Sept. 22, 1925. 1,554,230

B. F. POCHOBRADSKY

STEAM TURBINE

Filed Jan. 6, 1925 3 Sheets-Sheet 1

Fig. 1.

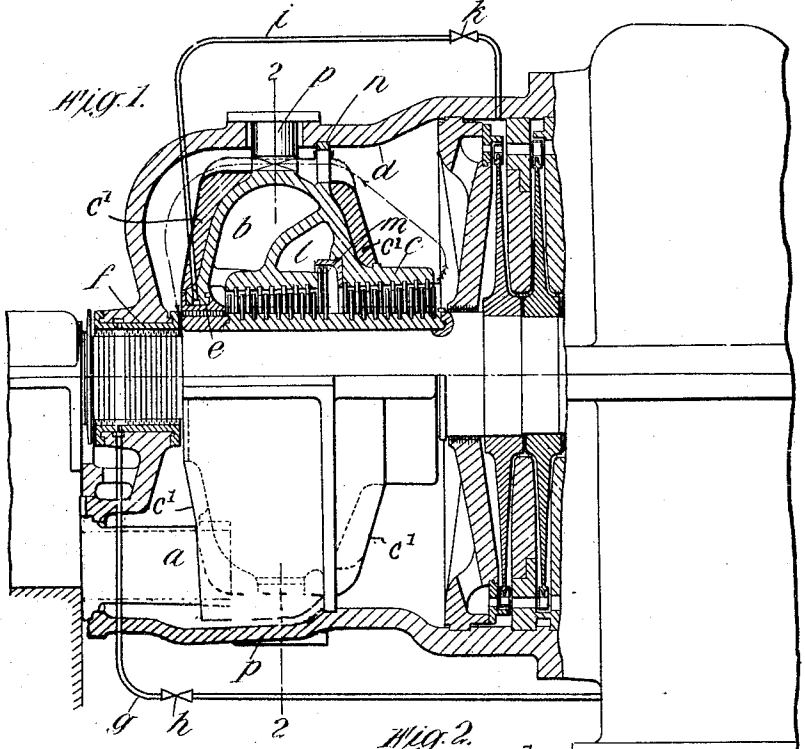
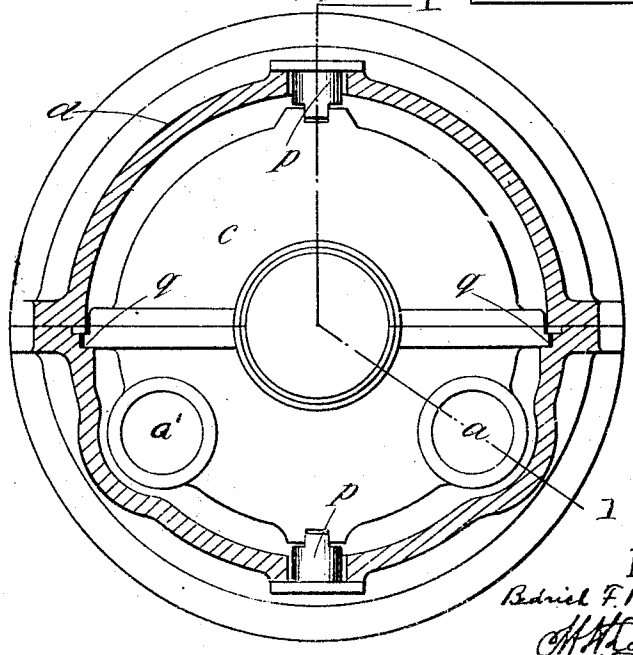


Fig. 2.



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Filed Jan. 6, 1925 3 Sheets-Sheet 2

Fig. 3.

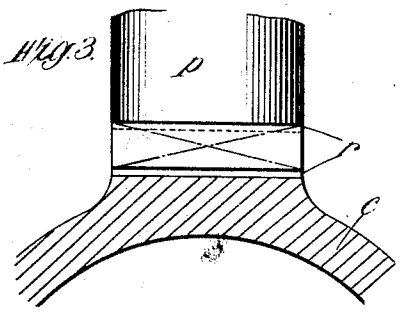


Fig. 4.

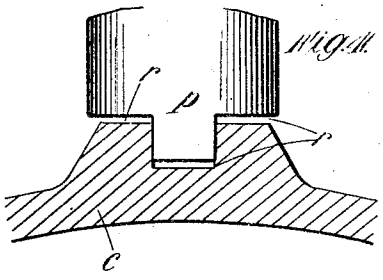


Fig. 5.

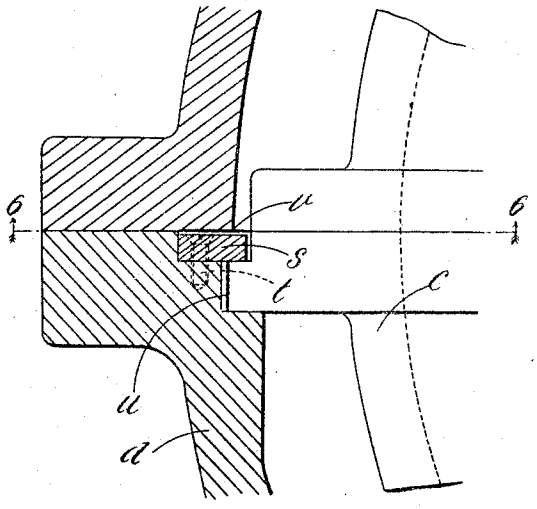


Fig. 7.

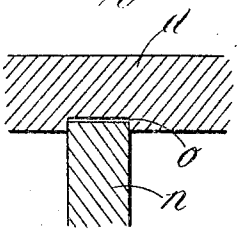


Fig. 6.

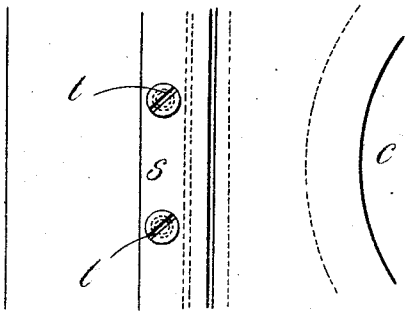
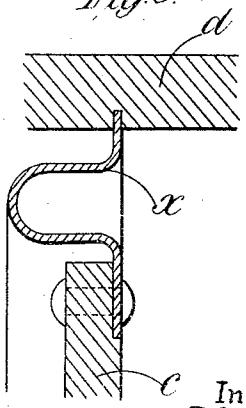


Fig. 8.



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STEAM TURBINE

Filed Jan. 6, 1925 3 Sheets-Sheet 3

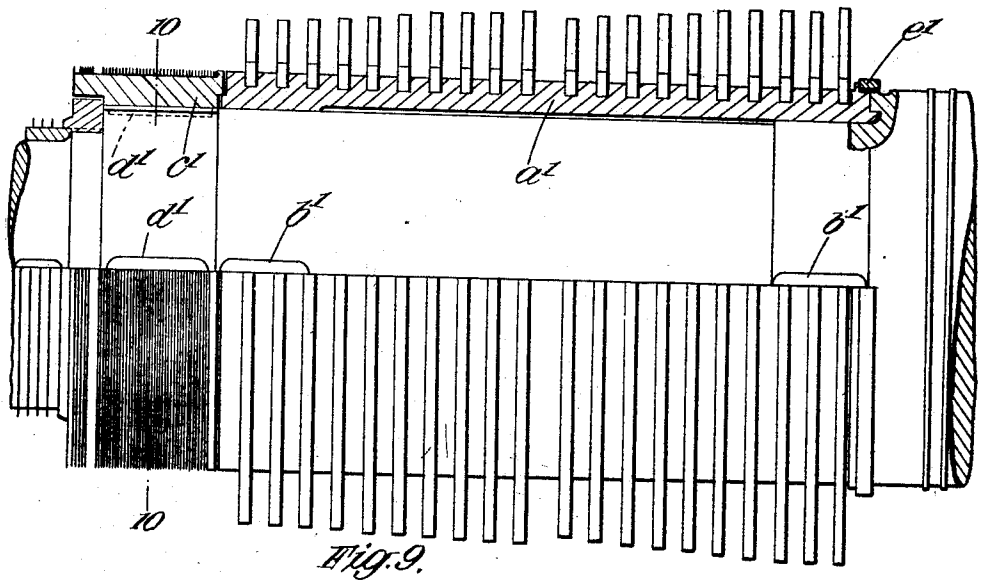


Fig. 9.

Fig. 10.

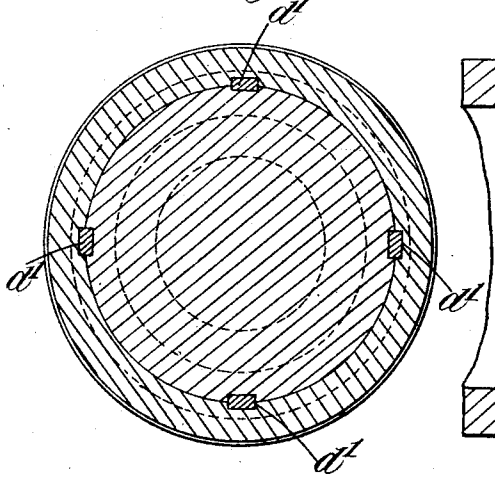
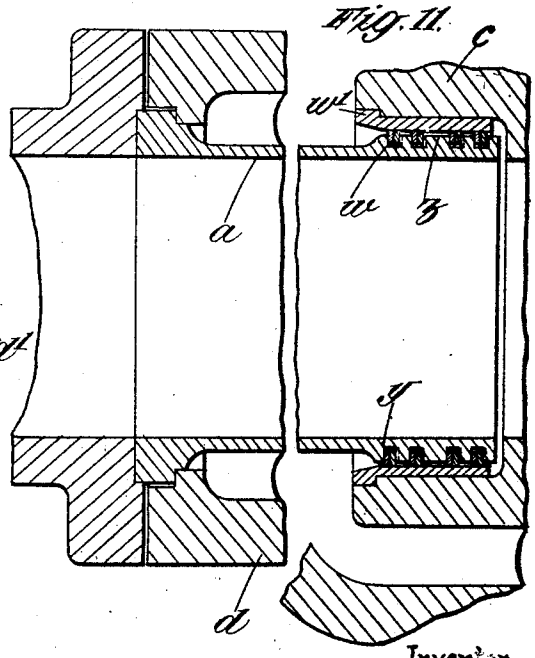


Fig. 11.



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1,554,230

UNITED STATES PATENT OFFICE.

BEDRICH FRANTISEK POCHOBRADSKY, OF SIDCUP, ENGLAND.

STEAM TURBINE.

Application filed January 6, 1925. Serial No. 784.

To all whom it may concern:

Be it known that I, BEDRICH FRANTISEK POCHOBRADSKY, of Sidcup, in the county of Kent, England, a British subject, have invented certain new and useful Improvements in Steam Turbines, of which the following is a specification.

This invention relates to improvements in steam turbines or turbines working with elastic fluid.

In the design of steam turbines hitherto known, two different methods are used, namely—a considerable expansion is allowed in the first stage, rendering that stage less efficient, or high temperature and pressure are allowed in the casing, which results in distortion, cracks, and other damage to the casing, as well as to other parts of the machine.

Turbines with an external and internal casing have previously been proposed, but such proposals had the disadvantage that either the inner casing had to withstand the whole steam pressure, the space between the two casings containing air at atmospheric pressure and no arrangement being made for free radial expansion of the internal casing, or the internal casing, acting as a carrier for nozzles and guide blades, was provided with openings in the wall thereof and the external casing had to withstand the various steam pressures and temperatures from the supply pressure onwards through the successive stages.

The object of the present invention is to eliminate the high stresses caused by high pressures and high temperature gradients in a single body such as a turbine casing or rotor shaft.

According to the present invention a fluid pressure turbine is provided with a high pressure portion having two casings arranged one inside the other in such a manner that the pressure of the working medium admitted first to the internal casing is resisted partly by the internal casing and partly by the external casing, the high temperatures being localized in the internal casing and the lower temperatures in the external casing, said internal and external casings being so connected as to be adapted to expand freely and independently of each other radially according to the temperatures and forces acting upon them, both said casings remaining concentric and, in the longitudinal direction, being relatively fixed in one plane, so as to permit expansion in both directions therefrom, whilst means are provided for maintaining a slight flow of working medium from the exhaust end of the internal casing towards the inlet end and around the whole of the internal casing so as to maintain moderate temperature in the space between the external and internal casings. The internal casing may be sub-divided to provide an additional admission chamber or chambers for higher loads. Preferably the internal casing is suitably lagged with non-conducting material to prevent undue heating of the external casing. Means are also provided for transferring any leakage of steam from the packing gland of the internal casing to a lower stage in the external casing. The moving element may be fixed, not on the shaft direct, but on a sleeve which is longitudinally fixed to the shaft in one plane only, from which it can expand freely and independently of the shaft in the longitudinal direction, and also radially whilst it remains concentric with the shaft.

The invention will be described with reference to the accompanying drawings of which Figure 1 is a longitudinal section of the high pressure portion of an elastic fluid turbine on line 1—1 of Fig. 2. Figure 2 is a section of the outer casing taken on the line 2—2 of Figure 1, Figures 3 and 4 are respectively a fragmentary side elevation and a fragmentary end elevation of a vertical keying arrangement, Figure 5 is a fragmentary elevation of a horizontal keying arrangement, Figure 6 is a sectional plan taken on the line 6—6 of Figure 5, Figure 7 is a fragmentary section of a flange detail, Figure 8 is a fragmentary view of an alternative connecting device, Figure 9 is an elevation partly in longitudinal section of a portion of the rotor shaft fitted with a sleeve, Figure 10 is a cross section taken on the line 10—10 of Figure 9 and Figure 11 is a longitudinal sectional elevation of a steam conduit.

As shown in the drawings steam is admitted by the inlet valves to a conduit *a* through which it reaches the admission

chamber *b* of the internal casing *c;* in this internal casing the steam expands to a moderate pressure and the corresponding heat drop is utilized efficiently in a number of stages; having passed these stages the steam is exhausted from the internal casing into the external casing *d* at a medium pressure and moderate temperature; it will be seen from Figure 1 that between the internal and external casings the pressure is the same as at the exhaust of the internal casing. The internal casing is, therefore, subjected to the forces due to the differences of pressures inside same and in the space surrounding the internal casing; the external casing of the H. P. portion is subjected to forces due to the difference of pressures inside of that casing and the surrounding atmosphere. In this manner by means of the two casings, internal and external, the action of the steam pressure is subdivided into two; one part of it is taken up by the internal casing and the remaining part by the external casing. Similarly the initial temperature of steam acts only on the internal casing, in which it is reduced in the successive stages to a medium temperature, and only that medium temperature acts on the external casing; it will be seen that the internal casing is subjected only to a moderate temperature difference or gradient from the admission chamber to the exhaust of that casing, the surrounding temperature being practically the same as that at the exhaust of the internal casing; the external casing is consequently subjected to a moderate temperature difference as the highest temperature acting upon it is substantially the medium temperature reached at the exhaust of the internal casing. The remaining heat drop after the steam has passed the internal casing is utilized in stages inserted in a continuation of the external casing or in an entirely separate casing.

The internal casing is provided at the inlet end with packing glands *e*, preventing the leakage of steam from the inlet side of the internal casing into the external casing. The internal casing is suitably lagged by non-conducting material *c'* to prevent the heat being transmitted from the internal casing to the surrounding steam and thus heating the external casing. To ensure that the temperature between the two casings shall be substantially the same as at the exhaust of the internal casing a steam circulation is maintained by means of the packing gland *f* in the external casing; a small leakage is allowed in this gland, this leakage being taken by means of a conduit *g*, adjustable by a valve *h* to a lower stage or the exhaust of the external casing. In the space between the internal and external casings a slight steam flow will take place from the exhaust of the internal casing in the direction of arrows indicated in Figure 1. Any leakage of steam which might take place in the gland *e* of the internal casing is taken from an intermediate space of that gland by means of a conduit *i*, preferably provided with a valve *k* for the purpose of adjustment, to a lower stage of the external casing.

In the embodiment shown the first stage has full admission for a given load and when higher loads are required this is accomplished by means of additional admission chambers, such as chamber *l* receiving steam from another inlet valve (not shown) through a separate conduit *a'*, Fig. 2, similar to conduit *a*. The additional admission chamber may admit steam to a stage or stages such as *m* interposed between the additional admission chamber and the lower stage of the internal casing. Such stage is formed by nozzles communicating with the additional admission chamber *l* and moving blades attached to or formed in one piece with the moving blades of one of the ordinary stages.

As shown in Figure 2, the internal casing *c* is preferably divided into two parts along a horizontal central plane, the two parts being bolted together so as to take up the forces due to pressure difference inside and outside of that casing. There is, however, no rigid connection between the internal and external casings which would prevent freedom of expansion, the two casings expanding differently owing to the different temperatures to which they are subjected. According to Figure 1, the internal casing is provided with a flange *n;* this flange is provided with openings to allow steam to flow in the direction of the arrows and fits in a groove of the external casing, a small radial clearance being allowed; the detail of this flange can be seen in Figure 7. It will be seen that by means of this flange the longitudinal position of the internal casing is fixed in the external casing in one plane at right angles to the axis of the shaft. The internal casing can freely expand on both sides of the flange *n*, and also radially owing to the clearance *o*. It is necessary that the centre line of the internal casing coincide with the centre line of the external casing whatever the temperature expansion of the two casings may be. This is achieved by means of keys arranged as shown in Figure 2, two keys *p*, fixed to the external casing and arranged in a vertical plane, fitting in keyways arranged in the internal casing, and the horizontal flange of the internal casing being provided with key-like projections *q*, fitting in keyways arranged in the external casing. These keys and keyways have radial clearances so as to allow free radial expansion, the central axial lines of the two

casings always coinciding. The keys and key-ways may be arranged on the one or the other casing respectively, or the keys may be separate and fit into key-ways arranged in both casings.

Figures 3, 4, 5 and 6 show details of such key arrangements. Figures 3 and 4 refer to the keys in the vertical plane; a radial clearance r being provided between the internal casing c and the key p, which latter is fixed to the external casing. Figures 5 and 6 refer to the keys in the horizontal plane. The key itself is formed on the horizontal flange of the bottom half of the internal casing c, the keyway being formed by a recess in the external casing d and a retaining member s fastened to the casing d by means of screws t. A radial clearance u is provided to allow free expansion of the internal casing and a clearance v is arranged between the retaining member s and the flange of the top half of the external casing d so that in bolting the horizontal joint of the external casing the keyway is not reduced and so that the free sliding of the key is assured.

The alternative arrangement for ensuring the coincidence of the centre lines of the two casings is shown in Figure 8. A flexible ring or rings such as x is or are provided, one end being fastened to the external casing, and the other to the internal casing. The rings x are so shaped as to allow sufficient flexibility for radial and longitudinal expansion.

The conduit for steam from outside to the internal casing such as a in Figure 1 is so arranged as to allow for the difference in expansion between the external casing d and the internal casing c. As an example the conduit a in Figure 11 is fastened rigidly at the inlet end to the external casing d by means of a flange of the steam chest or the outside steam pipe which is bolted rigidly to the external casing d. The other end of the conduit a is formed with grooves in which flexible piston rings w are fitted with a clearance y on the inside of the rings, which allows freedom of expansion of the internal casing c, the piston rings w sliding in an opening of the internal casing c which is preferably provided with a bush w' of suitable material. The clearance spaces y are preferably connected with the steam space z on the higher pressure side of the ring so as to ensure that the rings on the periphery are pressed against the wall of the opening in the casing c thus preventing steam leakage. Any longitudinal expansion results in the piston rings sliding in the opening of the casing c without causing undue stress in any portion of the machine.

In order to eliminate excessive heating and temperature dilatation of the rotor shaft the moving stages in the high pressure portion of the turbine are, according to this invention, mounted on a sleeve which may carry the moving blades attached thereto, either directly or through the medium of rings or discs. An example of a suitable construction is illustrated in Figures 9 and 10.

The sleeve a' as will be seen from Figure 9 is keyed on to the main shaft, the keys b' transmitting the power on to the main shaft.

In order to provide for free longitudinal expansion of the sleeve relatively to the shaft, the sleeve is fixed in one plane only; similarly, means are provided for free radial expansion of the sleeve keeping the sleeve always concentric with the main shaft.

One end of the sleeve a' is fitted into a ring c' attached to the main shaft by means of four keys d' arranged crosswise so that the ring c' remains concentric with the main shaft while the ring and the sleeve can freely expand radially. The other end of the sleeve may be arranged similarly or alternatively as shown in Figure 9, from which it will be seen that the end of the sleeve is turned down to fit into an annular groove undercut in the shaft. This type of construction may be used for the exhaust end of the internal casing owing to moderate temperature at that point. A nut e' fixes the longitudinal position of the sleeve at one point on the main shaft.

It is to be understood that the present invention applies not only to steam turbines but generally to elastic fluid turbines.

I claim:—

1. In an elastic fluid turbine, a high pressure portion of the turbine comprising two casings arranged one inside the other, means for ensuring the said casings will remain concentric but permitting free expansion radially of both said casings when heated, means for supplying working fluid to the internal casing, and means for maintaining a slight flow of working medium from the exhaust end of the internal casing towards the inlet end thereof around the whole of the internal casing between the external and internal casings.

2. A turbine according to claim 1, comprising connecting means between said casings, adapted to permit longitudinal expansion of the internal casing relative to a fixed connection with the external casing.

3. A turbine according to claim 1 comprising an internal casing sub-divided to provide a plurality of chambers for cooperation with groups of blades for varying loads substantially as described.

4. In a turbine according to claim 1 the combination of an internal and an external casing with a fluid supply conduit leading from the wall of the external casing into the internal casing, the connections therebetween being constructed in such a manner

that both said casings and said conduit when heated can expand freely and independently of one another.

5. A turbine according to claim 1 comprising an internal casing lagged by non-conducting material to prevent undue heating of the external casing.

6. A turbine according to claim 1 comprising a rotor shaft having a sleeve which carries the moving elements and which is longitudinally fixed to the shaft at one end only whereby the said sleeve can expand freely and independently of said shaft in the longitudinal direction.

7. A turbine according to claim 1 comprising a rotor shaft having a sleeve which carries the moving elements, and means to allow the sleeve to expand freely and independently of the shaft radially whilst said sleeve remains concentric with said shaft.

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