June 24, 1958 W. S. CASTLE ET AL 2,840,298

HEATED COMPRESSOR VANE

Filed Aug. 9, 1954 2 Sheets-Sheet 1

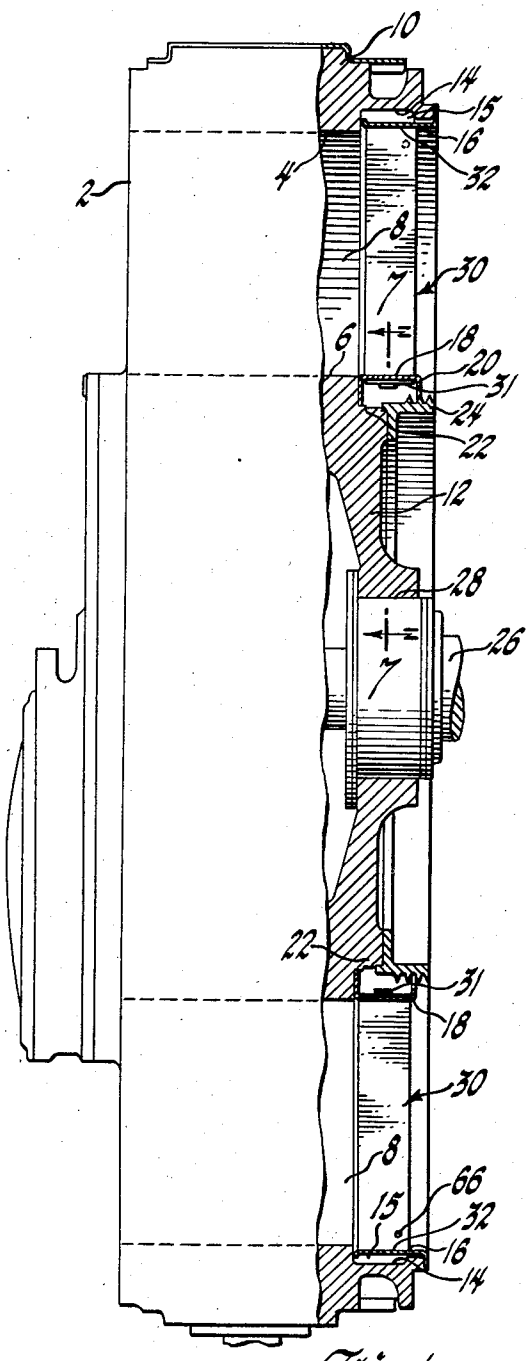

Fig. 1

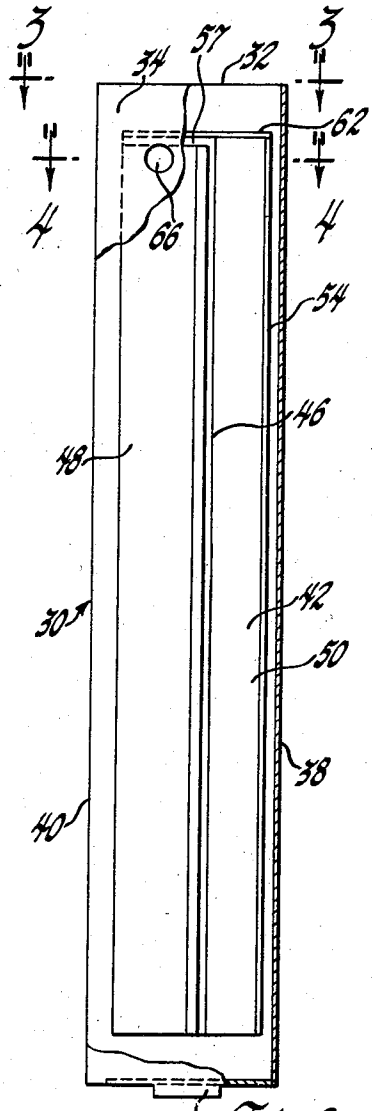

Fig. 2

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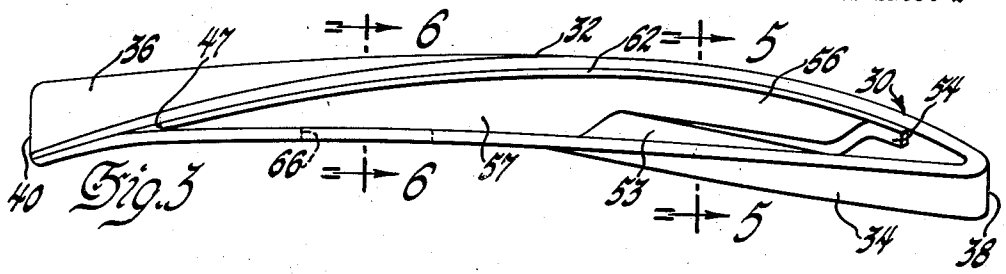

Fig. 3

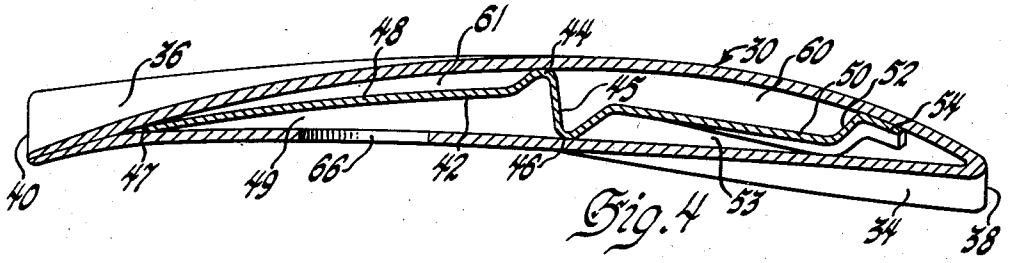

Fig. 4

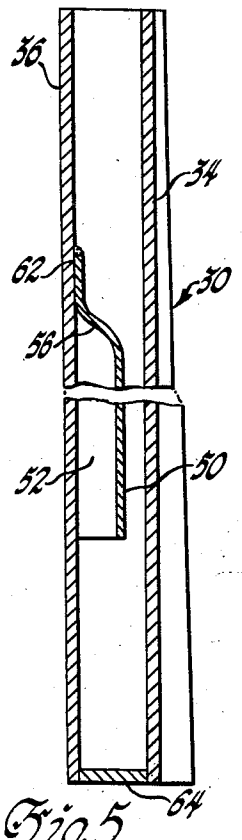

Fig. 5

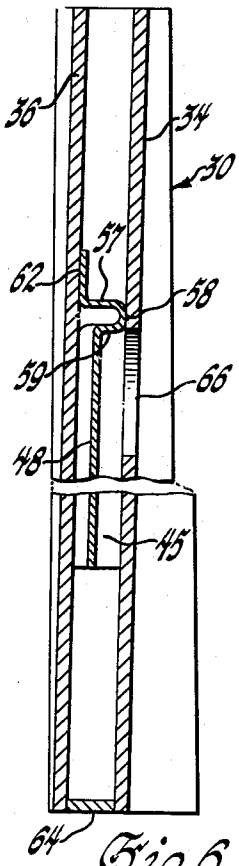

Fig. 6

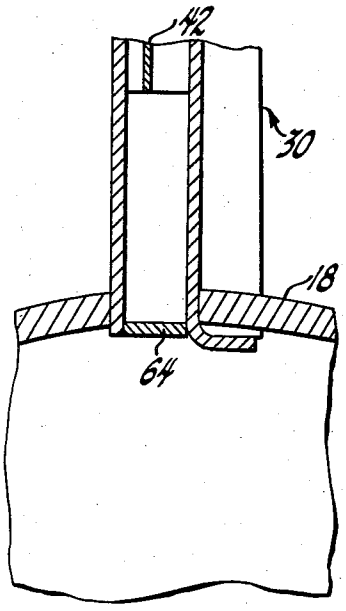

Fig. 7

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HEATED COMPRESSOR VANE

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Application August 9, 1954, Serial No. 448,633

2 Claims. (Cl. 230—132)

This invention relates to compressor inlet de-icing and more particularly to the elimination of ice formation on the compressor inlet guide vanes of a gas turbine aircraft engine.

Gas turbine engines require large quantities of air for their operation and at times must operate under atmospheric conditions wherein the air entering the engine contains moisture which may condense as ice or frost on the compressor inlet guide vanes. Such condensation forms deposits on the vanes which will obstruct and sometimes completely block the compressor inlet, thus disabling the engine.

This invention is primarily directed to an adequate arrangement for heating compressor inlet guide vanes to prevent ice formation on these vanes under certain atmospheric conditions and thereby prevent disabling of the engine.

The preferred embodiment of this invention shown herein relates specifically to a multistage axial flow compressor but it will be apparent that many of the principles and features of this invention are applicable to other situations where similar problems arise.

An object of this invention is to heat compressor inlet guide vanes by supplying heating fluid from a source to a fluid inlet at one end of each vane and directing the fluid through fluid passages in each vane to a fluid outlet on the vane. Another object of this invention is to heat compressor inlet guide vanes by supplying heating fluid from a source to a fluid inlet at one end of each vane and directing the fluid longitudinally through fluid passages in each vane to a fluid outlet on the vane. A further object of this invention is to heat compressor inlet guide vanes by supplying heating fluid from a source to a fluid inlet at one end of each vane and directing the fluid in reverse longitudinal directions through fluid passages within the vane to a fluid outlet on the vane. Yet another object of this invention is to provide a hollow compressor inlet guide vane with a partition member to form fluid passages within the vane for directing the flow of heating fluid through the vane.

These and other objects of this invention will be readily apparent from the following specification and drawings in which:

Figure 1 is a partially cut-away view of the forward frame of a multistage axial flow compressor;

Figure 2 is a cut-away view showing a compressor inlet guide vane and assembled partition;

Figure 3 is a view on the plane indicated by line 3—3 of Figure 2 showing the outboard vane end;

Figure 4 is a view on the plane indicated by line 4—4 of Figure 2;

Figure 5 is a view on the plane indicated by line 5—5 of Figure 3;

Figure 6 is a view on the plane indicated by line 6—6 of Figure 3;

Figure 7 is a view on the plane indicated by line 7—7 of Figure 1.

Referring now to Figure 1 of the drawings, the forward frame 2 of a multistage axial flow compressor has surfaces 4 and 6 defining the inlet to the compressor. A number of radial struts 8 join the outer frame portion 10 to the inner frame portion 12.

The surface 4 has a circumferentially extending groove 14 which receives the heated air from an intermediate stage of the compressor where the air has been heated due to compression and is under sufficient pressure to ensure adequate circulation through the compressor inlet guide vanes. The air may be brought to groove 14 in a number of different ways which are well known in the art. For a more complete description of the forward frame and a showing of one way of bringing the air to the groove 14, reference may be had to S. N. 285,169, filed April 30, 1952, John B. Wheatley et al., now Patent No. 2,800,273, and assigned to the assignee of the present invention.

An outer cylindrical shroud member 16 encloses the opening of groove 14 to form a chamber 15 for supplying the heated air to the compressor inlet guide vanes as will be hereinafter explained. An inner cylindrical shroud member 18 fits within a shouldered circumferential recess 22 in the inner frame portion 12 and has a circumferentially extending flange 20 spaced from a cylindrical labyrinth seal 24 secured to the inner frame portion 12. An axially extending flange portion (not shown) of the compressor rotor (not shown) fits between flange 20 and labyrinth seal 24. The compressor rotor (not shown) is supported on shaft 26 which is rotatably mounted within the forward frame at 28.

A number of compressor inlet guide vanes 30 are secured at their inboard ends 31 to the inner shroud member and at their outboard ends 32 to the outer shroud member. The vanes extend radially between the shrouds as is well known in the art. The outboard ends of the vanes extend through the outer shroud member into the chamber 15 to receive the heated air supplied from the compressor to this chamber.

Referring now to Figures 2 through 7, vane 30 has outer concave and convex faces 34 and 36, respectively, which meet at 38 to form a leading edge and at 40 to form a trailing edge. As can be seen in Figures 3 and 4, the vane is given a twist in order that the incoming air will be given the desired swirling motion as it enters the compressor.

A partition 42 is assembled within each vane as shown in Figure 2 and extends substantially the length of the vane. The partition has central curved portions 44 and 46 contacting the inner surfaces of faces 36 and 34, respectively, and joined by a web 45 to form an ogee curve. A curved portion 48 extends laterally from curved portion 44 toward the trailing edge of the vane and abuts the inner surfaces of faces 34 and 36 at 47. Web 45, curved portions 44 and 48, and a portion of the inner surface of vane face 34 defines a longitudinally extending passage 49 within the vane.

A portion 50 of partition 42 extends laterally from curved portion 46 toward the leading edge of the vane and has an edge 54 lying against the inner surface of vane face 36. Portion 50 is bent at 52 adjacent to edge 54. Curved portion 46, portion 50, and portions of the inner surfaces of vane faces 34 and 36 define a longitudinally extending passage 53 within the vane.

The outboard end of partition 42 is formed to provide an edge 62 contacting the inner surface of face 36, a portion 56 angularly extending from portion 50 to edge 62, and a U-shaped portion 57 (Figures 3 and 6) extending from partition portion 48 to edge 62 and engaging the inner surface of vane face 34 at 58. Thus, the outboard end of passage 53 is open to the outboard

end 32 of the vane, and the outboard end of passage 49 is closed to the outboard end of the vane by the U-shaped portion 57. The inboard end of each passage is open to the inboard end 31 of the vane, and a cross-sectional view taken at the inboard end of the assembled vane and partition would resemble Figure 4.

The inboard end of each vane has a closure 64 to ensure that no heating fluid will flow into the space between the inner shroud member 18 and the shouldered recess 22 of the inner frame portion 12. A fluid outlet 66 is provided in vane face 34 of each vane immediately to the inboard side of leg 59 of U-shaped portion 57 as shown in Figures 2 and 6.

The heating fluid passes from chamber 15 into the outboard end 32 of the vane, flows longitudinally of the vane through passage 53, and then flows in a reverse longitudinal direction through passage 49 to the fluid outlet 66, where it is discharged into the incoming air to the compressor.

Icing does not ordinarily occur unless the structure obstructs the flow of air containing moisture or changes the direction of flow of such air. The incoming air to the compressor strikes the leading edge 38 of the vane and the forward or concave vane face 34 and thus these portions of the vane are heated.

Some of the heating fluid will flow into the passages 60 and 61 formed by partition portions 48 and 50 and the inner surface of vane face 36 but since there is no outlet for either passage, there will be very little circulation of air in either passage. However, the air in these passages will be heated by conduction, for partition 42 will become heated by the heating fluid flowing in passages 49 and 53.

Thus, this invention provides longitudinally extending passages 49 and 53 within the vane for directing the flow of heating fluid in reverse longitudinal directions to heat vane face 34 and the leading edge 38 of the vane. Although only two such passages have been shown and described, obviously more may be used if desired.

While a specific embodiment of this invention has been shown and described various changes and modifications may be made within the scope and spirit of the invention without departing from it.

We claim:

1. A heated compressor vane having vane faces defining a hollow vane, said vane having a fluid inlet at one end thereof and a fluid outlet in one of said vane faces adjacent said fluid inlet, and a longitudinally extending partition member within said vane extending between the leading and trailing edges thereof and including intermediate rib portions in engagement with a respective vane face to locate said partition member in laterally spaced relationship thereto and define pairs of longitudinally extending passages with each of said vane faces, said passages being in communication with each

other at one end thereof with said partition member including laterally extending portions between said fluid inlet and said fluid outlet to close the other end of one pair of passages and the other end of one passage of the other pair of passages, whereby said other passage of said other pair will be in communication with said fluid inlet to direct the flow of heating fluid longitudinally of one portion of said one vane face and said one passage of said other pair will direct the flow of heating fluid in a reverse longitudinal direction of the other portion of said one vane face to said fluid outlet.

2. A heated compressor vane having vane faces defining a hollow vane, said vane having a fluid inlet at one end thereof and a fluid outlet in one of said vane faces adjacent said fluid inlet, and a longitudinally extending partition member within said vane extending from the trailing edge of said vane to a position on one of said vane faces adjacent the leading edge of said vane, said partition member including rib portions in engagement with a respective vane face to locate said partition member in laterally spaced relationship thereto to define adjacent pairs of longitudinally extending passages with each of said vane faces, said passages being in communication with each other at one end thereof with said partition member including a laterally extending portion between said fluid inlet and said fluid outlet to close the other end of one pair of passages and the other end of one passage of the other pair of passages, whereby said other passage of said other pair will be in communication with said fluid inlet to direct the flow of heating fluid longitudinally of said leading edge of said vane and the adjacent portions of each vane face and said other end of said other passage will be in communication with said fluid outlet to direct the flow of heating fluid in a reverse longitudinal direction of the other portion of said one vane face to said fluid outlet.

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