

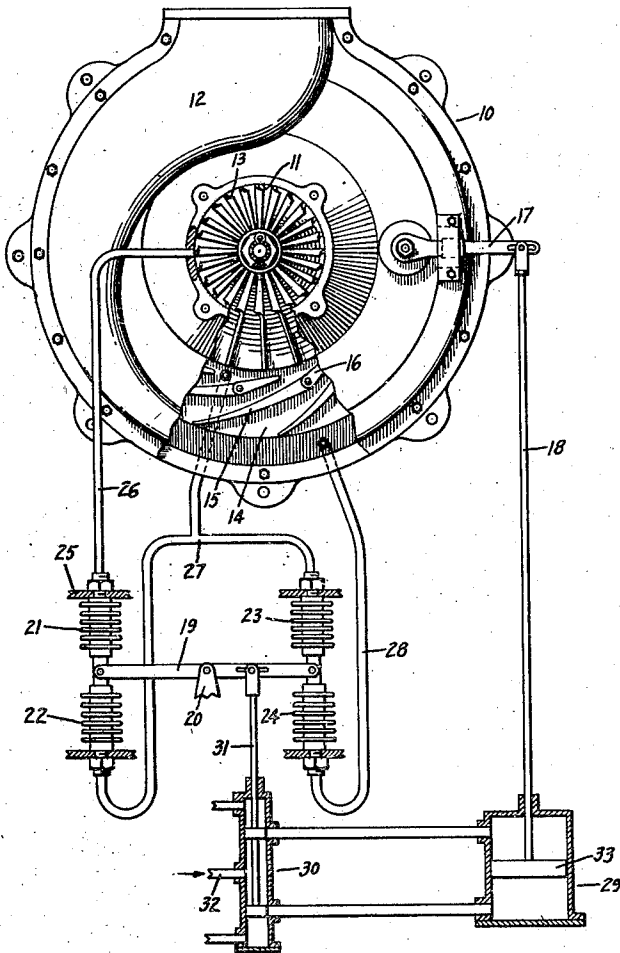
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CENTRIFUGAL TYPE COMPRESSOR

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CENTRIFUGAL TYPE COMPRESSOR

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1

The present invention relates to centrifugal compressors with variable vane diffusers used on aircraft for supercharging cabins and combustion engines. A compressor of this kind is disclosed in the copending application of M. G. Robinson, Serial No. 482,696, filed April 12, 1943, and assigned to the same assignee as the present application. More specifically, my invention relates to control mechanisms for the variable vane diffusers of such compressors and has for an object an improved arrangement to maintain best efficiency and stability during varying operating conditions.

During operation centrifugal compressors used on aircraft are subject to varying speed, especially when directly driven from an internal combustion engine for operating an aircraft propeller. In addition, such, compressors are subject to changes in inlet pressure with changes in altitude, and to changes in flow and speed due to varying demand for compressed air. I have found that the best overall efficiency and best stability of a centrifugal type compressor are attained within a wide range of its operation if the ratio of the static pressure rises across the impeller and across the diffuser is maintained substantially constant and equal to the ratio of the impeller efficiency and the diffuser efficiency. In modern compressors these efficiencies are substantially alike and therefore in general good compressor performance is maintained as long as the pressure rise across the impeller is maintained substantially equal to the pressure rise across the diffuser whereby the aforementioned constant equals 1. Accordingly a control mechanism according to my invention for varying the diffuser position of a centrifugal type compressor comprises means responsive to changes of the ratio of the pressure rise across the impeller and the pressure rise across the diffuser to maintain said ratio substantially constant over a wide range of the supercharger output.

For a better understanding of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawing.

The single figure of the drawing illustrates diagrammatically an arrangement embodying my invention.

The arrangement comprises a centrifugal compressor 10 having a casing forming an inlet 11 and a discharge scroll 12. An impeller with a plurality of vanes 13 is rotatably disposed in the casing. The vanes 13 form passages between them with inlets located in the inlet 11 of the casing and outlets for discharging compressed air into a

2

variable vane diffuser 14. The latter has a plurality of circumferentially spaced vanes of which each has a stationary portion 15 and a variable or movable portion 16 near the throat of the respective diffuser passage. Upon movement of the variable portion 16 the sectional inlet area or throat of the passages may be increased and decreased. Movement of the vane portion 16 may be effected in the manner described in the aforementioned application of M. G. Robinson by means including gears (not shown) and a lever 17 suitably supported on the casing and connected at its outer end to a stem or link 18.

The control mechanism for positioning the link 18 according to my invention comprises means responsive to the ratio of the pressure rise across the impeller and the diffuser. In the present example the control mechanism includes a lever 19 which has a central point supported on a fulcrum 20. The left-hand end of the lever is pivotally connected to two bellows 21 and 22 and the right-hand end of the lever 19 is connected to two other bellows 23 and 24. Each of the bellows 21 to 24 has an outer end fixed on a suitable support 25. The bellows 21 communicates by a pipe 26 with the inlet 11 of the compressor. The bellows 22 and 23 communicate through pipe means 27 with the inlet region of the diffuser and the bellows 24 communicates through a pipe 28 with the outlet region of the diffuser. Assuming that the pressure in the inlet of the impeller equals P_1 , that the pressure in the inlet of the diffuser equals P_2 and that the pressure in the outlet of the diffuser equals P_3 , then it is clear that the bellows or pressure responsive devices 21, 22 on the left-hand end of the lever 19 measure the pressure rise $P_2 - P_1$ across the impeller and the bellows or pressure responsive devices 23, 24 connected to the right-hand end of the lever 19 measure the pressure rise $P_3 - P_2$ across the diffuser, assuming that no pressure change takes place in the clearance space between the impeller and the diffuser. As long as the two pressure rises $P_2 - P_1$ and $P_3 - P_2$ are alike, generally as long as the ratio of these pressure rises is constant, the lever 19 remains stationary.

If, however, one of the pressure rises should change, for instance, due to a change in speed or altitude, then the lever 19 is turned and this turning movement is transmitted to the lever 17 to position the diffuser vanes by a hydraulic motor 29 controlled by a pilot valve 30. The pilot valve has two valve heads on a stem 31 pivotally connected to the lever 19 and an inlet 32 for receiving operating fluid under pressure. The hydraulic

3

motor 29 has a piston 33 connected to the lower end of the stem or link 18. Upon clockwise turning movement of the lever 19 fluid under pressure is supplied from the inlet 32 of the pilot valve to the lower face of the piston 33 whereby the latter is forced upward to vary the position of the diffuser vanes. Such positioning will continue until the original ratio of the aforementioned pressure differences has been reestablished and the lever 19 has returned to its original position in which the pilot valve heads are in line-in-line position with their respective ports.

During operation the ratio of the pressure rises across the impeller and the diffuser remains constant as long as the ratio Q/N is constant in which Q represents the volume flow through the supercharger and N the speed. Upon a change in inlet pressure P_1 , the other pressures P_2 and P_3 will change substantially proportionately to the change of the inlet pressure P_1 as long as Q/N is constant. Thus, a change in altitude of the aircraft does not affect the ratio of the pressure drops across the impeller and the diffuser as long as the ratio of the volume flow and the speed is constant. If during operation the outlet pressure of the diffuser P_3 changes upon a change of the supercharger speed, the ratio of the pressure rises across the impeller and the diffuser again remains constant and the other pressures P_1 and P_2 will change proportionately to the change of the pressure P_3 as long as the ratio of volume flow over speed remains constant. If, however, the diffuser inlet pressure P_2 changes at constant speed of the supercharger due to a change in flow, the ratio of pressure drops across the impeller and the diffuser will change. More particularly, an increase in flow through the impeller causes an increase of the diffuser inlet pressure P_2 (at constant P_1 and P_3) and such increase of the diffuser inlet pressure requires opening of the diffuser vanes to bring the diffuser inlet pressure P_2 back to its normal value. In the drawing an increase of the diffuser inlet pressure causes expansion of the bellows 22 and 23 whereby the lever 19 is turned clockwise about the fulcrum 20 and causes movement of the pilot valve to supply fluid under pressure to the space below the piston of the motor 29 and discharge of fluid from the space above the piston 33, resulting in upward movement of the piston 33 and movement of the variable portions 16 of the diffuser vanes to increase the inlet areas between the diffuser vanes and thereby to reduce the diffuser inlet pressure P_2 . The subsequent reduction of the diffuser inlet pressure causes the bellows 22, 23 to collapse, thereby effecting counterclockwise turning movement of the lever 19 about the fulcrum 20 and bringing the pilot valve back to its original line-in-line position. This follow-up or restoring action may be accomplished more directly by well known mechanical means such as are described in the copending application of E. L. Coe Serial No. 532,047 filed on the same date with the present application.

If during operation the diffuser inlet pressure P_2 decreases in response to a decrease in flow, similar movement of the mechanism takes place except that the various elements move in a direction opposite to that described above to decrease the diffuser inlet area and thereby to effect an increase of the diffuser inlet pressure P_2 .

Thus, with my invention I have accomplished a simple and effective arrangement for control-

4

ling variable diffusers of aircraft superchargers to obtain maximum efficiency and good stability over a wide range of the compressor output. For any given speed within the useful working range of the compressor the best efficiency occurs very nearly at the same value of the ratio of pressure changes or pressure differentials across the impeller and the diffuser. Also, the pulsation or surging flow of the compressor occurs always at a lower airflow than that which gives maximum efficiency. These two characteristics make the differential pressure ratio control particularly useful. With my differential pressure ratio control arrangement the diffuser inlet area is progressively reduced as the ratio of inlet volume flow to impeller speed is reduced.

At constant compressor speed, a decrease in the volume flow tends to increase the pressure rise across the diffuser as compared to the pressure rise across the impeller. In this case the control moves the variable portions of the diffusers to close the diffuser entrance area. At constant inlet volume flow, an increase in the compressor speed due to a demand for higher compressor discharge pressure causes an increase in the pressure rise across the diffuser. In this case the control will respond to effect a decrease of the diffuser inlet area.

Having described the method of operation of my invention, together with the apparatus which I now believe to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Centrifugal type compressor having an impeller and a variable vane diffuser for receiving medium discharged from the impeller, motor means for varying the position of the diffuser, and a mechanism for controlling the last named means including a first device responsive to static pressure rise across the impeller and a second device responsive to static pressure rise across the diffuser.

2. Centrifugal type compressor having an impeller and a diffuser for receiving compressed medium discharged from the impeller, said diffuser having a plurality of circumferentially spaced vanes with movable portions to vary the passages formed between the vanes, and a mechanism for positioning said portions in response to changes of the ratio of the static pressure rises across the impeller and the diffuser, said mechanism comprising a fulcrumed lever, a device responsive to the pressure rise across the impeller connected to a point of the lever, another device responsive to the pressure rise across the diffuser connected to another point of the lever, and motor means for adjusting the movable vane portions in response to movement of the lever.

3. In a centrifugal compressor the combination of an impeller, a variable diffuser, a motor arranged to adjust the variable diffuser, and a control mechanism for the motor including a first device responsive to the static pressure rise across the impeller and a second device responsive to the static pressure rise across the diffuser arranged to maintain substantially constant the ratio of pressure rise across the impeller to pressure rise across the diffuser.

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