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Description

Technical Field

This invention relates to diffusers.

Background Art

Diffusers are well known in the art. Webster's New Collegiate Dictionary (1981) defines diffusers as "a device for reducing the velocity and increasing the static pressure of a fluid passing through a system". The present invention is concerned with the most typical of diffusers, those having an inlet cross-sectional flow area less than their outlet cross-sectional flow area. While a diffuser may be used specifically for the purpose of reducing fluid velocity or increasing fluid pressure, often they are used simply because of a physical requirement to increase the cross-sectional flow area of a passage, such as to connect pipes of different diameters.

As hereinafter used in this specification and appended claims, "diffuser" shall mean a fluid carrying passage which has an inlet cross-sectional flow area less than its outlet cross-sectional flow area, and which decreases the velocity of the fluid in the principal flow direction and increases its static pressure.

If the walls of the diffuser are too steep relative to the principal flow direction, streamwise, two-dimensional boundary layer separation may occur. Streamwise, two-dimensional boundary layer separation, as used in this specification and appended claims, means the breaking loose of the bulk fluid from the surface of a body, resulting in flow near the wall moving in a direction opposite the bulk fluid flow direction. Such separation results in high losses, low pressure recovery, and lower velocity reduction. When this happens the diffuser is said to have stalled. Stall occurs in diffusers when the momentum in the boundary layer cannot overcome the increase in pressure as it travels downstream along the wall, at which point the flow velocity near the wall actually reverses direction. From that point on the boundary layer cannot stay attached to the wall and a separation region downstream thereof is created.

To prevent stall a diffuser may have to be made longer so as to decrease the required diffusion angle; however, a longer diffusion length may not be acceptable in certain applications due to space or weight limitations, for example, and will not solve the problem in all circumstances. It is, therefore, highly desirable to be able to diffuse more rapidly (i.e., in a shorter distance) without stall or, conversely, to be able to diffuse to a greater cross-sectional flow area for a given diffuser length than is presently possible with diffusers of the prior art.

Diffusers of the prior art may be either two- or three-dimensional. Two-dimensional diffusers are typically four sided, with two opposing sides being parallel to each other and the other two opposing sides diverging from each other toward the diffuser outlet. Conical and annular diffusers are also sometimes referred to as two-dimensional diffusers. Annular diffusers are often used in gas turbine engines. A three-dimensional diffuser can for example, be four sided, with both pairs of opposed sides diverging from each other.

One application for a diffuser is in a catalytic converter system for automobiles, trucks and the like. The converter is used to reduce exhaust emissions (nitrous oxides) and to oxidize carbon monoxide and unburned hydrocarbons. The catalyst of choice is presently platinum. Because platinum is so expensive it is important to utilize it efficiently, which means exposing a high surface area of platinum to the gases and having the residence time sufficiently long to do an acceptable job using the smallest amount of catalyst possible.

Currently the exhaust gases are carried to the converter in a cylindrical pipe or conduit having a cross sectional flow area of between about 16-32 cm^2 (2.5 - 5.0 square inches). The catalyst (in the form of a platinum coated ceramic monolith or a bed of coated ceramic pellets) is disposed within a conduit having, for example, an elliptical cross sectional flow area two to four times that of the circular inlet conduit. The inlet conduit and the catalyst containing conduit are joined by a diffusing section which transitions from circular to elliptical. Due to space limitations the diffusing section is very short; and its divergence half-angle may be as much as 45 degrees. Since flow separates from the wall when the half-angle exceeds about 7.0 degrees, the exhaust flow from the inlet pipe tends to remain a cylinder and, for the most part, impinges upon only a small portion of the elliptical inlet area of the catalyst. Due to this poor diffusion within the diffusing section there is uneven flow through the catalyst bed. These problems are discussed in a paper titled, Visualization of Automotive Catalytic Converter Internal Flows by Daniel W. Wendland and William R. Matthes, SAE paper No. 861554 presented at the International Fuels and Lubricants Meeting and Exposition, Philadelphia, Pennsylvania, October 6 - 9, 1986. It is desired to be able to better diffuse the flow within such short lengths of diffusing section in order to make more efficient use of the platinum catalyst and thereby reduce the required amount of catalyst.

In WO-A-87/03646 there is disclosed a diffusion device and catalytic conversion system as defined in the precharacterizing portion of claim 1 and claim 21, respectively. The delivery conduit of the known device has an end portion with two diametrically opposed impressions converging towards each other in the bulk fluid flow direction. Two branch conduits formed by the impressions serve to distribute the gas flow over the entire elliptical inlet of the catalyst body. Slotlike openings can be formed in the delivery conduit to deflect a part of the gas flow towards outmost parts of the elliptical inlet of the catalyst body.

Disclosure of the Invention

The object of the present invention is to provide a diffuser and a catalytic conversion system having improved operating characteristics and which can accomplish the same amount of diffusion in a shorter length than that of the prior art, or can achieve greater diffusion for a given length than prior art diffusers.

In accordance with the invention this is achieved by the provision of a diffusing device as claimed in independent claim 1 and by the provision of a catalytic conversion system as claimed in independent claim 21, respectively.

Accordingly, the present invention includes a thin, essentially two sided wall member disposed within the conduit upstream of a diffuser section inlet and spaced from the conduit wall surface, the member having a convoluted downstream portion which generates a plurality of adjacent vortices within the diffuser section rotating in opposite directions about respective axes extending in the direction of bulk fluid flow adjacent the plate-like member.

In one embodiment, the convoluted member is disposed upstream of a diffuser section inlet and is supported in closely spaced relation to the surface of the diffuser inlet conduit. The convoluted portion of the member comprises a plurality of adjoining, alternating, U-shaped lobes and troughs extending in the direction of bulk fluid flow near the member and terminating at a downstream edge, which is wave shaped. The trough depth and lobe height increase in the downstream direction, and the troughs and lobes are contoured and dimensioned such that each trough generates a pair of adjacent vortices downstream of the downstream edge of the member. The vortices energize the boundary layer adjacent the diffuser section wall and delay or eliminate its separation therefrom. Thus, a diffuser can accomplish the same amount of diffusion in a shorter length (i.e., can operate effectively with greater diffusion angles) or can achieve a greater amount of diffusion for a given length than was possible with prior art diffusers. The proper orientation of the member and its troughs and lobes can also result in the fluid leaving the troughs with a direction of momentum that carries it toward the diffuser wall surface.

It is believed that the vortices generated from each side wall surface at the trough outlet are large-scale vortices. (By "large-scale" it is meant the vortices have a diameter about the size of the overall trough depth.) These two vortices (one from each sidewall) rotate in opposite directions and create a flow field which tends to cause fluid from the trough and also from the nearby bulk fluid to mix with the fluid near the diffuser wall surface immediately downstream of the member. The net affect of these phenomenon is to direct bulk fluid outwardly toward the diffuser wall surfaces and also to create bulk fluid mixing within the diffuser section, all of which energize the boundary layer along the diffuser wall thereby improving diffuser performance. Even if the convoluted member is not close enough to the diffuser wall to energize the boundary layer and delay separation, or if the diffuser wall is much too steep to avoid separation, the mixing of bulk fluid within the diffuser caused by the large-scale vortices may still improve overall diffuser performance.

The troughs and lobes of the diffusion device or catalytic converter are preferably contoured such that they flow full (i.e., no streamwise, two-dimensional boundary layer separation occurs within the troughs). Thus, it is important there is no streamwise, two-dimensional boundary layer separation of the flow over the member immediately upstream of the troughs thereof as this would result in separated flow entering the troughs, which would inhibit the formation of strong vortices. The prevention of streamwise, two-dimensional boundary layer separation within the troughs is an important consideration in their design. For example, two-dimensional boundary layer separation may occur if the slope of the bottom of a trough is too steep relative to the nearby bulk fluid flow direction.

Preferably the troughs and lobes are U-shaped in cross section taken perpendicular to the downstream direction and are preferably smoothly curved (e.g., no sharp angles where trough sidewall surfaces meet the trough floor) to minimize losses. Most preferably the troughs and lobes form a smoothly undulating surface which is wave-shaped in cross section perpendicular to the downstream direction.

According to another aspect of the present invention, it is preferred that the fluid exiting from each trough have a lateral component of velocity as small as possible to minimize secondary flaw losses. For this reason the trough sidewalls, for a significant distance upstream of the trough outlet, are preferably parallel to the direction of bulk fluid flow entering the trough.

One important advantage of the present invention is its ability to improve diffuser performance without introducing substantial flow losses as a result of its own presence in the flow field.

In accordance with another aspect of the present invention, it is preferred that the trough sidewalls at the outlet be steep. This is believed to increase the intensity of the vortex generated by the sidewall. The word "steep" as used herein and in the claims means that, in cross section perpendicular to the direction of trough length, lines tangent to the steepest point on each sidewall intersect to form an included angle of no more than about 120°. Most preferably the walls are parallel to each other. For purposes of this application, when the walls are parallel the included angle shall be considered to be 0°.

Commonly owned EP-A-0 244 334 filed on April 7, 1987 titled, Airfoil Shaped Body, describes an airfoil trailing edge region with streamwise troughs and ridges (convolutions) formed therein defining a wave-like, thin trailing edge. The troughs in one surface define the ridges in the opposing surface. The troughs and ridges help delay or prevent the catastrophic effects of two-dimensional boundary layer separation on the airfoil suction surface, by providing three-dimensional relief for the low momentum boundary layer flow. The present invention, however, is directed to improving the performance of a diffuser located just downstream of a convoluted member.

The foregoing and other features and advantages of the present invention will be come more apparent in the light of the following detailed description of preferred embodiments thereof as shown in the accompanying drawings.

Brief Description of the Drawing

Fig. 1 is a perspective view which illustrates the use of a convoluted plate to reduce base drag in accordance with the teachings of related, commonly owned EP-A-0 315 563

Fig. 1A is a view taken generally in the direction 1A - 1A of Fig. 1.

Fig. 2 is a cross sectional view of a two dimensional diffuser incorporating the features of the present invention.

Fig. 3 is a view taken generally in the direction 3 - 3 of Fig. 2.

Fig. 4 is a graph displaying the results of tests for the embodiment of the present invention shown in Figs. 2 and 3, as well as the prior art.

Fig. 5 is sectional view of an axisymmetric diffuser incorporating the features of the present invention.

Fig. 6 is a view taken generally in the direction 6 - 6 of Fig. 5.

Fig. 7 is a sectional view of a two-dimensional "stepped" diffuser incorporating the features of the present invention.

Fig. 8 is a view taken generally in the direction 8 - 8 of Fig. 7.

Fig. 9 is a sectional view illustrating the use of convoluted plates in a heat exchanger application in accordance with the teachings of related, commonly owned EP-A-0 275 813.

Fig. 10 is a sectional view taken generally along the line 10 - 10 of Fig. 9.

Fig. 11 is a sectional view of a catalytic converter system incorporating the features of the present invention.

Fig. 12 is a view taken generally in the direction 12 - 12 of Fig. 11.

Fig. 13 is a sectional view showing another embodiment of a catalytic converter system incorporating the features of the present invention.

Fig. 14 is a view taken generally along the line 14 - 14 in Fig. 13.

Best Mode for Carrying Out the Invention

As will be more fully described hereinafter, the convoluted wall member of the present invention is used immediately upstream of or at a diffuser inlet to create fluid flow downstream of the member which help diffuse the fluid and also energize the boundary layer along the diffuser wall, whereby the diffuser performance is improved. The fluid dynamics is similar to the fluid dynamics involved in commonly owned EP-A-0 315 563 entitled Convoluted Plate to Reduce Base Drag, filed on June 30, 1988. Figs. 14 and 14A of EP-A-0 315 563 are reproduced in this application as Figs. 1 and 1A. In that application a convoluted plate was disposed upstream of a blunt end surface of a moving body to reduce base drag by generating certain fluid dynamic flow patterns downstream of the plate. As described therein, and with reference to Figs. 1 and 1A, a blunt based article is generally represented by the reference numeral 200. The article 200 has a smooth, relatively flat upper surface 202 over which fluid flows in the generally downstream direction represented by the arrows 204. The article 200 has a blunt base or end surface 206. Without the convoluted plate the flow along the surface 202 is assumed to separate from the article along the line 208. For purposes of the present discussion the separation line 208 shall be considered the beginning or upstream edge of the blunt end surface 206.

A convoluted wall member or plate 210 is mounted on and spaced from the surface 202 by means of support members or standoffs 212, only one of which is shown in the drawing. The plate 210 has an upstream or leading edge 214 and a downstream or trailing edge 216. While the plate may be fairly thin, the leading edge 214 should be rounded, like the leading edge of an airfoil, to assure that attached uniform flow is initiated on both the upper surface 218 and lower surface 220 of the plate. The plate may then taper to a smaller thickness, if desired, toward the trailing edge 216, such as to save weight or to minimize base drag of the plate itself.

A plurality of U-shaped troughs 222 and lobes 224 are formed in the plate. Adjacent troughs and lobes blend smoothly into each other forming an undulating or convoluted downstream portion of the plate which terminates as a wave-shape at its trailing edge 216. For vortices to be generated trough depth must increase in the downstream direction, although trough depth could reach its maximum upstream of the trough outlet and thereafter remain constant to the outlet. In Fig. 1, the plate leading edge 214 is straight and the plate is initially flat for a short distance. The troughs and lobes blend smoothly into the flat portion. Preferably, and as shown, trough depth (and lobe height) are zero at their upstream ends and are maximum at the downstream edge 216; however, the plate leading edge 214 could have a low amplitude wave shape, and the trough depth would increase from that initial amplitude. The contour and shape of the troughs and lobes is selected such that the troughs flow full throughout their length.

Since the plate 210 is attached to the article 200, the plate itself creates losses (i.e. drag) which should be minimized. If one initially considers an imaginary, smooth plate without convolutions and which is generally parallel, locally, to the surface above which it is disposed, the peaks and valleys of the troughs and lobes preferably extend an equal distance above and below such "imaginary" plate.

The vortices generated by the troughs and lobes on each side of the plate are shown schematically in the drawing. A vortex, having its axis in the bulk fluid flow direction, is generated off of each sidewall of each trough. Thus, the trough 226 generates a clockwise rotating vortex 228 from its right sidewall (as viewed in Fig. 1) and a counter clockwise rotating vortex 230 from its left sidewall. An adjacent trough 232 on the opposite side of the plate to the left of the trough 226 also generates a counter clockwise rotating vortex 234 from its right wall which combines with and reinforces the counter clockwise rotating vortex 230 to form what is effectively a single, stronger vortex. Similarly, the left sidewall of the trough 236 generates a clockwise rotating vortex 238 which combines with the clockwise rotating vortex 228 from the trough 226.

If the plate 210 is properly spaced and oriented relative to both the surface 202 and the blunt end surface 206, then the vortices generated therefrom will energize the boundary layer flow on the surface 202 downstream of the plate thereby resulting in the flow remaining attached to the article surface beyond the imaginary separation line 208. Furthermore, it is believed the bulk fluid flowing from the troughs and over the surface 202 is directed downwardly (in Fig. 1) into the space behind the blunt end surface 206 to further reduce the separation bubble which would otherwise be formed and thereby further reduce base drag.

For purposes of the following discussion, and still referring to Fig. 1, P is the peak to peak wave length at the plate trailing edge 216; A is the peak to peak wave height or amplitude (and may also be referred to as the trough depth); H is the distance between the surface 202 and the closest wave peaks of the trailing edge 216; and D is the distance between the trailing edge 216 and the upstream edge of the blunt end surface which is the separation line 208 as discussed above. Preferably the peak to peak wave length P is constant over the full length of the troughs.

Since the vortices do not become fully developed for a distance downstream of the plate edge 216, and because it is desired to have the vortices energize the boundary layer upstream of the line 208, it is preferred that the trailing edge 216 be located a distance D equal to one to two wave amplitudes A upstream of the blunt end surface 206. This does not mean that no benefit would be achieved if D were less than A or even zero; however, it is believed the advantages would be lessened. Similarly, if the plate is situated too far upstream from the end surface 206 the vortices might significantly or completely dampen out before reaching the end surface 206 and thereby provide little or no benefit.

The distance H should be sufficiently great to avoid creating secondary flow fields or blockage adjacent the surface 202 which might disrupt and cause separation of the boundary layer on the surface 202 before it reaches the line 208. It is believed that H should be at least about the thickness of the boundary layer. Concurrently, the distance H should be small to keep the vortices as close to the surface 202 as possible. The slope θ of the trough bottom relative to the bulk fluid flow direction adjacent the plate cannot be too shallow or too steep. If the slope is too shallow, the strength of the vortices generated will be too weak or they may not be generated at all as a result of losses from surface friction. It is believed that θ should be at least about 5°. On the other hand, if the slope is too steep the troughs will not flow full (i.e., there will be two-dimensional streamwise boundary layer separation within the troughs). This will hinder the formation of the vortices. It is likely that the greater the slope, the greater the intensity of the vortices, as long as the troughs flow full. It is believed that slopes greater than about 30° will not flow full. The optimum angle for any particular application will need to be determined by experimentation.

As far as the steepness of the sidewalls of each trough is concerned, substantially parallel sidewalls at the trailing edge 216 and for a distance upstream thereof are preferred. The steepness of the sidewalls may be represented by the included angle C (depicted in Fig. 1), which is the angle between lines tangent to the steepest points along the opposed sidewalls of a trough. As stated above, the closer the angle C is to 0°, the better; however, the angle C should be no greater than about 120° at the trough outlet.

Preferably the overall length of the plate from its leading edge 214 to its trailing edge 216 is equal to or slightly greater than the length L of the troughs and ridges. Excessive length, while not devastating, will also not provide any advantage and will simply add unnecessary surface drag, cost and weight. As mentioned above, the leading edge 214 should be rounded and the troughs and lobes should be shaped and sized along their entire length to assure that the troughs flow full throughout their length and generate vortices which are sufficiently strong to provide a benefit (i.e., drag reduction) deemed to be worthwhile considering the needs of the particular application.

In general, it is believed that the wave length P should be no less than about half and no more than about four times the wave amplitude A in order to assure the formation of strong vortices without inducing excessive pressure losses. The sum of the downstream projected cross-sectional flow areas of the trough outlets should be large enough, relative to the total downstream projected area of the blunt end surface to have a worthwhile impact on base drag. Practical considerations such as physical constraints, cost and weight, and even aesthetics will also have various degrees of impact upon the final configuration selected.

Figs. 2 - 3 show another application for the convoluted wall member or plate described in Figs. 1 and 1A; and that application is the subject of the present invention. With reference to Figs. 2 - 3, a conduit is generally represented by the reference numeral 300. The conduit 300 includes a fluid delivery section 302 and a diffuser section 304. Both are rectangular in cross section taken perpendicular to the flow direction, which is in the direction of the arrows 306. The delivery section 302 and the diffuser section 304 both include flat, parallel sidewalls 308. Thus, the diffuser section 304 provides only two-dimensional diffusion. The plane 310 is at the interface between the delivery section 302 and the diffuser section 304 and is coextensive with the diffusion section inlet 312.

Disposed within the conduit delivery section 302 are convoluted plates 314. One is attached to the upper wall 316 and the other to the lower wall 318 of the delivery section by means of legs 320. The large-scale vortices generated by the plates are illustrated by the spirals 322 and have axes generally parallel to the downstream direction 306.

The preceding description of Figs. 1 and 1A with respect to size, shape, contour and location of the convoluted plate 210 applies equally as well to the convoluted plate 314, with the plane 310 in Fig. 2 corresponding to the line 208 of Fig. 1 in diffusers which would separate at the inlet without the presence of the convoluted plates. Thus, all of the dimensions L, D, H, A and P, as well as the angle θ should be selected in the same manner as described with respect to Figs. 1 and 1A. While in the application of Figs. 1 and 1A the convoluted plate reduces base drag on a moving body, the present invention improves the performance of a diffuser by energizing the boundary layer along the diffuser walls and by causing general mixing and diffusion of the bulk fluid flow within the diffusing section 304.

A two-dimensional diffuser like that of Figs. 2 and 3 was tested both with and without convoluted plates. With reference to Figs. 2 and 3, the diffuser had the following dimensions: B = 536 mm (21.1 inch); F = 830 mm (32.7 inch); and E = 137 mm (5.4 inch). With respect to the convoluted plates, D = 58 mm (2.3 inch); L = 160 mm (6.3 inch); H = 6.3 mm (0.25 inch); A = 58 mm (2.3 inch); P = 43 mm (1.7 inch); W_i = 12.7 mm (0.5 inch); W_o = 30 mm (1.2 inch); θ_1 = 11°; and θ_2 = 15°. The sidewalls of each trough were parallel to each other, as shown in Fig. 3. While Figs. 2 and 3 depict the test apparatus with the dimensions hereinabove set forth such dimensions and the relative values of such dimensions to each other are not intended to limit the invention. For example, the troughs on both sides of each plate may be identical (i.e., $W_i = W_o$ and $a_1 = a_2$). Optimum configurations for a particular application may only be obtained by experimentation using the guidelines set forth herein.

In both series of tests (i.e., with and without the convoluted plates) the coefficient of performance of the diffuser was measured for diffuser half-angles α ranging from about 2° to 10°, which is equivalent to an outlet to inlet area ratio range of from about 1.4 to 3.1. The results of the tests are displayed in the graph of Fig. 4 wherein the curve A represents no convoluted plates and B represents the use of convoluted plates. For diffuser half-angles greater than about 6° (up to at least the maximum angle tested) the present invention outperformed (in terms of the coefficient of performance) the same diffuser without the convoluted plates. At a 10°

half-angle the present invention had a coefficient of performance higher than the maximum coefficient of performance (i.e., at a 6° half-angle) of the diffuser without the convoluted plates and about 25 percent greater than that of the same diffuser with a 10° half-angle and no convoluted plates. The present invention also delayed the onset of boundary layer separation to higher half-angles.

Figs. 5 and 6 illustrate the use of the present invention in conjunction with an axisymmetric three-dimensional diffuser 400. In that case a convoluted thin wall member 402 is axisymmetric, with the lobes and troughs extending axially in the downstream direction 404 and radially (in height and depth).

The invention can also be used in conjunction with a "stepped" diffuser, as shown in Fig. 7 and 8. A stepped diffuser may be considered one in which the diffuser half-angle is extremely steep, such as 90°. This type of diffuser is typically a conduit which includes a step change (i.e., sudden increase) in passage cross sectional flow area. In Figs. 7 and 8, fluid flowing a conduit 502 in the downstream direction is represented by the arrows 500. The conduit has an inlet section 501 of rectangular cross sectional area and an outlet section 503, also of rectangular cross sectional area. The inlet section has sidewalls 504 parallel to each other and the downstream direction, and upper and lower walls 507 also parallel to the downstream direction and to each other. A step change in the passage cross sectional area occurs at the plane 508. The discontinuity is only in the upper and lower walls 507. The sidewalls 504 remain parallel past the discontinuity for the entire length of the outlet section 503.

Disposed adjacent and supported from each of the upper and lower sidewalls 507 is a convoluted plate 510 similar to that shown in Figs. 2 and 3. The distance D of the plate upstream of the plane 508 should be anywhere from about zero to twice the trough depth and most preferably one to two times the trough depth.

Although with a stepped diffuser such as shown in Fig. 7 the convoluted plates cannot keep the flow attached to the walls, they can reduce the distance downstream of the plane 508 where reattachment of the flow to the upper and lower walls occurs. The bottom line is that the stepped diffuser will have lower losses than would occur without the use of the convoluted plates. Also, although in this embodiment a convoluted plate is disposed adjacent each of the upper and lower walls, a single, perhaps larger (in terms of wave amplitude) plate disposed in the center of the conduit would also provide benefits.

Commonly owned EP-A-0 275 813, entitled Heat Transfer Enhancing Device, filed on December 12, 1987 describes a convoluted plate similar to that described herein but used in heat transfer apparatus to improve heat transfer across a wall having fluids flowing on both sides thereof. Figs. 9 and 10 of this application correspond to Figs. 8 and 9, respectively, of that commonly owned application and show a convoluted wall or plate 800 disposed within a tube or conduit 802 which carries fluid flowing in the direction of the arrow 804. As best shown in Fig. 10, the plate 800 extends substantially across the tube along a diameter. The lobes and troughs in the downstream portion of the plate 800 generate adjacent counterrotating vortices 806, 808 downstream thereof which scrub the thermal boundary layer from the internal wall surface 810 of the tube and mix the core flow with the fluid flowing adjacent the wall. The net effect is to increase the coefficient of heat transfer between the fluid and the wall of the conduit 802 for the purpose of ultimately exchanging heat energy between the fluid within the conduit and fluid surrounding the conduit. As shown in Fig. 9, it is contemplated to dispose a plurality of convoluted plates 800 within the conduit, spaced apart along the axis of the conduit at distances which will ensure improvement in the heat transfer rate along the entire length of the conduit. This is, of course, required since the vortices generated by each plate 800 eventually die out due to wall friction and viscous effects.

While the present invention is not a heat transfer device, it does utilize the same convoluted plates disposed in a conduit for the purpose of influencing the fluid flow dynamics in a diffusion section of the conduit downstream of the plate. We have discovered that such plates generate large-scale vortices to 1) energize the boundary layer to improve diffuser performance, and 2) increase mixing of the bulk fluid across the duct in directions perpendicular to the bulk fluid flow, which also improves diffuser performance.

A specific application for the wall members of the present invention is in a catalytic converter system, such as for an automobile. Such a converter system is generally represented by the reference numeral 900 in Figs. 11 and 12. The converter system 900 comprises a cylindrical gas delivery conduit 902, an elliptical gas receiving conduit 904, and a diffuser 906 which is a transition duct or conduit between them. The bulk fluid flow direction is represented by the arrows 905 and is parallel to the axis 907 of the delivery conduit 902. The diffuser 906 extends from the circular outlet 908 of the delivery conduit to the essentially elliptical inlet 910 of the receiving conduit 904. The receiving conduit holds the catalyst bed (not shown). The catalyst bed is preferably a honeycomb monolith with the honeycomb cells parallel to the downstream direction. The inlet face of the monolith is at the inlet 910; however, it could be moved further downstream to allow additional diffusion distance between the delivery conduit outlet 908 and the catalyst. Catalysts for catalytic converters and catalyst bed configurations are well known in the art.

As best seen in Fig. 12, diffusion occurs only in the direction of the major axis 912 of the ellipse. The minor axis of the ellipse remains a constant length equivalent to the diameter of the delivery conduit outlet 908. Thus, the diffuser 906 of this embodiment is effectively a two-dimensional diffuser. Disposed within the delivery conduit 902 is a convoluted plate 914 having a plurality of parallel troughs therein. The plate 914 extends across the conduit 902 along approximately a diametral plane which is perpendicular to the major axis 912 of the elliptical gas receiving conduit 804. The plate 914 is attached at its side edges 920 to the conduit 902. The trough sidewalls 924 are preferably parallel to each other at the downstream wave-shaped edge 922 of the plate and are also preferably parallel to the ellipse major axis 912. Although optimum plate size and configuration will need to be determined by experimentation, using the teachings of the present invention as a guide, it is believed there should be at least two complete troughs on one side of the plate (there are three in the embodiment of Fig. 12) and the troughs should have a depth at their downstream edge which is a large percentage of the available space within the conduit. Although it is believed that the best results will be obtained when the trough depth direction is parallel to the major direction of diffusion, it is also believed that improved diffusion may be obtained with the plate 914 oriented in virtually any direction, such as perpendicular to the direction shown in Fig. 12.

If the conduit 902 of Figs. 11 and 12 has a diameter of 51 mm (2.0 inches), one possible set of dimensions for the plate 914 is a trough slope θ of 15°; a wave amplitude A of 25.4 mm (1.0 inch); a trough width W of about 7.6 mm (0.30 inch); and a plate thickness of about 0.76 mm (30 mils).

Figs. 13 and 14 show another embodiment of a catalytic converter system. This system is generally represented by the reference numeral 950 and comprises a cylindrical gas delivery conduit 952, an elliptical gas receiving conduit 954, and a diffuser 956 which is a transition duct or conduit between them. The bulk fluid flow direction is represented by the arrows 958 and is parallel to the axis 960 of the delivery conduit. The diffuser 956 extends from the circular outlet 962 of the delivery conduit and smoothly transitions to the elliptical inlet 964 of the receiving conduit, which holds the catalyst bed (not shown) whose inlet face corresponds with the plane of the inlet 964.

In this embodiment the converter system is considered to be analogous to the two-dimensional diffuser described in Figs. 2 and 3. Thus, a pair of slightly curved convoluted plates 966 are disposed within the delivery conduit 952, both extending across the duct in a direction substantially parallel to a diametral line which is parallel to the minor axis 968 of the elliptical receiving conduit and perpendicular to the major axis 970. The plates 966 are positioned close to, but are spaced from, the surfaces of the delivery conduit which are disposed above and below the diametral line or axis 968.

The plane 972 represents the axial location along the diffuser 956 where two-dimensional streamwise boundary layer separation would normally occur without the use of the convoluted plates 966. The downstream wave-shaped edges 974 must be spaced upstream of the plane 972 in order to delay separation of the flow beyond the plane 972. It is believed that best results will be obtained if the distance D is about one to two times the maximum wave amplitude of the plates 966. This allows some downstream distance for the large-scale vortices generated by the convoluted plates to become more fully developed before reaching the location of the plane 972.

In this embodiment the wave forms of the upper and lower plates 966 are out of phase. The wave forms could also be in phase as shown in the embodiment of Figs. 7 and 8, which may produce coupling of the generated vortices, and thereby further improve mixing. Assuming a 51 mm (two-inch) diameter for the delivery conduit 952, it is recommended that the maximum wave amplitude for each plate 966 be between about 12.7 and 11.4 mm (0.5 and 0.75 inch).

Claims

1. Diffusing device including a conduit (300;502) for carrying a fluid in a downstream direction and having wall means defining the internal flow surface of said conduit (300;502), said conduit (300;502) including an upstream fluid delivery portion (302;501;902;952) having an outlet end (908;962) with a first cross-sectional flow area, a downstream fluid receiving portion (503;904;954) having an inlet end (910;964) of second cross-sectional flow area larger than said first cross-sectional flow area, said wall means interconnecting said outlet end (908;962) and said inlet end (910;964) whereby fluid diffuses as it travels downstream from said outlet end into said fluid receiving portion, characterized in that a thin, vortex generating wall member (314;402;510;914;966) is disposed within said fluid delivery conduit

(302;501;902;952) upstream of said outlet end and having oppositely facing downstream extending flow surfaces, an upstream edge and a downstream edge (922,974), said wall member having a convoluted portion comprising a plurality of adjoining, alternating, U-shaped lobes and troughs extending in the direction of bulk fluid flow adjacent thereto and spaced from said internal flow surface and terminating at said downstream edge (922;974), said trough depth and lobe height increasing in the bulk fluid flow direction, the contours and dimensions of said troughs and lobes being selected to insure that each trough generates a pair of adjacent large-scale vortices downstream of said outlet end (908;962), said pair of adjacent vortices generated by each trough rotating in opposite directions about respective axes extending in the downstream direction.

2. Diffusing device according to claim 1, characterized in that said troughs and lobes initiate downstream of said upstream edge with substantially zero depth and height respectively.

3. Device according to claim 1, characterized in that each of said troughs is smoothly U-shaped along its length in cross section perpendicular to the downstream direction and blends smoothly with the lobes adjacent thereto to define a smoothly undulating surface which is wave-shaped in cross section perpendicular to the downstream direction.

4. Device according to claim 3, characterized in that the peak-to-peak wave amplitude of said downstream edge (922;974) is A, and said downstream edge (922;974) is located between about 1A and 2A upstream of said delivery conduit outlet end (908;962).

5. Device according to claim 3, characterized in that said outlet end of said delivery portion (501) of said conduit (502) and said inlet end of said receiving portion (503) of said conduit (502) are located in substantially the same plane (508) whereby there is a step-wise increase in cross-sectional flow area substantially in said plane (508).

6. Device according to claim 3, characterized in that said receiving portion inlet (910; 964) of said conduit is spaced downstream from said delivery portion outlet end (908;962) of said conduit, said device including a diffuser section (906;956) joining said outlet end (908;962) to said inlet end (910;964), said diffuser section (906;956) including a diffuser which gradually increases in cross-sectional area from said outlet end (908;962) to said inlet end (910;964).

7. Device according to claim 6, characterized in that said downstream edge (922;974) of said wall member (914;966) is positioned such that said large-scale vortices generated from said troughs create mixing of the bulk fluid within said diffuser section (906;956) and increases the coefficient of performance of said diffuser.

8. Device according to claim 6, characterized in that said wall member (914;966) is disposed sufficiently close to said internal flow surface of said fluid delivery portion (902;952) of said conduit that the large-scale vortices generated by said wall member (914;966) energize the boundary layer within said diffuser and increase the coefficient of performance of said diffuser.

9. Device according to claim 6, characterized in that said wall member (914;966) is located and oriented within said delivery portion (902;952) of said conduit such that flow separation from the wall of the diffuser initiates at diffuser half-angles greater than it would otherwise initiate at without the presence of said wall member (914;966).

10. Device according to claim 6, characterized in that said delivery portion (902; 952) of said conduit is symmetrical about a downstream extending axis (907;960).

11. Device according to claim 10, characterized in that said diffuser (400) is a three dimensional diffuser and said wall member (402) is symmetrical about said axis.

12. Device according to claim 10, characterized in that said delivery portion (902) of said conduit is cylindrical, and said wall member (914) extends across a diametral plane.

13. Device according to claim 6, characterized in that said wall member (914;966) extends across a substantial portion of the width of said delivery portion (902;952) of said conduit.

14. Device according to claim 3, characterized in that the slope of the bottoms of the troughs relative to the bulk fluid flow direction is between 5° and 30°, each of said troughs including a pair of facing sidewalls (924), wherein lines tangent to each of said pair of sidewalls (924) at their steepest points at said wall member downstream edge (922;974) from an included angle of between 0° and 120°.

15. Device according to claim 3, characterized in that the slope of the bottom of said troughs relative to the bulk fluid flow direction is between 5° and 30°; and each trough includes a pair of facing sidewalls (924) which are substantially parallel to each other.

16. Device according to claim 6, characterized in that said device is a catalytic converter (900;950) for delivering exhaust gases from said delivery portion (902;952) into and through said receiving portion (904;954) and that said receiving portion (904;954) has a catalyst bed disposed therein.

17. Device according to claim 16, characterized in that said delivery portion (902;952) is cylindrical and said diffuser and receiving conduit portion (909,904;956,954) are substantially elliptical in cross-section perpendicular to the downstream flow direction.

18. Device according to claim 17, characterized in that said diffuser is substantially a two-dimensional diffuser with diffusion parallel to the major axis (912; 970) of the elliptical cross-section.

19. Device according to claim 17, characterized in that the direction of trough depth is substantially parallel to the major axis (912;970) of the elliptical cross-section.

20. Device according to claim 19, characterized in that said wall member (914) is disposed substantially along a diametral plane including a minor axis of said elliptical cross-section, and said troughs are alternately above and below said plane.

21. Catalytic conversion system including a gas delivery conduit (902; 952) having an outlet (908;962) of first cross-sectional flow area, a receiving conduit (904;954) having an inlet (910;964) of second cross-sectional flow area larger than said first cross-sectional flow area and spaced downstream of said delivery conduit outlet (908; 962) and including a catalyst bed disposed therein, and an intermediate conduit (906; 956) defining a diffuser having a flow surface connecting said outlet (908;962) to said inlet (910;964), characterized in that

a thin vortex generating wall member (914;966) is disposed within said delivery conduit upstream of said outlet (908; 962) and having oppositely facing downstream extending flow surfaces, an upstream edge and a downstream edge (922; 974), said wall member (914; 966) having a convoluted portion comprising a plurality of adjoining, alternating, U-shaped lobes and troughs extending in the direction of bulk fluid flow adjacent thereto and spaced from said internal flow surface and terminating at said downstream edge (922;974), said trough depth and lobe height increasing in the bulk fluid flow direction, the contours and dimensions of said troughs and lobes being selected to insure that each trough generates a pair of adjacent large-scale vortices downstream of said outlet (908;962) and within said intermediate conduit (906; 956), said pair of adjacent vortices generated by each trough rotating in opposite directions about respective axes extending in the downstream direction.

22. Catalytic conversion system according to claim 21, characterized in that each of said troughs has a downstream extending floor which has a slope of no less than about 5° and no more than about 30° relative to the downstream direction.

23. Catalytic conversion system according to claim 22, characterized in that each of said troughs is smoothly U-shaped along its length in cross section perpendicular to the downstream direction and blends smoothly with the lobes adjacent thereto to define a smoothly undulating surface which is wave-shaped in cross-section perpendicular to the downstream direction.

24. Catalytic conversion system according to claim 23, characterized in that the peak-to-peak wave amplitude of said downstream edge (922;974) is A, and said downstream edge (922;974) is located between about 1A and 2A upstream of said delivery conduit outlet (908;962).

25. Catalytic conversion system according to claim 22, characterized in that said downstream edge (922;974) of said wall member (914;974) is positioned such that said large-scale vortices generated from said troughs create mixing of the bulk fluid within said intermediate conduit (906;956) and increases the coefficient of performance of said diffuser.

26. Catalytic conversion system according to claim 23, characterized by a pair of said wall members (974) spaced apart from each other and disposed adjacent but spaced from opposed internal surfaces of said delivery conduit (952).

27. Catalytic conversion system according to claim 23, characterized in that said delivery conduit outlet (908; 962) is circular and said receiving conduit inlet (910;964) is elliptical, and that the direction of the depth dimension of said troughs is substantially parallel to the major axis (912; 970) of the elliptical inlet (910;964).

28. Catalytic conversion system according to claim 23, characterized in that each of said troughs includes a pair of parallel, facing sidewalls (924).

29. Catalytic conversion system according to claim 28, characterized in that said diffuser is substantially a two-dimensional diffuser wherein the direction of diffusion is substantially parallel to said trough sidewalls (924).

30. Catalytic conversion system according to claim 23, characterized in that said troughs and ridges are sized, contoured and arranged to flow full over their length whereby two-dimensional boundary layer separation on the surface of said troughs and lobes does not occur during normal operation.

Patentansprüche

1. Diffusorvorrichtung mit einem Kanal (300; 502) zum Leiten eines Fluids in stromabwärtiger Richtung und mit einer Wandeinrichtung, welche die innere Strömungsoberfläche des Kanals (300; 502) bildet, wobei der Kanal (300; 502) einen stromaufwärtigen Fluidzuführteil (302; 501; 902; 952) aufweist, der ein Auslaßende (908; 962) mit einer ersten Strömungsquerschnittsfläche hat, einen stromabwärtigen Fluidempfangsteil (503; 904; 954), der ein Einlaßende (910; 964) mit einer zweiten Strömungsquerschnittsfläche hat, die größer als die erste Strömungsquerschnittsfläche ist, wobei die Wandeinrichtung das Auslaßende (908; 962) und das Einlaßende (910; 964) miteinander verbindet, wodurch sich das Fluid verteilt, wenn es sich von dem Auslaßende stromabwärts in den Fluidempfangsteil bewegt, dadurch gekennzeichnet, daß ein dünnes, Wirbel erzeugendes Wandteil (314; 402; 510; 914; 966) in dem Fluidzuführkanal (302; 501; 902; 952) stromaufwärts des Auslaßendes angeordnet ist und in entgegengesetzte Richtungen weisende, sich stromabwärts erstreckende Strömungsflächen hat, einen stromaufwärtigen Rand und einen stromabwärtigen Rand (922; 974), wobei das Wandteil einen gelappten Teil hat, der mehrere einander benachbarte, miteinander abwechselnde U-förmige Erhöhungen und Vertiefungen aufweist, die sich in der Richtung der Gesamtfluidströmung benachbart zu dieser und mit Abstand von der inneren Strömungsfläche erstrecken und an dem stromabwärtigen Rand (922; 974) endigen, wobei die Tiefe der Vertiefungen und die Höhe der Erhöhungen in der Gesamtfluidströmungsrichtung zunimmt, wobei die Konturen und Abmessungen der Vertiefungen und der Erhöhungen so gewählt sind, daß gewährleistet ist, daß jede Vertiefung ein Paar benachbarte, große Wirbel stromabwärts des Auslaßendes (908; 962) erzeugt, wobei das Paar benachbarte Wirbel, das durch jede Vertiefung erzeugt wird, in entgegengesetzten Richtungen um Achsen rotiert, die sich in der stromabwärtigen Richtung erstrecken.

2. Diffusorvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Vertiefungen und die Erhöhungen stromabwärts des stromaufwärtigen Randes im wesentlichen mit der Tiefe null bzw. im wesentlichen mit der Höhe null beginnen.

3. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jede Vertiefung auf ihrer Länge im Querschnitt rechtwinkelig zu der stromabwärtigen Richtung gleichmäßig U-förmig ist und gleichmäßig in die ihr benachbarten Erhöhungen übergeht, um eine gleichmäßig gewellte Oberfläche zu bilden, die im Querschnitt rechtwinkelig zu der stromabwärtigen Richtung wellenförmig ist.

4. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Spitze-Spitze-Wellenamplitude des stromabwärtigen Randes (922; 974) A ist und der stromabwärtige Rand (922; 974) zwischen etwa 1A und 2A stromaufwärts des Zuführkanalauslaßendes (908; 962) angeordnet ist.

5. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß das Auslaßende des Zuführteils (501) des Kanals (502) und das Einlaßende des Empfangsteils (503) des Kanals (502) in im wesentlichen derselben Ebene (508) angeordnet sind, wodurch es eine schrittweise Zunahme in der Strömungsquerschnittsfläche im wesentlichen in dieser Ebene (508) gibt.

6. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß der Empfangsteileinlaß (910; 964) des Kanals mit Abstand stromabwärts von dem Zuführteilauslaßende (908; 962) des Kanals angeordnet ist, wobei die Vorrichtung einen Diffusorabschnitt (906; 956) aufweist, der das Auslaßende (908; 962) mit dem Einlaßende (910; 964) verbindet, wobei der Diffusorabschnitt (906; 956) einen Diffusor hat, der in der Querschnittsfläche von dem Auslaßende (908; 962) zu dem Einlaßende (910; 964) allmählich zunimmt.

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß der stromabwärtige Rand (922; 974) des Wandteils (914; 966) so angeordnet ist, daß die großen Wirbel, welche durch die Vertiefungen erzeugt werden, eine Vermischung des Gesamtfluids innerhalb des Diffusorabschnitts (906; 956) hervorrufen und den Nutzeffekt des Diffusors vergrößern.

8. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß das Wandteil (914; 966) ausreichend nahe bei der inneren Strömungsfläche des Fluidzuführteils (902; 952) des Kanals angeordnet ist, so daß die großen Wirbel, die durch das Wandteil (914; 966) erzeugt werden, die Grenzschicht innerhalb des Diffusors mit Energie versorgen und den Nutzeffekt des Diffusors vergrößern.

9. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß das Wandteil (914; 966) innerhalb des Zuführteils (902; 952) des Kanals so angeordnet und ausgerichtet ist, daß die Strömungsablösung von der Wand des Diffusors bei Diffusorhalbwinkeln beginnt, die größer sind als sie sein würden, wenn die Strömungsablösung ohne das Vorhandensein des Wandteils (914; 966) beginnen würde.

10. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß der Zuführteil (902; 952) des Kanals um eine sich stromabwärts erstreckende Achse (907; 960) symmetrisch ist.

11. Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, daß der Diffusor (400) ein dreidimensionaler Diffusor ist und daß das Wandteil (402) um die Achse symmetrisch ist.

12. Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, daß der Zuführteil (902) des Kanals zylindrisch ist und daß sich das Wandteil (914) über eine diametrale Ebene erstreckt.

13. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß sich das Wandteil (914; 966) über einen wesentlichen Teil der Breite des Zuführteils (902; 952) des Kanals erstreckt.

14. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Neigung der unteren Seiten der Vertiefungen relativ zu der Gesamtfluidströmungsrichtung zwischen 5° und 30° beträgt, wobei jede Vertiefung zwei einander zugewandte Seitenwände (924) aufweist und wobei Linien, die zu jedem Paar Seitenwänden (924) an ihren steilsten Punkten an dem stromabwärtigen Rand (922; 974) des Wandteils tangential sind, einen eingeschlossenen Winkel zwischen 0° und 120° bilden.

15. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Neigung der unteren Seiten der Vertiefungen relativ zu der Gesamtfluidströmungsrichtung zwischen 5° und 30° beträgt und daß jede Vertiefung ein Paar einander zugewandter Seitenwände (924) aufweist, die im wesentlichen parallel zueinander sind.

16. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß die Vorrichtung ein katalytischer Konverter (900; 950) zum Zuführen von Abgasen auf dem Zuführteil (902; 952) in und durch den Empfangsteil (904; 954) ist und daß in dem Empfangsteil (904; 954) ein Katalysatorbett angeordnet ist.

17. Vorrichtung nach Anspruch 16, dadurch gekennzeichnet, daß der Zuführteil (902; 952) zylindrisch ist und daß der Diffusor- und der Empfangskanalteil (909, 904; 956, 954) im Querschnitt rechtwinkelig zu der stromabwärtigen Strömungsrichtung im wesentlichen elliptisch sind.

18. Vorrichtung nach Anspruch 17, dadurch gekennzeichnet, daß der Diffusor im wesentlichen ein zweidimensionaler Diffusor ist, wobei die Strömungserweiterung parallel der großen Achse (912; 970) des elliptischen Querschnitts erfolgt.

19. Vorrichtung nach Anspruch 17, dadurch gekennzeichnet, daß die Richtung der Tiefe der Vertiefung im wesentlichen parallel zu der großen Achse (912; 970) des elliptischen Querschnitts ist.

20. Vorrichtung nach Anspruch 19, dadurch gekennzeichnet, daß das Wandteil (914) im wesentlichen längs einer diametralen Ebene angeordnet ist, welche eine kleine Achse des elliptischen Querschnitts enthält, und daß die Vertiefungen abwechselnd oberhalb und unterhalb dieser Ebene sind.

21. Katalytisches Umwandlungssystem mit einem Gaszuführkanal (902; 952), der einen Auslaß (908; 962) mit einer ersten Strömungsquer-

schnittsfläche hat, einem Empfangskanal (904; 954), der einen Einlaß (910; 964) mit einer zweiten Strömungsquerschnittsfläche hat, die größer als die erste Strömungsquerschnittsfläche ist, mit Abstand stromabwärts von dem Zuführkanalauslaß (908; 962) angeordnet ist und ein in ihm angeordnetes Katalysatorbett aufweist, und einem Zwischenkanal (906; 956), der einen Diffusor bildet, welcher eine Strömungsfläche hat, die den Auslaß (908; 962) mit dem Einlaß (910; 964) verbindet, dadurch gekennzeichnet, daß
ein dünnes, Wirbel erzeugendes Wandteil (904; 966) in dem Zuführkanal stromaufwärts des Auslasses (908; 962) angeordnet ist und in entgegengesetzte Richtungen weisende, sich stromabwärts erstreckende Strömungsflächen und einen stromaufwärtigen Rand und einen stromabwärtigen Rand (922; 974) hat, wobei das Wandteil (914; 966) einen gelappten Teil hat, der mehrere einander benachbarte, miteinander abwechselnde U-förmige Erhöhungen und Vertiefungen aufweist, die sich in der Richtung der Gesamtfluidströmung benachbart zu ihm erstrecken und Abstand von der inneren Strömungsfläche haben und an dem stromabwärtigen Rand (922; 974) endigen, wobei die Tiefe der Vertiefungen und die Höhe der Erhöhungen in der Gesamtfluidströmungsrichtung zunehmen, wobei die Konturen und Abmessungen der Vertiefungen und Erhöhungen so gewählt sind, daß gewährleistet ist, daß jede Vertiefung ein Paar benachbarte, große Wirbel stromabwärts des Auslasses (908; 962) und innerhalb des Zwischenkanals (906; 956) erzeugt, wobei das Paar benachbarte Wirbel, das durch jede Vertiefung erzeugt wird, in entgegengesetzten Richtungen um Achsen rotiert, die sich in der stromabwärtigen Richtung erstrecken.

22. Katalytisches Umwandlungssystem nach Anspruch 21, dadurch gekennzeichnet, daß jede der Vertiefungen einen sich in stromabwärtiger Richtung erstreckenden Boden hat, der eine Neigung von nicht weniger als etwa 5° und von nicht mehr als etwa 30° relativ zu der stromabwärtigen Richtung hat.

23. Katalytisches Umwandlungssystem nach Anspruch 22, dadurch gekennzeichnet, daß jede der Vertiefungen auf ihrer Länge im Querschnitt rechtwinkelig zu der stromabwärtigen Richtung gleichmäßig U-förmig ist und gleichmäßig in die dazu benachbarten Erhöhungen übergeht, um eine gleichmäßig gewellte Oberfläche zu bilden, die im Querschnitt rechtwinkelig zu der stromabwärtigen Richtung wellenförmig ist.

24. Katalytisches Umwandlungssystem nach Anspruch 23, dadurch gekennzeichnet, daß die Spitze-Spitze-Wellenamplitude des stromabwärtigen Randes (922; 974) A ist und daß der stromabwärtige Rand (922; 974) zwischen etwa 1A und 2A stromaufwärts des Zuführkanalauslasses (908; 962) gelegen ist.

25. Katalytisches Umwandlungssystem nach Anspruch 22, dadurch gekennzeichnet, daß der stromabwärtige Rand (922; 974) des Wandteils (914; 974) so angeordnet ist, daß die großen Wirbel, die durch die Vertiefungen erzeugt werden, eine Vermischung des Gesamtfluids innerhalb des Zwischenkanals (906; 956) hervorrufen und den Nutzeffekt des Diffusors steigern.

26. Katalytisches Umwandlungssystem nach Anspruch 23, gekennzeichnet durch ein Paar der Wandteile (974), die gegenseitig beabstandet und benachbart zu, aber beabstandet von den entgegengesetzten inneren Oberflächen des Zuführkanals (952) angeordnet sind.

27. Katalytisches Umwandlungssystem nach Anspruch 23, dadurch gekennzeichnet, daß der Zuführkanalsauslaß (908; 962) kreisförmig und der Empfangskanaleinlaß (910; 964) elliptisch ist und daß die Richtung der Tiefenabmessung der Vertiefungen zu der großen Achse (912; 970) des elliptischen Einlasses (910; 964) im wesentlichen parallel ist.

28. Katalytisches Umwandlungssystem nach Anspruch 23, dadurch gekennzeichnet, daß jede Vertiefung ein Paar parallele, einander zugewandte Seitenwände (924) aufweist.

29. Katalytisches Umwandlungssystem nach Anspruch 28, dadurch gekennzeichnet, daß der Diffusor im wesentlichen ein zweidimensionaler Diffusor ist, wobei die Richtung der Strömungserweiterung im wesentlichen parallel zu den Vertiefungsseitenwänden (924) ist.

30. Katalytisches Umwandlungssystem nach Anspruch 23, dadurch gekennzeichnet, daß die Vertiefungen und die Erhöhungen gegenüber der Strömung über ihrer vollen Länge so bemessen, konturiert und angeordnet sind, daß es zu keiner zweidimensionalen Grenzschichtablösung an der Oberfläche der Vertiefungen und der Erhöhungen während des normalen Betriebes kommt.

Revendications

1. Dispositif diffuseur comprenant un conduit (300;502) de transport d'un fluide dans une direction aval et comportant des parois définissant la surface d'écoulement interne de ce conduit (300;502), ce conduit (300;502) comprenant une zone amont fournissant un fluide (302;501;902;952), ayant une extrémité de sortie (908;962) possédant une première aire de section transversale de passage de l'écoulement, une zone aval recevant le fluide (503;904;954) possédant une extrémité d'entrée (910,964) ayant une seconde aire de section transversale de passage de l'écoulement, plus grande que la première aire de section transversale de passage de l'écoulement, les parois reliant l'extrémité de sortie et l'extrémité d'entrée de telle façon que le fluide diffuse lorsqu'il se déplace vers l'aval à partir de l'extrémité de sortie, dans la zone recevant le fluide, caractérisé en ce qu'un mince élément de paroi (314;402;510;914;966), générateur de tourbillons, est disposé dans le conduit d'alimentation du fluide (302;501;902;952), en amont de l'extrémité de sortie (312), et ayant des surfaces d'écoulement opposées se faisant face et s'étendant vers l'aval, un bord amont et un bord aval (922,974), ledit élément de paroi ayant une partie ondulée comprenant une pluralité de nervures et de gorges en forme de U, alternées et jointives, et s'étendant dans la direction de l'écoulement de la masse de fluide qui leur est adjacent, et séparées de la surface d'écoulement interne, et se terminant au bord aval (922,974), la profondeur des gorges et la hauteur des nervures augmentant dans la direction de l'écoulement de la masse de fluide, les contours et les dimensions des gorges et des nervures étant choisis pour que chaque gorge produise une paire de tourbillons voisins, à grande échelle, en aval de l'extrémité de sortie, ladite paire de tourbillons voisins produits par chaque gorge tournant dans des sens opposés, autour d'axes respectifs s'étendant dans la direction aval.

2. Dispositif suivant la revendication 1 caractérisé en ce que les gorges et les nervures débutent en aval du bord amont, avec une profondeur et une hauteur respectivement égales à zéro.

3. Dispositif suivant la revendication 1 caractérisé en ce que chacune des gorges, vue en section droite perpendiculairement à la direction aval, est régulièrement en forme de U sur toute sa longueur, et elle se raccorde progressivement avec les nervures qui lui sont adjacentes, de façon à définir une surface ondulée progressive qui, vue en section droite perpendiculairement à la direction aval, a la forme d'une onde.

4. Dispositif suivant la revendication 3 caractérisé en ce que l'amplitude de l'onde, de crête à crête, à l'endroit du bord aval (922;974) est A, et le bord aval est situé à une distance comprise entre environ 1A et 2A, en amont de l'extrémité de sortie du conduit.

5. Dispositif suivant la revendication 3 caractérisé en ce que l'extrémité de sortie de la portion d'alimentation (501) du conduit (502) et l'extrémité d'entrée de la portion de réception (503) du conduit (502), sont disposées sensiblement dans un même plan (508) où se produit une augmentation sans transition ou à gradin de la section transversale de passage de l'écoulement.

6. Dispositif suivant la revendication 3 caractérisé en ce que l'extrémité d'entrée (910;964) de la portion de réception du conduit est espacée en aval de l'extrémité de sortie (908;962) de la portion d'alimentation du conduit, ledit dispositif comprenant une section de diffuseur (906;956) reliant l'extrémité de sortie (908;960) à l'extrémité d'entrée (910;964), cette section de diffuseur comprenant un diffuseur dont l'aire de la section transversale augmente progressivement de l'extrémité de sortie (908;962) vers l'extrémité d'entrée (910;964).

7. Dispositif suivant la revendication 6 caractérisé en ce que le bord aval (922,974) de l'élément de paroi (914;966) est situé de façon que les tourbillons à grande échelle produits à partir des gorges créent un mélange de la masse de fluide à l'intérieur de la section de diffuseur (906;956) et augmentent le coefficient d'efficacité du diffuseur.

8. Dispositif suivant la revendication 6 caractérisé en ce que l'élément de paroi (914;966) est disposé suffisamment près de la surface d'écoulement interne de la portion d'alimentation du fluide (902;952) pour que les tourbillons à grande échelle produits par l'élément de paroi augmentent l'énergie de la couche limite à l'intérieur du diffuseur et augmentent le coefficient d'efficacité de celui-ci.

9. Dispositif suivant la revendication 6 caractérisé en ce que l'élément de paroi (914;966) est disposé et orienté, à l'intérieur de la portion d'alimentation (902;952) du conduit, de façon

que la séparation du flux à partir de la paroi du diffuseur débute avec des demi-angles du diffuseur plus grands qu'elle n'aurait lieu sans la présence de l'élément de paroi (914;966).

10. Dispositif suivant la revendication 6 caractérisé en ce que la portion d'alimentation (902;952) du conduit est symétrique autour d'un axe s'étendant vers l'aval.

11. Dispositif suivant la revendication 10 caractérisé en ce que le diffuseur (400) est un diffuseur à trois dimensions et l'élément de paroi (402) est symétrique autour dudit axe.

12. Dispositif suivant la revendication 10 caractérisé en ce que la portion d'alimentation (902) du conduit est cylindrique et l'élément de paroi (914) s'étend dans un plan diamétral.

13. Dispositif suivant la revendication 6 caractérisé en ce que l'élément de paroi (914;966) s'étend en travers d'une partie substantielle de la largeur de la portion d'alimentation (902;952) du conduit.

14. Dispositif suivant la revendication 3 caractérisé en ce que la pente des fonds des gorges, par rapport à la direction de l'écoulement de la masse de fluide, se situe entre 5° et 30°, chacune des gorges comprenant une paire de parois latérales (924) se faisant face, dans lesquelles les tangentes à chacune des parois de la paire de parois latérales (924), en leurs points de plus grande pente, à l'endroit du bord aval de l'élément de paroi, forment un angle inclus compris entre 0° et 120°.

15. Dispositif suivant la revendication 3 caractérisé en ce que l'inclinaison des fonds des gorges, par rapport à la direction de l'écoulement de la masse de fluide, est comprise entre 5° et 30°, et chaque gorge comprend une paire de parois latérales se faisant face (924), qui sont sensiblement parallèles l'une à l'autre.

16. Dispositif suivant la revendication 6 caractérisé en ce que ledit dispositif est un convertisseur catalytique (900;950), délivrant des gaz d'échappement, à partir de la portion d'alimentation (902;952), dans et au travers de la portion de réception (904;954) et en ce que la portion de réception (904;954) possède un lit de catalyseur disposé à l'intérieur de celle-ci.

17. Dispositif suivant la revendication 16 caractérisé en ce que la portion d'alimentation (902;952) est cylindrique et le diffuseur et la portion de réception (909,904;956,954) du conduit sont sensiblement de section transversale elliptique, perpendiculairement à la direction aval du flux.

18. Dispositif suivant la revendication 17 caractérisé en ce que le diffuseur est essentiellement un diffuseur à deux dimensions dont la diffusion a lieu parallèlement à l'axe majeur (912;970) de la section transversale elliptique.

19. Dispositif suivant la revendication 17 caractérisé en ce que la direction de la profondeur des gorges est sensiblement parallèle à l'axe majeur (912;970) de la section transversale elliptique.

20. Dispositif suivant la revendication 19 caractérisé en ce que l'élément de paroi (914) est disposé sensiblement le long d'un plan diamétral comprenant l'axe mineur de la section transversale elliptique, et les gorges se situent alternativement au-dessus et au-dessous de ce plan.

21. Système de conversion catalytique comprenant un conduit d'alimentation en gaz (902;952) possédant un orifice de sortie (908;962) ayant une première aire de section transversale de passage de l'écoulement, un conduit de réception (904;954) possédant un orifice d'entrée (910;964) ayant une seconde aire de section transversale de passage de l'écoulement, plus grande que la première aire de section transversale de passage de l'écoulement et espacé, vers l'aval, de l'orifice de sortie (908;962) du conduit d'alimentation et comportant un lit de catalyseur disposé dans le conduit, et un conduit intermédiaire constituant un diffuseur (906;956), possédant une surface d'écoulement reliant l'orifice de sortie (908;962) à l'orifice d'entrée (910;964), caractérisé en ce qu'un mince élément de paroi (914;966), générateur de tourbillons, est disposé dans le conduit d'alimentation en amont de l'orifice de sortie (908;962), et il possède des surfaces d'écoulement opposées se faisant face, s'étendant vers l'aval, un bord amont et un bord aval (922;974), cet élément de paroi (914;966) ayant une partie ondulée comprenant une pluralité de gorges et de nervures alternées et jointives, en forme de U, s'étendant dans la direction de l'écoulement de la masse de fluide qui lui est adjacent, étant séparé de la surface d'écoulement interne, et se terminant à l'endroit du bord aval, la profondeur des gorges et la hauteur des nervures augmentant dans le sens de l'écoulement global du fluide, les contours et les dimensions des gorges et des nervures étant choisis de façon à assurer que chaque gorge produise une paire de tourbillons à grande échelle voisins, en aval de l'orifice de sortie (908;962) et à l'intérieur du conduit intermédiaire (906;956), ladite paire de tourbillons voisins produits par chaque gorge tournant dans des directions opposées autour d'axes s'étendant dans la direction aval.

22. Système de conversion catalytique suivant la revendication 21 caractérisé en ce que chacune des gorges a un fond s'étendant vers l'aval ayant une pente au moins égale à 5° et inférieure à environ 30° par rapport à la direction aval.

23. Système de conversion catalytique suivant la revendication 22 caractérisé en ce que chacune des gorges, vue en section droite, perpendiculairement à la direction aval, est sensiblement en forme de U sur toute sa longueur, et se raccorde avec les nervures adjacentes pour définir une surface ondulée régulière en forme d'onde, vue en section droite perpendiculairement à la direction aval.

24. Système de conversion catalytique suivant la revendication 23 caractérisé en ce que l'amplitude de crête à crête de l'onde du bord aval (922;974) est A et le bord aval (922;974) est situé à une distance comprise entre environ 1A et 2A en amont de l'orifice de sortie (908;962) du conduit d'alimentation.

25. Système de conversion catalytique suivant la revendication 22 caractérisé en ce que le bord aval (922;974) de l'élément de paroi (914;974) est situé de façon telle que les tourbillons à grande échelle produits à partir des gorges créent un mélange de la masse de fluide à l'intérieur du conduit intermédiaire (906;956) et augmentent le coefficient d'efficacité du diffuseur.

26. Système de conversion catalytique suivant la revendication 23 caractérisé en ce qu'il comprend une paire d'éléments de paroi (974) espacés l'un de l'autre et disposés de façon adjacente; mais espacés des surfaces internes opposées du conduit d'alimentation (952).

27. Système de conversion catalytique suivant la revendication 23 caractérisé en ce que l'orifice de sortie (908;962) du conduit d'alimentation est circulaire et l'orifice d'entrée (910;964) du conduit de réception est elliptique, et en ce que la direction de la profondeur des gorges est sensiblement parallèle à l'axe majeur (912;970) de l'orifice d'entrée elliptique (910;964).

28. Système de conversion catalytique suivant la revendication 23 caractérisé en ce que chacune des gorges comprend une paire de parois latérales parallèles (924) se faisant face.

29. Système de conversion catalytique suivant la revendication 28 caractérisé en ce que le diffuseur est essentiellement un diffuseur à deux dimensions dans lequel la direction de diffusion est sensiblement parallèle aux parois latérales (924) des gorges.

30. Système de conversion catalytique suivant la revendication 23 caractérisé en ce que les gorges et les nervures ont des dimensions, des contours, et sont disposées de façon à produire un écoulement total sur toute leur longueur, si bien que la séparation de la couche limite à deux dimensions sur la surface des gorges et des nervures n'intervient pas durant le fonctionnement normal.

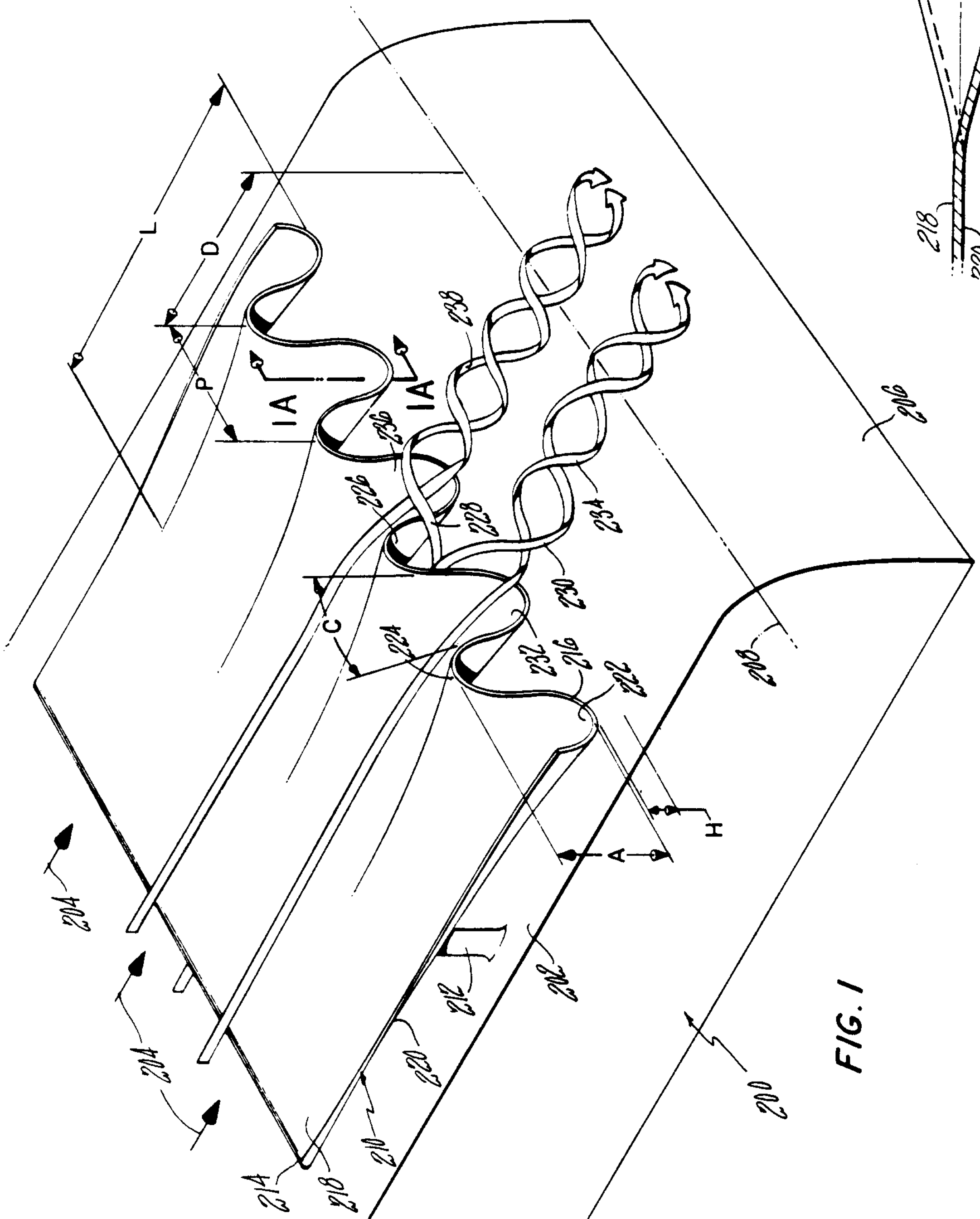

L
D
P
IA
IA
C
A
H
200
202
204
204
204
206
208
210
212
214
216
218
220
222
224
226
228
230
232
234
236
238

FIG. 1

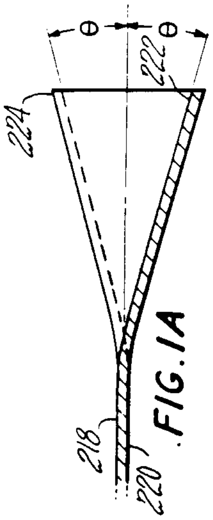

θ
θ
222
224
218
220

FIG. 1A

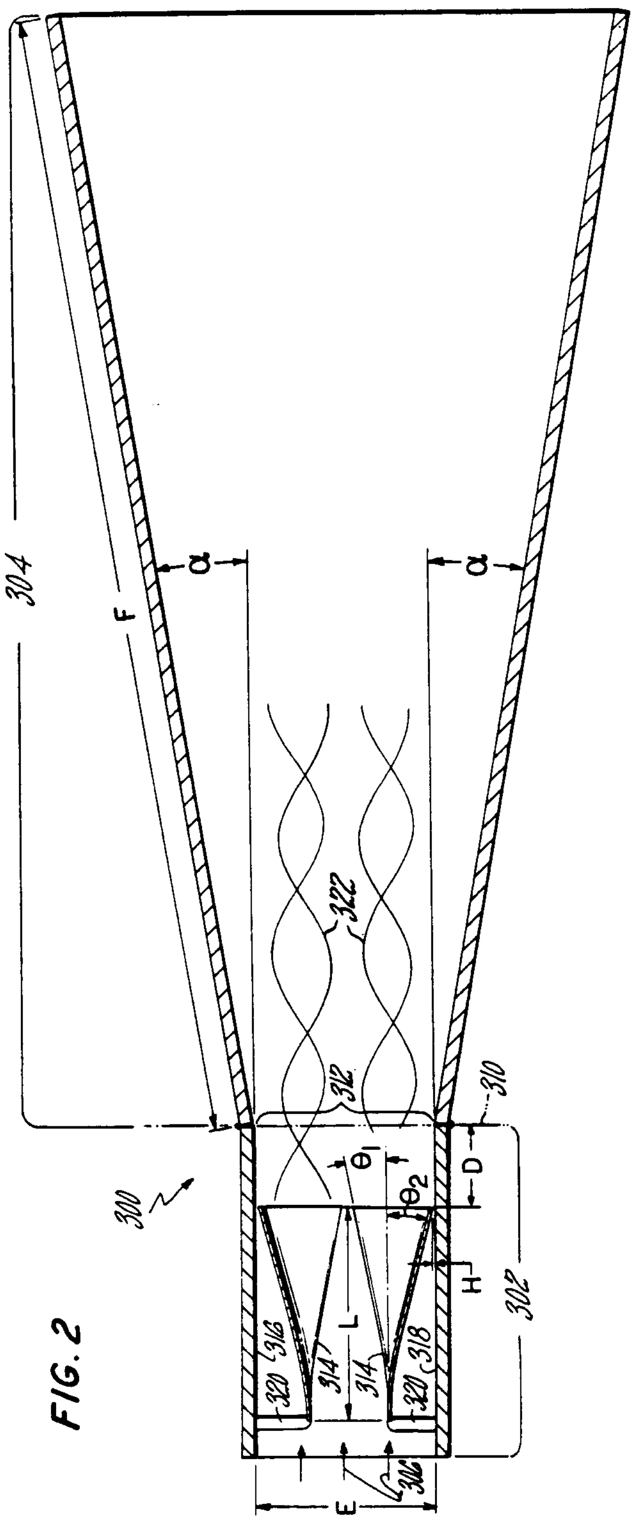

300
302
304
306
310
312
314
316
318
320
322
F
α
D
E
H
L
θ1
θ2

FIG. 2

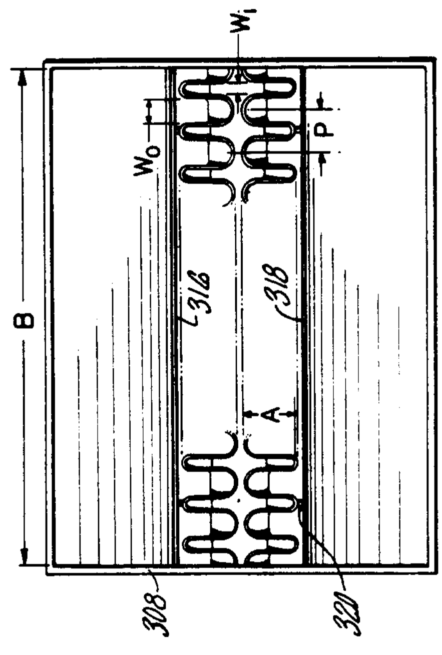

308
316
318
320
A
B
P
W0
W1

FIG. 3

FIG. 4

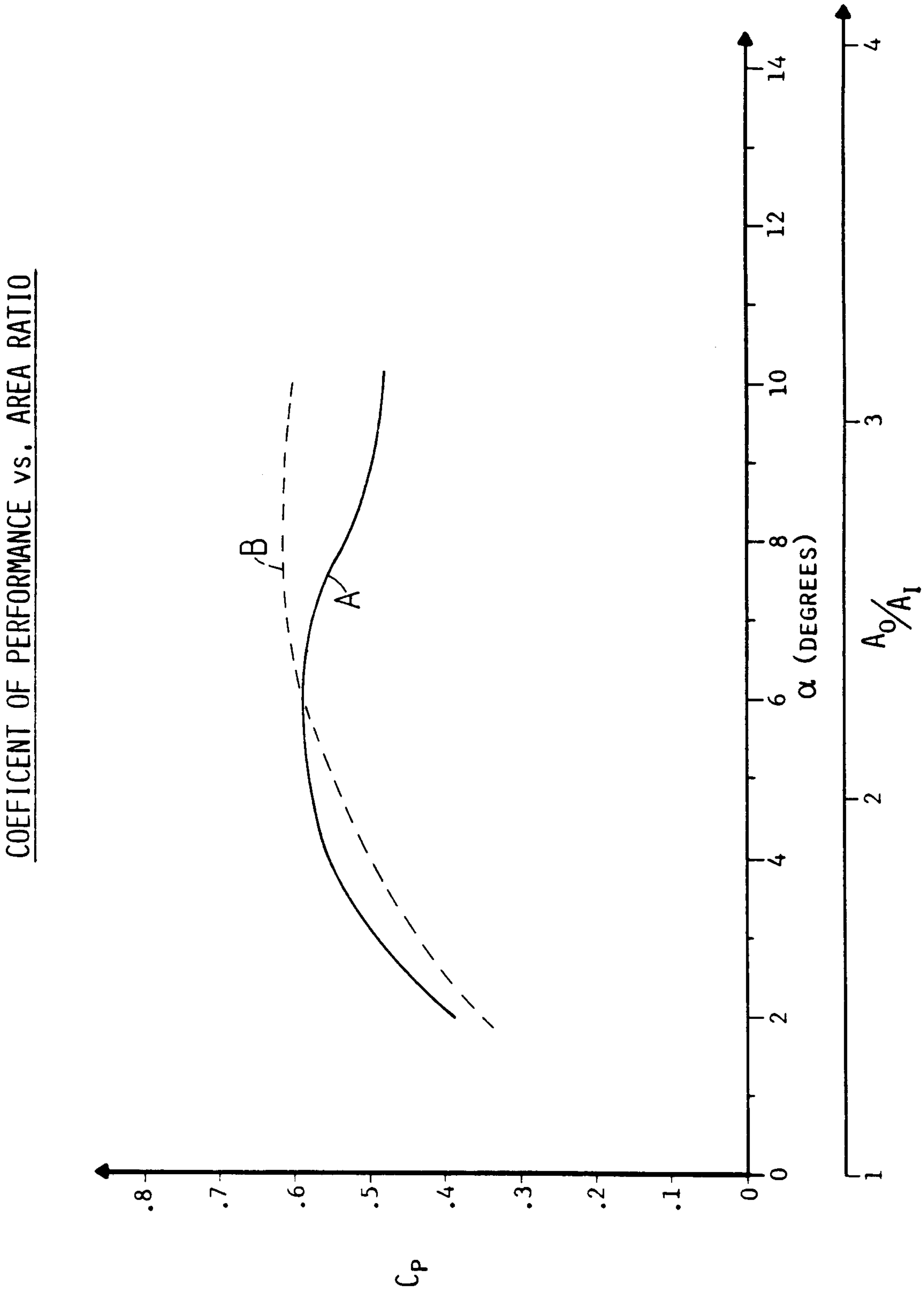

COEFICENT OF PERFORMANCE vs. AREA RATIO
C_P
.8
.7
.6
.5
.4
.3
.2
.1
0
0
2
4
6
8
10
12
14
α (DEGREES)
1
2
3
4
A_O/A_I
A
B

FIG. 6

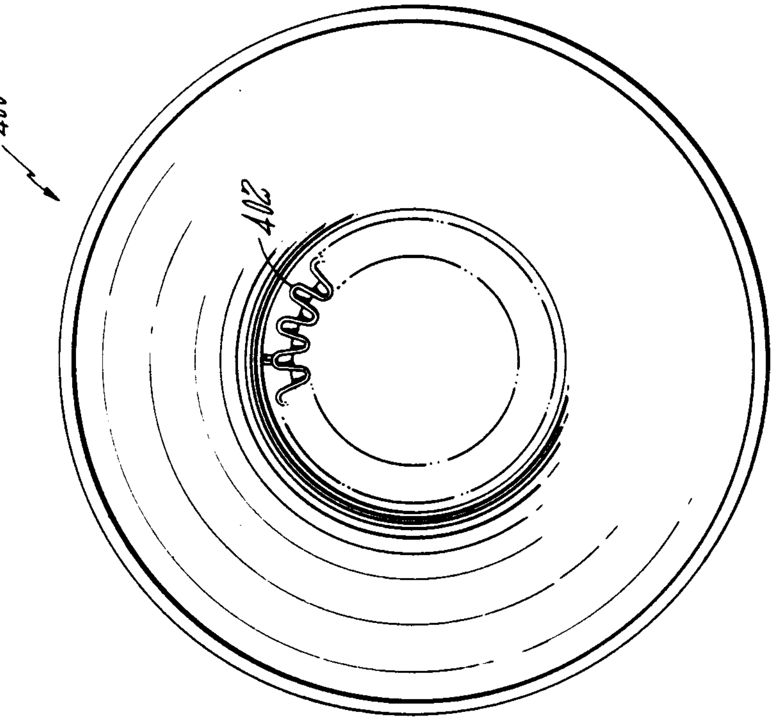
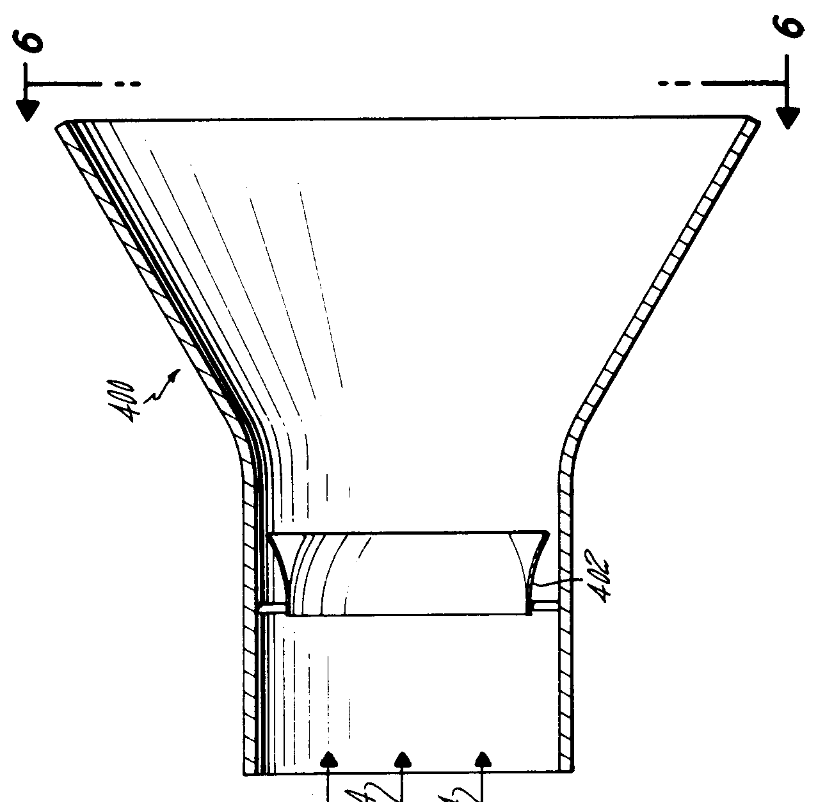


FIG. 5



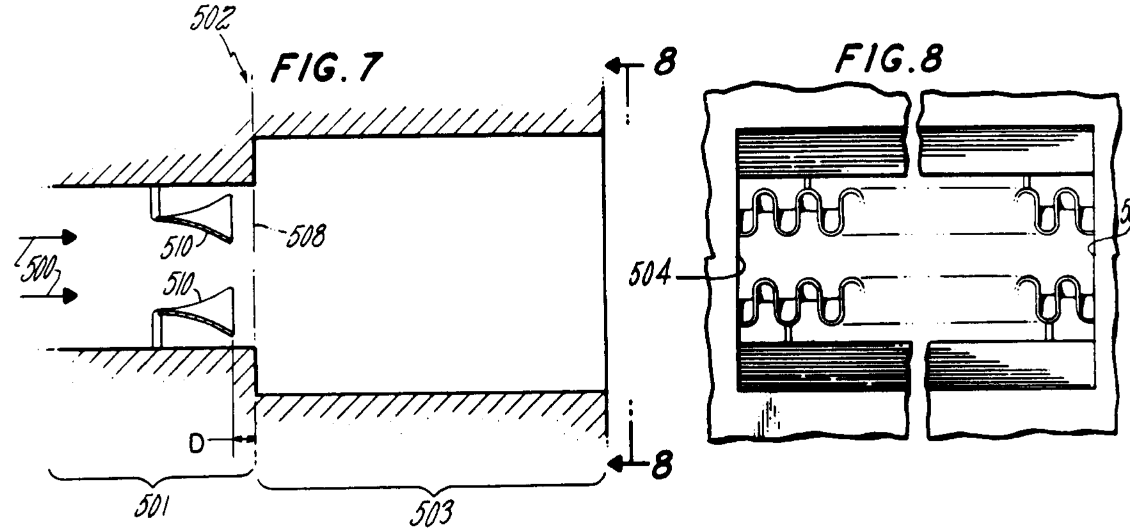


FIG.7

FIG.8

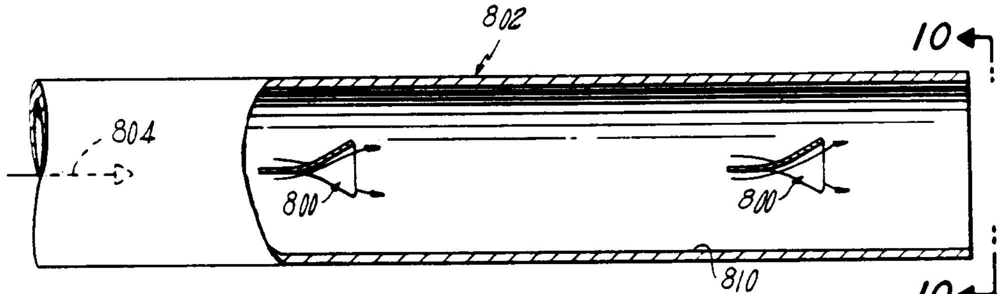


FIG.9

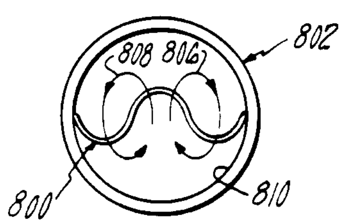


FIG.10

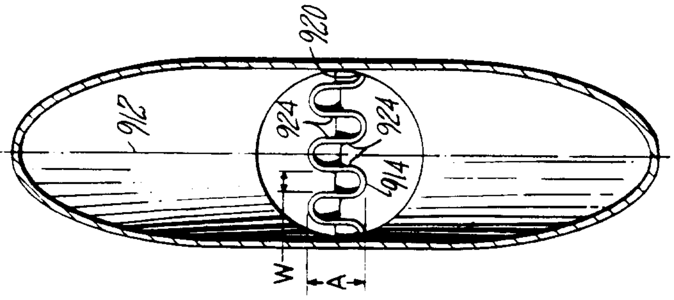

920
912
924
924
914
W
A

FIG. 12

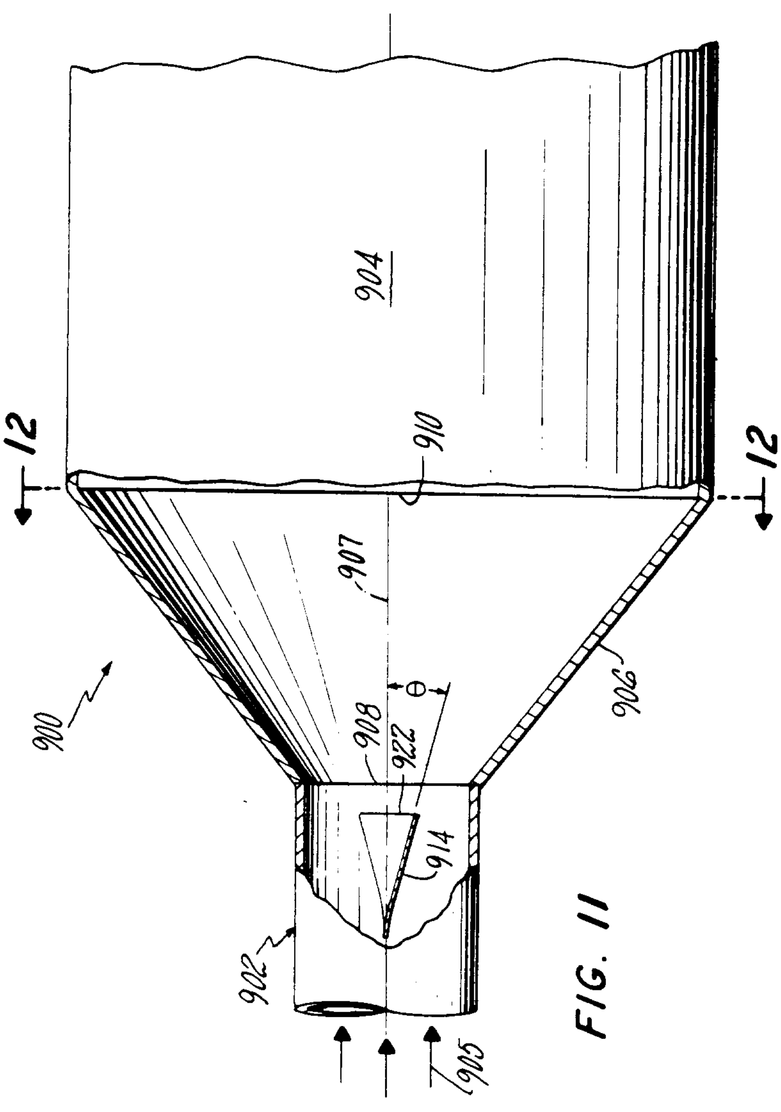

12
12
900
904
910
907
908
922
θ
906
914
902
905

FIG. 11

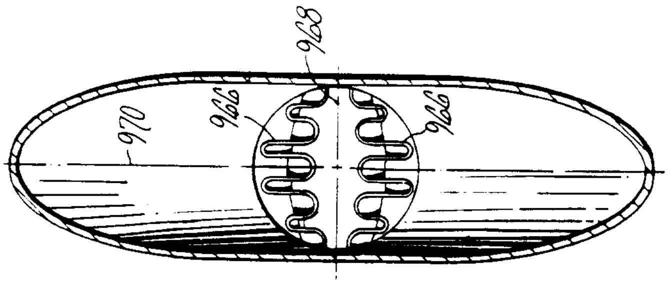

968
970
966
966

FIG. 14

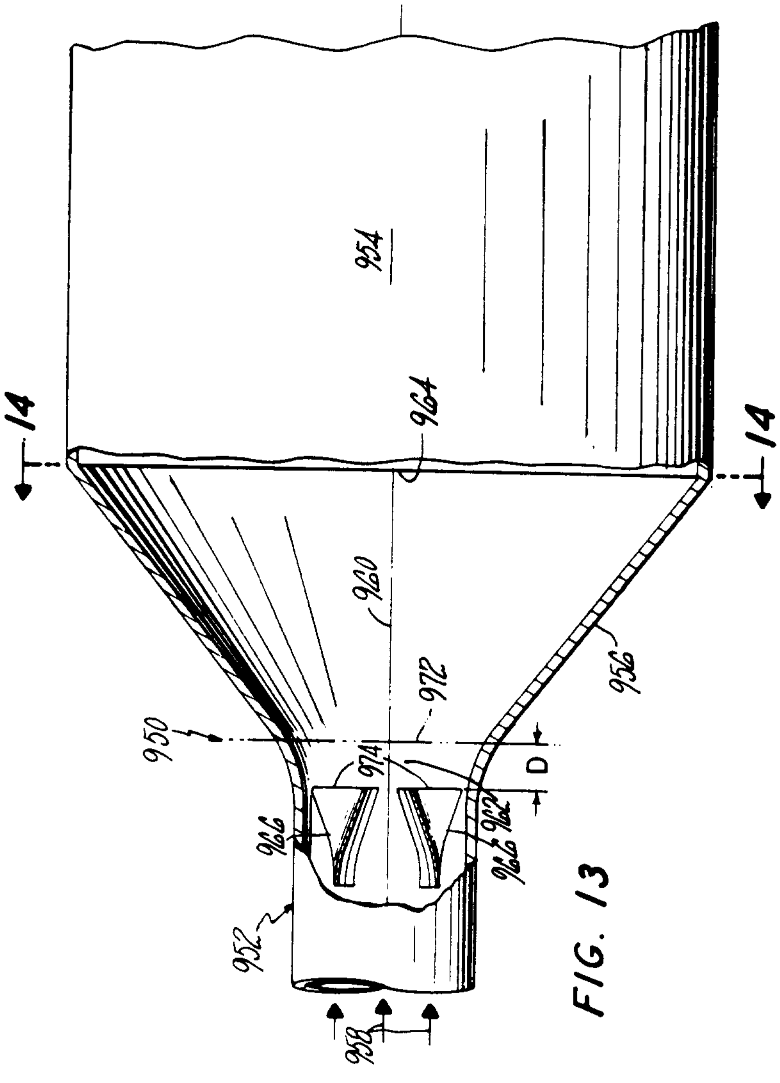

14
14
954
964
960
972
950
956
974
D
966
962
976
952
958

FIG. 13