

- [54] **COMPRESSOR WITH IMPROVED PERFORMANCE DIFFUSER**
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 [58] Field of Search 415/82, 207, 211, 210; 60/39.36

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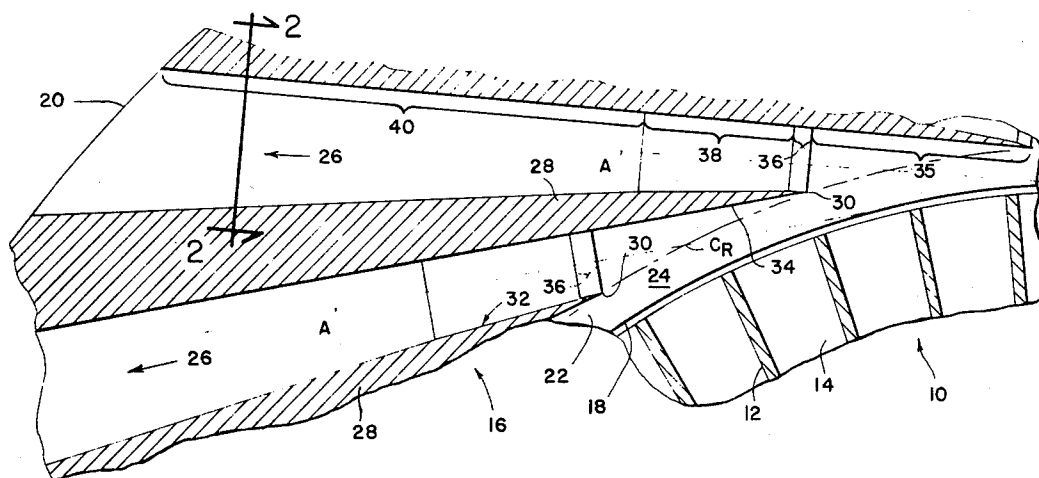
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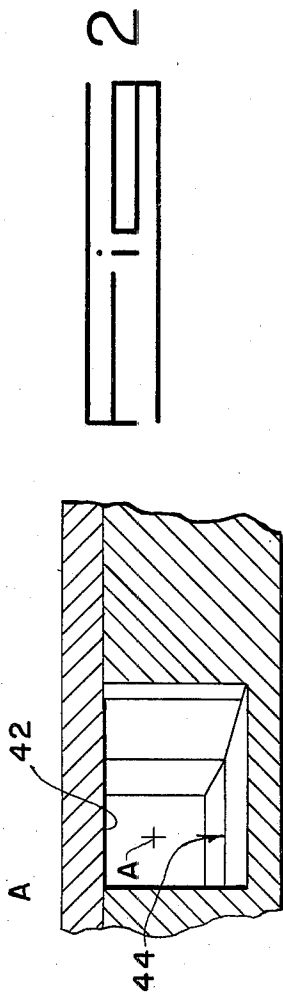
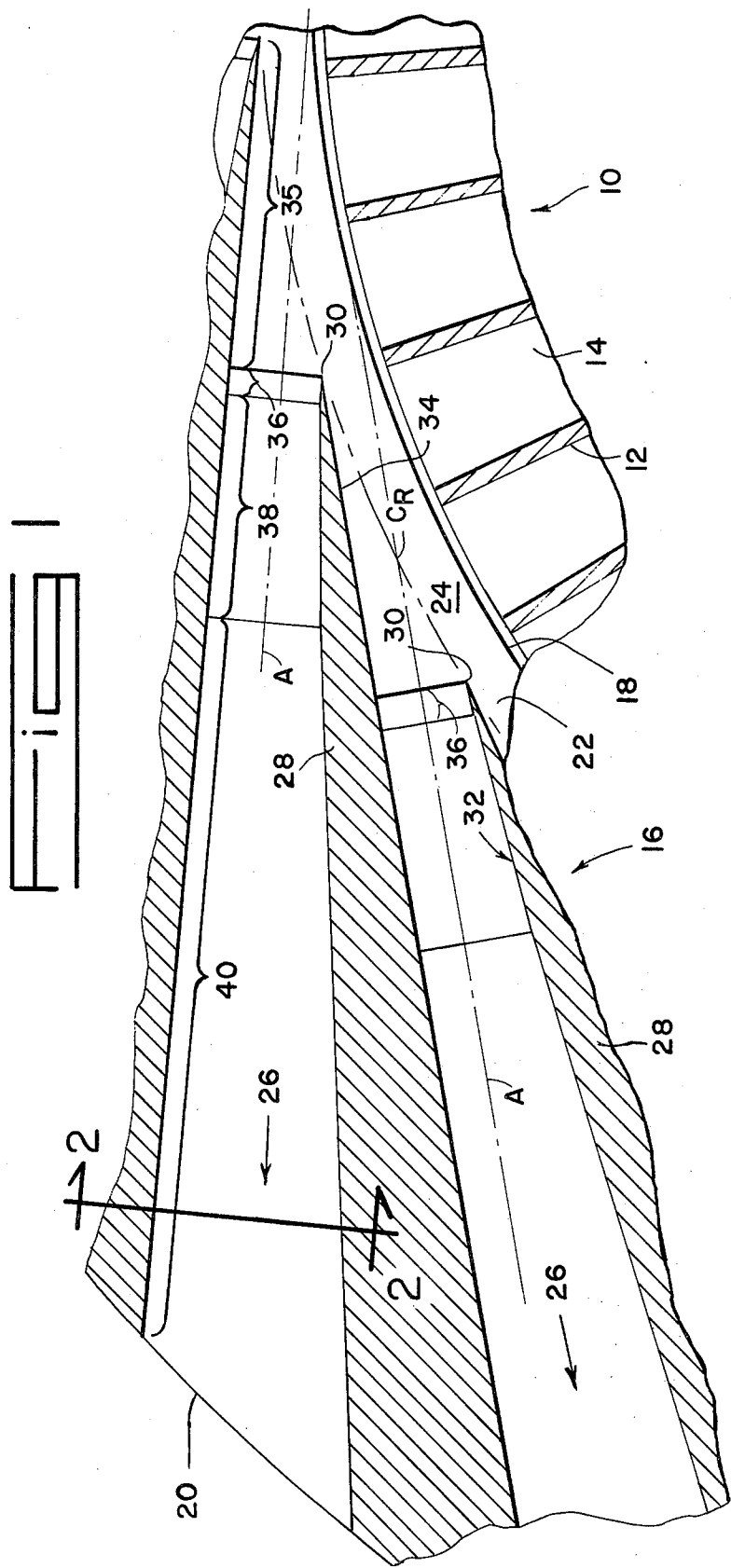
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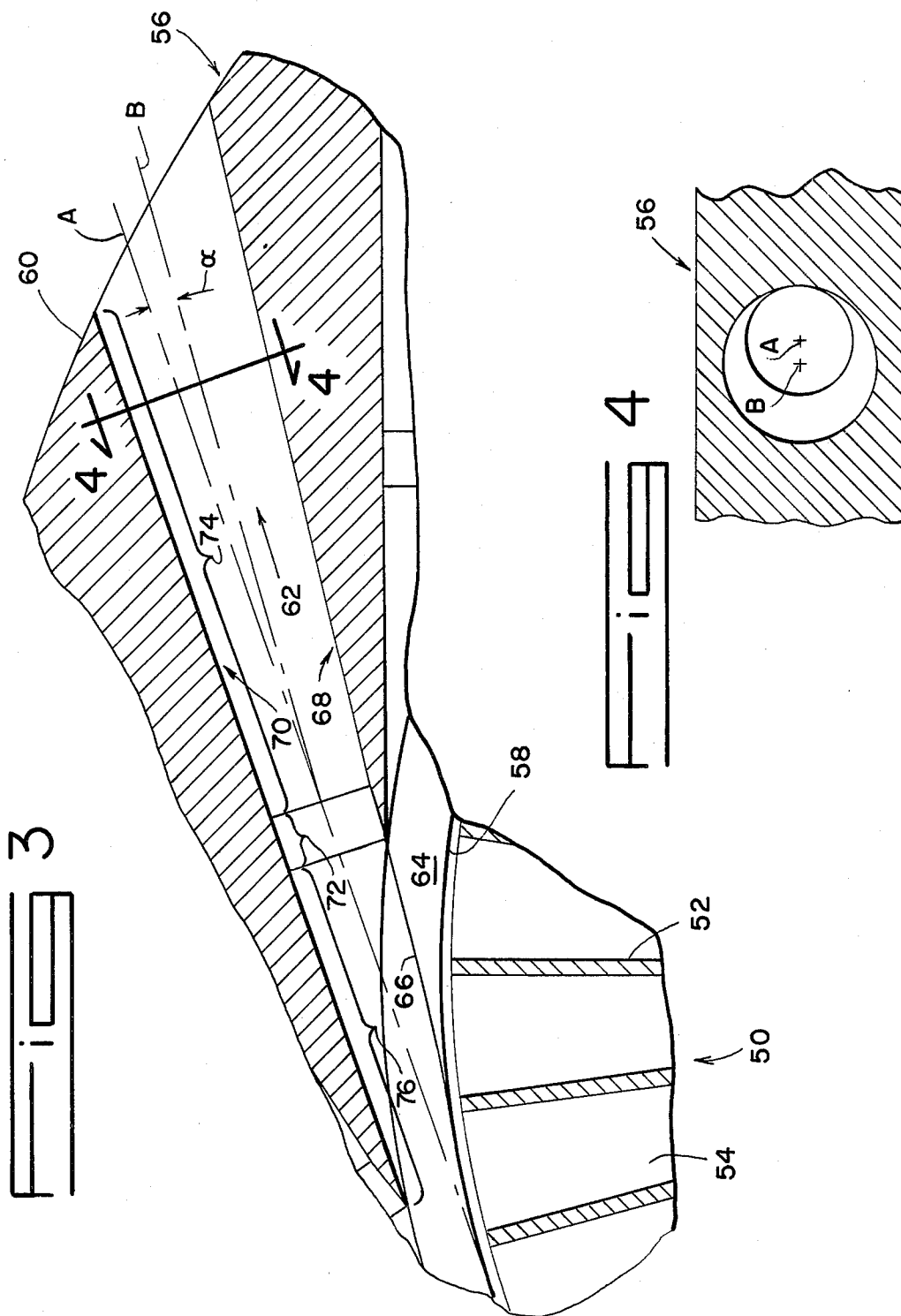
[57] ABSTRACT

A diffuser which surrounds a centrifugal impeller has a plurality of tangential diffuser passages in which all of the divergence in the passages is provided in the radially outward facing wall of the passage to equalize buildup of the boundary layer in the passages.

12 Claims, 4 Drawing Figures







COMPRESSOR WITH IMPROVED PERFORMANCE DIFFUSER

The present invention relates to compressors and more specifically to diffusers used in connection with a compressor.

Recent attempts to improve performance in centrifugal compressors have brought to light phenomena that detracts from optimum performance for a compressor. These problems are encountered in compressor diffusers which generally comprise a series of tangential expanding passages which receive the discharge from a bladed rotor for the purpose of increasing the static pressure of the air. These passages are formed so that they intersect one another at the periphery of the impeller thus forming inlets to the throats of the passages that have unequal wall lengths. This geometry causes a significant boundary layer to be built up on the side of the throat in line with the elongated inlet section. With existing compressor diffusers the boundary layer is substantially increased in the expanding diffuser passage downstream of the throat, thereby producing a substantial difference in energy level between the walls of the diffuser. This in turn significantly lowers efficiency and performance.

The above problems are eliminated by a compressor which comprises a bladed turbomachine rotor rotatable to discharge air with a substantial tangential velocity component. An annular housing has an inlet section adjacent the discharge of the rotor and has an annular outlet section. The housing has a plurality of generally tangentially directed diffuser passages extending between the inlet and outlet sections. They intersect one another at the inlet so that air from the rotor is discharged into the passages. The passages are defined by radially inward and outward facing walls and have throat sections of constant cross-sectional flow area with a central axis and downstream sections of increasing cross-sectional flow area, the radially inward facing wall of the passages being substantially parallel to the axis of the throat and the radially outward facing wall diverging away from the central axis so that substantially all of the divergence in the passages is on the radially outward facing walls.

The above and other related features of the present invention will be apparent from a reading of the following 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 cross-sectional view of a channel-type diffuser embodying the present invention;

FIG. 2 is a cross-sectional view of the diffuser of FIG. 1, taken on line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view of a pipe diffuser which shows an alternate embodiment of the present invention; and

FIG. 4 is a cross-sectional view of the diffuser of FIG. 3, taken on line 4—4 of FIG. 3.

Referring to FIG. 1 there is shown a compressor assembly comprising a centrifugal impeller 10 in which a series of radial blades 12 project forward from an annular disc 14 suitably journaled for rotation in a fixed housing. The air that is accelerated and diffused in the impeller is discharged into a diffuser 16 having an inner diameter 18 closely surrounding the periphery of the impeller 10 and an outer diameter 20 forming a dis-

charge from the diffuser. A pair of spaced opposed walls 22 (only one of which is shown) define a vaneless inlet space 24 for the diffuser 16. The radially outward portion of the inlet 24 is defined by a reference circle C_R from which a plurality of diffuser passages 26 extend.

As apparent from FIG. 1, these passages are generally tangent to the periphery of the impeller 10. The passages 26 are formed between wedge-shaped elements 28 of diffuser 16 which terminate in a leading edge 30. The wedge elements 28 have a radially outward facing wall 32 and a radially inward facing wall 34. As is apparent from FIG. 1 the one side of the wedge 28 forms a side wall of a passage and the other side forms the side wall for the adjacent passage.

Each passage 26 has a rectangular throat section 36 of constant cross section. A section 35 on wall 34 extends upstream of throat section 36 to the edge 30 of the adjacent passage. Extending downstream from the throat 36 is a first diffusing section 38 in the form of a four-sided pyramidal frustum. Downstream of section 38 is an outlet diffusing section 40 formed from a pyramidal frustum of expanding cross-sectional area.

As is particularly apparent from FIG. 2, the portions of sections 36, 38 and 40 that are defined by wall 34 are coplanar, while the portions of these passages defined by wall 32 are not. In addition, first wall 42 of each passage 26 is coplanar throughout sections 36, 38 and 40, while a second wall 44 diverges away from wall 42.

The longitudinal axis A of throat 36 is a central line extending parallel to each of the walls of section 36. The longitudinal axes of all throat sections 36 are tangent to a common circle which has approximately the same diameter as the periphery of rotor impeller 10. As will be pointed out later, the portion of sections 36, 38 and 40 defined by wall 34 are all parallel to this axis A, while the portion of these sections defined by wall 32 diverge away from axis A.

Referring to FIG. 3 there is shown a diffuser which illustrates an alternate embodiment of the present invention. This diffuser comprises a centrifugal impeller 50 having a plurality of blades 52 which project forward from a disc 54. An annular housing 56 has an inner diameter 58 surrounding the periphery of impeller 50 and an outer diameter 60 forming a discharge for the diffuser. This housing 56 has a plurality of diffuser passages 62 extending generally tangentially with respect to the periphery of impeller 50. Passages 62 intersect near their inlet end to form a pseudo annular vaneless space 64 in which a series of scallop-shaped leading edges 66 form scallop-shaped inlets to the diffuser passages 62.

The diffuser passages 62 are formed by radially outward facing walls 68 and radially inwardly facing walls 70. Although these walls are curved and blend into one another with no defined demarcation point, they will be so referred to in order to explain the present invention. The diffuser passageways 62 have a throat section 72 cylindrical in form and a diffusing section 74 of frustroconical shape extending from the throat section 72. A section 76 of wall 70 extends upstream of throat section 72 to the throat section 72 of the adjacent passage. The central axes A of throat sections 72 for passages 62 all lie in the same radial plane. The axis B of the frustroconical sections 74 also lie in the same plane but are angled with respect to the axis A of throat section 72 so that the inwardly facing wall 70 of section 74 is par-

allel to the axis A. Preferably, this angle α is approximately 3° .

In operation the impeller for both compressors rotates at a high R.P.M. discharging air into the inlet regions of the diffuser. Before the air enters throat section 36 or 72 it must pass along the wall section 35 or 76 on the inward or suction side of the passages. Since the air must travel a substantial distance before it reaches throat section 36, a significant boundary layer is built up along wall 34 or 70 before it reaches the throat sections. However, once the air reaches the throat sections along that wall there is very little if any divergence. The reason for this is that the radially inward facing wall in the passages is parallel to the longitudinal axis of the throats in the passages. Consequently, there is no divergence on that side of the passage and therefore no further buildup of the boundary layer. In both of the diffusers the divergence is primarily provided by the outwardly facing walls 32 or 68. A boundary layer will be built up along this wall because of the divergence. However, it is built up in such a way that a uniform boundary layer is provided on both walls of the passages adjacent its exit. The result of this is that there is generally a constant level of energy across the diffuser passages which greatly facilitates performance.

While the diffuser with the rectangular shape has first and second walls 42 and 44 diverging to a different extent relative to the air into the passages 26, they do not create such a significant difference in boundary layer that would effect the energy level in the passages.

While the present invention has been described in connection with centrifugal impellers, it should be apparent that it should be equally applicable to turbomachine rotors of other types without departing from the its spirit and scope.

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 compressor comprising:

a bladed turbomachine rotor rotatable to discharge air with a substantial tangential velocity component; and

an annular housing having an inlet section adjacent the discharge of said rotor and an annular outlet section, said housing having a plurality of generally tangential diffuser passages extending between said inlet and outlet sections and intersecting one another at said inlet whereby air from said rotor is discharged into said passages;

said passages being defined by radially outwardly facing and radially inwardly facing walls and having throat sections of constant cross-sectional flow area with a central axis tangent to a common circle having the same diameter as the periphery of said rotor, plus downstream sections of increasing cross-sectional flow area, the radially inward facing wall of said passages being substantially parallel to said axis and the radially outward facing wall diverging away from said central axis, whereby substantially all of the divergence in said passages is on the radially outward facing walls.

2. A compressor as in claim 1 wherein each of said passages has a section on the radially inward facing wall extending upstream of said throat section to the throat section of an adjacent passage.

3. A compressor as in claim 2 wherein said passages have a circular cross section, the throat section being cylindrical and the downstream section being in the form of a truncated cone extending from said cylindrical throat section, the axis of said cone being angled with respect to the central axis of said cylindrical throat so that the radially inward facing wall of said cone is parallel to the central axis of said cylindrical throat section.

4. A compressor as in claim 3 wherein the axis of said truncated cone is at an angle of approximately 3° with respect to the central axis of said throat.

5. A compressor as in claim 2 wherein the passages have a rectangular cross-sectional shape, the throat section defined by opposed walls parallel to one another and to a central axis and the downstream section is defined by a pyramidal frustum extending from the throat section in which the radially inward facing wall is coplanar with the radially inward facing wall in said throat section.

6. A compressor as in claim 2 wherein: said rotor is a centrifugal impeller having a radially outward peripheral discharge; and the inlet section of said annular housing is adjacent to and radially outward from said peripheral discharge and the outlet section is radially outward from said inlet section.

7. A compressor as in claim 6 wherein said passages are circular in cross section, the throat sections being defined by cylinders having central axes lying in a single plane and the downstream sections are defined by truncated cones having their axes lying in the same plane as that for said cylindrical throat sections, the axes of said truncated cones being angled with respect to the axes of said cylindrical throat sections so that the radially inward facing wall of said truncated cone is parallel to the axis of said cylindrical throat sections.

8. A compressor as in claim 7 wherein the axes of said truncated cones are at an angle of approximately three degrees with respect to the axes of said cylindrical throat sections.

9. A compressor as in claim 7 wherein said passages project through said inlet section to form a pseudo vaneless inlet region and scallop-shaped leading edges to said passages, the section upstream of said throat section on said radially inward facing wall extending into said inlet region.

10. A compressor as in claim 6 wherein said passages are rectangular in cross-sectional shape and said throat sections are defined by opposed parallel walls, the throat sections having central axes lying in the same plane and the downstream sections are defined by pyramidal frustums extending from the throat section and in which the wall is coplanar with the radially inward facing wall in said throat section.

11. A compressor as in claim 10 wherein said diffuser passages are formed with first and second walls defining the channel height through said passages, the first walls of each of said passages lying in a common plane and the second wall in the downstream section of each passage diverging away from said first wall.

12. A compressor as in claim 10 wherein said housing has a vaneless inlet space surrounding said impeller, said inlet space extending to a reference circle where the radially outward and inward facing walls of adjacent passages intersect.

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