United States Patent

O'Connor

[15] **3,706,510**

[45] **Dec. 19, 1972**

[54] **PIPE DIFFUSER WITH AUXILIARY BLEED SYSTEM**

[72] Inventor: **John A. O'Connor, Orange, Conn.**

[73] Assignee: **Avco Corporation, Stratford, Conn.**

[22] Filed: **Aug. 2, 1971**

[21] Appl. No.: **168,205**

[52] **U.S. Cl.** **415/145,** 415/207, 415/211
[51] **Int. Cl.** **F01b 25/00,** F04d 29/44
[58] **Field of Search**......415/144, 145, 148, 207, 208, 415/186, 211

[56] **References Cited**

UNITED STATES PATENTS

2,289,231	7/1942	Auger et al.	415/211
2,620,626	12/1952	Lysholm	415/207
3,333,762	8/1967	Vrana	415/207
3,420,435	1/1969	Jarosz et al.	415/207
3,604,818	9/1971	Cronstedt et al.	415/207

FOREIGN PATENTS OR APPLICATIONS

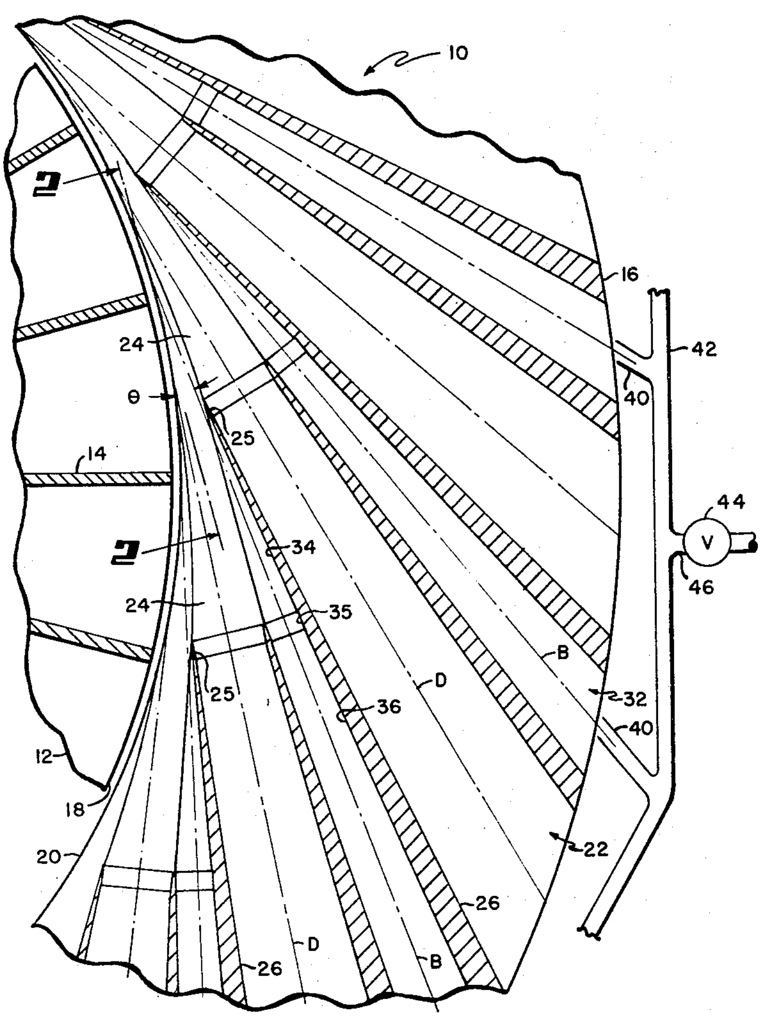
581,164	7/1933	Germany	415/211

Primary Examiner—Henry F. Raduazo
Attorney—Charles M. Hogan et al.

[57] **ABSTRACT**

The disclosure illustrates a "pipe" diffuser having basic flow passages sized to handle the output requirements of a centrifugal compressor without a bleed requirement. The diffuser has a series of auxiliary bleed passages intersecting the inlet portions of the pipe diffuser passages. The bleed passages are sized to handle a supplementary bleed flow requirement when needed.

5 Claims, 4 Drawing Figures



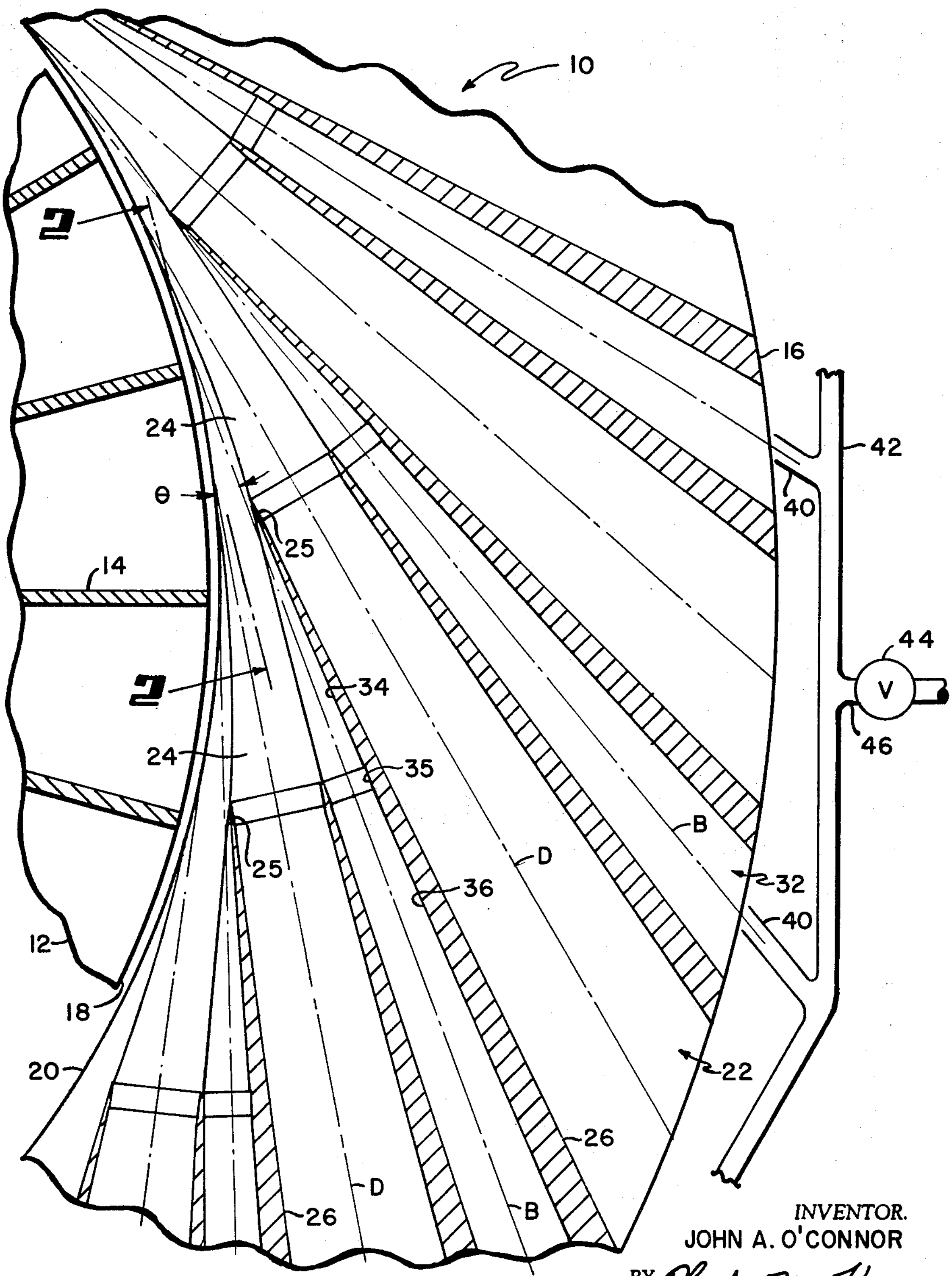


Fig 1

INVENTOR.
JOHN A. O'CONNOR
BY Charles M. Hogan
Gary M. Gron
ATTORNEYS.

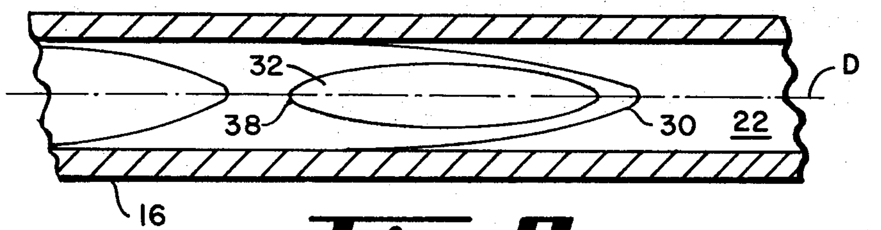


Fig 2

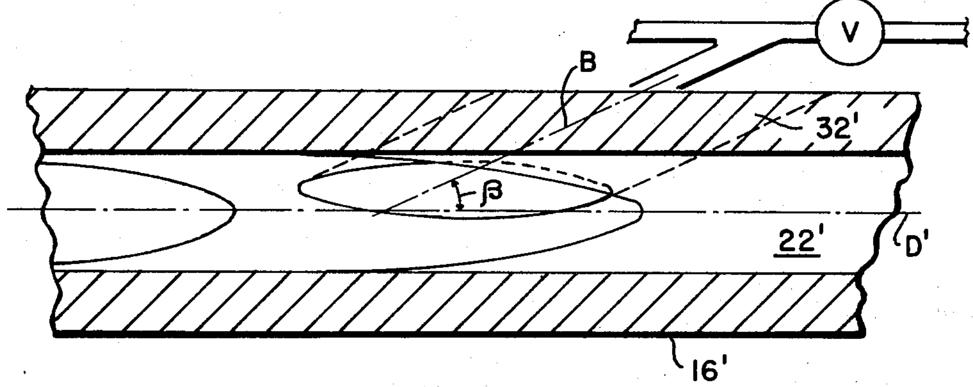


Fig 3

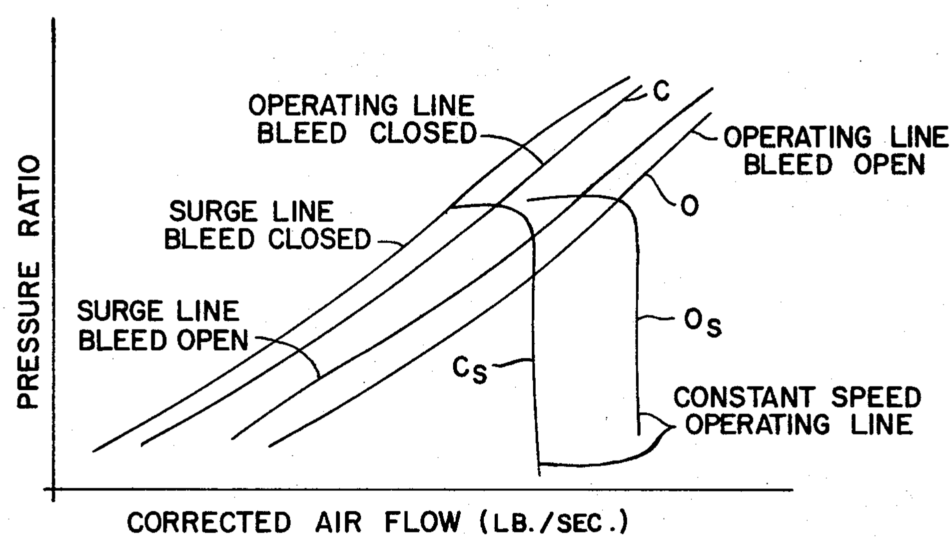


Fig 4

INVENTOR.
JOHN A. O'CONNOR
BY Charles M. Hogan
Gary M. Gron
ATTORNEYS.

PIPE DIFFUSER WITH AUXILIARY BLEED SYSTEM

The present invention relates to compressors and more particularly to centrifugal compressors.

In recent years the so-called "pipe" diffuser has been proposed for use with centrifugal compressors designed to discharge air at supersonic velocities. This type of diffuser is described in U.S. Pat. No. 3,333,762 in the name of J. C. Vrana. Briefly, the pipe diffuser comprises a series of circular passages drilled in an annular member surrounding a centrifugal impeller. The passages are oriented so that they intersect adjacent the periphery of the impeller to produce a series of scalloped leading edges to the inlets of the passages. This permits greater stability in the handling of transonic and supersonic flow discharged from the impeller. The reason for this is that the scalloped leading edges conform better to the velocity distribution of the flow than a straight leading edge of a normal diffuser. The net result is a centrifugal compressor with an improved efficiency capability at higher pressure ratios.

When such a diffuser is incorporated in a centrifugal compressor used in an auxiliary power unit (APU), certain problems may arise. Generally speaking, the output requirements of APU's range between several modes of operation which demand widely varying compressor performance. At one extreme the compressor bleed is closed and the APU engine produces maximum power output, for example, to drive an alternator. At the other extreme there is a no-load condition and a substantial amount of air is bled from the compressor for cabin pressurization and other uses. Differences in airflow requirements at these two operating conditions make it difficult to size the flow passages of the compressor and the diffuser to operate efficiently under the maximum power condition and the maximum bleed condition.

If the throat area of the diffuser is sized to provide adequate surge margin for the compressor at the maximum power output condition (minimum airflow), the diffuser may choke when the maximum bleed flow is called for. This is because the flow through the diffuser is greater than the throat area can handle at the chocking condition. This choking of the diffuser causes high losses and poor efficiency for operation in bleed mode.

Therefore it is an object of the present invention to provide a centrifugal compressor that operates at high efficiency over a wide range of pressure ratios and flow rates.

These ends are achieved by a pipe diffuser having flow passages intersecting to form scalloped inlet edges receiving flow from a centrifugal impeller. A series of auxiliary bleed passages extend from the diffuser passages to receive a portion of the air stream flowing through the diffuser. A means is provided to selectively permit or block flow through the bleed passages so that the effective throat area of the diffuser is varied.

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 sectional fragmentary view of a centrifugal compressor embodying the present invention;

FIG. 2 is a view of the diffuser of FIG. 1 taken on line 2—2 of FIG. 1;

FIG. 3 is an alternate embodiment of the compressor diffuser shown in FIGS. 1 and 2;

FIG. 4 is a compressor MAP for the centrifugal compressor of FIG. 1.

Referring to FIG. 1 there is shown a centrifugal compressor, generally indicated by reference character **10**, which incorporates a rotatable impeller **12** having a series of radial blades **14**. An annular diffuser housing **16** has an inner diameter **20** closely adjacent the periphery **18** of impeller **12**. A series of generally tangentially directed diffuser passageways **22** are formed around the periphery of diffuser housing **16**. These passages each comprise inlet portions **24**, a throat section **25** and a conical outlet portion **26**. The longitudinal axes D of the passages **22** are oriented so that they are all tangent to a reference circle, herein shown as the periphery **18** of impeller **12**. The inlet portions **24** of passages **22** intersect to form a series of scalloped shaped entrance edges **30**, as particularly shown in FIG. 2.

A series of bleed passages **32** are formed in the diffuser housing **16** adjacent the diffuser passages **22**. The passages **32** each comprise an inlet portion **34**, a throat **35** and a generally conical outlet portion **36**. The inlet portions **34** intersect the inlet portions **24** of passages **22** to form elliptically shaped inlets **38** (see FIG. 2). The outlet portions of the passages **32** connect through branch conduits **40** to a bleed manifold **42** having a suitably actuated flow control valve **44** in an overboard supply conduit **46**. As seen in FIG. 1, the axes D of passages **22** and axes B of passages **32** intersect at an angle θ which is large enough to permit a separate bleed flow collecting conduit arrangement around the periphery of diffuser housing **16**. However, θ is small enough so that the static pressure recovery in the auxiliary bleed passages **32** are of the same order as those of the main passages **22**.

During operation of the compressor **10** the impeller **12** rotates at a high rate of speed which causes air to be discharged generally tangentially from the tips of blades **14** at a high velocity. The air thus discharged enters the diffuser passages **22** where it is de-accelerated to a subsonic level in the inlet portions **24** for passage through throats **25** and subsonic diffusion in the outlet portions **26**. The flow areas of throats **25** are sized to provide an effective flow in impeller **12** for a no-bleed condition that permits a maximum efficiency.

During this state, as shown on FIG. 4, the compressor operating line C is as shown in relation to the surge line of the compressor. This line is at a relatively high level of efficiency, as seen by the constant speed operating line C_s. It should be noted that the compressor operates well upon the horizontal portion of line C_s so that it is away from a choked condition.

In the absence of the bleed system comprising passages **32**, a condition where air would be bled downstream of diffuser passages **22** causes the compressor to operate on the lower portion of line C_s and into the choked region. This greatly lowers the overall efficiency of the compressor **10**.

However, when the bleed flow is demanded for compressor **10**, valve **44** is opened, thus permitting flow into bleed passages **32**. The flow areas of passages **32** are sized to efficiently handle the bleed open requirements of the compressor **10**. This increases the effective throat area of the diffuser and thereby moves the operating lines to line **0** and the constant speed line to **0**, on FIG. 4.

It can be seen that the compressor still operates at an efficient level well away from a choked condition. As a result, the compressor **10** efficiently handles a wide range of flow rates without the need for complicated and expensive variable passage geometry.

When bleed is no longer called for, valve **44** is closed to block off passages **32** and the diffuser functions in a normal fashion.

The bleed passages **32** may be positioned so that their center lines B lie in the same plane as the center lines D of the diffuser passages (see FIG. 2) or they may be positioned at an obtuse angle relative to this plane. This modification is shown in FIG. 3 where passages **32'** have their longitudinal axes B' positioned at angle with respect to the plane containing the longitudinal axes D' of passages **22'**. This permits an axial shifting of the outlets of the two systems and reduces the mechanical interference between them.

While a preferred embodiment of the present invention has been described, it should be apparent to those skilled in the art that other modifications may be performed with equivalent results 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 compressor assembly comprising:

a rotatable bladed centrifugal impeller;

an annular diffuser housing surrounding the periphery of said impeller, said diffuser housing having a plurality of generally tangentially directed primary diffuser passages intersecting adjacent the periphery of said impeller to form a series of generally scalloped inlet edges to said diffuser passages, said diffuser having a series of auxiliary bleed passages extending from said diffuser passages; the intersection between them being forward of the primary passage throat; and

means for selectively permitting or blocking flow through said bleed passages whereby the effective total throat area of said diffuser is varied.

2. A compressor assembly as in claim **1** wherein the longitudinal axes of the diffuser and bleed passages intersect at an angle sufficiently small so that the static pressure recovery potential in the secondary bleed passages is of the same order as in the primary passages.

3. A compressor assembly as in claim **1** having predetermined flow requirements for bleed closed and bleed open conditions and wherein:

said primary diffuser passageways have a flow area to provide maximum efficiency for a bleed closed condition;

said auxiliary bleed passages have a flow area sized to provide maximum efficiency for a bleed open condition.

4. A compressor assembly as in claim **1** wherein the longitudinal axes of said diffuser passages substantially lie in a given plane and wherein the longitudinal axes of the bleed passages lie in the same plane and in between adjacent diffuser passages.

5. A compressor assembly as in claim **1** wherein the longitudinal axes of said diffuser passages lie in a given plane and the longitudinal axes of said bleed passageways extend from said diffuser passageways at an oblique angle relative to said plane.

* * * * *