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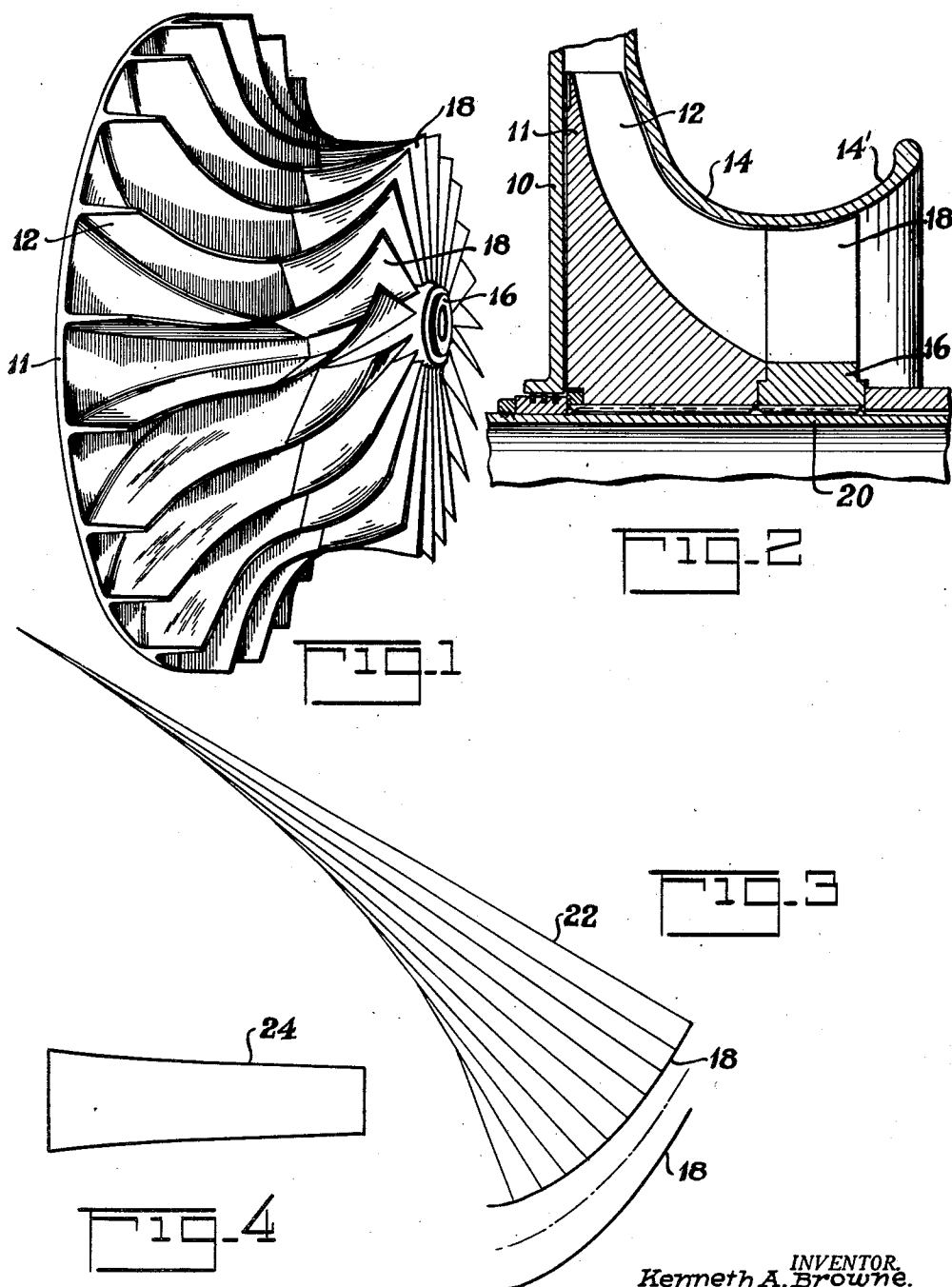
K. A. BROWNE

2,398,203

CENTRIFUGAL COMPRESSOR ENTRY VANES

Filed Nov. 20, 1943

2 Sheets-Sheet 1



INVENTOR
Kenneth A. Browne.
BY *John Stalk*
ATTORNEY

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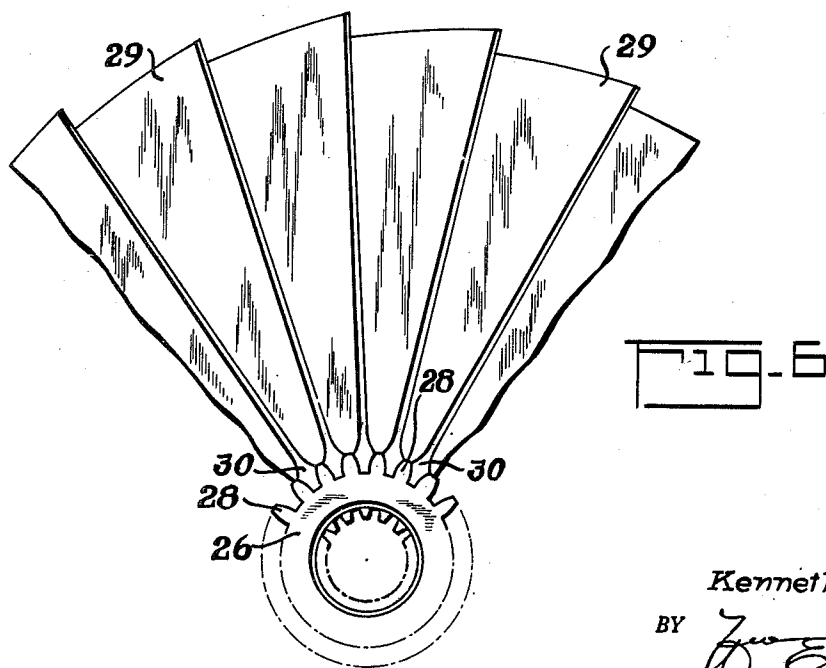
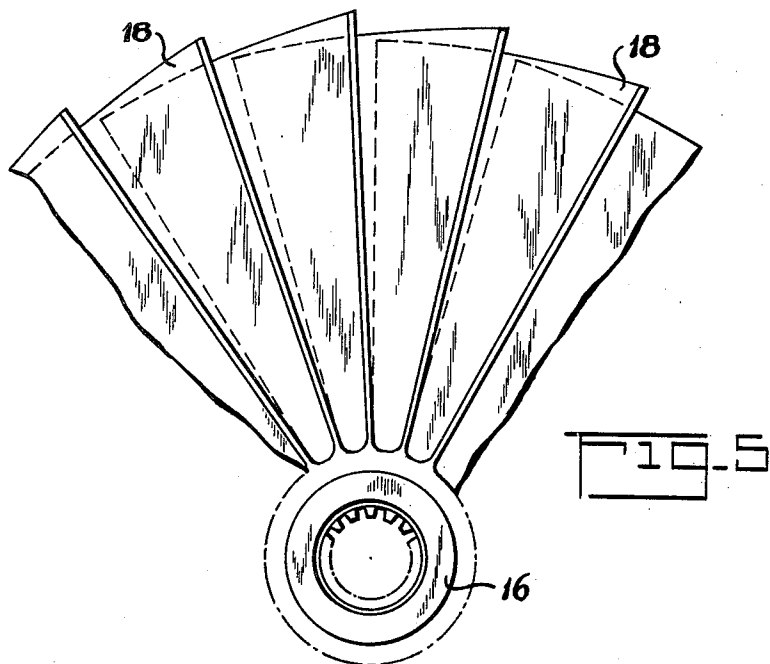
K. A. BROWNE

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2 Sheets-Sheet 2



INVENTOR.
Kenneth A. Browne.

BY

John E. Hall

ATTORNEY

UNITED STATES PATENT OFFICE

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CENTRIFUGAL COMPRESSOR ENTRY VANE

Kenneth A. Browne, Ridgewood, N. J., assignor
to Wright Aeronautical Corporation, a corporation
of New York

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5 Claims. (Cl. 230—134)

This invention relates to centrifugal compressors and is particularly directed to an entrance vane construction for such a compressor.

The theoretical pressure head available from a centrifugal compressor is a function of the square of the rotational velocity of the outer periphery of the impeller, neglecting the various impeller losses and assuming that the rotational pick-up velocity of the entering fluid is negligible in comparison to the periphery velocity of the impeller. The conventional supercharger impeller, as used on aircraft engines, has a large entrance opening in order to provide a large specific capacity. This entrance opening may be as much as 50% of the impeller diameter and, therefore, the inherently large pick-up velocity of the entering fluid considerably reduces the efficiency and pressure head otherwise available from the compressor. Accordingly, it is an object of this invention to provide an entrance vane construction for a centrifugal compressor in which the entrance vanes are designed to gradually convert the rotational pick-up velocity of the entering fluid into static pressure. Furthermore, with a large impeller entrance opening, in the absence of any appreciable conversion of the relative rotational velocity of the entering fluid, there is a low pressure area at the outer periphery of the entrance opening which tends to cause fluid circulation, resulting in non-uniform fluid velocities and even reverse flow conditions, thereby reducing compressor efficiency. In the conventional supercharger impeller, the entrance edges of the impeller vanes are bent in the direction of their rotation primarily in order to improve the compressor efficiency by minimizing the turbulence of the entering fluid. Such conventional bent impeller vanes may to some extent also act as diffusers to convert some of the rotational velocity of the entering fluid into pressure, but these bent vanes are very inefficient in this respect because a large angle cone is inefficient as a diffuser as compared to a small angle cone.

It is a further object of this invention to provide a curved entrance vane construction for an impeller of a centrifugal compressor in which the radius of curvature of the entrance vane portions gradually decreases in a downstream direction. It is a further object of this invention to so select the changing radii of the entrance vane portions to produce a gradually increasing channel area between the adjacent vanes such that the relation between the cross-sectional area and length of the fluid path between the outer

periphery of adjacent vanes is similar to that of a round cone diffuser having an initial diverging cone angle of about 4°. Also, because the impeller of an aircraft supercharger rotates at exceptionally high speeds, in the neighborhood of 20,000 R. P. M., it is essential that the major portion of the vanes be radial. For this reason, bending the flat radial vanes of a conventional impeller to obtain the desired diffuser is not suitable or practical.

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

Fig. 1 is a perspective view disclosing a conventional impeller with the entrance vane construction of this invention,

Fig. 2 is a partial radial section illustrating the impeller mounted on its driveshaft,

Fig. 3 is a development of the peripheral curvature of the entrance vanes,

Fig. 4 is a view of an equivalent round cone diffuser,

Fig. 5 is a front view of the entrance section, and

Fig. 6 is a front view of a modification.

Referring to the drawings and particularly to Figs. 1 and 2, a conventional supercharger is illustrated at 10 comprising an impeller 11 having a plurality of vanes 12 and a shroud 14. An entrance vane section 16 is clamped in front of the impeller 11 with its vanes 18 terminating in alignment with the impeller vanes 12. The impeller 11 and its entrance section 16 are both drivably splined to the impeller shaft 20. The vanes 18 of the entrance section are curved in the direction of rotation of the impeller and the entrance edge of these vanes are so directed that for a designed rotational speed and entrance velocity the air enters the vanes without shock. In addition, the radius of curvature of vanes 18 gradually decreases in a downstream direction. Accordingly, and as appears in Figs. 1 and 3, the channel area between the vanes 18 gradually increases toward the impeller vanes 12.

Fig. 3 illustrates a development of the outer periphery of the entrance vanes 18. The entrance edges of the vanes 18 are designed for a particular rotational speed so that the air enters the vanes without shock; that is, so that the tangent to the outer entrance edge of the vanes is substantially parallel to the direction of the relative velocity of the entering air. Furthermore, as illustrated in Fig. 3, the radius of curvature 22 of the outer periphery of the vanes 18

gradually decreases in a downstream direction. Considering the area between the outer periphery of the vanes 18, as illustrated in Figure 3, to be of unit height, the change in the radius 22 is made such that the relation between the length of the mean flow path through this unit height space and the cross-sectional area of this space along this path is identical to that of the round cone diffuser having a conical frustum shape as illustrated in Figure 4. That is, the small and large ends of the conical frustum have an area respectively equal to the cross-sectional area normal to the flow path at the entrance and discharge ends of the unit height space illustrated in Figure 4 and this conical frustum and unit height space have a similar change in area between these ends. The round cone diffuser 24 has an initial cone angle of not more than 10° and preferably the diffuser has an initial cone angle of approximately 4° with a small gradual increase in the cone angle toward the discharge end. In order to develop the desired expansion, e. g., for an impeller having a 12" outer diameter and 22 vanes, the entrance section should be approximately 2¾" long.

Preferably the shroud 14 is provided with a nozzle-like entrance portion 14' and the entrance vanes 18 extend into this nozzle-like entrance portion. That is, the upstream ends of the outer periphery of the entrance vanes 18 may flare radially outwardly into the nozzle entrance as seen in Fig. 2. This construction results in a reduction in the axial length which would otherwise be necessary if minimum diameter of the nozzle-area entrance portion were located in front of or at the impeller entrance as is the usual practice.

As best seen in Figs. 1, 5, and 6 in the drawings, the entrance edges of the vanes 18 are radial and each section of the vanes in any plane perpendicular to the axis of the impeller is radial. This construction is quite desirable because of the high rotational speeds of air craft supercharger impellers and the consequent bending stress that develops unless the blades are radially disposed. For this reason, any appreciable bending of the flat radial vanes of a conventional impeller is not practical. The impeller of this invention is made in two sections: the conventional impeller section 11, and the entrance vane section 16. These two sections are clamped together on the impeller drive shaft with the vanes 18 forming a continuation of the vanes 12. Obviously, these two sections could be made in one piece. If desired, the downstream end of the impeller vanes 16 may be curved slightly with the entrance vanes 18 shaped to form a substantially smooth continuation of such bent vanes.

The entrance section 16 may be a single casting as illustrated in Fig. 5, or the entrance vanes may be separately formed as in Fig. 6. In Fig. 6 the hub 26 is provided with splines or gear teeth 28 cut along a curved path corresponding to the radial projection of the outer periphery of the vanes 18'. It is also satisfactory to cut the splines 28 on a path having a constant helical angle so chosen that the helix corresponds as closely as possible to the true radial projection of the outer periphery of the vanes 18', thereby simplifying the machining operation. The vanes 29 may be preformed with a substantially rectangular butt or root section and then held in place in a suitable fixture so that their root sections may be machined by a standard gear shaper to provide a gear tooth root section 30. This con-

struction insures an accurate fit between the root end of the blades 29 and the helical splines 28 on the hub 26. The whole assembly is then copper-brazed or bonded by other suitable means to produce a virtually integral assembly. In general, brazing methods require a very close fit of the parts to be secured together in order to provide a strong bond and this condition is obtained by the above-described gear cutting method.

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

I claim as my invention:

1. An entrance vane section adapted to be secured in front of an annular impeller of a centrifugal compressor for rotation therewith, said entrance section comprising a plurality of radially extending vanes and being adapted to form a substantially smooth axial continuation of the impeller, said entrance vanes being curved in the direction of rotation of the impeller with a radius of curvature which decreases in the direction of flow therethrough, the outer periphery of said entrance vanes defining a surface diverging in an upstream direction at the entrance end of the impeller.

2. In combination, a centrifugal fluid impeller having a plurality of circumferentially spaced radial vanes, each of said vanes having an entrance vane portion curved in the direction of rotation of the impeller with a radius of curvature which gradually decreases in the direction of flow through the impeller thereby providing a flow path between said entrance vane portions of gradually increasing cross-sectional area in the direction of the flow, the increase in the cross-sectional area of the flow path between the outer periphery of the entrance vane portions being similar to the increase in area of a round conical frustum whose angle of divergence is not more than 10°.

3. In combination, a centrifugal fluid impeller having a plurality of circumferentially spaced radial vanes, each of said vanes having an entrance vane portion curved in the direction of rotation of the impeller with a radius of curvature which gradually decreases in the direction of flow through the impeller thereby providing a flow path between said entrance vane portions of gradually increasing cross-sectional area in the direction of the flow, the increase in the cross-sectional area of the flow path between the outer periphery of the entrance vane portions being similar to the increase in area of a round conical frustum whose angle of divergence is not more than 10°, said entrance vane portions being radially disposed.

4. In combination, a centrifugal fluid impeller having a hub portion and a plurality of circumferentially spaced vanes extending therefrom, each of said vanes having a curved entrance vane portion, said entrance portions being radially disposed, said entrance portions from their outer periphery to and including the intersection of their root ends with said hub portion being curved in the direction of rotation of the impeller, the radius of said curvature gradually decreasing in a downstream direction to provide a flow path between said entrance vane portions of gradually increasing cross-sectional area in the direction

of the flow, the increase in said cross-sectional area being similar to the increase in area of a round conical frustum whose angle of divergence is not more than 10° .

5. In combination, a centrifugal fluid impeller having a hub portion and a plurality of circumferentially spaced vanes extending therefrom, each of said vanes having a curved entrance vane portion, said entrance portions from their outer periphery to and including the intersection of their root ends with said hub portion being curved

in the direction of rotation of the impeller, the radius of said curvature gradually decreasing in a downstream direction to provide a flow path between said entrance portions of gradually increasing cross-sectional area in the direction of the flow, the increase in the cross-sectional area of the flow path between the outer periphery of the entrance vane portions being similar to the increase in area of a round conical frustum whose angle of divergence is not more than 10° .

KENNETH A. BROWNE.