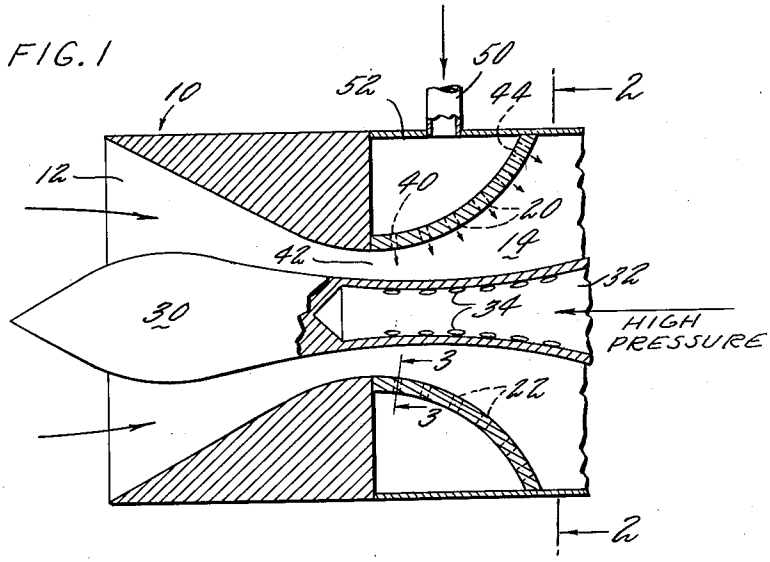
March 3, 1964 J. G. LEE 3,123,285

DIFFUSER WITH BOUNDARY LAYER CONTROL

Filed Jan. 21, 1963

FIG. 1



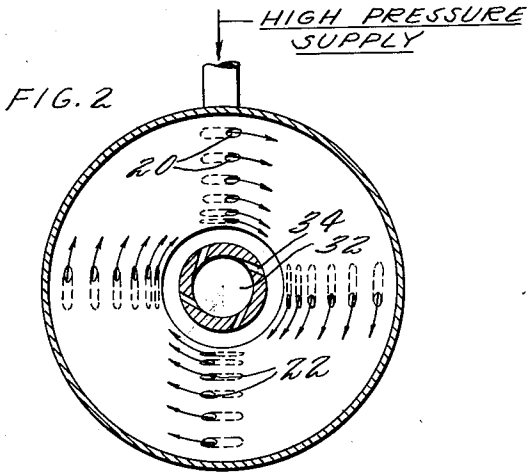


FIG. 2

FIG. 3

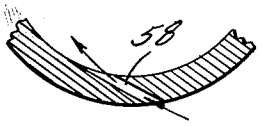
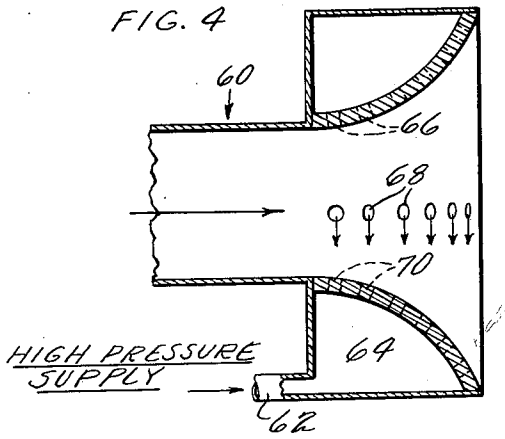


FIG. 4



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United States Patent Office 3,123,285 Patented Mar. 3, 1964

3,123,285

DIFFUSER WITH BOUNDARY LAYER CONTROL

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Filed Jan. 21, 1963, Ser. No. 252,821
5 Claims. (Cl. 230—133)

This invention relates to boundary layer control and more particularly to boundary layer control for subsonic diffusers.

In my Patent No. 2,594,042 entitled "Boundary Layer Energizing Means for Annular Diffusers," which issued on April 22, 1952, I pointed out how a diffuser could be made very short by rotating at least a portion of the diffuser wall. In that patent it was pointed out that by rotating the diffuser wall about the axis of flow therethrough, the boundary layer adjacent to that wall is also rotated by entrainment and the centrifugal force developed in the entrained air forces it outwardly and along the diffuser wall. The complicated mechanism required for that type of device makes it unattractive.

It is therefore a primary object of this invention to provide a boundary layer control similar to that described in the above patent but eliminating the requirement for complicated rotating mechanism.

It is a further object of this invention to utilize one or more jets of air which inject high energy fluid tangentially along the diffuser wall so that the entrained boundary layer will be rotatable about the axis of flow through the diffuser.

These and other objects of this invention will become readily apparent from the following description of the drawing in which:

FIG. 1 is a schematic illustration of the invention embodied in a typical annular diffuser shown in partial section;

FIG. 2 is a section taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged partial detailed illustration of a typical ejection port, and

FIG. 4 is another form of diffuser.

Referring to FIG. 1, a typical convergent-divergent annular diffuser is generally indicated at 10 which has a convergent inlet 12 and a subsonic diffuser 14. As seen both in FIGS. 1 and 2, the diffuser 14 includes one or more sets of nozzles 20 and 22 which emit high energy air tangentially along the inner wall of the diffuser so that the boundary layer flowing therealong is entrained for rotation about the axis of flow through the diffuser.

The low energy boundary layer when caused to rotate will be centrifugally bound to the diffuser wall thereby maintaining unseparated flow even though the diffuser has a relatively high divergence.

The diffuser 10 includes a spike or inner body 30 which contains a hollow portion 32. The spike also may contain a plurality of sets of passages 34 for ejecting flow tangentially of the outer surface of the spike and in the same direction of rotation as the flow from the passages 20 and 22. As seen better in FIG. 2, the sets of openings 34 are located 45° from the adjacent passages 20 in the outer wall of the diffuser.

As illustrated in FIG. 1, it will be noted that the opening 40 in the vicinity of the throat 42 is relatively small while the passage 44 at the downstream end of the diffuser is relatively large. Thus, by selectively sizing the apertures, different quantities of flow could be introduced at selected points, and despite the variation of pressure within the diffuser resulting from the changing velocity in the main stream, any desired amount of rotational energy could be provided along the surface of the diffuser.

Actually the pressure within the diffuser at point 40 will be lower than at 44, and the pressure in the plenum chamber will be constant. Therefore, the velocity through the tangential port at 40 will be greater than at 44. Hence more flow will have to be provided at 44 by a larger opening.

A high pressure fluid passage 50 leads to a plenum chamber which in turn acts as a manifold to feed flow to the passages 20 and 22. Likewise, high pressure fluid is fed into the hollow portion 32 to feed fluid to passages 34 in the inner body 30.

FIG. 3 is an enlarged view showing a typical port 58 which is set at an angle so as to inject the air as closely tangentially as possible along the inner wall of the diffuser.

One advantage the proposed pressure energized diffuser has is that the energizing fluid may also serve as a coolant. In the event of a powerplant installation, it could also serve as a mixing device, as for example if it were desired to mix cool gaseous hydrogen with air prior to combustion, or if it were desired to introduce a catalyzing or inhibiting agent or other substance into the fluid stream.

FIG. 4 shows a typical ordinary diffuser 60 which is unlike the annular plug-type diffuser shown in FIG. 1. In this instance, high pressure fluid is fed through the passage 62 to a plenum chamber 64 which in turn feeds a plurality of sets of ejection passages 66, 68 and 70. The size of these passages in a downstream direction similar to that described in FIG. 1, may also be desirable.

As a result of this invention, it will be apparent that a highly efficient but relatively simple mechanism has been provided to avoid separation on high divergence subsonic diffusers. This permits a rapid increase in the pressure of the main fluid stream in a relatively short axial distance. In high performance powerplants, for example, where the inlet construction is an important weight factor, the weight saving alone is very significant.

Although several embodiments of this invention have been illustrated and described herein, it will be apparent that various changes and modifications may be made in the construction and arrangement of the various parts, without departing from the scope of this novel concept.

I claim:

1. In an intake duct for an air consuming mechanism such as an axial flow device, means for moving the air through the duct including a diffuser adjacent the downstream end thereof, said diffuser including a longitudinal axis and comprising at least an outer wall portion substantially arcuate in cross section and diverging in a downstream direction and forming an abruptly continuously increasing cross-sectional area whereby adverse pressure gradients are introduced in the flow stream through the duct as a result of the decreasing velocity and increasing pressure, means for energizing substantially only the boundary layer moving adjacent along said wall portion comprising a plurality of relatively small ejecting passage means in said wall portion for injecting secondary fluid into said boundary layer in a multiplicity of relatively high energy streams and in a direction tangentially of said arcuate wall section and substantially about said axis to induce centrifugal forces in said boundary layer and reduce the onset of separation in said abruptly increasing cross section.

2. In an intake duct according to claim 1 including an inner body having a longitudinal axis and a wall portion spaced inwardly from said first-mentioned arcuate wall portion thereby forming an annular abruptly diverging diffuser portion and including a second set of secondary injection passage means for injecting fluid into the boundary layer and in a direction tangentially of said inner body wall portion and about the longitudinal axis thereof.

3. In an intake duct according to claim 1 wherein said ejecting passage means comprise a plurality of discharge passages spaced in a downstream direction.

4. In an intake duct according to claim 3 wherein said discharge passages vary in dimension in a downstream direction.

5. In an intake duct according to claim 2 wherein said second set of secondary injection passage means are spaced in a downstream direction and vary in dimension in a downstream direction.

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