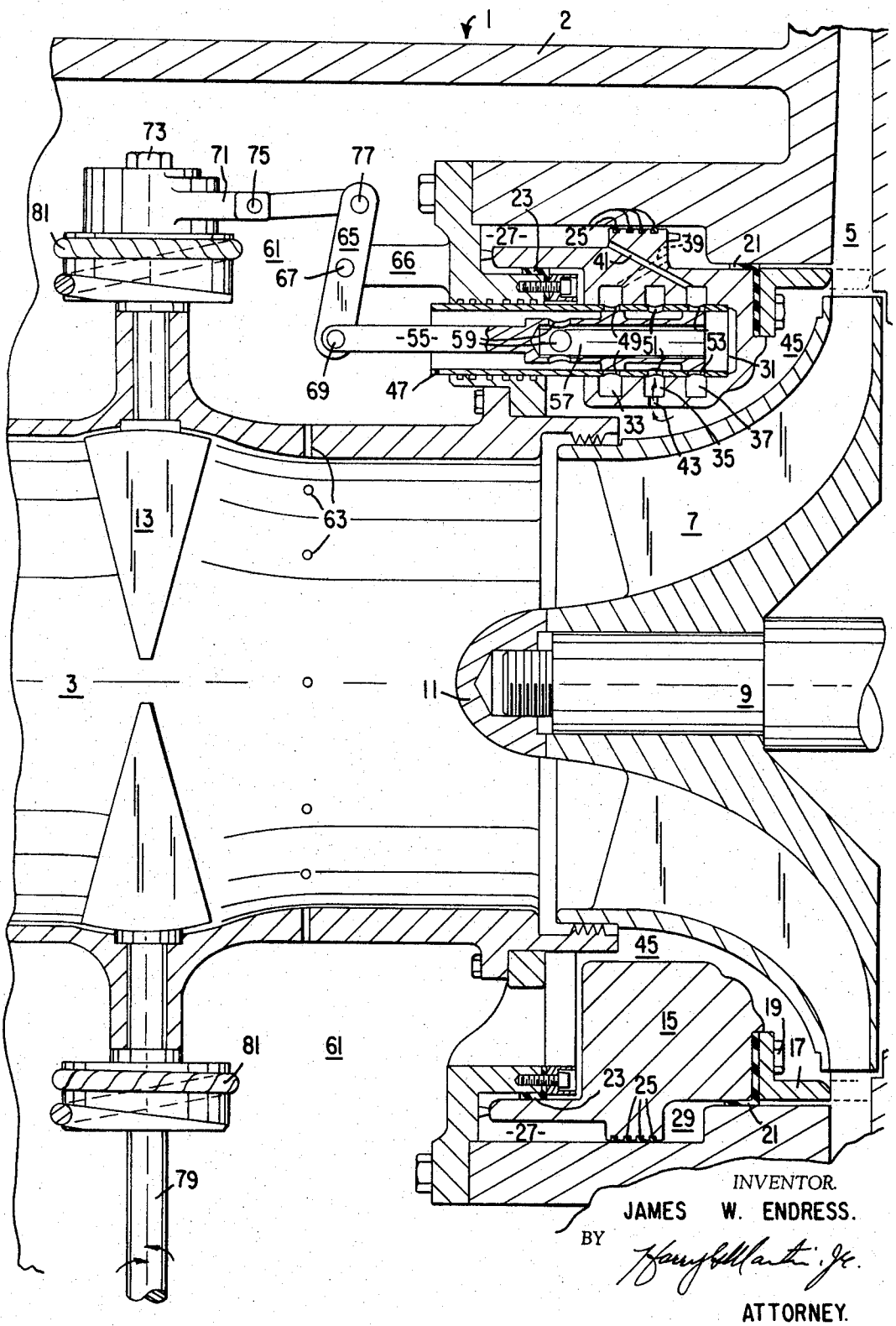
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CENTRIFUGAL GAS COMPRESSOR

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CENTRIFUGAL GAS COMPRESSOR

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ABSTRACT OF THE DISCLOSURE

A centrifugal compressor for operation over an extended range having interrelated inlet guide vanes and a diffuser blocking ring mechanism to vary compressor capacity without inducing compressor surge. A valve, operably connected to the guide vanes is arranged to subject the opposite sides of the diffuser blocking ring mechanism to compressor suction and discharge pressure to vary the position of the blocking ring mechanism in the diffuser passage.

This invention relates to gas compression equipment. More particularly, this invention relates to centrifugal gas compressors. Still more particularly, this invention relates to centrifugal gas compressors subjected to large load variations.

One of the major problems arising in the use of centrifugal gas compressors for applications where the compression load varies over a wide range is flow stabilization through the compressor. The compressor inlet, impeller and diffuser passage must be sized to provide for the maximum volumetric flow rate desired. When there is a low volumetric flow rate through such a compressor, the flow becomes unstable. As the volumetric flow rate is decreased from a stable range, a range of slightly unstable flow is entered. In this range there appears to be a partial reversal of flow in the diffuser passage, creating noises and lowering the compressor efficiency. Below this range, the compressor enters what is known as surge, wherein there are periodic complete flow reversals in the diffuser passage, destroying the efficiency of the machine and endangering the integrity of the machine elements. Since a wide range of volumetric flow rates is desirable in many compressor applications, numerous modifications have been suggested to improve flow stability at low volumetric flow rates. One of the most accepted and successful modifications has been the addition of guide vanes in the inlet of the compressor to vary the flow direction and quantity of entering gas. However, since the instability at low flow rates is also related to the diffuser configuration, it would appear desirable to vary diffuser configuration in response to the load on the machine to provide a more flexible compressor.

It is therefore the chief object of this invention to provide a method of varying the capacity of a centrifugal compressor to provide a large range of stable flow rates.

It is another object of this invention to provide a centrifugal gas compressor having means therein to stabilize the gas flow therethrough at extremely low flow rates.

It is a further object of this invention to provide means for automatically interrelating inlet guide vane movement with movement of diffuser flow restriction means to optimize compressor efficiency over a wide range of flow rates.

The objects of this invention are attained by providing a centrifugal gas compressor with inlet guide vanes and diffuser restriction means.

Valve means operable in response to guide vane rotation provide diffuser gas pressure on one side of the diffuser restriction means and inlet gas pressure on the other side of the diffuser restriction means to position the diffuser restriction means in relation to guide vane position to provide peak efficiency at any flow rate.

Other objects and features of my invention will be apparent upon a consideration of the ensuing specification and drawing in which the figure is an elevational view partly in section of a portion of the centrifugal compressor including the impeller, inlet guide vanes and diffuser passage, the compressor incorporating my invention.

Referring more particularly to the drawing, there is shown a gas compressor 1 of the well-known centrifugal type wherein gas to be compressed is induced to flow in an axial direction into a vaned impeller connected to a suitable driver for imparting rotary motion thereto. As the gas is compressed during its travel through the compressor, it is directed radially from the impeller to a diffuser passage communicating with the tip of the impeller. The compressor includes a housing 2 with inlet passage 3 and diffuser passage 5 formed therein. Only a portion of the housing is shown, it being understood that such a construction is conventional in equipment of the kind under consideration. An impeller 7 affixed to shaft 9 by nut 11 is provided in housing 2 between the inlet passage 3 and diffuser passage 5. Inlet guide vanes 13 journalled for rotation in housing 2 are positioned about the inlet passage to control the direction and quantity of gas flow therethrough. Diffuser restriction means comprised of annular ring 15 having extension ring 17 bolted thereto by bolts 19 is mounted in housing 2 for axial movement therein. Sealing members 21 and 23 along with O-rings 25 are provided to create pressure tight chambers 27 and 29. A cylindrical cavity 31 is formed in annular ring 15 having three radial cavities 33, 35, and 37 formed in the side wall thereof. A passageway 39 in annular ring 15 communicates between radial cavity 33 and chamber 29. A passageway 41 in annular ring 15 communicates between radial cavity 37 and chamber 27. A passageway 43 in annular ring 15 communicates between radial chamber 35 and clearance space 45. A cylindrical valve guide 47 having openings 49, 51 and 53 therein aligned with radial cavities 33, 35 and 37 respectively is securely disposed in chamber 31 preferably by an interference fit.

In order to effect movement of the diffuser ring 15, there is provided actuator means including valve stem 55, mounted for sliding movement within valve guide 47. A cylindrical cavity 57 and radial passages 59 in valve stem 55 provide communication between the end of chamber 31 nearest the diffuser and housing cavity 61. A plurality of radial passages 63 in the portion of the housing forming inlet 3 communicate housing cavity 61 with inlet passage 3. A link 65, mounted on post 66 by pivot pin 67, is operably connected to a valve stem 55 by pivot pin 69. Guide vane arm 71 attached to one of the guide vanes 13 by bolt 73, is operably connected to link 65 as by ball joints 75 and 77. A control rod 79 is mounted for rotation about its longitudinal axis to rotate one of the guide vanes 13. Cable 81, interlaced around guide vanes 13 provides an interconnection therebetween to provide simultaneous rotation of all the guide vanes in response to rotation of rod 79. The control rod 79 can be rotated by any well known means (not shown) such as electric, pneumatic or hydraulic positioners responsive to an operating condition of the compressor, or its associated equipment which is indicative of the load on the compressor. Thus if the compressor were to be used in a refrigeration machine, the positioning means could be responsive to the temperature of the chilled water leaving the machine, this temperature being related to the quantity of refrigerant being lifted from the low side to the high side of the machine by the com-

pressor. If the compressor were being used to compress air, the positioning means could be responsive to ambient temperature since this is an indication of the air density and therefore the quantity of air being compressed.

The compressor, with the control arrangement described, functions as follows. Extension ring **17**, attached to annular ring **15**, is capable of axial movement within diffuser passage **5** to close or partially close the passage, note the position indicated in dotted lines. Annular ring **15** is basically pressure balanced due to its configuration. When pressure is supplied to chamber **27**, annular ring **15** will move to close the diffuser. When the pressures in chambers **27** and **29** are balanced, the piston will be stationary. When pressure is supplied to chamber **29**, annular ring **15** will move to open the diffuser passage. Extension ring **17** along with annular ring **15** are automatically positioned as follows: Movement of guide vanes **13** by actuator rod **79** will move stem **55** by means of the linkages heretofore described. If the valve stem is moved to the right of the location shown in the figure, chamber **27** will be in communication with chamber **45** which is at diffuser pressure because of the passageway between the impeller tip and ring **17**. The open passage between the two aforementioned chambers, would consist of passageway **43**, radial cavity **35**, radial cavity **37** and passageway **41**. At the same time, chamber **29** will be in communication with housing cavity **61** which is at inlet pressure due to passages **63**. The open passage between cavity **61** and chamber **29** would consist of passageway **39**, radial cavity **33** and the left end of valve guide **47** which is open to cavity **61**. The pressure imbalance between chambers **27** and **29** would thus move annular ring **15** to the right until the open passageways heretofore described are closed by the relative movement of the valve guide with respect to the valve stem. Movement of the valve stem to the left will result in reversing the movement of annular ring **15**. As can be seen from the foregoing description, movement of the guide vanes will effect movement of the diffuser restriction means which will result in increasing the lift capability of the compressor over the complete range of flow rates attainable.

While I have described a preferred embodiment of my invention, it is to be understood that my invention is not limited thereto but may be otherwise embodied within the scope of the following claims.

I claim:

1. A centrifugal gas compressor comprising a housing having an inlet passage and a diffuser passage formed therein, an impeller mounted in said housing between the inlet and diffuser thereof, a plurality of guide vanes rotatably mounted in the housing to vary the quantity of gas flowing through the inlet passage, diffuser restriction means, mounted for movement within the diffuser passage to restrict flow of gas therethrough, actuator means for moving said diffuser restriction means, said actuator means including valve means, operable in response to guide van rotation to provide diffuser gas pressure on one side of said diffuser restriction means and inlet gas pressure on the other side of said diffuser restriction means to cause movement thereof.

2. A centrifugal gas compressor according to claim **1** wherein said valve means includes a first valve member, a second valve member adapted for movement relative to said first valve member, said first valve member being operably connected to said guide vanes for movement therewith, said second valve member being operably connected to said diffuser restriction means, movement of said first valve member from an equilibrium position relative to said second valve member causing movement of said diffuser restriction means and said second valve member back into equilibrium position relative to said first valve member.

3. A centrifugal gas compressor according to claim **1** wherein said valve means includes a valve body, formed in said diffuser restriction means, a valve stem, adapted for movement relative to said valve body, said valve stem being operably connected to said guide vales for movement therewith, movement of said valve stem from an equilibrium position relative to said valve body causing movement of said diffuser restriction means to move said valve body back into equilibrium position relative to said first valve member.

4. A method of increasing the lift capability of a centrifugal gas compressor having an inlet and a diffuser comprising the steps of providing a variable restricted inlet:

restricting the flow of gas through the compressor inlet in response to the load imposed on the compressor,

supplying gas at inlet pressure and diffuser pressure to a control which is responsive to the inlet gas flow restriction, and

restricting flow of gas through the diffuser in response to a predetermined relation between the inlet and diffuser pressure from the control.

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HENRY F. RADUAZO, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,362,624 January 9, 1968

James W. Endress

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 6, for "van" read -- vane --; line 26, for "vales" read -- vanes --.

Signed and sealed this 18th day of March 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents