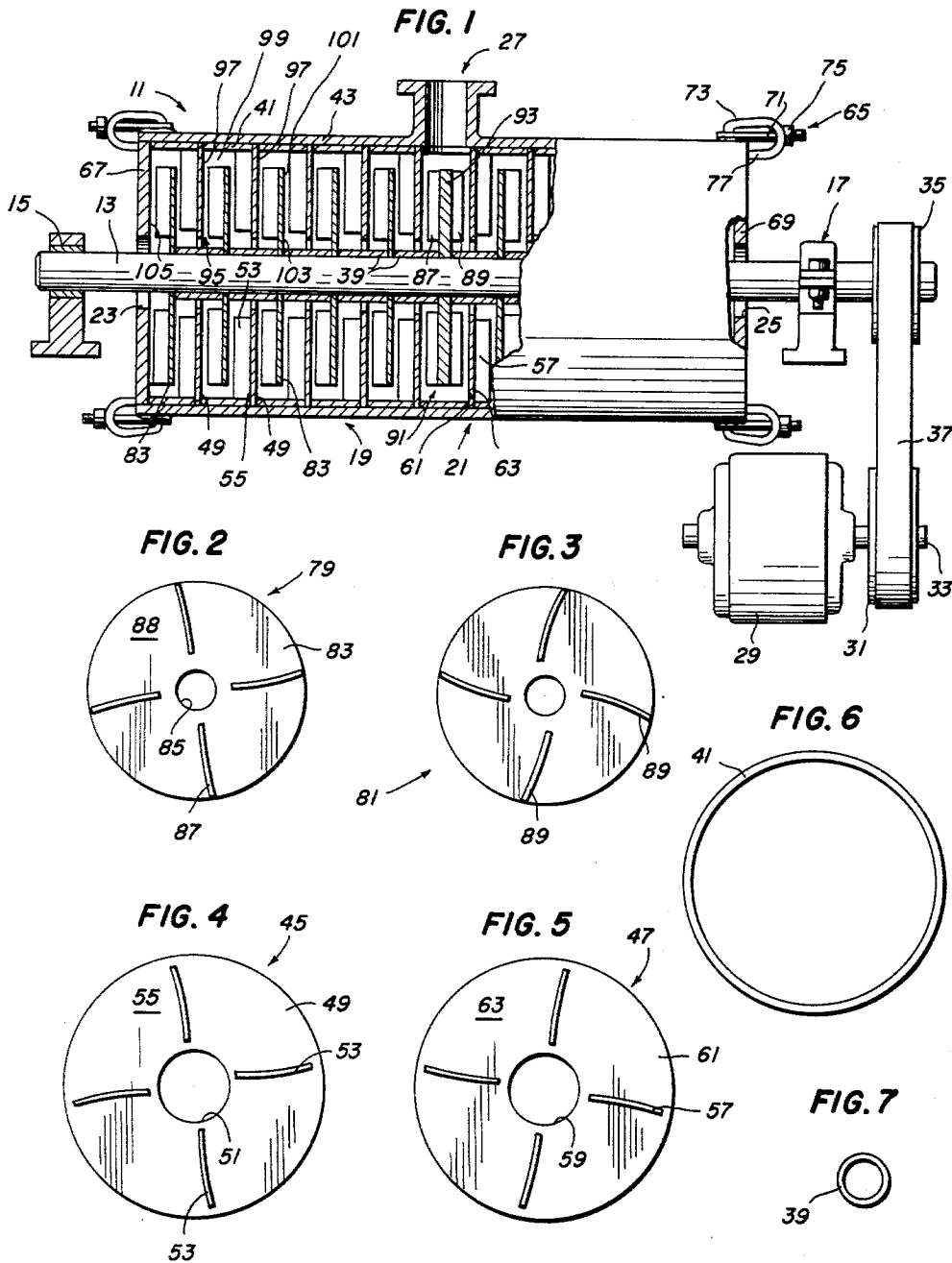


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A. M. CALDWELL
MULTI-STAGE COMPRESSOR

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1

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MULTI-STAGE COMPRESSOR

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This invention relates to a multi-stage compressor of the type for compressing gases, such as air, oxygen, and the like.

Heretofore, compressors of the above-mentioned type have been relatively complicated and expensive. For example, in the usual type of compressor for compressing oxygen, there are many moving parts, such as pistons, valves, levers, etc., and the cost usually runs into several tens of thousands of dollars. Also, there are many problems involved. For example, in the compression and liquification of oxygen, there is the danger of explosion, and consequently there is the necessity of using soap-suds for the lubricant in place of oil, since if oil were used, it might come in contact with the oxygen and cause an explosion. In addition, in the piston type of compressor, there are many losses which reduce the efficiency of the compressor. The present invention is directed towards overcoming the above-mentioned and other disadvantages in compressors.

Thus, one of the objects of the present invention is to provide a simple, yet highly efficient and relatively inexpensive, compressor for compressing gases, such as air, oxygen, and the like.

A further object is to provide a multi-stage compressor which includes a single rotor.

A further object is to provide such a compressor which has the bearings of the rotor on the exterior of the casing of the compressor and consequently needs no lubrication in the interior of the casing.

A further object is to provide such a compressor that can be easily added to in order to increase the compression thereof.

A further object is to provide such a compressor that has two opposing portions so that no thrust bearings are required.

A further object is to provide such a compressor wherein the compression can easily be regulated by changing the r.p.m. of the rotor.

A further object is to provide such a compressor in which the losses are at a minimum and which runs substantially free when the compressed gases are not being drawn off.

A further object is generally to improve the design and construction of compressors.

The means by which the foregoing and other objects of the present invention are accomplished and the manner of their accomplishment will be readily understood from the following specification upon reference to the accompanying drawings, in which:

FIG. 1 is a side elevational view of the device of the present invention, with parts broken away and sectionalized for purposes of illustration.

FIG. 2 is an end elevational view of one of the rotatable units in the left-hand portion of the device of FIG. 1.

FIG. 3 is an end elevational view of one of the rotatable units in the right-hand portion of the device of FIG. 1.

FIG. 4 is an end elevational view of one of the stationary units in the left-hand portion of the device of FIG. 1.

FIG. 5 is an end elevational view of one of the stationary units in the right-hand portion of the device of FIG. 1.

FIG. 6 is an end elevational view of one of the outer sleeves of the device of the present invention.

FIG. 7 is an end elevational view of one of the inner sleeves of the device of the present invention.

2

Referring now to the drawings in which the various parts are indicated by numerals, the compressor 11 of the present invention comprises, in general, a horizontal shaft 13, a pair of spaced support bearings 15, 17 adjacent opposite ends of the shaft and rotatably supporting the shaft, a first series of compressor stages 19 located around shaft 13 in one-half of the compressor 11 (the half to the left in FIG. 1), and a second series of compressor stages 21 equal in number to the stages 19 and located around the shaft on the opposite half of the compressor 11 (the half to the right in FIG. 1). Compressor 11 has two opposed inlet openings at the opposite ends of the compressor, shown as at 23 and 25, and an outlet opening 27 for the compressed gas located in the middle of compressor 11. Means is provided for rotatably driving shaft 13 in a clockwise direction as viewed from the end to the left in FIG. 1 and preferably includes a motor 29 having a pulley 31 on the shaft 33 thereof which rotatably drives pulley 35 by means of the continuous drive belt 37, and which pulley 35 is fixedly mounted on shaft 13 to cause rotation thereof.

Compressor 11 is preferably of built-up or composite construction so that additional stages 19, 21 can be added to increase the compression. Thus, a plurality of equal length inner sleeves 39, which act as spacers in a manner later to be described, are fitted over shaft 13 along the length thereof. A plurality of enlarged outer sleeves 41, which are concentric with shaft 13 and spaced outwardly from inner sleeves 39, are fitted into an outer cylindrical casing 43, which is also concentric with shaft 13.

A plurality of stationary units 45, 47 are provided in spaced apart relationship along the interior of casing 43, with the outer peripheral edges of the units being disposed between adjacent pairs of outer sleeves 41. Stationary units 45 are located in the belt half of compressor 11, as viewed in FIG. 1, and stationary units 47, which are equal in number to stationary units 45, are located to the right, as viewed in this figure. Each of the stationary units 45 includes a stationary circular plate 49 having a central hole 51 of a larger diameter than shaft 13 and inner sleeve 39 and through which the shaft with the inner sleeves thereon extends in spaced relationship thereto. Each of stationary units 45 additionally includes a plurality of circumferentially spaced and generally radially extending arcuate blades 53 that are fixedly mounted on the upstream face 55 (face to the left in FIG. 1) of plate 49. Each of the blades 53 extends from adjacent central hole 51 in a slightly counterclockwise curved path, as viewed in FIG. 4, to a place adjacent but spaced from the outer periphery of plate 49 and adjacent outer sleeve 41. Each of the blades 53 also extends substantially perpendicularly to the left, as viewed in FIG. 1, of upstream face 55. In addition, each of blades 53 is preferably of a constant width, as best seen in FIG. 1.

Stationary units 47 are of similar construction to stationary units 45, except that the blades 57 thereof are reversed in their arcuate paths, that is, as viewed in FIG. 5, the blades 57 curve clockwise from adjacent the central hole 59 in plate 61 towards the outer peripheral edge thereof. Also, it will be noted that the upstream face 63 of the plate 61 is to the right-hand side of the plate as viewed in FIG. 1.

Units 45, 47 are held fixed in outer casing 43 by suitable means as by the clamps 65 which press inwardly on the opposite circular ends 67, 69 of compressor 11 to clamp outer sleeves 41 and the outer peripheries of stationary units 45, 47. Each of the clamps 65 preferably includes a threaded stud 71 fixedly mounted on casing 43 adjacent the end thereof and a substantially L-shaped member 73 having an aperture therein through which the

stud 71 extends and which has a nut 75 threadedly engaged on stud 71. It will be understood that by turning nuts 75, the portions 77 of L-shaped members 73 will urge inwardly on the circular ends 67, 69.

A plurality of rotary units 79, 81 are alternated with stationary units 45, 47 and are respectively mounted on shaft 13 between adjacent inner sleeves 39 for rotation with the shaft. The rotary units 79 are located in the left half of compressor 11, as viewed in FIG. 1, and the rotary units 81 are located in the right half of the compressor, as viewed in this figure. Each of the rotary units 79 includes a circular plate 83 having a central hole 85 therein through which shaft 13 extends. Plate 83 is concentric with shaft 13, and the inner peripheral portions of the circular plate 83 adjacent central hole 85 are disposed between an adjacent pair of inner sleeves 39. The circular plate 83 is fixedly mounted on shaft 13 for rotation therewith, as by suitable means such as suitable clamping means, not shown, or by preferably welding the circular plate 83 to shaft 13. In addition, rotary unit 79 includes a plurality of blades 87 fixedly attached to plate 83 on the upstream face 88 thereof and similar in construction and arrangement to blades 53. Thus, blades 87 curve counterclockwise, as viewed in FIG. 2. Similarly, the rotary unit 81 includes blades 89 similar to the arrangement and construction of blades 57, and thus curve clockwise, as viewed in FIG. 3. Rotary units 79, 81 are concentric with shaft 13 and are smaller in diameter than the inside diameter of outer sleeves 41 so that there is space therebetween. Also, the rotary units 79, 81 are spaced from the adjacent stationary units 45, 47.

The central rotary unit 91 is preferably a combination of one rotary unit 79 and one rotary unit 81, that is, the rotary unit 91 preferably includes a circular plate 93 which is of double thickness to correspond to the combined thicknesses of the circular plates of rotary units 79, 81, and the blades 87, 89 are disposed on opposite sides of plate 93, as best seen in FIG. 1.

It will be understood from the foregoing description that compressor 11 is made up of a plurality of compressor stages 19, 21, with the compressor stages being established by the following: For each of compressor stages 19, there is an upstream portion having an inlet opening therein, which, for the end one of the compressor stages 19, comprises end 67 with inlet opening 23 and, for the other compressor stages 19, comprises a plate 49 with the hole 51 therein. Also, for each compressor stage 19, there is a first passageway 95 defined by the space between the downstream face 97 of the preceding or upstream plate 49 (except for the end one to the left) and plate 83 for the gas to move from the inlet outwardly towards the outer periphery of the rotary unit 79. Also, it will be understood that a second passageway 99 is established between the outer periphery of rotary unit 79 and outer sleeve 41 for the gas to move around the edge of the rotary unit to the backside or downstream side thereof. In addition, it will be understood that a third passageway 101 is established between the downstream face 103 of plate 83 and the upstream face 55 of plate 49 for the gas to pass to the central opening 51 which serves as an exit for one stage and the entrance to the next stage. It will be understood that the first passageway 95 for the first stage 19 to the left in FIG. 1 is established between the downstream face 105 of end 67 and the upstream face 88 of circular plate 83. Also, it will be understood that, for the central compressor stage, there is no third passageway, but the compressed gas simply exits through outlet opening 27. In addition, it will be understood that a suitable cooling jacket, not shown, of well known construction is preferably provided around casing 43. Further, it will be understood that the three above mentioned passageways are provided for each of the compressor stages 21 in a manner similar to that heretofore described for each of compressor stages 19, but with the gas flow being opposite and in towards the middle for the two halves of the compressor 11.

From the foregoing description it will be seen that the compressor 11 of the present invention provides a simple, yet highly efficient and relatively inexpensive compressor for compressing gases. In addition, it will be understood that such a compressor can be readily and easily added to for increasing the compression thereof, and which is extremely compact as compared with previous compressors. Also, such a compressor is provided in which no lubrication is needed on the interior thereof, thereby eliminating any danger in compressing gases such as oxygen, and such a compressor is provided in which the compression can be easily regulated by changing the r.p.m. of the rotor.

Although the invention has been described and illustrated with respect to a preferred embodiment thereof, it is to be understood that it is not to be so limited since changes and modifications may be made therein which are within the full intended scope of this invention as hereinafter claimed.

I claim:

1. A compressor for gases comprising a casing, a horizontal shaft, extending through said casing, a pair of spaced support bearings rotatably supporting said shaft, exhaust means located adjacent a place intermediate the ends of said shaft, a plurality of stationary plates disposed in said casing, a plurality of outer sleeves in said casing alternated with said plates and engaging opposite sides of said plates, a first series of compressor stages located around said shaft on one side of said exhaust means, a second series of compressor stages located around said shaft on the opposite side of said exhaust means from said first series, a first inlet means for said first series located remote from said exhaust means, a second inlet means for said second series located remote from said exhaust means and said first inlet means, said first series and said second series of compressor stages being in equal and opposing relationship to cancel any end thrust thereof on said shaft, means operably coupled to said shaft for the rotation thereof; each of said compressor stages comprising one of said stationary plates, an upstream portion having a central aperture, said upstream portion being mounted around said shaft with said shaft extending through said aperture and spaced from said upstream portion to provide an inlet, a circular rotary plate having a central hole therein and having an upstream face remote from said exhaust means, said rotary plate having fixedly mounted on said shaft and being spaced downstream of said upstream portion to establish a first passageway for the gas to move, a plurality of first blade means mounted on said upstream face of said rotary plate for causing the gas to move outwardly through said first passageway towards the outer periphery of said rotary plate upon rotation of said shaft to compress the gas, said rotary plate being smaller in diameter than said casing to provide a second passageway for the gas to move around the outer periphery of said rotary plate towards said exhaust means, said one of said stationary plates having a central opening, said one of said stationary plates being disposed in concentric relationship to said shaft and adjacent the downstream end of said outer sleeve and downstream of said rotary plate with said shaft extending through said central opening in spaced relationship to said one of said stationary plates to provide an exit, said one of said stationary plates having an upstream face adjacent and spaced from said rotary plate to provide a third passageway, fixed blade means mounted on said upstream face of said one of said stationary plates to direct the gas from said second passageway inwardly through said third passageway to said exit.

2. A compressor for gases comprising a casing, a horizontal shaft, extending through said casing, a pair of spaced support bearings rotatably supporting said shaft, exhaust means located adjacent a place intermediate the ends of said shaft, a plurality of stationary plates disposed in said casing, a plurality of outer sleeves in said casing alternated with said plates and engaging opposite

5

sides of said plates, a first series of compressor stages located around said shaft on one side of said exhaust means, a second series of compressor stages located around said shaft on the opposite side of said exhaust means from said first series, a first inlet means for said first series located remote from said exhaust means, a second inlet means for said second series located remote from said exhaust means and said first inlet means, said first series and said second series and said second series of compressor stages being in equal and opposing relationship to cancel any end thrust thereof on said shaft, means operably coupled to said shaft for the rotation thereof; each of said compressor stages comprising one of said stationary plates, an upstream portion having a central aperture, said upstream portion being mounted around said shaft with said shaft extending through said aperture and spaced from said upstream portion to provide an inlet, an inner sleeve mounted on said shaft, an enlarged outer sleeve concentric with said shaft and said inner sleeve and spaced outwardly from said inner sleeve and located downstream of said upstream portion, a circular rotary plate having a central hole therein and having an upstream face remote from said exhaust means, said rotary plate being mounted on said shaft adjacent the upstream end of said inner sleeve with said shaft extending through said central hole and with said rotary plate being spaced downstream of said upstream portion to establish a first passageway for the gas to move, a plurality of first blade means mounted on said upstream face of said rotary plate for causing the gas to move, a plurality of first blade means mounted on said upstream face of said rotary plate for causing the gas to move outwardly through said first passageway towards the outer periphery of said rotary plate upon rotation of said shaft to compress the gas, said rotary plate being smaller in diameter than said outer sleeve to provide a second passageway for the gas to move around the outer periphery of said rotary plate towards said exhaust means, said one of said stationary plates having a central opening, said one of said stationary plates being disposed in concentric relationship to said shaft and adjacent the downstream end of said outer sleeve and downstream of said rotary plate with said shaft extending through said central opening in spaced relationship to said one of said stationary plates to provide an exit, said one of said stationary plates having an upstream face adjacent and spaced from said rotary plate to provide a third passageway, fixed blade means mounted on said upstream face of said one of said stationary plates to direct the gas from said second passageway inwardly through said third passageway to said exit.

3. A compressor for gases comprising a cylindrical casing including opposite circular ends respectively having central holes there through; a shaft extending axially through said casing, through said central holes in spaced relationship to said ends to establish opposed inlets for said compressor, and extending beyond said ends; bearing means located outside of said casing and rotatably

6

supporting said shaft, means coupled to said shaft for the rotational drive thereof, exhaust means for said casing located adjacent the mid-portion thereof to divide said compressor into a first half between said exhaust means and one of said circular ends and a second half between said exhaust means and the other of said circular ends, a plurality of inner sleeves mounted on said shaft, a plurality of outer sleeves mounted in said casing spaced outwardly of said inner sleeves, a plurality of stationary plates respectively mounted between adjacent ones of said outer sleeves with said outer sleeves respectively engaging opposite sides of said stationary plates and said stationary plates respectively having central circular holes through which said shaft and said inner sleeves pass in spaced relationship to said stationary plates, a plurality of rotary plates respectively fixedly mounted on said shaft between adjacent ones of said inner sleeves and alternated with said stationary plates and in spaced relationship thereto, a plurality of arcuate blade means mounted on one of the sides of each of said rotary plates and stationary plates with the blade means in said first half being mounted on the sides of said rotary plates and stationary plates towards said one of said circular ends and the blade means in said second half being mounted on the sides of said rotary plates and stationary plates towards said other of said circular ends for causing the gases to move inwardly from said opposed inlets, radially outwardly of said rotary plates, around the peripheral edges of said rotary plates and inwardly between said rotary plates and said stationary plates and so on towards said exhaust means where the compressed gases are exhausted.

4. The compressor of claim 3 in which is provided clamping means mounted on said casing and respectively engaging said opposite circular ends to clamp said outer sleeves and the outer peripheries of said stationary plates there between.

5. The compressor of claim 3 in which said means coupled to said shaft drives said shaft in a clockwise direction as viewed from said one of said circular ends, said blade means in said first half curve counterclockwise from adjacent said shaft outwardly as viewed from said one of said circular ends, and said blade means in said second half curve clockwise from adjacent said shaft outwardly as viewed from said other of said circular ends.

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