No. 843,237. PATENTED FEB. 5, 1907.

F. D. SHEPHERD.

STEAM TURBINE.

APPLICATION FILED MAR. 31, 1906.

2 SHEETS—SHEET 1.

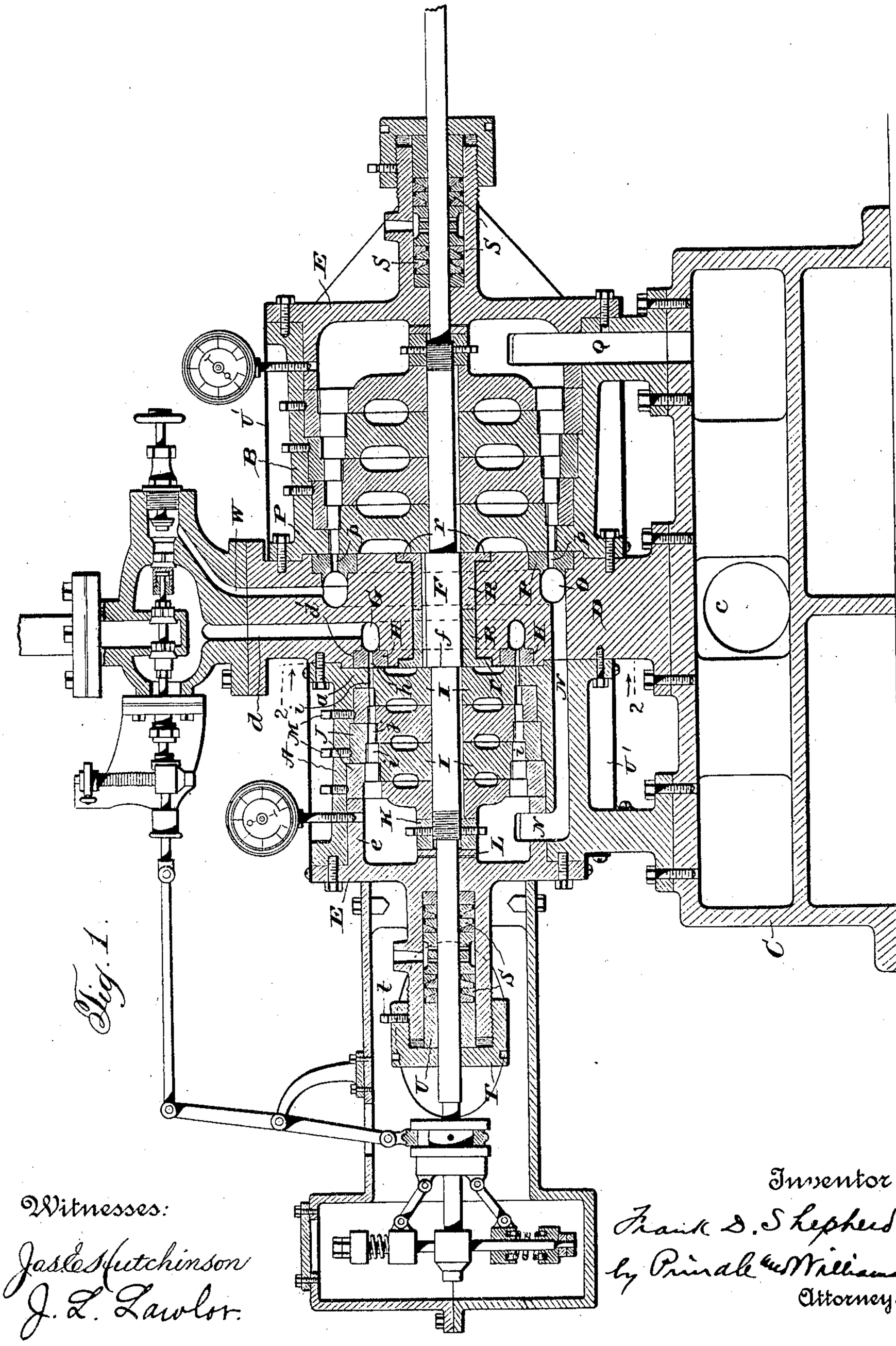

Fig. 1.

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2 SHEETS—SHEET 2.

Fig. 2.

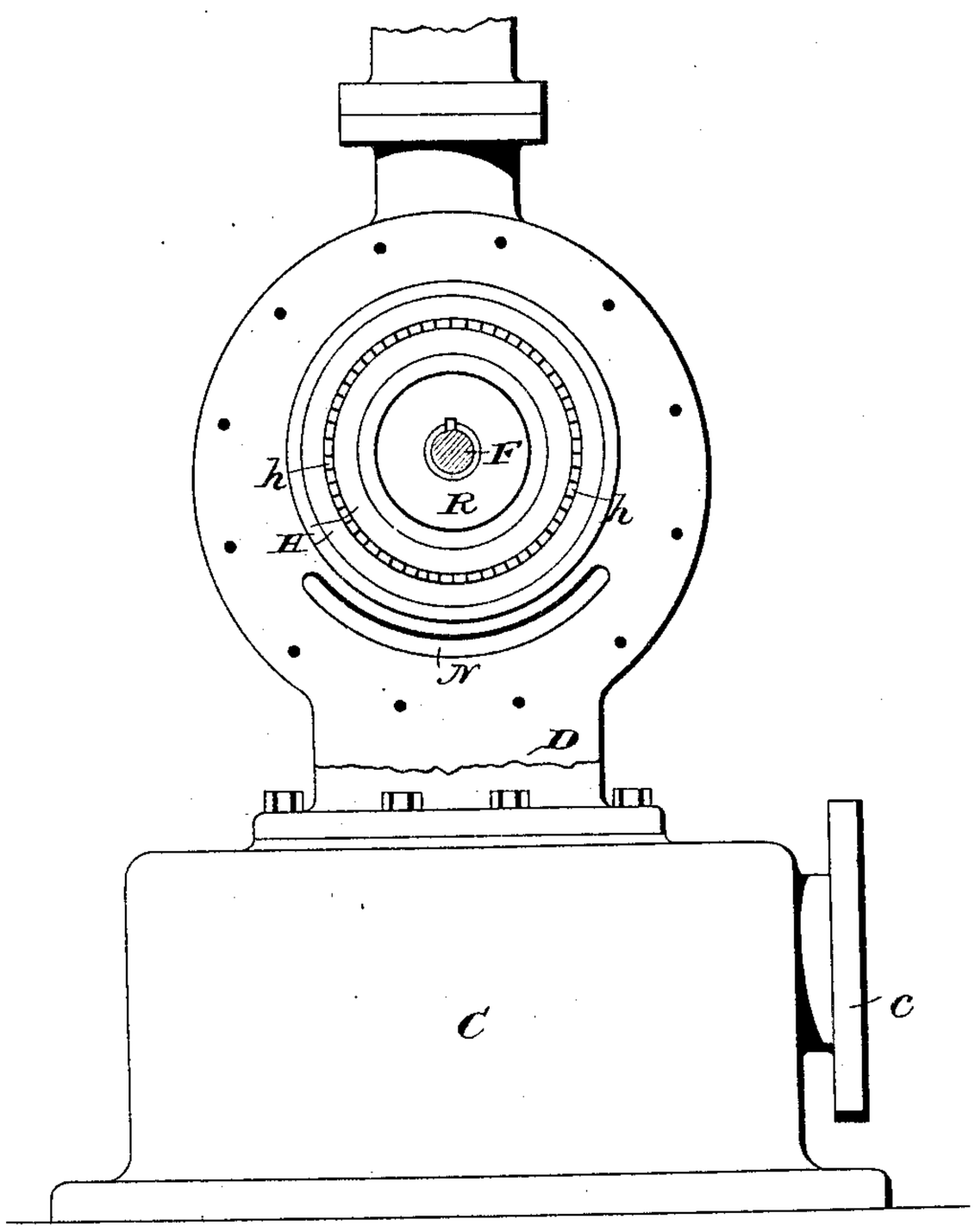
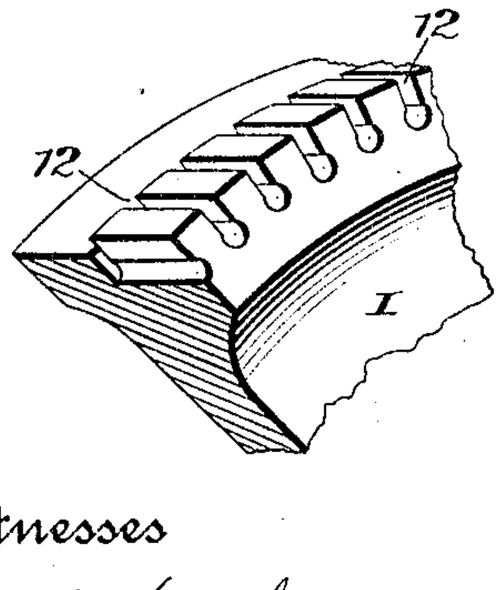


Fig. 3.



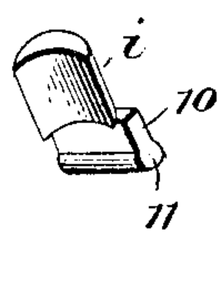
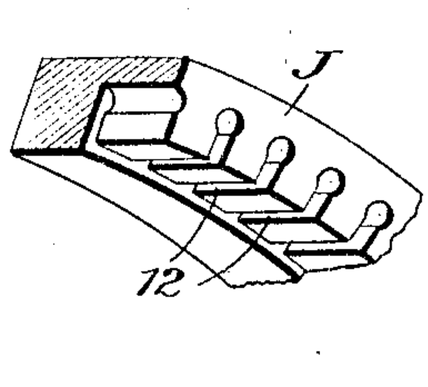


Fig. 4.



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STEAM-TURBINE.

No. 843,237. Specification of Letters Patent. Patented Feb. 5, 1907.

Application filed March 31, 1906. Serial No. 309,219.

To all whom it may concern:

Be it known that I, FRANK D. SHEPHERD, of Salt Lake City, in the county of Salt Lake and in the State of Utah, have invented a certain new and useful Improvement in Steam-Turbines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section of a steam-turbine embodying my invention; Fig. 2, a cross-section on the line 2 2 of Fig. 1; Fig. 3, a detail view in perspective of a portion of one of the blade-carrying disks and one of the blades detached therefrom, and Fig. 4 a similar view of a portion of one of the blade-carrying rings.

The object of my invention is to so improve the construction of steam-turbines as to enable the utilization of the maximum proportion of the energy of the steam and to simplify and cheapen the cost of building; and to attain these objects of efficiency and economy my invention consists in the turbine constructed substantially as hereinafter specified and claimed.

In making my invention I have improved upon the turbine of my Patent No. 755,062, issued March 22, 1904, and in the embodiment of my invention which I have selected for illustration the turbine is a compound one of two main stages and comprising a high-pressure cylinder A and a low-pressure cylinder B in axial alinement with each other and mounted upon a suitable bed or base C. Interposed between the two cylinders is a steam-chest D, to which the cylinders are respectively bolted by flanges, and the opposite ends of the cylinders are closed by heads E, bolted to the flanged outer ends of the respective cylinders. A shaft F runs through the steam-chest and through the two cylinders, a stuffing-box being provided on each cylinder-head E.

In the steam-chest there is an annular channel or chamber G, concentric with the shaft, to which runs from the throttle-valve a port or passage *d* for the supply of steam to such annular channel for delivery to the high-pressure cylinder, and contiguous to and concentric with said steam-channel the steam-chest has an annular groove or recess *d'* in its side next the high-pressure cylinder for the reception of a ring H, that contains the guide ports or nozzles for the delivery of steam into the high-pressure cylinder. The ring conforms in shape to the recess, and its fit is so close thereto that when it is pressed into the cavity it will fit the same steam-tight, and it is secured in place therein by an inwardly-turned flange *a* on the high-pressure cylinder, which overlaps the outer side of the ring. The ports or nozzles *h* of the ring H are made with square corners, and their delivery ends are as wide or substantially as wide radially as the width radially of the blades *i* of the first disk I, into which said ports or nozzles discharge, as a result of which construction there are no dead spaces and the formation of eddy-currents in the steam which results in friction and loss of energy. There is a series of disks I mounted side by side upon the shaft F and keyed thereto, and all except the last or outermost disk have a thickness axially double the length axially of their peripheral blades *i*, and by this construction I avoid the use of separate blank or blind disks, such as I employed in the turbine of my patent above referred to, this combining in a single disk of the blade-carrying and blank or blind disks, not only resulting in a stronger construction, but one reducing the cost of construction and assembling by reason of the reduction of the number of parts. In like manner the rings J, which carry the guide-blades *j*, that project radially in alinement with the portion of the disk I having no blades, comprise in a single piece the blade-carrying member and the blank or blind member opposite the disk-blades *i* with the like advantage of economy of construction. The last or outermost disk of the series at its periphery is only wide enough in an axial direction to accommodate its blades *i*, and said disk is used as a rotor-cap for the series of disks, the shaft contiguous to said last disk being threaded and a collar K screwed thereon. That at one end engages said last disk and serves to clamp the series of disks against a shoulder *f* on the shaft formed by the enlargement of the portion thereof within the steam-chest. The collar or nut K is prevented from becoming loose on the shaft by radial set-screws *k*, whose inner ends impinge on the thread and are of some soft metal to prevent marring of the thread by contact therewith, and between the collar or nut and the adjacent cylinder, head there is a friction-ring L, encircling the shaft which maintains the disks, and consequently their blades in proper relative position, and prevents the blades cutting into each other. The use of the last disk of the

series as a cap simplifies and cheapens the construction, and for a like reason the last ring J of the series is engaged by the inner ends of a ring-form flange *e*, projecting inward from the cylinder-head, said flange exteriorly fitting the cylinder. By making the flange integral with the head instead of separate therefrom the construction is cheapened, and there is also the advantage that the shaft-opening through the head is accurately alined. To provide for the expansion of the steam as it traverses the cylinder by increasing the length of the blades, which increase in length is from each velocity and pressure stage to the next succeeding one, the disks are successively reduced in diameter and the rings are successively increased in diameter, a seat for each ring being provided in the cylinder by boring the latter, and, as I combine two rings in one, this expedient economizes in cost of construction by reducing the number of bores of the cylinder. Each ring is securely held in place against rotation by a radial screw M, fastened to the cylinder-wall from the outside thereof and entering at its inner end a recess or cavity in the ring. The ring at the steam-inlet end of the cylinder abuts against the cylinder-flange *a*.

The blades both for the disks and the rings have each a shank or tenon 10, at the inner end of which is a cylindrical enlargement 11, and in each disk or ring, as the case may be, there is a radially-extending slot 12, whose inner end is enlarged by a cylindrical opening, so that the slot conforms in shape and size to the shank or tenon of a blade, the blade shank or tenon being slid endwise into said slot. The advantage of this construction is cheapness of manufacture, because the cylindrical enlargements of the radial slots can be bored in the disks and rings on a drilling-machine and the remainder of the slots cut out in a slotting-machine, and the shanks or tenons can be accurately and yet cheaply made by a punching-machine. It will thus be seen that no hand-work at all is required, and yet the blades are most accurately fitted to the disks and rings.

The steam after passing the last disk in the series in the high-pressure cylinder enters a port N, that extends from that end of the high-pressure cylinder through the wall of the cylinder parallel with the cylinder-axis to and partially through the steam-chest, where it communicates with an annular channel or chamber O therein, concentric with the annular steam-chest channel or chamber G, but larger in diameter and in cross-section than the latter, but otherwise similar thereto, and delivering steam into the low-pressure cylinder or the next main stage through a ring P, having ports *p*, the latter and the ring and the manner of mounting the latter being similar in all respects to the ring H and the construction of said next main stage being in all respects similar to that of the high-pressure cylinder or the first main stage, already described, so that a specific description of said construction is unnecessary. The form of the port N in cross-section is, as best shown in Fig. 2, curvilinear, its curvature being concentric with the cylinder; and as it is contiguous to the steam-channel G in the steam-chest D the steam passing through said port N and into said channel O, having lost some of its temperature in its passage through the high-pressure cylinder, will be slightly superheated as it approaches the high-pressure end of the cylinder and said steam-channel G and will be further superheated as it passes around the steam-channel O, the walls of the various passages referred to being kept at a high temperature by the steam in the steam-channel G.

As will be seen by reference to Fig. 1 of the drawings, there is an abrupt and comparatively great increase of diameter of the first disk, or the disk at the steam-inlet end of the second main stage, over the diameter of the disk at the outer or exhanst end of the first main stage, and I make this difference in diameter because the velocity of the steam after it leaves the last disk of the first main stage is so great as to require the first disk of the second main stage to have such diameter as to give a substantial increase of peripheral speed to the blades thereof, such peripheral speed being a little less than the velocity of the steam impinging thereon, and the diameters of the suceeding disks of the second main stage are such as to make the speed of the blades thereof just right with reference to the velocity of the steam, the speed of the blades of all the disks being less than the velocity of the steam. It will be observed that the area of the blades of the first piston of the second main stage is less than that of the area of the blades of the last piston of the first main stage, the blades of the first piston of the second main stage being much shorter radially than the blades of the last piston of the second main stage, and this relation of the blades of the said first and last pistons I employ because thereby I am able to utilize the steam to the best possible advantage. The result is that the progressive changes of the pressure and velocity of the steam from the time it enters the high-pressure cylinder or the first main stage until it is ready to leave the low-pressure cylinder or the last main stage are so compensated for by changes in diameter, area, and peripheral speed of the blades as to utilize all the energy of the steam in power applied to the shaft less that lost in unavoidable friction, and loss by friction is reduced to a minimum by giving the proper angles to the blades and by balancing the pistons of one main stage against those of another. Be-

sides the waste of power, which would result by having the velocity of the steam in excess of the peripheral speed of the blades, there would also be a loss due to the cutting away of the blades by the action of the steam thereon if it should be permitted to move too rapidly thereagainst.

Exhaust-steam from the low-pressure cylinder is passed through a port Q, that opens downward from the low-pressure end of said cylinder through the leg thereof into the base C, such base being chambered or hollowed and provided with a suitable connection *c* for the attachment of an exhaust-pipe. Should a condenser be used, it can be built in the base, with the advantage of compactness, saving room, and also the advantage of having the vacuum close to the turbine.

Leakage of steam from the high-pressure cylinder to the low-pressure cylinder through the steam-chest where the shaft passes therethrough is prevented by a bushing, which for facility of construction is made of two pieces R and R, applied to the enlarged portion of the shaft in the steam-chest, said bushing having at each of its outer ends an annular flange *r*, seated in an annular cavity in the side of the steam-chest provided for it. The bushing fits the steam-chest sufficiently close to have skin friction only, and when it is revolved with the shaft centrifugal force is sufficient to maintain the joints between the bushing and the steam-chest steam-tight. Leakage of steam from each cylinder outward along the shaft is provided against by the stuffing-boxes hereinbefore referred to. Any desired packing may be employed in these stuffing-boxes; but I prefer the packing shown, which consists of two sets or series of cone packing-rings S in the stuffing box or gland, between which is a perforated oil-spool, and between the outermost cone-ring of one series and the cap T of the gland or stuffing-box is interposed a collar U, which encircles the shaft and which by the screwing up of the cap acts on the cones to expand them, and thus tighten the packing, as well as taking up wear and centering the shaft. The cap T is held in the position to which it may be adjusted by a soft-pointed set-screw *t*, that passes radially through the cap and impinges on the thread of the gland or box on which the cap is screwed.

Each cylinder is surrounded by a jacket U, and they at their low-pressure ends are provided with vacuum and low-pressure gages, respectively, of a very sensitive character to show the conditions of the cylinders at these points, and each steam channel or chamber of the steam-chest will be provided with a gage.

A port W is provided in the steam-chest for the supply of steam at boiler-pressure to the low-pressure cylinder for use in starting up the engine and also for use in the emergency of an overload being thrown on the engine, said port in the case of an overload being automatically opened through connections with the governor mechanism with which my engine is provided, but which is not necessary to be described in this application, as it forms the subject of a separate application for patent, which I have filed.

I of course do not limit the scope of my invention to the details of construction which I illustrate and describe, as changes in these respects may be made which will involve no departure from the scope of my invention, nor do I limit myself to any particular number of main stages.

Having thus described my invention, what I claim is—

1. In a turbine-engine, the combination of a cylinder, a piston therein having radially-extending blades, a source of supply of an operating fluid, such as a steam-chest, a ring having a seat in a cavity in said steam-chest concentric with the blades and provided with ports whose dimensions at their ends adjoining or toward the blades are the same as, or substantially the same as the dimensions of said blades, and a flange on the cylinder overlapping said ring.

2. In a turbine-engine, the combination of a cylinder, a series of blade-carrying disks in the cylinder, a source of supply of operating fluid, such as a steam-chest at one end of the cylinder, a ring having a seat in said steam-chest and provided with ports for the delivery of fluid to the cylinder, the cylinder having a flange overlapping said ring, a series of rings carrying guide-blades, said rings being placed side by side in the cylinder, the series at one end abutting against said cylinder-flange, and a head at the other end of the cylinder having an integral flange within the cylinder and engaging the other end of the series of rings.

3. In a turbine-engine, the combination of a cylinder, a series of blade-carrying disks therein, the blades occupying but a portion of each disk in an axial direction, a series of rings in the cylinder having guide-blades that likewise extend over the respective ring only partially in an axial direction, the blades on the rings being opposite the portions of the disks over which the disk-blades do not extend, and the blades of the disks being opposite the portions of the rings over which the ring-blades do not extend, a flange on the cylinder against which one end of the series of rings abut, and a cylinder-head having an integral flange within the cylinder abutting against the other end of the series of rings.

4. In a turbine-engine, the combination of high-pressure and low-pressure cylinders, and a steam-chest having an annular chamber or channel for the supply of steam to the high-pressure cylinder, and having an annular chamber or channel for the supply of

steam to the low-pressure cylinder, said chambers or channels being side by side, whereby the steam in one may receive heat from the steam in the other.

5. In a turbine-engine, the combination of high-pressure and low-pressure cylinders, a steam-chest having an annular chamber or channel for the supply of steam to the high-pressure cylinder, and having an annular chamber or channel for the supply of steam to the low-pressure cylinder, said chambers or channels being side by side, whereby the steam in one may receive heat from the steam in the other, and a port leading from the high-pressure cylinder to the channel or chamber for the supply of steam to the low-pressure cylinder, said port passing contiguous to the high-pressure channel or chamber in the steam-chest.

6. In a turbine-engine, the combination of a plurality of main stages provided with rotating pistons, the first piston of a succeeding main stage being of substantially greater diameter than the last piston of the next preceding stage, the pressure-receiving area of said first piston being substantially less than the pressure-receiving area of said last piston, and a port leading from one stage to the next.

7. In a turbine-engine, the combination of a plurality of main stages provided with rotating pistons, the first piston of a succeeding main stage being of substantially greater diameter than the last piston of the next preceding stage, a steam-chest intermediate the different stages having contiguous channels or chambers for the supply of steam to the respective stages, and a port extending from one stage to the channel or chamber of the next stage.

8. In a turbine-engine, the combination of high-pressure and low-pressure cylinders, a wall interposed between the cylinders, a piston-carrying shaft passing through said walls, and a bushing on the shaft having at each end circumferential flanges engaging the wall, said bushing being mounted on the shaft to rotate therewith, the revolution of the bushing with the shaft resulting in the maintenance of steam-tight joints between the bushing and the wall.

9. In a turbine-engine, the combination of high-pressure and low-pressure cylinders, a wall interposed between the cylinders, a piston-carrying shaft passing through said wall, a piston-engaging shoulder on said shaft at each side of the wall, means for holding the pistons against said shoulder and a bushing on said shaft having at each end circumferential flanges engaging the wall.

10. In a turbine-engine, the combination of high-pressure and low-pressure cylinders, a steam-chest between the two cylinders, a shaft passing through the cylinders and the steam-chest, piston-disks on the portion of the shaft in each cylinder, a bushing on the portion of the shaft within the steam-chest having circumferential flanges seated in cavities or recesses in the steam-chest, such portion of the shaft being notched, and the shoulder formed thereby being engaged by the end one of the disks in each cylinder, a collar or nut on the shaft engaging the other end one of the disks in each cylinder, a stuffing-box for the shaft where it passes from each cylinder, contiguous, concentric channels or chambers in the steam-chest for the supply of steam to the cylinders, respectively, and a port leading from the high-pressure cylinder to the chamber or channel which supplies steam to the low-pressure cylinder, a base or bed on which the cylinders and steam-chests are mounted, and an exhaust-port leading from the low-pressure cylinder to a chamber in said base or bed.

In testimony that I claim the foregoing I have hereunto set my hand.

FRANK D. SHEPHERD.

Witnesses:
W. O. McClain,
Will Atkins.