R. H. RICE.

CENTRIFUGAL COMPRESSOR.

APPLICATION FILED NOV. 26, 1918.

1,350,941.

Patented Aug. 24, 1920.

Fig. 1.

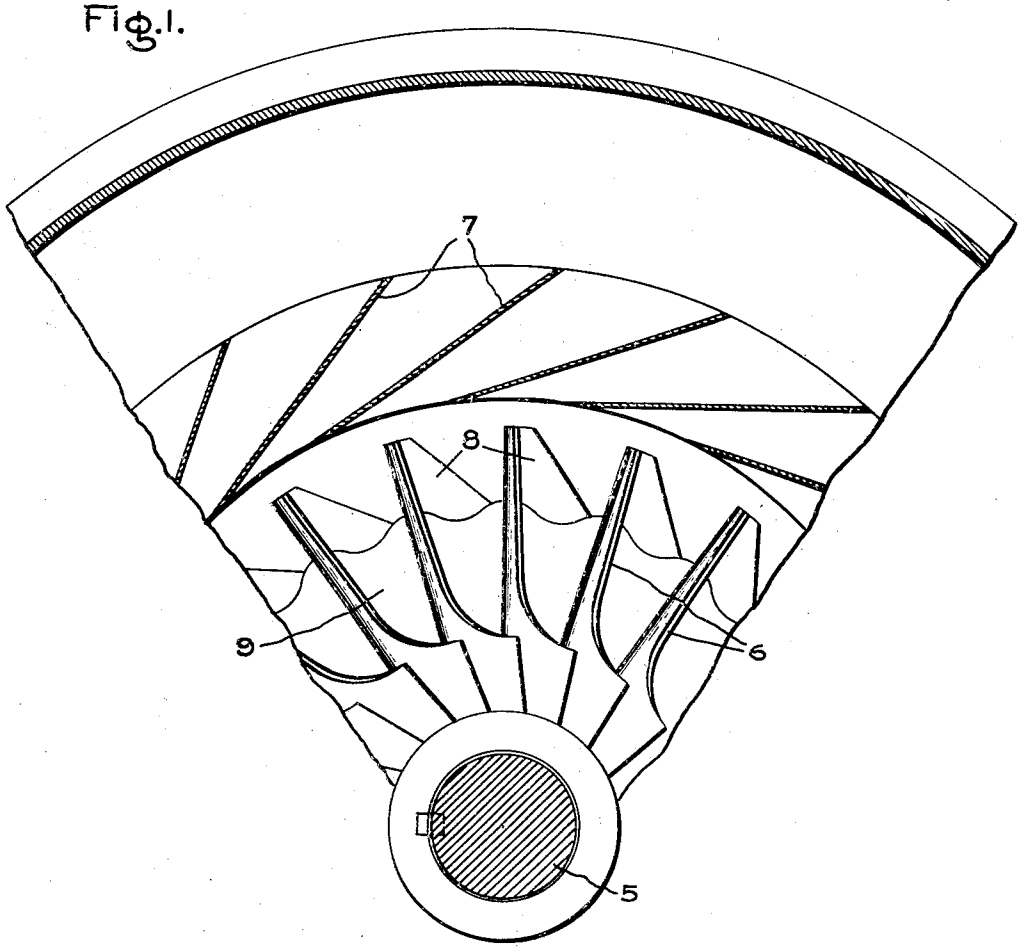
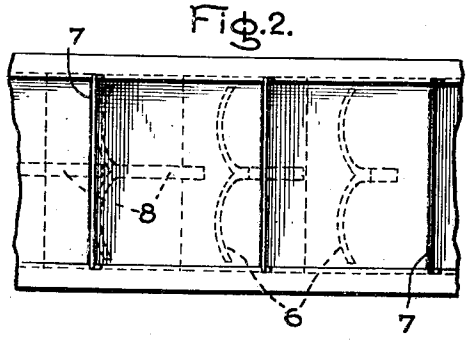


Fig. 2.



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UNITED STATES PATENT OFFICE.

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CENTRIFUGAL COMPRESSOR.

1,350,941. Specification of Letters Patent. Patented Aug. 24, 1920.

Application filed November 26, 1918. Serial No. 264,161.

To all whom it may concern:

Be it known that I, RICHARD H. RICE, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Centrifugal Compressors, of which the following is a specification.

The present invention relates to centrifugal compressors comprising an impeller having blades which receive the air or other gas being handled at their radially inner ends, impart velocity to it, and then discharge it at their peripheries to stationary discharge vanes wherein a portion of the velocity is converted into pressure.

With such a machine if we conceive a meridian plane to be passed through the center line of the impeller shaft and another plane to be passed through the middle of the impeller perpendicular to the shaft, the energy imparted to a particle of air by the rotation of the impeller may be considered to be a function of (1) the radial distance from the shaft, (2) the angular distance from the meridian plane, and (3) the axial distance from the central perpendicular plane. Usually, however, impellers are built so that energy variations in an angular and in an axial direction are negligible relatively to the energy variations in a radial direction; in other words, cylindrical surfaces coaxial with the shaft may be regarded nearly enough as equipotential surfaces.

Neglecting the effect of gravity, the energy of a particle of air within an impeller may be expressed by the formula

$$E=\frac{p}{d}+\frac{v^2}{2_g}$$

where

E=energy in ft. lbs. per lb.
p=pressure in lbs. per sq. ft.,
d=density in lbs. per cu. ft.,
v=velocity in ft. per second,
g=acceleration of gravity in ft. per second per second.

But while the total energy in a particle of air may be considered as independent of its angular distance from the imaginary fixed meridian plane, it will be apparent that unless the number of impeller blades is very large (theoretically infinite), there will be an appreciable difference of pressure between two successive blades along any given circumference concentric with the shaft. That is, the pressure will be a maximum at the driving face of a blade and a minimum at the back of it. Now, considering a case where the exit edges of the impeller blades and the inlet edges of the stationary vanes are both straight and parallel to the shaft, it will be seen that at the instant an impeller blade passes a discharge vane the pressure between the blade and the vane changes suddenly from a maximum to a minimum which gives rise to a considerable shock on the impeller blade, which, if the blade is not firmly anchored or stiffened, may cause it to vibrate. Also since the energy along any concentric circumference is substantially constant the maximum pressure at the driving face must be accompanied by a minimum velocity of the air, and the minimum pressure at the back of the blade by a maximum velocity of the air; and the sudden change of this velocity as an impeller blade passes a discharge vane gives rise to an objectionable noise.

The object of the present invention is to provide an improved arrangement which will reduce the shock on the impeller vanes to a minimum and also greatly reduce the noise caused by the ends of the blades passing the stationary vanes.

According to my invention I make the exit edges of the impeller blades and the inlet edges of the discharge vanes bear such relation to each other that instead of such edges passing each other instantly as in the example referred to above, they pass each other gradually so that the time of the complete crossing of a blade and a vane is materially increased, with the result that the pressures on the vanes are varied gradually. By this means it will be seen no sudden shock will be imparted to the blades due to their passing quickly from a region of one pressure to a region of a different pressure.

In the drawing, Figure 1 is a side elevation of a portion of a centrifugal compressor embodying my invention, and Fig. 2 is a developed top plan view looking down on Fig. 1.

Referring to the drawing, 5 indicates a shaft carrying an impeller provided with blades 6, and 7 indicates stationary discharge vanes which surround the impeller. Blades 6 are curved as shown in Fig. 2, and have at

their longitudinal centers radially extending strengthening ribs 8. 9 indicates the web of the impeller which is cast around the inner ends of the blades. Preferably end blades 6 are formed in what may be considered as two curved halves fastened together at their adjacent edges, as this gives a blade of great strength and stiffness, and this is the arrangement illustrated in the drawing. Since the inlet edges of the discharge vanes are straight and parallel to the center line of the shaft and the discharge edges of the impeller blades are curved, the discharge edge of an impeller blade does not pass the inlet edge of a discharge vane throughout its axial width at the same instant, but passes it gradually. As a result, both the shock on the blade and the noise are materially reduced. At the same time the blades being curved are stiffened against vibration.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

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

1. In a centrifugal compressor, an impeller having a set of blades, and a set of discharge vanes which surround the impeller, said discharge vanes having substantially the same axial width as the blades and extending radially and circumferentially whereby the fluid discharged to them from the blades is guided in a combined radial and tangential path, said discharge vanes serving to convert velocity into pressure, the inlet edges of the discharge vanes and the discharge edges of the impeller blades being so arranged relatively to each other that such edges pass each other gradually.

2. In a centrifugal compressor, an impeller having a set of blades, and a set of discharge vanes which surround the impeller, said discharge vanes having substantially the same axial width as the blades and extending radially and circumferentially whereby the fluid discharged to them from the blades is guided in a combined radial and tangential path, said discharge vanes serving to convert velocity into pressure, the adjacent edges of one of said sets being so arranged that successive points thereof taken in an axial direction do not lie in the same axial plane whereby such adjacent edges pass each other gradually.

3. In a centrifugal compressor, an impeller having a set of blades, and a set of discharge vanes which surround the impeller, said discharge vanes having substantially the same axial width as the blades and extending radially and circumferentially whereby the fluid discharged to them from the blades is guided in a combined radial and tangential path, said discharge vanes serving to convert velocity into pressure, the inlet edges of the discharge vanes being substantially parallel to the axis of the shaft, and the exit edges of the impeller blades being curved.

4. In a centrifugal compressor, an impeller having a set of blades and a set of discharge vanes which surround the impeller, said discharge vanes having substantially the same axial width as the blades and extending radially and circumferentially whereby the fluid discharged to them from the blades is guided in a combined radial and tangential path, said discharge vanes serving to convert velocity into pressure, the inlet edges of the discharge vanes being substantially parallel to the axis of the shaft, and the impeller blades being curved to stiffen them and to cause the exit edges of the blades to pass gradually the inlet edges of the discharge vanes.

5. In a centrifugal compressor, an impeller having a set of blades, and a set of discharge vanes which surround the impeller, said discharge vanes having substantially the same axial width as the blades and extending radially and circumferentially whereby the fluid discharged to them from the blades is guided in a combined radial and tangential path, said discharge vanes serving to convert velocity into pressure, the inlet edges of the discharge vanes being substantially parallel to the axis of the shaft, the impeller blades being formed with two radially extending curved parts to stiffen them and to cause the exit edges of the blades to pass gradually the inlet edges of the discharge vanes.

In witness whereof I have hereunto set my hand this 23d day of November, 1918.

RICHARD H. RICE.