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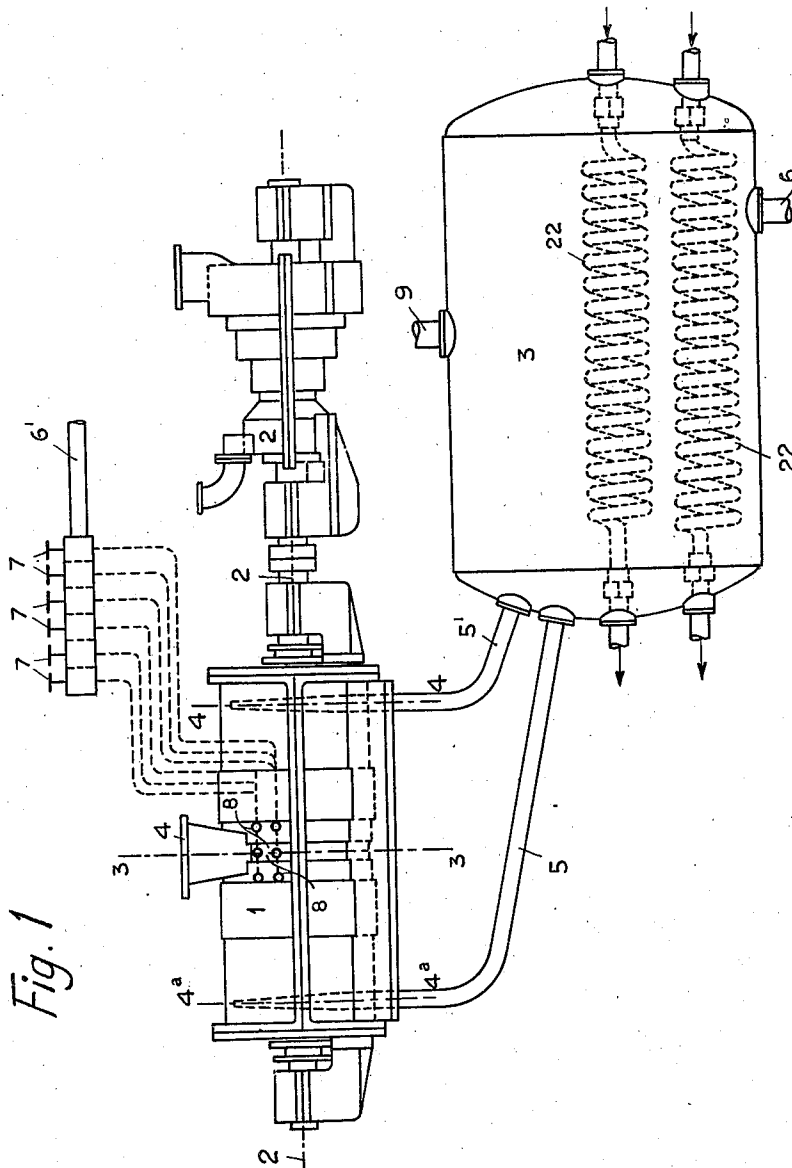
E. VIANELLO

1,751,537

APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

Filed July 9, 1926

5 Sheets-Sheet 1



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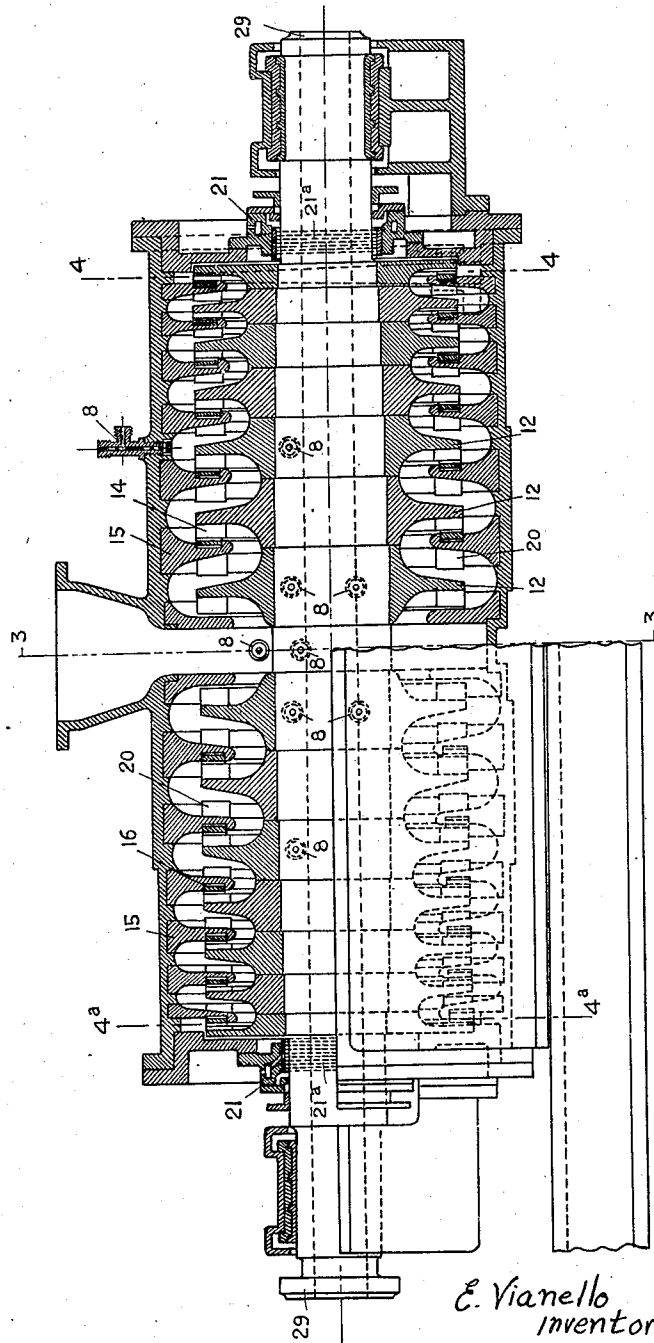
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APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

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5 Sheets-Sheet 2

Fig. 2



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APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

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5 Sheets-Sheet 3

Fig. 3

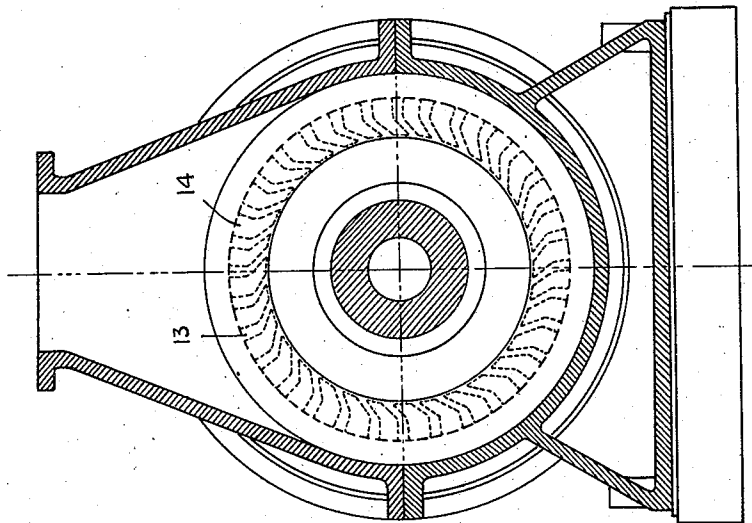


Fig. 4

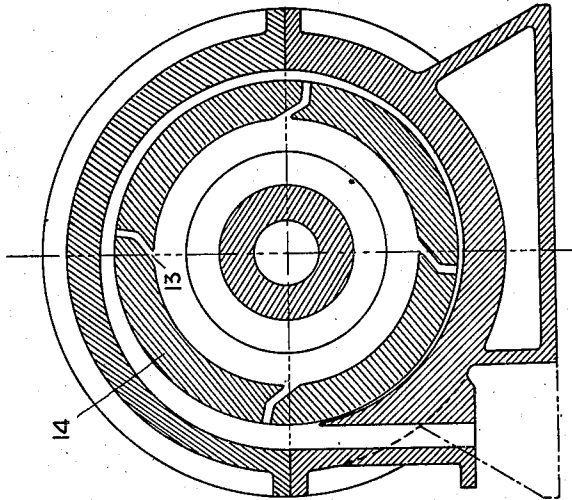


Fig. 5

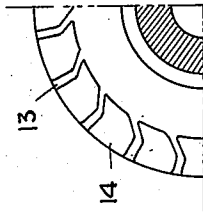
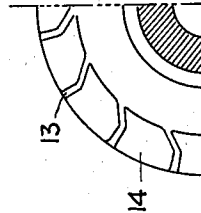


Fig. 6



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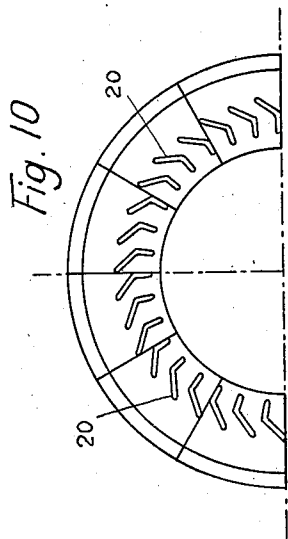
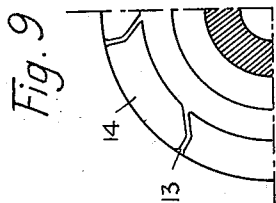
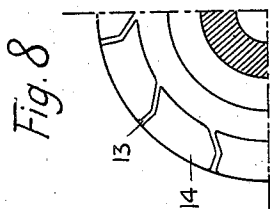
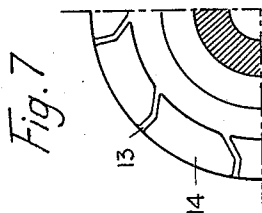
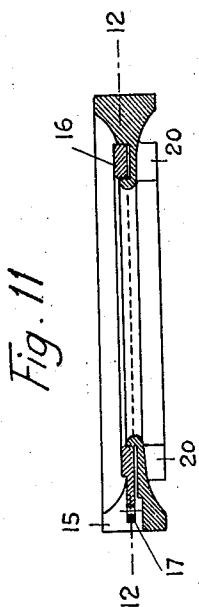
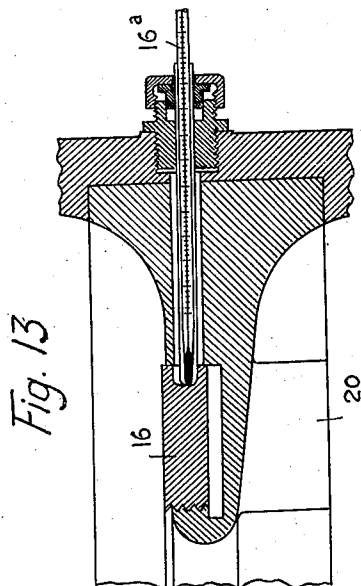
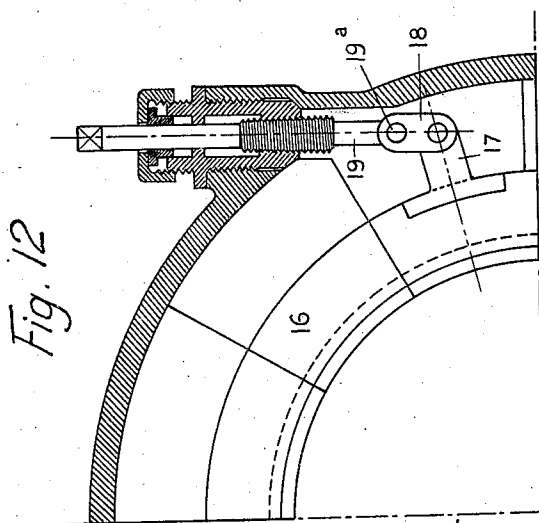
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APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

Filed July 9, 1926

5 Sheets-Sheet 4



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APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

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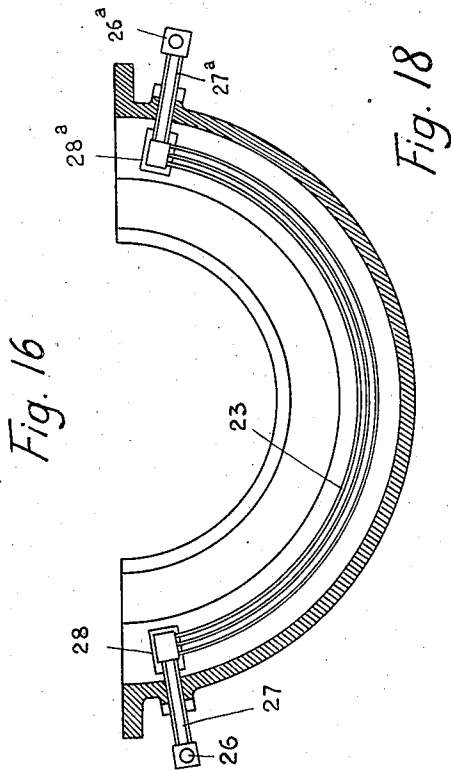


Fig. 18

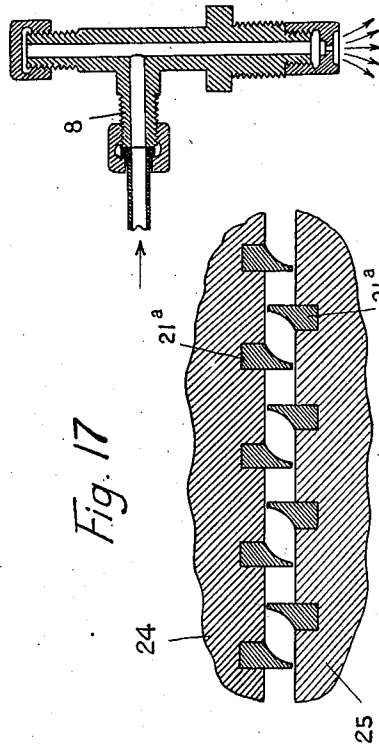


Fig. 17

Fig. 15

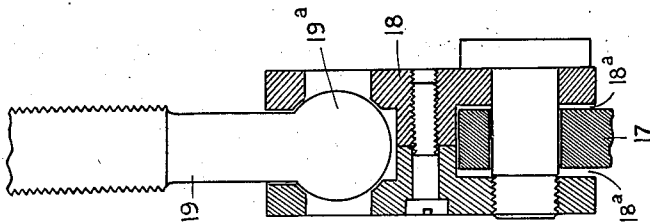
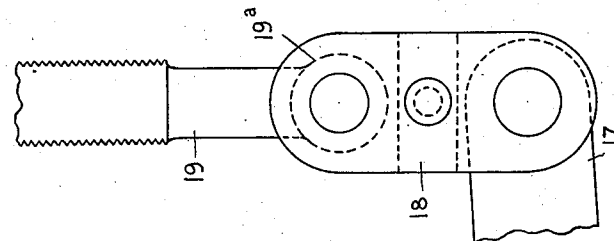


Fig. 14



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UNITED STATES PATENT OFFICE

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APPARATUS FOR COMPRESSING AIR, GASES, OR VAPORS

Application filed July 9, 1926, Serial No. 121,455, and in Italy February 25, 1921.

The present application is a continuation in part of my former application 596,487.

The invention relates to a multistage turbine-compressor for air, gas or vapors.

5 The object of this invention is to provide a turbo-compressor capable of producing a very high rate of compression with a large efficiency.

10 A further object is to secure a simultaneous high compression of fluid in aeriform and liquid condition.

15 To the end of increasing the rate of compression and the efficiency of the turbo-compressor, devices have already been proposed but none of the proposed types is adapted to work with efficiency at the very high speed required in centrifugal compressors destined to achieve a very large rate of compression because no proper means are provided for
20 preventing the retrograde motion of the fluid to be compressed throughout the clearance, or which allow a very extended reduction of the passageways through the impellers and in the same time to keep very high the
25 centrifugal force.

My improved turbo-compressor comprises a number of rotating wheels adapted for a very high angular speed, each rotating wheel being a pressure stage of the turbo-compressor
30 and being formed of a disk having a rim which projects towards the suction side or the turbo-compressor, this rim being provided with one or more ports or narrow passageways, the direction of which is radial at the outlet side and makes an angle of 50 degrees to 60 degrees with the radius at the inlet inside

35 The area of the cross section that these passageways present between the entrance and the exit of each passageway, is calculated in such a way as to ensure that the volume and pressure of every kilogram or fluid passing through them during the normal working of the turbo-compressor, remain between the
45 limits established by the laws of the adiabatic or isothermal compression of air, gas or vapors. Owing to the great reduction in volume required for a very extensive rate of compression, the reduction of the total area
50 of the cross-section of the passageways

through the rims of the rotating wheels is ensured, by decreasing from wheel to wheel the axial extent of the rims and also the ratio of the circumferential total extent of the passageways to the whole circumference of the wheel. In this way it is possible to keep very high the centrifugal effect, also in case the capacity by volume of the ports must be very reduced.

55 In the rotating wheels, the total area of the passage way through the ports must be extremely reduced for the necessity of conforming with the said laws. Further, it must be noted that the said high effect may be also ensured in cases in which the turbo-compressor must be adapted for a small capacity of fluid to be delivered per minute.

60 In order to ensure perfect tightness of the rotating ports, there are stationary diaphragms fixed at the inner side of the casing of the turbo-compressor which are extended inwardly as far as the inner edge of the rotating rims which carry the ports. These diaphragms are provided on their high-pressure side with packing rings
70 screwed in the body of the diaphragms, means being provided to move the packing rings towards and away from the rim of the corresponding rotating wheel, from the outside of the casing so as to form a tight wall at the low pressure side of the ports crossing the rim of each rotating wheel. The stationary diaphragms on their low pressure side are provided with deflectors which direct the fluid along a line which makes an angle of
80 50 to 60 degrees with the radius at the outer periphery and run along the radius at the inner periphery of the deflectors.

85 There are also provided mechanical atomizers by means of which water is injected in proximity to the suction end of the turbo-compressor, the arrangement being such as to form a mixture of steam and water containing at least sixty per cent by weight of water in case an adiabatic compression of saturated steam is to be accomplished, so that a gradual condensation of the steam in the turbo-compressor will take place. It is known in fact, that in any adiabatic com-
90 10

pression of saturated steam a condensation of the steam is produced when the fraction of steam weight in the mixture at the beginning of the compression is about 0.4 or less and that there will be an evaporation of the water contained in the mixture in case the fraction of steam weight in the mixture is more than about 0.4. In case of an isothermal compression of air or permanent gas so much water will be injected as is sufficient to keep the temperature nearly constant.

The invention will now be described with reference to the accompanying drawings, which illustrate by way of example, an apparatus for carrying out my invention and in which:

Fig. 1 shows the general arrangement of the apparatus in which the turbo-compressor is driven by a steam turbine.

Fig. 2 shows a vertical sectional view on line 2—2 of Fig. 1.

Fig. 3 is a sectional view on line 3—3 of Fig. 1 and Fig. 2.

Fig. 4 is a sectional view on line 4—4 or 4^a—4^a of Figures 1 and 2.

Figures 5, 6, 7, 8 and 9 are partial views of the second, third, fourth, fifth and sixth (low pressure to high pressure side) rotating wheels of the turbo-compressor.

Fig. 10 is a partial view of a stationary diaphragm of the turbo-compressor.

Fig. 11 is an axial sectional view of a stationary diaphragm in which a regulating gear is provided.

Fig. 12 is a partial cross sectional view on line 12—12 of Fig. 11.

Fig. 13 is a partial axial sectional view of a stationary diaphragm.

Fig. 14 is an enlarged side view of a detail.

Fig. 15 is a sectional view of the same.

Fig. 16 is a fragmentary sectional view of the casing of the turbo-compressor showing a nest of cooling tubes.

Fig. 17 is an enlarged fragmentary sectional view of one of the packing glands of the turbo-compressor.

Fig. 18 is an enlarged view of an atomizer relating to Fig. 2.

The complete apparatus as represented in Fig. 1 includes the following parts:

The turbo-compressor 1, the steam turbine 2, the receiver 3 and the atomizers 8, 8.

The working of the apparatus proceeds as follows:

The centrifugal multistage compressor 1 driven by the steam turbine 2 aspires the aeriform fluid by means of the suction pipe 4 and delivers the compressed fluid to the receiver 3 by means of the pipes 5 and 5' and through an internal tubular extension, which directs the fluid towards the bottom of the receiver. During the compression the temperature of the fluid is kept within the established limits by means of an injection of

water very finely atomized through the atomizers 8, 8 which are arranged on the casing.

A section of an atomizer 8 is shown in Fig. 2 and Fig. 18.

In case an adiabatic compression with saturate vapor is to be effected, the atomizers 8, 8 are used in order to form at the suction side of the turbo-compressor, a mixture of vapor and liquid having the initial required quality.

In case of an isothermal compression with air or permanent gases the atomizers are controlled in such a way as to keep the temperature nearly constant; but of course in case of an adiabatic compression of permanent gases the mechanical atomizers are not to be used.

The atomized liquid is intimately mixed with the aeriform fluid owing to the whirling effect exerted on the fluid by the rotating wheels, the angular speed of which is kept very high.

In case of an isothermal compression of air the liquid which drops to the bottom of the receiver 3 is impelled by the differential pressure or by means of a pump through the pipe 6 to a cooler in which its temperature is decreased or is rejected in the surroundings and lost. From the cooler or the surroundings the water returns to the atomizers through the pipe 6' and valves 7, 7, 7. At the same time the compressed aeriform fluid, by means of the pipe 9 placed at the upper part of the receiver, passes to the apparatus for the intended utilization.

The shaft 29 of the compressor (see Fig. 2) is hollow and has such a size as to withstand with safety the exceptional stress to which it is subjected owing to the high number of revolutions per minute. The rotating wheels 12 are each made in one piece and pressed and keyed on the shaft. They are arranged in two equal sets, each set comprising seven wheels symmetrically disposed with respect to the line 3—3 so that the axial thrusts on the shaft are counterbalanced and the fluid is compelled to flow from the middle section 3—3 towards the sections 4—4 and 4^a—4^a.

Figures 3, 4, 5, 6, 7, 8, 9 show the ports or passageways 13, 13 crossing the rim 14 of the rotating wheels 12. These figures and Figure 2 show that the ports are directed as before described with respect to the radius and that the cross sections of the ports in their entirety on each rim, decrease from wheel to wheel owing to the reduction in the axial length of the ports or passage-ways (Fig. 2) and also owing to the reduction of the ratio of the sum of the circumferential extent of the passageways in each rotating wheel to the whole circumference of the wheel.

The stationary diaphragms 15, 15 prevent the fluid from returning to the low pressure side. They are made of cast iron or bronze

of two or more segments fixed on the casing. Owing to the presence of such diaphragms between each wheel and the next, a tight stationary large passage is created, limited by the diaphragms, the casing and the back of each rotating wheel.

In order to secure tightness of the rotating ports 13, the stationary diaphragms are provided with packing rings 16, 16 screwed in the body of the diaphragms (see Figures 11, 12 and 13). By means of the arm 17 fixed to the ring, a connecting rod 18 and the threaded rod 19 it is possible from the outside of the casing of the turbo-compressor to rotate the ring 16 and consequently to move it more or less toward the rim of the rotating wheel with which it cooperates. A universal joint 19^a, shown in detail in Figures 14 and 15, is provided between parts 18 and 19 to permit this. The clearance space 18^a allows the packing ring 16 to move axially two or three millimeters. All the diaphragms being provided with such a device, it will be possible to regulate exactly and separately for each diaphragm the clearance between the packing rings and the rims of the rotating wheels and so to correct any defect of construction and compensate the variation in the relative position of the moving and stationary parts depending on the thermal effects during the working of the turbo-compressor. Any excessive approaching of the rings 16, 16 towards the rim of the rotating wheels will be indicated by the indications of thermometers 16^a arranged as shown in Fig. 13.

Each ring is for practical convenience divided into a number of sectors (two or more) equal to the number into which each diaphragm 15 is divided.

The diaphragms 15, 15 on their low pressure sides are provided with deflectors 20, 20 (Figures 2 and 10) situated in an annular circumferential zone, which zone corresponds as regards the internal and external diameters with the zone of the corresponding rotating ports. These deflectors direct the fluid from the free space into which every rotating wheel discharges, towards the center of the next rotating wheel. They make an angle of about 60 degrees with the radius at the outer periphery and run towards the center at the inner periphery, as shown in Fig. 10.

The auxiliary steam turbine 2 that drives the turbo-compressor is of the ordinary type. It has no peculiarity of any importance. It must be adapted to rotate the turbo-compressor at a very high speed.

The receiver 3 is provided with a man-hole, pressure gauge and a thermometer (not shown). In the lower part it may be provided, if necessary, with a nest of tubes 22 destined to be subjected to the circulation of

cold water to refrigerate the compressed fluid coming from the pipe 5, 5'.

The final pressure which may be reached with the compressor depends on the diameter and number of rims and the number of revolutions per minute.

If the compressor discharges to the atmosphere, there may be effected a very large rarefaction in an air-tight space from which it draws and in this case the compressor will act as a vacuum pump.

In case of an isothermal compression of air or a permanent gas the subtraction of heat necessary for keeping constant the temperature may be effected by means of nests of cooling tubes 23 (Fig. 16) arranged at the inside of the casing of the turbo-compressor, in correspondence to each impeller wheel or by means of a cooling jacket, not shown, surrounding the casing of the turbo-compressor.

As shown in Fig. 16, the cooling water enters each nest of tubes by means of a header 26, pipe 27 and box 28, and discharges through a box 28^a, pipe 27^a and header 26^a.

The packing glands may be of the ordinary type. In the form of construction disclosed, they are constituted by labyrinth elements 21^a of the type shown in Fig. 17, fixed alternatively on the shaft 29 and on the packing box 21.

As may be seen, the described centrifugal multistage compressor, when destined to compress saturated steam, is but an inverted cycle steam turbine. It is however to be observed that with an ordinary steam turbine rotating in the inverted direction it is not possible to obtain the same result as with the described turbo-compressor; because it is not constructed to compel the fluid to flow towards spaces in which the pressure is gradually increased from stage to stage.

What I claim is:—

1. A centrifugal compressor for air, gases, vapors and the like including a plurality of rotating wheels each having an integral rim projecting towards the suction side of the compressor and a plurality of ports changing in number and size from wheel to wheel and disposed at an angle of 50–60 degrees to the radius at the inner periphery of the rim and radial at the outer periphery thereof, said ports presenting successive sections of passage varying in the same rim according to the change of the velocity and the change of the specific volume of the fluid dependent on the isothermal compression, diaphragms preceding each rotating wheel and provided on the side towards the ports of said wheel with rings axially displaceable from the outside of the casing to effect tightness of said ports and provided on the opposite side with a crown of deflectors each disposed at an angle of 50–60 degrees at the outer periphery of

the crown and radial at the inner periphery, means for maintaining the temperature of the fluid undergoing compression at a predetermined value and means for securing tightness between the shaft and the ends of the casing.

2. A centrifugal compressor for air, gases, vapors and the like including a plurality of rotating wheels each having an integral rim projecting towards the suction side of the compressor and a plurality of ports changing in number and size from wheel to wheel and disposed at an angle of 50-60 degrees to the radius at the inner periphery of the rim and radial at the outer periphery thereof, said ports presenting successive sections of passage varying in the same rim according to the change of the velocity and the change of the specific volume of the fluid dependent on the isothermal compression, diaphragms preceding each rotating wheel and provided on the side towards the ports of said wheel with rings axially displaceable from the outside of the casing to effect tightness of said ports and provided on the opposite side with a crown of deflectors each disposed at an angle of 50-60 degrees at the outer periphery of the crown and radial at the inner periphery, a series of atomizers adapted to inject liquid in the space preceding certain of the wheels to maintain the temperature of the fluid undergoing compression at a predetermined value.

In testimony whereof I have signed my name to this specification.

EMILIO VIANELLO.

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