Nov. 18, 1969 F. K. KUNDERMAN 3,478,955

VARIABLE AREA DIFFUSER FOR COMPRESSOR

Filed March 11, 1968 2 Sheets-Sheet 1

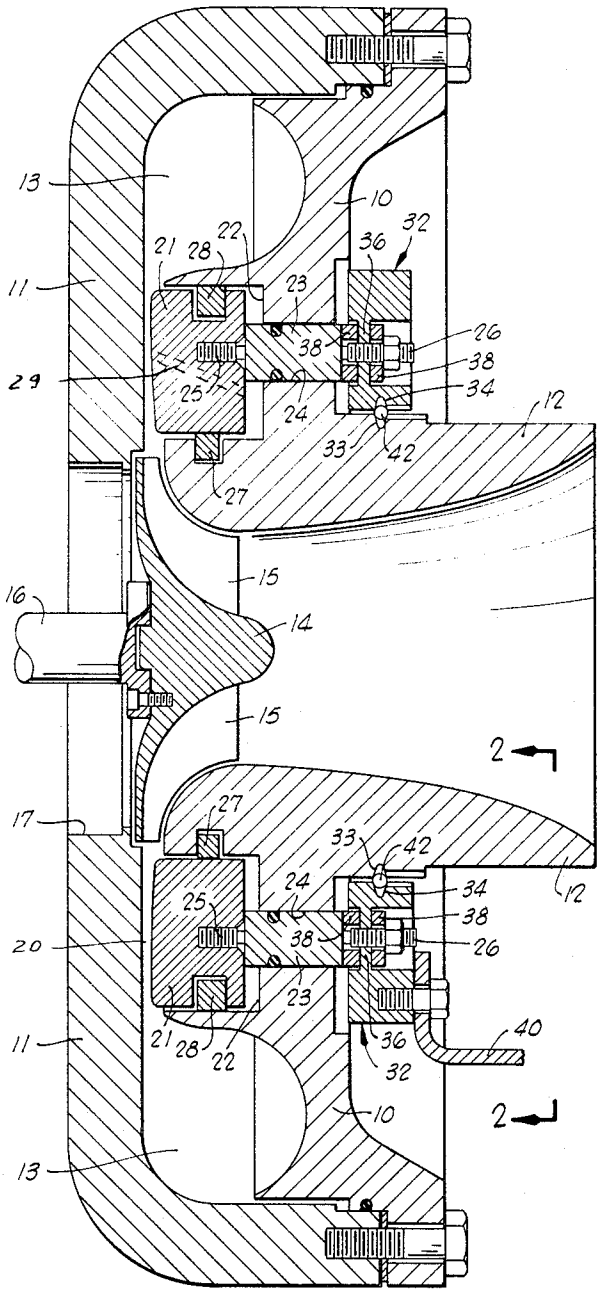

Fig. 1

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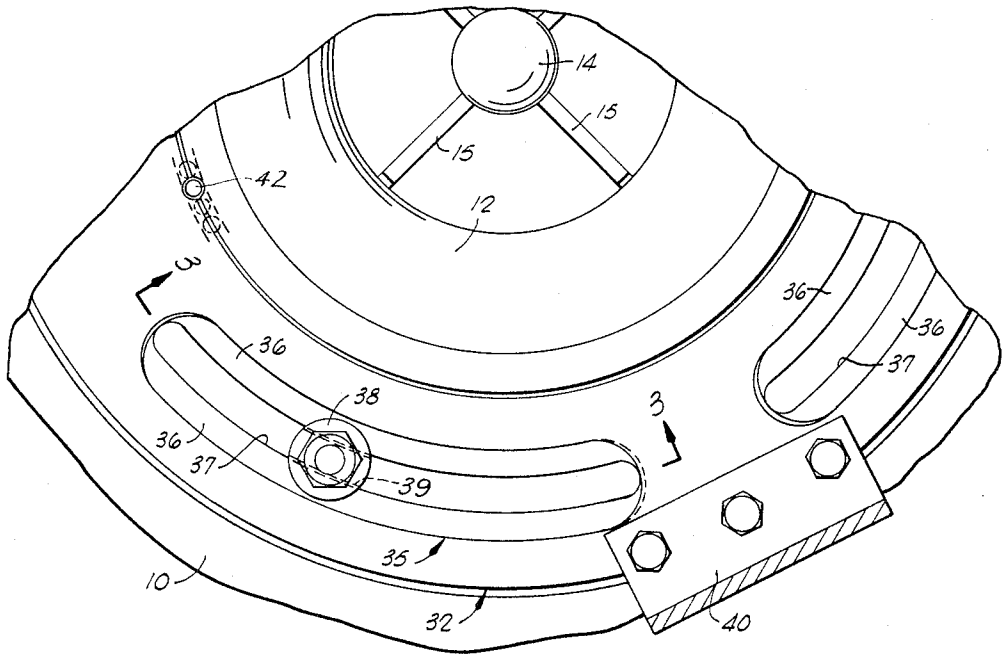

Fig. 2

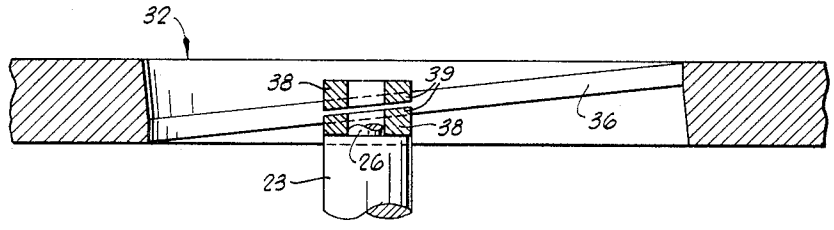

Fig. 3

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United States Patent Office

3,478,955
Patented Nov. 18, 1969

3,478,955

VARIABLE AREA DIFFUSER FOR COMPRESSOR

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Filed Mar. 11, 1968, Ser. No. 712,114
Int. Cl. F04d 27/02; F04f 5/48
U.S. Cl. 230—114 9 Claims

ABSTRACT OF THE DISCLOSURE

A centrifugal compressor having a vaneless diffuser, one wall of which is defined by an annular member movable relative to the other wall to reduce or increase the width of the diffuser passage. The annular wall is mounted on four posts which extend through openings in the compressor casing and guide the reciprocating movement of the wall. The opposite ends of the posts are operatively coupled to helical cams in an annular control member mounted for rotation on the casing. Oscillation of the control member, by means of any suitable control mechanism, effects corresponding reciprocating movement of the movable annular wall.

Background of the invention

In the design of compressors or compressor systems for supplying plant air, that is compressed air for the operation of air-powered tools for example, provision must be made for fluctuating demands which is characteristic of this type of load; and it is a characteristic of constant speed centrifugal compressors that they operate at peak efficiency for a relatively narrow range of volume flow. Surge or pulsation is an unstable operating condition of centrifugal compressors which occurs when the flow rate in the compressor has been reduced to some value below a designated operating point of the machine. Intensity of surge can be such that it produces violent shocks which may be damaging to the machine.

One approach for extending the range of volume flow at which a constant speed centrifugal compressor will operate at peak efficiency and for lowering the design flow rate point at which surge will occur is to provide a diffuser having a variable flow area which can be adjusted in accordance with the demanded flow rate through the compressor. It is known to provide vaneless diffusers wherein one wall of the diffuser passage is an annular member which may be moved relative to the other to vary the diffuser width.

Summary of the invention

An object of this invention is to provide a centrifugal compressor having a vaneless diffuser with one variable wall defined by an annular member, and an improved mechanism for adjusting the position of the movable wall in accordance with desired conditions.

According to the invention, a centrifugal compressor is provided with a vaneless annular diffuser passage or channel which communicates the compression chamber with the discharge chamber, one of the opposing walls of the diffuser chamber being defined by an annular wall

member movable relative to the opposing wall. The annular wall member is supported and guided for reciprocating movement in the compressor casing by parallel posts. The posts are coupled at their opposite ends to an annular control member, mounted for rotation on the compressor casing, having cams for effecting reciprocation of the wall member in response to oscillation of the control member.

Brief description of the drawing

The invention is embodied in apparatus illustrated in the accompanying drawings in which:

FIG. 1 is a sectional view of a centrifugal compressor in a plane through the impeller axis;

FIG. 2 is a fragmentary view of the compressor looking toward the inlet side thereof, along the line 2—2 of FIG. 1; and

FIG. 3 is a sectional view of a portion of the control assembly as viewed along the line 3—3 of FIG. 2.

Description of the preferred embodiment

Referring to the drawings, there is shown a centrifugal compressor **10** having a casing defined by casing portions **10** and **11**, secured together adjacent the outer peripheries by suitable bolts. The compressor casing defines a compression chamber between the inlet nozzle **12**, in the casing portion **10**, and the annular discharge chamber **13**, adjacent to the outer periphery of the casing. An impeller **14** having blades **15** to mounted for rotation within the compression chamber, being secured to a suitable shaft **16** which extends through an opening **17** in the casing portion **11**. The opening **17** may accommodate suitable seal or bearing housings for the impeller shaft.

Surrounding the impeller **14** is a vaneless diffuser which is an annular radially directed passage **20** communicating the outer periphery of the impeller **14** and the discharge chamber **13**. A fixed wall of the diffuser passage is defined by the casing portion **11**; and a movable wall **21** of the diffuser passage is defined by an annular member which is disposed in an annular groove **22** in the casing portion **10** concentric with the axis of rotation of the impeller. The movable wall member is generally rectangular in cross section, with the surface defining the diffuser wall surface being contoured for smooth air flow. Correspondingly, the annular groove **22** is generally rectangular in cross section, and is dimensioned to receive the movable wall member with a relatively close fit.

The movable wall **21** is supported and guided for reciprocating axial movement on four cylindrical posts **23** which extend through cylindrical bores **24** in the casing portion **10**, these bores being parallel to each other and being circumferentially equally spaced concentric with the impeller axis. The posts **23** are dimensioned for a close sliding fit within the respective bores **24**; and the posts are provided with threaded studs **25** and **26** projecting from opposite ends thereof. The posts **23** are rigidly secured to the movable wall **21** by the threaded engagement of the studs **25** in suitable threaded holes in the movable wall member.

In order to prevent circulation of gas around the mov-

able wall member **21**, that is radially through the groove **22**, which may occur because of the pressure gradient which exists across the diffuser wall during normal operation of the compressor, sealing devices are provided at the inner and outer peripheries of the wall member. An inner piston type seal ring **27** is disposed in a suitable annular groove in the inner cylindrical wall of the annular groove **22** to provide a seal between this cylindrical wall and the inner cylindrical wall of the wall member **21**. An outer seal ring **28** is disposed in an annular groove in the outer cylindrical wall of the movable wall member **21** to provide a seal between this cylindrical wall and the outer cylindrical wall of the annular groove **22**.

With these seals and the seals for the post **23** to be described, there is created a trapped pocket or space between the movable wall member and the bottom of the annular groove **22**. It is desirable to vent this trapped pocket; and this is accomplished by providing one or more vent passages **29** through the movable wall member. Preferably, these vent passages open to the diffuser side of the wall member at a precise radial location, again because of the pressure gradient across the movable wall member. The radial location is selected so that the pressure extant in the trapped pocket and acting on the movable wall member corresponds to the average pressure acting on the diffuser side of the movable wall, that is that the forces acting on the opposite sides of the movable wall are balanced so as not to effect the positioning of the movable wall by the means to be described.

To prevent a leakage of gas from the trapped pocket to the exterior of the casing **12**, O-ring seals are disposed in suitable annular grooves in the cylindrical walls of the posts **23** for sealing engagement with the walls of the bores **24**.

From the foregoing it will be seen that the movable diffuser wall **21** is mounted and guided for reciprocating axial movement relative to the fixed diffuser wall, is prevented from rotation relative to the casing, and is gas-tightly sealed in the casing.

The reciprocating movement of the movable diffuser wall **21** is controlled by a control member **32**, which is an annular ring member mounted for rotation on the exterior of the casing portion **10** concentric with the impeller axis. The inlet nozzle **12** of the casing portion **10** defines an outer cylindrical surface within which is provided an external ball race **33**; and the inner cylindrical surface of the control ring **32** is provided with a complementary ball race **34**. With suitable balls **42**, then, the control ring **32** is rotatably secured to the housing portion **10** and prevented from relative axial movement.

The control ring **32** provides angularly equally spaced helical cams **35** which are defined by inclined arcuate webs **36**, the webs being divided radially by arcuate slots **37** concentric with the axis of rotation of the control ring.

The helical cams **35** are so related to the posts **23** that the post studs **26** extend through the respective slots **37**. The opposite faces of the webs **36** are engaged by bearing members **38** in the form of wedge-shaped washers having bosses **39** which extend into the slots **37**, two of which are positioned over each of the respective threaded studs **26** and secured thereon by means of suitable nuts. These bearing members may be fabricated of a suitable bearing material such as oilite bronze, and function as followers of the helical cams. Each of the helical cams has the same relation to the plane of rotation of the control ring **32** so that as the control ring is oscillated the movable diffuser wall is positioned in selected parallel planes relative to the fixed diffuser wall.

A control arm **40** is suitably secured to the control ring **32**; and this may be actuated by any suitable control mechanism to oscillate the control ring in response to the operating conditions of the compressor, for example. The above described mechanism provides a very positive and precise control for varying the width of the diffuser passage **20**.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A centrifugal compressor comprising

a casing defining a compression chamber and an annular discharge chamber; an impeller disposed in said compression chamber;

an annular diffuser passage, communicating said compression chamber and said discharge chamber, defined by confronting walls at least one of which is movable relative to the other to enlarge or restrict said diffuser passage; said movable wall comprising a ring member disposed for axial movement relative to said casing; said ring member being supported on a plurality of posts which extend in a direction parallel to the axis of said impeller; means on said casing for guiding the rectilinear movement of said posts parallel to the axis of said impeller;

an annular control member mounted for rotation on said casing in axial alignment with said movable wall and parallel thereto; said control member defining a plurality of cams, each of said cams being defined by opposed surfaces of said control member inclined along an arc relative to the plane of rotation of said control member;

and means coupling said posts to respective control member cams whereby oscillation of said control member relative to said casing effects rectilinear movement of said posts relative to said casing and corresponding rectilinear movement of said movable diffuser wall.

2. A centrifugal compressor as set forth in claim **1** wherein said casing is provided with a plurality of bores extending parallel to the axis of rotation of the impeller; said bores being dimensioned to receive said posts with a sliding fit for supporting and guiding said movable wall.

3. A centrifugal compressor as set forth in claim **1** wherein the casing portion, opposite from the portion defining the fixed diffuser wall, is provided with an annular groove having a generally rectangular cross section; and wherein said movable diffuser wall is generally rectangular in cross section and dimensioned to be received within said annular groove with a relatively close fit; and said movable wall being fully received within said groove, in the maximum flow position of said movable wall, whereby the movable wall and the adjacent casing portion define a smooth diffuser wall surface.

4. A centrifugal compressor as set forth in claim **3** including sliding seal rings for the adjoining cylindrical surfaces of said movable wall and said annular groove.

5. A centrifugal compressor as set forth in claim **3** including seal means between the inner walls of said annular groove and said movable wall member, and between the outer walls of said annular groove and said movable wall member for preventing gas flow radially through said annular groove.

6. A centrifugal compressor as set forth in claim **5** including vent means through said movable wall for venting the annular space between said wall and the bottom of said annular groove; said vent means opening to the diffuser side of said movable wall at a predetermined radial position, such that the forces acting on the opposite sides thereof are controlled.

7. A centrifugal compressor as set forth in claim **1** wherein said control member is mounted on said housing by means of complementary ballraces formed respectively in a peripheral wall of an axially projecting portion of said casing and an inner wall of said annular control member; and said members being coupled together by means of balls disposed within said ballraces.

8. A centrifugal compressor as set forth in claim **1** wherein said cams are helical cams defined by angularly

spaced inclined web portions of said control member, said web portions having a uniform thickness and being radially divided by arcuate slots concentric with the axis of rotation;

and wherein said posts extend through said arcuate slots and are provided with follower means engaging both of the opposing surfaces of said web portions.

9. A centrifugal compressor as set forth in claim **8** wherein each of said posts includes an axially extending stud extending through an arcuate slot in said control member; and a pair of bearing members supported on said stud for sliding engagement with the opposite faces of the associated cam web.

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U.S. Cl. X.R.

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