United States Patent

Soo

[15] **3,658,437**

[45] **Apr. 25, 1972**

[54] DIFFUSER INCLUDING VANELESS AND VANED SECTIONS

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[22] Filed: **Mar. 27, 1970**

[21] Appl. No.: **23,321**

[52] U.S. Cl. ..... **415/181**, 415/207, 415/211, 415/219 A

[51] **Int. Cl.** **F04d 29/40**, F04d 17/08

[58] **Field of Search** ..... 415/207, 209, 211, 181, 219, 415/219 A

[56] **References Cited**

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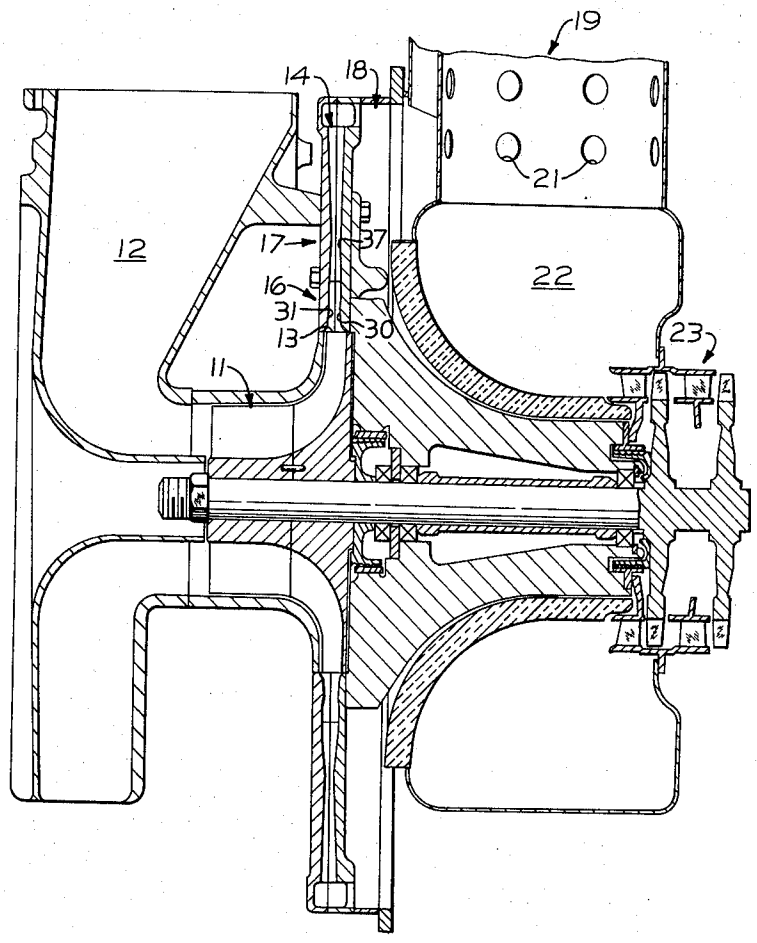
Primary Examiner—Henry F. Raduazo

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[57] **ABSTRACT**

A diffuser for use in turbomachinery to improve overall efficiency, the diffuser including a vaneless diffuser section for reducing supersonic fluid flow to subsonic speed and a multichannel diffuser section for achieving maximum pressure recovery and delivering the fluid to a suitable collector, one of the diffuser sections providing a flow path of decreasing and then increasing cross section configured to minimize boundary layer losses.

2 Claims, 7 Drawing Figures

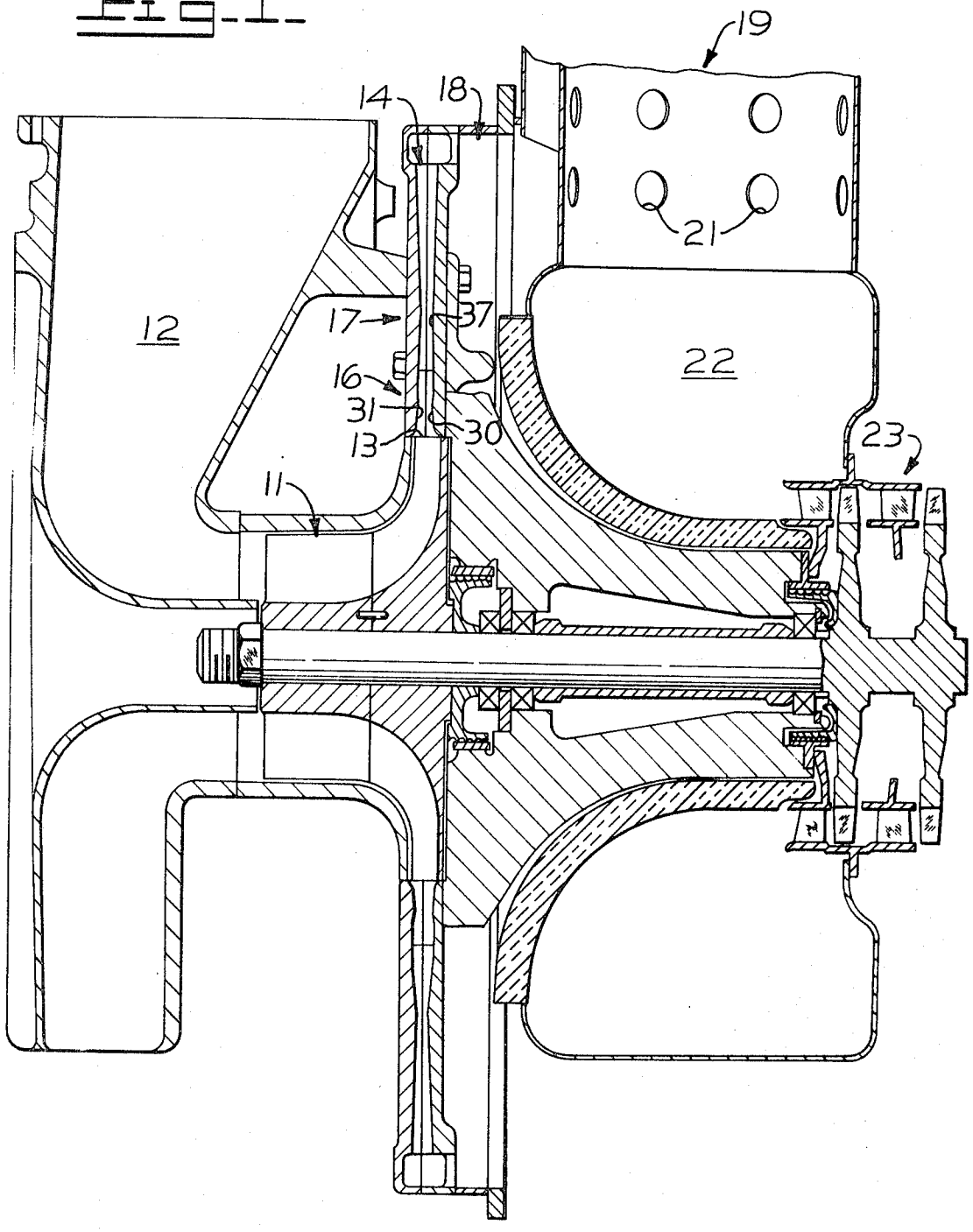


PATENTED APR 25 1972

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Fig. 1



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Fig-2-

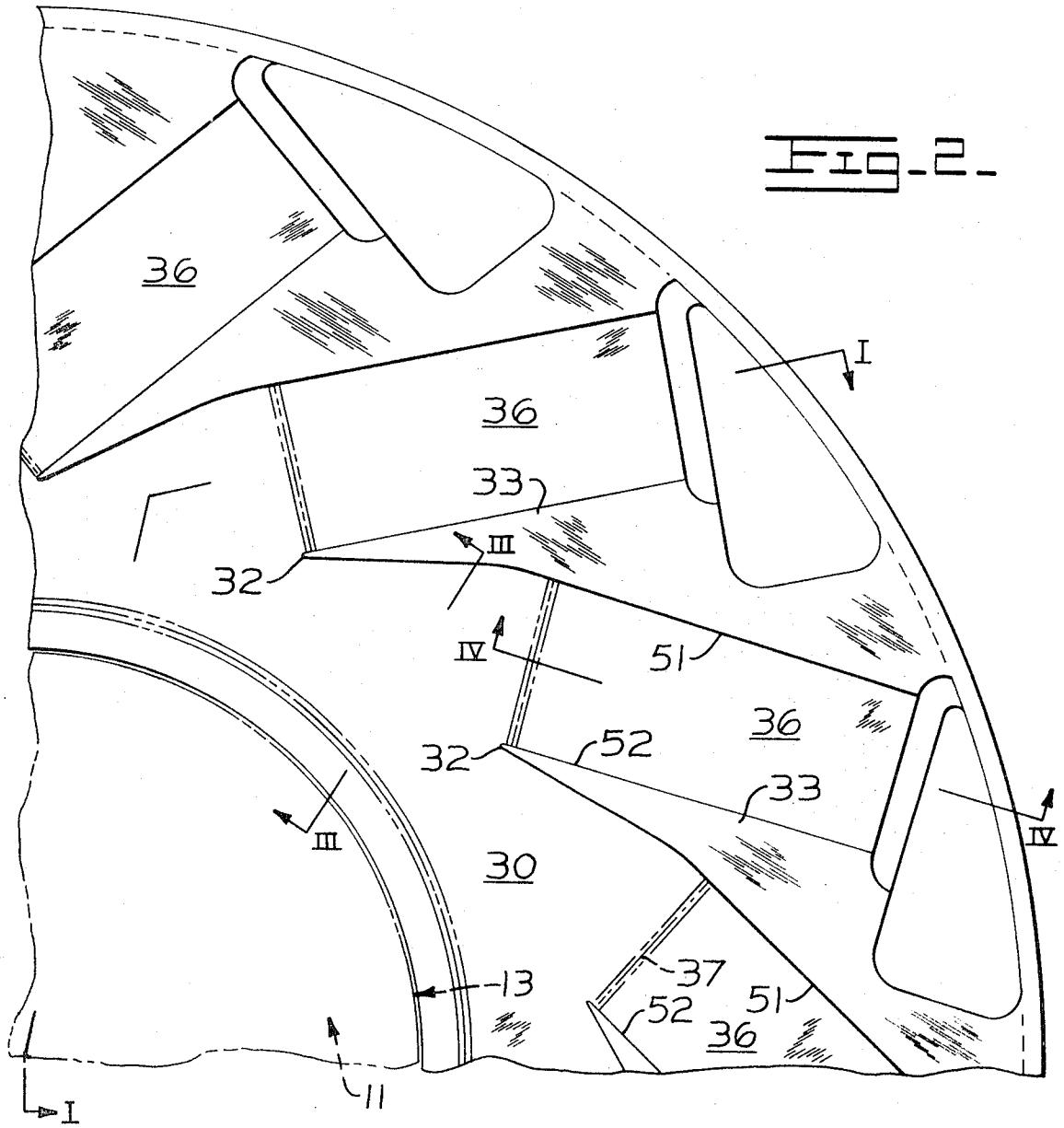
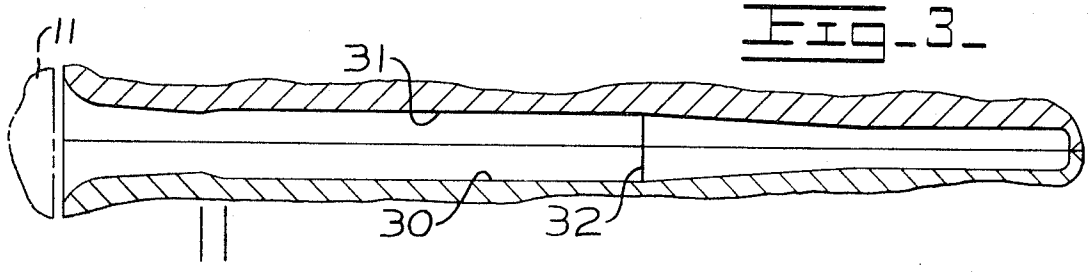


Fig-3-



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Fig-4-

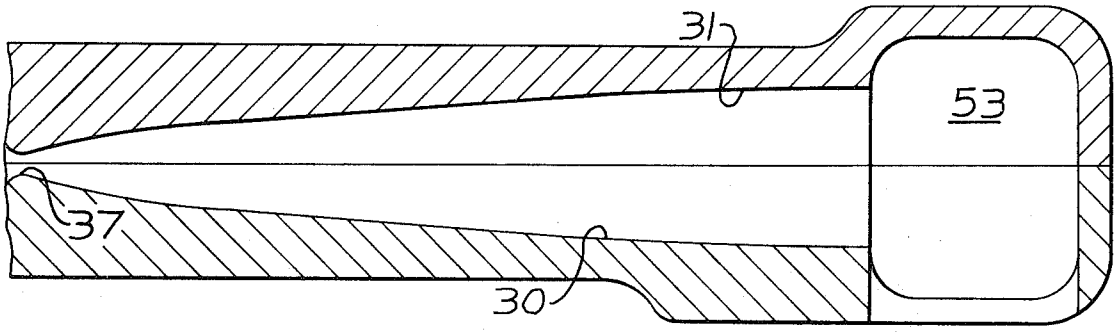


Fig-5-

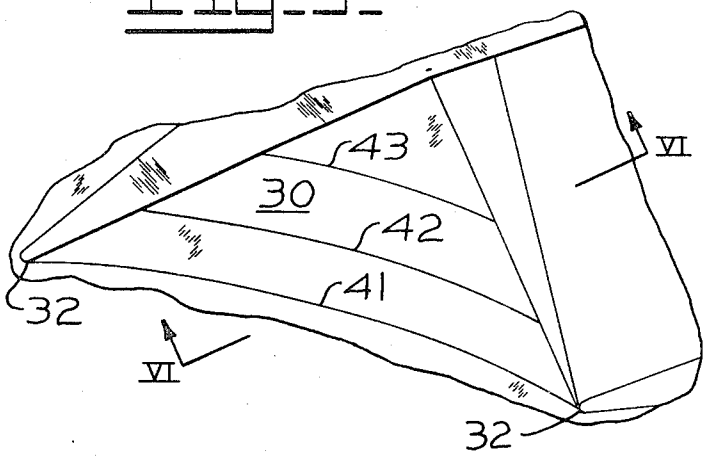


Fig-7-

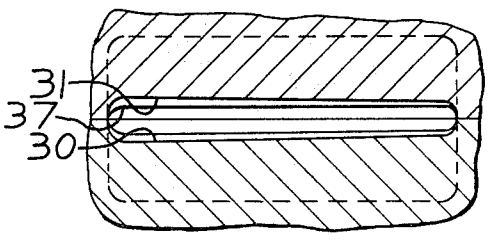
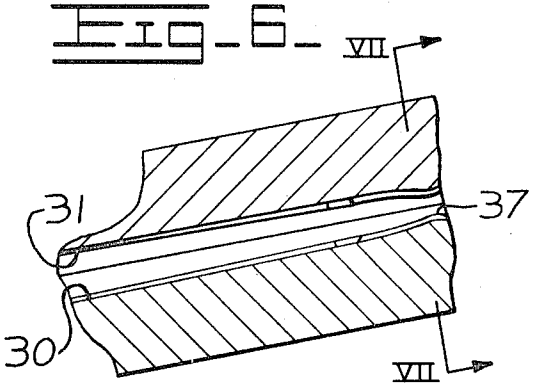


Fig-6-



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DIFFUSER INCLUDING VANELESS AND VANED SECTIONS

RELATED U.S. PATENTS

The present invention is described having reference to an earlier filed Pat. application, now U.S. Pat. No. 3,289,921 issued Dec. 6, 1966, to Shao L. Soo and assigned to the assignee of the present invention.

The present invention relates to a diffuser for use with a centrifugal compressor in various turbomachines to decrease velocity and increase pressure of fluid exiting the compressor impeller rotor. More particularly, the present diffuser includes an initial vaneless portion for reducing high Mach number flow (including transonic and supersonic fluid flow) from the rotor to lower Mach number flow while minimizing boundary layer losses. Fluid flow is delivered from the vaneless portion into a vaned diffuser portion defining multiple channels for achieving maximum pressure recovery with fluid flow from the vaned diffuser section being delivered to a suitable collector. Fluid flow through a diffuser constructed according to the present invention is subject to more accurate boundary layer control so that overall efficiency is increased within a given outer diameter diffuser envelope.

Conventional vaned diffusers of a type including a separator and collector or having multiple tangential channels are well known in the prior art. However, shock waves and pressure waves are commonly developed in these diffusers during supersonic and transonic fluid flow. These shock waves tend to disrupt the flow pattern through the diffuser and accordingly lower diffuser efficiency.

Accordingly, it is an object of the present invention to provide a compact diffuser capable of optimum pressure recovery.

It is a further object to accomplish such efficiency through the use of a first vaneless section within the diffuser followed by a vaned section.

It is a still further object to provide such a diffuser wherein at least a portion of the diffuser is characterized by a cross section which decreases and then increases in a manner suitable for maintaining fluid flow under a condition of imminent boundary layer separation.

It is a still further object to provide the decreasing and increasing cross section by means of opposing walls which converge toward each other and then diverge in a downstream direction.

It is another object of the invention to provide elements within the vaned diffuser section for forming multiple tangential channels to provide for increased pressure recovery within the diffuser.

It is still another object of the invention to form opposing surfaces of adjacent elements in parallel relation with radially spaced apart walls converging and then diverging within the vaned diffused section.

Other objects and advantages of the present invention are made apparent in the following description having reference to the accompanying drawings.

In the drawings:

FIG. 1 is a sectioned view of the compressor portion of a gas turbine engine including a diffuser constructed in accordance with the present invention;

FIG. 2 is a fragmentary, sectioned view taken from one side of FIG. 1 to illustrate a portion of the compressor impeller or rotor and the fluid path from the rotor through the diffuser;

FIG. 3 is a view taken along section lines III—III of FIG. 2;

FIG. 4 is a view taken along section lines IV—IV of FIG. 2;

FIG. 5 is an enlarged view of a portion of FIG. 2 to more clearly illustrate construction of the entry way into one of the multiple channels of the vaned diffuser sections;

FIG. 6 is a view taken along section lines VI—VI of FIG. 5, and

FIG. 7 is a view taken along section line VII—VII of FIG. 6.

A turbomachine of the type illustrated in FIG. 1 includes a compressor rotor 11. Fluid such as air enters the rotor from

region 12. Accelerated fluid exits the rotor at its periphery 13 and enters a diffuser 14 which is constructed according to the present invention. The diffuser 14 includes a vaneless portion or region generally indicated at 16 and a vaned region which is indicated at 17. The location and construction of the vaneless and vaned sections of the diffuser is described in greater detail below.

Fluid from the vaned diffuser section enters an annular collector 18. A portion of the fluid in the collector passes into a single combustion chamber 19 through a plurality of ports indicated at 21 and then into a chamber 22 from where the fluid passes into turbine means 23 in a generally conventional manner.

With the rotor 11 operating at its design speed, for example 28,800 rpm, the rotor may have a fluid absolute velocity at its peripheral exit 13 which is at least transonic and may be supersonic. The vaneless diffuser portion 16 reduces the fluid flow rate from supersonic or transonic speeds to a subsonic inlet speed suitable for the vaned diffuser portion. The diffuser section is an annularly open region wherein the shock waves do not tend to arise from the supersonic and transonic speeds of fluid flow. Thus, the fluid velocity may be reduced without introducing shock waves into the flow pattern of the diffuser.

Normally, shock waves arise due to interaction of supersonic or transonic fluid flow with vanes or blades in a vaned diffuser section. However, in the present diffuser the fluid velocity is reduced to subsonic speed before entering the vaned diffuser section. Thus, shock waves do not tend to be created and the vaned diffuser section is capable of providing maximum pressure recovery within a given diffuser envelope.

Referring now to FIG. 2 as well as FIG. 1, the vaneless diffuser section 16 is formed as an annularly open region between radially spaced apart walls 30 and 31. The vaneless section may be identified more accurately in FIG. 2 as lying between the periphery 13 of the rotor and a circle defined by the leading edges 32 of vane islands 33 within the vaned diffuser sections.

As may be seen in FIG. 1 but more clearly shown in FIG. 3, the radially spaced apart walls 30 and 31 converge together and then diverge slightly within the vaneless diffuser section.

The vaned diffuser section includes multiple channels 36 which are arranged in tangential relation to the rotor 11. Each of the channels 36 has a similar throat such as that indicated at 37 in FIGS. 2 and 4.

A transition section of the diffuser is formed generally between the annularly open vaneless region and the multiple channels 36 of the diffuser. The transition section delivers fluid flow from the annularly open region 16 into the respective channels 36. The transition section is formed generally of a plurality of triangularly shaped areas respectively located at the entry to each of the channels 36, one of these triangular areas of the transition section being more clearly shown in FIG. 5. Lines 41, 42 and 43 in FIG. 5 represent constant spacing between the walls 30 and 31. Having particular reference to FIGS. 5, 6 and 7, the transition section is contoured in a manner best illustrated in FIG. 6. As may be best seen in FIG. 6, the walls 30 and 31 diverge just upstream from the throat 37 in each of the channels 36. The manner in which the divergency between the walls 30, 31 extends between the vane islands or elements 33 may be seen by combined reference to FIGS. 5–7.

Referring again to FIG. 2, opposing walls, for example those indicated at 51 and 52 on adjacent vane elements 33 to form a channel 36 are preferably arranged in parallel relation. To form a cross section which decreases and then increases in a downstream direction through each channel 36, the radially spaced apart walls 30, and 31 within the vaned diffuser section are contoured in a manner best illustrated for example in FIG. 4. As seen in that figure, the walls converge together to form the throat 37 and then diverge in a downstream direction toward a chamber 53 for each channel which is in communication with the collector 18 (see FIG. 1). With reference to the vaned diffuser section, it is noted that the vane islands 33

could also be replaced by generally conventional blades or foils of a type used in conventional diffuser designs.

Having further reference to FIG. 2, it may be noted that the opposite surfaces **51, 52** of each vane island **33** are arranged in more nearly parallel relation for a portion of each vaned island which extends beyond one of the adjacent channels **36** into the diffuser transition section. Thus, the surface **51** of each vane island **33** is formed with an obtuse angle to allow for the parallel relation of the walls **51, 52** within the vaned diffuser section.

The converging diverging relation of the walls **30, 31** within the vaneless and vaned sections of the diffuser are selected to establish a condition of imminent boundary layer separation within the diffuser. General considerations and specific examples for establishing the convergent-divergent contour of opposing walls to maintain such a condition are set forth in greater detail in U.S. Pat. No. 3,289,921 referenced above.

Accordingly, the vaneless diffuser region accomplishes the purpose of reducing supersonic or transonic fluid flow to subsonic speeds without the introduction of shock waves or pressure waves. The vaned diffuser section may then operate at optimum efficiency to pressurize the fluid flow within a compact diffuser envelope. Maximum pressurization is achieved within the diffuser through the convergent-divergent contouring of the walls **30, 31** to maintain a condition of imminent boundary layer separation.

I claim:

1. In a turbomachine, a diffuser for conditioning fluid flow of at least transonic speed from a rotor and transmitting it to a collector means, the diffuser comprising

an annularly open region for receiving fluid flow from the rotor, the annularly open region being formed by spaced apart walls for conditioning fluid flow from the rotor,

a diffuser section comprising means forming multiple tangential channels for delivering fluid flow to the collector means, and

a transition section for delivering fluid flow from the annularly open region to the multiple channel diffuser section,

the annularly open diffuser region having a convergent-divergent configuration selected to produce a condition of imminent boundary layer separation, the transition section being configured for maintaining the condition of imminent boundary layer separation, each of the multiple channels also having a convergent-divergent configuration in a downstream direction selected to establish a condition of imminent boundary layer separation.

2. In a turbomachine, a diffuser for conditioning fluid flow of at least transonic speed from a rotor and transmitting it to a collector means, the diffuser comprising

an annularly open region for receiving fluid flow from the rotor, the annularly open region being formed by spaced apart walls for conditioning fluid flow from the rotor,

a diffuser section comprising means forming multiple tangential channels for delivering fluid flow to the collector means, and

a transition section for delivering fluid flow from the annularly open region to the multiple channel diffuser section,

at least a portion of the diffuser having a cross section which converges and then diverges in the direction of flow to establish and maintain a condition of imminent boundary layer separation in order to minimize boundary layer losses,

the initial portion of the annularly open diffuser region converging in the direction of flow for accelerating the velocity of fluid flow from the rotor,

the rotor being of a type for delivering fluid flow radially outwardly from its periphery, the spaced apart walls forming the annularly open region being arranged in substantially radial relation to the rotor, the multiple channel diffuser section means being a plurality of elements circumferentially arranged between walls spaced apart in substantially radial relation to the rotor, surfaces of the plurality of elements forming opposite sides of each channel being generally parallel, the spaced apart walls in the multiple channel diffuser section converging toward each other and then diverging in a downstream direction for producing a condition of imminent boundary layer separation.

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