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H. W. BURDETT ET AL
COMPRESSOR

2,548,465

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2 Sheets-Sheet 1

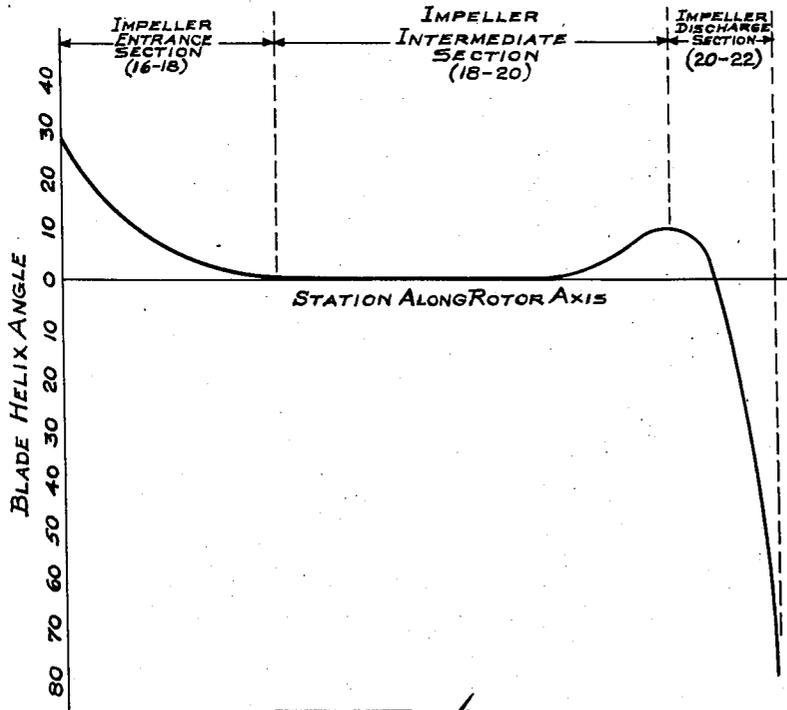
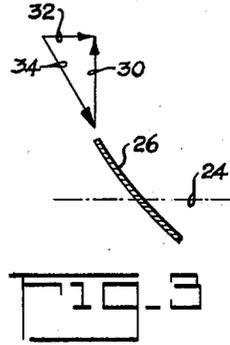
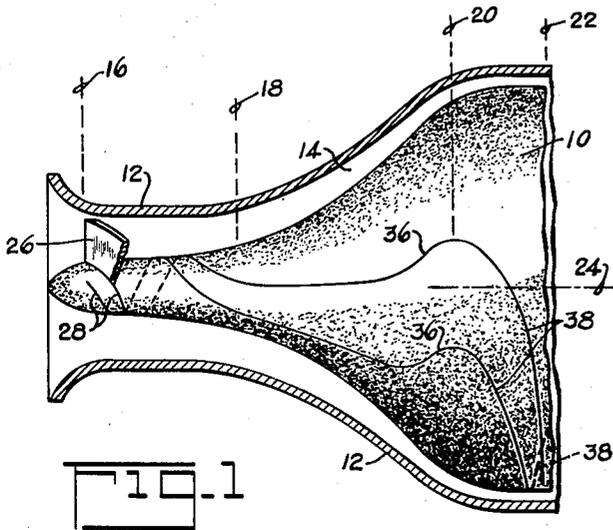


FIG. 4

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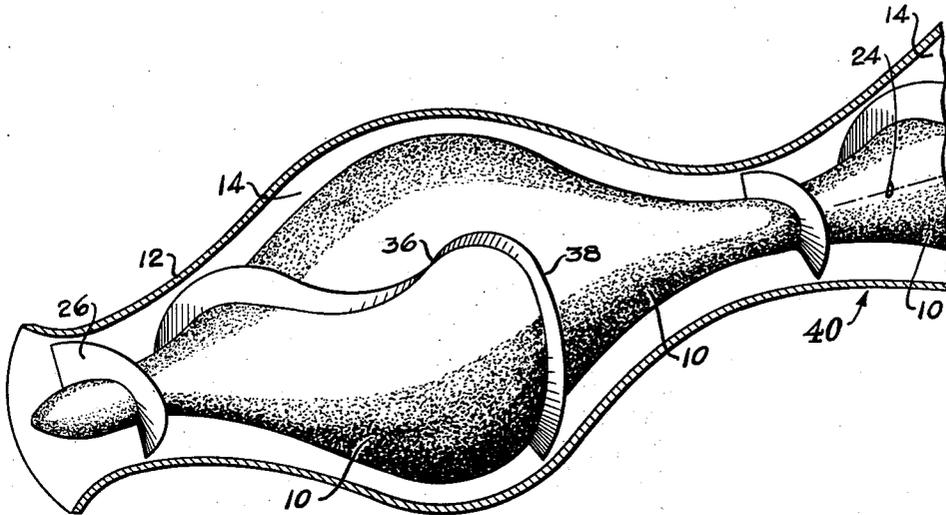


FIG. 2

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UNITED STATES PATENT OFFICE

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COMPRESSOR

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4 Claims. (Cl. 230-119)

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This invention relates to fluid compressors and is more particularly directed to fluid compressors of the centrifugal type.

The conventional centrifugal compressor comprises radially extending fluid impeller blades each disposed in a plane including the axis of the compressor. The outlet of a conventional centrifugal compressor is provided with relatively fixed diffuser vanes for converting the rotational velocity of the compressed fluid into pressure head. An object of this invention consists in curving the discharge end of the centrifugal impeller blades so that the rotating blades themselves are effective to eliminate the rotational velocity of the compressed fluid. For this purpose, the rotatable impeller blades are provided with a curved rearward portion at their discharge ends to retard the rotational velocity of the compressed fluid. In addition, the radially inner and outer walls of the compressor are substantially axial at the discharge end of the impeller blades thereby converting the radial flow of the compressed fluid into axial flow.

Other objects of this invention will become apparent upon reading the annexed detailed description in connection with the drawing in which:

Figure 1 is a sectional view through a single stage compressor embodying the invention;

Figure 2 is a perspective view partly in section of a multi-stage compressor;

Figure 3 is a diagrammatic view illustrating the relation between the axial velocity of the entering air, the rotational velocity of the impeller and the entrance end of the impeller blades; and

Figure 4 is a graph illustrating the helix angle of the impeller blades at each station along the impeller.

Referring to the drawing, a rotor member 10 is surrounded by a shroud 12 radially spaced therefrom to provide an annular space or path 14 therebetween for the fluid to be compressed. The annular space or fluid path 14 has an entrance section extending approximately between the dashed lines 16 and 18 (Figure 1), an intermediate section extending approximately between the dashed lines 18 and 20 and a discharge section extending approximately between the dashed lines 20 and 22. As illustrated, the entrance section 16, 18 and the discharge section 20, 22 of the annular fluid path 14 are both coaxial with the impeller axis 24 and extend substantially axially therealong, with the discharge section having a substantially larger diameter. The intermediate section 18, 20 of the annular

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fluid path 14 smoothly joins said entrance and discharge sections. A plurality of circumferentially spaced ribbon-like vanes 26 extend across said annular space 14 from the entrance section to the discharge section, each of said vanes being secured to the rotor 10 for rotation therewith. For simplicity only one vane 26 has been illustrated in the perspective view of Figure 2 while in Figure 1 a portion of only one vane 26 has been illustrated and the intersection of the root end of only a pair of vanes 26 with the rotor 10 has been indicated by the lines 28.

The rotor member 10 is rotatable counterclockwise when viewed from the left of Figures 1 and 2 and air or other gas to be compressed enters the relatively small diameter entrance section of the annular fluid path 14. In this entrance section, the entrance edges of the vanes 26 are directed so that the fluid enters the compressor substantially without shock and the vanes are curved to gradually impart rotational velocity to the entering fluid.

The design of the entrance end of the vanes 26 is diagrammatically illustrated in Figure 3. In Figure 3, the line 24 indicates the axis of rotation of the compressor, vector 30 indicates the rotational velocity of a vane 26, vector 32 indicates the axial velocity of the entering air and vector 34 indicates the velocity of the entering air relative to said vane 26. As illustrated, the entrance edge of a vane 26 is made substantially tangent to the vector 34 and each vane 26 gradually curves as indicated. Obviously, at a particular rotative speed of the impeller, the tangential velocity of each vane 26 will vary with the radial distance from the compressor axis so that the direction of the entrance edge of each vane varies radially along its entrance edge.

The vanes 26 gradually straighten and flatten out so that, upon entering the intermediate section of the annular fluid path 14, the vanes 26 are substantially co-planar with the compressor axis 24. Accordingly, the fluid to be compressed enters the vanes 26 substantially without shock and the curvature of the vanes is such as to gradually impart rotational velocity to the fluid.

The intermediate section 18, 20 of the annular fluid path 14 flares outwardly in a downstream direction so that the fluid is compressed outwardly by the centrifugal forces acting thereon. The vanes 26 are substantially co-planar with the compressor axis throughout the intermediate section 18, 20 except, at the downstream end of this section, the vanes 26 curve forwardly in the direction of impeller rotation as indicated at 36.

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This forward curvature of the impeller vanes 26 increases the rotational velocity of the compressor fluid thereby increasing the centrifugal compression without a corresponding increase in speed of the compressor. That is, in the region of the forwardly curved vane portions 36, in one revolution of the impeller a particle of the compressed fluid rotates more than one revolution as it moves radially outwardly and axially along the impeller.

Upon leaving the intermediate section 18, 20 the compressed fluid enters the axially extending discharge section 20, 22 of the annular fluid path 14. In this discharge section, the vanes 26 are curved rearwardly—that is, opposite to the direction of the compressor rotation—as indicated at 38. As a result of this rearward curvature of the impeller vanes 26, the rotational velocity of the compressed fluid is gradually decreased as it flows to the discharge end of the compressor so that, at the discharge end, the compressed fluid preferably only has an axial velocity. The slowing down of the rotational velocity of the compressed fluid by the impeller vane portions 38 results in the compressed fluid doing work on the impeller vanes thereby helping to rotate the compressor rotor member 10. Thus, the rearwardly curved vane portions 38 not only help to straighten out the flow of the compressed fluid but, in so doing, energy is extracted from the fluid to help rotate the compressor. In the discharge section of the fluid path 14, the shroud 12 converts the radially outward velocity of the compressed fluid to axial flow.

The aforescribed curvature of each vane 26 is graphically illustrated in Figure 4 in which the "helix angle" is the angle between a plane including the impeller axis and passing through a point on the line of intersection of a vane with the impeller and a tangent to said line of intersection at said point. The specific magnitude of said angle at each station along the impeller will depend on such factors as the rotational velocity of the impeller rotor, the physical characteristics of the particular fluid to be compressed, the magnitude of the compression ratio desired, etc. Thus, the forwardly curved vane portions 36 may start anywhere along the intermediate section 18, 20—e. g. this forward curvature may start at the beginning of the intermediate section 18, 20 in order to provide a more gradual forward curvature.

The compressor may be provided with a second stage 40 as illustrated in the perspective view of Figure 2. Since the compressed fluid, leaving the first stage, has no rotative or radially outward velocity, it is free to return to the smaller diameter of the entrance to the second compressor stage.

As illustrated, the shroud 12 is not attached to the vanes 26 for rotation therewith, but as is conventional practice it may be. Thus, centrifugal compressors are generally provided either with a fixed shroud over corresponding edges of the impeller blades or a shroud is secured to the impeller blades along these edges. The appendant claims are intended to be broad enough to cover these conventional alternative constructions.

With the aforescribed construction, the forwardly curved impeller vane portions 36 provide a relatively high centrifugal pressure with a relatively low speed of the compressor rotor 10. Also, deceleration of the rotational velocity of the compressor fluid by the impeller vane por-

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tions 38 results in a low relative velocity of the compressor fluid and the flow straightening vane portions 38 as compared to the usual fixed type of flow straightening vanes. Also, the rotating flow straightening vane portions 38 provide for smooth uninterrupted continuity of the compressor fluid flow path therethrough as contrasted with the interrupted flow path provided by fixed type flow straightening vanes.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications.

We claim as our invention:

1. A centrifugal compressor comprising a rotatable member; a shroud radially spaced from said rotatable member to provide an annular fluid flow space therebetween, said annular space having a portion flaring radially outwardly in a downstream direction relative to fluid flow therethrough and merging at its downstream end with a substantially axially extending portion of said annular space; and a plurality of ribbon-like vanes secured to said rotatable member and projecting across said space toward said shroud to divide said space into a plurality of fluid flow paths; each of said ribbon-like vanes being substantially co-planar with the axis of said rotatable member along the upstream end of the outwardly flaring portion of said annular space, and, along the downstream end of said outwardly flaring portion, said vanes being curved about said axis in the direction of rotation of said rotatable member, and, along the axially extending portion of said annular space, said vanes being curved about said axis in the opposite direction.

2. A centrifugal compressor comprising a rotatable member; a shroud radially spaced from said rotatable member to provide an annular fluid flow space therebetween; said annular space having a substantially axially extending upstream end section, a substantially axially extending downstream end section of larger radius than said upstream end section, and an intermediate section joining said end sections; and a plurality of circumferentially-spaced similar ribbon-like vanes secured to said rotatable member and projecting across said space toward said shroud to divide said space into a plurality of fluid flow paths; each of said vanes being curved about the axis of said rotatable member in the axially-extending upstream end section of said annular space for gradually imparting rotational velocity to the entering fluid and, along the upstream end of the intermediate section of said annular space, said vanes being substantially co-planar with the axis of said rotatable member, and, along the downstream end of said intermediate section, said vanes being curved about said axis in the direction of rotation of said rotatable member, and, along the axially extending downstream end section, said vanes being curved about said axis in a direction opposite to the direction of rotation of said rotatable member.

3. A centrifugal compressor comprising a rotatable member, a shroud radially spaced from said rotatable member to provide an annular fluid flow space therebetween, said annular space having a portion flaring radially outwardly in a downstream direction relative to fluid flow therethrough and merging at its downstream end with

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a substantially axially extending portion of said annular space; and a plurality of ribbon-like vanes secured to said rotatable member and projecting across said annular space toward said shroud to divide said space into a plurality of fluid paths; each of said ribbon-like vanes along at least a portion of the outwardly flaring portion of said annular space being curved about the axis of said rotatable member in the direction of rotation of said rotatable member, and, along said axially extending portion of said annular space, said vanes being curved about said axis in the opposite direction.

4. A centrifugal compressor comprising a rotatable member; a shroud radially spaced from said rotatable member to provide an annular fluid space therebetween; said annular space having a substantially axially extending downstream end section of larger radius than said upstream end section, and an intermediate section joining said end sections; and a plurality of circumferentially-spaced similar ribbon-like vanes secured to said rotatable member and projecting across said space toward said shroud to divide said space into a plurality of fluid paths; each of said vanes being curved about the axis of said rotatable member in the axially extending upstream end section of said annular space for

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gradually imparting rotational velocity to the entering fluid, and, along at least the downstream end of said intermediate section, said vanes being curved about said axis in the direction of rotation of said rotatable member, and, along the downstream axially extending end section of said annular space, said vanes being curved about said axis in a direction opposite to the direction of rotation of said rotatable member.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,042,506	De Vallat	Oct. 29, 1912
2,083,996	Jonn	June 15, 1937
2,236,706	Damonte	Apr. 1, 1941
2,284,141	Funk	May 26, 1942
2,354,653	Allen	Aug. 1, 1944
2,446,552	Redding	Aug. 10, 1948

FOREIGN PATENTS

Number	Country	Date
489,318	Great Britain	July 25, 1938