Feb. 14, 1933. P. E. GOOD 1,897,649

METHOD AND APPARATUS FOR MINIMIZING SOUND

Filed Dec. 27, 1929 2 Sheets-Sheet 1

Fig. 1.

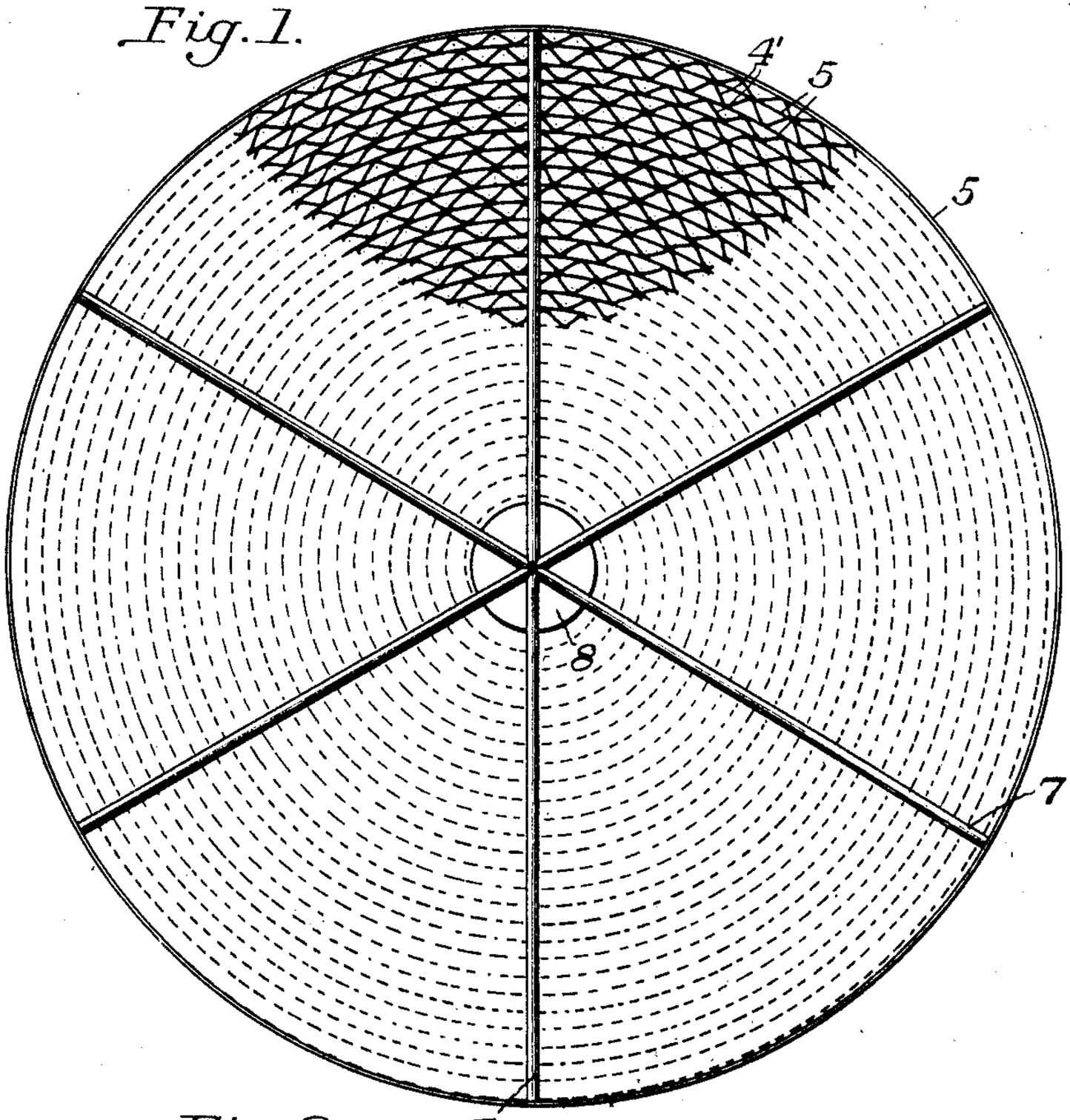
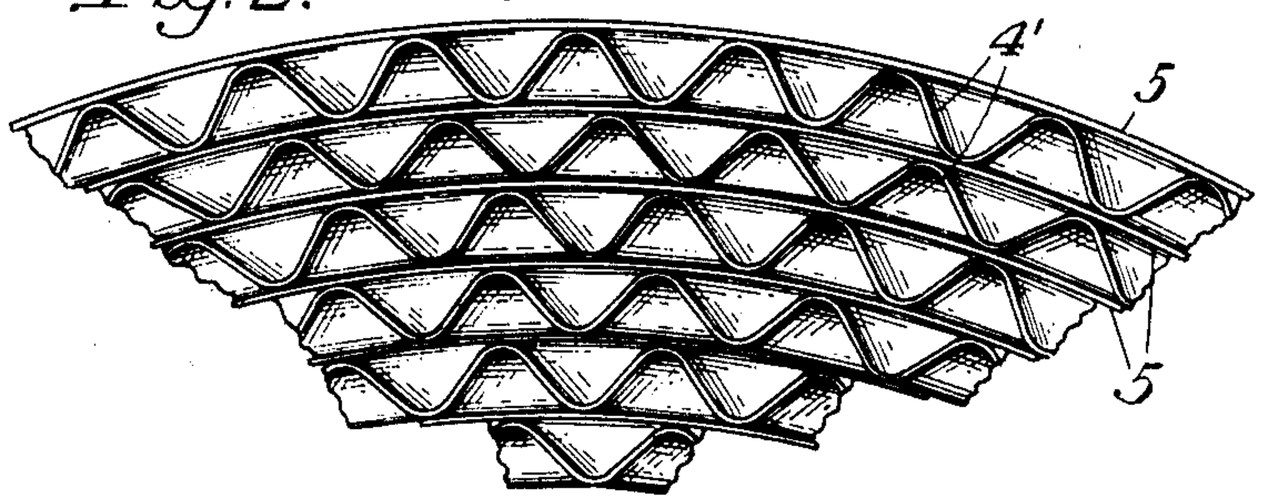


Fig. 2.



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Filed Dec. 27, 1929 2 Sheets-Sheet 2

Fig. 3.

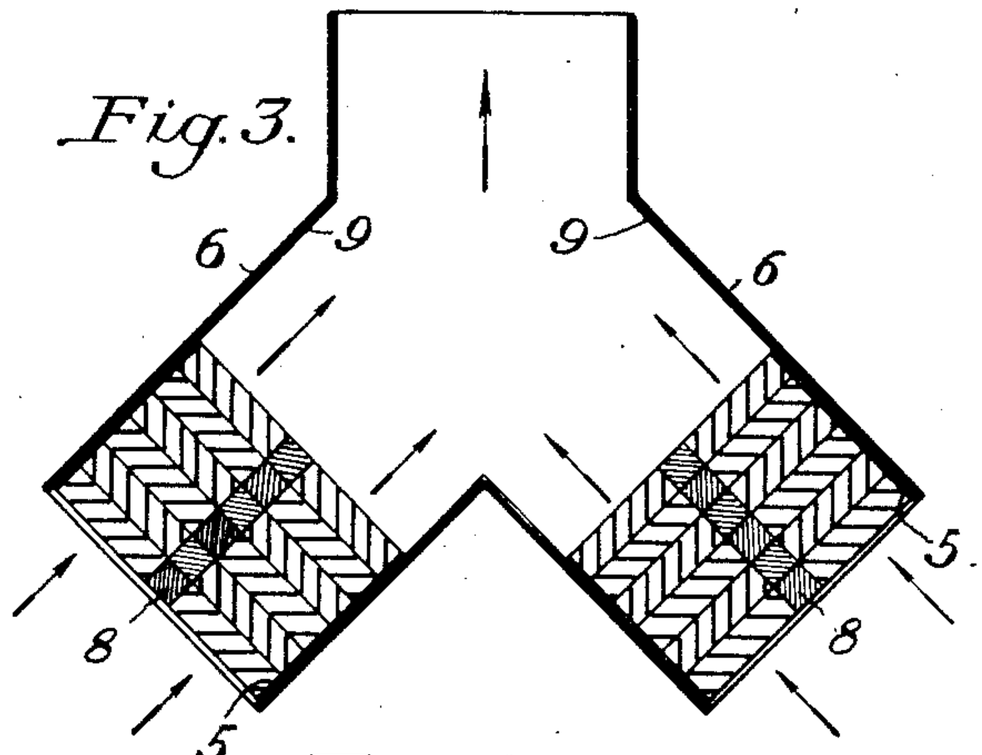


Fig. 4.

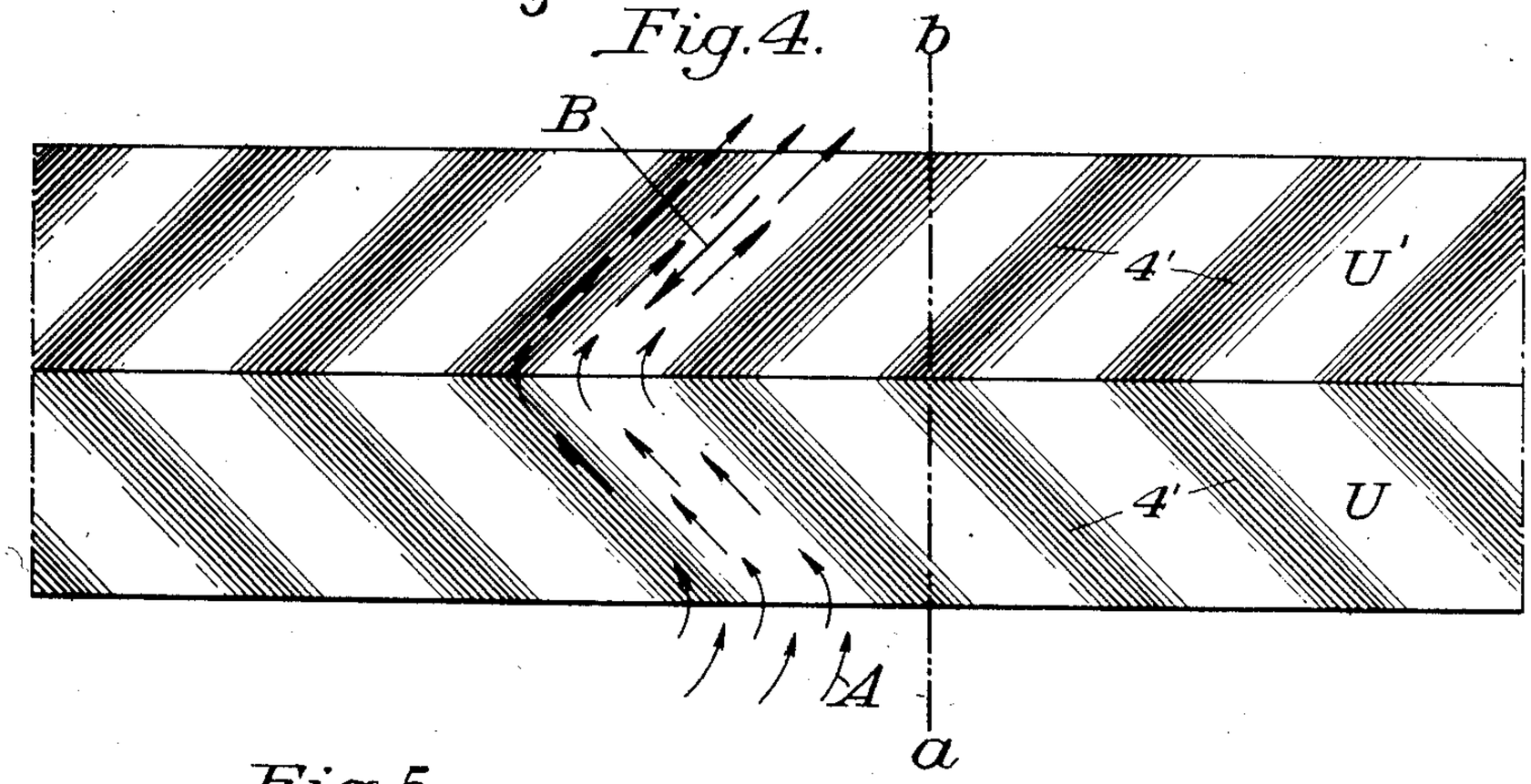


Fig. 5.

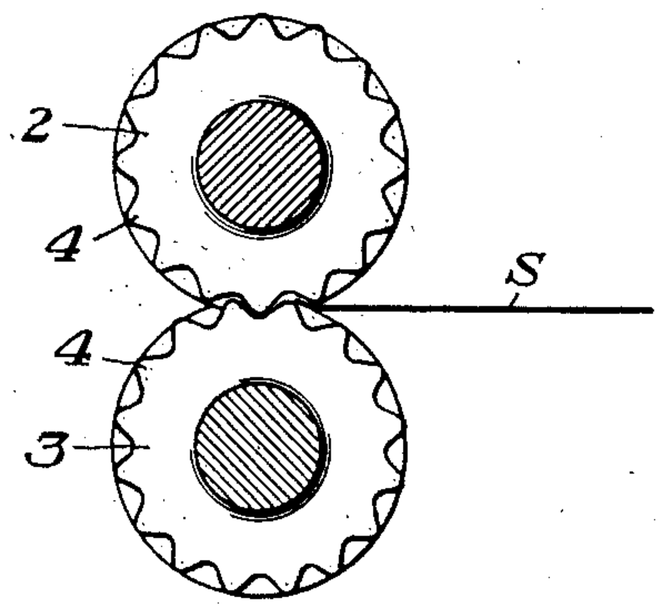
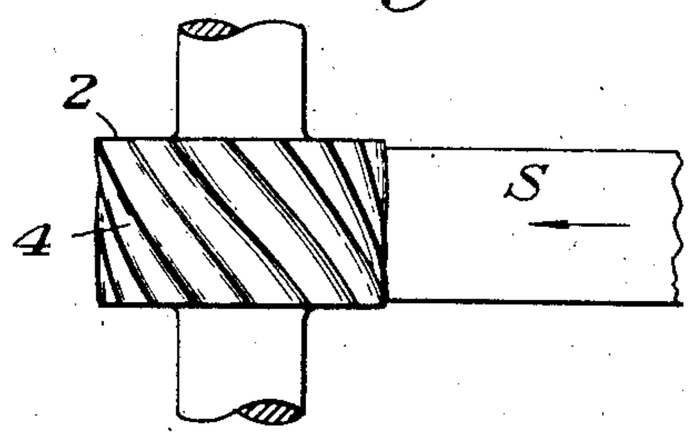


Fig. 6.



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR MINIMIZING SOUND

Application filed December 27, 1929. Serial No. 416,866.

The present invention relates broadly to the art of air handling in connection with blowers, compressors and the like, and more particularly to an improved method and apparatus for muffling or dampening sound waves set up in the air stream by such air handling mechanisms. For purposes of a clear understanding of the invention it will be described in connection with a blower, although it will be understood that the utility of the invention is not limited with respect to the particular construction or type of apparatus with which it is utilized.

Air entering a blower inlet, regardless of the care which is taken in the design of the blower itself, necessarily encounters some shock upon entering a rapidly rotating impeller. It is impossible by any means of design now known to completely avoid this shock and particularly with variable loads. It is likewise difficult, if not impossible, to design an apparatus which will carry even a fixed load without producing some noise.

The impact and the shock of the air produced by the rotating impeller sets up eddies and, in addition thereto, also produces noise, which is itself one form of wave vibration. The noises so produced may be of various pitches and are exceedingly objectionable. Inasmuch as the velocity of the air entering the blower impeller is below the acoustic velocity, the noise is transmitted backwardly through the air stream.

The present invention, therefore, has for one of its objects the provision of an improved construction such that the backward travel of such sound waves is interfered with or prevented to such an extent that objectionable noise is eliminated.

In the accompanying drawings I have shown for purposes of illustration only, a preferred embodiment of the present invention.

In the drawings, Figure 1 is a front elevational view of one form of muffling unit constructed in accordance with the present invention,

Figure 2 is a detail top plan view, on an enlarged scale, of a portion of the unit illustrated in Figure 1,

Figure 3 is a diagrammatic view, partly in section, illustrating one type of blower intake,

Figure 4 is a partial sectional view through a plurality of units in operative position within an intake as illustrated in Figure 3,

Figure 5 is a diagrammatic side elevational view of one form of apparatus for producing muffling strips of the character illustrated in Figure 2, and

Figure 6 is a top plan view of the construction illustrated in Figure 5.

Since sound is definitely known to be a wave phenomenon, baffling is recognized in the art as one means of producing silencing. The present invention utilizes baffling for the entering air such that the direction of the wave motion may be interfered with and the sound energy dissipated. High pitched noises, which are produced by extremely short sound waves, are the most objectionable to the ear, the most irritating to the nerves and the most penetrating. The present invention provides means for effectively eliminating sounds of this character.

In carrying out the present invention, I preferably proceed in the manner illustrated diagrammatically in Figures 5 and 6. In accordance with this disclosure, I take a strip S of relatively soft steel or similar material and pass it between corrugating rollers 2 and 3 having teeth 4 extending at an angle of approximately 45° to the axis of rotation and of such construction as to provide a sufficient space therebetween for the reception of the material. It will be apparent that after the strip has passed between the corrugating rolls it assumes a contour such as illustrated in Figures 1 and 2.

The length of the strip may initially be chosen with respect to the size of the unit which it is desired to produce. The necessary amount of corrugating material having been formed, it is matched with a spacing strip 5 having a width substantially equal to the width of the corrugated strip, but being substantially flat in cross section. The spacing strip 5 and the corrugated strip are then wound, in any desired manner, into the form of a unit substantially as illustrated in

Figure 1, having an outside diameter correlated to the inside diameter of the air intake 6 in which it is to be positioned. After the units have been formed, they may be held in assembled relationship in any desired manner.

The desired number of units having been constructed in the general manner referred to, they may be inserted in the intake of the blower or other device in the general manner illustrated in Figure 3. From this figure it will be apparent that adjacent units are reversed one with respect to the other so that the air entering the intake is subjected to repeated changes in direction each equal to substantially 90°, the actual air flow at any instant being at an angle of approximately 45° to the axis of the intake or to the axis of the units as a whole.

This condition is illustrated in detail in Figure 4 in which the arrows A represent the direction of flow of a given portion of the air. In this figure there are illustrated two units U and U′, the axes of the units being illustrated by the line *ab*. During travel of the air through the unit U, it flows at an angle of 45° to this axis. At the junction point between the two units it is deflected by an amount equal to twice the angle of obliquity of the individual corrugations, and thereby caused to travel through the unit U′ in a direction substantially normal to its direction of travel through the unit U.

During the time that the air is being transmitted through the silencer in the general manner illustrated in Figure 4, sound is being transmitted through the same path but in the opposite direction.

In the transmission of sound in an air column there are three phenomena which must be considered. The first of these is reflection, the second refraction, and the third diffraction, The present silencer is constructed with respect to each of these phenomena.

Considering first the phenomenon of reflection as applicable to sound waves, it is well known that waves are reflected backward from a surface against which they impinge by reason of the elastic nature of the air. The reflection is such that its angle is always exactly equal to the angle of incidence. With this general statement, it may be assumed that sound waves are travelling backwardly in the general direction indicated by the arrows B in Figure 4. It will be apparent that this direction is at exactly 90° to the up stream side of the corrugations 4′. This being true, the sound is reflected backwardly into the air column exactly in the direction from which it arrived. This tendency of the silencer to reflect the sound backwardly in exactly the same path as that from which it has come constitutes one of the features of the present invention.

Considering the question of refraction, it is well known that when sound is travelling in a medium such as air, and the air undergoes a change of velocity, there is a change in direction. When the air stream turns at the junction between the units U and U′, the inertia of the air tends to effect a compression, and sound, by the process of refraction, is transmitted around the corner. In this transmission around the corner, however, the air runs into a region of lower density due to the effect of centrifugal force, so that it is again refracted, again in the direction toward the center of curvature. Subsequently, the air impiges upon the wall of the confining passage and is reflected, or it is transmitted backwardly where it is subjected to a repetition of the previous conditions but in the opposite direction. In other words, the process of refraction continuously aids the sound waves to turn the corners provided, but in being refracted around such corners, refraction takes place to a greater degree than if there was no change of density in the air stream due to centrifugal force. As a consequence, the construction illustrated from the standpoint of refraction complicates the passage of sound waves so that they have no opportunity to be transmitted backwardly through any air column effect. The result of the construction, therefore, is such as to produce even greater complications in the refraction path.

Coming now to the question of diffraction, while it is true that the major portion of the sound wave travel is in a straight line, there is a continuous transmission of energy to a slight degree at angles diverging from the path or propagation. While it is a relatively insignificant method of transmitting sound, and is in reality nothing but a dispersion of the energy of the sound waves so that it accounts for very little of the sound transmission, it is nevertheless a component which must be taken into account if silence is to be considered. It is also more decidedly a significant factor with high pitched notes than with notes of low pitch. By providing a curved and involved path of the character herein referred to, diffraction is made much more difficult.

Units of the character herein described can be readily and inexpensively made in any desired sizes and shapes such that they may be quickly assembled in the desired relationship to function as a silencing medium. When so assembled they produce a multiple reflection of sound backward in the direction of propagation in a sinuous path of flow. The number of units may be varied at will so that the number of changes in the direction of movement of the air stream may be multiplied correspondingly and the confusion and absorption of deflective currents correspondingly increased. As a general

rule, however, it will be found that the higher the pitch of the notes being dealt with, the greater the number of units required.

I have herein considered the phenomena of reflection, refraction and diffraction of sound. The present structure, however, lends itself admirably to the utilization of materials such that sound may be minimized by absorption. If it is desired to make use of this phenomenon, the strip material S, utilized for the formation of the corrugations, may be of papier maché or of metal with a suitable absorbing coating applied thereto. This coating could obviously be of a rough material applied in semi-liquid form, or it could be in the nature of a woven fabric completely covering the same. In any event, the construction would be such that the material itself constituting the main portion of each of the units would possess absorbing characteristics. In such case it would also be desirable to construct the spacers 5 of similar material so as to gain all the advantage possible from absorption.

In Figure 1, one of the units is illustrated as having bracing means 7 extending in a generally radial direction. Such spacing means are not illustrated in Figure 4. It is apparent, however, that where they are provided they will tend to provide a slight space between adjacent units which might in some cases be desirable. It is obvious that the corrugations would not necessarily register as accurately as illustrated in Figures 3 and 4 and that in many cases at least the edge of one corrguated strip would lie directly over the opening in the adjacent element. A slight space between the units such as would be afforded by the reinforcing means 7 would provide against restriction in the air flow at points where the air is deflected through substantially 90°. Where the units are constructed with respect to absorption properties, the rods 7 would be of similar construction. This could be accomplished by utilizing ordinary electrical wire, for example, having a fabric or rubber coating thereon.

The center plug 8 illustrated in Figure 1 is desirable for two reasons. In the first place, it prevents the formation of a continuously open core through which sound waves could directly travel, and it provides a center on which the corrugated material may be conveniently wound. In case of a structure designed with respect to absorption properties, this plug would naturally be so selected as to likewise possess the desired degree of absorption.

Also, where the phenomenon of absorption is depended upon for the maximum benefits, the intake 6 may be of special construction such as obtained by a proper choice of material for the intake itself or by the application of a suitable coating or lining 9 thereto.

While I have herein illustrated and described a preferred embodiment of the present invention, it will be understood that changes in the construction, arrangement and contour of the individual parts and units may be made therein without departing either from the spirit of the present invention or the scope of my broader claims.

I claim:

1. In the method of preventing noise transmission, the steps comprising dividing an air flow into a series of separate air streams radially and circumferentially spaced, and subjecting the entire body of said air streams to repeated and successive changes in direction each substantially equal to 90°.

2. In the method of preventing noise transmission, the steps comprising producing an air flow in a generally axial direction, dividing the flow into a series of individual streams each progressing in an axial direction, and deflecting the entire flow of the individual streams at frequent and successive intervals by such an amount that the actual direction of travel at any time after initial deflection is at substantially 45° to said axial direction.

3. Silencing means for sound waves, comprising a unit including a corrugated strip-like body having corrugations extending at an angle of substantially 45° to its side edges.

4. Silencing means for sound waves, comprising a unit including superimposed layers of strip having corrugations extending at an angle of substantially 45° to the side edges of said strip, and a spacing strip intermediate successive layers.

5. As an article of manufacture, a sound silencing unit comprising superimposed layers of strip material having corrugations formed therein, each extending at substantially 45° to the side edges, and substantially smooth sided spacing strips intermediate the successive layers.

6. Silencing means, comprising a series of axially arranged, individual and readily separable units each including corrugated members having side edges and having corrugations extending at an angle of substantially 45° to both of the side edges of the members with the successive units reversed side for side to dispose the corrugations in successive units in opposite directions.

7. As an article of manufacture, a sound silencing unit, comprising superimposed spirally wound layers of strip material having sound absorption characteristics, the superimposed layers extending in completely overlapping relationship with the plane of the edges of successive convolutions of each layer normal to the general direction of fluid flow through the unit.

8. As an article of manufacture, a sound silencing unit comprising completely superimposed co-extensive layers of strip material

having sound absorption characteristics, said material having a series of corrugations formed therein with each corrugation extending generally transversely of the strip material.

9. As an article of manufacture, a sound silencing unit, comprising superimposed layers of strip material having sound absorption characteristics, said material having a series of corrugations formed therein, with each corrugation extending at an angle of substantially 45° to each of the side edges of the strip material.

10. Silencing means, comprising a series of identical units each unit comprising a plurality of superimposed layers of strip material having absorption characteristics, said units being axially alined with alternate units reversed side for side, said units being constructed to provide a tortuous flow path therethrough with the plane of the edges of all of the units substantially normal to the general direction of fluid flow through the silencing means.

11. Silencing means, comprising a series of similar units each including superimposed layers of strip material having aborption characteristics, said units being constructed to each provide a series of separate tortuous flow paths therethrough in each of the layers, the flow path in each of the units extending at an angle of substantially 90° to the flow path of adjacent units.

12. Silencing means for sound waves, comprising a substantially cylindrical unit including alternate layers of corrugated strip-like material and substantially flat spacing material, the corrugations in said strip-like material extending at an angle of substantially 45° to the opposite sides of the strip-like material.

13. Silencing means for sound waves, comprising a substantially cylindrical unit including a solid core having spirally wound therearound in alternate layers a spacing strip of substantially flat material, and a corrugated strip, with the corrugations in said last mentioned strip extending at an angle of approximately 45° to its edge portions.

In testimony whereof I have hereunto set my hand.

PAUL E. GOOD.