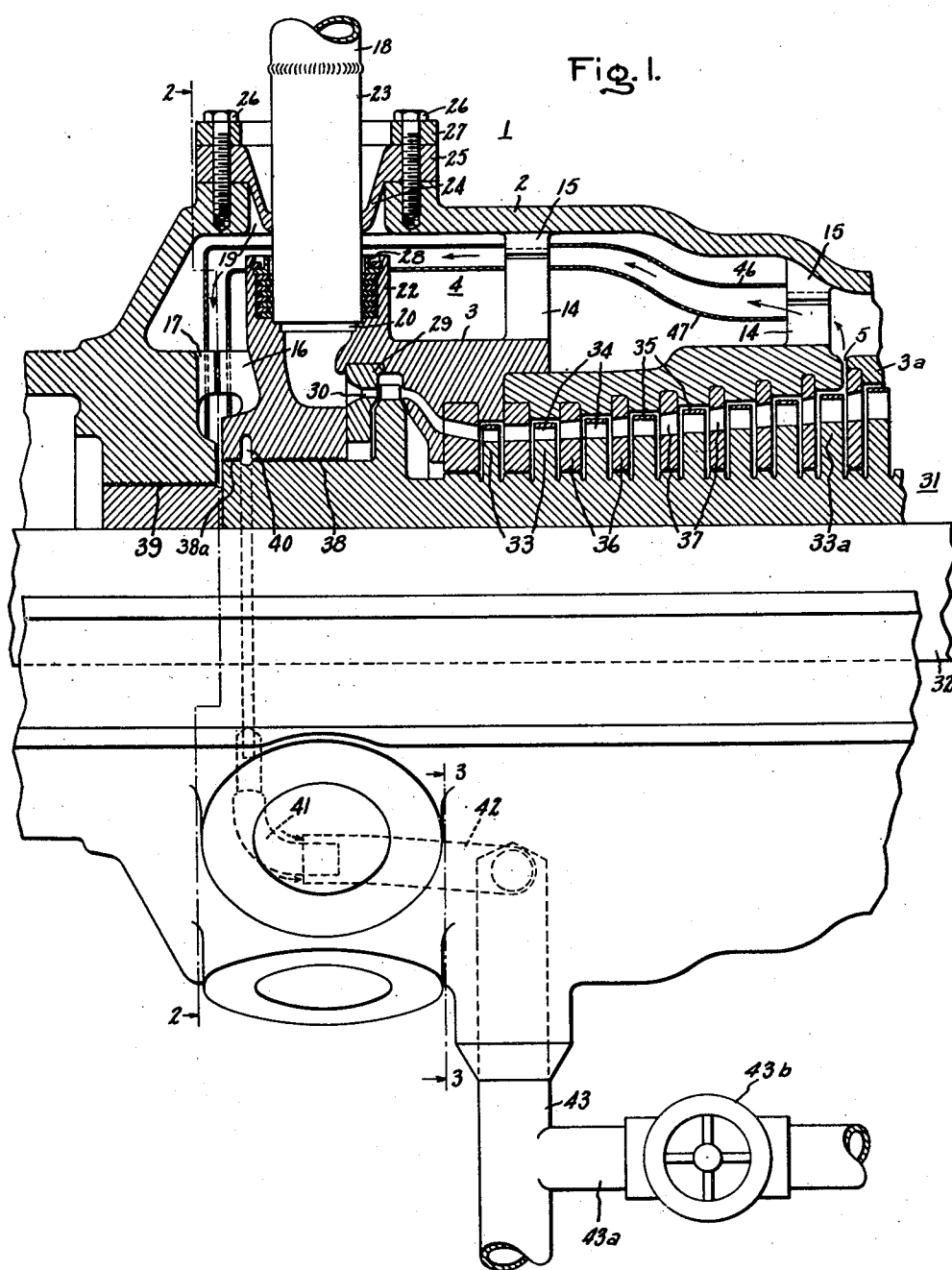


2,467,818

2 Sheets-Sheet 1



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April 19, 1949.

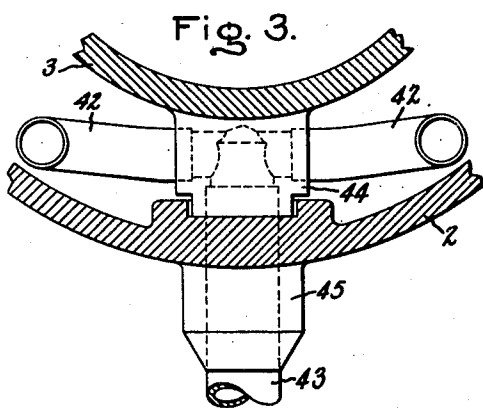
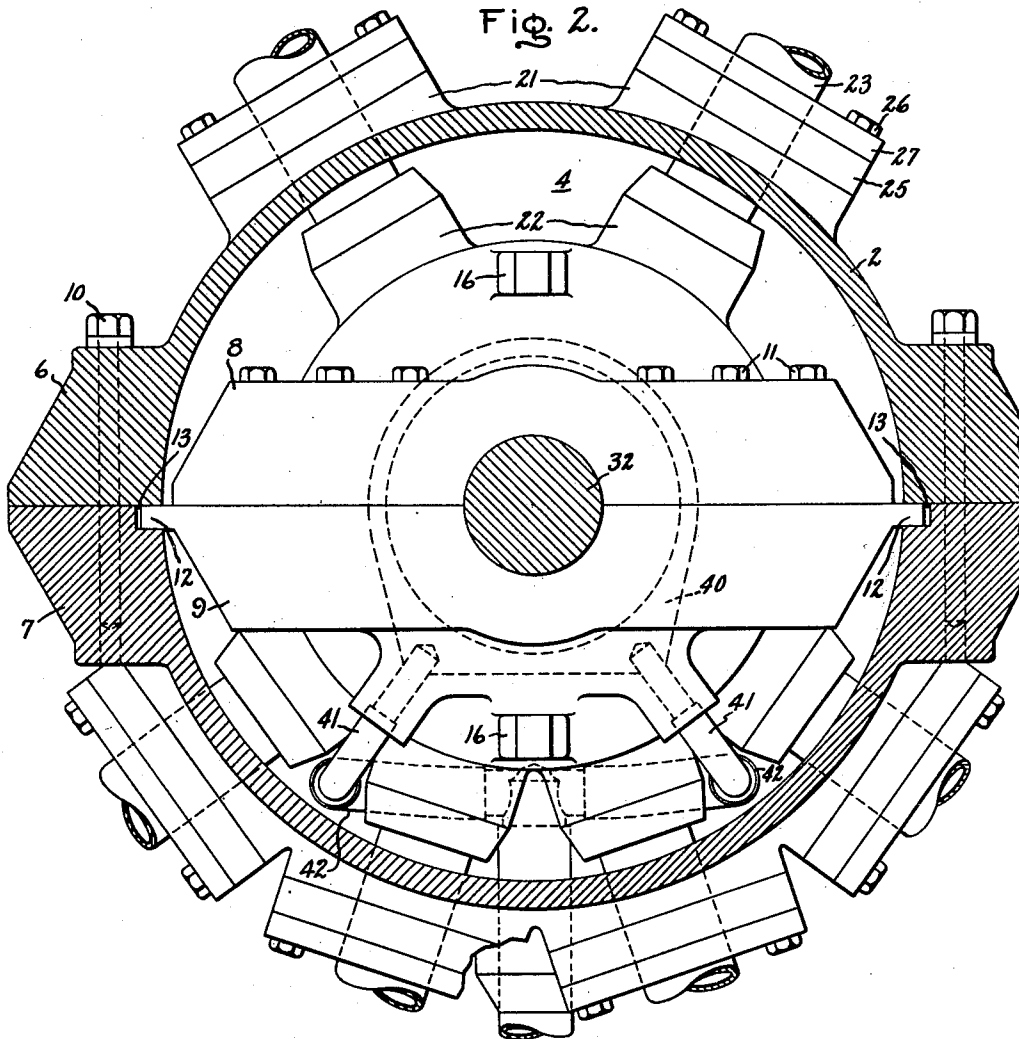
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2,467,818

HIGH-TEMPERATURE TURBINE CASING ARRANGEMENT

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2 Sheets-Sheet 2



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HIGH-TEMPERATURE TURBINE CASING
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5 Claims. (Cl. 60—67)

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The present invention relates to double casing, high temperature elastic fluid turbines. More particularly it relates to a method of and arrangement for maintaining the outer casing of a double casing, high temperature, elastic fluid turbine at a relatively low temperature.

Since a high thermal efficiency can be attained in a steam turbine by utilizing a high temperature, high pressure elastic fluid operating medium, present day turbines are being designed to accommodate highly superheated steam over 1000° F. However, the design of such turbines presents many problems, one of the most important being the selection of materials for the rotor, casing, buckets, etc.

There are three main factors to consider when selecting materials to be used in a high temperature, high pressure elastic fluid turbine. These factors are the rupture strength, creep strength, and metallurgical stability of a material. The first of these, rupture strength, is concerned with the pressure to which a material will be subjected. Therefore it is conceivable that nearly any one of the standard, inexpensive materials could be thickened to a degree such that it would be able to withstand any pressure within reasonable limits. However, the creep strength and metallurgical stability of any material are primarily functions of the temperature to which the material may be subjected. Nearly all inexpensive low carbon steels ordinarily used for steam turbines have very low creep strength when subjected to temperatures of the order of 1050° F. Furthermore, nearly all are metallurgically unstable at such temperatures; that is the carbon contained in the steel precipitates along the grain boundaries causing a phenomenon known as "graphitization" which reduces the allowable working stress of the steel to a point which is far below the stresses encountered in present-day turbines. Therefore, it may be seen that the creep strength and metallurgical stability factors place very definite limitations on the selection of high temperature materials for steam turbines and the like.

Special austenitic materials such as the so-called "cobalt ascaloy" and "18-8" chrome-nickel steel have high creep strength and are metallurgically stable at temperatures of the magnitude described, but the cost of such materials is very high when compared with the cost of standard steels such as those of the chrome-molybdenum-vanadium type ordinarily used for the casings, rotors, etc., of steam turbines. Those parts of a turbine which directly contact the high

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temperature steam would necessarily have to be constructed from these austenites. They include the inner casing, the buckets of the first few stages where temperature conditions are most severe, and possibly the rotor in high speed machines where the shaft and bucket-wheels are integral. In addition, the outer casing would ordinarily have to be cast from the austenites also because it has been found that with the designs now in use, radiant heat from the inner casing causes the outer casing to assume a temperature of only 15-25 degrees below that of the inner casing.

It is well known that by decreasing the normal working temperature of chrome-molybdenum steel, for instance from 1050° F. to 900° F. the creep strength for an allowable creep rate may be increased to about four times its former value, and what is more important, the steel at 900° F. will be metallurgically stable. Since in this temperature range the creep strength increases rapidly as a function of decrease in temperature and the transition from metallurgical instability to metallurgical stability occurs, readily available inexpensive materials could be substituted for the high cost austenites which would ordinarily be required for the outer casing of a high temperature elastic fluid turbine provided the outer casing is maintained at a temperature such that the creep strength exceeds the maximum working stress and the material is metallurgically stable. This invention provides an arrangement which permits the substitution of inexpensive materials for high cost materials which ordinarily would be required in a double casing high temperature elastic fluid turbine.

Accordingly, an object of the invention is to provide an improved method of and arrangement for limiting to a preselected value the temperature of the outer casing of a double casing high temperature elastic fluid turbine.

Another object is to provide in a double casing high temperature elastic fluid turbine, means for maintaining safe allowable stresses in an outer casing, cast from standard low cost materials.

A further object is to provide a novel arrangement for cooling the "forward" end portion of the shaft and surrounding structure in a high temperature elastic fluid turbine.

Still another object is to provide in an elastic fluid turbine means for the quick disposal of the high temperature packing leakage.

Other objects and advantages will be apparent from the following description taken in connec-

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tion with the accompanying drawings in which Fig. 1 is a longitudinal sectional view of an elastic fluid turbine embodying the invention; Fig. 2 is a radial sectional view taken on the plane 2—2 of Fig. 1 and Fig. 3 is a fragmentary sectional view taken on the plane 3—3 of Fig. 1.

Referring now to the drawings, a multi-stage elastic fluid turbine 1 includes an outer casing 2 enclosing an inner casing 3 with an annular chamber 4 defined therebetween. Inner casing 3 is preferably constructed and arranged to include one or more separate sections 3a so that an annular fluid extraction gap 5 is defined between the sections. As is customary, outer casing 2 includes upper and lower halves having flange portions 6, 7, (Fig. 2) while inner casing 3 includes upper and lower halves having flange portions 8, 9. Flange portions 6, 7 and 8, 9 are connected to form joints by a plurality of suitable threaded fastenings 10, 11 respectively. Inner casing 3 is supported within outer casing 2 by a plurality of radially projecting extensions 12 formed on flange 9 of the inner casing which engage recessed portions 13 formed in flange 7 of the outer casing.

Inner casing 3 is centered within outer casing 2 by means of a plurality of radially outward projecting tongued keys 14 which are arranged to form radial clearances with radially inward projecting grooved keys 15 formed on the inner surface of outer casing 2. These keyed portions permit even radial expansion of inner casing 3 with respect to outer casing 2 so that the two casings are maintained substantially concentric for all operating conditions of turbine 1. Similarly, the relative axial movement of inner casing 3 is permitted by axially outward extending tongued keys 16 formed on the "forward" end of casing 3 which are adapted to engage axially inward projecting grooved keys 17 formed in outer casing 2.

In the present instance, it is preferred to have the turbine inlet valves (not shown) housed in a separate casing and placed at some point external of the turbine (such as in front of the turbine) rather than have the valves mounted on outer casing 2. Inlet conduits 18 communicate the inlet valves with elastic fluid inlet ports 19, 20 defined by the "bossed" portions 21, 22 circumferentially spaced about casings 2, 3 respectively as shown in Fig. 2. Each conduit 18 has a separate end portion 23 and may be secured thereto by weld or other suitable means. Formed integral or by weld to conduit end portion 23 is a flexible axially extending flange 24 having a radially projecting bolting ring 25 which is secured to casing 2 by suitable threaded fastenings 26. In order to distribute the bolting stresses evenly throughout ring 25, a collar 27 may be interposed between ring 25 and the head portions of threaded fastenings 26. The end portion 23 of conduit 18 is secured in inlet port 20 by means of a "slip joint" 28 which may be any one of several known types, the details of which are not considered material to the present invention.

Inlet port 20 communicates with a first stage nozzle ring 29 having a plurality of circumferentially spaced nozzle partitions 30 and is secured by suitable fastening means (not shown) to casing 3.

A rotor indicated generally at 31 is supported within casing 3 by means of suitable bearings (not shown) and comprises a shaft 32 having a plurality of bucket-wheels 33 which may be formed integral with shaft 32. Circumferentially spaced around bucket-wheels 33 and secured

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thereto are a plurality of buckets 34 enclosed by bucket covers 35. Stationary diaphragms 36 in the form of discs containing a plurality of blades 37 forming nozzle passages are supported in casing 3 and are associated with wheels 33 for directing elastic fluid to the respective bucket annuli.

Formed in casings 2, 3 are labyrinth packing seals 38, 39 respectively which form close clearances with shaft 32 thereby resisting the flow of elastic fluid axially outwardly along the shaft. Such leakage can not be entirely prevented so that the portion of high temperature operating fluid which leaks outwardly between shaft 32 and seal 38 will be collected in an annular groove 40 provided in casing 3 adjacent seal 38. The hot fluid thus collected will pass through conduits 41 (Fig. 2) to axially extending, open-end extraction conduits 42 provided in chamber 4 beneath inner casing 3. For reasons which will be apparent from a description of the operation of the invention given hereinafter, conduits 41 extend axially into the open ends of conduits 42 and the outer diameter of the former is smaller than the inner diameter of the latter. As shown in Fig. 1 and more particularly in Fig. 3, extraction conduits 42 communicate with a single radially outwardly projecting conduit 43 within a bossed portion 44 formed on inner casing 3. Conduit 43 extends through a bossed portion 45 formed on outer casing 2 and communicates with a suitable heat reclaiming device such as a boiler feedwater heater (not shown).

During operation, extremely high temperature elastic fluid such as steam from a separate valve chest (not shown) enters the turbine through conduits 18 and inlet ports 20 to the first stage nozzles 30 and thence flows axially through the respective buckets 34 and nozzles 37 imparting rotational energy to the rotor 31. In traversing the flow path through buckets 34 and nozzles 37, substantial pressure and temperature drops are experienced by the steam so that by the time it reaches bucket-wheel 33a adjacent extraction gap 5, its temperature is very cool relative to the hot steam entering the turbine. Since the "forward" end of chamber 4 is in communication with the open ends of extraction conduits 42 and conduits 42 in turn communicate with a suitable heat reclaiming device, the pressure of which is considerably lower than that of the cool steam at wheel 33a, a portion of this cool steam will be extracted through gap 5 to chamber 4 and will flow toward the forward end thereof to conduits 42 as indicated by the arrows in Fig. 1. In following this "reversed" flowpath in chamber 4, the cool extraction steam exerts a substantial cooling or temperature limiting effect on outer casing 2 and other appurtenant structure adjacent chamber 4, particularly in that area surrounding steam inlet conduits 18 where the most serious temperature conditions are encountered.

Meanwhile, the high temperature leakage steam throttling through seal 38 with an accompanying relatively small decrease in temperature collects in groove 40. Seal 38 and the entrance annulus area between conduits 41 and 42, depending upon the relative magnitude of the flow of elastic fluid through conduits 41 and conduits 42, can be proportioned so that the pressure drop experienced by the high temperature steam throttling through seal 38 is greater than the pressure drop experienced by the operating steam in passing from the first stage nozzle 30 to wheel 33a. Thus the relatively cool extraction steam in chamber 4 will be at a pressure slightly greater

than that of the high temperature packing leakage collected in groove 40. Because of this, the high temperature steam in groove 40 is prevented from flowing axially to the left through seal 38a (Fig. 1) to chamber 4 where it would exert a highly undesirable heating effect on the cool extraction steam and contiguous structure such as the outer casing 2, shaft 32, and bearings (not shown). Instead, all of the steam in groove 40 will pass through conduits 41 to conduits 42 where it mixes with and appreciably raises the temperature of the cool extraction steam entering through the open ends of conduits 42 from chamber 4. The mixture then passes out of the turbine through conduit 43 to the above-mentioned heat reclaiming device. As a safety precaution, a bypass conduit 43a containing valve 43b is connected at its upstream end to conduit 43 as shown in Fig. 1. The downstream end of conduit 43a may be connected to any medium of lower pressure such as a lower pressure stage of turbine 1, the turbine exhaust or to another heat reclaiming device. Thus during normal operation, valve 43b may be closed and the steam in conduit 43 passes to the heat reclaiming device connected thereto. If, however, the heat reclaiming device should become inoperative, valve 43b would be immediately opened and the steam in conduit 43 would bypass through conduit 43a to a medium of lower pressure thereby ensuring the continuous and uninterrupted flow of cooling steam in chamber 4.

It has been found that if a double casing steam turbine having an inlet steam temperature of the order of 1050° F. is cooled in accordance with the above-described method, the outer casing may be maintained at a temperature of the order of 900° F. thus permitting the use of ordinary steels. If it is desired to maintain the outer casing at a still lower temperature, radiation shields 46, 47 may be provided in chamber 4 as indicated in Fig. 1, and the relatively cool extraction steam caused to flow between the shields thereby exerting an appreciable temperature limiting effect on outer casing 2. The degree of this temperature limiting effect is dependent to a certain extent upon the velocity of the extraction steam flowing between the shields, which in turn is dependent upon the relative positions of the two shields. It will be obvious that one of the radiation shields may be omitted and the extraction steam caused to flow between a single shield and outer casing 2. Here again the temperature limiting effect exerted by the cool extraction steam on outer casing 2 is dependent to a degree upon the velocity of the extraction steam while the velocity is dependent upon the position of the shield relative to outer casing 2. The exact position of shields 46, 47 of Fig. 1 is not considered material to an understanding of the present invention since anyone reasonably skilled in the theories of heat transfer may readily calculate the shield positions necessary to maintain a preselected outer casing temperature, the value of which may range between the temperature of the inner casing 3 and the temperature of the fluid in chamber 4.

Thus it will be seen that this invention provides an improved method of and arrangement for limiting the temperatures of the outer casing and the forward end portion of the shaft of double casing elastic fluid turbines thereby permitting the use of ordinary low-cost materials for increased operating temperatures.

While a particular embodiment of the inven-

tion has been illustrated and described, it will be obvious to those familiar with the art that various changes and modifications may be made without departing from the invention, and it is intended to cover in the appended claims all such changes and modifications as come within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an extraction type elastic fluid turbine for elevated temperatures and pressures having a bladed multi-stage rotor supported in an inner casing carrying stationary blades and surrounded by a spaced outer casing, one or more concentric radiation shields supported in the annular space between said inner and outer casings, conduit means for supplying motive fluid at high temperature and pressure to one end of the inner casing, first labyrinth shaft sealing means at the high pressure end of the inner casing, second shaft seal means at the adjacent end of the outer casing and forming an annular chamber with said first seal, walls defining passages for circulating comparatively cooler fluid from a low pressure stage of the rotor between the radiation shields and said inner and outer casings to said annular chamber, first extraction conduit means for withdrawing motive fluid from said low pressure stage, said first conduit means having an open end portion located between the inner and outer casings and adjacent the high pressure end of the inner casing, and walls defining second conduit means adapted to receive leakage and cooling fluid at an intermediate region of said first shaft seal, said second conduit being constructed and arranged to discharge said fluid into the open end of said first conduit whereby substantially all of the high temperature leakage in said first shaft seal is removed to the extraction conduit.

2. In an extraction type elastic fluid turbine for elevated temperatures and pressures having a bladed multi-stage rotor supported in an inner casing carrying stationary blades and surrounded by a spaced outer casing, conduit means for supplying motive fluid at high temperature and pressure to one end of the inner casing, first labyrinth shaft sealing means at the high pressure end of the inner casing, second shaft seal means at the adjacent end of the outer casing and forming an annular chamber with said first seal, walls defining passages for circulating comparatively cooler steam from a low pressure stage of the rotor between the inner and outer casing to said annular chamber, first extraction conduit means for withdrawing motive fluid from said low pressure stage, said first conduit means having an open end portion located between the inner and outer casings and adjacent the high pressure end of the inner casing, and walls defining second conduit means adapted to receive leakage and cooling fluid at an intermediate region of said first shaft seal, said second conduit being constructed and arranged to discharge said fluid into the open end of said first conduit whereby substantially all of the high temperature leakage in said first shaft seal is removed to the extraction conduit.

3. In an elastic fluid turbine for elevated temperatures and pressures having a bladed multi-stage rotor supported in an inner casing carrying stationary blades and surrounded by a radially spaced outer casing, the combination of one or more radiation shields supported in the annular space between said inner and outer cas-

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ings, conduit means for supplying motive fluid at high temperature and pressure to one end of the inner casing and means for circulating comparatively cool motive fluid from a low-pressure stage of the turbine through the passages formed by said inner and outer casings and the radiation shields, whereby the transmission of heat from said inner casing to said outer casing is reduced.

4. In an elastic fluid turbine for elevated temperatures and pressures having a bladed multi-stage rotor supported in an inner casing carrying stationary blades and surrounded by a radially spaced outer casing, conduit means for supplying motive fluid at high temperature and pressure to one end of the inner casing, walls defining passages for circulating comparatively cooler steam from a low pressure stage of the rotor between the inner and outer casings, at least one extraction conduit means having an open end portion located between the inner and outer casings and adjacent the high pressure end of the inner casing, said extraction conduit being adapted to receive through the open end portion thereof said cooler steam.

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5. In an elastic fluid turbine having a bladed multi-stage rotor supported in an inner casing carrying stationary blades and surrounded by a radially spaced outer casing, the combination of one or more radiation shields supported in the annular space between said inner and outer casings, conduit means for supplying motive fluid at high temperature and pressure to one end of the inner casing, walls defining passages for circulating comparatively cooler steam from a low pressure stage of the rotor between the radiation shields and the inner and outer casings, at least one extraction conduit means having an open end portion located between the inner and outer casings and adjacent the high pressure end of the inner casing, said extraction conduit being adapted to receive through the open end portion thereof said cooler steam.

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