This invention relates generally to centrifugal gas or vapor compressors and particularly to devices in which the gases re-enter the impeller in multiple stages from annular gas passages which are disposed axially around the impeller shaft centerline.

The main objective of this invention is to provide an improved means of interstage labyrinth sealing between the multistage rotating impeller and the stationary casing.

Another objective of this invention is to provide an improved impeller structural rigidity by means of spacer rings interposed between adjoining stages of the multistage impeller.

Re-entry type centrifugal compressors of the adjacent parallel flow type in the past have not been commercially marketed, because manufacturing costs were too high to obtain reasonable efficiencies. To achieve reasonable efficiencies interstage gas leakage must be minimized particularly at the outer periphery of the impeller. Since labyrinth seal leakage varies directly with the diameter of the seal it is important to minimize the diameter at the labyrinth seal interface.

The impeller of this type compressor in vicinity of the second and higher stages is conventionally supported in a cantilever manner from the main backplate of the first stage impeller. A rigid, reinforced impeller construction is desirable to allow the impeller stages to be bolted or riveted together so as to minimize axial wobble of the components as well as to minimize radial displacement of the components relative to shaft centerline. This rigid, reinforced construction of the cantilever supported impeller resists the distortion effects of centrifugal force and allows minimum vibration plus confining of the impeller to a more concentric shape which allows the labyrinth seal radial clearances to be held to a minimum with reduced labyrinth seal leakage. Labyrinth seal leakage varies approximately as the second power of this interface radial clearances.

Freon refrigerants when compressed exhibit a much higher degree of compressibility than air or monatomic gases. The machine to be described herein will be used primarily for compressing Freon refrigerants and as such the axial impeller vane width at impeller tip is considerably reduced in relation to vane axial width near the inlet with gas passages that are gradually tapered to narrower axial width as the gas flow progresses radially outward. These tapered gas passages for Freons are more pronounced than in air compressors and relatively large axial gaps are inherently required between adjacent stage endplates. An objective of this invention is to utilize these axial gaps as locations for interstage labyrinth seals and for impeller reinforcing spacer rings.

The foregoing and other objects and advantages of this invention will be clear to those skilled in the art from the following specification in connection with the attached drawings, in which:

FIGURE 1 is a perspective view of the compressor representing a preferred embodiment of the invention; and

FIGURE 2 is a vertical sectional view.

Referring to the drawings in which a preferred embodiment of the invention is disclosed, a conventional vertically positioned electric driving motor is referred to generally as M. Gas leakage along the motor drive shaft 10 is restricted by a labyrinth seal 12 that is secured to a bottom or base 14 that flares outwardly at 16 into a vertically disposed cylindrical compressor casing 18. The casing bottom or base 14 is apertured at 20 to receive the motor shaft 10. The casing 18 is gradually curved at 22 to merge into a flat section 24 projecting from the flared portion 16.

The compressor outer casing 18 has a cover 26 connected thereto by means of a plurality of bolts or attachment screws 27. A low pressure gas inlet pipe 28 projects through and is secured centrally to the cover 26. The connection of the cover 26 and inlet pipe 28 forms a gradually curved inner surface 29. The inlet pipe 28 depends downwardly to a point immediately adjacent a multistage centrifugal impeller, later to be described. The cover 26 also has secured and depending therefrom one or more high pressure gas outlet pipes 30.

A first stage impeller back plate 32 has a hub 34 keyed at 36 on the motor shaft 30. Secured to the back plate 32 are a multiple of first stage impeller vanes 38 projecting upwardly and diagonally outward therefrom. The multiple vanes 38 taper gradually toward the outer periphery of the backplate 32. A bell-shaped stage dividing member 40 is secured to and overlies the multiple impeller vanes 38. The inner upper edges of the central opening of the first division bell 40 have seal seating surfaces 42 that are either seated in or close proximity to coinciding surfaces 44 on a labyrinth seal ring 46 secured about the lower end of the lower pressure inlet pipe 28. The division bell 40 is gradually and concentrically curved at 48 into a gradual downward taper toward the outer periphery of the first stage back plate 32 and upon the similarly tapered multiple vanes 38. A first stage outer seal seat ring 56 having seating surfaces 52 is secured upon and adjacent the outer periphery of the first division bell 40. A second stage back plate 54 overlies the division bell 40 and is secured inwardly thereto at 56. The back plate 54 is supported on as well as attached to 58 to the first stage outer labyrinth seal ring 50.

The high pressure gases expelled from the constricted bladed peripheral openings 59 in the first stage multiple impeller are projected radially outward to the inner surface of the outer casing 18. An annular first stage diffusion chamber 60 is provided to contain the high pressure gases by means of a disk-shaped outer partition 62 within and spaced from the outer casing 18. The partition 62 is connected for assembly purposes in one plural manner designated 64 to an inner and upper circular disc partition 66 that is supported at 67 by one or both of the high pressure outlet pipes 30. The partition 62 is formed with a flat lower surface 68 that is fixedly sustained immediately adjacent the rapidly rotating peripheral edge of the second stage back plate 54. The flat surface 68 is curved concentrically and gradually at 70 to merge into vertical circular sides of the casing 62. The vertical sides are curved gradually at 74 to merge with and be connected in the plural bolted manner 64 to an outer annular peripheral edge 78 of the inner circular partition 66. The partition 66 is curved gradually at 79. The completely open concentric diffuser chamber 60 is formed to circulate the high pressure gas or vapor from the first stage of the multiple re-entry compressor generally designated C.

An outer stationary labyrinth seal ring 80 is secured to the under flat lower surface 68 of the outer partition or disc 62. The seal ring 80 has sealing surfaces 82 coinciding in conventional manner with the adjacent surface 52 on the first stage impeller outer labyrinth seal 50.
ring 50. The labyrinth sealing means herebefore described restricts any interstage gas leaks. The annular first stage diffusion chamber 60 directs the highside vapors radially outward, upward and inward to the second stage inlet annular space between walls of pipe 28. The gas flow is uninterrupted and gradually curved manner until it enters a bell-shaped inlet 86 of the second stage of the multistage compressor C.

The impeller outer labyrinth seal ring 50 is shown as a separated part. An alternate type construction would be to have the configuration of the labyrinth seal ring 50 formed as an integral part of either the first division bell 40, or as an integral part of the second stage back plate 54.

The second stage back plate 54 has a multiple of second stage impeller vanes 90 thereon which are radially disposed and taper outwardly in a manner similar to the first stage impeller vanes 38. The second stage vanes 90, however, are somewhat smaller than the vanes 38. A second stage division bell 92 overlies and is secured on the upper edges of the second stage impeller vanes 90. The bell 92 tapers outwardly and a series of inner edges 94 on an open centering ring 96 provide sealing surfaces with a thinning portion 98 on second stage stationary labyrinth seal ring 100 on the lower peripheral edge of the previously described upper and inner annularly disposed partition or disc 66. The bell 92 is gradually curved at 102 to provide the gas re-entry bell shaped opening 86. The first and second stage bells, 40 and 92 respectively, are curved and tapered in parallel planes to form smooth compressor re-entry gas passages or diffusion chamber 103. The second stage impeller compresses the gases through impeller passages which are slightly reduced in size and area. This second stage impeller size and area reduction is required to accommodate a gas which is compressed or flowing in the first stage impeller. A third stage impeller back plate 104 is secured at its inner edge 106 to the bell 92 and at its outer end is attached upon a second stage outer labyrinth sealing ring 108. A second concentric disc or partition 110 positioned inwardly of the first outer partition 62 has its upper inner edge 112 bolted in a plural manner at 114 to the outer peripheral edge 116 of a second upper and inner disc shaped partition 118. The disc 118 is secured to and supported at 120 by one of the high pressure outlets 30. The second partition 110 has a lower flat side 132 and an inner circular edge 124 which assumes a stationary position immediately adjacent the rotating peripheral edge of the back plate 104. A stationary circular sealing ring 126 is attached to the upper side of the flat surface 122 and the inner edges 128 thereof coincide in the usual manner with the sealing surfaces on the second stage labyrinth outer seal ring 24. As stated before, the labyrinth sealing devices restrict interstage gas leakage.

The movement of the compressor vapors in the second stage of the compressor C is exactly the same as described for the first stage. The third stage impeller back plate 104 has also a series of multiple impeller blades 136 thereon which are somewhat smaller but formed in exactly the same manner as first and second stage vanes 38 and 90 respectively. A third stage division bell 138 smaller but of larger inside diameter and formed the same as the first and second stage bells, has an integral round rim 140 that also has sealing surfaces 142 thereon. The upper and inner second stage disc-like partition 118 has a stationary labyrinth sealing ring 144 on its lower edge that engages the sealing surfaces 142. An annular open faced disc 146 of torous of doughnut shape is supported from one of the high pressure outlets 30. The disc 146 has a third said labyrinth seal seating surfaces of said spacer rings, for the purpose of minimizing interstage gas leakage.

2. A device as claimed in claim 1 wherein a multistage impeller with gas passages having a large axial width near
impeller gas inlet and a relatively smaller axial width near impeller gas outlet, partitions enclosing gas passages, said passages to have a gradually downward taper toward the outer periphery, said partitions to define the differences in said axial widths of impeller inlet and impeller outlet, labyrinth packing located between tapered partitions of subsequent impeller stages, said packing occupying an axial width approximately equal to the difference between the axial widths of said impeller gas inlet and said gas outlet, whereby the assembly of the impeller with tapered gas passages does not require any increase in overall impeller axial width to provide axial space for the labyrinth packing.

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