

July 24, 1923.

1,463,110

A. J. WORTHEN

ROTARY FLUID PRESSURE PRODUCING APPARATUS

Filed Nov. 4, 1921

2 Sheets-Sheet 1

Fig. 1.

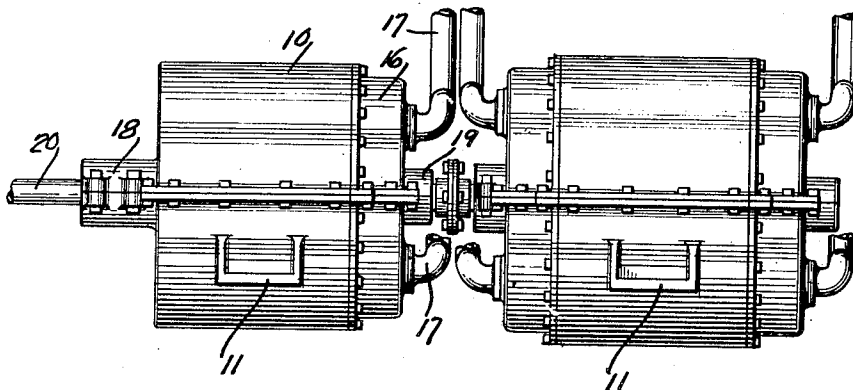


Fig. 2.

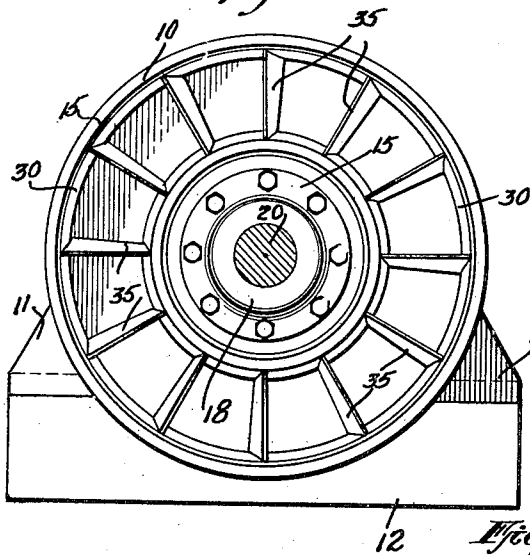


Fig. 3.

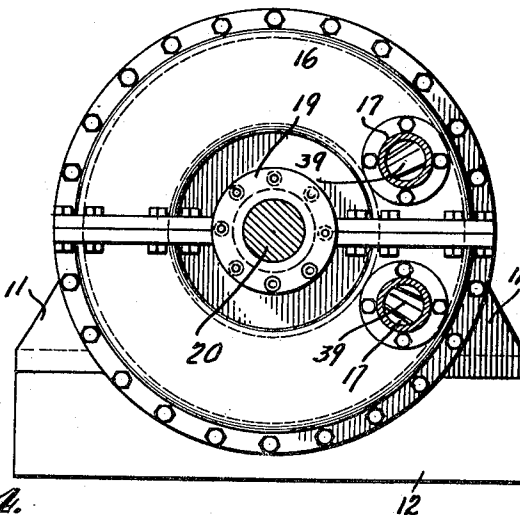
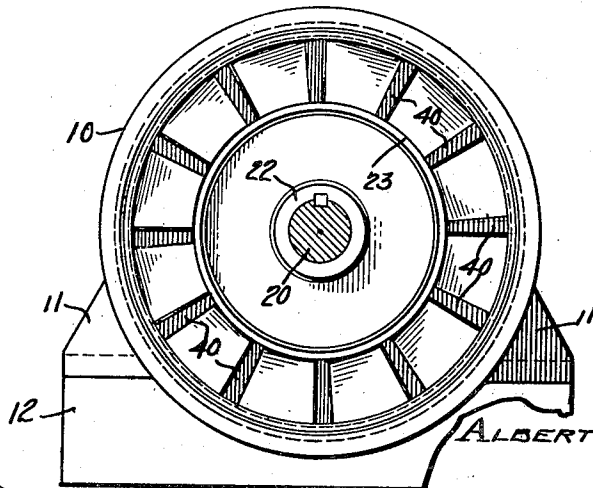


Fig. 4.



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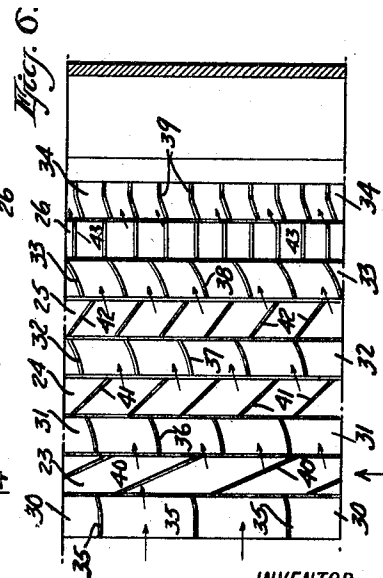
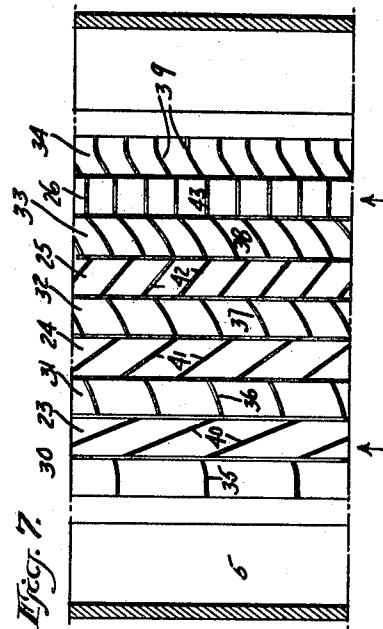
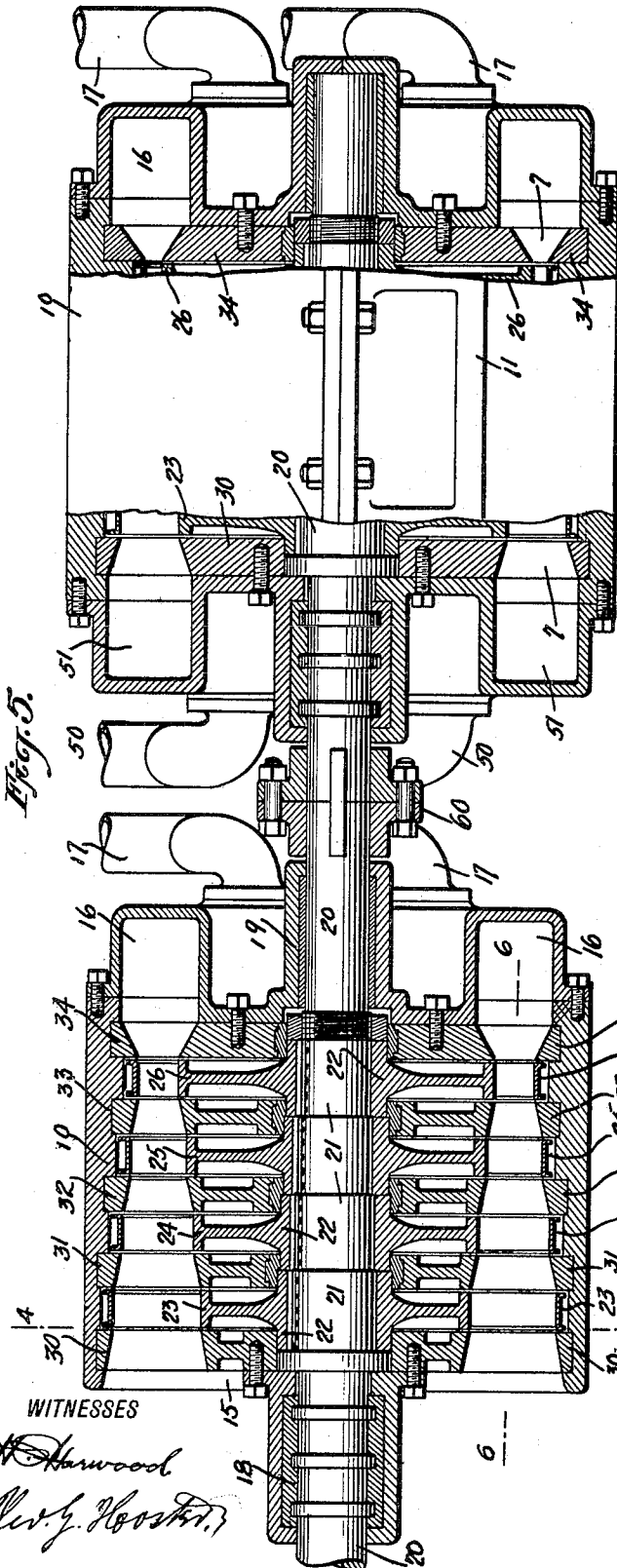
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ROTARY FLUID PRESSURE PRODUCING APPARATUS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

ALBERT J. WORTHEN, OF SAN FRANCISCO, CALIFORNIA.

ROTARY FLUID-PRESSURE PRODUCING APPARATUS.

Application filed November 4, 1921. Serial No. 512,742.

To all whom it may concern:

Be it known that I, ALBERT J. WORTHEN, a citizen of the United States, and a resident of San Francisco, in the county of San Francisco and State of California, have invented a new and Improved Rotary Fluid-Pressure Producing Apparatus, of which the following is a full, clear, and exact description.

The invention relates to compressors in which the velocity of the air, gas or other fluid is converted into pressure energy, and its object is to provide a new and improved rotary fluid pressure producing apparatus arranged to obtain a high over-all efficiency and reduce mechanical losses and losses of the fluid, due to windage, to a minimum.

Another object is to deliver a large volume of air or gas at a high compression ratio.

Another object is to provide an apparatus of this type which is very simple and durable in construction and composed of comparatively few parts not liable to get easily out of order.

Another object is to render the apparatus exceedingly compact and to permit of running the same without producing undue vibrations.

With these and other objects in view, the invention consists of certain novel features of construction, as hereinafter shown and described and then specifically pointed out in the claims.

A practical embodiment of the invention is represented in the accompanying drawings forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a side elevation of the improved rotary fluid pressure producing apparatus arranged as a duplex unit;

Figure 2 is an enlarged elevation of the air or gas entrance end of the apparatus;

Figure 3 is a similar view of the discharge end of the apparatus with the discharge pipes shown in section;

Figure 4 is a cross section of the apparatus on the line 4—4 of Figure 5;

Figure 5 is an enlarged longitudinal central section of the apparatus, part being shown in elevation;

Figure 6 is a sectional plan view of the first unit of the apparatus, the section being on the line 6—6 of Figure 5; and

Figure 7 is a similar view of the second unit of the apparatus, the section being on the line 7—7 of Figure 5.

Figures 1 to 5 show a two-unit air compressor, but it is deemed advisable to first describe the left-hand single unit as it in itself forms a complete air compressor and can be run without the other unit. The rotary air compressor is mounted in a suitably constructed casing 10 provided at the sides with lugs 11 for supporting the air compressor on a suitable foundation 12. The left-hand or air entrance end 15 of the casing 10 is open and the right-hand end of the casing is provided with a discharge chamber 16 having one or more outlet or discharge pipes 17 for conducting compressed air to a place of use. The open end 15 is provided with a thrust bearing 18 and the discharge chamber 16 is provided with a thrust bearing 19, and in the said bearings 18 and 19 is journaled a driven shaft 20 provided with steps 21, on which are keyed or otherwise secured the hubs 22 of a series of spaced velocity producing wheels 23, 24, 25 and 26 which coast with stationary velocity producing diaphragms 30, 31, 32, 33 and 34 extending between the corresponding velocity producing wheels and being secured in the casing 10 in any suitable manner. The first or air entrance diaphragm 30 is located in the open end 15 of the casing 10, and the last diaphragm 34 is located adjacent the discharge member 16 and discharges compressed air into the same. It is understood that the shaft 20 and its velocity producing wheels 23, 24, 25 and 26 form the rotor, and the casing 10 and its velocity producing diaphragms 30, 31, 32, 33 and its pressure converting diaphragm 34 form the stator of the apparatus.

The diaphragms 30, 31, 32, 33 and 34 are provided with guide vanes or blades 35, 36, 37, 38 and 39, of which the vanes 35, 36, 37 and 38 of the velocity producing diaphragms 30, 31, 32 and 33 define gradually decreasing passages having their walls converging towards the discharge chamber 16, while the vanes 39 in the last diaphragm 34 define a passage opening into the chamber 16 and having its walls diverging to the said chamber to eliminate shock in the process of converting the velocity of the fluid into pressure and to deliver the compressed air or gas at comparatively low velocity into the

said chamber. The velocity producing wheels 23, 24, 25, and 26 are provided with vanes or blades 40, 41, 42 and 43 set at gradually increasing angles relative to the motion in which the wheels rotate, as will be readily understood by reference to Figure 6. Thus the vanes 40 are set at a small angle relative to the direction of rotation of its velocity producing wheel 23, and the other vanes 41, 42 and 43 are correspondingly set relative to their wheels with the angles increasing until the vanes 43 are set at right angles or 90° with the direction of rotation of the velocity producing impeller wheels nearly parallel to the axis of the apparatus.

When the compressor is in operation the air is drawn in by way of the first velocity producing diaphragm 30 by the action of the vanes 40 of the first velocity producing wheel 23, and the air is delivered by this velocity producing wheel to the next velocity producing diaphragm 31, and this operation is repeated throughout the series of alternate velocity producing diaphragms and velocity producing wheels. The air travels in about the direction of the arrows indicated in Figure 6 and attains a high velocity in passing from one stage to the next. After acquiring the maximum velocity possible in the last velocity stage the velocity gradually diminishes while the pressure increases. In order to impart to the air a high velocity without subjecting it to shock recourse is taken by stepping up the velocity in stages, that is, a higher velocity is given to the air in each succeeding stage. This is accomplished by giving an increasing blade pitch or angle in each set of moving blades 40, 41, 42 and 43, as will be readily understood by comparison of the parts shown in Figure 6. In a compressor with a 32-inch mean blade diameter and 4,000 revolutions per minute, the angle or blade pitch in each velocity producing wheel will be 20°, 41°, 64°, and 90°. The velocities will be 35.5, 71, 106.5 and 142 inches per time revolution. The increase of angle or blade pitch is so arranged that the work or energy is evenly distributed over the respective velocity producing wheels in order to obtain a high efficiency. By reference to Figure 6 it will be noticed that the air is taken in at the first stationary velocity producing diaphragm 30 in a direction parallel to the axis of the apparatus and at an angle of 90° with the direction of rotation of the velocity producing wheels. In passing through each velocity stage the air flow gradually assumes a direction with the direction of rotation. This action is due to the increase of angle of the vanes or blades in each velocity unit and designated as the "velocity of whirl." Furthermore, the "velocity of flow," that is, the air being displaced and pushed

into the compressor by moving the vanes or blades, also increases with each succeeding stage so that at the end of the fourth or expeller stage (at velocity producing wheel 26) the velocity of the air leaving the impeller and entering the guide vanes 39 will be the resultant of the two component velocities, namely, velocity of flow and velocity of whirl.

As stated above, the velocity of flow increases in each succeeding velocity stage and a corresponding decrease of effective area or blade area is necessary, and hence the moving blades in each succeeding stage will be shorter (see Figure 6). The air passages in the velocity producing diaphragms converge to the length of the blade of the corresponding moving velocity producing wheel. The action of the converging passages and action of the moving blades combined will increase the velocity of flow of the air or gas. In the passage of the diaphragms the air flow increases by virtue of convergence of walls of passage, and in the velocity producing wheels or impellers by virtue of the increase of blade pitch or angle. The same also holds true in the case of the increase of velocity of whirl. By reference to Figure 6, it will be noticed that the guide vanes 35, 36, 37 and 38 are slightly curved and the cross sectional area is smaller at the exit than at the entrance, consequently there will be an increase of velocity denoted as "velocity of whirl." In the velocity producing wheels an increase of velocity of whirl is had on account of an increase of blade pitch, and as before stated, diaphragms and impellers work in unison consequently, there will be no shock when the blade impinges upon the moving air. The air will have a higher velocity leaving the passage as compared to the entrance velocity. This increase of velocity is also due to the reduction of vane annulus. The vane annulus is smaller at the exit than at the entrance. Due to these two factors, namely, convergence of passage and reduction of cross sectional area between the guide vanes, a reduction of annulus, will result which tends to accelerate the air. When the moving blades of the respective velocity producing wheel impinge upon the air, the air leaving the guide vanes will have a velocity approximately that of the velocity due to the action of the moving blades in the respective velocity stage. In consequence, therefore, the impact factor is eliminated. It will be noticed that the air is guided on to the moving blades with an initial velocity, and in a direction that the flowing air has in relation to the moving blades.

In Figures 1 and 5 is disclosed a duplex unit compressor and in this case the compressed air discharged by the pipe 17 is delivered to a cooler from which the cooled

compressed air passes by way of pipes 50 into an entrance chamber 51 of the second or right-hand unit, shown in Figures 1 and 5. This unit is otherwise constructed the

same as the one on the left-hand side, and hence further description of the same is not deemed necessary. In practice, the shaft 20 of the right-hand unit is connected by a suitable coupling 60 with the shaft 20 to cause the velocity producing wheels of the two units to rotate in unison. It is understood that the air gradually comes to rest when the pressure increases and hence the volume of the air will be smaller when at atmospheric pressure; and, in the case where two compressors are used, it re-compresses the once compressed air. Then the effective area or blade area in the second or right hand unit exposed to act upon the air must be proportionately smaller with the diminishing volume. It is understood that this second unit composes the second pressure stage and there may be as many as deemed necessary to obtain the predetermined pressure. In order to insure a high thermo-dynamic efficiency, the air is preferably cooled between each pressure stage, as above mentioned. The compression will be nearly isothermal.

Amongst the advantages of the apparatus shown and described relative to other types of compressors are the following: By reference to Figure 6 it will be noticed that the air flows parallel with the axis of the apparatus. The direction that the air takes in flowing through does not suffer much loss due to windage as is the case in centrifugal types of compressors where the air has to follow a contortious course from stage to stage. A higher compression efficiency is the result. In the centrifugal type of compressor the air is taken in at the center of the impellers. In a parallel flow turbine compressor the air is taken in at the periphery of the impeller, consequently, there is a much larger orifice of passage or area to act upon the air as compared to the centrifugal type. For the same weight of compressor, the parallel flow compressor will deliver a much larger volume of air. As compared to the reciprocating type compressor, which is large, heavy, cumbersome and expensive in construction and maintenance, the turbine compressor has the advantage of lightness and compactness, higher efficiency of compression, and cheapness in manufacturing and running. It will also be noticed that the apparatus is composed of comparatively few parts, not liable to get easily out of order. Explosions that sometimes occur in the reciprocating type of compressor are entirely eliminated because the air is absolutely free of oil. It will further be noticed that the apparatus is exceedingly compact and owing to the

continuous turning motion there is no vibration and a much less heavy foundation is required.

While I have referred to the compression of air or gas throughout the above description it is of course understood that the scope of the invention as recited in the subjoined claims is not confined to air or gas as it may be used to equal advantage to impart a high head to water or other liquids and in this way act as a pump or the like.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. In a rotary fluid pressure producing apparatus, a plurality of velocity producing wheels mounted to rotate in unison and spaced apart, successive wheels having vanes set at gradually increasing angles relative to the movement of the wheels, and stationary velocity-producing diaphragms between the said wheels, successive diaphragms having passages gradually decreasing in size, one of the wheels having passages established by vanes having substantially plane surfaces at substantially right angles to the direction of movement of the wheel.

2. In a rotary fluid pressure producing apparatus, a casing open at one end and provided with a discharge chamber at the other end, a shaft journaled in the said casing and provided with a series of spaced velocity producing wheels having vanes set at gradually increasing angles with the vanes of the outermost wheel in the open end of the casing at the smallest angle relative to the rotation of the wheels, and velocity producing diaphragms fixed in the casing and extending between the said wheels, successive diaphragms having passages gradually decreasing in size in the direction of the rotation of the wheels.

3. In a rotary fluid pressure producing apparatus, a casing open at one end and provided with a discharge chamber at the other end, a shaft journaled in the said casing and provided with a series of spaced velocity producing wheels having vanes set at gradually increasing angles with the vanes of the outermost wheel in the open end of the casing at the smallest angle relative to the rotation of the wheels, velocity producing diaphragms fixed in the casing and extending between the said wheels, successive diaphragms having passages gradually decreasing in size in the direction of the rotation of the wheels, and a pressure-producing discharge diaphragm adjacent the said discharge chamber and having openings with walls diverging toward the said discharge chamber.

4. In a rotary fluid pressure producing apparatus, a casing open at one end and provided with a discharge chamber at the other end, a shaft journaled in the said casing and

provided with a series of spaced velocity producing wheels having vanes set at gradually increasing angles with the vanes of the outermost wheel in the open end of the casing at the smallest angle relative to the rotation of the wheels, and velocity producing diaphragms fixed in the casing and extend-

ing between the said wheels, successive diaphragms having passages gradually decreasing in size in the direction of the rotation 10 of the wheels, the passages having walls converging toward the discharge chamber except the last one having its walls diverging.

ALBERT J. WORTHEN.