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(54) **DOUBLE CONE FOR GENERATION OF A PRESSURE DIFFERENCE**

DOPPELKEGEL ZUR ERZEUGUNG EINER DRUCKDIFFERENZ

CONE DOUBLE POUR LA GENERATION D'UNE DIFFERENCE DE PRESSION

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(74) Representative: **AMMANN PATENTANWÄLTE AG
BERN
Schwarztorstrasse 31
3001 Bern (CH)**

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(73) Proprietor: **DCT Double-Cone Technology AG
3602 Thun (CH)**

(72) Inventor: **STARK, John
CH-3665 Wattenwil (CH)**

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Description

BACKGROUND

[0001] The present invention relates to a double-cone arrangement for creating a pressure difference in a fluid flowing through the double-cone arrangement. Specifically, the present invention deals with a double-cone device that produces enhanced suction and reduced wear and tear.

[0002] A double-cone device comprises an entry unit, an exit unit, each of hollow frustoconical shape, and a central section referred to as orifice. When fluid flows through such a device, the orifice section exhibits suction properties. The suction property makes a double-cone device useful for many applications ranging from well pumping to separation processes such as desalination and deionization. The double-cone device is used in these applications for providing pressure amplification to the fluids used in these processes.

[0003] The double-cone device has been described in the US patent application US4792284 titled "Device for creating and exploiting pressure difference and the technical applications thereof". The double-cone device, as described in this patent, is illustrated in FIG.1.

[0004] Double-cone device 100 consists of two coaxial frustoconical sections, referred to as entry cone 102 and exit cone 104, held together by a cylindrical tube 110. Entry cone 102 is characterised by its length L_1 , larger diameter D_1 , smaller diameter d_1 , and conical angle θ_1 . Similarly, exit cone 104 is characterised by its length L_2 , larger diameter D_2 , smaller diameter d_2 and conical angle θ_2 . The region of minimum diameter between the two sections is referred to as orifice 106. Double-cone device 100 is fed with a feed flow that enters entry cone 102 and discharges out through exit cone 104. The feed flow can be any fluid i.e. either liquid or gas.

[0005] Cylindrical connecting tube 110 surrounds the area around the orifice. An inlet 108 on cylindrical connecting tube 110 allows suction of fluid from outside device 100 to be drawn into orifice 106.

[0006] During the flow within double-cone device 100, the feed flow undergoes a pressure variation that is a function of the geometry of double-cone device 100 and the fluid velocity at the inlet of entry cone 102. This pressure variation within double-cone device 100 is illustrated in FIG.2. As shown in FIG.2, the pressure within double-cone device 100 gradually falls as the fluid flows through entry cone 102 and then again rises in exit cone 104. The pressure is minimum at point ($Z=0$) within orifice 106. Also, pressures P_1 at the beginning ($z = -L_1$) of the entry cone 102 and P_2 at outlet point ($z = L_2$) of exit cone 104 are different. This difference in pressure $\Delta P = P_1 - P_2$ is referred to as the pressure-drop across device 100.

[0007] Behaviour of the feed flow or the pressure variation within the device is a function of various factors including geometrical parameters such as the conical angles of the entry and exit cones, external pressures at

the inlet of the entry cone and the outlet of the exit cone. Specifically, higher the external pressure lower the pressure at the orifice. This results in a higher suction force at the orifice.

[0008] The performance of a double-cone device is usually measured in terms of its pressure amplification. Pressure amplification for a double-cone device is defined as the ratio of the pressure P_2 at the outlet of the exit cone to the pressure-drop ΔP across the device. Pressure amplification can be improved by reducing the pressure-drop or increasing the exit pressure. Another performance measuring parameter is the noise that is generated by a double-cone device. High noise level can lead to rapid wear and tear of the device and is generally considered to be environmentally unacceptable. Further, wear and tear of the device must be minimised so as to ensure that the device has a long lifecycle.

[0009] Various modifications have been made in basic double-cone design to improve its performance.

[0010] One such modification has been described in PCT patent application PCT/CH99/00403 (WO 01/16493) titled "Double-cone for generation of a pressure difference". The patent describes a double-cone device comprising an entry and an exit cone connected by their small diameter ends to create an orifice. Further, the inlet is provided in the exit cone away from the orifice. The entry conical angle θ_1 has also been refined to be less than 5° . These modifications decrease noise and wear and tear of the double-cone device.

[0011] Another modification has been described in PCT patent application PCT/CH02/00134 (WO 02/075109) titled "Double-cone device and pump". The double-cone device comprises an entry cone and an exit cone that are connected through a third cone. An inlet is provided in the exit cone. The smaller diameter ends of the entry cone and the third cone are connected to form an orifice. The conical angle of the third cone is less than that of the exit cone. Further, the conical angle of the third cone must be in the range 1° to 5° . The introduction of the third cone and the positioning of the inlet away from the orifice reduce wear and tear. This is because the wall material is not subjected to a very high stress, as is the case with the original double-cone structure. Pressure-drop across the device also reduces, leading to better suction performance.

[0012] While various modifications have been made to the double-cone design, further improvements can be made to enhance the pressure amplification, reduce the noise levels and to stabilise the flow. For example, in the existing device under certain running conditions, the noise generation can reach the order of 110 to 115 decibels whilst the human noise tolerance level is around 85 decibel. Hence, there is a need for a double-cone device with lower noise levels. Further, in the existing double-cone devices, the flow within the device destabilises at high flow rates. Hence, there is a need to improve the design to stabilise the flow at high flow rates.

SUMMARY

[0013] An object of the present invention is to provide a double-cone device with enhanced pressure amplification.

[0014] Another object of the present invention is to provide a double-cone device with enhanced suction pressure at the inlet.

[0015] Another object of the present invention is to provide a double-cone device with reduced noise levels.

[0016] Another object of the present invention is to reduce the wear and tear in a double-cone device thereby increasing its lifetime.

[0017] Another object of the present invention is to improve the flow profile of the fluid flowing through a double-cone device.

[0018] Another object of the present invention is to provide a double-cone device with reduced working temperature.

[0019] Yet another object of the present invention is to provide a double-cone device, which can work efficiently at higher flow velocities, as compared to the existing double-cone devices.

[0020] At least the first mentioned object is attained by the embodiment of the present invention, the gap in the exit cone away from the orifice is replaced by a porous section, modelled as region with infinite holes of very small size, between the exit cone and the orifice. This porous section is made of material such as ceramics.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The preferred embodiments of the invention will hereinafter be described in conjunction with the appended drawings provided to illustrate and not to limit the invention, wherein like designations denote like elements, and in which:

FIG.1 illustrates a double-cone arrangement described in Patent Number US4792284 titled "Device for creating and exploiting pressure difference and the technical applications thereof";

FIG.2 shows the pressure variation of the feed flow as it flows across the various sections of the double-cone device;

FIG.3 illustrates a continuous geometry double-cone device which does not form part of the present invention;

FIG.4 illustrates a continuous geometry double-cone device with a porous section.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0022] The present invention discloses a double-cone device with continuous geometry having a first tapering

section and a second diverging section. A section of porous material on the second section, beyond the orifice, facilitates suction into the device. The orifice is the point at which the tapering section ends and the diverging section begins, which is also the section of minimum diameter of the device.

[0023] FIG. 3 illustrates a double-cone device 300 of continuous geometry. Device 300 comprises two hollow frustoconical sections referred to as first tapering section (hereinafter entry cone) 302 and a second diverging section (hereinafter exit cone) 304 and a plurality of holes 306 on exit cone 304. The section of minimum diameter of device 300 is also referred to as orifice 308. Orifice 308 is also the exit section of entry cone 302 and entry section of exit cone 304. In a preferred embodiment, edge of the orifice should be sharp and the section should be perfectly circular. It should be apparent to one skilled in the art that edge can also be smooth.

[0024] Entry cone 302 is characterised by its length L_1 , larger diameter D_1 and conical angle θ_1 . Similarly, exit cone 304 is characterised by its length L_2 , larger diameter D_2 and conical angle θ_2 .

[0025] In a preferred embodiment of the present invention, entry conical angle θ_1 is less than or equal to 5° while the exit conical angle θ_2 is less than or equal to 4° . Values of L_1 , D_1 , L_2 and D_2 can be chosen corresponding to the chosen value of θ_1 and θ_2 . It must be apparent to one skilled in the art that other values of the entry cone angle and the exit cone angle can be used without deviating from the scope of the present invention. However, for the provided choice of angles, the device achieves reduced noise levels and requires a lower energy input.

[0026] Double-cone device 300 is fed with feed flow 310 that enters entry cone 302 and discharges through exit cone 304. Feed flow 310 can be any fluid such as a liquid or a gas.

[0027] Feed flow 310 undergoes a pressure variation within double-cone device 300. Pressure within double-cone device 300 gradually falls as feed flow 310 flows through entry cone 302 and then again rises in exit cone 304. The pressure is minimum at orifice 308. Low pressure around the region of orifice 308, in the exit cone, allows material 312 from outside of device 300 to be sucked into device 300 through holes 306.

[0028] Holes can be of any shape such as square shaped, elliptical shaped and circular shaped.

[0029] According to the present invention, the entry section of the exit cone is made of porous material, instead of having the plurality of holes. This embodiment is described using FIG.4.

[0030] FIG.4 shows a double-cone device 400 comprising entry cone 302, exit cone 304, and a porous section 402. The geometry of the device is continuous and entry cone 302 and exit cone 304 are made of first material, which can be the standard material used for making double-cone devices, such as steel. Porous section 402 is made of a porous material such as ceramic or glass compounds. Porous concrete compounds are ideal for

use in large double-cone devices. Other examples can be creation of porous section by chemical leaching of suitable materials. For instance, compounds composed of various alloys and plastics can be used to form the geometry and the porous section is then formed by subjecting the appropriate region to chemical or electrical attack. Feed flow 310 flows through device 400 moving from the inlet of entry cone 302 and discharging into outlet of exit cone 304. The discharge includes feed flow 310 as well as sucked material 404. Material 404 is sucked into device 400 through porous section 402.

[0031] For the porous material, hole sizes in the range of 50 to 500 μm are used to provide a relatively silent suction (low noise levels) without reducing the suction capacity. Also, the diameter of porous section 402 should preferably be less than 1.5 times the diameter of orifice 308.

ADVANTAGES

[0032] The present invention provides enhanced pressure amplification and reduced noise.

[0033] Noise in a double-cone device is generated by a flow profile that does not respect the chosen geometry. In other words, the flow is not fully in contact with the double-cone walls. Also, in existing devices, the flow profile changes sharply as feed flow moves from the entry cone to the orifice region. The present invention reduces this noise by creating a flow profile that more closely follows the wall geometry than in existing double-cone devices.

[0034] The continuous geometry of the double-cone device of the present invention causes the feed flow profiles in orifice 308 and exit cone 304 to remain in contact with the wall. This is because the continuous geometry does not allow flow feed 310 to become free, as is the case in existing double-cone devices. Hence, there is no drastic change in the flow profile as feed flow 310 moves from orifice 308 to exit cone 304. This improved flow profile leads to a significant reduction in the noise levels. Further, the improved flow profile reduces the wear and tear of the device. Additionally, improved flow profile allows the device to work efficiently at much higher flow rates than that possible with the existing devices.

[0035] Continuous geometry also leads to an increase in the pressure amplification as compared to the existing double-cone devices. The pressure amplification that can be achieved is a function of the flow regime within the double-cone. Specifically, the pressure amplification is a function of the axial flow velocity component. More dominant the axial flow velocity component, greater is the amplification that can be achieved. The continuous geometry reduces the tendency for the non-axial flow velocity components to increase in magnitude resulting in the increase in pressure amplification.

[0036] For example, a continuous geometry double-cone device results in around 50% increase in pressure amplification as compared to the performance of an ex-

isting double-cone device. The noise generated by the continuous geometry double-cone device also decreases. For the existing double-cone device, a noise level of around 100 dB is generated while the continuous geometry double-cone generates noise of around 80 dB. Specifically, in one experiment performed on continuous geometry double-cone of entry conical angle 5° and exit conical angle 2° , a pressure-drop of only 10 bar was developed whilst developing a pressure amplification of ~ 1.8 at a noise level of $\sim 80\text{dB}$. This performance was $\sim 50\%$ better in pressure amplification than an existing device of comparable power.

[0037] Further, for $\theta_1 \leq 5^\circ$ the tendency of feed flow to rotate within device 300 is reduced. Rotation of the feed flow causes energy consumption. Hence, the provided choice of entry angle reduces the energy consumption due to rotation. The reduction in energy consumption results in increase in the pressure amplification that can be achieved.

[0038] For $\theta_2 \leq 4^\circ$, the flow profile of feed flow within exit cone 304 is stabilised. Stability in flow allows device 300 to be used efficiently even at higher flow rates. Energy consumed by device 300 is also reduced. Further, the noise generated by device is reduced.

[0039] For example, an existing double-cone device with entry conical angle 5° and exit conical angle 5° failed to perform efficiently when used as a specific hydraulic reverse pumping application. On the other hand, the double-cone device according to the present invention with an exit conical angle 2° worked without any problem.

[0040] The use of holes, as opposed to sliced sections removed from the exit cone in the existing double-cone devices, leads to an enhanced suction pressure downstream of the orifice 308. The suction force depends on the pressure that is generated in the neighbourhood of the orifice 308. The pressure in this region is a function of various parameters. The parameters include geometry of double-cone device 300, pressure applied at the outlet of exit cone 304 and the position of inlets to suck the material into device 300. Specifically, if the inlet for sucking the material is closer to the orifice, the suction force is higher. This is because the suction force depends on the pressure existing in orifice 308. Lower the pressure in orifice 308, higher is the suction force. The pressure rises dramatically with distance from the orifice 308. Hence, to maximise the suction force, the suction inlet should be as close to orifice 308 as possible. The present invention utilises this fact to achieve higher suction by using plurality of holes 306 near the orifice.

[0041] Holes 306 are used since they can be placed closer to orifice plane than a slice taken out of the exit cone, as is the case with existing devices. When a slice is removed from the exit cone a free jet is created that does not reestablish contact with the exit cone walls until well into the exit cone. This problem is aggravated by flow speed. If the removed slice is too close to the orifice the jet speed is too high for the exit cone to exercise an adequate influence on the main flow near the orifice.

Hence, the slice cannot be placed close to the orifice.

[0042] While the preferred embodiments of the invention have been illustrated and described, it will be clear that the invention is not limited to these embodiments only. Numerous modifications and changes will be apparent to those skilled in the art without departing from the scope of the invention which is defined by the appended claims.

Claims

1. A double-cone device (400) of continuous geometry for creating a pressure difference in a fluid flowing through the device, the device comprising:

- a. a first tapering section (302) of essentially hollow frustoconical shape;
- b. subsequently to the first section, a second porous diverging section (402) of essentially hollow frustoconical shape to achieve suction; and
- c. subsequently to the second section, a third diverging section (304) of essentially hollow frustoconical shape, extending from the end of the porous section;
- d. the transition between first and second section constituting an orifice,

so that due to the continuous geometry, the flow profiles of a fluid fed through the device remains in contact with the wall of the device in the orifice and the second and third section.

2. The device according to claim 1, wherein conical angle of the first tapering section is greater than 0° and at most 10°, preferably at most 5°.
3. The device according to claim 1, wherein conical angle of the third diverging section is greater than 0° and at most 10°, preferably at most 4°.
4. The device according to claim 1, wherein the porous section has larger diameter greater than smaller diameter of the first tapering section and less than 1.5 times the smaller diameter of the first tapering section.

Patentansprüche

1. Doppelkonusvorrichtung (400) mit kontinuierlicher Geometrie zur Erzeugung eines Druckunterschieds in einem durch die Vorrichtung strömenden Fluid, wobei die Vorrichtung umfasst:

- a. einen ersten sich verjüngenden, im Wesentlichen hohlen kegelstumpfförmigen Abschnitt (302);

- b. nach dem ersten Abschnitt einen zweiten porösen, sich erweiternden, im Wesentlichen hohlen kegelstumpfförmigen Abschnitt (402) zur Erzielung einer Saugwirkung; und
- c. nach dem zweiten Abschnitt einen dritten sich erweiternden, im Wesentlichen hohlen kegelstumpfförmigen Abschnitt (304), der vom Ende des porösen Abschnitts ausgeht;
- d. wobei der Übergang zwischen dem ersten und dem zweiten Abschnitt eine Öffnung bildet,

so dass die Strömungsprofile eines durch die Vorrichtung geleiteten Fluids infolge der kontinuierlichen Geometrie in der Öffnung sowie im zweiten und dritten Abschnitt mit der Wand der Vorrichtung im Kontakt bleiben.

2. Vorrichtung nach Anspruch 1, wobei der Kegelwinkel des ersten sich verjüngenden Abschnitts grösser als 0° ist und höchstens 10° beträgt, vorzugsweise höchstens 5°.
3. Vorrichtung nach Anspruch 1, wobei der Kegelwinkel des dritten sich erweiternden Abschnitts grösser als 0° ist und höchstens 10° beträgt, vorzugsweise höchstens 4°.
4. Vorrichtung nach Anspruch 1, wobei der poröse Abschnitt einen grösseren Durchmesser aufweist, der grösser ist als der kleinere Durchmesser des ersten zulaufenden Abschnitts und kleiner als 1,5-mal der kleinere Durchmesser des ersten sich verjüngenden Abschnitts.

Revendications

1. Dispositif à double cône (400) à géométrie continue pour créer une différence de pression dans un fluide s'écoulant à travers le dispositif, ledit dispositif comprenant:

- a. une première section se réduisant (302) de forme essentiellement tronconique creuse;
- b. après la première section, une deuxième section divergente (402) de forme essentiellement tronconique creuse pour produire un effet d'aspiration; et
- c. après la deuxième section, une troisième section divergente (304) de forme essentiellement tronconique creuse s'étendant à partir de l'extrémité de la section poreuse;
- d. la transition entre la première et la deuxième section constituant un orifice,

de telle manière qu'en raison de la géométrie continue, les profils d'écoulement d'un fluide alimenté à travers le dispositif reste en contact avec la paroi du

dispositif dans l'orifice et dans la deuxième et la troisième section.

2. Dispositif selon la revendication 1, où l'angle conique de la première section se réduisant est supérieur à 0° et égal à 10° au plus, préférablement à 5° au plus. 5
3. Dispositif selon la revendication 1, où l'angle conique de la troisième section divergente est supérieur à 0° et égal à 10° au plus, préférablement à 4° au plus. 10
4. Dispositif selon la revendication 1, où la section poreuse a un grand diamètre supérieur au petit diamètre de la première section effilée et inférieur à 1,5 fois le petit diamètre de la première section se réduisant. 15

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Prior Art

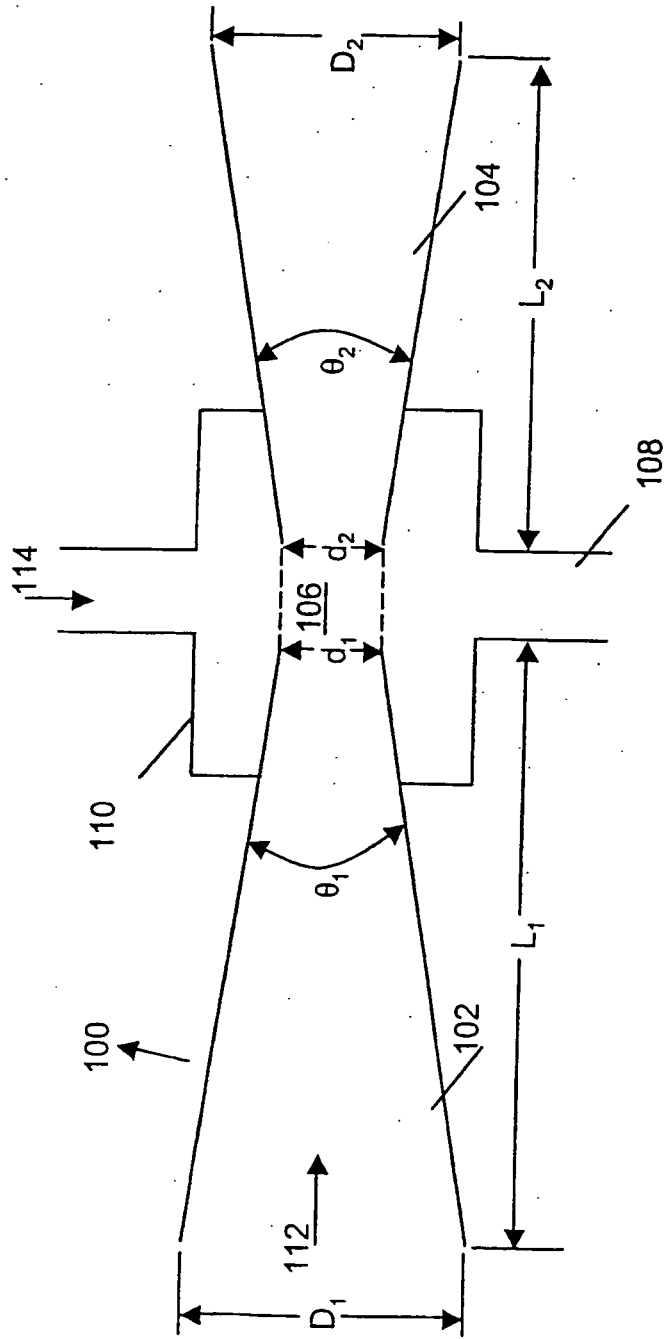


FIG.1

Prior Art

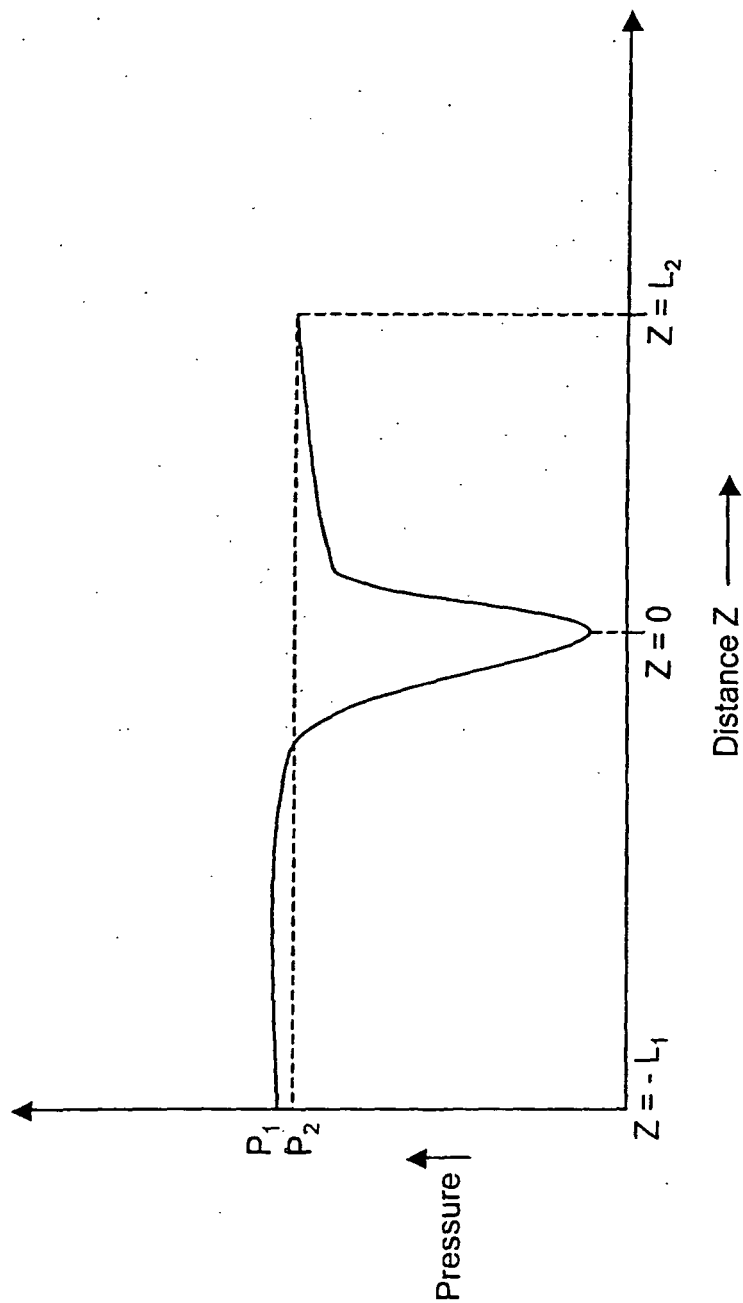


FIG.2

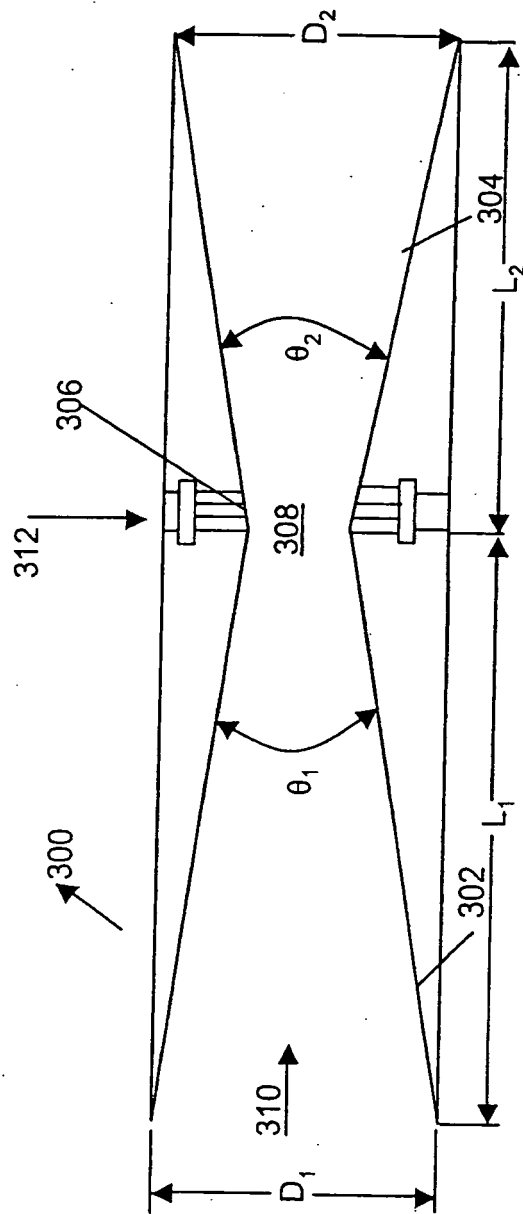


FIG.3

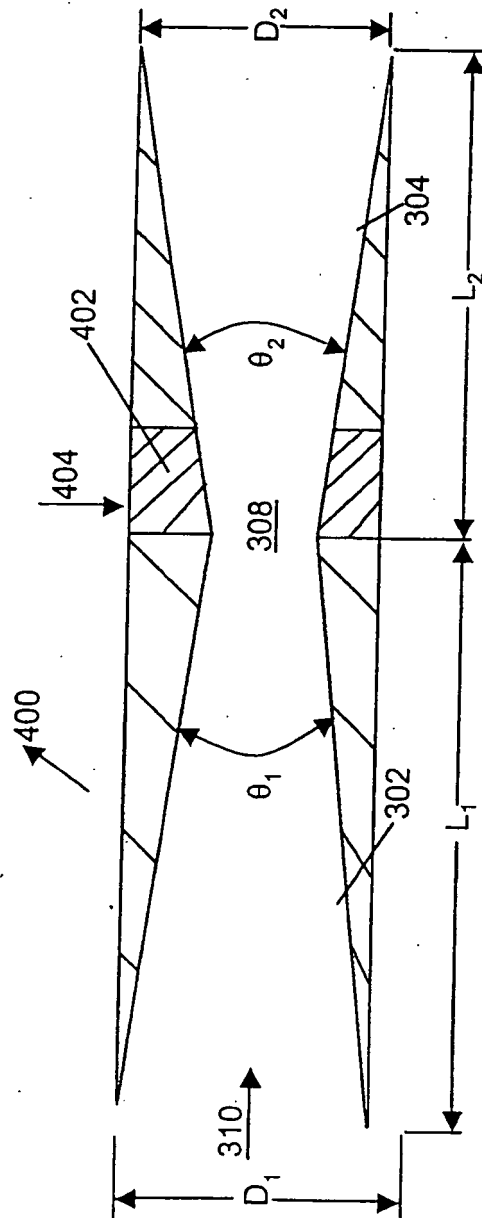


FIG.4

REFERENCES CITED IN THE DESCRIPTION

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