United States Patent [19]

Bandukwalla

[11] **3,778,186**

[45] **Dec. 11, 1973**

[54] **RADIAL DIFFUSER**

[75] Inventor: **Phiroze Bandukwalla,** Indianapolis, Ind.

[73] Assignee: **General Motors Corporation,** Detroit, Mich.

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[52] **U.S. Cl.** **415/481,** 415/207, 415/211

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

[58] **Field of Search** 415/181, 207, 211, 415/DIG. 1

[56] **References Cited**

UNITED STATES PATENTS

3,333,762	8/1967	Vrana	415/181
2,708,883	5/1955	Keller et al.	415/211
2,596,646	5/1952	Buchi	415/211

FOREIGN PATENTS OR APPLICATIONS

555,308	8/1943	Great Britain	415/211
85,754	6/1957	Netherlands	415/211

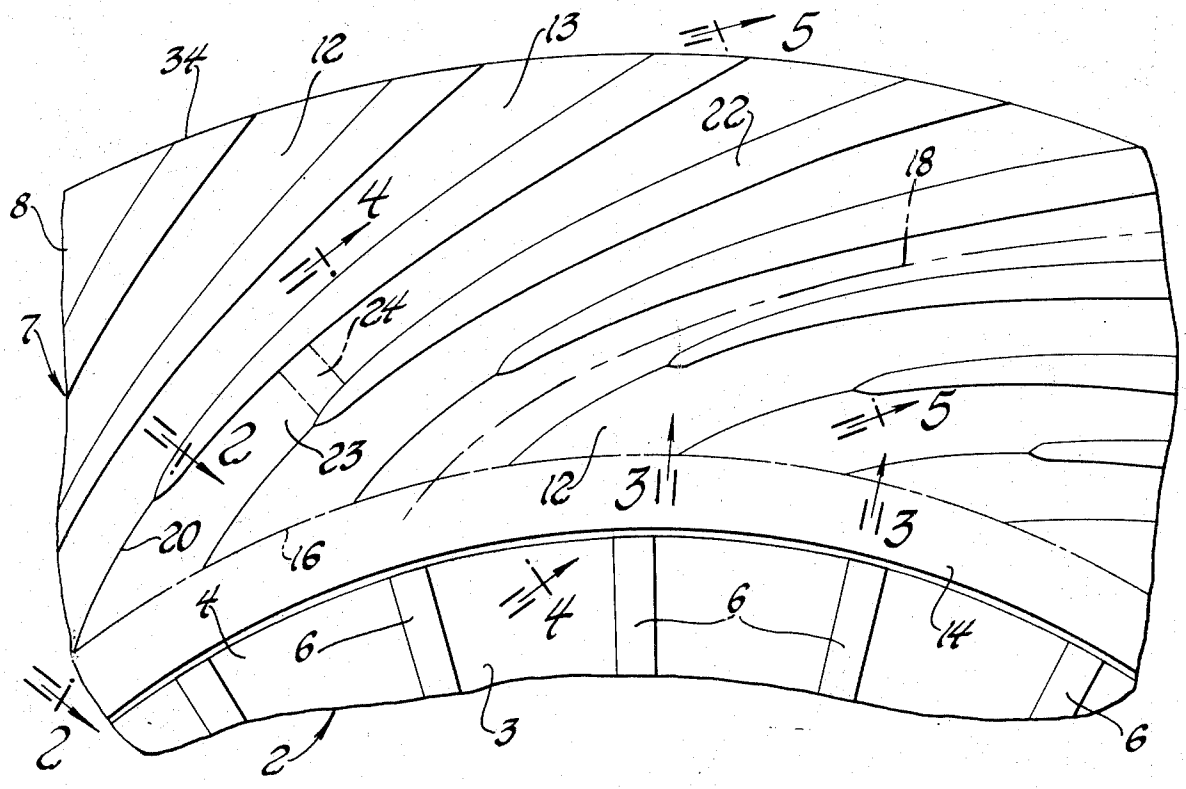
Primary Examiner—Henry F. Raduazo

Attorney—Paul Fitzpatrick et al.

[57] **ABSTRACT**

A diffuser for a centrifugal compressor has diffusing passages of circular or oval cross section which converge toward a throat and then diverge. The passages are of generally spiral curvature, at least in the converging portion. The entrances of the diffuser passages merge to define leading edges of generally elliptical shape between the passages.

2 Claims, 5 Drawing Figures



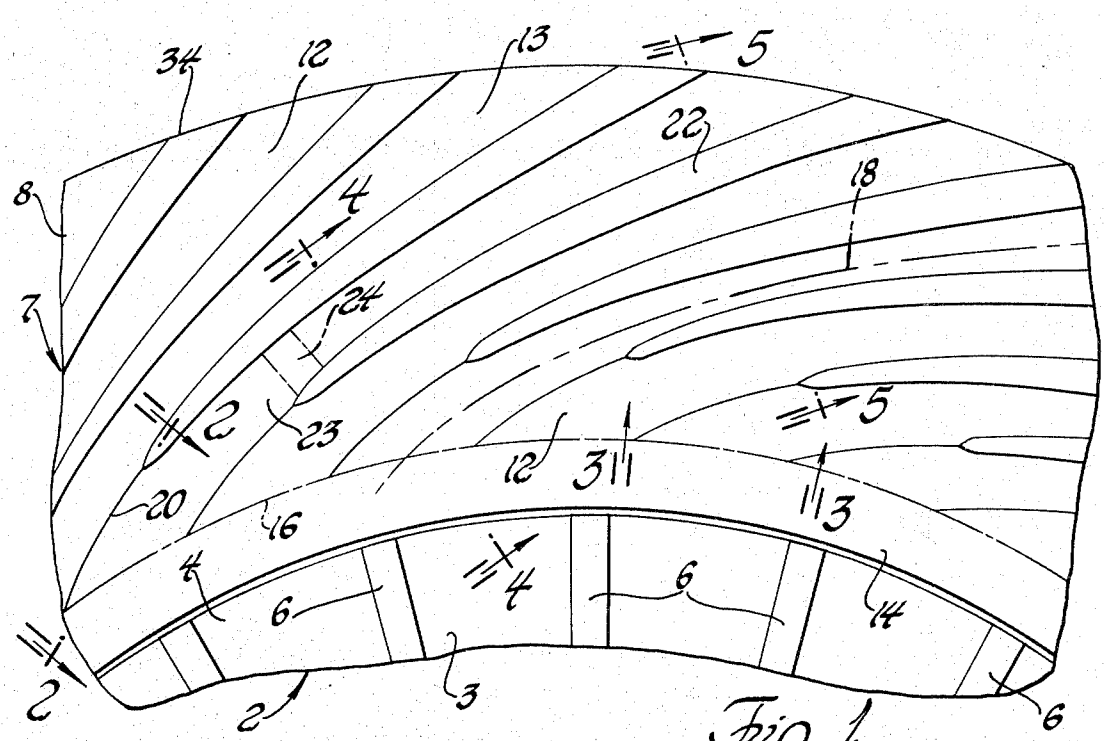


Fig. 1

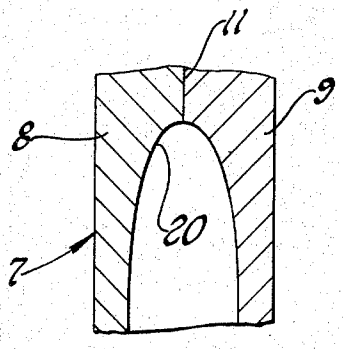


Fig. 2

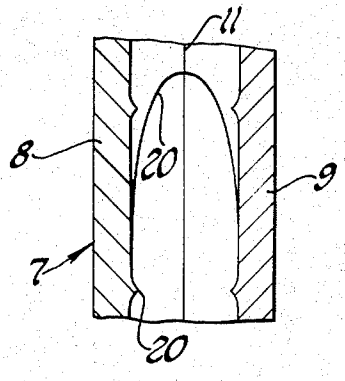


Fig. 3

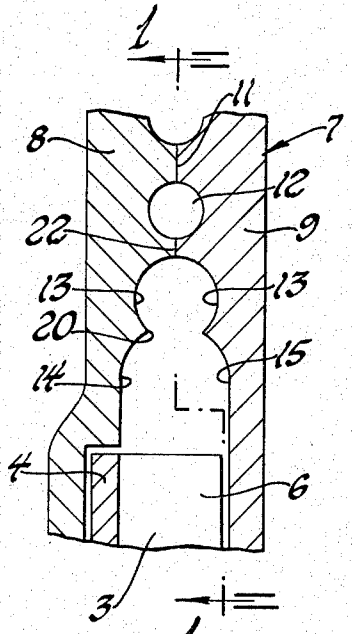


Fig. 4

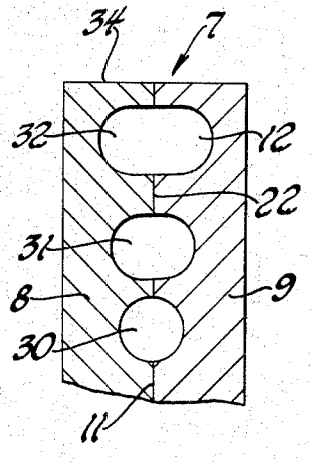


Fig. 5

RADIAL DIFFUSER

The invention described and claimed herein was made in the course of work under a contract with the Department of Defense.

My invention is directed to diffusers for centrifugal compressors in which the flow from the rotor is supersonic.

The principal object of my invention is to improve the efficiency and flexibility of radial flow compressors. It is a further object to provide a diffuser capable of accepting supersonic flow from a radial flow impeller with a minimum of shock and a diffuser suitable for high Mach number flows which is of a compact structure.

A further object is to provide a diffuser having passages curved to accord with the expanding vortical flow from the impeller.

A still further object is to provide a diffuser which is readily fabricated.

The nature of my invention and its advantages will be apparent to those skilled in the art from the succeeding detailed description of the preferred embodiment of my invention.

FIG. 1 is a partial radial sectional view of a centrifugal compressor perpendicular to the axis of rotation of the rotor on the planes indicated by the line 1—1 in FIG. 4.

FIG. 2 is a fragmentary sectional view taken on the plane indicated by the line 2—2 in FIG. 1.

FIG. 3 is a fragmentary sectional view taken on the plane indicated by the line 3—3 in FIG. 1.

FIG. 4 is a fragmentary sectional view taken on the plane indicated by the line 4—4 in FIG. 1.

FIG. 5 is a fragmentary sectional view taken on the plane indicated by the line 5—5 in FIG. 1.

As is well known, centrifugal compressors are devices in which a bladed rotor or impeller impels air (or other gas) in a tangential and radial direction, imparting a high velocity to the air. The air delivered from the impeller, which is flowing radially and circumferentially of its axis of rotation, is delivered to a diffuser in which the kinetic energy of the air is largely converted to potential energy of pressure. One example of a centrifugal compressor is disclosed in Atkinson U.S. Pat. No. 2,819,012, Jan. 7, 1958. Another is shown in Conklin et al U.S. Pat. No. 3,027,717, Apr. 3, 1962. The following U.S. Pat. Nos. may also be of interest: Buchi No. 2,596,646, May 13, 1952; Dallenbach et al. No. 2,967,013, Jan. 3, 1961; and Vrana No. 3,333,762, Aug. 1, 1967.

Since the general arrangement of centrifugal compressors is well known, there is no need here to provide overall drawings of such a device. As illustrated in FIGS. 1 and 4, the compressor 2 includes a rotor or impeller 3 having an annular disk 4 and blades 6 extending from the face of the disk. The rotor turns clockwise as illustrated in FIG. 1. It discharges air with a substantial radial component, and normally a greater circumferential component, of velocity from the perimeter of the rotor 3 into a stationary diffuser 7.

The diffuser 7 is made up of a back plate 8 and a front plate 9, preferably meeting on a plane surface. So far as the diffuser portions of these plates are concerned, they are preferably symmetrical. The diffuser plates may continue toward the axis of rotation to define a housing for the compressor rotor or they may be fixed to such a housing. The diffuser may be machined

from two annular plates having plane mating surfaces indicated by the line 11. The forward surface of the rear plate and the rear surface of the front plate are machined or otherwise formed to provide diffusing passages 12 with half of each passage in the back plate and half in the front plate, defined by grooves 13 in each plate. A cross-section of each passage 12, as will be apparent from FIGS. 4 and 5, is preferably elliptical, it being understood that a circle is a special case of an ellipse. The faces of the front and back plate immediately adjacent to the periphery of the rotor indicated at 14 and 15, respectively, in FIG. 4, and at 14 in FIG. 1 may be plane. The diffusing passages begin at the cylindrical surface indicated by broken line 16 in FIG. 1.

Each passage 12 has a curved generally logarithmic spiral centerline indicated by the broken line 18 in FIG. 1. The initial portions of these passages merge due to the intersection of the grooves 13, the passages intersecting in such manner as to provide a generally elliptical leading edge 20 (see particularly FIGS. 2 and 3) which constitutes the beginning of a dividing rib 22 having a flat upper surface corresponding to the junction plane 11 of FIGS. 2 and 3.

The diffusing passages 12 have an initial converging portion 23 which terminates at a throat 24. The section of FIG. 4 is taken near the throat of the passage indicated by the numeral 12 in that figure. Beyond the throat, the passage diverges as indicated by the successively larger cross sections 30, 31, and 32 in FIG. 5, the passages ultimately terminating in the exterior periphery 34 of the annular diffuser 7. The relatively slowly moving flow of air is then supplied from a suitable plenum surrounding the diffuser (not illustrated) to the point of use.

The supersonic flow entering the diffuser is diffused in the initial converging portion 23 of the diffuser up to the throat 24. Since the centerlines 18 of the diffuser passages are curved to accord with the naturally vortexing flow coming off the impeller, diffusion is effectively and smoothly handled and no shock is experienced at the entrance to the throat 24 because the throat curves with the flow.

While the diffusing passages in the diverging part of the diffuser may have a straight centerline, I prefer that the centerline still curve in a spiral as indicated in the drawing to avoid unnecessary deflection of a diffusing gas flow through the passage.

It will be noted that the diffusing passages as illustrated start off as a circular cross section and become elliptical towards their outer ends as illustrated in FIG. 5. The entire cross section of the passage might be elliptical if desired, and the long axis of the ellipse might be in a radial direction relative to the axis rather than parallel to the axis of rotation as illustrated in FIG. 5. By virtue of the gradual entrance of the gas into the diffusing passages, and the conformity of the passages to the natural approximately logarithmic spiral of flow of the vortexing gas, there is no forced turning of the gas and smooth outlet conditions from the impeller and through the diffuser are obtained.

While I have referred to the mating surfaces of the sections of the diffuser as flat, obviously these surfaces could depart somewhat from a flat condition; for example, they might be in the shape of a very blunt cone or follow a spherical surface of large radius.

It will be apparent that the passages can be formed by milling with a spherical mill in a numerically con-

trolled machine, for example. Also, the diffuser may be precision cast in the two pieces shown, or as a unit.

If in two pieces, the plates **8** and **9** may be bolted, cemented, or brazed together to provide the complete annular diffuser.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

I claim:

1. A centrifugal compressor including a rotor discharging radially and tangentially of the axis of the rotor and a diffuser body defining diffuser passages having entrances adjacent the periphery of the rotor, the passages having arcuate cross-sections and merging adjacent the rotor so that the body defines approximately elliptical leading edges at the intersections of the passage boundaries, each passage including a first converging portion with a spiral centerline terminating at a throat and a second diverging portion beginning at and extending in a continuous spiral downstream from the throat.

2. A centrifugal compressor including a rotor discharging radially and tangentially of the axis of the rotor and a diffuser body defining diffuser passages having entrances adjacent the periphery of the rotor, the passages having arcuate cross-sections and merging adjacent the rotor so that the body defines approximately elliptical leading edges at the intersections of the passage boundaries, each passage including a first converging portion terminating at a throat and a second diverging portion beginning at and extending downstream from the throat, both portions having continuous spiral centerlines meeting at the throat.

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