VORTEX COMPRESSOR

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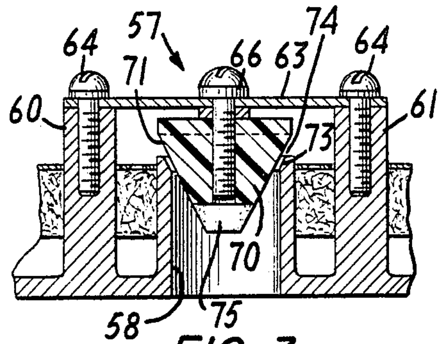

FIG. 3

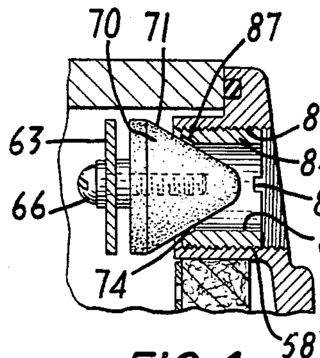

FIG. 4

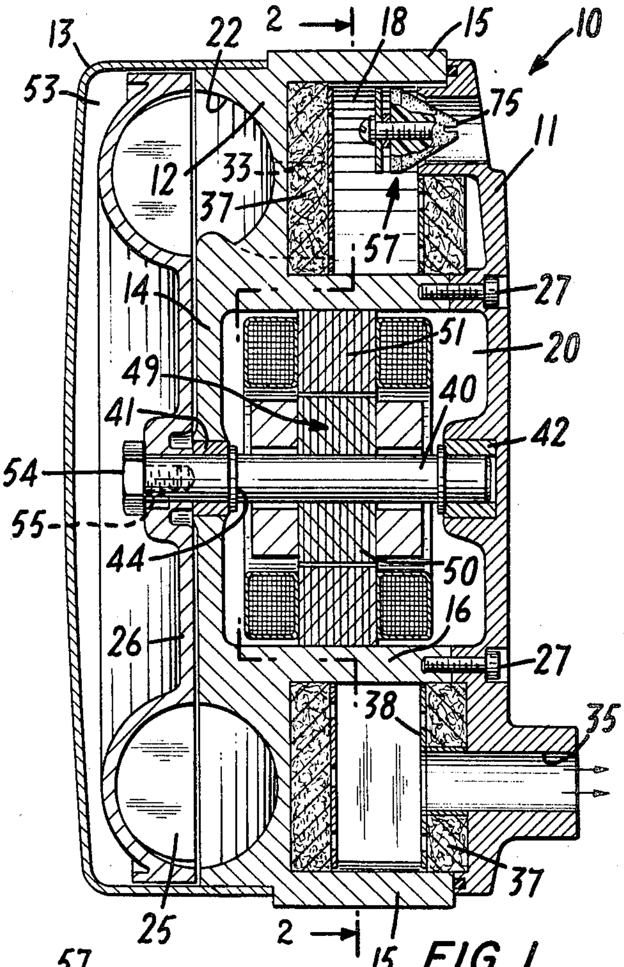

FIG. 1

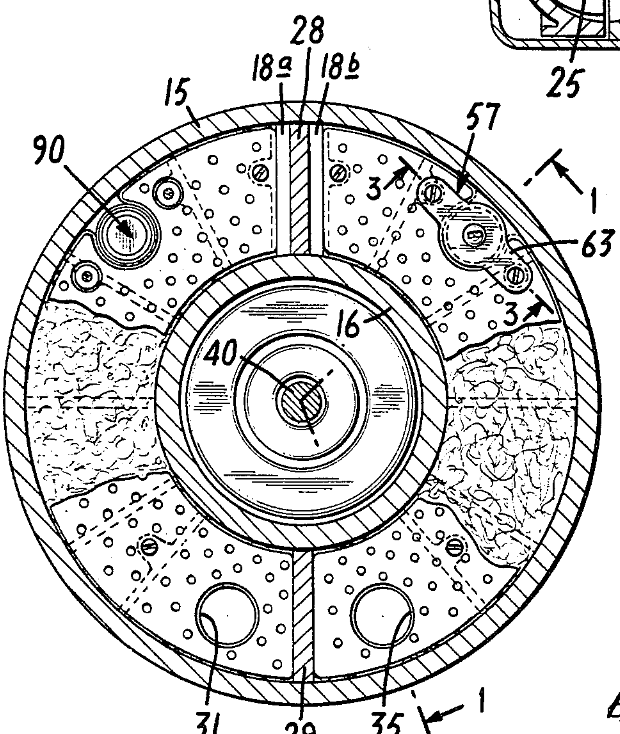

FIG. 2

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VORTEX COMPRESSOR

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ABSTRACT OF THE DISCLOSURE

This improvement in vortex compressors provides means for regulating the output pressure of such devices while maintaining rotor operation at its optimum and most efficient speed through the utilization of a bleed valve communicating between the interior of the compressor and the atmosphere. Several forms of bleed valves are described.

The present invention relates to compressors of the regenerative or vortex type, and more particularly, to means for regulating the output pressure of such devices so as to increase their operating efficiency.

Vortex compressors have been used as pumps for liquids, vapor mixtures, and gases, such as air, generally in applications where a high-pressure head and moderate flow are required. They have also been employed as effective vacuum sources for vacuum cleaners, control systems, etc.

Upon rotation of the impeller in a vortex compressor, the centrifugal force imparted to the fluid establishes a pressure differential between the fluid at the root of the impeller blade, closer to the axis of rotation, and the tip of the blade. This difference in fluid pressure causes a vortex current, which is basically perpendicular to the plane of rotation of the impeller. Increasing vortex currents naturally cause an increase in the internal friction of the pump and a concurrent decrease in pump efficiency.

Heretofore, when it was desired to operate a vortex compressor at a particular point on its pressure versus throughput characteristic, the general practice has been to throttle or restrict the throughput. However, the power consumption of this type of compressor increases as throughput decreases and a reduction in throughput caused a corresponding reduction in efficiency.

Various attempts have been made in the past to overcome the above difficulties. In one arrangement control of the operating conditions is effected by recirculating part of the output of the compressor back into the intake manifold. While this approach is effective to some degree, it has a significant disadvantage inasmuch as the recirculation continually adds energy to the flow and overheating can result under certain conditions.

In accordance with the present invention, the above-indicated difficulties in vortex compressor control are overcome by providing a valve to bypass or bleed off some of the pressurized fluid to the exterior of the compressor. By such means, the power consumption of the vortex compressor for providing a particular output pressure is significantly less than that resulting from the use of throttling devices. Moreover, since no recirculation of the bypassed fluid occurs, the overheating problem encountered by prior art bleed valve arrangements is avoided. When the compressor is used as a pump, the bleed valve is located on the high pressure side; when used as a vacuum source, it is placed on the low pressure side.

The vortex compressor of the invention comprises an impeller, input and output chambers, and input and output manifolds adapted to cooperate with their corresponding chambers. The compressor is interchangeably usable as a pump or vacuum source and is formed with bypass

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bores extending from the input and output chambers to the outside surface. Bleed valves are mounted in either or both of the bores, as desired, to control the fluid flow between the compressor chambers and the ambient atmosphere. Preferably, such a valve comprises two spaced support columns extending from the interior surface of the compressor for supporting a conical member coaxially with and partially within the bore. The conical member is axially movable and by adjusting its position within the bore, the area of the annular passage formed between the bore and the conical member may be varied, thereby providing means for controlling the flow through the bypass bore which, in turn, regulates the pressure at the input and/or output manifolds.

For a more complete understanding of the invention, reference may be had to the following detailed description taken in conjunction with the figures of the accompanying drawings, in which:

FIGURE 1 is a view in vertical section through a vortex compressor according to the invention showing the bleed valve; the section through the compressor being taken along the line **1—1** of FIGURE 2;

FIGURE 2 is a sectional view taken along the line **2—2** of FIGURE 1;

FIGURE 3 is a view in section of the bleed valve, partially broken away and taken along the line **3—3** of FIGURE 2; and

FIGURE 4 is a view in partial cross-section illustrating another form of bleed valve.

Referring to FIGURES 1 and 2 of the drawings, a vortex compressor **10** has a housing with three basic supporting elements: a cover plate **11**, a frame **12** and a cup-shaped casing **13** surrounding the rear or impeller end of the member **12** and secured thereto by press fitting or other suitable means.

The frame **12** comprises a circular web **14** at its left-hand end as seen in the drawing, an outer cylindrical member **15**, and an inner cylindrical member **16**; both members **15** and **16** extending concentrically from the right-hand surface of the web **14** and preferably integral therewith. Defined between the two cylindrical members **15** and **16** is an annular chamber **18**, whereas the interior surface of the inner member **16** defines a central cylindrical cavity **20**.

Formed in the left-hand surface of the web **14**, opposite the chamber **18**, is a toroidal channel **22** of semi-circular cross-section. The channel **22** forms a stator which is adapted to co-operate with a series of blades **25** provided on an impeller member **26** in a manner described later.

As shown in FIGURE 1, the cover plate **11** is secured to the frame **12** by machine screws **27** which pass through the plate **11** and are anchored within the cylindrical member **16** of the frame **12**. The annular channel **18** is actually divided into separate intake and outlet chambers **18***a* and **18***b*, respectively, by means of two baffle plates **28** and **29**, each secured to the cylindrical members **15** and **16** (FIGURE 2).

Fluid from an intake port **31** flows into the annular chamber half **18***a* and then, by means of an opening (not shown) provided in the web **14**, into the stator channel **22** of the compressor. The opening **33** communicates with the annular chamber half **18***b* and receives the high pressure discharge from the impeller **26**. From the chamber half **18***b*, the pressurized fluid is discharged through the output port **35** provided in the cover plate **11**.

Preferably, suitable mufflers **37** and perforated retaining plates **38** are disposed within the annular chamber **18** to suppress noise, as disclosed in copending application Ser. No. 517,412, filed Dec. 29, 1965, by Dwight E. Harris and Gunther Zoehfeld for "Regenerative Compressors with Integral Mufflers," and assigned to the present assignee.

A shaft **40** is axially situated within the cavity **20** and rotatably mounted in bearings **41** and **42**, the bearing **41** being supported in the web **14** of the frame **12** and the bearing **42** in the cover plate **11**. Thrust rings **44**, fixed to the shaft **40**, are adapted to cooperate with and engage their respective bearings **40** and **41** to permit axial loads imparted to the shaft **40** to be absorbed by the journal bearings **41** and **42**.

A motor **49**, within the cavity **20**, includes a rotor **50** fixed to the shaft **40** and a stator **51** secured to the interior surface of the cylindrical member **16** by any appropriate means. The motor **49** drives the shaft **40** which extends beyond the web **14** and supports the impeller **26** within the cup-shaped member **13**. The impeller **26** is secured to the shaft **40** and held in a fixed position by means of a key **55** simultaneously engaging a slot in impeller **26** and a slot in shaft **40**, and held in place by screw **54**.

The blade members **25** of the impeller **26** are disposed adjacent to and adapted to cooperate with the fixed stator channel **22**. Upon rotation of the shaft **40** by the motor **49**, the impeller **26** develops vortex currents as it rotates inasmuch as the pressure at the tip of each blade **25** is greater than the pressure developed at its root. The rotating impeller **26** draws fluid, for example air, in through the intake port **31** into the chamber **18*a***. The pressure of the fluid is thereafter raised by the rotary action of the impeller **26** with respect to the stator and directed out through the opening **33** into the annular chamber **18*b*** from where it is discharged through the output port **35**. Thus a low pressure is established at the intake port **31** and a high pressure at the outlet **35**.

A bleed valve **57**, shown in FIGURE 2 to be an integral part of the compressor **10**, is disposed, for example, within the output chamber **18*b*** adjacent a cylindrical bore **58** extending through the cover plate **11** between the chamber **18*b*** and the exterior of the compressor **10**. The valve **57** is carried by two spaced support columns **60** and **61** integrally formed on the cover plate **11**, which extend into the confines of the cavity **18*b***. A flat plate **63**, anchored by machine screws **64** to the free ends of the support columns **60** and **61**, fixedly holds threaded bolt member **66** which is aligned with the axis of the bore **58** and has its free end extending into the bore. A conical valve element **70** has its external surface **71** tapering inwardly into the bore **58** to cooperate with the corresponding flared surface **73** at the inner end of the bore which provides the valve seat.

The annular passage **74** defined between the surfaces **71** and **73** permits the pressurized fluid to be bypassed from the chamber **18*b*** without passing through the manifold **35** thereby reducing the output pressure delivered through the manifold **35**. The position of the member **70** within the bore **58** may be varied by inserting a screw driver into a slot **75** provided in the blunted forward end of the conical member **70** and rotating the member **70**, advancing or retracting it along the axis defined by the threaded member **66**. If the conical member **70** is advanced into the bore **58**, the area of the annular passage **74** will be reduced and the output pressure of the compressor **10** increased; whereas if the member **70** is retracted, the output pressure will be reduced.

Another embodiment of a bleed valve according to the invention is shown in FIGURE 4 and includes a conical member **70** having a conical surface **71**, a plate **63**, and a threaded member **66** substantially identical with corresponding members of FIGURE 3. Here, however, the bore **58'** formed in the cover plate **11** is provided with a threaded internal surface adapted to engage a thread **81** formed on the outer surface of a tubular insert member **84**. The member **84**, also formed with a bore **86**, is provided with a frusto-conical surface **87** at its rear end and which flares inwardly into the bore **86** and a slot **85** in its forward end, which, by means of a screw driver, facilitates its rotation thereby and enables it to be advanced or retracted in relation to the member **70**. If the insert member **84** is moved towards the conical surface **71**, the flow area of the annular passage **74** defined between the surfaces **71** and **87** will be reduced; whereas if it is moved away from the member **70**, the annular passage area will be increased and the output pressure at the output port **35** reduced.

If the bleed valve is to be used in the inlet chamber **18*a***, the same valve structure as shown in FIGURES 3 or 4 may be similarly mounted adjacent the opening **90** provided in the cover plate **11**. When not used, the opening **90** would be sealed by a suitable plug.

As will be recognized, the bleed valve allows an adjustable portion of the compressor throughput to be dissipated into the ambient atmosphere. Thus, to achieve a desired operating point on the delivered pressure versus throughput characteristic for the compressor, the unit can be designed to provide the desired pressure at whatever volume delivery rate results in lowest power consumption. Then, the bleed valve can be adjusted to allow a portion of the throughput to escape and leave the desired fluid flow at the output. Insofar as the compressor is concerned, it is delivering fluid at optimum efficiency for the desired pressure. The bleed valve in the inlet chamber provides a similar control when the compressor is used as a vacuum source. The trimming action provided by the bleed valve enables proper system performances regardless of fluid density or power frequency to the motor at a particular location and compensates for varying degrees of fluid leakage in the system with which it is used.

In comparison, conventional throttling controls reduce the compressor throughput, moving the operating point to a higher pressure value on the characteristic and consequently increasing power consumption. Moreover, the heating problems encountered in recirculating bleed systems, such as are commonly used to minimize compressor stall, are avoided.

While there is shown and described preferred embodiments of the invention, it is to be understood that it is not limited to the precise elements of their construction. For example, automatically controlled bleed valves may be provided and could, for example, be operated by a motor or other mechanical connections. Therefore, the invention as described is merely exemplary and should be limited only as set forth in the claims.

I claim:

1. A vortex compressor comprising a housing, rotor and stator means in said housing, means for driving said rotor with respect to said stator means to increase the pressure of fluid supplied thereto, fluid inlet and outlet chambers in said housing communicating with said stator to, respectively, supply fluid at a relatively low pressure to said rotor and stator means and extract fluid at a higher pressure therefrom, inlet and outlet ports communicating respectively with said inlet and outlet chambers, said housing being formed with a bore extending from the exterior of the compressor to one of said chambers, and valve means being insertable in said bore for defining a passage in relation to said bore, said valve means being contoured to reduce the passage flow area in a first position and increase said area in a second position thereby controlling the operational characteristics of the compressor.

2. A vortex compressor according to claim **1** wherein said valve means includes a valve element having a tapering external surface extending into said bore.

3. A vortex compressor according to claim **2** including an insert member in threaded engagement with said housing, said insert member defining said bore which is cooperable with said valve element to define said passage.

4. A vortex compressor according to claim **3** wherein said valve means includes two spaced column members formed on said housing, a plate secured to the free ends of said columns, and an elongated threaded member extending into said bore, said valve element being in threaded engagement with said elongated member and movable along an axis defined by said elongated member.

5. A vortex compressor according to claim **1** wherein said housing is formed with an additional bore extending from the exterior of the compressor to the other of said chambers, and further including valve means insertable in said additional bore to vary the passage flow area of said bore.

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