United States Patent [19]

O'Connor

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[54] **DIFFUSER FOR CENTRIFUGAL COMPRESSOR**

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[21] Appl. No.: **162,242**

[52] **U.S. Cl.** **415/181,** 415/207, 415/211

[51] **Int. Cl.** **F04d 21/00,** F04d 29/44

[58] **Field of Search** 415/181, 207, 211, 415/182, 187

[56] **References Cited**

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3,333,762	8/1967	Vrana	415/207
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3,604,818	9/1971	Cronstedt	415/207

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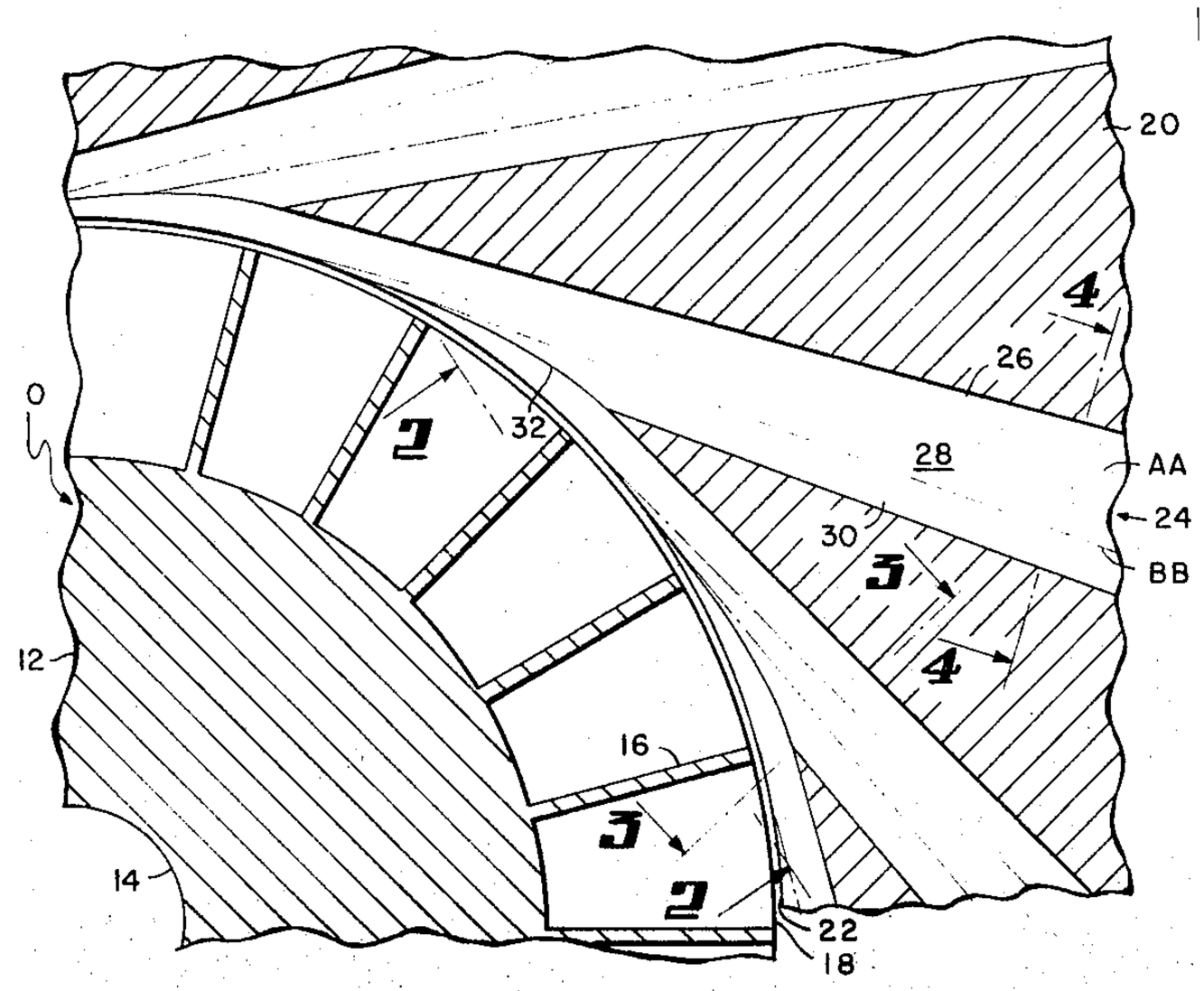
[57] **ABSTRACT**

The disclosure illustrates a diffuser of the "pipe diffuser" type in which the intersecting inlet flow passages are formed by the volume swept by a cylinder displaced from a first position in which its longitudinal axis is tangent to a reference circle to a second position. This enables the diffuser to handle a given flow rate with a minimum number of passages and provide increased flow range for the stage.

1 Claim, 7 Drawing Figures



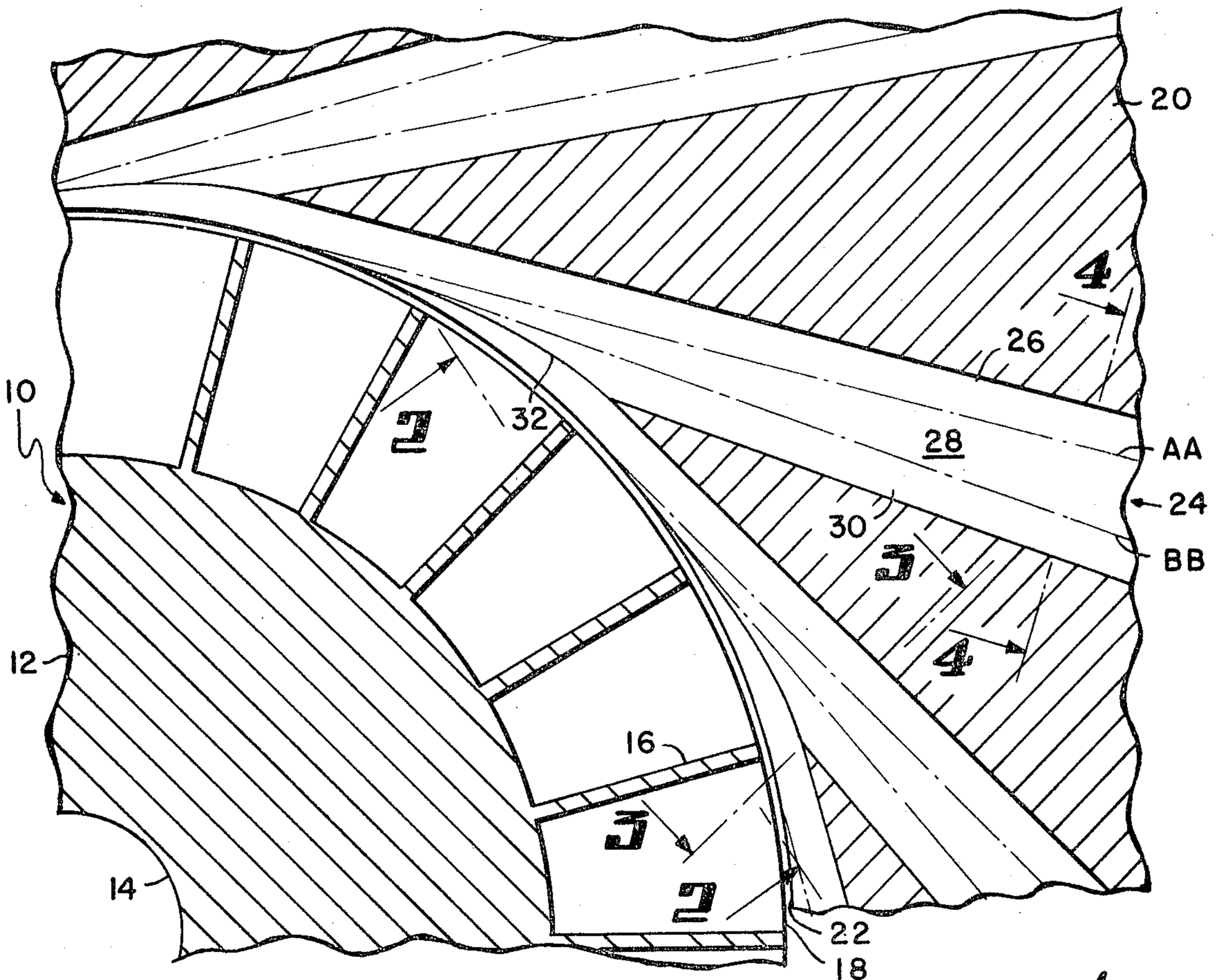


Fig 1

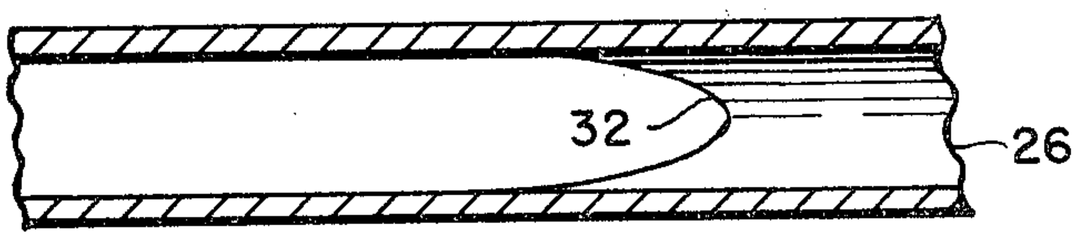


Fig 2

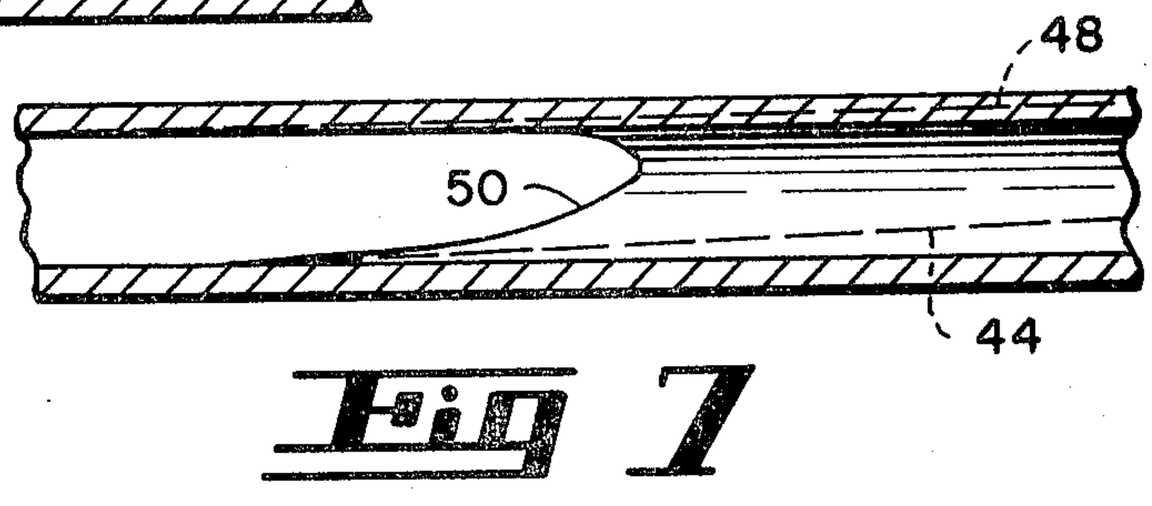


Fig 7

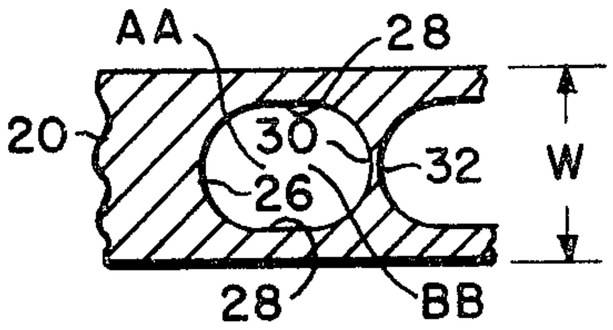


Fig 3

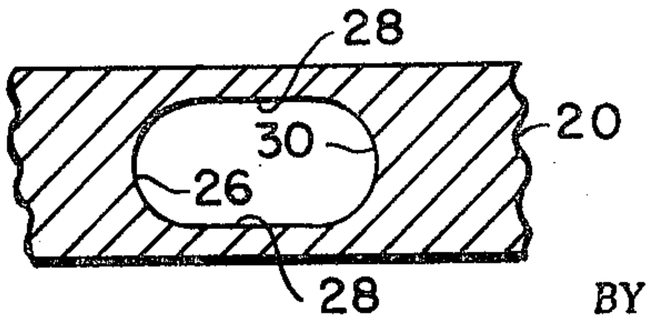


Fig 4

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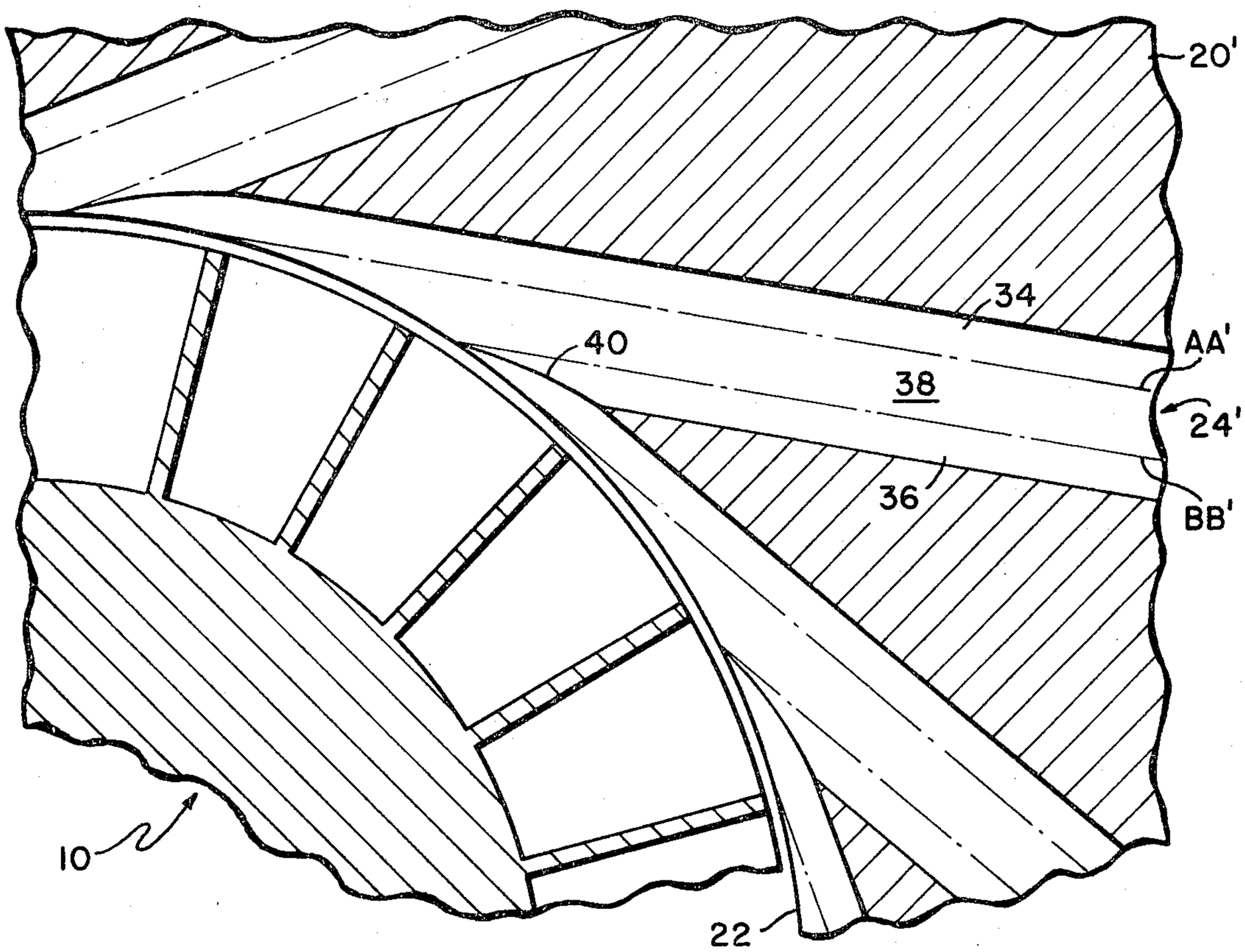

Fig 5

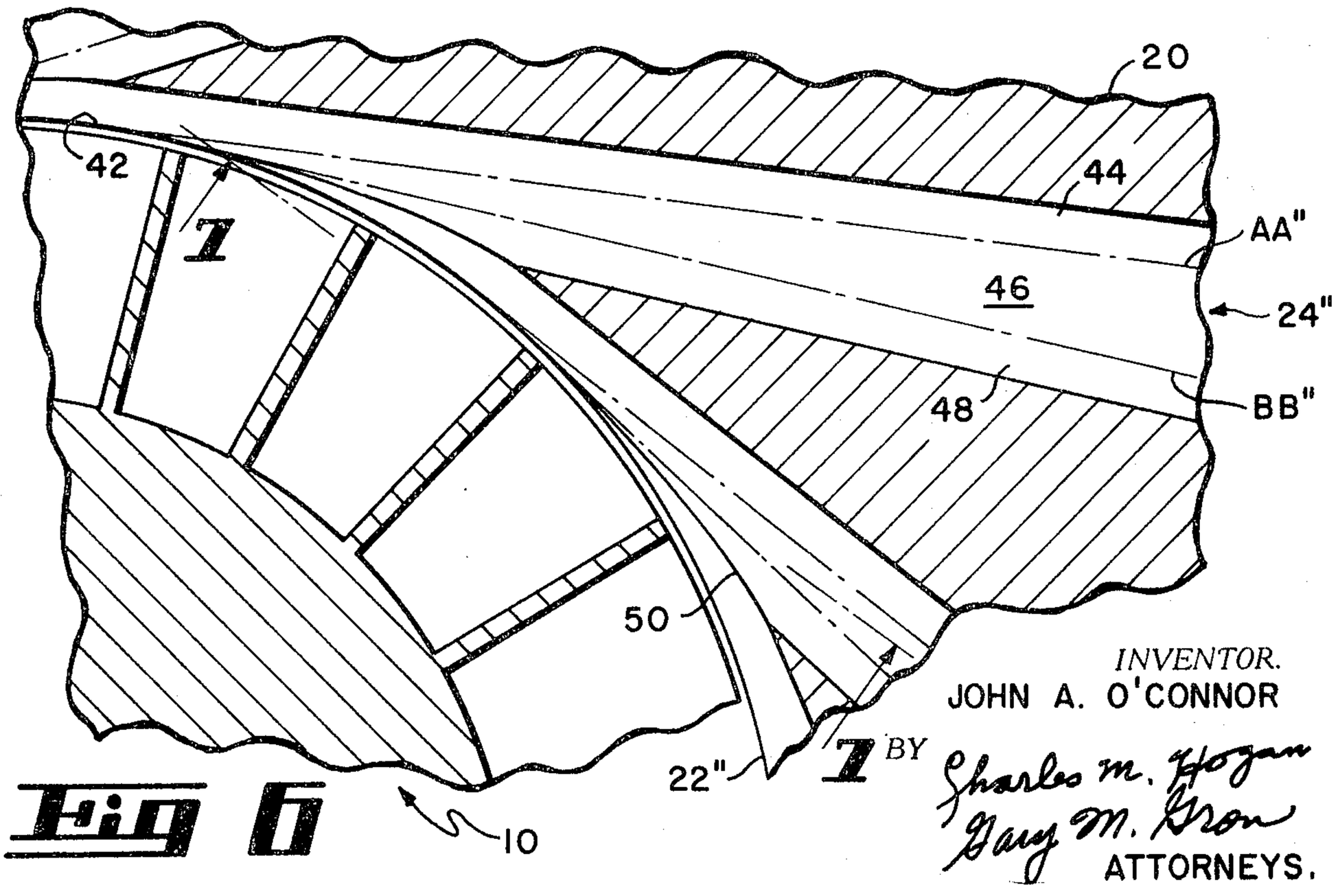

Fig 6

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DIFFUSER FOR CENTRIFUGAL COMPRESSOR

The present invention relates to diffusers and more particularly to diffusers of the "pipe diffuser" type.

In recent years there have been notable advances in diffusers for centrifugal impellers. An early example of this may be found in the patent to Vrana, U.S. Pat. No. 3,333,762, issued on Aug. 1, 1967. This patent describes a diffuser in which pipe-like flow passages with scalloped leading edges are formed by drilling a plurality of intersecting holes in a housing. This type of diffuser provides a low cost high efficiency diffuser that effectively handles supersonic airflow from a centrifugal compressor impeller.

An additional example of a modified "pipe diffuser" is found in the patent application to Cronstedt et al., filed on Dec. 10, 1969, Ser. No. 883,819, now U.S. Pat. No. 3,604,818 and of common assignment with the present invention. This latter development utilizes diamond-shaped intersecting passages to produce generally V-shaped leading edges, as opposed to the elliptical edges of the Vrana patent.

In the design of a centrifugal stage to provide for a certain pressure ratio at a given rotational speed, the impeller exit radii is chosen to provide the required work input. The impeller channel width is usually selected to provide a limiting diffusion in the impeller. The diffuser throat area must be sized to pass a flow slightly greater than design airflow.

In some cases the design resulting provides a relatively high radius, narrow width impeller exit requiring a high pipe number to provide the required throat area for the stage. This pipe diffuser with high pipe numbers tends to increase the stalling flow of the stage and reduces range because of a combination of poor leading edge incidence and excessive leading edge loading.

Therefore it is an object of the present invention to provide a diffuser of the above general type that has a substantially increased flow range, a minimum number of passages and more favorable inlet flow conditions.

These ends are achieved by a diffuser comprising a generally annular housing surrounding the periphery of a centrifugal impeller. The housing has a plurality of intersecting passageways formed in it. Each of the passageways are formed at their intersecting inlet ends by the volume of housing swept by a cylinder displaced from a first position, having its longitudinal axis tangent to a reference circle and lying in the plane formed by the reference circle to a second predetermined position. The passageways intersect adjacent the periphery of the centrifugal impeller thereby forming a series of elliptical leading edges to the passageways. This reduces the pipe number which results in a reduced leading edge incidence and loading and allows the stage to operate to a lower stall airflow at a fixed speed resulting in an increased operating range for the stage.

The above and other related objects and features of the present invention will be apparent from a reading of the description of the disclosure shown in the accompanying drawings and the novelty thereof pointed out in the appended claims.

In the drawings:

FIG. 1 is a fragmentary sectional view of a diffuser embodying the present invention, along with a centrifugal impeller with which it is used;

FIG. 2 is a fragmentary section view of FIG. 1 taken on line 2—2 of FIG. 1;

FIGS. 3 and 4 are sectional views respectively taken on lines 3—3 and 4—4 of FIG. 1 showing the shape of the diffuser passageways;

FIG. 5 is a fragmentary sectional view of another diffuser showing an alternate embodiment of the present invention;

FIG. 6 is still another diffuser illustrating a different embodiment of the present invention; and

FIG. 7 is a view taken on line 7—7 of FIG. 6.

Referring now to FIG. 1 there is shown a centrifugal compressor impeller 10 comprising a hub 12 having a central opening 14 for mounting on a rotatably journaled shaft (not shown). A series of vanes 16 extend radially from the hub so that rotation of the hub accelerates air flowing between the vanes for discharge from the periphery 18 of the impeller at a relatively high velocity up to and exceeding sonic levels.

An annular diffuser comprising a housing 20 surrounds the periphery 18 of impeller 10. Housing 20 has an inner opening 22 positioned closely adjacent the periphery 18 of centrifugal impeller 10. Housing 20 has a plurality of inlet passageways 24 formed around its periphery which receive the air discharged from impeller 10. Inlet passageways 24 connect with suitable diverging subsonic passageways (not shown) either of the conical or other type.

The inlet passages 24 are formed by the volume swept by a cylinder as it is displaced from a first position in which it is tangent to a reference circle to a second position. A cylinder as described herein is taken to mean the surface traced by a straight line (termed a generatrix) moving parallel to a fixed straight line, as defined in Webster's New International Dictionary, Second Edition. From this it is seen that the cylinder would not necessarily be limited to one with a circular cross section.

In the embodiment shown in FIG. 1 the one side of the passage 24 is formed by the edge of a circular cross section cylinder whose longitudinal axis AA is tangent to a reference circle which, as shown, coincides with the inner diameter 22 of housing 20. The cylinder is translated and rotated to a second position where its longitudinal axis BB is tangent to the same reference circle 22 but at a point circumferentially spaced somewhat from the point of tangency of center line AA. The net result is that the passageway 24 has a first curved wall 26, triangularly shaped upper and lower midsections 28 and an opposing curved wall 30. It can be seen, particularly in FIG. 2, that the inner section of curved walls 26 and 30 forms an elliptically shaped leading edge 32 for the passages 24. As shown in FIGS. 3 and 4, the passages thus formed have a substantial cross-sectional flow area for a given diffuser pipe width W. This diffuser pipe width is set approximately equal to the impeller exit width.

Referring to FIG. 5 there is shown another embodiment of the present invention in which passageways 24' are formed from a cylinder whose longitudinal axis AA' is tangent to a reference circle, herein shown as the inner diameter of the diffuser 22' to form a first curved side wall 34. The cylinder is laterally translated to a position in which its center line BB' is spaced from but parallel to axis AA' to produce an opposing side wall 36 and generally rectangularly shaped top and bottom walls 38. This arrangement also forms a scalloped leading edge 40 which is somewhat shorter than the scalloped leading edge of the embodiment shown in FIG.

1. It can be seen that this embodiment offers an opportunity for a greatly increased cross-sectional entrance flow area per pipe, as does the embodiment of FIG. 1.

FIG. 6 illustrates still another embodiment of the present invention in which passageways 24'' are formed by a cylinder whose axis AA'' is tangent to a reference circle, shown in inner diameter 22'' of the housing 20''. In this case the longitudinal axis of the cylinder is rotated in the plane of the reference circle 22'' and also rotated slightly out of the plane of circle 22'' so that its axis BB'' intersects axis AA'' at the point 42 at which AA'' is tangent to reference diameter 22''. It should be pointed out that the point of intersection of axis BB'' and AA'' does not necessarily have to be at point 42. The result of the displacement is that a first curved wall 44 is formed along with inclined triangular top and bottom walls 46 and a curved side wall 48. The intersection of side walls 48 and 44 of adjacent passages produces a scalloped leading edge 50 that is nonsymmetrical with respect to a central axis through the passages as shown in FIG. 7. This permits a tailoring of the scalloped leading edge 50 to accept a nonsymmetrical flow pattern from impeller 10''. The angle which axis BB'' makes with the reference plane determines the shape of leading edge 50 and this may be selected to produce a particular leading edge configuration.

All the embodiments shown above allow for a given impeller geometry and diffuser throat area requirement, a diffuser to be constructed for a minimum number of pipes and with entrance region geometry suited to the attainment of maximum operating range for this type of diffuser. By incroporation of flexibility in forming the separate passages by use of both translation and rotation of the basic cylinder, the entrance region can

be tailored to match a given impeller profile yielding improved efficiency and range.

While the preferred embodiments of the present invention have been described, it should be obvious to those skilled in the art that it may be practiced other than specifically illustrated without departing from the spirit and scope of the present invention.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. A diffuser for a centrifugal impeller, said diffuser comprising a generally annular housing surrounding the periphery of and coaxial with the axis of said centrifugal impeller, said housing having a plurality of intersecting inlet passageways, each of said passageways intersecting at their inlet ends and defined by the volume of housing swept by a cylinder rotated from a first position having its longitudinal axis tangent to a reference circle normal to the axis of said impeller and lying in the plane formed by said reference circle to a second predetermined position wherein the axis of said cylinder is rotated in a direction parallel to said reference plane and rotated in a direction normal to said plane, thereby forming curved side walls and upper and lower flat midsections connecting said side walls, said midsections being inclined with respect to the plane of said reference circle whereby adjacent passages intersect to form scalloped leading edges nonsymmetrical with respect to a longitudinal axis of the passageway, the longitudinal axis of said cylinder being rotated in the direction normal to the reference plane about the point at which the longitudinal axis of the cylinder in the first and second positions intersect.

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