

[72] Inventors **Val Cronstedt**
Williamsport, Pa.;
Gary M. Gron, Cincinnati, Ohio
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 [73] Assignee **Avco Corporation**
Williamsport, Pa.

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Primary Examiner—Henry F. Raduazo

Attorneys—Charles M. Hogan and Irwin P. Garfinkle

[54] **CENTRIFUGAL COMPRESSOR DIFFUSER**
6 Claims, 7 Drawing Figs.

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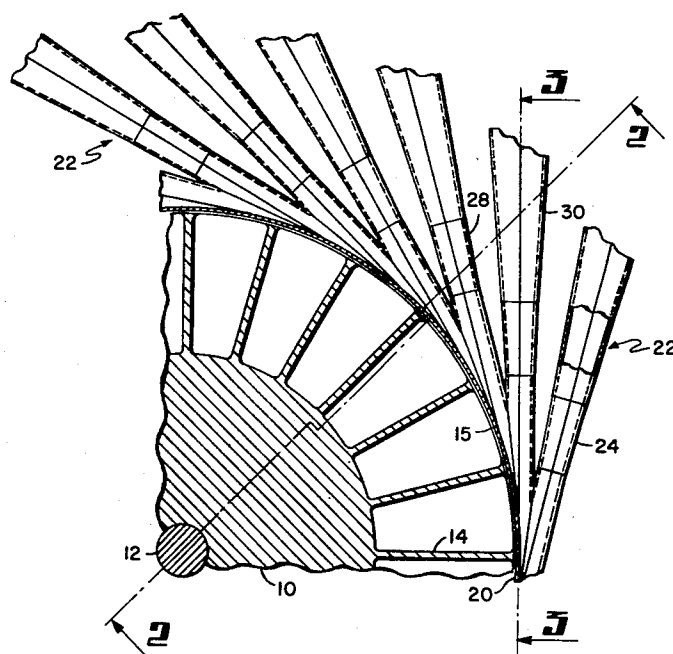
[50] Field of Search..... 415/211,
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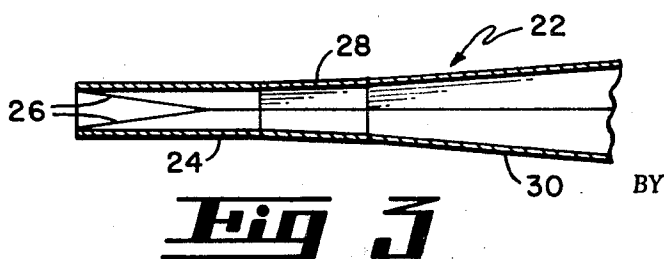
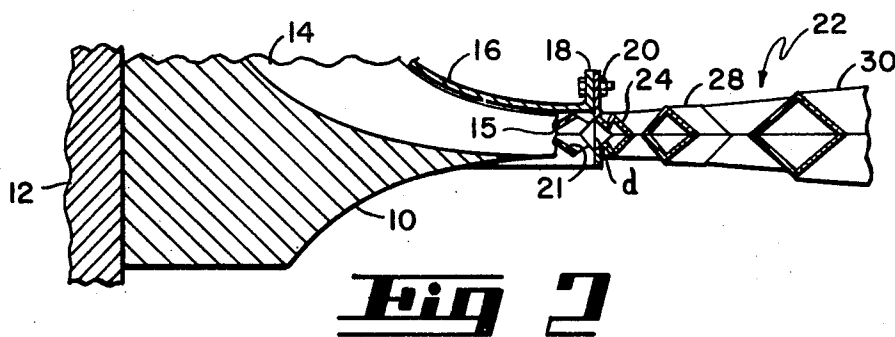
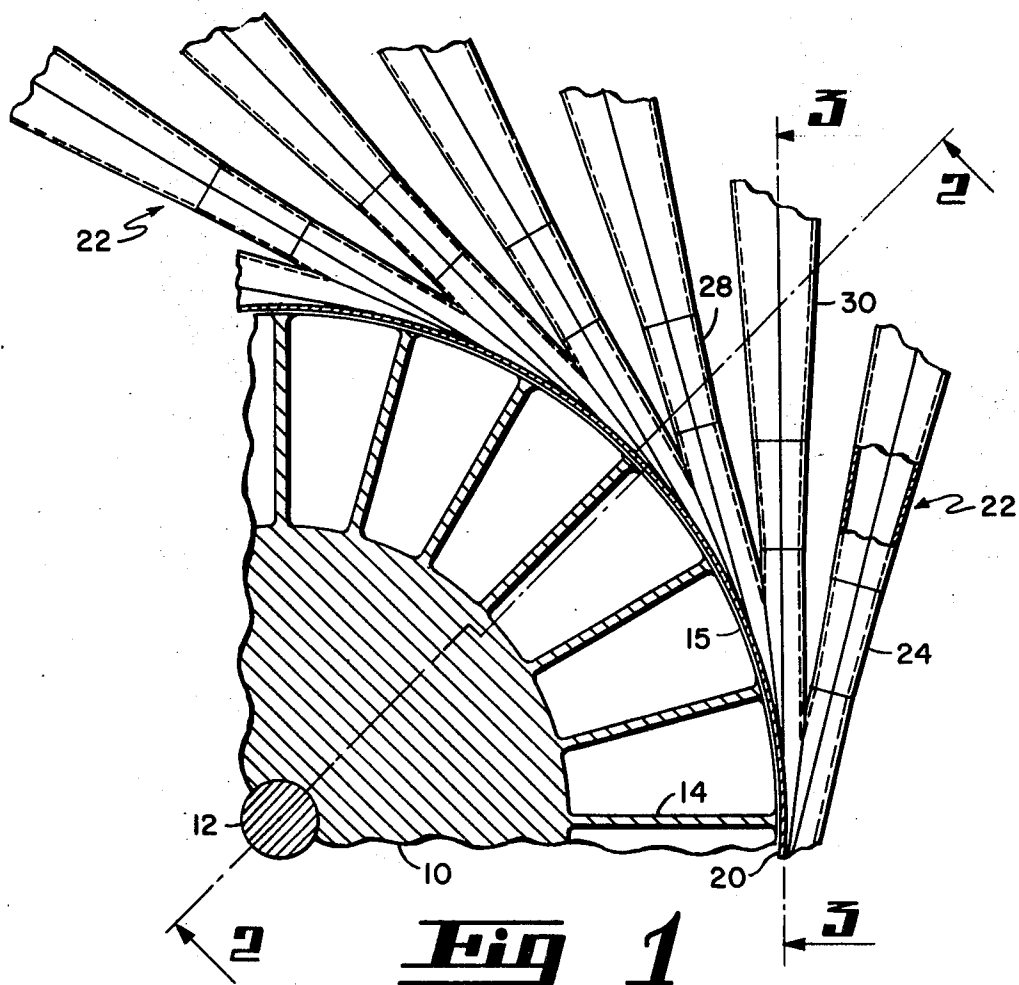
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ABSTRACT: The disclosure illustrates an annular diffuser assembly that receives gas discharged from a compressor impeller at supersonic velocity. The diffuser consists of a series of passages extending in a direction generally tangential to the impeller and spaced around the impeller so that their inlet ends intersect. The passageways each have a straight-sided polygon cross-sectional shape so that the diffuser passages have a series of generally V-shaped entrances. The diffuser passages may be formed with a particular cross-sectional shape to compensate for the variations in velocity of the airstream discharged from the impeller. The passageways may be formed from intersecting tubular elements or may be formed in opposing faces of a pair of sandwiched discs.





INVENTORS.
VAL CRONSTEDT
GARY M. GRON
BY *Charles M. Hogan*
John P. Garfinkel
ATTORNEYS.

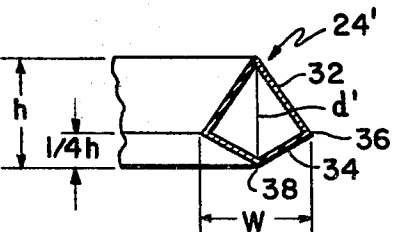


Fig 4

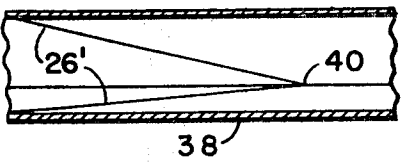


Fig 5

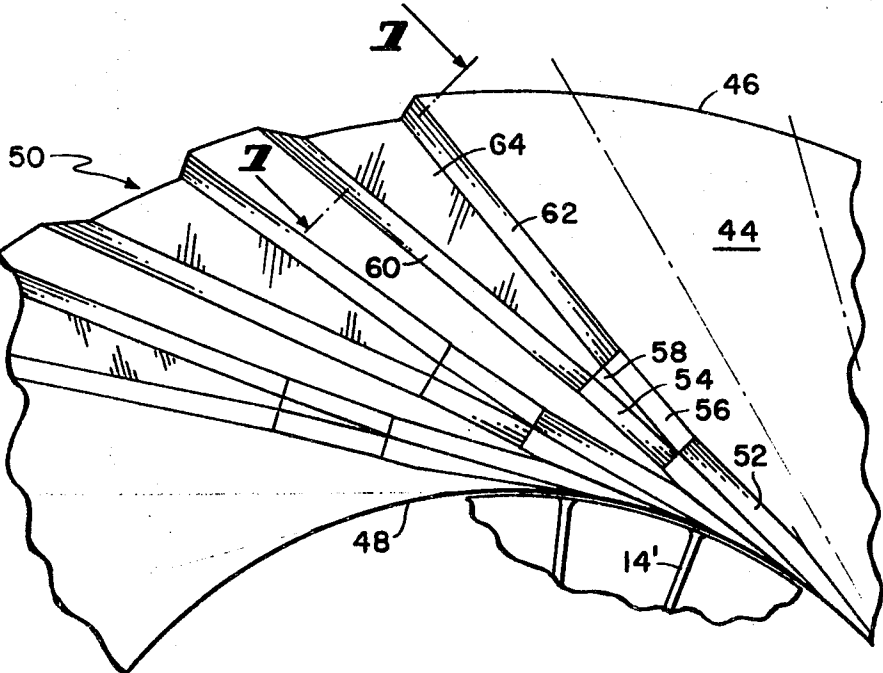


Fig 6

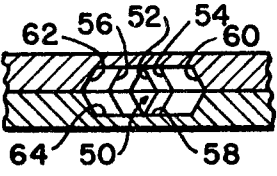


Fig 7

INVENTORS
VAL CRONSTEDT
GARY M. GRON
BY *Charles M. Hogan*
Don P. Gay
ATTORNEYS.

CENTRIFUGAL COMPRESSOR DIFFUSER

The present invention relates to essentially radial outflow centrifugal compressor diffusers and more particularly to diffusers adapted to receive supersonic flow.

In recent years the centrifugal supersonic compressor has been used for gas turbine engines because it is mechanically simple and produces substantial pressure increases necessary for high performance. The adoption of compressors of this type has prompted a substantial amount of development work in the area of diffusers which are particularly adapted to receive a supersonic gas flow discharged from a rotating impeller.

One result of this development has been the patent to Vrana, U.S. Pat. No. 3,333,762, entitled "Diffuser for Centrifugal Compressor." In that patent a diffuser is formed by a series of curvilinearly enclosed passages surrounding an impeller. These passages are closely spaced so that their inlet ends form a vaneless diffuser space adjacent the periphery of the impeller and a series of scalloped leading edges to the passages. This type of diffuser offers significant advantages in producing high pressure rises at high efficiency.

The above diffuser is manufactured by machining a series of holes around the periphery of a blank which would appear to be a relatively simple manufacturing process.

An object of the present invention is to provide a diffuser of the above general type which has a configuration also making it capable of highly simplified, economical and accurate manufacture.

In the broader aspects of the present invention the above ends are achieved by providing a diffuser which comprises a means for forming a plurality of diffuser passageways extending generally tangentially from the periphery of an impeller surrounded by the diffuser passageways. The passage ways are spaced from one another around the periphery of the impeller so that they intersect each other at their inlet ends. The passageways have straight-sided polygon cross-sectional shapes that form generally V-shaped entrances to the diffuser passageways.

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 transverse cross-sectional view of a centrifugal compressor with a diffuser embodying the present invention;

FIG. 2 is a view taken on lines 2—2 of FIG. 1;

FIG. 3 is a fragmentary view of FIG. 1 taken on lines 3—3 of FIG. 1;

FIG. 4 is a cross-sectional view of a passageway that is incorporated in a diffuser embodying the present invention;

FIG. 5 is a longitudinal section view of the passageway in FIG. 4 illustrating the shape of the generally V-shaped inlet wedge which results when the passageway of FIG. 4 intersects an adjacent passageway;

FIG. 6 is a transverse view of another diffuser illustrating an alternate embodiment of the present invention;

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

Referring particularly to FIGS. 1, 2 and 3, there is shown a compressor including an impeller 10 mounted on a shaft 12. The shaft 12 may receive a rotating input from a suitable source, such as a turbine wheel of a gas turbine engine. A series of radial blades 14 extend axially from the disc 10 towards a fixed annular shroud 16. When the compressor is incorporated in a gas turbine engine the shroud 16 may form, in part, the outer casing for the engine.

An annular ring 20 surrounding the periphery of the impeller blades is attached to flange 18. A series of tubular passageways, generally indicated by reference character 22, extend from the annular ring 20 in a direction generally tan-

gential to the periphery 15 of the impeller. The passageways 22 are spaced around the periphery of the ring 20 so that they intersect one another adjacent their inlet ends 24. The tubular passageways 22 may be secured to the ring 20 and to each other by welding, as illustrated.

As shown in FIG. 2, the inlet portions of the passageways 24 have a straight-sided polygon cross-sectional shape. This results in generally straight V-shaped entrances 26 to the plurality of diffuser passageways around the periphery (see FIG. 3). For supersonic flow into the diffuser it is desirable that the inlet portions 24 be of constant cross-sectional area and that the downstream portions 28 and 30 be divergent to diffuse the air flowing therethrough.

As illustrated in FIG. 2, the straight-sided polygon cross-sectional shape of the passages 22 is in the form of a square having one diagonal d parallel to the axis of rotation of the impeller disc 10. As illustrated in the specification and in the claims, the diagonal d defines the height of the passageways and the distance of the walls from the diagonal d determines the width of the particular passageways.

It has been found that the flow discharged from the impeller blades 14 varies in velocity and direction along the axial termination of the impeller blades 14. The fixed shroud 16 creates a boundary layer which substantially reduces the radial velocity of the air immediately adjacent its surface. The air towards the center of the blades 14 has a greater velocity and the air adjacent the surface of the impeller disc 10 is reduced due to another boundary layer. However, its reduction is not as great because the impeller 10 is rotating with the stream. The result of this is that the velocity distribution of air across the axial extent of the blades 14 is biased towards the disc of the impeller 10. This biasing of the velocity across the axial extent of the impeller blades also causes a variation in the direction of the velocity vectors across the axial termination of the impeller blades 14.

The passageway cross-sectional shape shown in FIG. 4 is particularly adapted to conform to the above velocity distribution. The passageway inlet 24' is a four-sided polygon symmetrical about a diagonal d' which is parallel to the axis of rotation of impeller 10 and which defines the height h of the passageway. The sidewalls 32 and 34 are symmetrical about the diagonal d' and extend towards apexes 36 which define the width w of the passageways.

The apexes 36 are positioned towards the bottom side 38 of the passageway which is adjacent the periphery of the impeller disc 10. When a plurality of these passageways are positioned around the periphery of the impeller, as in FIG. 1, a series of generally V-shaped entrances 26' are formed, as shown in FIG. 5. It is apparent that these inlet edges 26' have a downstream point 40 which is positioned towards the bottom wall 38 of the passageway 24'. This particular shape conforms approximately to the velocity and flow distribution of the air discharged from the impeller.

The straight-sided polygon cross-sectional shape of the diffuser passageways 22 and 22' enables a substantial degree of simplicity in their manufacture. As shown in FIG. 1, the passageways may be formed from tubular elements welded or brazed to one another at their points of intersection and secured as by welding to the inner ring 20. In addition to being manufactured out of tubular stock, a diffuser may be fabricated as illustrated in FIGS. 6 and 7.

In these figures the diffuser comprises a pair of annular discs 44 (only one of which is shown in FIG. 6) which have a circular outer periphery 46 and an inner hole 48 which surrounds the periphery of the impeller blades 14'. Each of the discs 44 has a series of grooves, generally referred to by reference characters 50, formed in one of their faces. These grooves define one half of the diffuser passageway and when the discs 44 are sandwiched together, as shown in FIG. 7, the opposing grooves 50 define the diffuser passageway.

As particularly illustrated in FIGS. 6 and 7, the passageways have a square cross-sectional shape at their inlet ends 52. Downstream from the inlet section 52, walls 54 and 56 diverge

from one another but have the same angular relationship as the walls in the inlet sections 52. As a result, a passageway of equal height is formed and the increasing flow area is provided for through top and bottom walls 58 having diverging edges. This feature is even more emphasized in the outlet end of the passageway having the sidewalls 60 and 62 and top and bottom walls 64.

Thus it is apparent that the increase in cross-sectional area of the individual passageways may be accomplished without an increase in the axial dimension of the diffuser. This has two advantages, the first of which is that it provides an extremely compact diffuser assembly and the second of which is that it utilizes more of the annular space within the disks 44 thereby reducing their cost.

The forming of the straight grooves 50 and the opposite discs 44 enables the use of highly accurate and automated machines which are capable of producing in a rapid fashion passageways of highly accurate dimensions. This enables a significant reduction in the cost of the diffuser.

Because the diffuser passageways have straight sides they lend themselves to inexpensive manufacture. This manufacturing advantage is achieved while at the same time providing a diffuser with flow paths that will provide a high level of performance. In addition, the straight-sided passageways enable the selection of V-shaped entrance edges which accept the biased velocity distribution from a supersonic impeller. Furthermore, the passageways may be formed with diverging downstream portions without increasing the axial dimension of the impeller.

While the preferred embodiment of the present invention has been described, it is apparent that those skilled in the art may employ diffusers other than those specifically shown without departing from the spirit of the present invention. Therefore, its scope should be determined solely by the appended claims.

We claim:

1. In a centrifugal compressor, a diffuser receiving air from the periphery of a circular impeller, said diffuser comprising: means for forming around the periphery of said impeller a plurality of identical spaced diffuser passageways intersecting adjacent their inlet ends and extending generally tangentially from the periphery of said impeller; said passageways having a straight sided polygon cross-sectional shape symmetrical about diagonal line that extends through the median axis of and defines the height of said passageways, said diagonal line being parallel to the axis of rotation of said impeller; each of said passageways having at least two walls on either

side of said diagonal line intersection at corners defining the width of said passageways, the walls of adjacent passageways intersecting so that adjacent corners intersect to form the apex of V-shaped entrance wedges between adjacent passageways.

2. Apparatus as in claim 1 wherein said passageways are square in cross-sectional shape and have one diagonal thereof parallel to the axis of rotation of said impeller.

3. Apparatus as in claim 1 wherein said diffuser passageway means comprises a plurality of intersecting tubular elements extending from an annular plate surrounding said impeller.

4. Apparatus as in claim 1 in combination with an impeller wherein:

said impeller comprises a plurality of radial blades extending in an axial direction from a disc toward a fixed annular shroud, the velocity distribution of the fluid flow from said impeller being biased toward said disc;

said diffuser passageways each have a four-sided polygon cross-sectional shape symmetrical about said diagonal defining the height of said passageways, said diagonal being parallel to the axis of rotation of said impeller;

the walls of said passageway extending from said diagonal to apexes defining the width of said passageways, the apexes being positioned from the midpoint of the passageway height toward the disc of said impeller;

whereby the generally V-shaped entrances to said passageways have their most downstream point positioned to accommodate the biased distribution of fluid flow from said impeller.

5. Apparatus as in claim 1 wherein said diffuser passageway means comprises:

a pair of sandwiched discs, each having an interior hole for surrounding the periphery of said impeller and grooves in opposing faces of the discs extending from the interior hole to the exterior of said disc, the grooves in each disc shaped to define said diffuser passageways when said discs are sandwiched together.

6. Apparatus as in claim 5 wherein:

The inlet end of said passageways is generally square in cross-sectional shape and has one of its diagonals defining the height of said passageway, said diagonal being parallel to the axis of rotation of said impeller;

the downstream portion of said passageways is of equal height with the inlet ends and has a pair of parallel sides normal to said diagonal and having diverging edges; whereby divergent passageways are formed in the downstream end of said diffuser.

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