Jan. 7, 1969 S. JAROSZ ET AL 3,420,435

DIFFUSER CONSTRUCTION

Filed Feb. 9, 1967 Sheet 1 of 2

FIG_1

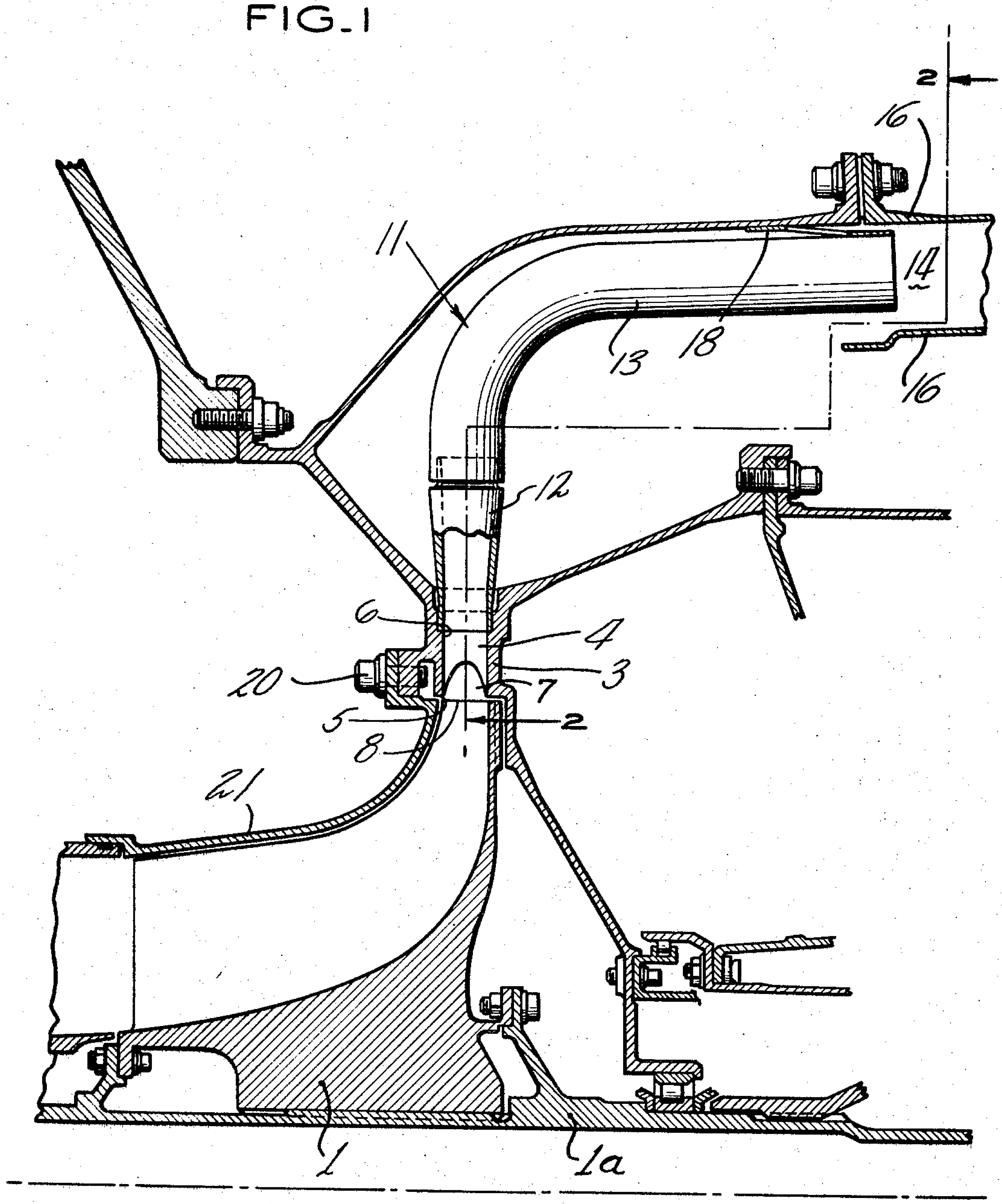

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FIG.3

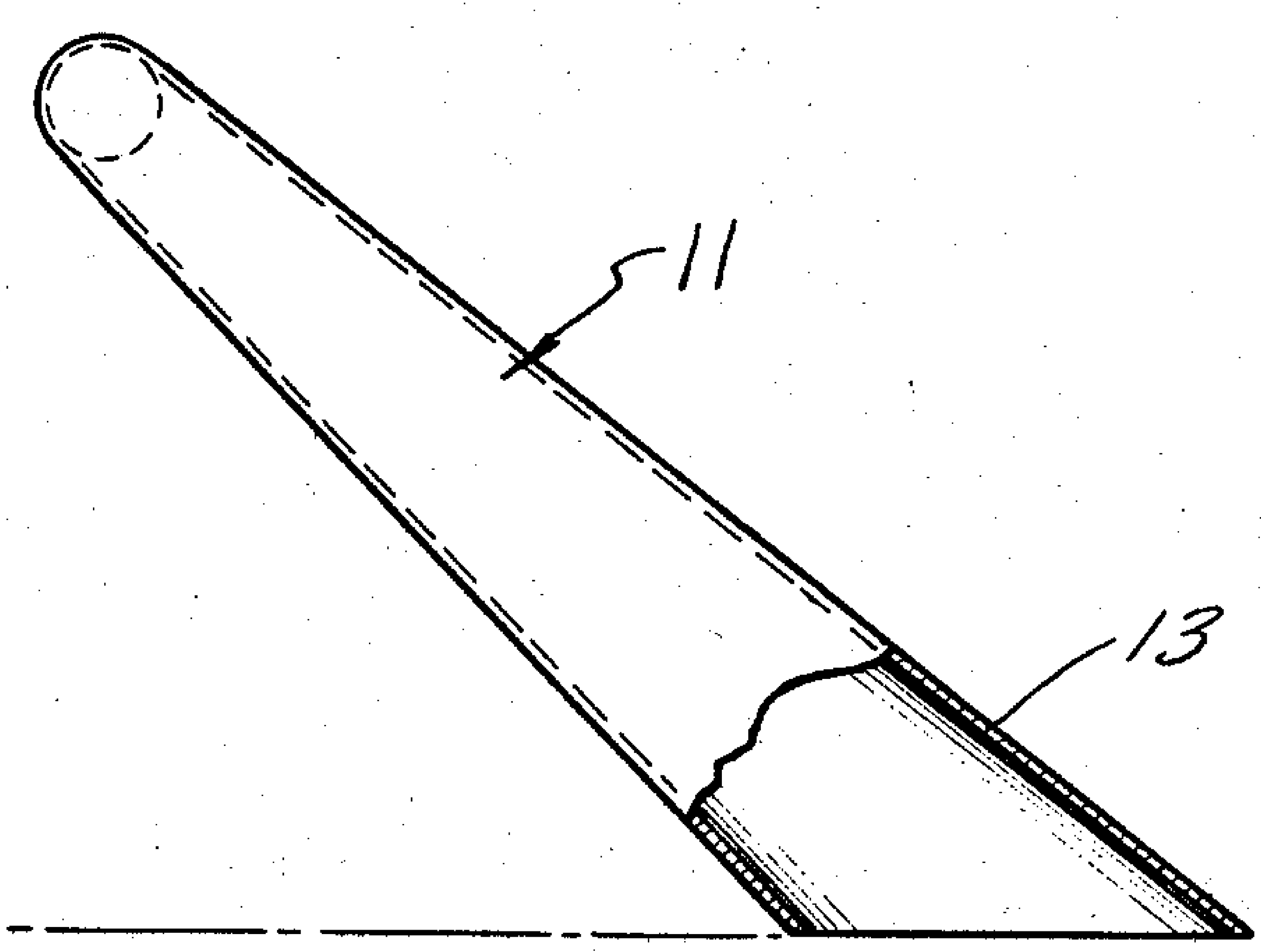
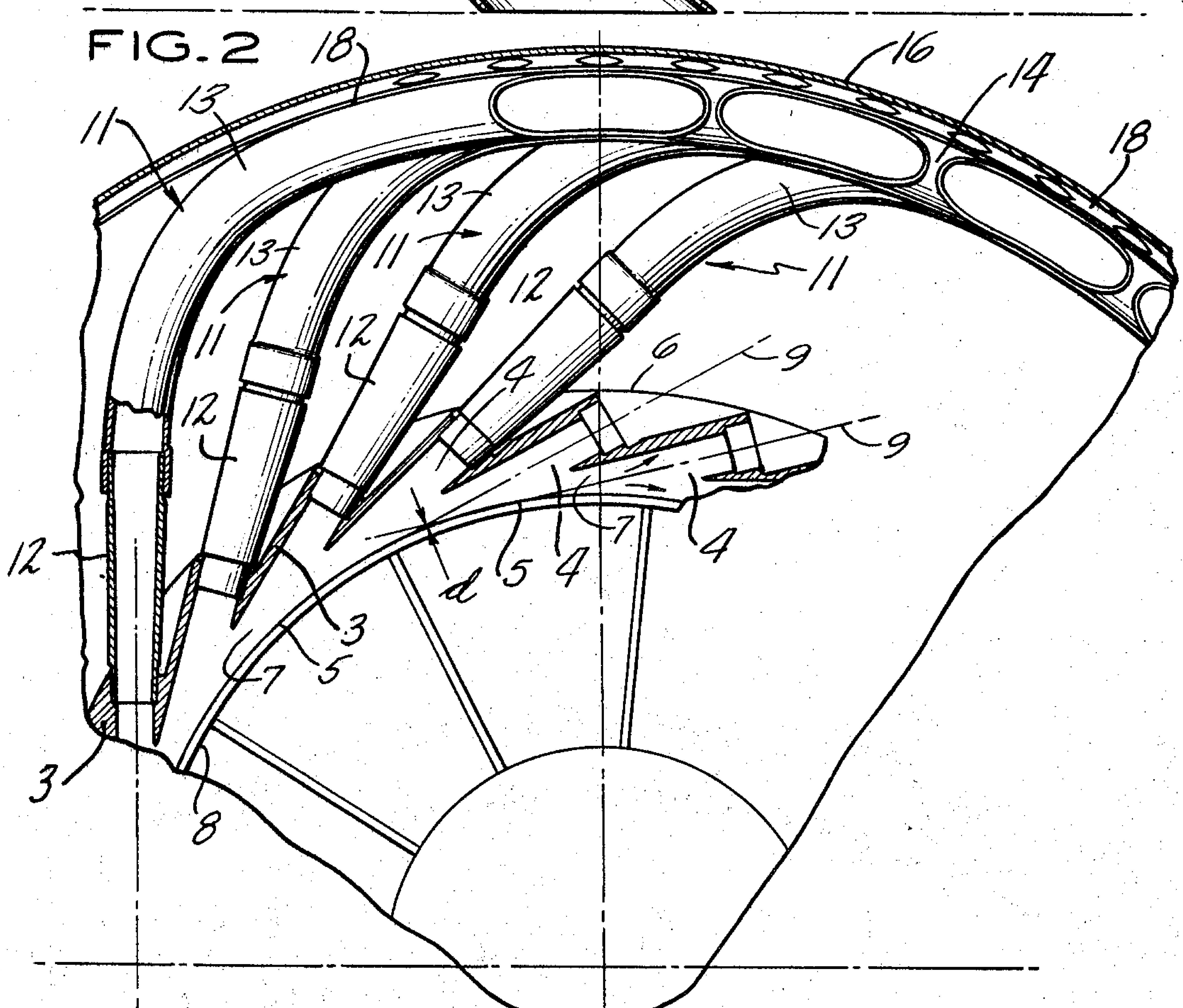


FIG.2



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3,420,435
DIFFUSER CONSTRUCTION

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Int. Cl. F04d *17/08;* F04d *29/00*

ABSTRACT OF THE DISCLOSURE

A diffuser for a centrifugal compressor in which the air from the impeller is discharged into a plurality of passages tangential substantially to the outer periphery of the impeller with diffusing extension tubes at the outer ends of the tubes for turning the flow from a swirling radial condition to a swirling axial condition and with these extension tubes terminating in segmental-shaped outlets which together form substantially a complete annulus.

Background of the invention

The present invention relates to improvements in the construction of centrifugal compressors, and more specifically, to improvements in a diffuser for such centrifugal compressors. The invention is more partciularly, although not exclusively, concerned with centrifugal and mixed flow (axial/radial) compressors which form part of gas turbine engines, and leads to special advantages in the construction of aircraft gas turbine engines. In these engines, the compressor discharges air under pressure axially in an annular path to the inlet to the combustion chamber. An engine of this type is shown for example in Newland Patent No. 3,152,443.

In centrifugal compressors of the type with which the invention is more particularly concerned, an impeller is arranged to deliver a compressible fluid, normally air, at high velocities to a diffuser in which the air is decelerated to produce a pressure rise.

The copending patent application of Vrana, Ser. No. 410,642, filed Nov. 12, 1964, now abandoned, having the same assignee as this application and for which a continuation-in-part Ser. No. 594,727 was filed Nov. 16, 1966, now Patent No. 3,333,762, describes and claims a novel diffuser construction which is aimed at substantially improving the efficiency within the compressor. In that application a diffuser member in the form of an annulus surrounds the impeller and has flow passages which extend outwardly from the inner circumferential surface thereof, and which, at the inner circumferential surface, overlap to define an uninterrupted annular space between the impeller and the diffuser member, which space forms a diffusion zone. The information and arrangement of the overlapping passage ends at the inner surface of the annular member result in the provision of efficient swept back leading edges on the walls between adjacent passages.

Summary of invention

The preferred diffuser and its mode of construction in accordance with the present invention make use of an integral annular diffuser member as described in the above-cited application Ser. No. 410,642. However, the present invention is also concerned with overcoming other disadvantages in the mode of construction of known compressors and diffusers, particularly where, for example, in gas turbine engines the air is directed by the diffuser into an annulus in which the flow is essentially parallel to the axis of the annulus, although there may also be some swirl.

Due to limitations imposed by the shape of the engine, fluid compressed by the centrifugal compressor, after being directed in a radial or tangential direction by the impeller, is redirected along the length of the engine in a direction generally parallel to the impeller axis, which is normally coextensive with the turbine axis. This redirectioning of the compressed fluid is conventionally carried out in a diffuser housing provided with partitions of intricate construction. Further complexity is introduced in that the fluid must be collected from around the multiple diffuser vanes and accordingly mountings must be provided for the diffuser vanes in such a housing.

The present invention aims at overcoming these further disadvantages of complex construction by providing a structure which is simple and economic, and which nevertheless makes full use of the space allowed by the available space for the diffusion and expansion of the compressed fluid.

The disadvantages are in general terms overcome by providing with the diffuser member, the extensions for the tangential passages at their outward ends formed by bent tube sections of relatively simple shape of expanding cross section terminating in axially directed (but also swirling) outlets which together approximates to a continuous duct of annular cross section.

In more specific terms, the present invention includes, in a centrifugal compressor provided with an impeller, a diffuser comprising an annular member mounted around the periphery of the impeller, and having an annular inner surface with a plurality of tangential passages extending outwardly from the inner surface and adapted to conduct a compressible fluid impelled therethrough by the impeller wherein each passage is extended beyond said outer surface by a separately formed tube which is bent so as to direct fluid therein from an initial direction outwardly from the impeller axis to a subsequent direction substantially parallel to the axis of the impeller in the shape substantially of an annulus.

According to yet another aspect of the present invention, there is provided for use in a gas turbine aircraft engine, the following components in combination:

A centrifugal compressor provided with an impeller;

A diffuser comprising an annular member mounted about the periphery of said impeller and having an inner circumferentially extending surface and an outer circumferentially extending surface;

A plurality of passages in said annular member extending tangentially outward from said inner surface thereof, said passages being substantially tangent to a common circle concentric with said impeller and of radius approximately equal to the maximum radius of the impeller, said passages being adapted to conduct a compressible fluid at high velocities;

A plurality of tube extensions each having a substantially right angle bend, each tube being mounted at the outer end of a said passage so that the inner surfaces of tube and passage are flush, each bent tube being adapted to redirect the flow of fluid from its initial outward tangential direction to a direction generally parallel to the impeller axis;

Each tube extension having a cross section which increases in dimension from the end adjacent the passages to its outer discharge end;

The outer discharge ends of said tube extensions being arranged in substantially cylindrical formation around the impeller axis in side-by-side relation with their long cross-sectional dimensions aligned circumferentially, so that said fluid is therein finally expanded substantially over the full circumference of said cylindrical formation.

Brief description of the drawings

Having thus generally described the nature of the invention, particular reference will be made to the accompanying drawings showing by way of illustration a preferred embodiment thereof, and in which:

FIG. 1 shows in part longitudinal cross section a portion of a gas turbine compressor showing parts of an impeller and diffuser constructed in accordance with the present invention.

FIG. 2 is a cross section along the line 2—2 of FIG 1.

FIG. 3 is a perspective view of one of the tube extensions.

Description of the preferred embodiment

In the drawings, there is shown a centrifugal impeller **1** on a shaft **1***a*. The impeller may form part of the compressor of an aircraft gas turbine engine. The impeller **1** may succeed a series of axial compressor stages.

Surrounding impeller **1** and mounted by bolts **20** to the remainder **21** of the impeller housing, is an annular diffuser member **3** which also assists in defining the stator section or housing of the centrifugal compressor. The member **3** is provided with a plurality of fluid flow passages **4**, FIG. 2, extending outwardly from the inner annular circumferential surface **5** to the outer circumferential surface **6** of the annular member **3**. The passages **4** are curvilinear in cross section and for many purposes may be of circular cross section. It will be apparent that absence of axial curvature of the passages **4** renders their construction by boring relatively simple.

As shown, the passages **4** are of uniform cross section although they may taper in a direction towards the impeller axis thereby forming a conical fluid flow diffusion zone.

The passages **4** are arranged so that each intersects its next adjacent passage in the vicinity of the inner surface **5** of member **3**, so as to define an uninterrupted annular diffusion space **7** outwardly of the inner surface **5**. The annular space **7** constitutes the first, or upstream fluid flow diffusion zone.

Preferably, as apparent from FIGURE 2, the center lines **9** of the passages **4** are tangent to the surface **5** which is close to the periphery of the impeller **1**. The tangency circle, however, may even coincide with the outer periphery of the impeller. It is not necessary for the tangent circle to be of such diameter but it is desirably of approximately the same diameter as the maximum diameter of the impeller **1**. Furthermore, although passages **4** preferably extend as shown in the same plane as the impeller blades, i.e. at right angles to axis **2**, they may be arranged to be moderately off-set, to be in line with the discharge from the impeller, to form a frusto-conical array.

Preferably, also as described in the above-noted copending application Ser. No. 410,642, the center lines **9** intersect with each other a short distance *d* outwardly from tangency circle **5**. The distance *d* should be less than one-half the maximum transverse dimension of the passages **4**, so as to avoid having a solid segment of member **3** between adjacent passages.

The necessary redirectioning of the fluid flow is accomplished by the provision of extension tubes **11** each of which extends from the discharge end of one of the passages **4**. The preferred form of each such extension tube is two tube portions as shown, an inner tube **12** and a separate outer tube **13**, the latter incorporating a bend to direct the flow into an axial direction. Such a form provides the advantage that it renders manufacture relatively simple (curvature is in one plane), and incorporates the change of fluid flow direction and variation of area of the duct cross section both in the same tube.

The inner tube **12** in effect forms a straight extension of the passages **4** and fits within a counterbored outer end of the passage **4** so the inner surface of the tube is flush with the passage. The tubes **12** taper such that they increase in cross-sectional area toward the outlet and

constitute a diffusing extension of the passages. Obviously this taper may be as great as permissible without detrimentally affecting the flow through the tubes.

The outer tubes **13** constitute tapering or diverging-walled passages for the further flow of the air from the impeller and these tubes are constructed to curve in a transverse direction, as shown in FIG. 2, to increase the circumferential component of flow in these tubes. The curvature is such that the tubes **13** become substantially tangent to an annular passage **14** that represents the discharge of the compressor and may, in a gas turbine engine, form the inlet to the burner. This passage **14** is located between an outer annular casing wall **15** and an inner wall **16** spaced inwardly therefrom.

While these tubes **13** are curved, as viewed transversely, FIG. 2, they are also turned in an axial direction through substantially a 90° angle, as viewed longitudinally, FIG. 1, this turning being at right angles to the transverse curvature as will be apparent. Although the bend is shown to be a 90° bend in FIG. 1, it will be apparent from the developed view of FIG. 3 that, as seen from this point of view, the tube portions, in fact, approach the discharge annulus at an acute angle so that a substantial circumferential component of flow exists at this point. This means that the effective change in flow direction is not a full 90° but is as much as 30° less than that, thereby improving the aerodynamics of the flow. The exit opening of each tube is therefore not at right angles to the tube axis but at a substantial angle thereto, as shown in FIG. 3, with the result that even without flattening of the tube end the shape would be elliptical.

The tube **13** may be a constantly tapering tube from end to end and may thus be made from a tapering sheet of material by securing together the opposite edges to form a tapering unbent tube. The tube is then flattened at its larger end to elliptical or flattened configuration and the tube is then bent lengthwise substantially in the plane of the minor axes of the elliptical cross sections into a 90° curve. This simple bending is the only required bend if the configuration is that shown in FIG. 2 where the center line of the outlet end of the tube is located on a radius of the diffuser that is parallel to the passage **4** to which that tube is connected. Obviously the outlet end of the tube is cut off at an oblique angle, as shown in FIG. 3.

The dimensions of the tubes **13** at their outer ends are selected so that these outlet ends are substantially in engagement circumferentially with one another. Thus the discharge from these tubes almost completely fills the annulus in which they are located. For ideal conditions the discharge ends may be flattened or expanded such that each discharge end is approximately the shape of a segment of an annulus thereby more completely filling the full annulus.

The shape may be described as a flattened oval in which the major axis is curved to follow the annulus. Obviously the ultimate is an oval so flattened as to be equivalent substantially to a rectangle having rounded corners and in which the longitudinal sides are curved to follow the curvature of the discharge annulus. In any event the outer tube portions desirably taper from end-to-end in order to continue the diffusing process throughout the length. This particular form of tube with the curvature shown such that air from the impeller by the tube is turned to have both a substantial axial component and a circumferential component with the radial flow component eliminated has been found to be particularly adapted to accomplish this turning with a minimum of disturbance in the flow and also with a maximum of efficiency. The substantially circular flow from the passages **4** in which the air has both a radial and a circumferential component converts into the approximately elliptical flow path without any material flow disturbance.

It will be understood that in this arrangement the tube portions **12** and **13** overlap at the point of joining so as to provide a substantially uninterrupted inner surface for the air flow. The outer tubes may be supported within the surrounding compressor casing **16** at their outer ends by connecting strips **18** welded to the casing and to the tube ends, as shown.

We claim:

1. In a centrifugal compressor provided with an impeller,

a diffuser comprising an annular member mounted about the periphery of said impeller and having an inner surface;

means defining a plurality of passages extending through said annular member tangentially outward from said inner surface thereof, the axes of said passages being substantially tangent to a common circle substantially concentric with a periphery of said impeller, said passages being adapted to conduct a compressible fluid at high velocities;

each of said passages intersecting an adjacent passage at said inner surface so as to define leading edges at the entrance to said passages of closely controlled repeatability;

a plurality of separate tubes increasing in cross-sectional area toward the outlet end and each having substantially a right angle bend therein as viewed in plan, each tube being mounted in the outer end of a said passage to form a substantially continuous extension, each bent tube being adapted to redirect the flow of fluid from its initial outward tangential direction to a direction having a substantial component of axial flow, the several outlet ends of the tubes together forming and substantially filling a discharge annulus.

2. A diffuser as claimed in claim **1** wherein each said tube is bent at substantially a right angle as viewed longitudinally to impart an axial flow to the fluid.

3. A diffuser as claimed in claim **2** wherein the portion of the tube directed axially is, at its end remote from the bend, of generally elongated oval cross section.

4. A diffuser as claimed in claim **1** wherein the axially directed end of said tube extension varies in shape as it increases in cross-sectional area to a discharge end that is substantially a flattened ellipse with the several ellipses substantially filling the entire annulus.

5. A diffuser as claimed in claim **1** wherein the axially directed portions of the tubes are arranged in side-by-side formation around the impeller axis, with their long cross-sectional dimensions aligned circumferentially, so that said fluid is therein expanded substantially over the full circumference of the annulus.

6. A diffuser as claimed in claim **1** wherein the axially directed portions also have a substantial circumferential direction such that the tube ends make an acute angle with the plane of the discharge annulus.

7. In a centrifugal compressor provided with an impeller, a diffuser comprising an annular member mounted around the periphery of the impeller, said annular member having an inner surface, and means defining a plurality of passages extending through said annular member tangentially outwardly from the inner surface and in line with the discharge from the impeller, a separately formed tube element forming a continuation of each of said passages and extending beyond said annular member, said tubes each having an inner passage portion forming a continuation of said initial passage in direction and an outer passage portion which is bent both circumferentially and axially with respect to said inner passage portion whereby the impelled fluid passes through said diffuser in a smooth flow changing its direction from a radial to axial as it passes in a downstream direction, said passages in said tubes terminating in an axially directed annulus that substantially fills the entire annulus.

8. A centrifugal compressor as in claim **1** in which each tube is made up of a plurality of separate sections.

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