No. 815,155.

PATENTED MAR. 13, 1906.

H. F. FULLAGAR.

TURBINE.

APPLICATION FILED FEB. 17, 1905.

2 SHEETS—SHEET 1.

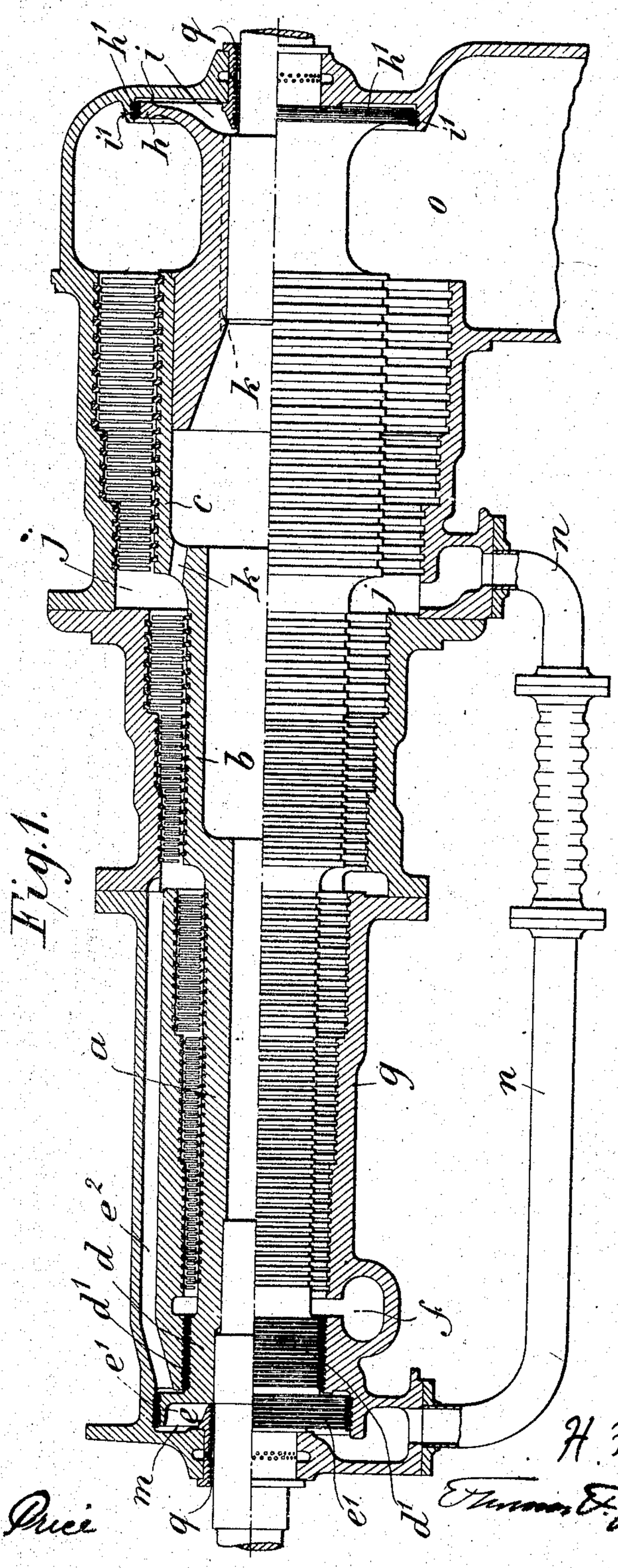

Fig. 1.

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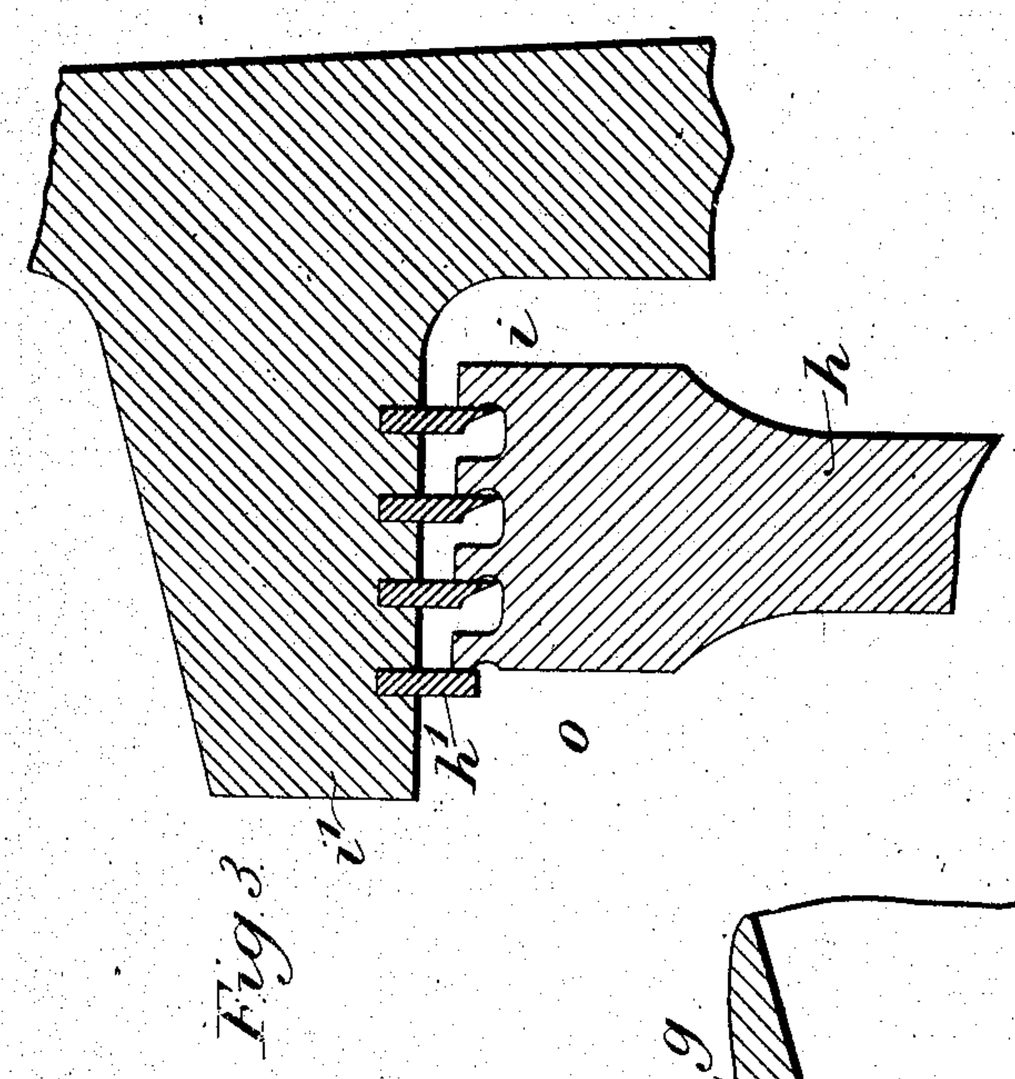

Fig. 3.

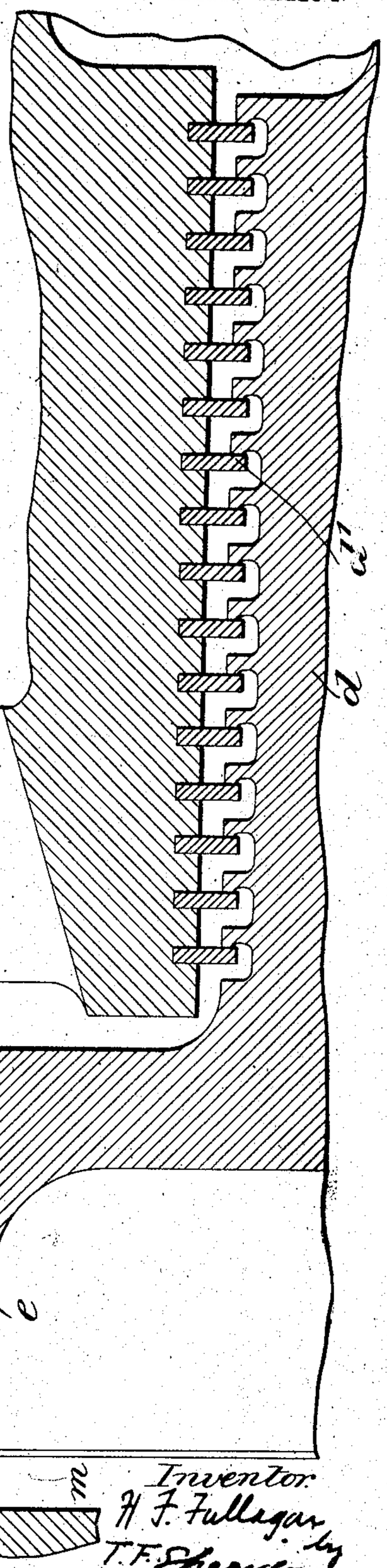

Fig. 2.

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UNITED STATES PATENT OFFICE.

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TURBINE.

No. 815,155. Specification of Letters Patent. Patented March 13, 1906.

Application filed February 17, 1905. Serial No. 246,125.

To all whom it may concern:

Be it known that I, HUGH FRANCIS FULLAGAR, a subject of the King of Great Britain and Ireland, residing at Newcastle-upon-Tyne, in the county of Northumberland, England, have invented Improvements in Turbines, of which the following is a specification.

In axial-flow turbines, which have several sets of rotary and stationary blades and in which the rotary blades are mounted upon a stepped shaft or drum (hereinafter called the "spindle" or "rotor,") increasing in diameter from the inlet to the exhaust, it is usual, in order to balance the end thrust of the steam or other working fluid, (hereinafter referred to as "steam,") upon the rotary rings of blades and annular surfaces of the steps of the spindle to provide the spindle at its inlet end with similar but reversely-arranged steps the diameters of which correspond to those of the main or working steps carrying the rotary rings of blades plus an amount corresponding usually to the radial length of the blades in the rings of blades upon those steps or to the mean radial length of the blades in the rings of blades where several rings of blades of different length are used on each step, the reversely-arranged steps being provided in lieu of blades with ordinary labyrinth packing devices, thus forming what are usually called "balance-pistons," so that the end pressure of the steam upon the annular surfaces of these balancing steps or pistons is equal to and counterbalances the steam-pressure upon the first-mentioned steps and the rotating rings of blades carried thereby. In order to insure that the pressure of steam upon the corresponding working and balancing steps shall be exactly equal during the working of the turbine, the parts of corresponding diameter of the two sets of steps are connected by passages or ports, the outer side of the largest balance-piston being connected with the exhaust. With this arrangement, however, as the balance-pistons have to be made of different diameters that are dependent upon and approximate to the different diameters of the rotary rings of blades in the corresponding sets thereof which they are designed to counterbalance or upon the mean diameters of the rings of blades in the several sets when the rings of blades in each set are of varying diameter, it follows that the turbine-casing or "stator" has to be made of a stepped shape to accommodate the balance-pistons, and when there are a number of such pistons the casing at the corresponding end of the turbine has to be made of considerable diameter to accommodate the outermost and largest balance-piston, which is objectionable in practice. To obviate this, according to this invention a balance-piston is provided at the exhaust end of the turbine-spindle adjacent to and inside the outer walls of the exhaust-chamber between it and the last set of turbine-blades.

In one arrangement I remove the largest balance-piston from the spindle at the inlet end of the turbine and attach it thereto at the exhaust end at a part thereof adjacent to and inside the outer end wall of the exhaust-chamber located at the outlet end of the last and largest set of rings of blades, such balance-piston being arranged in a chamber the rear or pressure end of which is connected to the steam-space between the two last bladed steps of the spindle, the usual labyrinth packing being provided between the piston and the wall of the chamber to retard the flow of steam from the piston-chamber to the exhaust-chamber. The front or exhaust end of the chamber containing the balance-piston of next smaller size and located at the inlet end of the turbine is connected, as usual, to the steam-space between the two last bladed steps of the spindle, while the steam-space between the two first bladed steps of the spindle is connected to the rear or pressure side of said next smaller balance-piston. This arrangement enables the diameter of the inlet end of the turbine-casing to be reduced, although the balance-piston for the last bladed portion of the spindle is of large diameter.

The manner of carrying out the invention is illustrated by the accompanying drawings, wherein—

Figure 1 represents, partly in longitudinal section and partly in elevation with the rings of blades removed, an example of turbine constructed according to this invention. Figs. 2 and 3 are detail views, to a larger scale, of the balance-pistons.

The turbine-spindle comprises three bladed steps *a*, *b*, and *c*. To two of these—namely, *a* and *b*—there correspond balance-pistons *d*

and *e*, provided with labyrinth packing devices *d'* and *e* of ordinary type, the pistons *d* and *e* being arranged on the opposite side of the steam-inlet *f* of the turbine-casing *g* to the bladed steps *a* and *b*, and the adjacent end surfaces of the bladed step *a* and the piston *d* being in direct communication, while the adjacent end surfaces of the bladed step *b* and the piston *e* are in communication through a pipe or passage e^2 in the usual manner. To balance the end thrust on the inlet end of the bladed step *c* instead of a balance-piston arranged as an annular step of larger diameter than the piston *e* and at the farther side thereof from the bladed steps *a*, *b*, and *c*, there is employed a piston *h*, separate from the piston *e* and placed in a space or chamber *i* at the exhaust end of the bladed step *c*, that part of the space or chamber *i* that is farthest from the step *c* being in communication with the steam-space *j* between the last two bladed steps *b* and *c* of the spindle through symmetrically-arranged passages *k*, extending through the spindle and the piston, so that the rear end surface of the latter is subject to the pressure of the steam in the said space *j*. The front end of the space or chamber *m* containing the balance-piston *e* at the opposite side of the steam-inlet *f* is shown in the illustrated example in communication through the pipe *n* with the steam-space *j* between the two last-bladed steps of the spindle. The space or chamber *i* containing the balance-piston *h* is separated from the exhaust-space *o* by an ordinary labyrinth packing device *h'* between the piston *h* and the inwardly-projecting wall *i'* of the said space or chamber *i*.

q q are glands between the ends of the turbine-casing and the spindle.

Turbines constructed according to this invention have advantages over those of previously-known construction. For instance, they are more compact and loss of steam and power is reduced, since it is possible to employ finer clearances upon small balance-pistons than can be used with small ones, both because any deviation or vibration of the spindle causes a greater variation of clearance the larger the piston, and also because such large pistons, having a high peripheral velocity, are liable to cause serious damage if they should come accidentally into hard contact with the part of the casing or cylinder that surrounds them. Also, owing to this high peripheral velocity, the unavoidable presence of water in the packing-grooves causes very considerable friction and loss of power.

Other advantages are that one equalizing-passage in the casing or cylinder can be dispensed with and both the glands *q q* are subject to about atmospheric pressure.

The details of construction may be altered without departing from the essential features of the invention.

What I claim is—

1. In a turbine, the combination of a bladed casing, a bladed spindle located therein, balance-pistons located in separate chambers having separate exhausts, and each adapted to balance a portion of the endwise thrust on the spindle due to fluid-pressure, one of said pistons being outside the exhaust-space.

2. In a turbine, the combination of a bladed casing having an inlet for motive fluid and an outlet for exhaust, a spindle located within said casing and provided with groups of blades fixed upon portions of said spindle of different diameters, a balance-piston for each group of blades, the balance-pistons for the several groups, except that for the group upon the largest portion of the spindle, being of different diameters and arranged in a chamber that is common to them, is of different diameters to suit the pistons, and is in communication with the interior of the casing at different parts thereof so that each balance-piston will be subject to the action of motive fluid of the same pressure as that to which the corresponding group of blades is subjected, and the balance-piston for the group of blades upon the largest portion of the spindle being arranged in a chamber that is separate from that containing the other balance-pistons, has a separate exhaust, and is in communication with the interior of the casing at a part thereof between its ends.

3. In a turbine, the combination of a bladed casing having an inlet for motive fluid and an outlet for exhaust, a spindle located within said casing and provided with groups of blades fixed upon portions of said spindle of different diameters, a balance-piston for each group of blades, the balance-pistons for the several groups, except that for the group upon the largest portion of the spindle, being of different diameters and arranged in a chamber that is common to them, is of different diameters to suit the pistons, and is in communication with the interior of the casing at different parts thereof so that each balance-piston will be subject to the action of motive fluid of the same pressure as that to which the corresponding group of blades is subjected, and the balance-piston for the group of blades upon the largest portion of the spindle being arranged in a chamber that is separate from that containing the other balance-pistons, is upon the opposite side of the outlet-space to the blades and is in communication with the interior of the casing at a part thereof between its ends.

4. In an axial-flow turbine, the combination of a bladed casing or stator having an inlet-space and an exhaust-space, a spindle or rotor within said casing, blades and balance-pistons upon said spindle, one of said pistons being at the inlet end of the turbine and another at the exhaust end of the turbine at the exterior portion of the exhaust-space, and a

passage through the rotor connecting the exterior side of the balance-piston with the interior chamber of the turbine to furnish fluid under pressure thereto above the exhaust-pressure, substantially as described.

5. In an axial-flow turbine, the combination of a bladed casing or stator, a bladed spindle or rotor located therein, an exhaust-chamber arranged between the bladed spindle and one end wall of the casing or stator, a balance-piston upon said rotor arranged between the exhaust-chamber and the end wall of the casing, a balancing-chamber between said balance-piston and the end wall of the casing, and a passage through the rotor connecting the interior of the casing with the balancing-chamber, substantially as described.

6. A bladed turbine having a single balance-piston spaced from the bladed portion near the low-pressure end, and other separate means for balancing.

7. A turbine having in the outer side of its exhaust-chamber a single balance-piston, and other independent means for balancing.

8. A chambered support, a bladed rotor, pressure balance-pistons thereon, means of communication from a chamber to one piston and from the same chamber separate means of communication to a second piston, one of the pistons being spaced from the blades.

9. A chambered support, a rotor, pressure balance-pistons thereon, means of communication from a chamber through the rotor to one piston and from the same chamber means of communication outside the rotor to a second piston.

Signed at Newcastle-on-Tyne, England, this 4th day of February, 1905.

HUGH FRANCIS FULLAGAR.

Witnesses:
H. NIXON,
W. H. SCOTT.