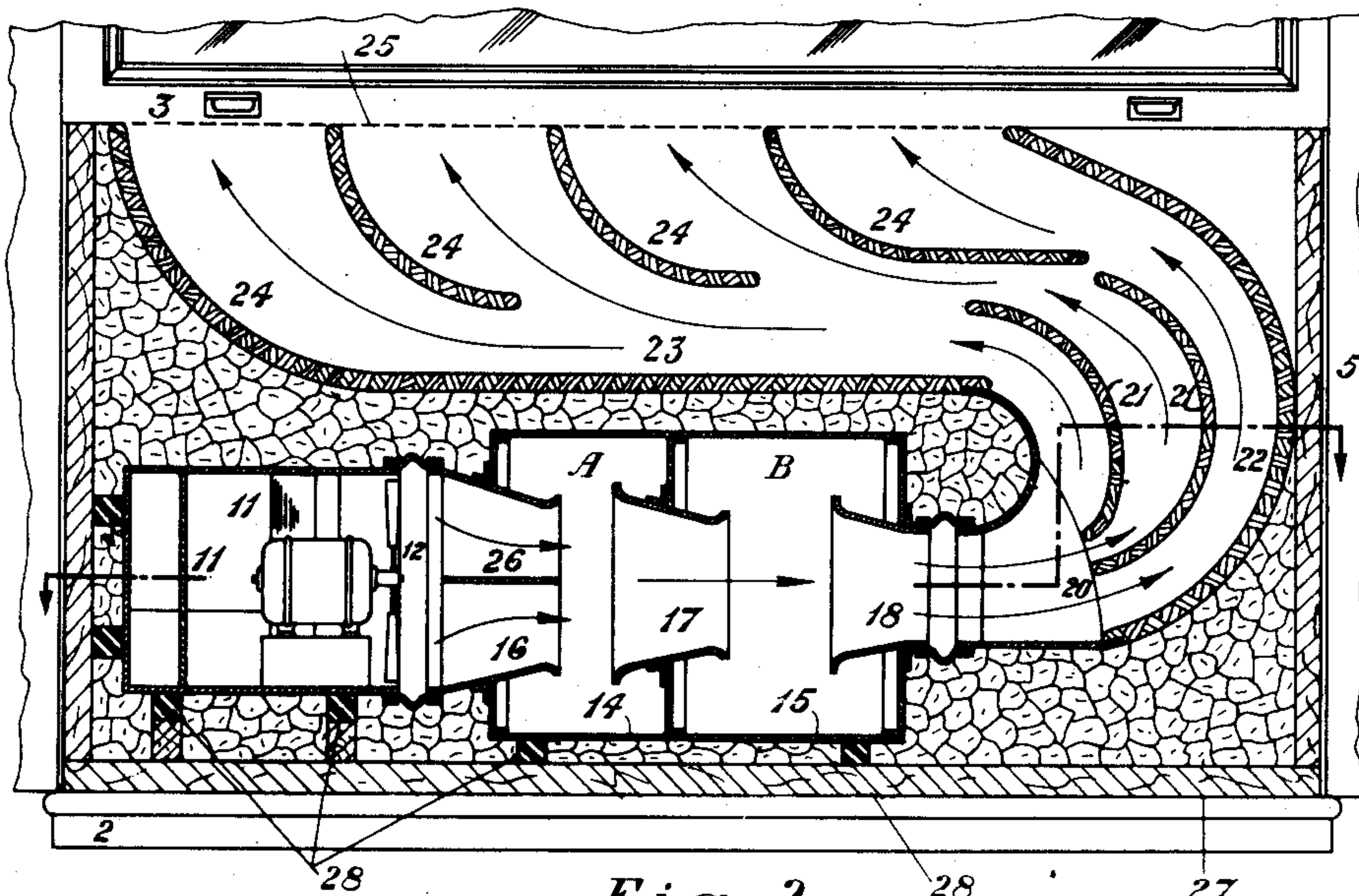


Fig. 2

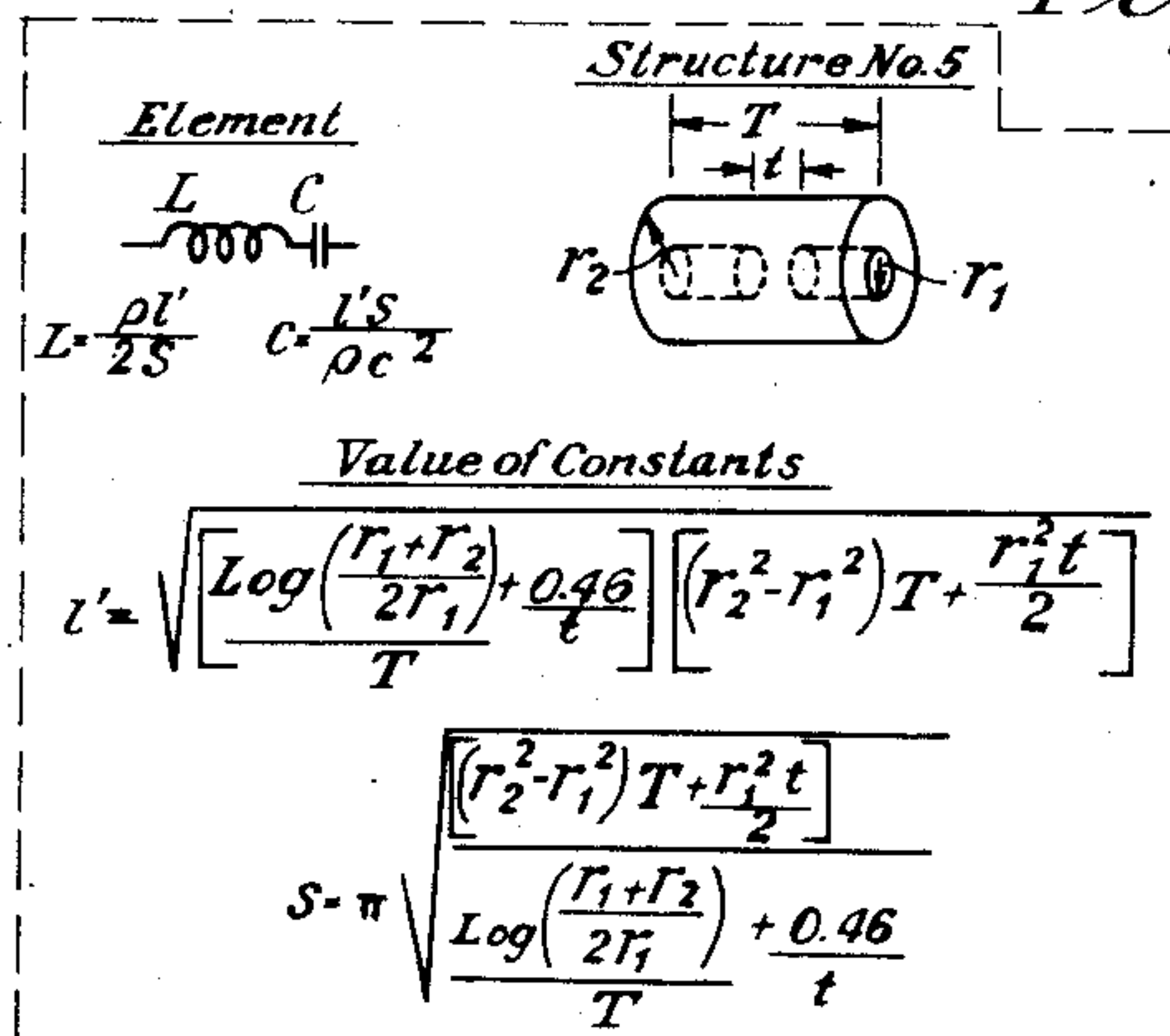


Fig. 3

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VENTILATOR

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3 Claims. (Cl. 98—94)

This invention relates to window ventilators and more particularly to those designed to exclude street noise.

The object of this invention is to provide a window ventilator which is compact yet capable of attenuating outside noises to a high degree in its air passages while permitting the flow of a large volume of air.

A feature of this invention is the inclusion in a window ventilator of this kind of an acoustic filter together with a duct having a lining of sound absorbing material and containing turns or baffles.

In the drawing, Figure 1 shows a cross-section taken horizontally through a window ventilator incorporating the present invention and Fig. 2 shows a cross-section taken vertically through the same ventilator. The section lines on one figure indicate the plane of the section in the other figure. Fig. 3 shows the theoretical type of filter section used in the window ventilator.

In window ventilators designed up to the present time the use of sound absorbing material and baffles to reduce the transmission of noise through its air passages has been common. The advantages to be derived from the combination of an acoustic filter with absorbing material and baffles reside in the characteristics of these two methods of attenuating sound in the air passages. The characteristics complement each other, the filter being most effective at frequencies where the absorbing material and baffles ordinarily provide little noise reduction, and the absorbing material and baffles being most effective at frequencies where the noise attenuation of the filter is small.

Sound absorbing materials are generally most efficient at frequencies above 500 cycles per second. Unless the material is very thick, in the order of three to six inches, its absorbing efficiency for frequencies below 150 cycles per second is approximately one-third that of 1000 cycles per second. A duct or air passage lined with sound absorbing material will, therefore, permit the passage of a greater portion of low-frequency sound energy than high-frequency sound energy unless very thick materials are used. In order that a window ventilator provide satisfactory reduction of street noise, it should attenuate as wide a range of frequencies as possible, since noise usually contains sound energy over a band of frequencies ranging from about 60 cycles to 8000 cycles or higher.

In ducts, the use of turns or baffles covered with sound absorbing material further assists in attenuating the higher frequencies more than the lower frequencies. Due to the laws of propagation of sound waves, baffles or turns absorb effectively only when the dimensions of the baffle or the cross-sectional dimensions of the turn

are large compared to the wave-length of the sound wave. From the foregoing discussion it may be seen that it is difficult to construct a compact window ventilator, having passages lined with sound absorbing material alone which will effectively attenuate low-frequency components of outside noise.

While it is possible to design acoustic filters to attenuate any desired frequency range, there are decided limitations in the attenuation range of an acoustic filter that can be used in a window ventilator whose main branches must have a large area in order to pass a large volume of air. It has been found that a filter of this type becomes ineffective for higher frequencies whose wave length is less than the cross-sectional dimensions of the main branches.

In a window ventilator the most desirable type of acoustic filter is a low-pass structure whose dimensions may be computed from the following formulas taken from Table II, Column I, of an article entitled "The Approximate Networks of Acoustic Filters" by W. P. Mason in the Journal of the Acoustical Society of America, January, 1930.

$$L = \frac{c}{2\pi f_a} \quad (1)$$

$$l' = \frac{\sqrt{2}c}{2\pi f_a} \quad (2) \quad 90$$

$$S_1 = \pi r_1^2 = \frac{f_2 \rho c}{Z_0 f_a} \quad (3)$$

$$S_2 = \pi r_2^2 = \frac{(f_a^2 - f_2^2) \rho c \sqrt{2}}{f_2 f_a Z_0} \quad (4) \quad 95$$

$$Z_0 = \frac{\rho c}{S_1 \sqrt{1 + \frac{l' S_2}{2 S_1 L}}} \quad (5)$$

where

c = velocity of sound = 34,000 cm./sec.

ρ = density of air = 0.001205 gram./cm.³.

Z_0 = characteristic impedance.

f_1, f_2, f_a are critical frequencies shown in the drawing labeled "Attenuation characteristic" in Column 1 of Table II.

L, l', S_1, S_2 , are dimensions as shown in the drawing labeled "Structure" in Columns 1 and 2 of Table II.

r_1 = radius of cylinder whose cross section area is S_1 .

r_2 = radius of cylinder whose cross section area is S_2 .

A more practical side branch construction is given in structure 5, Table I, of the above paper and for simplicity is reproduced in Fig. 3 of the present drawing. This construction is used in the filter incorporated in the particular window

ventilator described herein. The design formulas are:

$$v = \sqrt{\left[\frac{\text{Log} \left(\frac{r_1 + r_2}{2r_1} \right) + \frac{0.46}{t}}{T} \right] \left[(r_2^2 - r_1^2)T + \frac{r_1^2 t}{2} \right]} \quad (6)$$

$$S_2 = \pi \sqrt{\frac{\left[(r_2^2 - r_1^2)T + \frac{r_1^2 t}{2} \right]}{\left[\frac{\text{Log} \left(\frac{r_1 + r_2}{2r_1} \right) + \frac{0.46}{t}}{T} \right]}} \quad (7)$$

where r_1 , r_2 , t and T are dimensions as shown in the figure accompanying structure 5, Table I.

The above design formulæ presuppose an infinite structure. In order to obtain the same characteristics in a finite structure, it is necessary, therefore, to terminate the filter in its characteristic impedance, that is, the acoustic impedance at the sound output end of the main passage (as distinguished from the air output end, although they may be identical) should be equal to the characteristic impedance of the filter at all frequencies. When the sound output end of the passage terminates in free air, this condition does not exist. An exponential horn of the correct dimensions may be connected to the passage to provide the correct termination. For frequencies in the order of 100 cycles per second, the area of such a horn at the mouth must be over five square feet and for lower frequencies it must be greater. This is too large for a compact ventilator design. When, however, a duct having turns or baffles lined with an efficient sound absorbing material is connected to the sound output end of an acoustic filter, the attenuation characteristics are improved by the acoustic load impedance of the duct. Furthermore, the high frequencies that pass through the filter are attenuated by the absorbing material. The combination of filter and lined duct thus attenuates sound energy over a wide range of frequencies. The use of baffles at the filter opening to improve the performance of the filter by increasing the acoustic impedance into which the filter works constitutes another valuable feature of this invention.

In the particular design shown, the window ventilator 1 is mounted on an inside window sill 2. The lower window sash 3 is closed down on top of the outer vertical side 4 of the ventilator. The ventilator is fastened to the window frame 5 by means of a strip of metal 6 sliding jointly in the sash runway 7 and the slot 8 formed by the metal channel 9, which is fastened to the outer vertical side 4 of the ventilator. Air is drawn in through the outside opening 10 by the suction of the fan 12 being directed around the turn in the duct by vanes 11 as is common in ducts having sharp turns, and is forced through the cylindrical shaped low-pass acoustic filter 13.

The filter is built in two sections A and B. In accordance with common practice, section A has a lower cutoff frequency than section B so that the combination results in a better attenuation characteristic than two identical sections in tandem. Each section consists of tubes entering either end of a cylindrical chamber of larger dimensions, as shown in Fig. 3. For example, section A includes tubes 16 and 17 entering cylindrical chamber 14, while section B includes tubes 17

and 18 entering the still larger cylindrical chamber 15. The truncated conical shape of the main branches 16, 17 and 18 is such that air at high velocity will pass smoothly from one branch to the next in the direction indicated by the arrows, in accordance with aerodynamical theory. The transverse vanes 26 in the main branch 16 prevent any air turbulence in the filter due to the rotary motion imparted by the fan. After leaving the main branch 18 the air expands into the duct 20, being directed by vanes 19. As shown in Fig. 2, the air then passes around an expanding turn covered with absorbing material 22 on the far side and having vanes or baffles 21 of sound absorbing material, which prevent turbulence in the air flow and absorb noise. The velocity of the air is further reduced by expansion in the upper duct 23 to a point where there will be no appreciable air hiss at the outlet grille 25. Vanes or baffles 24 of sound absorbing material, whose curvature is reverse to that of the baffles 21, distribute the air uniformly along the outlet grille 25 and further attenuate the noise. The baffles, above described, increase the acoustic impedance into which the filter works and thereby improve the attenuation characteristics, as previously stated.

The absorbing material 27 is provided throughout and rubber mountings 28 are also provided, as shown on the drawing, to reduce the transmission of vibrations.

While the above description relates to a particular construction, it is to be understood that various modifications may be made in the design without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A ventilating device including an intake, means to draw air through said intake and force it through the ventilating device, an acoustical filter on the output side of said last-mentioned means, and an open-ended expanding chamber provided with sound absorbing baffles on the output side of said filter.

2. A ventilating device including an intake, means to draw air through said intake and force it through the ventilating device, an acoustical filter on the output side of said last-mentioned means, an open-ended expanding chamber on the output side of said filter, said expanding chamber being curved longitudinally and of gradually increasing cross-section as the outlet is approached, and curved vanes of sound absorbing material so positioned as to direct the air toward the opening and at the same time exercise a baffling effect for the sound.

3. A ventilating device including an intake, means to draw air through said intake and force it through the ventilating device, an acoustical filter on the output side of said last-mentioned means, an open-ended expanding chamber on the output side of said filter, said expanding chamber being developed in the form of a reverse curve and having gradually increasing cross-section as the output is approached, and curved vanes of sound absorbing material arranged at each turn of the expanding chamber to direct the air and exercise a baffling effect for the sound.

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