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BOUNDARY LAYER CONTROL APPARATUS FOR COMPRESSORS

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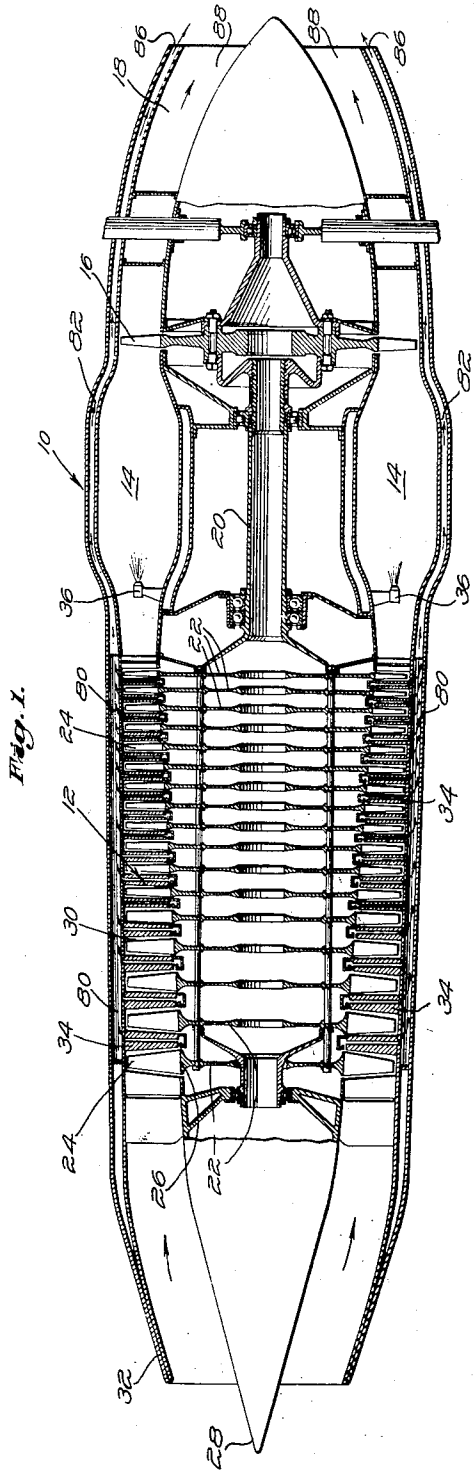


Fig. 1.

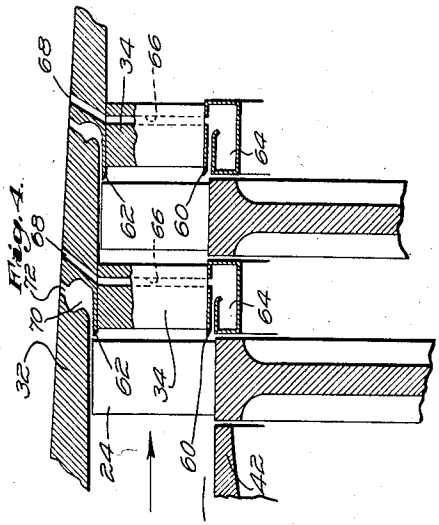


Fig. 4.

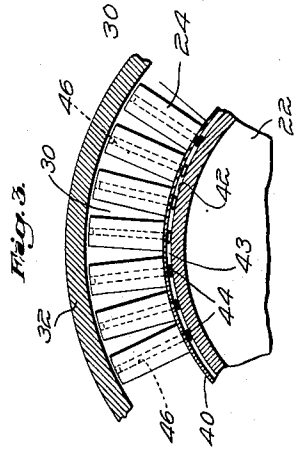


Fig. 3.

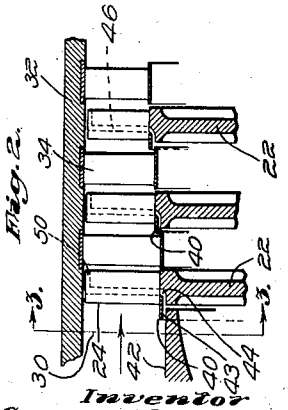


Fig. 2.

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BOUNDARY LAYER CONTROL APPARATUS FOR COMPRESSORS

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Original application November 22, 1950, Serial No. 197,144, now Patent No. 2,738,921, dated March 20, 1956. Divided and this application August 24, 1955, Serial No. 530,349

1 Claim. (Cl. 230—122)

This application is a division of application Serial No. 197,144, filed November 22, 1950, now Patent No. 2,738,921, by George F. Hausmann.

This invention relates to boundary layer control for compressors and the like.

It is an object of this invention to provide a boundary layer control mechanism for axial flow compressors whereby the boundary layer flow along the walls of the compressor is continuously removed.

Another object of this invention is to provide a boundary layer control of the type described comprising mechanism for removing the boundary layer flow adjacent the inner and/or outer wall of a compressor passage and exhausting the boundary layer to a low pressure region.

A still further object of this invention is to provide a boundary layer control of the type described wherein the boundary layer is removed from the inner compressor wall and is exhausted through spanwise passages internally of the compressor blades, and from such passages to a low pressure region or to the region adjacent the outer ends of the blades.

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

Fig. 1 is a cross-sectional view of a gas turbine engine including an axial flow compressor utilizing a preferred embodiment of this invention.

Figs. 2 and 3 are cross-sectional views illustrating modification of the Fig. 1 construction.

Fig. 4 is a cross-sectional view illustrating another modification of this invention.

Referring to Fig. 1, a gas turbine engine **10** is illustrated having an axial flow compressor section **12**, a burner or combustion section **14**, a turbine **16** and an exhaust nozzle **18**. The turbine **16** drives a shaft **20** which in turn supports and drives a plurality of compressor blade rotors **22**. The rotors **22** comprise a plurality of hub elements fixed together to form a hub which thus disposed carries a plurality of peripherally as well as axially spaced impeller blades **24**. The outer periphery **26** of the hub forms a downstream continuation of the inlet cone **28** thereby comprising the inner wall for the compressor passage **30**. A casing **32** surrounds the compressor thereby forming an outer wall for the passage **30** and may carry a plurality of stator blades **34** which are successively interposed between the impeller blades carried by each of the rotors **22**. A plurality of fuel nozzles **36** may be provided for injecting fuel into the burner or combustion section **14**.

In order to increase the efficiency of the compressor and the individual compressor blades it is desirable to remove the boundary layer which may build up along the walls of the compressor passage **30**. As illustrated in Fig. 2, the rotors **22** carry flanged annular members **40** which form a scoop spaced from the inner wall **42** of the compressor passage **30**. The scoop **40** extends upstream and terminates in a lip which is located upstream of the compressor blade **24**. The scoop **40** forms an annular chamber **43** with the inner wall **42** of the compressor passage which communicates via apertures **44** in the base of the rotor blades (see also Fig. 3) with drilled passages **46** in each of the impeller blades **24**. The passages **46** terminate in an opening **50** adjacent the trailing edge and the outer extremity of the blade **24**.

In a compressor passage as illustrated, a suction action is developed within the drilled passage **46** by the pressure gradient between the root and tip of the rotating blades. Since the pressure gradient is proportional to the difference of the square of the tangential velocity at the roots and tips of the blades, a lower pressure will exist at the outer extremity of each of the rotating blades than at the root thereof thereby inducing flow through the chamber **43**, the apertures **44**, passages **46** and out through the opening **50** adjacent the tip of the blades. Thus the air is actually centrifuged outwardly from within the blade passages **46** so that a pumping action occurs.

Since the area of an axial flow compressor passage is reduced at each successive downstream compressor stage, each successive scoop **40** extends outwardly into the stream a greater amount than the adjacent upstream scoop. This result is produced by enlarging the diameter of each successive hub **22** in a downstream direction or by spacing each successive downstream scoop farther from the axis of rotation of the rotors.

Fig. 4 illustrates another modification of the principles just described which modification comprises the bleeding of boundary layer flow from along both the outer and inner walls **32** and **42**, respectively, of the compressor passage **30**. In this version of the invention a scoop **60** is provided adjacent the root end of the stator blades **34** and a second scoop **62** is provided adjacent the radially extreme end of the stator blades **34**. The scoop **60** inducts boundary layer air into an annular chamber **64** which communicates with drilled passages **66** in stator blades **34**, which passages in turn lead to the surrounding atmosphere via the passage or restriction **68** in the outer casing **32**. Similarly the scoop **62** inducts boundary layer flow along the outer wall and emits this fluid into a second annular chamber **70** also leading to the atmosphere by means of the opening or restriction **72**.

Since the boundary layer is removed from along the compressor walls at a point downstream of the first compressor stage, the surrounding or atmospheric air will be of a lower pressure than that existing adjacent the scoops **60** and **62**. As a result, a continuous flow of boundary layer fluid is maintained from along the compressor walls to the outside relatively low pressure air.

Rather than exhausting boundary layer air via the openings **68** and **72** to the atmosphere, it may be desirable as illustrated in Fig. 1 to conduct this fluid via passages **80** to annular chambers **82** which surround the burner or combustion section **14**. Thus, any desired portions adjacent the burner area or other critical areas can be cooled by the boundary layer flow which is removed from the compressor walls. This boundary layer flow will then pass outwardly to the atmosphere if so desired. In order to improve the flow of boundary layer air it may be desirable to discharge the air via an opening **86** adjacent the exhaust nozzle **88**. In this manner the ejector action of the turbine exhaust will improve the exit flow of boundary layer fluid and provide a pumping force.

As a result of this invention it is apparent that a simple yet efficient boundary layer control apparatus has been provided whereby no external power is necessary to conduct boundary layer flow away from the walls of an axial flow compressor.

Although only certain 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 the arrangement of the various parts without departing from the scope of this novel concept.

What it is desired to obtain by Letters Patent is:

In an axial flow compressor having a plurality of impeller blades, a hub, said blades extending radially from said hub and forming a plurality of rows, a casing surrounding said impeller blades and forming with said hub an annular passage having inner and outer walls converging in a downstream direction, stator blades carried by said casing and extending across said annular passage in alternate rows cooperating with said impeller blades, scoops carried by the ends of at least one row of stator blades adjacent said hub and adapted to intercept the boundary layer flow along the inner wall of said annular passage, said scoops intercepting the boundary layer at

a point immediately upstream of the leading edge of said stator blades, passage means in said stator blades connecting said scoops with the outer radial ends of said stator blades, a source of pressure lower than the pressure in said compressor, and scoop means carried by the outer radial ends of said one row of stator blades and intercepting the boundary layer flow along said outer walls immediately upstream of the leading edge of said stator blades, said scoop means having a fluid connection with said source.

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