

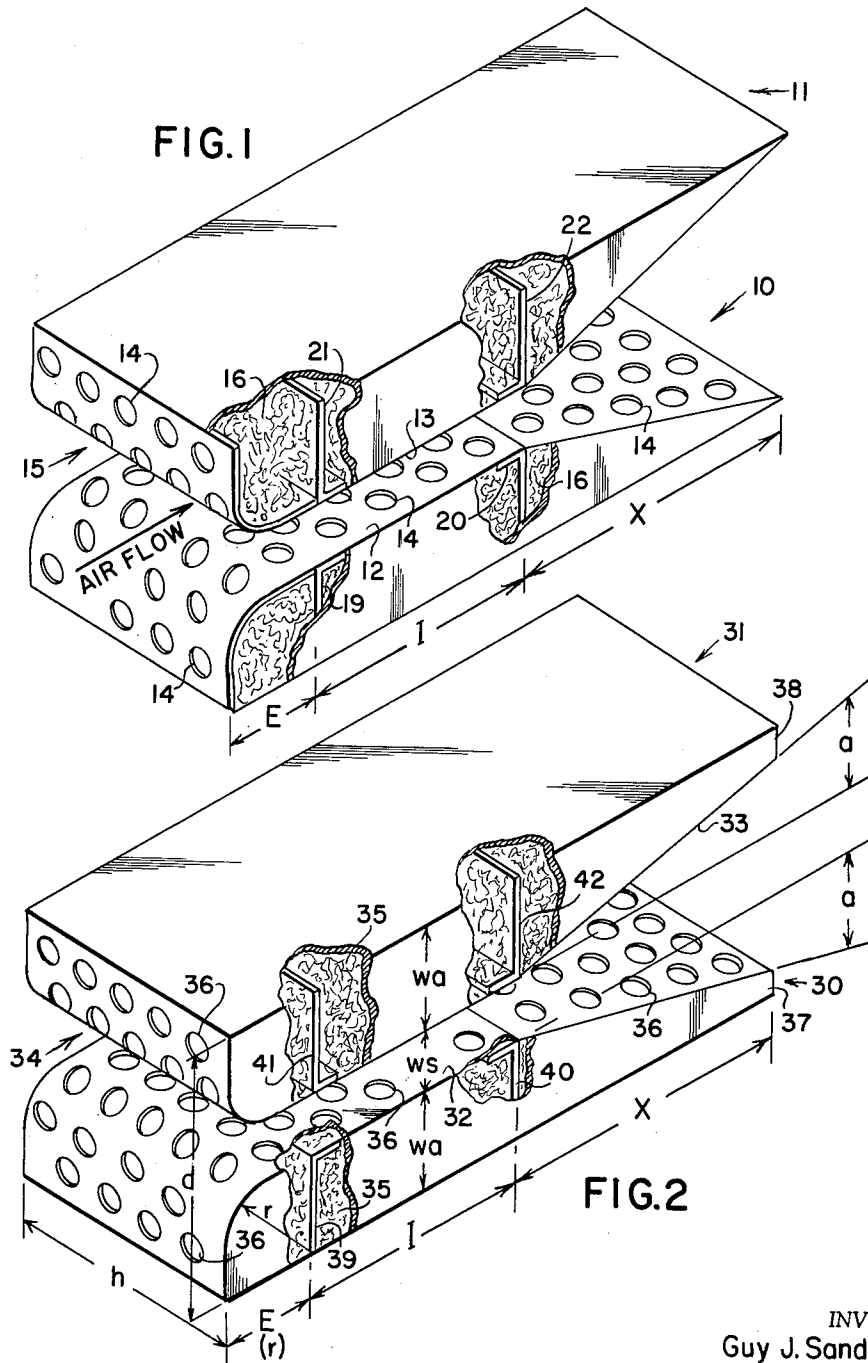
May 8, 1962

G. J. SANDERS ET AL
NOISE ATTENUATING APPARATUS

3,033,307

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3 Sheets-Sheet 1



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3 Sheets-Sheet 2

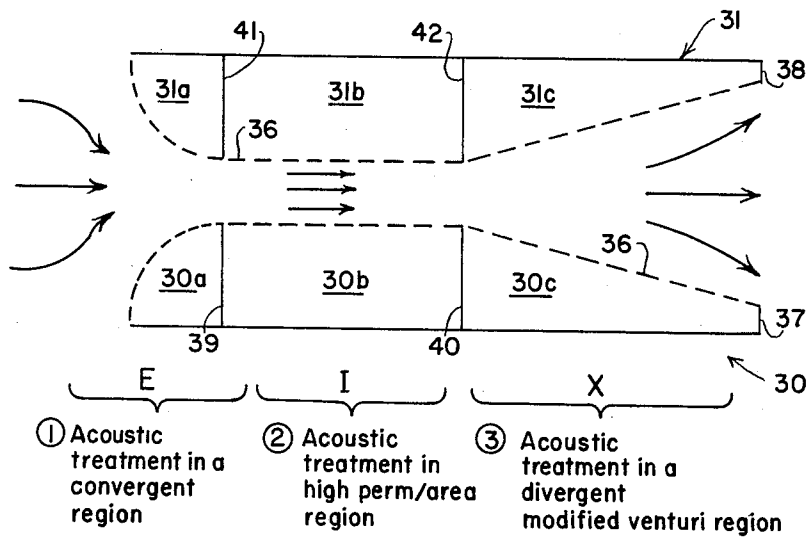


FIG. 3

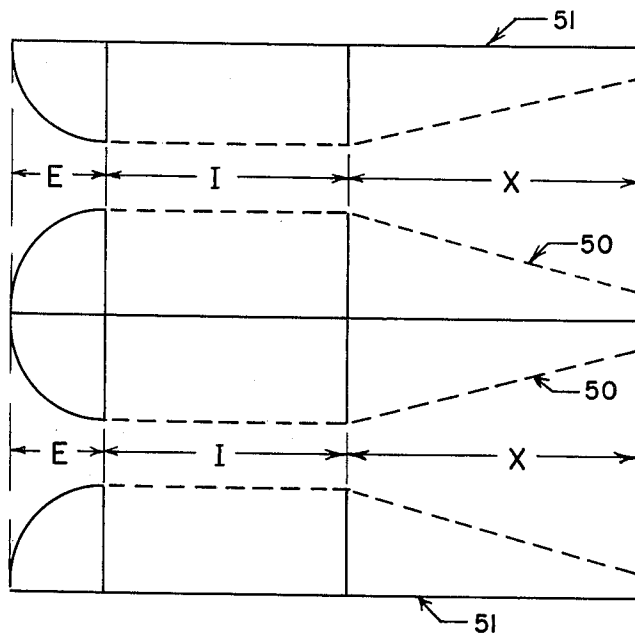


FIG. 4

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FIG. 5

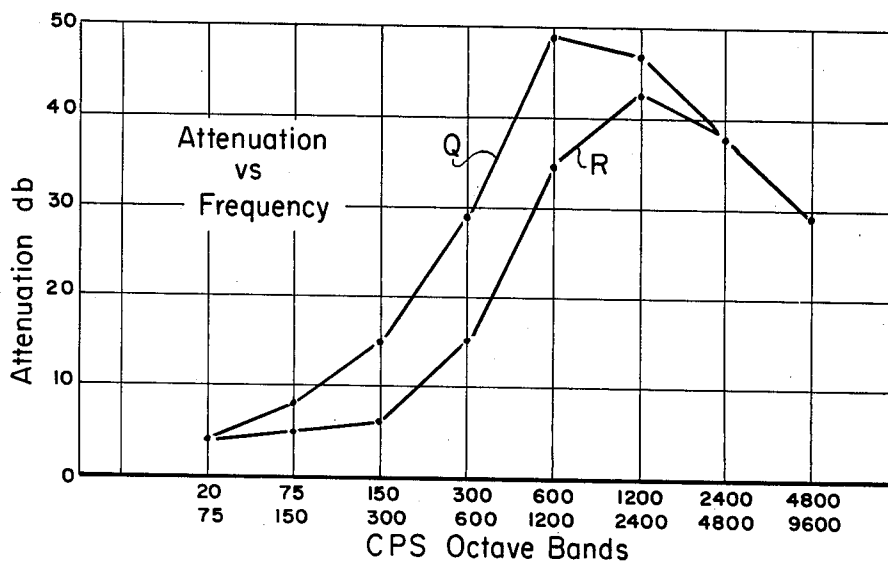
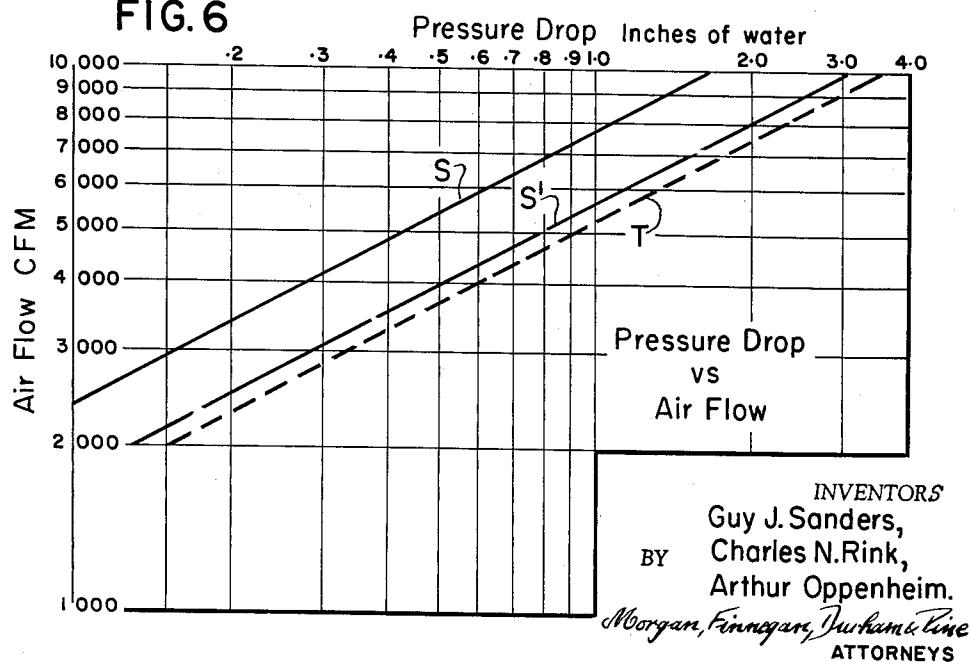


FIG. 6



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3,033,307

NOISE ATTENUATING APPARATUS

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15 Claims. (Cl. 181-59)

This invention concerns a method and apparatus for attenuating noise carried in a fluid medium and more particularly to both a method of controlling the treatment and the propagation path of the medium and to a duct designed according to the method, whereby high noise attenuation is attained and adverse pressure drops are avoided.

The movement of a fluid medium and the propulsion thereof as by a propeller, jet device, pump and the like, inevitably results in the generation of energy lying in the noise spectrum. Such energy is undesirable both in its deleterious effects on the listener and in its adverse reaction with mechanical structures.

The satisfactory elimination of such noise is an involved and complicated problem per se, and its difficulty is compounded because the suppression of noise frequently must be accomplished without developing pressure changes which have an adverse effect on the system associated with the generation of the noise. Additional complications arise because the fluid medium is frequently contaminated, being in some cases highly corrosive, and because very high temperatures are quite often involved.

The criteria for good noise suppression together with minimum pressure drop are frequently divergent. That technique which provides optimum noise attenuation is usually productive of high pressure drops, while arrangements providing negligible pressure drops are frequently ineffective in producing good attenuation.

Prior art solutions to the problem of noise suppression generally involve the use of perforated baffles to impede the flow of the medium in question and to create tortuous propagation paths. The use of absorptive materials, such as for lining ducts, and the use of resonant chambers are also found frequently in prior art structures.

A typical structure involving a combination of these elements might comprise a multiple duct system formed from splitters lined with absorbent materials. The splitters may be dimensioned so as to provide additional attenuation associated with resonance phenomena and explicit resonant chambers may even be supplied integrally with the splitters. The physical orientation of the elements is generally designed to provide a tortuous path, it being believed that this technique is necessary to effectively attenuate the higher frequency components of the noise.

These solutions have been more or less successful, but like most technological efforts there is substantial room for improvement. Noise continues to be a constant and perplexing problem as more powerful machines are built and as demands grow for even quieter surroundings. Silent operation is a much-sought-after virtue in practically all machinery including those associated with vehicles, industrial equipment, air conditioners and the like.

In meeting the stringent and continually increasing requirements for minimum noise, the problem of eliminating this noise without at the same time producing excessive pressure drop has become acute, especially since such pressure drops affect very substantially the performance of the machine in question. The limit on noise attenuation is quite frequently set by the maximum pressure drop which the system can tolerate. Compressors, jet

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engines, blowers and the like are designed to work in environments having specified pressure conditions. A noise attenuating system which disturbs these conditions is of course violating the primary function associated with the machine in question. In the extreme this is equivalent to shutting off the machine to eliminate the noise.

It is accordingly an object of the present invention to provide the prime function of noise control which is to achieve a maximum noise reduction with a minimum pressure drop. To this end the invention, in giving consideration to factors which affect both noise attenuation and pressure drop, provides a technique wherein the propagation path which describes the movement of the noise carrying medium is shaped and subjected to acoustic treatment techniques such that the medium itself is gradually confined to a region having a high perimeter-to-area ratio, is thereafter maintained in this region for a predetermined interval and is finally permitted to expand in a controlled fashion, all of these steps being accompanied by simultaneous acoustic treatment.

In accordance with the invention, a duct is provided having a controlled dimension to produce a novel contour and being acoustically lined for additional noise attenuation. Effective attenuation of noise energy is thereby accomplished notwithstanding the fact that the duct presents a straight-through or line-of-sight propagation path. Accompanying the high attenuation characteristic of the structure is an extremely low pressure drop feature such that the invention provides more attenuation per unit of pressure drop than functionally comparable devices known heretofore.

It is accordingly an object of the invention to provide a high noise attenuation characteristic without at the same time producing substantial pressure drops.

It is another object of the invention to provide a high ratio of attenuation to pressure drop with a simple, readily fabricated, and yet durable structure.

It is another object of the invention to provide the above described characteristics with a structure which is adaptable to service as a basic building block from which multi-unit sound control structures may be constructed.

These and other objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the methods, steps, instrumentalities and combinations pointed out in the appended claims.

The invention consists of the novel steps and method and the novel parts, constructions, arrangements, combinations and improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof illustrate embodiments of the invention, and together with the description, serve to explain the principles of the invention.

FIGURE 1 is a perspective sectionalized view of a two-cell unit with portions broken away;

FIGURE 2 is a perspective sectional view of another two-cell unit with portions broken away and having a different duct contour and with dimensional notation added;

FIGURE 3 is a schematic view with legends, graphically illustrating certain techniques of the invention;

FIGURE 4 is a diagrammatic view of a three-cell unit;

FIGURE 5 is a graph displaying comparative data representing attenuation characteristics as achieved by the invention versus attenuation of prior art devices; and

FIGURE 6 is a graph displaying comparative data relating to pressure drop as a function of flow rate in prior art devices, in a device built according to the invention, and in a device with certain features of the invention omitted.

In FIG. 1 there is illustrated a pair of stacked splitter units 10 and 11. Contoured surfaces 12 and 13, including a curved entrance, E, straight intermediate region, I, and tapered exit, X, are arranged adjacent each other, one splitter thereby being the mirror image of the other and the contoured surfaces thus forming the upper and lower boundaries of duct passageway 15. It should be noted in this connection that the duct may be arranged as illustrated in FIGURE 1 or rotated through any angle, e.g. 90°, so that the long transverse dimension of passageway 15 need not be horizontal. Accordingly, the terms "upper and lower" and "left and right" are given in a relative sense only.

For bounding the sides of the duct passageway, flat plates (not shown), with or without absorbent material may be used. These plates may also serve as side covers for splitters 10 and 11.

Filling the interior of the splitters 10 and 11 is an acoustic absorbent material 16 such as glass fibre. The absorbent material 16 may be matted or randomly arranged and may have a uniform or variable density, the choice depending upon the particular attenuation characteristic desired. For some applications the interior of the splitters may be left empty or merely lined so as to provide resonant chambers. For subjecting the noise carrying medium passing through passageway 15 to the acoustic treatment provided by the splitter interiors, the contoured surfaces 12 and 13 are perforated as by holes 14, so that acoustic energy is coupled to the absorbent material or resonant chambers to provide attenuation.

As disposed in splitters 10 and 11, the absorbent material 16 subjects the sound energy carried in the medium passing through the duct to a dissipative attenuation and by this means the sound amplitude is reduced. This attenuation is optimized by virtue of the high cross-sectional perimeter-to-area ratio in the intermediate, minimum width, section I of passageway 15. However, such a high ratio, while ideal from the viewpoint of attenuation, introduces a problem associated with the transition section E extending from the intake of the duct to this intermediate restricted section. The problem is again manifested in the transition region X extending from the intermediate section to the duct outlet. Because such transitions generally introduce substantial pressure drops, the art has heretofore avoided the utilization of a region having an optimum perimeter-to-area ratio. The applicants have determined, however, that by a special contouring of the transition regions the medium may be introduced to, and educted from, a restricted area having a high perimeter-to-area ratio without producing excessive pressure drop.

In part, this result is achieved by providing the entrance portion E of the duct with a generally bell-shaped configuration. Accordingly, the medium as it enters the duct between splitters 10 and 11 is gradually confined in a smooth and continuous manner and the pressure drop is accordingly minimized. The loss coefficient for such a bell-shaped entrance generally approximates the value .05, loss coefficient being understood in its normal sense as representing the ratio of head loss to velocity head.

While the above described inlet region E provides a smooth transition from the duct entrance to the intermediate region I, it is not effective in dealing with the problem of expanding the passageway in the exit portion, X. Such an expansion is required if pressure recovery is to be achieved, and yet the turbulence and drag which accompanies a change in cross-sectional area has to be minimized in order that losses can be minimized.

To the end that an optimum expansion can be realized, the venturi principle may be exploited. This principle establishes the fact that such an optimum expansion can be realized with a divergence angle of approximately $2\frac{1}{2}^{\circ}$ – $3\frac{1}{2}^{\circ}$. See Russell, G. E., *Textbook of Hydraulics*, Holt, N.Y., 1918, pp. 79–80, 123–126. (This angle will hereinafter be referred to as the "venturi" angle.) This

range represents a compromise between drag and turbulence; its implementation in the structure of FIGURE 1 is evident in the exit section X where surfaces 12 and 13 each diverge in the range $2\frac{1}{2}^{\circ}$ – $3\frac{1}{2}^{\circ}$ with respect to the longitudinal axis of the duct. (The total duct angle is 5° – 7° which is the same as the total optimum venturi angle.) By this arrangement the structure of FIGURE 1 enables acoustic treatment of the medium in a constricted high perimeter/area region with a subsequent expansion and concurrent acoustic treatment which provides maximum attenuation per unit of pressure drop, an accomplishment which insures successful noise attenuation.

While a passageway with a venturi divergence angle provides optimum expansion in that there is a minimum pressure loss, this venturi angle, being extremely small, frequently results in a prohibitively long structure. Accordingly, the art heretofore has favored a unit of practical size with a divergence angle considerably greater than $2\frac{1}{2}^{\circ}$ – $3\frac{1}{2}^{\circ}$ in which there is a linear expansion from the intermediate region of the duct to the outlet of the duct. The transition was accomplished, therefore, in a reasonably smooth and continuous manner although losses were admittedly not minimized.

In contrast with the prior art technique, the applicants have effectively combined a divergence angle greater than the optimum venturi value with an abrupt change in duct cross-sectional area and have effectively applied this technique to ducts where a venturi angle would be impossible to implement. Such an arrangement is shown in FIGURES 2–4.

It would seem in view of the foregoing that a passageway with an angle of divergence substantially different from the venturi value and with a sharp change in cross-sectional area as illustrated in FIGURES 2–4 would be unsatisfactory from the viewpoint of minimizing pressure drop and would also be unsatisfactory in that turbulence would be generated with a concomitant generation of noise. The applicants have determined, however, that this is not true, that it is in fact possible to minimize pressure drop even though the angle of divergence is greater than the venturi angle and is accompanied by an abrupt change or discontinuity in cross-sectional area. The pressure drop obtained by such a combination is actually smaller than the pressure drop obtained by a straight line, non-venturi divergence from the point of minimum width to the point of maximum width, which, as was noted above, is the type of expansion generally employed in the art. In the prior art technique abrupt changes in cross-sectional area are avoided, but the applicants have found that a comparatively large divergent angle when combined with such a discontinuity can produce a minimum pressure drop if the angle of divergence is properly selected in combination with the area change at the discontinuity. Accordingly, a structure of practical size is realized and at the same time the structure produces more attenuation per unit pressure drop than any duct known heretofore.

The duct of FIGURE 2 which implements the above feature of the invention comprises a pair of stacked splitters 30 and 31 arranged so that one is the mirror image of the other. Contoured surfaces 32 and 33 lie adjacent and form the upper and lower boundaries of passageway 34. Aside from the shape of the exit section the unit of FIGURE 2 is similar in structural detail to the unit of FIGURE 1. Accordingly, the interiors of splitters 30 and 31 are filled with absorbent material 35 such as glass fibre but as noted with respect to the structure of FIGURE 1, the interiors may comprise hollow chambers with or without an absorbent lining to provide attenuation according to resonant effects. For subjecting the noise carrying medium transmitted through passageway 34 to the acoustic treatment, perforations 36 in contoured surfaces 32 and 33 are provided. These perforations may cover the entire contoured surfaces including the entrance region E, intermediate region I, and exit

section X. Perforations may also be provided on trailing surfaces 37 and 38, but this feature is not essential.

With the input transition region E contoured as indicated and described, the noise carrying medium may be confined to an area having a large perimeter-to-area ratio, thus optimizing the acoustic treatment; the medium may then be allowed to expand in a controlled fashion as noted more fully hereinafter with a concurrent acoustic treatment, without the generation of pressure drops normally encountered in prior art structures.

It may be seen from the above that the geometric characteristics of the duct play an important role in attaining maximum attenuation per unit of pressure drop. Dimensions are also important and by way of providing an exemplary set of values, reference may be had to the dimensional notation of FIGURE 2. Except as otherwise noted, these dimensions apply to all the structures illustrated.

Before considering specific dimensions it should be observed that insofar as geometric properties are concerned, the cross-section of the duct passageways, 15, FIGURE 1 and 34, FIGURE 2, are rectangular. This feature results from the desirability of subjecting the noise carrying medium to acoustic treatment in a region having a high perimeter-to-area ratio. Such a high ratio is best achieved with a rectangular structure in which one side is substantially longer than the other. The perimeter/area ratio of such a configuration is substantially greater than a circular or square configuration having an equivalent cross-sectional area. Thus, in FIGURE 2 the transverse dimension h is large compared with the transverse dimension w_s , thereby insuring such a condition.

In addition to being small compared with dimension h , the transverse dimension w_s in region I should be in general less than $2w_a$ where w_a is the splitter thickness in region I. Stated alternatively, the width d of the passageway at the entrance to the duct is $2w_a + w_s$. This is seen in FIGURE 2. Since $2w_a$ is greater than w_s , then d is greater than $2w_s$ or, w_s is less than $d/2$. In the example given hereinbelow w_s is actually less than w_a , in which case w_s is less than $d/3$. All of these dimensions may be related to wavelength by noting that dimension w_a will in general be equal to one-quarter the wavelength of the frequency of interest for optimum silencing, this frequency lying generally in the central region of the noise spectrum. The radius r shown in FIGURE 2 is preferably equal to w_a , but it should be noted that acceptable convergence may be achieved by a sloping inlet having other than a circular contour. A straight line converging entrance with faired leading and trailing edges (not shown) has been found to minimize pressure drop to an acceptable degree for some installations. As for the dimension I, it is assigned a value in accordance with the total attenuation desired. Thus, if the region I provides in the frequency range of interest an attenuation of 10 db per foot and the required total attenuation is 30 db, then a length of three feet is selected.

The divergence angle α as is noted hereinbefore is an important consideration in minimizing pressure drop. In FIGURE 1, the optimum venturi angle is employed. For a configuration similar to the one shown in FIGURE 2, the optimum angle has been determined to be 6° semi-angle (total angle 12°). This angle depends, however, upon the distance X which is available for expanding the propagation path and on the relation between w_s and w_a . The optimum angle for a particular value of X and w_s/w_a may be found by a test or by plotting the relationship describing the pressure loss as a function of (1) the velocity head in the intermediate region I, (2) the loss coefficient for the exit section X, (3) the loss coefficient for the abrupt expansion at the termination of the splitters, and (4) the ratio of outlet velocity (at the trailing edge of the exit section X) to the intermediate velocity (in region I), and thereafter determining graphically or

otherwise, that area ratio which provides minimum pressure drop for the assigned value of X.

The attributes assigned above to the structures of the invention depend upon an additional structural feature which has not been described thus far. This feature relates to the septa 19 and 20 of splitter 10, the septa 21 and 22 of splitter 11, and the corresponding elements 39-42 of FIGURE 2. Without these septa or functionally equivalent arrangements, the actual performance of the ducts described in FIGURES 1 and 2 is not optimum. The reason for this has been found to be associated with extraneous propagation paths which couple region E to region I and region I to region X. In the absence of septa or equivalent elements it has been observed that components of the noise carrying medium pass into the interior of the splitters in the entrance region E thereafter passing out of the splitters and into the passageway 15, 34 in the intermediate sections I. Similar phenomena has been observed at the exit section where extraneous paths originate in the intermediate section I, pass through the interiors of the splitters and return again to the duct passageway at exit region X. The effect of these extraneous paths is to mar the uniform and continuous flow of the medium through passageway 15, 34, the resultant choking and turbulence generating additional noise and corrupting the low pressure drop characteristic of the duct.

It was found that these conditions could be eliminated by utilizing the septa 19 to 22 in FIGURE 1 and 39 to 42 in FIGURE 2, which elements introduce a high static impedance in these potential side paths, thus preventing flow over these routes and consequently eliminating the resultant turbulence. These septa may also serve as mechanical stiffeners for the splitters. They need not be impervious to acoustic energy but should be impervious to steady state velocity transmission.

As an alternative arrangement to that shown in FIGURES 1 to 3, the entrance septa may be replaced by giving the entrance surfaces E an imperforate character. Such an arrangement is illustrated in FIGURE 4. As before, these surfaces may be suitable for the transmission of acoustic energy but should be impervious to steady state transmission.

FIGURE 3 illustrates in summary fashion the general characteristics described heretofore. It may be observed in this figure that the medium in which the noise energy is propagated, while being concurrently subject to acoustic treatment, is gradually confined to a region having a high perimeter/area ratio and is thereafter allowed to expand in a controlled manner in a venturi exit, or as illustrated, in a modified venturi exit. Insuring a properly controlled transmission of the medium are the septa 39-42 illustrated diagrammatically at the entrance and exit regions.

In illustrating the conditions to which the medium is subjected, the legend "acoustic treatment" has been employed since as mentioned hereinbefore the invention contemplates attenuation by the action of an absorbent material such as glass fibre, attenuation by high passageway impedance and attenuation by resonance phenomena. To this end the chambers bounded by the septa 39 to 42 and the external surfaces of splitters 30 and 31, designated 30a, 30b and 30c in splitter 30, and 31a, 31b and 31c in splitter 31, may be dimensioned so as to act as resonators. These alone, or in combination with absorbent material provide the acoustic treatment which accompanies the dimensionally controlled movement of the noise carrying medium. When such chambers are used, perforations 36 may be altered in number, position and dimension to provide coupling of the chambers to the medium at optimum points along the transmission path.

By way of observing a comparison between the duct of FIGURES 1 to 3 and a prior art arrangement, reference may be had to FIGURES 5 and 6. FIGURE 5 is a co-

ordinate plot of attenuation in decibels as a function of frequency expressed in octaves. The results plotted are for a three-foot long unit constructed in accordance with the present invention (curve Q) and for a similar sized unit embodying prior art techniques (curve R). It may be observed that the attenuation achieved by the disclosed structure is markedly superior throughout almost all of the noise spectrum. Moreover, although not evident in this graph, the pressure drop in the prior art arrangement is one and one-half times that of the disclosed structure so that the improvement is two-fold.

Illustrated in FIGURE 6 is a plot on a logarithmically arranged scale of pressure drop as a function of air flow in a prior art device (curve T) and in the present device with (curve S) and without (curve S') septa. These results were obtained in ducts having dimensions 2' x 2' x 3' having equivalent attenuation.

In employing ducts designed according to the present invention, individual units may be used as such or the units may be stacked transversely of the propagation path, side by side or vertically to form extended passageways or multiple passageways or both. An illustration of a vertical stacking of the duct units is found in FIGURE 4 where a duct formed by splitters 50 and 51 is combined with another duct formed by identical splitters 50 and 51. The unit of FIGURE 4 may also be constructed as a single basic unit instead of being formed by the installation of two separate units. Moreover, the single splitters 50 may be replaced by substantially flat wall members with suitable accompanying acoustic treatment provided, for example, by an absorbent lining applied to the walls. While performance is somewhat reduced by such a modification, it is nevertheless superior to presently known arrangements. The arrangement of FIGURE 4 is otherwise similar to the structure of FIGURES 2 and 3 except for the use of imperforate entrance sections as noted hereinbefore.

For purposes of illustration a set of data are provided herein to serve as a guide in constructing a duct according to the principles of the invention, the data having reference to FIGURE 2:

- (1) Splitter material—#22 gauge galvanized, perforated steel sheet with $\frac{3}{32}$ " diameter holes on $\frac{3}{16}$ " staggered centers.
- (2) Septa-stiffeners—#22 gauge galvanized steel angled at ends for welding to stiffener surface.
- (3) Absorbent material—glass fibre.
- (4) External duct walls—#22 gauge galvanized steel.
- (5) Assembly—splitter surfaces tabbed to provide contact surfaces which are welded to sides of duct; edges of duct walls crimped and turned over to form interlocking connections.
- (6) Dimensions:

w_s	-----	2 $\frac{7}{8}$ "
w_a	-----	4 $\frac{9}{16}$ "
E	-----	4 $\frac{9}{16}$ "
I	-----	11 $\frac{1}{4}$ "
X	-----	14 $\frac{3}{16}$ "
a	-----	6"
h	-----	12"

It is seen from the above that h is more than $4w_s$. The perimeter-area ratio in region I is calculated thus:

$$P/A = \frac{2(h + w_s)}{hw_s}$$

For simplification assume $h = 4w_s$. Then

$$P/A = \frac{2(h + h/4)}{h^2/4} = \frac{10}{h}$$

For $h = 12$, then $P/A = 5/6$. Since $h > 4w_s$ then P/A in the example is greater than $5/6$.

The invention in its broader aspects is not limited to the specific mechanisms shown and described but de-

partures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having an intermediate region of substantially rectangular cross section the long side dimension of which is at least four times that of the short side, said wall members having leading end sections forming a smoothly converging entrance to said intermediate region of said duct and trailing end sections forming a tapered and truncated exit section having an included angle of taper greater than 7° whereby pressure recovery is optimized without sacrificing compactness.

2. Acoustic means including a plurality of pairs of opposing wall members configured according to claim 1 to form a plurality of said ducts.

3. Apparatus according to claim 1, in which the included angle of taper of said exit section is approximately 12° .

4. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having a perimeter-area ratio greater than approximately $5/6$ and a divergent and truncated exit section having an included angle of divergence greater than 7° .

5. Acoustic means as claimed in claim 4 in which at least one of said wall members includes acoustic absorbent material of a thickness greater than $\frac{1}{2}$ the minimum spacing between said wall members.

6. Acoustic attenuating means for use in a conduit conducting noise bearing fluid comprising at least two opposing wall members forming a passageway, one lateral dimension of said passageway between said wall members varying progressively in an entrance region along the direction of propagation from a predetermined entrance value to a decreased value less than one-half said entrance value, said decreased value occurring at one boundary of a constricted region in said passageway having a cross-sectional dimension greater than four times said decreased value, said lateral dimension thereafter increasing gradually and then abruptly in a divergent region having an angle of taper greater than 7° , said wall members also including acoustic attenuation means and septum means.

7. Acoustic attenuating means for use in a conduit conducting noise bearing fluid comprising at least two opposing wall members forming a passageway, said wall members being spaced and contoured whereby one lateral dimension of said passageway between said wall members varies progressively in an entrance region along the direction of propagation from a predetermined entrance value to a decreased value in a constricted region between said wall members, said constricted region having a perimeter-area ratio greater than $5/6$, said lateral dimension thereafter increasing gradually then abruptly in a divergent region having an included angle of taper greater than 7° , said wall members also including acoustic attenuation means in said entrance, constricted and divergent regions and septum means, said septum means being located to impede transmission of the medium within said wall members from the entrance region to the constricted region and from the constricted region to the divergent region.

8. Acoustic attenuating means for attenuating audio-frequency sound in a gaseous medium comprising at least two opposing wall members forming a duct for said medium, one lateral dimension of said duct varying progressively along the direction of propagation from a predetermined entrance value to a decreased value less than $\frac{1}{2}$ said entrance value, said decreased value being maintained substantially constant in a constricted region of

rectangular cross-section having dimensions in a ratio greater than 4, said lateral dimension thereafter increasing, in a divergent region having an included angle of divergence greater than 7° in a substantially linear manner and thereafter changing abruptly to an increased value, said wall members also including acoustic attenuation means.

9. Line-of-sight attenuating means for attenuating acoustic energy in a flowing gaseous medium comprising spaced wall members oriented to provide a relatively long, smooth passage for the flow of gaseous medium between them, said spaced wall members being formed as acoustically absorbing members having a perforated wall adjacent the passage, at least one of the wall members being smoothly curved near the entrance of the passage and tapered and truncated at the exit portion of the passage to form a passage which is of gradually diminishing width in the entrance portion, of constant width in an intermediate portion having another cross sectional dimension greater than approximately four times said constant width, and of gradually increasing and then abruptly increasing width in the exit portion, said exit portion having an included angle of taper greater than 7° , said constant width being less than twice the thickness of one of the wall members, and a transversely extending partition in at least one of said wall members impervious to the transmission of said medium and dividing said wall into separate chambers.

10. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having an intermediate region of substantially rectangular cross section the long side dimension of which is at least four times that of the short side, said wall members having leading end sections forming a smoothly converging entrance to said intermediate region of said duct, the cross section in said entrance having a side corresponding with said short side which is greater than three times said short side, and trailing end sections forming a tapered and truncated exit section having an included angle of taper greater than 7° whereby pressure recovery is optimized without sacrificing compactness.

11. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having an intermediate region of substantially rectangular cross section the long side dimension of which is at least four times that of the short side, said wall members having leading end sections forming a smoothly converging entrance to said intermediate region of said duct and trailing end sections forming a tapered and truncated exit section having an included angle of taper greater than 7° , said trailing end

sections including an abrupt bend at the terminus of said taper for forming said truncation, whereby pressure recovery is optimized without sacrificing compactness.

12. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having an intermediate region of substantially rectangular cross section the long side dimension of which is at least four times that of the short side and the perimeter/area ratio of which is greater than approximately $5/6$, said wall members having leading end sections forming a smoothly converging entrance to said intermediate region of said duct and trailing end sections forming a tapered and truncated exit section having an included angle of taper greater than 7° whereby pressure recover is optimized without sacrificing compactness.

13. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating perforated wall members forming a duct having an intermediate region of substantially rectangular cross section the long side dimension of which is at least four times that of the short side, said wall members having septa for isolating said intermediate region and having leading end sections forming a smoothly converging entrance to said intermediate region of said duct and trailing end sections forming a tapered and truncated exit section having an included angle of taper greater than 7° whereby pressure recovery is optimized without sacrificing compactness.

14. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having a perimeter-area ratio greater than approximately $5/6$ and a divergent and truncated exit section having an included angle of divergence greater than 7° , said wall members being perforated and including acoustic absorbent material.

15. For use in a conduit conducting noise bearing fluid, acoustic means comprising opposing acoustic attenuating wall members forming a duct having a perimeter-area ratio greater than approximately $5/6$ and a divergent and truncated exit section having an included angle of divergence greater than 7° , said wall members being perforated and including acoustic absorbent material and said duct providing line-of-sight transmission therethrough.

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