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TURBINE APPARATUS

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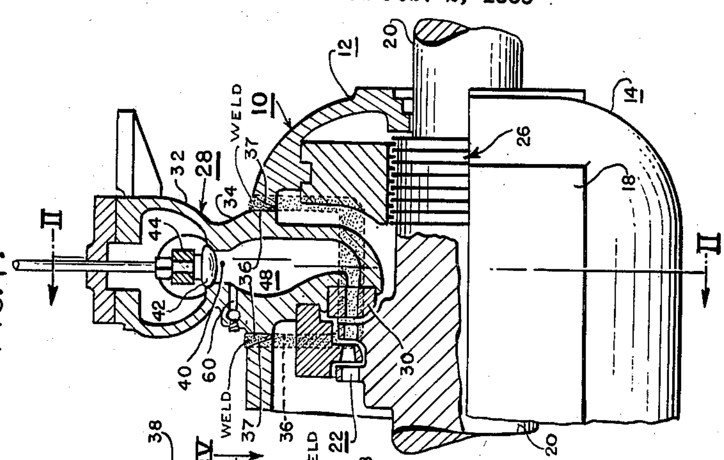

FIG. 1.

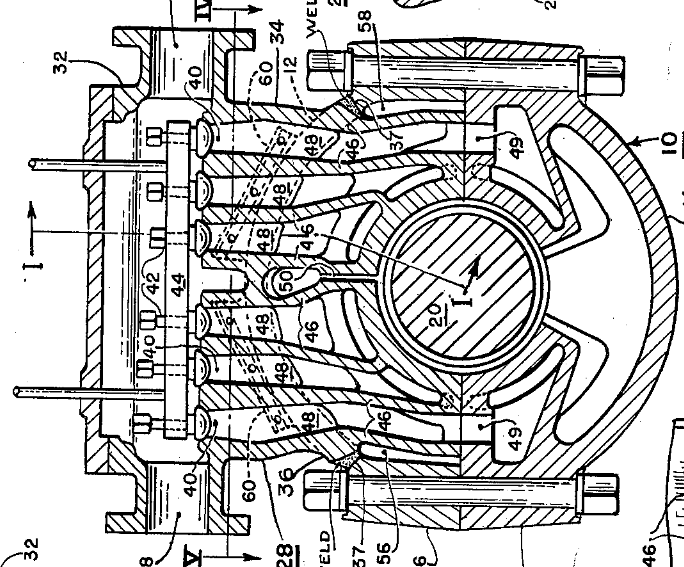

FIG. 2.

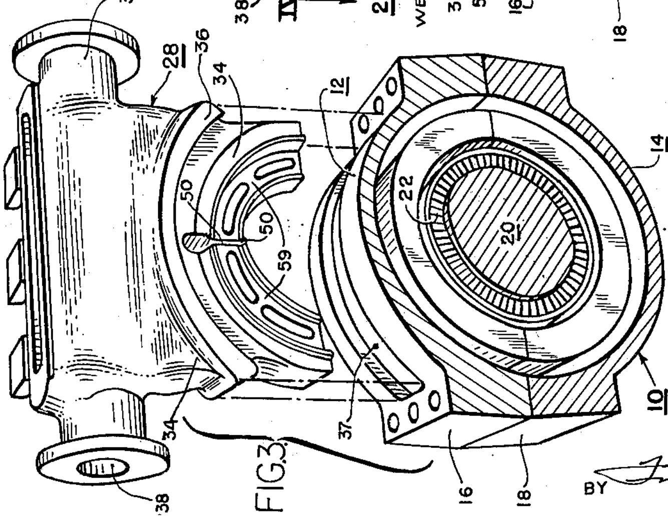

FIG. 3.

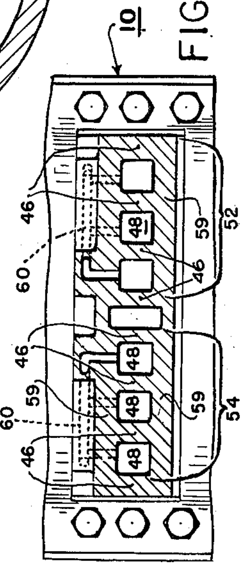

FIG. 4.

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TURBINE APPARATUS

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5 Claims. (Cl. 253—39)

This invention relates to elastic fluid turbine apparatus, especially steam turbines, and more particularly to an improved construction of the casing, the valve chest, and the passageways between the valve chest and the interior of the casing.

The invention is particularly applicable to turbines in which pressurized steam from a boiler is supplied to a valve chest and distributed therefrom through passageways or nozzle boxes to nozzle groups, the latter being arranged in an annular array within the casing and upstream of the first stage blading. The valve chest is provided with governor-controlled valves that are sequentially movable to open and close a plurality of flow paths between the chest and the passageways. During part-load operation, for example, some valves will be open, others will be closed, and steam will flow through those passageways open to the valve chest.

Where apparatus of the type set forth experiences frequent load changes or frequent starting and stopping, and the inlet steam temperature is at least 850° F., fatigue failures in the casing flanges and the nozzle boxes may be caused when their component parts are subjected to repeated, alternately large and small temperature differentials. This condition is termed "thermal cycling" and is thought to be the major cause of fatigue failures in casing and nozzle box parts.

The construction disclosed in U.S. Patent 2,527,445, issued October 24, 1950, to George W. Pentheny and assigned to the assignee of the present invention, is capable of coping with the problem of thermal cycling, even for inlet steam temperatures above 1200° F. For commercial reasons, however, it is desirable to provide an arrangement as effective as Pentheny's but less expensive to construct. More particularly, the problem has arisen in turbines of single-wall casing construction and driven by steam having an inlet temperature in the range of between 850° and 1000° F.

According to the present invention, the casing is of tubular, single-wall construction with an opening formed therein. An integrally cast, cavernous body is provided for conducting the elastic fluid to nozzle groups within the casing. The cavernous body, which may be of higher strength material than the casing, comprises a valve chest and wall structure including partitions defining passageways or nozzle boxes between the chest and the nozzle groups. The valve chest is formed integrally with the wall structure, as is a circumferentially and axially extending flange which fits the opening in the casing, and is joined to the margin thereof by welding.

The passageways are arranged in a series which extends transversely of the rotor axis and they are divided into at least two groups which are spaced from each other, as well as from the wall of the casing. This arrangement permits portions of the wall structure connecting the partitions of each group to elongate, due to thermal expansion, in a direction transverse to the rotor axis without imposing forces on the casing and without buckling.

Another condition which imposes bending stresses on portions of the wall structure connecting the partitions results when one partition undergoes greater thermal expansion than a neighboring partition in the same group. This condition produces warping in the wall members connecting these partitions. Preliminary to describing the cure for this condition it is necessary to mention that it is caused during part-load operation wherein a partition common to an open and a closed passageway is heated by the steam flowing through the open passageway, and the other partition of the closed passageway is unheated. In accordance with the invention, each group of passageways has conduit means providing restricted steam communication between its passageways so that the temperature difference between its partitions will be minimized. When, in operation, at least one passageway of a group has fluid passing therethrough and there is at least one passageway of the same group closed to the valve chest, a small quantity of fluid "bleeds" from the open passageway into the closed passageway in order to heat its surrounding wall structure. The detrimental effects of a large temperature difference between the partitions are thereby avoided.

The various objects, features and advantages of the invention will appear more fully from the detailed description which follows, taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a view of a portion of a steam turbine embodying the invention, the upper half showing a section taken on line I—I of Fig. 2, and the lower half being shown in elevation;

Fig. 2 is a transverse sectional view taken on line II—II of Fig. 1;

Fig. 3 is an exploded, perspective view of the apparatus of Fig. 1, but with the nozzle groups removed; and,

Fig. 4 is a horizontal sectional view taken along line IV—IV of Fig. 2.

Referring to the drawing in detail, the invention is applied to an axial-flow steam turbine comprising a cylinder or casing 10 which is formed about a horizontal axis and includes an upper half 12 and a lower half 14, these halves having respective flanges 16 and 18. The casing halves are joined together at the flanges by suitable bolts and have a rotor 20 journalled therein and coaxially aligned therewith. A plurality of stages for extracting energy from the steam is conventionally provided by cooperating, annular rows of blades, generally indicated at 22. In order to minimize the leakage of steam from the inlet end of the casing 10, the usual annular seals 26 are provided between the rotor and casing parts.

Pressurized steam is conducted through an opening in the upper casing half 12 to groups of nozzles 30, arranged in an annular array upstream of the first stage blading, by means of a cavernous body 28, the latter being of integral construction and including: a valve chest 32, wall structure 34, and a circumferentially and axially extending, arcuate flange member 36. The flange member 36 is adapted to fit a similar shaped opening 37 in the upper casing half 12 and their respective marginal portions are joined together by welding. The location of the welded joint will be discussed hereinafter in greater detail.

The valve chest 32 has inlet openings 38, adapted for connection to a source of pressurized steam such as a boiler (not shown), and also has as many outlet openings 40 as there are nozzle groups 30. In this embodiment, there are six openings 40 and six nozzle groups 30. These openings 40 are arranged in a horizontal series that extends transversely with respect to the rotor axis. The valve chest 32 is further provided with a valve 42 for each outlet opening 40, these valves being carried by a vertically movable, horizontal lift bar 44. Movement of the lift bar 44 moves the valves 42 in succession to open and close the openings 40, all of which is well known in the art.

The primary function of the wall structure 34 is to conduct the elastic fluid from the outlet openings 40 in the valve chest 32 to the nozzle groups 30. Since some of the valves 42 may be in position to close some openings 40, while other openings are opened to the valve chest 32, it is desirable for the wall structure 34 to define a plurality of passageways 48 downstream of the chest between associated openings and nozzle groups. To this end, there is a series of horizontally spaced, internal partitions 46 included in the wall structure 34, which series extends transversely of the rotor axis and defines fluid passageways 48. The lower casing half 14 is provided with two passageway extensions 49 for the purpose of completing the means for conducting steam from the valve chest 32 to the two nozzle groups 30 in the lower casing half 14. A centrally disposed pair of partitions 46 also define a space 50 which divides the passageways 48 into two groups 52 and 54. The end partitions 46 of the series are arranged in spaced relationship with the interior walls of the upper casing half 12 so that, as viewed in Fig. 2, there are left and right spaces 56 and 58, respectively, between the wall structure 34 and the upper casing half 12. The wall structure 34 also includes a pair of axially spaced wall members 59 for each of the passageway groups 52 and 54, which members 59 extend transversely of the rotor axis and connect together the partitions 46 of each group. (See Fig. 4.) Unlike prior art structures, the members 59 can elongate due to thermal expansion without buckling or damaging the casing because the spaces 50, 56 and 58 permit the unresisted elongation of the members 59 of either or both groups. The elimination of repeated stressing of the rigid casing 10 and the wall structure 34 prevents their failure and avoids difficult and costly repairs. Additionally, the wall structure 34 may be made from a stronger, through more expensive, material, since the wall structure is made separately from the upper casing half 12. Furthermore, the spaces 56 and 58 are provided without having to use a coring process during casting of the body 28, as is required for making the space 50.

As mentioned previously, the cavernous body 28 includes a flange member 36 formed integrally with the wall structure 34 and welded to portions of the upper casing half bounding the opening 37 therein. It is noteworthy that the flange member 36 is of arcuate shape and extends axially and circumferentially about the rotor axis, as do the surrounding wall portions to which it is welded. The line of jointure between welded parts is axially and circumferentially aligned with the wall portions bounding the opening 37 in order to preserve the axial integrity of the upper casing half 12. As can be seen in Fig. 2, wherein the flange member 36 is mostly shown in dotted arcuate lines, the partitions 46 reinforce the wall structure 34 in axial direction, since portions of the partitions 46 are in axial alignment with the upper casing half 12, the welded joint, and the flange member 36. This feature can be best appreciated by now referring to Fig. 1 and visualizing steam forces within the casing 10 operating in axial, outwardly opposite directions on the end walls thereof; these forces tend to separate the casing into two halves along a circumferential line extending through the opening 37. By placing the welded joint and the partitions 46 in axial alignment with surrounding portions of the upper casing half 12 there is no moment arm provided, which would impose bending forces on the joint.

The cavernous body 28 further includes conduit means, such as an internal manifold 60, providing restricted communication between the passageways 48 of each of the two groups 52 and 54. Of the various methods which may be used for forming the manifold 60 it is most conveniently formed during the casting of the cavernous body 28 by a coring process that is well known in the foundry art. The purpose of the manifold 60 is to "bleed" a small quantity of inlet steam from any passageway 48 open to the valve chest 32 and deliver it to the closed or inactive passageways in the same group in order to heat their wall structure. Preheating of the wall structure prevents it from suffering a thermal shock, that is, a large temperature gradient in a short period of time, as a result of the sudden opening of the closed passageway and introducing high temperature steam thereto. Preheating also minimizes the temperature difference between the partitions 46 of a closed passageway in the situation where one of its partitions is in common with an open passageway through which hot steam is flowing. Thus, the partitions 46 of a closed passageway undergo a similar amount of thermal expansion and the portions of the wall members 59 connecting them do not warp.

Referring again to Fig. 2, it will be noted that the valves 42 associated with the right-hand group of passageways 48 are arranged to open in succession from left to right, and it follows that elastic fluid will flow through the left-hand passageway before the other two in that group. During part-load operation, for example, the common partition 46 between an open and closed passageway would be much hotter than the other partition of the closed passageway were it not for the small quantity of steam issuing from the manifold 60 into the closed passageway. During frequent load changes of a turbine not having such means for heating the closed passageways, a condition known as "thermal cycling" may be caused, wherein one passageway will be continually open to the valve chest 32, and an adjacent passageway will be alternately opened and closed to the valve chest, thus subjecting the portions of the wall members 59 connecting the partitions of the alternately opened and closed passageway to alternating bending moments. Without preheating, thermal cycling can cause a fatigue failure in this portion of the wall member 59. The manifold 60 provides a solution to this problem.

From the foregoing, it will be apparent that the spacing of the passageways 48 from the upper casing half 12 prevents buckling of the members 59 and the transfer of forces to the casing when the members 59 elongate due to thermal expansion; the preheating of the passageways 48, by means of the manifold 60, reduces the temperature difference between adjacent partitions 46 and minimizes the chances of the wall members 59 failing from fatigue; and the structural arrangement lends itself well to inexpensive fabrication, while not impairing the strength of the casing 10 for resisting axial forces tending to separate the casing in two halves along a circumferential line through the opening 37.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In an elastic-fluid turbine, a casing, a rotor, blading carried by the rotor and the casing, said casing including a wall portion formed about the rotor axis and being provided with an opening in said wall portion, means extending through said opening for conducting elastic fluid to the blading from a source of pressurized fluid exteriorly of the casing, said conducting means comprising a plurality of nozzle groups, a valve chest, and wall structure integrally formed with said valve chest and defining a series of fluid passageways between the chest and each of the nozzle groups, said wall structure including an exterior surface portion which fits said opening and is joined to the margin of said wall portion bounding said opening, said wall structure including a

series of partitions which are spaced from each other and the casing, said series extending transversely with respect to said rotor axis, there being two spaced partitions disposed between at least one pair of neighboring passageways.

2. In an axial-flow elastic-fluid turbine, a casing, a rotor having a row of blades, said casing including a wall portion formed about the rotor axis and being provided with an opening in said wall portion, an annular array of nozzle groups positioned upstream of said blades, a cavernous body extending through said opening for conducting elastic fluid to the nozzle groups from a source of pressurized fluid exteriorly of the casing, said body being integrally formed and comprising a valve chest, wall structure connected to said valve chest and defining a series of fluid passageways downstream of the chest, and an axially and circumferentially extending flange member connected to said wall structure and fitting said opening, said wall structure including a series of partitions which are spaced from each other and the casing, said series extending transversely with respect to said rotor axis, there being two spaced partitions disposed between at least one pair of neighboring passageways, the margin of said flange member and the margin of said wall portion bounding the opening being connected together along a line of jointure that is axially and circumferentially aligned with said wall portion, said flange member, and portions of said partitions.

3. In an axial-flow elastic-fluid turbine, a casing, a rotor, said casing including a tubular wall portion formed about the rotor axis and being provided with an arcuate opening in said wall portion, means including an annular array of nozzle groups and a cavernous body extending through said opening for conducting elastic fluid from the exterior to the interior of the casing, said body including a valve chest, wall structure integrally formed with said valve chest and defining a series of fluid passageways extending from the chest to the respective nozzle groups, and means connecting said wall structure to said tubular portion adjacent said opening, said wall structure including a series of horizontally spaced partitions which extends transversely with respect to said rotor axis, there being two spaced partitions centrally disposed in said series between at least one pair of neighboring passageways, said two spaced partitions dividing the series into two groups each comprising a plurality of passageways, and means providing restricted communication between the passageways of each group.

4. In an axial-flow steam turbine, a horizontal-axis rotor, a casing, blading carried by the rotor and the casing, said casing having an opening formed therein, an annular array of arcuate nozzle groups positioned upstream of the blading, a cavernous body extending through said opening for conducting steam to the nozzle groups, a welded connection between the body and a portion of said casing bounding the opening therein; said body comprising a valve chest having an inlet opening and as many outlet openings as there are nozzle groups, wall structure including horizontally spaced partitions integrally formed with said valve chest and defining steam passageways downstream of the respective outlet openings, valves for the respective outlet openings movable in succession to open and close said outlet openings, there being two partitions defining a space between at least two groups of neighboring passageways, and conduit means formed in said body providing restricted steam communication between the passageways of each group.

5. In an axial-flow steam turbine, a horizontal-axis rotor, a casing including an upper half and a lower half, blading carried by the rotor and the casing, said upper casing half having an opening formed therein, an annular array of arcuate nozzle groups positioned upstream of the blading, a cavernous body extending through said opening for conducting steam to the nozzle groups; said body comprising a valve chest having an inlet opening and as many outlet openings as there are nozzle groups, valves for the respective outlet openings movable in succession to open and close said outlet openings, wall structure including horizontally spaced partitions integrally formed with said valve chest and defining steam passageways, there being one passageway between respective ones of said outlet openings and said nozzle groups, and an axially and circumferentially extending flange member formed integrally with said wall structure to fit the opening in said upper casing half and being joined to the margin of said upper casing half bounding the opening therein, said partitions being spaced from said upper casing half, there being two partitions defining a space between two groups of neighboring passageways, and conduit means formed in said body providing restricted steam communication between the passageways of each group.

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