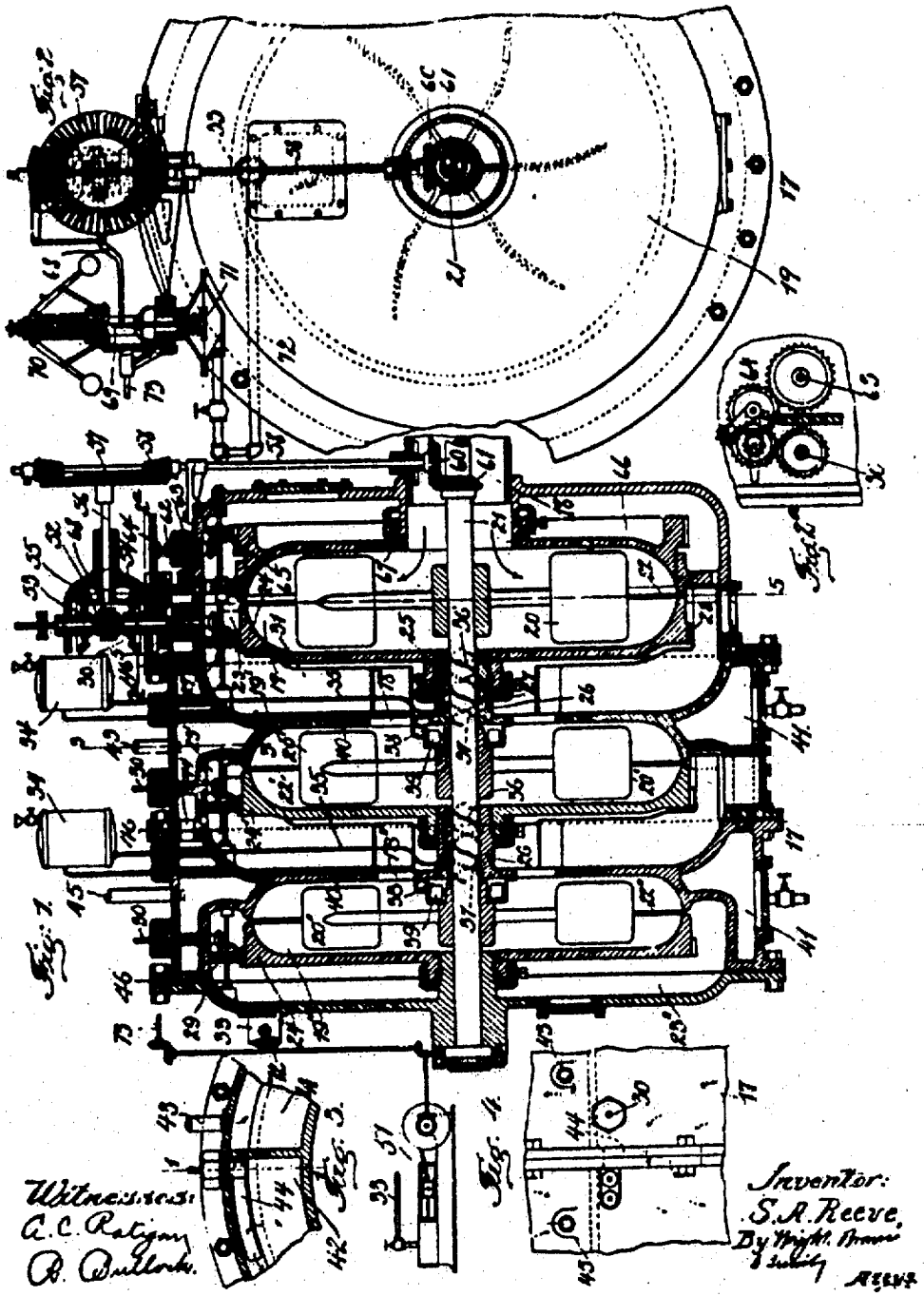
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APPARATUS FOR CENTRIFUGAL FLUID COMPRESSION.

APPLICATION FILED APR. 1, 1904.

902,605. Patented Nov. 3, 1908.

2 SHEETS—SHEET 1.



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2 SHEETS—SHEET 2.

Fig. 5.

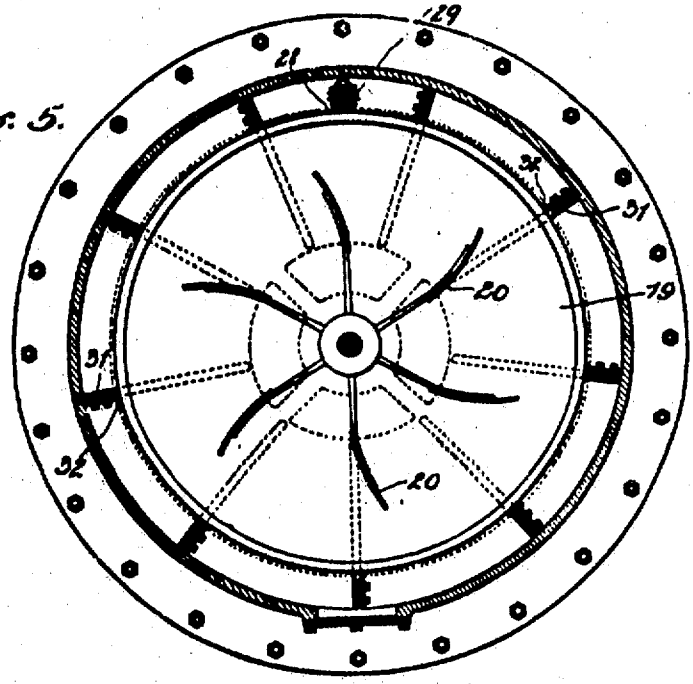


Fig. 6.

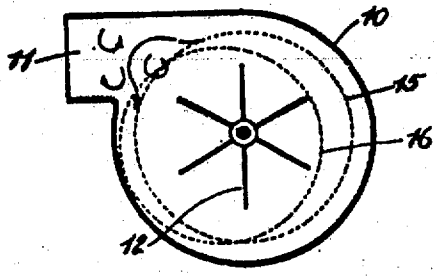


Fig. 7.

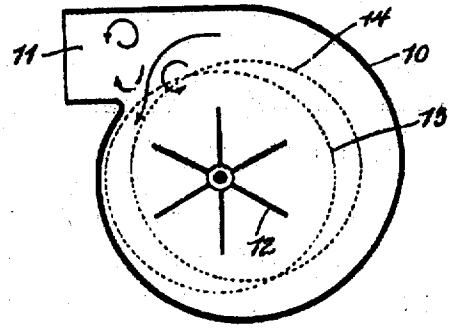
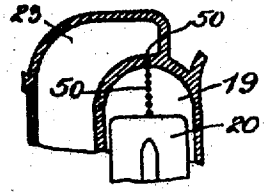


Fig. 8.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR CENTRIFUGAL FLUID COMPRESSION.

No. 806,605. Specification of Letters Patent. Patented Nov. 5, 1905.

Application filed April 1, 1904. Serial No. 201,126.

To all whom it may concern:

Be it known that I, SIDNEY A. REEVE, of Worcester, in the county of Worcester and State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Centrifugal Fluid Compression, of which the following is a specification.

An embodiment of my invention is shown in the accompanying drawings in which,

Figure 1 represents a longitudinal section of a multi-stage centrifugal compressor constructed according to my invention. Fig. 2 represents an end elevation looking from the right in Fig. 1. Fig. 3 represents a detail plan view of the gearing included in the automatic control-devices. Fig. 3 represents a section on line 3—3 of Fig. 1. Fig. 4 represents a fragmental plan view. Fig. 5 represents a section on line 5—5 of Fig. 1. Figs. 6 and 7 represent respectively sectional views illustrating the action of the conventional type of fan-blower equipped respectively with concentric and eccentric runners. Fig. 8 represents a detail section, showing a modification.

The same reference characters indicate the same parts in all the figures.

The primary object of my invention is to provide an improved apparatus for compressing fluids, such as air and other gases, on the centrifugal principle, by the continuous application of power, to much higher pressures than can be practicably or economically attained by the prevailing types of fan-blowers.

It is well known that the ordinary centrifugal fan-blower consists of a casing having an axial inlet for the air or other gas to be compressed and a tangential outlet, the air receiving a rotary movement within this casing by the action of a bladed fan or runner mounted eccentrically within the casing. The eccentricity of the runner within the casing is necessitated by the fact that the air is taken out usually at only one point on the circumference of the casing and hence the clearance-space between the ends of the blades and the circumferential wall of the casing is given a spiral form in order that the volumes of air leaving the periphery of the blades, which accumulate from the point most remote in an angular direction from the outlet-pipe to said outlet-pipe, may be properly accommodated. Such a type of blower, while suitable for low pressures, becomes very inefficient and wasteful of power when it is attempted to speed it for the development of high pressures, such as are required in many situations and for which it is at present customary to employ cylinder-and-piston compressors. Among the causes of its inefficiency are, the continuous interference with the natural circular whirl of the air in the fan, occasioned by the irregular contour of the space within the casing and by the eccentricity of this space with respect to the fan-shaft, the high frictional losses caused by the relatively-large surface exposed to the fluid flow at high velocities in proportion to a given size of effective whirl, the restriction of the effective whirl to a diameter only slightly larger than that of the fan circumference, the lagging of those fluid portions outside of the effective whirl to a velocity materially slower than that of the fan with resulting diminished centrifugal tendency and internal friction of the fluid, the large frictional and eddy losses occasioned when the output of the fan is anything less than that for which its spiral clearance is designed, etc.

For a better understanding of the last-mentioned and other objections to the ordinary fan-blower, reference may be had to Fig. 7, in which 10 is the blower-casing, 11 its tangential outlet, and 12 the fan or runner eccentrically mounted within casing 10. At full-load or when there is a maximum out-take through the pipe 11, the whirl created by the fan may be assumed to take the form of the dotted-line circle 13 concentric with the fan-shaft. It is obvious that under these conditions, the effective whirl available for centrifugal action is considerably less in diameter than the diameter of the casing 10, from which fact certain of the losses above mentioned arise. At no-load or when there is no out-take through pipe 11, the whirl created by the fan tends to take a position concentric with the fan-casing 10, as represented by the dotted-line circle 14. Since the latter circle is eccentric to the fan-shaft, large frictional and eddy losses will be occasioned by the fact that the blades of the fan must plow through the neutral or central portion of the whirl and much eddy disturbance, of the nature indicated by the arrows, also takes place at the entrance to the pipe 11. At any stage between no-load and full-load, the difficulties mentioned will

be present in proportionate degree. Consequently the type of fan in question necessarily wastes much of its power which might go into the compression of the air or other fluid in simply heating up the fluid. At comparatively low pressures such as those for which fan-blowers are now employed, this proportional loss of work is not especially noticeable, but should it be attempted to use this type of fan-blower to attain compression pressures comparable with those attained by cylinder-and-piston compressors, the proportion of work appearing as heat in the fluid would prohibit economical employment of the device in question, more especially as in going to greater pressures and densities the heat of the fluid acts as a cumulative expanding influence counteracting the centrifugal compressive influence of the fan.

The defects of the spiral-clearance fan shown in Fig. 7 are not remedied by mounting the fan or runner concentrically in the casing as seen in Fig. 6, for while at no-load or out-take the whirl is concentric with the fan, as indicated by dotted-line circle 15, giving rise, let it be said, to only the eddies produced at the entrance of the pipe 11, yet at full-load, the tendency of the whirl is to take an eccentric position represented by dotted circle 16, in order to allow the volumes of air to take their natural spiral path to the pipe 11, and under such circumstances the fan 12 plows across the central or neutral portion of the whirl and sets up great internal friction and eddies in the air.

My present invention seeks to avoid and minimize the objections above mentioned by providing improvements in a centrifugal fan or compressor in whose construction the whirl created by the rotating fan or runner is divorced from the outlet-seeking portions of the air upon which centrifugal force has practically expended its effect, thus allowing a larger effective whirl in proportion to the diameter of the runner, smaller surfaces in proportion to the circumference and volume of the effective whirl, and avoiding the large amount of waste work due to the creation of eddies and internal friction within the body of fluid incident to the conventional type of centrifugal fan-blower. Among the important results thus obtained is the feasibility of conducting a multi-stage compression by a suitable combination of units constructed according to my invention, as more fully hereinafter described, which combination constitutes a part of my invention.

Referring to the drawings, 17 indicates a sectional casing, the first section of which has an axial inlet 18 to a compression-chamber 19 containing a bladed rotary fan or runner 20 attached to a shaft 21, which may be rotated by suitable means. The outlet from this chamber is by way of a slot 22 extending throughout the circumference of the fan-chamber and having a total cross-sectional area of aperture, preferably about the same as would be required for the out-take pipe of a conventional fan-blower of the same capacity. The runner 20 rotates with a considerable clearance or corridor-space between its circumference and the outer wall of the chamber 19 in order to give a large effective whirl relatively to the diameter of the runner and to allow for adjustment of the whirl in accordance with variable load. Radially beyond the outlet-slot 22, the fluid reaches a chamber 23 through which it flows centripetally to the axial inlet 18' to the next fan-chamber 19' containing a fan or runner 20' fixed to the shaft 21. The chamber 19' has a slot-outlet 22' to a chamber 23' similar to 23, from whence the fluid enters the third fan-chamber 19'', and so on as far as it may be desired to carry the number of stages, three stages being herein shown merely as representative of the multi-stage idea contained in my invention.

One wall of the fan-chamber 19 is constituted by a disk 24 whose hub is threaded at 25 upon the exterior of one of the bearings 26 for the shaft 21, a suitable stuffing-box 27 being provided to prevent back-flow along the threads from a higher-pressure chamber into a lower-pressure chamber. On the rim of the disk 24 are formed gear-teeth 28 meshing with the teeth of a pinion 29 rotated through bevel-gearing by a shaft 30 which extends to the outside of the casing. By this means the disk 24 may be rotated and thereby be adjusted axially to vary the width of the slot 22 for different volumes of output. The interior of chamber 23 is divided by radial fins or partitions 31 into a series of conduits or portions of the general conduit or chamber 23, the purpose being to prevent rotation and consequent centrifugal action of the fluid in chamber 23 which would tend to oppose that of the fluid in chamber 19. The fins 31 have, as best seen in Fig. 5, curved knife-edged plates 32 designed to deflect the radial-tangential currents of air from the casing 19 to a radial direction of flow. The remaining sections or compartments of the compressor are in like manner provided with adjustable disks for varying the widths of their outlet-slots, and with radial fins to prevent rotation of the fluid within their outlet-chambers. The final outlet is through pipe 33 (Fig. 1). The compression-chambers and fans decrease in volume and size successively to correspond with the increased density of the fluids handled in the successive stages of compression.

Oil is carried to the bearings 26 between

successive sections of the compressor from elevated reservoirs 34 through pipes 35 to helical grooves 36 cut in the shaft 21. Similar but oppositely-pitched grooves 37 are cut in the bearings 26 and both sets of grooves lead to chambers 38 surrounding the shaft and containing paddles 39 rotating with the shaft. The centrifugal action of these paddles combined with the propulsive action of the grooves 36 37 upon the oil forces the latter upwardly through return-pipes 40 to the reservoirs 34, from whence it descends and again flows through the bearings.

For the purpose of absorbing part of the heat of compression if it is desired to cool the fluid as it is compressed, by a suitable medium such as water, or for the purpose of conserving this heat in a suitable medium such as water, air or gas, to be adapted to any subsequent useful purpose, the fan-chambers 19 19′ 19″ and outlet-chambers 23 23′ 23″ are jacketed by means of chambers 41 whose ends are divided by partitions 42. The first of these chambers has an inlet-pipe 43 for the introduction of the cooling or heat-conserving fluid and an outlet 44 to the next chamber 41, from which latter leads an outlet-pipe 45. The direction of the cooling fluid is indicated by arrows in Figs. 3 and 4. In the case of air or other gas contained in the chambers 41, much of the heat of compression would remain in the main flow which would be useful in employing the air compressed by this apparatus for a heat-engine.

Between the sections of the casing 17 are located heat-insulating packings 46 designed to prevent the backward conduction of heat through the metal of the walls from the chambers of higher compression and heat to those of lower compression and heat.

In the operation of the apparatus the rotation of the fan or runner 20 in the first fan-chamber 19 creates a whirl of the fluid taken in through inlet 18 and as this whirl takes place within a chamber of perfect rotational form, there is an absence of the eddies and internal friction hereinbefore mentioned. Centrifugal force acting on the particles of fluid in the whirl forces this fluid radially and tangentially through the slot 22 into the chamber 23 through which it flows centripetally to the inlet 18′ of the next fan-chamber, the compression process being repeated in this chamber and so on, each fan imparting a successive increment of compression until finally the fluid is in a highly-compressed condition and attains a final outlet through pipe 33. When once through the slot 22 the fluid is unable to return and all back eddies are avoided. The combined influences of the oil-grooves on shaft 21 and the paddles 39 on said shaft tend to produce a constant flow of oil in the direction of the higher pressures, and its circulation through pipes 35 40 and reservoir 34, the oil serving the double function of lubricating the shaft-bearings and preventing back-flow of compressed fluid along the shaft.

It is to be noted that the constant-temperature conditions maintained in the several departments of a compressor of this type are in marked contrast to the tendency toward temperature rise which is observed in piston compressors, in which the successive compressions taking place in the same cylinder make the walls steadily hotter and hotter and render artificial cooling means an essential requisite in order to prevent impairment of the parts. This increase of temperature is particularly noticeable at the higher pressures. My improved centrifugal compressor is not subject to abnormal increase of temperature characteristic of cylinder-and-piston compression to high pressures and on the other hand the type of apparatus involved is able to stand a much higher temperature without injury.

In Fig. 8 is shown a modification wherein the circumferential or circumambient outlet from the fan-chamber 19 instead of being in the form of a slot is embodied in a circumferential series of holes 50. These form an outlet substantially the same in effect as the slot, although the slot is preferred as being more easy to adjust.

In Fig. 1 a continuation of the compressed-air pipe 33 is shown as extended on a smaller scale to a motor 51, representing a device which may be driven by the compressed air.

Figs. 1, 2 and 2ª illustrate means for automatically controlling the width of outlet-slot and the width of whirl for the first compressing-unit, which means might also be applied to one or more of the other units. If the width or thickness of whirl be varied, this will increase the quantity of fluid subjected to centrifugal action and accordingly will vary the capacity or output of the machine without varying the pressure of the delivered fluid. One of the sides of the fan-casing can be moved to vary the width of the whirl, and the width of the outlet-slot should also be varied to correspond with the different output, the variation preferably being proportional. Splined to the shaft 30 of the first compressor-unit is a double clutch-member 52 adapted to engage either one of the clutch-members on a pair of bevel-gears 53 54, wherewith engages a third bevel-gear 55 which is continuously driven through shaft 56, gears 57 58, shaft 59 and gears 60 61 from the shaft 21. According to whether the clutch-sleeve 51 engages the upper or the lower bevel-gear, the shaft 30 will be rotated in one direction or the other, thereby either increasing or decreasing the width of slot 22. The shaft 30 is connected with a parallel shaft 63 by

change-gearing 64 and is connected by gearing 65 with the movable side 66 of the fan-chamber 19 which screws on a thread 67. By this means the width of the whirl is varied and the width of the slot varied proportionately or in any other desired ratio according to the arrangement of the gearing. Shaft 30 is shown as under both speed and pressure control. A lever 68 is connected with a spindle 69 affected both by a fly-ball governor 70 and a pressure-diaphragm 71. The latter receives pressure through a branch-pipe 72 from the delivery-pipe 33 and the governor receives motion by shaft 73 from the apparatus propelled by the compressed fluid delivered by the compressing apparatus. Should the pressure drop from increased demand of the driven apparatus, the capacity of the machine will be automatically increased and vice versa. Should the speed of the driven apparatus vary from an increase or decrease of load, the capacity of the compressor will be automatically prepared to correspond with the increased or decreased demand. Obviously either the pressure or speed-control could be used separately.

I claim:—

1. In a centrifugal fluid compressor, the combination of a compression-chamber having relatively-movable walls between which is formed an outlet-slot, one of said walls being threaded, a complemental stationary threaded member, gearing for rotating the adjustable wall to adjust the width of said slot, an inlet to said chamber, and means to produce a whirl of fluid within the chamber.

2. In a centrifugal fluid compressor, the combination of a compression-chamber having walls between which is formed an outlet-slot, one of said walls being formed with an internal thread, an externally-threaded shaft-bearing engaging said internal thread, means to rotate the adjustable wall for varying the width of the outlet-slot, a shaft mounted in said bearing, and a bladed runner on said shaft within the chamber.

3. In a centrifugal fluid compressor, the combination of a compression-chamber having walls between which is formed an outlet-slot, one of said walls being threaded and rotatable, a complemental threaded member, a stuffing-box to prevent fluid-flow along the threads, an eduction conduit inclosing said stuffing-box, an inlet to said chamber, and means to produce a whirl of fluid within the chamber.

4. In a centrifugal fluid compressor, the combination of a compression-chamber, a bladed runner for creating a whirl of fluid therein, and means for varying the width of the part of said chamber occupied by the runner.

5. In a centrifugal fluid compressor, the combination of a compression-chamber having a circumambient outlet, a bladed runner for creating a whirl of fluid within said chamber, means for varying the width of said outlet, and means for varying the width of the part of said chamber occupied by the runner.

6. In a centrifugal fluid compressor, the combination of a compression-chamber having inlet and outlet, means for creating a whirl of fluid within said chamber, and speed-controlled means for varying the width of said chamber.

7. In a centrifugal fluid compressor, the combination of a compression-chamber having inlet and outlet, means for creating a whirl of fluid within said chamber, and pressure-controlled means for varying the width of said chamber.

8. In a centrifugal fluid compressor, the combination of a compression-chamber having an inlet and a circumambient outlet, means for creating a whirl of fluid within said chamber, and speed-controlled means for varying the width of said outlet.

9. In a centrifugal fluid compressor, the combination of a compression-chamber having an inlet and a circumambient outlet, means for creating a whirl of fluid within said chamber, and pressure-controlled means for varying the width of said outlet.

10. In a centrifugal fluid compressor, the combination of a compression-chamber having an inlet, a circumambient outlet, and a side wall movable to vary the width of said chamber, means for varying the width of said outlet, and speed-controlled mechanism for actuating said movable wall and said outlet-varying means.

11. In a centrifugal fluid compressor, the combination of a compression-chamber having an inlet, a circumambient outlet, and a side wall movable to vary the width of said chamber, means for varying the width of said outlet, and pressure-controlled mechanism for actuating said movable wall and said outlet-varying means.

In testimony whereof I have affixed my signature, in presence of two witnesses.

SIDNEY A. REEVE.

Witnesses:
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A. C. RATIGAN.