No. 822,149.

PATENTED MAY 29, 1906.

P. F. ODDIE.

MULTIPLE STAGE REACTION TURBINE.

APPLICATION FILED DEC. 19, 1905.

3 SHEETS—SHEET 1.

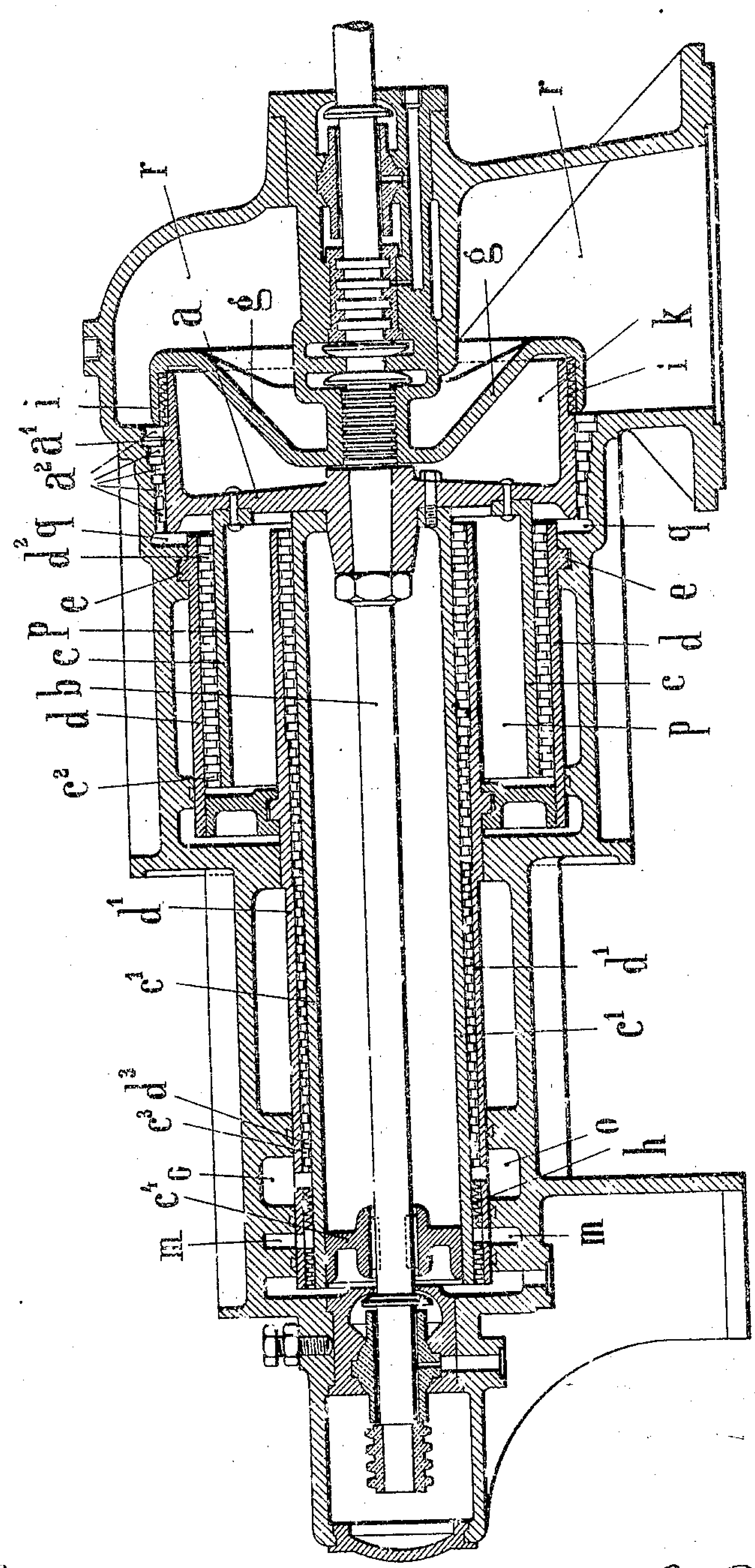

Fig. 1.

Witnesses.
W. Max. Duvall.
Samuel Turley

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3 SHEETS—SHEET 2.

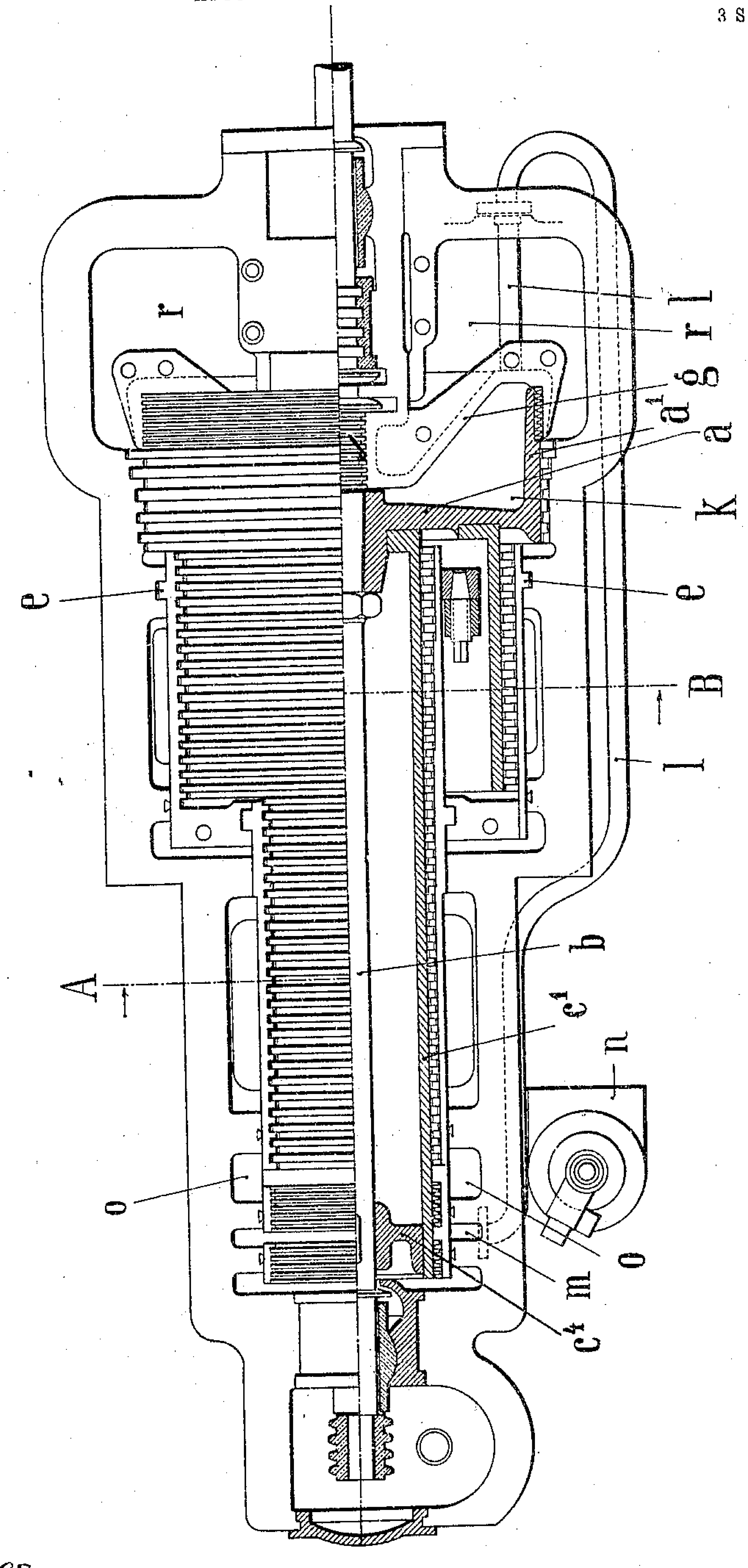

Fig. 2.

Witnesses.
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3 SHEETS—SHEET 3.

Fig. 3. (A—B.)

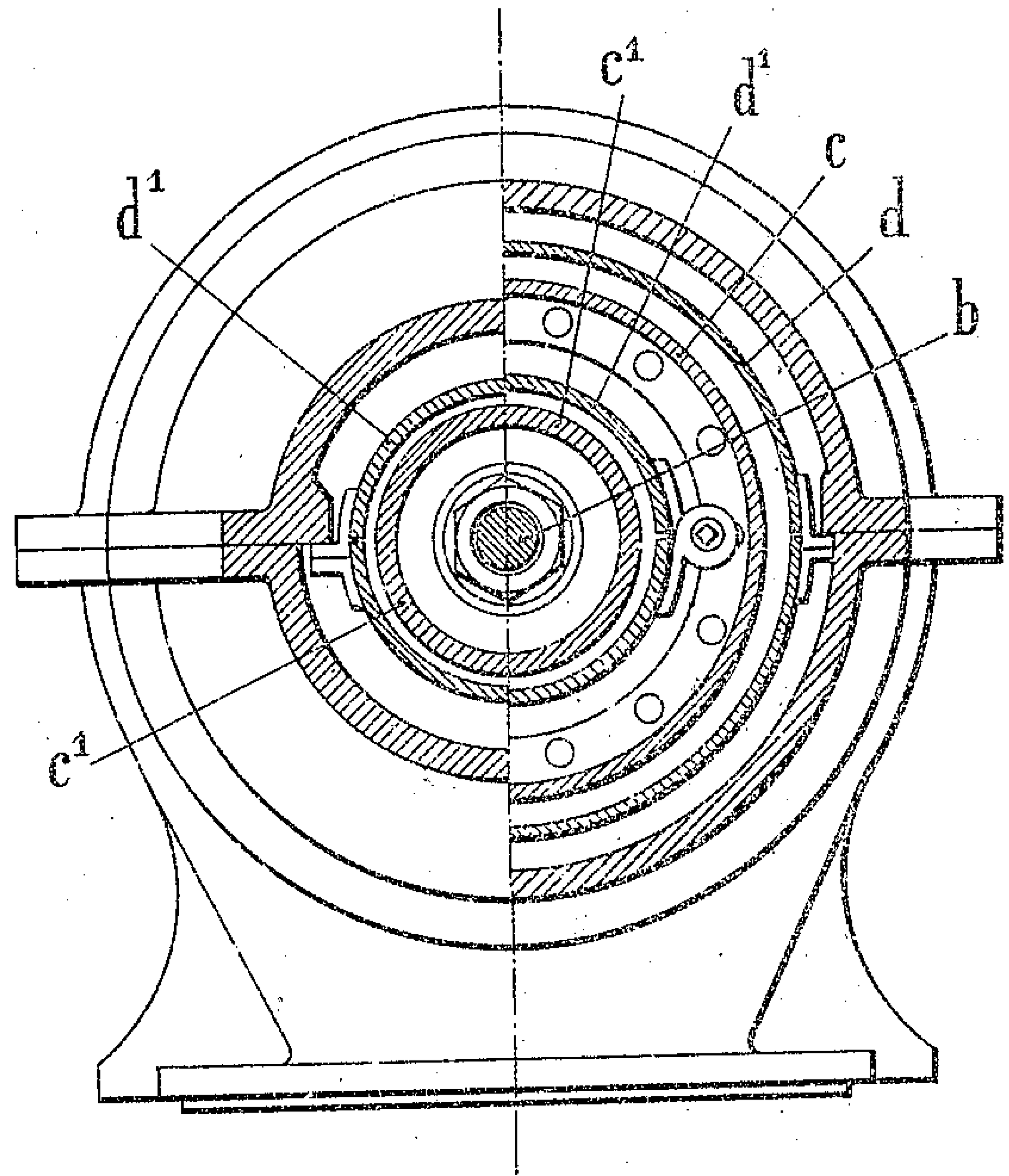


Fig. 4.

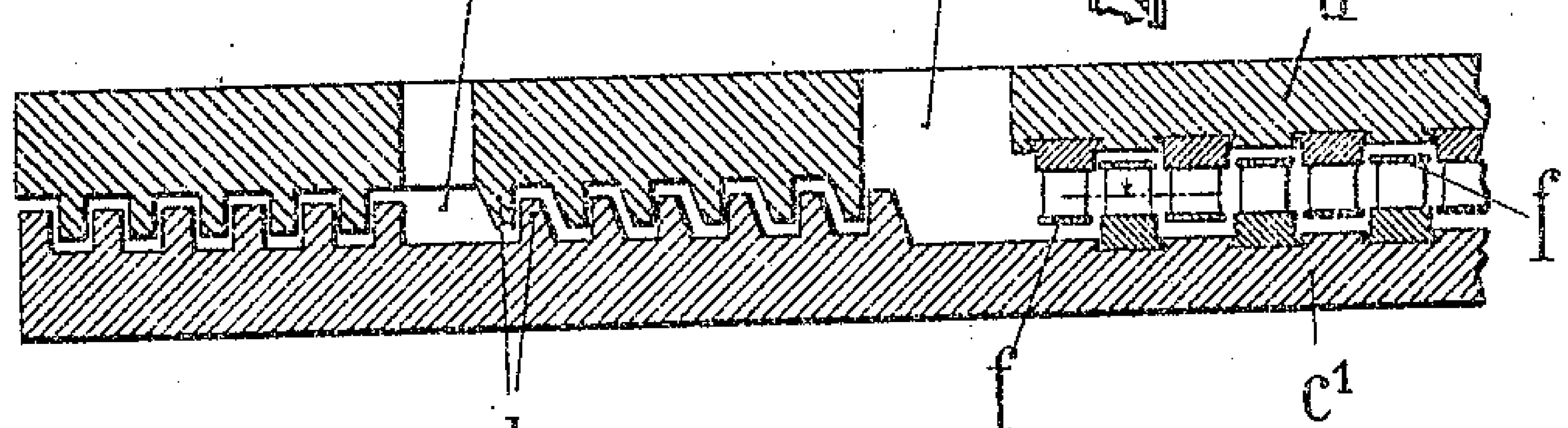
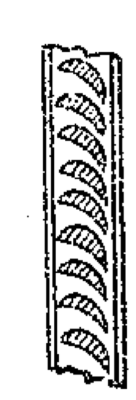


Fig. 6.



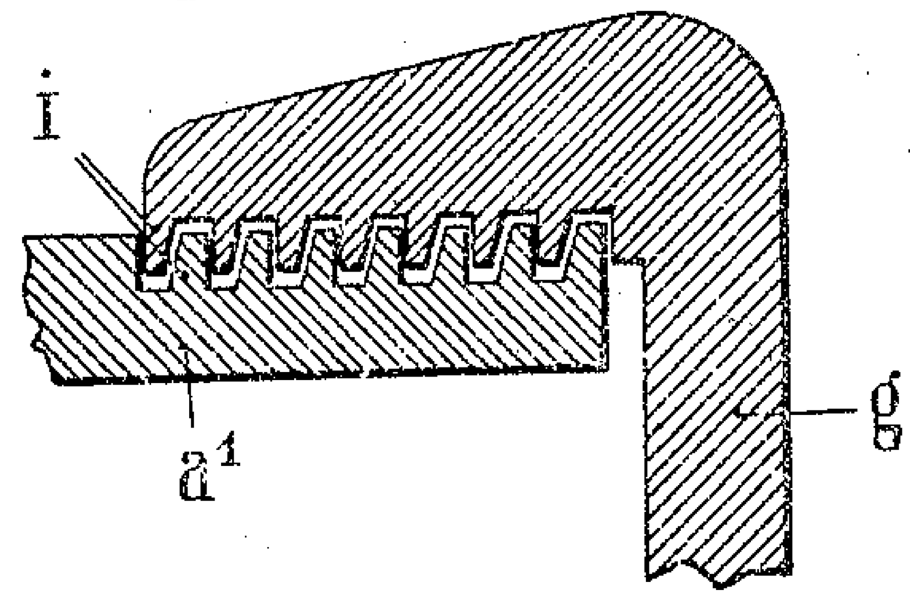


Fig. 5.

Witnesses.
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UNITED STATES PATENT OFFICE.

PHILIP FRANCIS ODDIE, OF LONDON, ENGLAND.

MULTIPLE-STAGE-REACTION TURBINE.

No. 822,149. Specification of Letters Patent. Patented May 29, 1906.

Application filed December 19, 1905. Serial No. 292,488.

To all whom it may concern:

Be it known that I, PHILIP FRANCIS ODDIE, engineer, a subject of the King of Great Britain and Ireland, residing at 85 Worple road, Wimbledon, London, England, have invented certain new and useful Improvements in Multiple-Stage-Reaction Turbines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to multiple-stage-reaction turbines, and has for its object the construction of a turbine of this type which shall avoid the following defects of the multiple-reaction turbines as hitherto constructed: First, a loss of steam between the ends of the rotor-blades and the casing and the ends of the stator blades and rotor; second, great length between centers of bearings, causing danger of breakdown by the rotor-blades coming in contact with the inner walls of the casing; third, dangers and difficulties due to unequal expansion between rotor and casing, especially with highly-superheated steam; fourth, difficulties in the packing-boxes and losses in connection with air being drawn into the condenser.

Referring to the drawings, Figure 1 represents a vertical sectional view of the turbine, according to my invention. Fig. 2 is partly a horizontal section and partly a plan view with the casing removed. Fig. 3 is a cross-section taken in the line A B of the Fig. 2, showing the segments carrying the fixed blades and encircling the revolving blades. Fig. 4 is a sectional detail showing the labyrinth packing-rings of smaller diameter and the adjacent blades. Fig. 5 is a sectional detail showing the labyrinth packing-rings of larger diameter on the opposite end of the turbine. Fig. 6 is a detail and shows also the blades.

In carrying out my invention I make use of a disk or wheel *a*, firmly attached to a shaft *b* and having on its periphery a flange *a'*, on the outer edge of which are formed or attached blades a^2. On the side of this disk are fixed weldless tubes *c c'*, also carrying revolving blades c^2 c^3, respectively. The ring *c'* is made considerably longer than the ring *c*. The ends of the blades do not come in near contact with the inner periphery of the outer casing, and the radial clearance may be made indefinitely large.

The tubes, which are made of steel, bronze, or other suitable material, are attached at one end only and are free to expand toward the other end. The outer end of the ring of smallest diameter fits on and is supported by a bracket c^4, which is free to slide lengthwise in the direction of the shaft. Similar tubes *d d'*, carrying the rings of fixed blades d^2 d^3, are attached to the outer casing at one end only, the point of attachment *e* corresponding as nearly as possible to the position where the shaft *b* is held. By this simple arrangement all difficulties connected with uneven expansion are avoided, as these tubes carrying the fixed and revolving blades, being made of the same material and approximately of the same thickness, will be heated by the steam passing through the turbine equally at every point, and being fixed at one end only the expansion of both will be equal. The fixed and revolving blades are covered or closed by light rings *f*, and the clearance between these rings and the succeeding set of blades can be made exceedingly small and will remain constant under all conditions of working, whether running light or under full load, with saturated or with highly-superheated steam. It is of course an essential condition for this method of working that the disk should revolve in the same relative position axially—in other words, that as regards axial thrust the disk should be in equilibrium so as to exclude the possibility of any appreciable wear on the thrust-block. A novel and perfectly automatic method of balancing the thrust has therefore been introduced. It consists of a thrust-block *g*, formed in the usual way with concentric rings turned on the shaft, corresponding to grooves formed in a bearing, the peculiarity, however, being that the rings have a slight clearance approximately equal to half the clearance between the fixed and revolving blades of the turbine. The shaft can move, therefore, slightly axially in both directions. Oil under pressure is pumped into the thrust-block, which offers a certain amount of resistance to the axial movement. At one end of the turbine there is a system of labyrinth packing *h*, consisting of fixed and revolving rings with points of near contact on one side only, Fig. 4, and at the other end of the turbine there is another larger set of packing-rings *i*, Fig. 5, whose point of near contact is also on one side only, but opposed to the smaller set of packing-rings. This set of packing-rings incloses a chamber *k*, this chamber being in communication by the pipe *l* with a chamber *m*, into which the steam passing through the first set of packing-rings escapes. At the commencement the clearance in the thrust-block will allow the thrust to move the rotor slightly from left to right. This will cause the leakage on the smaller set of packing-rings to increase and the leakage from the larger set of packing-rings to decrease. Hence the pressure in the chamber *k* inclosed by these two sets of packing-rings will increase, and this pressure, reacting on the end-exposed area of the disk *a*, will counteract the thrust.

Should the thrust decrease so that the balancing effort of the steam in the chamber becomes greater than the thrust, the rotor will move slightly from right to left, which will cause the smaller set of packing-rings to become tighter and to pass less steam, while the larger set of labyrinth packing-rings will allow steam to pass from the chamber into the exhaust *r*, so that the pressure in the chamber decreases until the equilibrium is restored. The area of the disk inclosed by this chamber is so calculated that a pressure of about one and one-half atmospheres, absolute, balances the thrust under normal load and is slightly above the atmospheric pressure when running light or without load. The importance of this system of equalizing the expansion of the rotor and stator elements, combined with an automatic balancing of the thrust under all conditions, can hardly be overestimated, since it means increased economy, owing to the reduction of leakage and to the possibility with a given speed of commencing at a higher peripheral velocity of rotor. The system of balancing is also attended with another distinct advantage, inasmuch as it does away with the difficulties experienced with the packing-boxes, as they are exposed neither to high-pressure steam nor to vacuum and there is no possibility of air or oil being drawn into the condenser.

It must not be forgotten that just in the same way as the leakage between the blades is diminished by the system of equalizing the expansion between the revolving and fixed blades and the automatic system of balancing, so is the system of labyrinth packing made far more effective and simple than has hitherto been possible.

I now come to the last point to be considered—namely, the reduction of length of my turbine over others of the same type.

With the same number of turbine-rings the reduction of length would amount to about fifty per cent., due to, first, the possibility of commencing at a higher initial velocity of drum; second, the method of automatic balancing occupies far less space than the balancing-drums hitherto used; third, the equalization of expansion between the blade-carrying elements avoids the necessity of large axial clearances between the fixed and revolving blades to allow for unequal expansion; fourth, the shaft passing into the balancing-chamber being not exposed to vacuum the bearings, thrust-block, &c., can be brought close up to the disk. The length is still further reduced by the telescopic arrangement shown, by which the turbine is divided into high and low pressure stages.

The steam enters at *n* and passes into the circular recess *o*. It then passes alternately through the fixed and revolving blades into the chamber *p* between the tubes *c* and *c'*, which form a receiver. It then passes through the next set of blades into the chamber *q* and from thence through the set of blades on the periphery of the flange *a'* of the disk *a* into the exhaust-chamber *r*. Thus where two tubes are employed, as shown in the drawings, the first set of turbine-blades on the ring *c'* may be said to be the high-pressure set, those on the tube *c* may be said to be the middle-pressure set, and those on the periphery of the disk the low-pressure set. This latter arrangement is not bought at the cost of accessibility of the parts. As soon as the outer cover is removed the tubes carrying the fixed blades can be instantly removed and the fixed and revolving blades be examined without disturbing the bearings or removing the rotor. In this respect the accessibility compares favorably with the Parsons type, where it is necessary to remove the rotor to examine the fixed blades in the lower portion.

The saving of space is of course far more striking on larger sizes and is of the utmost importance when dealing with turbine for ships' propulsion.

The removal of the defects mentioned means the clearance between the blades remains practically constant, whether the turbine is running with saturated or superheated steam, light or at full load.

In conclusion, one word as to the relative cost of manufacture of my turbine. This should compare favorably with the turbine at present in use for the following reasons: The blades being short can be stamped in lengths of suitable material, these lengths or ribbons of blades being merely bent round and fastened in grooves on the rotor and stationary rings, forming thus a more solid, accurate, and at the same time considerably cheaper method than at present in use. The rings being made of weldless tubes require very little machining, and the expensive process of balancing the turbine is greatly simplified. The reduction on length means also a reduction in weight, and the machining of the outer casing is very simple, a point of great importance especially with large units.

Having described my invention, I declare what I claim is—

1. In a turbine, the combination of a supporting-frame a casing therein provided

with fixed blades, said casing being fastened at one end and free to expand at the other end, and a rotary part carrying blades located within said casing, said rotary part being fastened at one end to a support, and free to expand at the other end, substantially as described.

2. In a turbine, the combination of a supporting-frame, a casing therein provided with fixed blades, said casing being fastened at one end and free to expand at the other end, and a rotary part carrying blades located within said casing, said rotary part being fastened at one end to a support and free to expand at the other end, said casing and rotary part being fastened at opposite ends so as to expand and contract telescopically in opposite directions, substantially as described.

3. In a turbine, the combination of a supporting-frame, a casing mounted therein, and provided with fixed blades, a rotary part provided with blades mounted within said casing, said rotary part being provided with two sets of labyrinth packing-rings of different diameters, one set being located near each end, said casing and said rotary part being each fastened at one end only and adapted to expand in opposite directions, substantially as described.

4. In a turbine, the combination of a casing provided with fixed blades, a rotary part therein provided with blades, two sets of labyrinth packing-rings on said rotary part, one set near each end, and said sets being of different diameters and arranged to face in opposite directions, said casing and rotary part being each fastened at one end only and free to expand in opposite directions, substantially as described.

5. In a turbine, the combination of a supporting-frame and a two-part casing, each part being provided with fixed blades, mounted on said support, one of said casings being larger than the other and concentric therewith leaving a steam-chamber therebetween, and a rotary part composed of two parts each carrying blades, one part being larger and arranged concentrically relatively to the other, and said casing and said rotary part being fastened at one end only and free to expand at the other in opposite directions, substantially as described.

6. In a turbine, a rotary part therefor comprising an axle, a disk firmly secured to said axle, a cylindrical part provided with blades on its outside secured at one end to said disk, the other end being free to expand, and a larger cylinder carrying blades concentric with said first-named cylinder and fastened at one end to said disk and free to expand at the other end, substantially as described.

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

PHILIP FRANCIS ODDIE.

Witnesses:

H. D. JAMESON

F. L. RAND.