

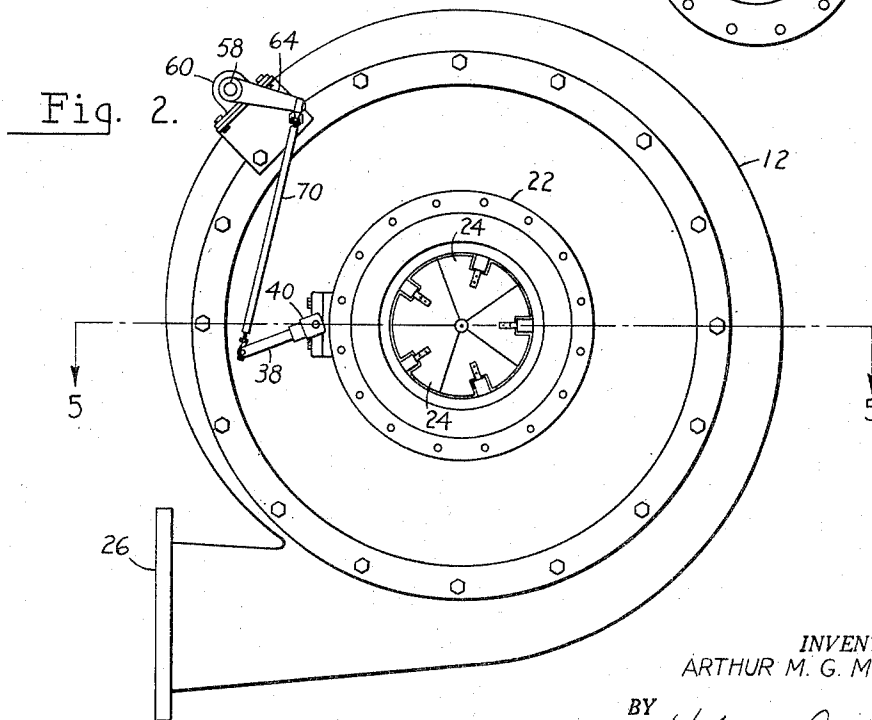
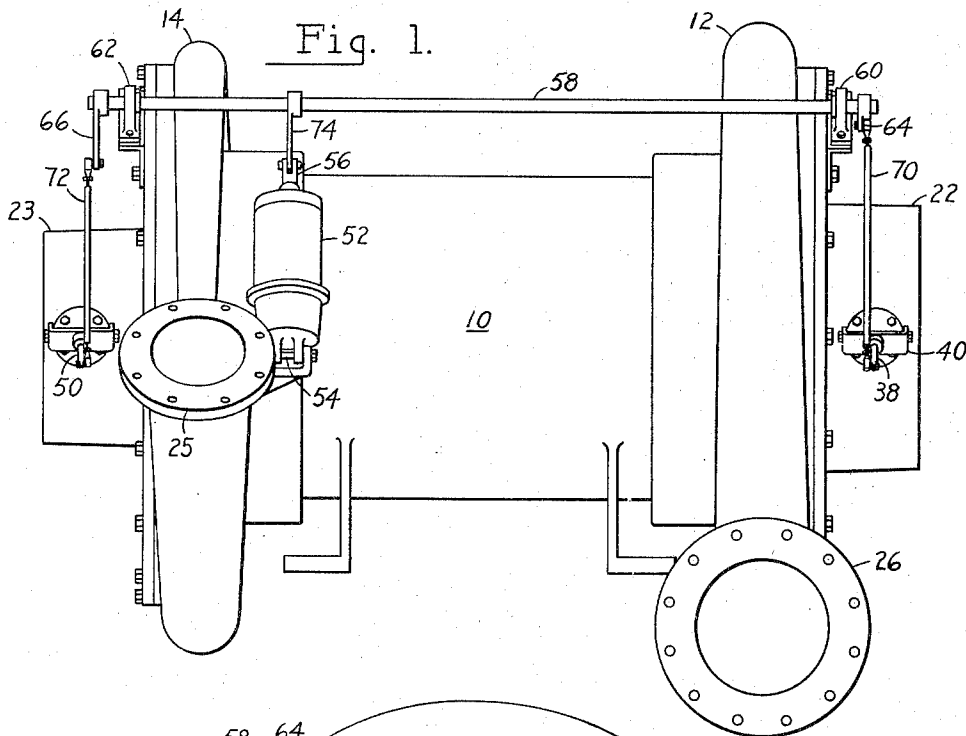
Dec. 24, 1957

A. M. G. MOODY
CENTRIFUGAL COMPRESSOR AND METHOD OF
CONTROLLING THE SAME

2,817,475

Filed Jan. 22, 1954

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 3.

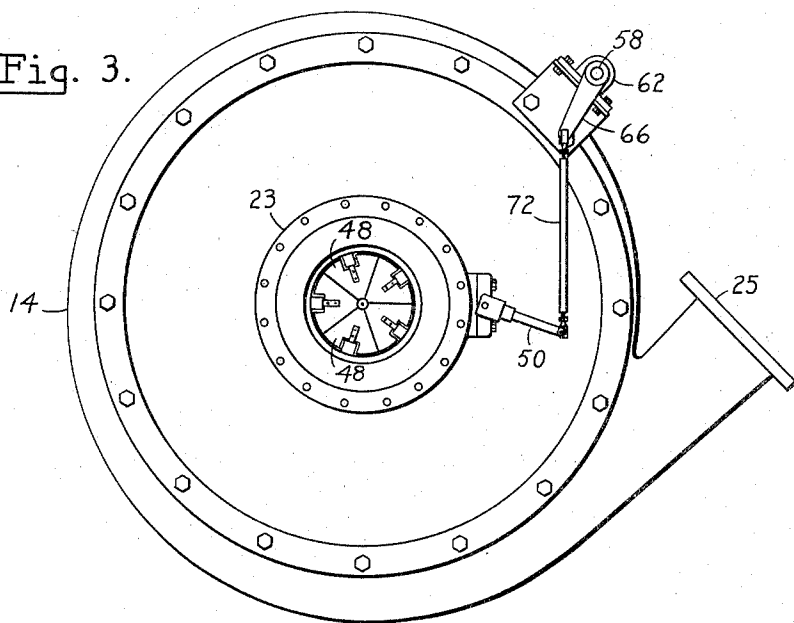
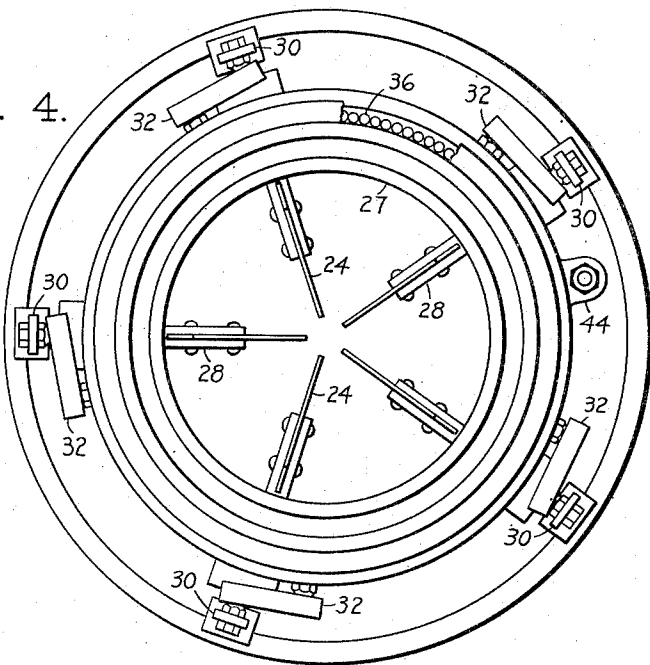


Fig. 4.



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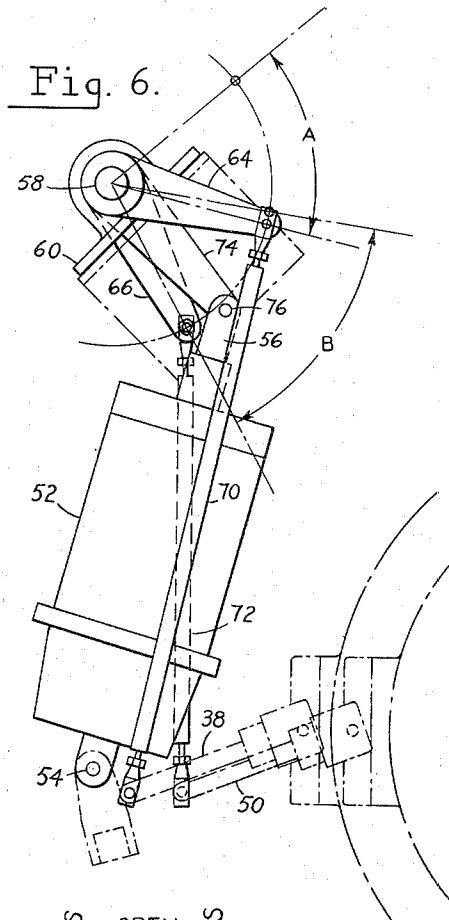
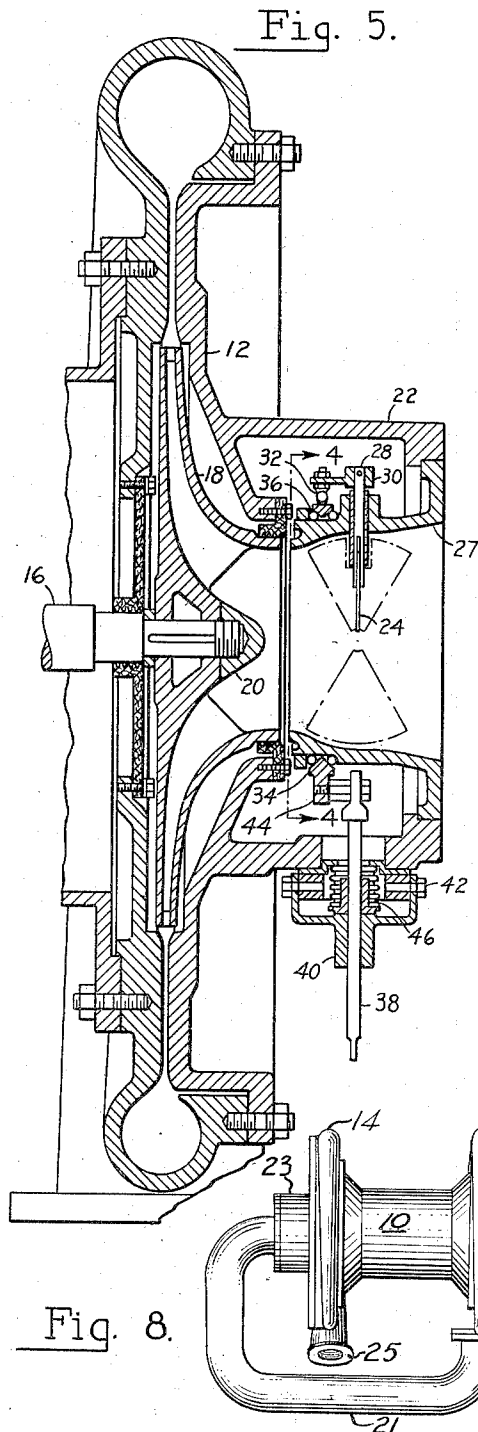
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1ST STAGE VANE POSITION-DEGREES	2ND STAGE VANE POSITION-DEGREES
90	90
80	76
70	61
60	48
50	36
40	25
30	16
20	8.5
10	3.5
CLOSED	

Fig. 7.

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1

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CENTRIFUGAL COMPRESSOR AND METHOD OF CONTROLLING THE SAME

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Application January 22, 1954, Serial No. 405,525

2 Claims. (Cl. 230—114)

This invention relates to centrifugal compressors and particularly to compressors which have means for controlling the capacity over a wide range. Prior to this invention inlet guide vanes have been used to control the capacity of centrifugal compressors. However, it has been impossible to reduce the capacity of a multi-stage compressor beyond a certain minimum at which surge occurs.

It is an object of this invention to provide a control for the adjustable inlet vane of a multi-stage centrifugal compressor which will reduce the point at which surge occurs and thus increase the operating range of the compressor.

It is a further object of this invention to provide control mechanism having a single motor to adjust the guide vanes of each stage to different angular positions with respect to the flow.

Other objects and advantages of this invention will appear as the specification proceeds to describe the invention with reference to the accompanying drawings, in which:

Figure 1 is a plan view of the compressor including the control mechanism.

Figure 2 is the end view taken from the right hand side of Figure 1.

Figure 3 is an end view taken from the left hand side of Figure 1.

Figure 4 is a sectional view taken on line 4—4 of Figure 5.

Figure 5 is a sectional view taken on line 5—5 of Figure 2.

Figure 6 is a view of the control mechanism showing the relative positions of the controls for each stage.

Figure 7 is a chart showing the relative angular positions of the guide vanes for each of the two stages.

Figure 8 is a view of the compressor including the pipe between stages.

The compressor illustrated has an electric motor 10. Other suitable prime movers might be used instead of the electric motor 10. At one end of the electric motor 10 is the first stage 12 of the compressor. To the other end of the electric motor 10 is secured the second stage 14 of the compressor. The motor 10 has a shaft 16 which has a shaft extension at each end to which are secured the impellers for the stages 12 and 14. Figure 5 shows impeller 18 mounted in the housing of the first stage 12 and secured to the end of shaft 16 by a nut 20. Another impeller not shown is mounted on the other end of the shaft 16 in the housing of the second stage 14.

An inlet housing 22 conducts gas to the first stage 12 of the compressor, and a similar inlet housing 23 conducts gas to the second stage 14 of the compressor. A cross-over pipe 21 conducts gas from the discharge opening 26 of the first stage to the inlet 23 of the second stage. The compressed gas is discharged from the compressor through opening 25 to which a discharge pipe, not shown, is secured.

2

An adjustable inlet vane mechanism is mounted in inlet housing 22. A similar adjustable inlet vane mechanism is mounted in housing 23 of the second stage. It will suffice, therefore, to describe in detail only the inlet vane mechanism of the first stage since that of the second stage is similar. A plurality of inlet vanes 24 are secured to shafts 28 which are rotatably mounted in a vane housing 27. An arm 30 is fixedly secured to each shaft 28, and links 32 are pivotally connected to arms 30 and to a control ring 34 which is rotatably mounted on vane housing 27 by means of ball bearings 36.

A lever 38 is fixedly mounted in a bracket 40 which is pivoted to housing 22 at 42. The inner end of lever 38 is pivotally secured to a lug 44 on the ring 34. A flexible metal bellows 46 surrounds lever 38 and is sealed at one end to housing 22 and at the other end to bracket 40. The bellows 46 seals the opening in inlet housing 22 through which lever 38 extends but it permits movement of the lever 38 all as shown in Figure 3. Guide vanes 48 are pivotally mounted in the inlet 23 of the second stage in a manner similar to the mounting for the vanes 24 in the inlet 22 of the first stage. A lever 50 extends from housing 23 and is connected to vanes 48 by a mechanism similar to that described with reference to the vane control for the first stage.

A fluid motor 52 is pivotally secured at 54 to motor 10. Fluid motor 52 is of a well known type having a fluid pressure actuated piston or diaphragm to which is secured the rod 56. Fluid motor 52 is connected to a source of pressure not shown and the pressure is modulated according to the capacity desired from the compressor. A control shaft 58 is rotatably mounted in bearings 60 and 62 which are secured to stages 12 and 14 respectively. An arm 74 is fixedly secured to shaft 58 and the outer end of arm 74 is pivotally secured to rod 56. It is thus evident that motor 52 acting through rod 56 and arm 74 controls the rotative position of shaft 58. A crank 64 is secured to shaft 58 at one end and a crank 66 is secured to shaft 58 at its other end. A connecting rod 70 is pivotally secured at one end to crank 64 and at the other end to lever 38. A connecting rod 72 is pivotally secured at one end to crank 66 and at its other end to lever 50.

I have found that as the capacity of the compressor is reduced considerably from full load capacity, the second stage receives a reduced volume of gas from the first stage and the compressor will tend to surge unless the spin vanes at the inlet of the second stage are inclined at a greater angle to flow than are the vanes of the first stage. The desired relative angular positions of the vanes are shown graphically in Figure 7. In order to obtain the relative angular vane positions of Figure 7, the cranks 64 and 66 are angularly spaced on the shaft 58. Figure 6 shows the control mechanism in a position in which the vanes of both stages are fully closed. In order to move the vanes from fully closed to fully open position crank 66 will move through the angle B and crank 64 will move through the angle A. It can be seen by reference to Figure 6, which shows the mechanism in a position for closed vanes, that counterclockwise movement of arm 74 will cause relatively rapid initial angular movement of the vanes 24, and the angular position of crank 66 will cause relatively slow initial angular movement of vanes 48. The correct angular position of cranks 64 and 66 can be determined by experiment.

Although the invention has been shown in connection with a two stage compressor, it is also applicable to a compressor having more than two stages. For instance, a three stage compressor would have a control for substantially reduced output in which the control would hold the spin vanes of each stage at a greater angle with

respect to flow than that of the vanes of the next preceding stage.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated, as modifications thereof may be suggested by those skilled in the art without departure from the essence of the invention, and I desire to be limited only by the claims.

I claim:

1. A centrifugal compressor comprising a first and a second stage each having an impeller, an inlet, and an outlet, means for conducting gas from the outlet of the first stage to the inlet of the second stage, spin vanes pivotally adjustably mounted in the inlet of said first stage about axes radial to the axis of rotation of the impeller of said first stage, spin vanes pivotally adjustably mounted in the inlet of said second stage about axes radial to the axis of rotation of the impeller of said second stage, a motor, a first crank driven by said motor, a first connecting rod driven by said first crank and connected to the spin vanes of the first stage for angularly adjusting the same, a second crank driven by said motor, a second connecting rod driven by said second crank and connected to the spin vanes of the second stage for angularly adjusting the same, said second crank and said second connecting rod making a greater angle than said first crank and said first connecting rod when the spin vanes of both stages are in closed position whereby when the spin vanes angularly are adjusted between open and closed position, the spin vanes of the first stage are inclined at a lesser angle with respect to flow than the spin vanes of the second stage.

2. A centrifugal compressor comprising a first and a second stage each having an impeller, a circular inlet and outlet, means for conducting gas from the outlet of the first stage to the inlet of the second stage, sector shaped vanes pivotally mounted in the inlet of said first stage in cooperative relationship about axes in planes radial to the axis of the inlet of said first stage, sector shaped vanes pivotally mounted in the inlet of said second stage in cooperative relationship about axes in planes radial to the axis of the inlet of said second stage, a motor, a first crank driven by said motor, a first connecting rod driven by said first crank and connected to the sector shaped vanes of the first stage for angularly adjusting the same, a second crank driven by said motor, a second connecting rod driven by said second crank and connected to the sector shaped vanes of the second stage for angularly adjusting the same, said second crank and said second connecting rod making a greater angle than said first crank and said first connecting rod when the sector shaped vanes are in closed position whereby when the sector shaped vanes are adjusted between open and closed position, the sector shaped vanes of the first stage are inclined at a lesser angle with respect to flow than the sector shaped vanes of the second stage.

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