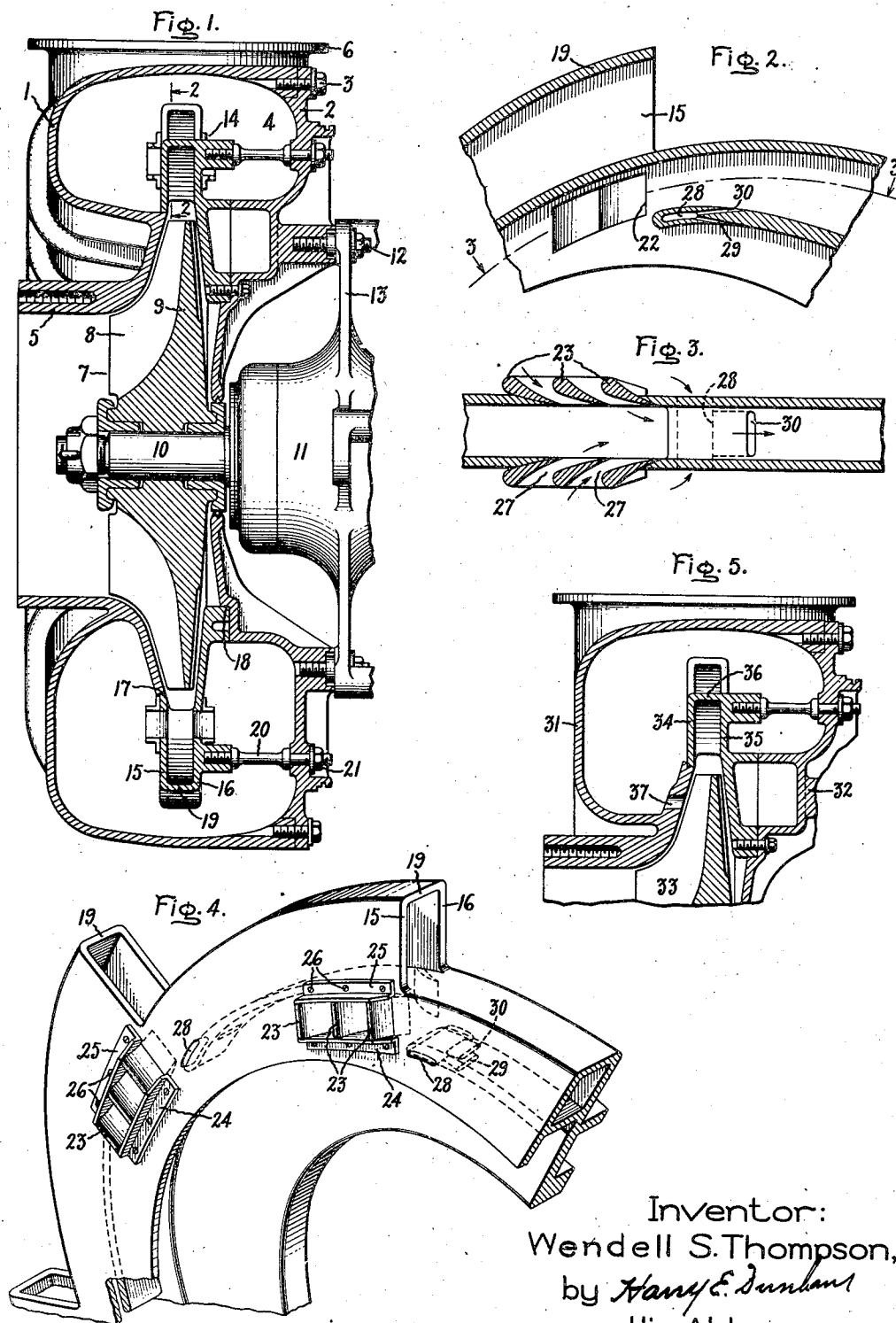


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W. S. THOMPSON
CENTRIFUGAL COMPRESSOR

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Inventor:
Wendell S. Thompson,
by *Harry E. Dunham*
His Attorney.

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CENTRIFUGAL COMPRESSOR

Wendell S. Thompson, Lynn, Mass., assignor to
General Electric Company, a corporation of
New York

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The present invention relates to centrifugal compressors having impellers for impelling medium to be compressed and diffusers for converting velocity energy of the medium discharged from the impeller into pressure energy and a discharge chamber or scroll for receiving medium from the diffuser and discharging it to a consumer. Difficulties are experienced with this type of compressor due to pulsations and consequent instability at low flow or load. The basic cause of such pulsations is believed to be the complete breakdown and reversal of the boundary layer in the diffuser passages occurring when the volume of flow through such passages becomes too small. This instability at low flow may be reduced and the operating range of the compressor accordingly enlarged by the provision of adjustable diffusers. Another way of reducing instability is by the recirculation of compressed medium from the discharge chamber or scroll through the impeller and diffuser passages.

The object of my invention is to provide an improved construction and arrangement of compressors including means for recirculating compressed medium from the scroll which is simple in construction and efficient in operation. This is accomplished in accordance with my invention by the provision of recirculating nozzles arranged to receive compressed medium from the scroll and to discharge such medium into an intermediate region of the impeller and diffuser passages at a velocity substantially equal to the velocity existing in such region. With such arrangement little mixing of fluid takes place in said passages and accordingly the recirculation is effected with little loss of efficiency. With the recirculation of compressed medium the diffuser passages remain substantially filled at different load conditions, particularly while the net compressor flow is reduced.

At low flow a large percentage of the static pressure rise in the compressor occurs beyond the impeller discharge. This large rise makes available a large pressure ratio for effecting recirculation between the compressor discharge and the point of re-entry into the impeller diffuser passages, that is into the flow passages of the compressor at a point ahead of the diffuser inlet. With such a large pressure ratio a large proportion of the flow may be recirculated. At high load condition, this is, as the maximum diffuser flow is approached the static pressure rise through the diffuser becomes less and may even become negative at very high flow. Therefore, as full flow is approached, less and less flow is recirculated. In other words, the amount of flow recirculated is automatically regulated with changes in net flow through the compressor. An arrangement of this kind moves the pulsa-

tion point to lower flow values without decreasing the maximum flow and without appreciably affecting the efficiency of the compressor during low flow conditions. The efficiency during low flow conditions may be maintained at a high value by the provision of variable recirculation nozzles and means for increasing the nozzle areas of the recirculation nozzles with decreasing net flow.

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.

In the drawing Fig. 1 illustrates a sectional view of a centrifugal compressor such as are used as superchargers on aircraft; Fig. 2 is an enlarged sectional view along lines 2—2 of Fig. 1; Fig. 3 is a sectional view along lines 3—3 of Fig. 2; Fig. 4 is a perspective view, partly broken away, of the diffuser of Fig. 1; and Fig. 5 illustrates a sectional view of a modification of my invention.

The centrifugal compressor in Figs. 1 to 4 inclusive comprises a casing having two halves 1 and 2 secured together by a row of bolts 3 and having inner portions defining an impeller chamber and outer portions defining a discharge chamber or scroll 4. The casing half 1 has a central portion forming an inlet conduit 5 for conducting medium, such as air, to be compressed to the impeller chamber. The casing half 1 also forms a flanged discharge conduit 6 for discharging compressed medium to a consumer, not shown. An impeller 7 is located in the impeller chamber and has a plurality of circumferentially spaced blades 8 secured to a disk 9 and forming impeller passages between them. The impeller is secured to an overhung portion of a shaft 10 supported on a bearing 11 and may be driven in known manner by an exhaust gas-operated turbine (not shown) with a bucket wheel secured to another overhung portion of the shaft 10. The compressor casing is supported by a plurality of bolts 12 on the arms 13 of a spider integral with the casing of the bearing 11. Medium impelled by the impeller is passed through a diffuser 14 into the discharge chamber or scroll 4. The diffuser in the present example has two spaced walls 15 and 16 supported on shoulders 17 and 18 respectively of the casing halves 1 and 2. A plurality of circumferentially spaced curved diffuser vanes 19 are located between and integrally formed with the walls 15, 16. The diffuser is rigidly secured to the casing half 2 by a plurality of circumferentially spaced studs 20 and nuts 21.

The arrangement so far described is typical of centrifugal type compressors. According to my invention, means are provided for recirculating at

low load part of the compressed medium from the scroll 4 through a portion of the impeller diffuser passages. In the embodiment of Figs. 1 to 4 inclusive recirculation is effected at low load through the major portion of the diffuser passages. To this end the walls 15, 16 have openings 22 near the inlets to the diffuser passages, Figs. 2, 4. Recirculating nozzles are associated with these openings. In the present example each recirculating nozzle means is formed by three circumferentially spaced curved vanes or blades 23 secured at their ends to angle irons 24, 25, which latter are attached to the side walls of the diffuser by bolts 26. The blades 23 have thick inlet portions and sharp edged outlet portions. The outlet edges of the blades are located in the plane of the inner surfaces 15, 16. The outer of the three blades 23 have portions engaging suitably shaped edges of the respective walls 15, 16. The three blades 23 form two nozzle passages 27 for conducting compressed medium from the scroll to the diffuser passages.

While in the present instance such recirculating nozzles are provided with regard to both side walls 15, 16 of the diffuser, in other cases only one of said side walls may be provided with recirculating nozzles. With these recirculating nozzles the diffuser passages may be filled with fluid during low load operation, thereby reducing the tendency to pulsation of the compressor. The nozzles have an additional advantage in that they reduce or accelerate the boundary layer of slowly flowing fluid along the side walls of the diffuser, thereby increasing the efficiency thereof.

In the present example I have shown other recirculating nozzles or nozzle passages associated with the diffuser vanes 19. Each diffuser vane near its inlet portion is provided with an axial opening 28 extending through the side walls 15, 16 of the diffuser and thereby communicating with the scroll. Two nozzle passages 29, 30, Fig. 2, are formed through opposite sides of the diffuser vane to establish communication between the opening 28 and the diffuser passages. During operation, compressed medium flows from the discharge chamber 4 through the openings 28 and the nozzle passages 29, 30 to be discharged therefrom along the opposite surfaces of the respective diffuser vanes into the diffuser passages. This medium at low net flow fills the passages and also accelerates the boundary layers along the diffuser vanes.

The compressor in Fig. 5 comprises a casing having casing halves 31 and 32, corresponding to casing halves 1 and 2 of Fig. 1 and enclosing an impeller 33 and a diffuser having side walls 34 and 35 and a plurality of circumferentially spaced vanes 36, corresponding to the vanes 19 of Fig. 1. The diffuser is in all respects similar to that of Fig. 1 except that it is not provided with recirculation nozzles. The recirculation of compressed medium from the scroll through a part of the impeller diffuser passages in the present example is accomplished by the provision of openings or nozzles 37 in the casing half 31, which nozzles are located at a point radially inward from the outlet of the impeller. With such arrangement the fluid is recirculated through the outer parts of the impeller passages and through the entire diffuser passages. The nozzles 37 when properly located and designed will discharge compressed medium to an intermediate region of the

impeller passages at a velocity which is substantially the same as the absolute velocity of the air in the particular region of the impeller. The mixing losses produced by mixing of medium flowing through the inlet of the impeller and through the nozzles 37 thereby are kept at a minimum. By moving the point of entry back toward the impeller inlet the pressure drop across the recirculation nozzle becomes greater and accordingly the discharge velocity from the nozzle likewise becomes greater. As the point of re-entry is moved from the impeller exit toward the impeller entrance the absolute velocity of the medium becomes smaller. Hence, by placing the re-entry or recirculating nozzles over the open side of the impeller the velocity of the air discharged from such nozzles can be readily made the same as the velocity within the impeller passages near the nozzles.

Therefore, by discharging the medium from the recirculation nozzles in substantially the same direction as the absolute velocity of the medium in the impeller passages at the point of re-entry, the recirculation may be accomplished without incurring appreciable losses thereby.

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

1. A diffuser for centrifugal type compressors including a side wall having circumferentially spaced openings, a plurality of circumferentially spaced curved vanes secured to the side wall, and a plurality of recirculation nozzles each including circumferentially spaced substantially radial blades disposed in said openings and secured to the side wall.

2. A centrifugal compressor comprising a casing forming an impeller chamber and a discharge scroll, an impeller located in the impeller chamber, a diffuser substantially located in the discharge scroll and having axially spaced side walls and circumferentially spaced vanes secured to the side walls and forming diffuser passages therewith, and means for circulating compressed fluid from the discharge scroll to the inlet portion of the diffuser passages, said means comprising recirculating nozzles in the side walls adjacent the inlets of the diffuser passages and transverse passages extending through the radially inner ends of the vanes and at least one side wall and communicating with the discharge scroll, and nozzles formed in the vanes for receiving compressed fluid from said transverse passages and discharging it into the diffuser passages in substantially the direction of the fluid flow in the diffuser passages.

3. A diffuser arranged to be supported at least partly within the discharge scroll of a centrifugal compressor and having side walls lying substantially in axially spaced parallel planes and a plurality of circumferentially spaced vanes secured to said walls to define therewith radially and tangentially extending diffuser passages, said walls and vanes having a plurality of passages and nozzles arranged to receive fluid from the discharge scroll and to discharge said fluid into each diffuser passage adjacent the inlet thereto and around substantially the entire periphery of said inlet and in substantially the same direction as the fluid flowing through the diffuser passage.

WENDELL S. THOMPSON.