

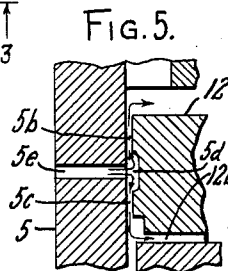
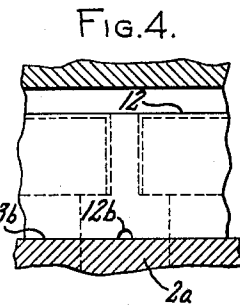
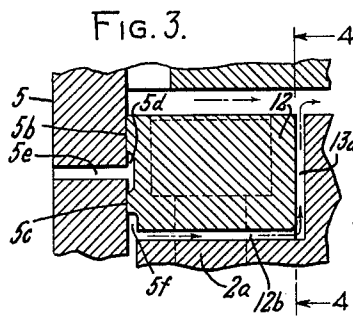
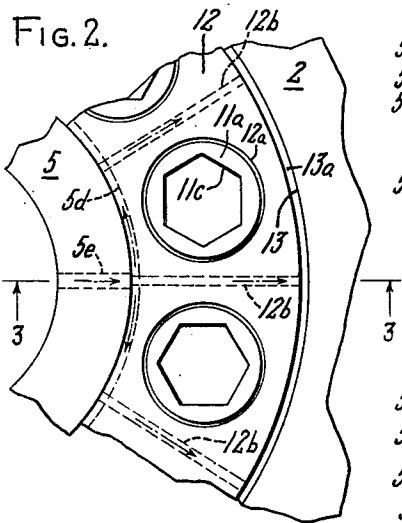
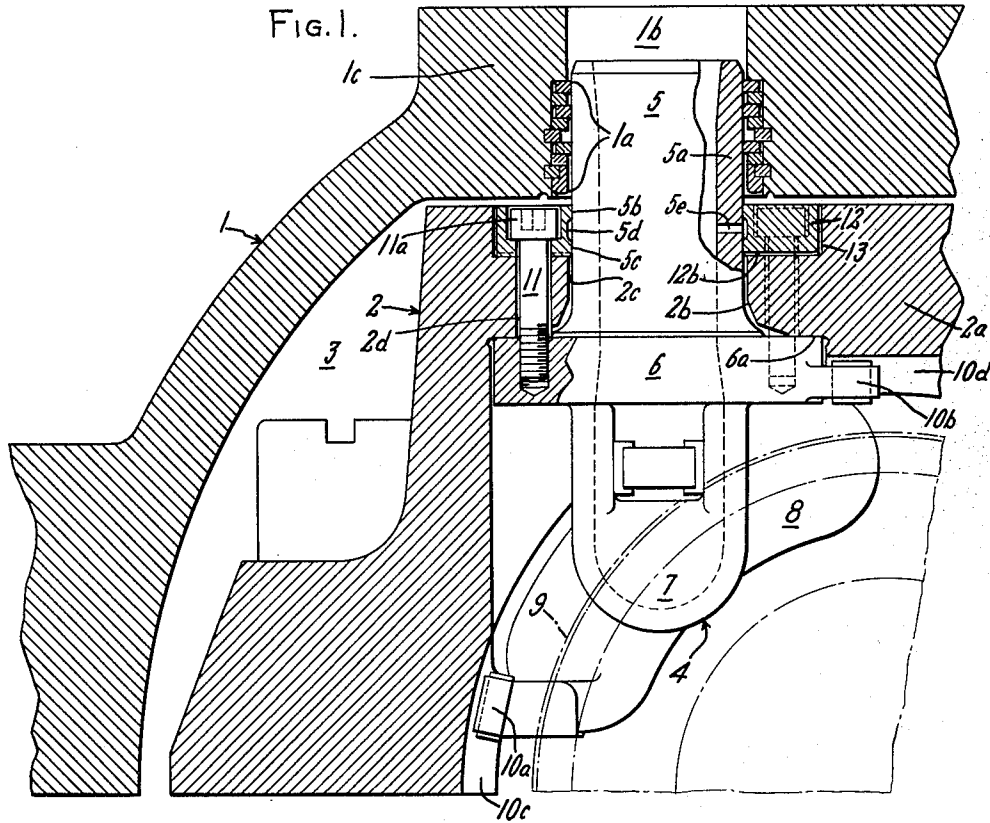
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BOLTED NOZZLEBOX FOR HIGH PRESSURE STEAM TURBINE

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BOLTED NOZZLEBOX FOR HIGH PRESSURE STEAM TURBINE

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4 Claims. (Cl. 253—78)

This invention relates to steam turbines for very high pressures and temperatures, specifically to a bolted nozzle-box construction for a steam turbine intended for operation with motive fluid on the order of 1050° F. and 2400 p.s.i.a.

Very large steam turbines for high pressures are customarily arranged with an inner high pressure shell or casing disposed within an outer casing, the space between being subjected to a pressure intermediate the motive fluid pressure and atmospheric pressure. Thus the total pressure drop is taken across two casings, the inner one of which may be fabricated of special austenitic or other high temperature alloys, while the lower pressure and lower temperature steam between the casings permits the outer casing to be made of ordinarily cast steel or other alloys suitable for such lower temperatures. This well-known double shell construction necessitates special means for conducting the high pressure motive fluid through the outer shell and delivering it to the rotor contained within the inner shell. In recent years, this arrangement has taken the form of one or more integral "nozzleboxes" formed separately from the inner shell and suitably secured thereto in appropriate relation to the first stage rotor bucket wheel. A short section of inlet conduit is secured to or formed integral with the nozzle-box and an appropriate packing device cooperates with this inlet conduit portion at the location where it passes through the outer shell. This construction requires special means for securing the nozzlebox in proper position on the inner shell, and one construction for accomplishing these purposes is described in the United States patent to Sheppard and Maxwell, No. 2,800,299, issued July 23, 1957 and assigned to the same assignee as the present application.

The object of the present invention is to provide a somewhat simpler and less expensive bolted construction for securing an integral nozzlebox to the inner shell of a double shell steam turbine.

Another object is to provide a bolted nozzlebox construction of the type described in which special means are provided for preventing excessive bending stresses from developing in the bolts due to differential expansion upon rapid temperature change of the members with which the respective ends of the bolts are associated.

Other objects and advantages will become apparent from the following description, taken in connection with the accompanying drawings in which

Fig. 1 is a transverse sectional view of a double shell turbine having an integral nozzlebox with a bolted connection to the inner shell, incorporating the invention;

Fig. 2 is a plan view of a portion of the nozzlebox bolting flange; and

Figs. 3, 4, and 5 are detail sectional views of the nozzlebox bolting ring illustrating the manner of operation.

Generally stated, the invention is practiced by providing the integral nozzlebox and inlet conduit portion with a heavy circumferential flange adapted to receive a circumferential row of bolts. The heads of the bolts engage

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a ring member fabricated separately from the nozzle-box and provided with special cooling passage means for insuring that radial expansion and contraction of this bolt head ring follows generally the expansion and contraction of the integral flange, so as to prevent bending of the bolts.

Referring now more particularly to Fig. 1, the invention is illustrated as applied to a high pressure steam turbine having an outer casing 1 and contained therein a massive inner casing 2 with a space 3 defined therebetween. As will be appreciated by those familiar with high pressure steam turbine design, steam from an appropriate lower temperature and lower pressure portion of the flow path is admitted to the intermediate space 3 so that the outer shell 1 is subjected to lower temperatures and a moderate pressure differential, while the inner casing 2 may be made of high temperature alloys appropriate for temperatures on the order of 1000° F. Both inner and outer shells are of comparatively heavy cross-sectional areas because of the pressure differentials thereacross.

The integral nozzlebox is illustrated generally at 4. This comprises an integral inlet conduit portion 5, a heavy circumferential flange portion 6, a lower "elbow portion" 7 which serves to turn the motive fluid into an arcuate nozzle carrying portion 8. The side of the nozzlebox 8 on the far side of the assembly, as viewed in Fig. 1, defines an arcuate row of nozzles (not indicated in the drawing) for delivering motive fluid to the first stage bucket wheel, shown in phantom at 9.

The nozzlebox 8 may be appropriately oriented with respect to the bucket wheel 9 by a plurality of projecting lug portions 10a, 10b disposed to be received in recesses or grooves in the inner shell 2. For instance, the lug 10a may be received in an annular recess 10c and the lug 10b is shown disposed in a recess 10d. Thus, the nozzlebox 8 is prevented from rotating about the axis of the inlet conduit 5, which motion would of course alter the desired clearances between the nozzles and the bucket wheel.

This invention relates particularly to the special means for bolting the flange 6 to the top wall portion 2a of the inner shell.

It will be seen that the very thick wall portion 2a, which may be on the order of 9 inches thick in a turbine of which the first stage bucket wheel is on the order of 38 inches in diameter, defines a radially extending recess 2b adapted to receive the nozzlebox inlet conduit portion 5, with a substantial annular clearance space 2c defined therebetween. This clearance space may for instance be on the order of 1/8 inch. It will also be seen that the upper annular surface of the heavy bolting flange 6 defines an annular seating area identified 6a, sealingly engaging a cooperating annular surface of the wall portion 2a.

The upper or inlet end of the integral inlet conduit portion 5 is sealingly received in the outer casing 1 and is provided with a multiple ring packing 1a, the details of which are not material here, although it may be noted that this packing may be as illustrated in United States Patent 2,649,315, issued in the name of P. G. Ipsen on August 18, 1953 and assigned to the assignee of the present application. It will be understood that this packing is of a type which permits limited transverse shifting of the inlet conduit portion 5 relative to the outer casing 1, as may be required by differential thermal expansion between the inner and outer casings. The motive fluid supply conduit will be connected to the outer shell 1 communicating with the inlet port 1b by means not shown, the details of which are not material to an understanding of the present invention.

This invention relates most specifically to the means

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by which the head ends of the bolts 11 which secure the heavy flange 6 to the even heavier shell portion 2a, are caused to expand and contract in a radial direction, relative to conduit 5, at roughly the same rate as the flange 6, in order that excessive bending stresses will not be imposed on the bolts. To this end, the circumferential row of bolts 11 are arranged with their heads 11a engaging a "lean ring" 12 disposed in an annular recess 13 in shell portion 2a.

It will be seen in Fig. 2 that the lean ring 12 defines a significant annular clearance space 13a with the inner wall of recess 13 and is provided with a circumferential row of recesses 12a in which the bolt heads 11a are disposed. The bolt heads may be provided with polygonal recesses 11c adapted to be engaged by a suitable wrench for turning the bolts. It is also to be noted in Fig. 1 that the bolt holes in the lean ring 12 and the inner shell portion 2a define significant annular clearance spaces, identified 2d.

With the arrangement thus far described, differential thermal expansion of the associated parts when rapid temperature changes occur might be as follows:

Assume first that the turbine is cold, as after a prolonged shutdown, and that motive fluid on the order of 1050° F. is admitted through the inlet conduit portion 5. Because the walls 5a of this inlet conduit portion are comparatively thin, relative to the massive casing portions 1c, 2a, the conduit portion 5 expands rapidly to a value approaching that of the motive fluid. The massive casings 1, 2 heat at a much slower rate, with the result that the conduit portion 5 "grows" radially, as is freely permitted by the annular clearance space 2c and the radial sliding action of the multiple ring packing 1a. It is now important to note that the inner periphery of the lean ring 12 engages snugly the outer surface of conduit portion 5 as shown at 5b, 5c. (For reasons which will appear later, the inner periphery defines an annular recess identified 5d.) Because of lack of clearance at 5b, 5c, the rapid radial expansion of conduit portion 5 forces the lean ring 12 to expand, within its elastic limit, thus carrying the head ends of the bolts 11 radially outward with it. Because of the transmission of heat by conduction from the inlet conduit wall 5a through the contact areas 5b, 5c to the lean ring 12, the latter will tend to grow radially at a rate roughly approaching that of the radial expansion of the bolting flange 6. It is to be noted that conduction of heat at the surfaces 5b, 5c is very efficient because of the great pressure exerted by the expanding conduit 5 on the inner periphery of ring 12.

The net result is that the head ends of the bolts 11 move radially outward at about the same rate as the lower end portions, which are threaded into the flange 6. Thus, during the heating cycle, the bolts remain generally parallel to the position occupied when in the "cold" condition.

Assume now that the turbine is being shut down, or that the load is rapidly reduced and the control valve opening is decreased to hold turbine speed constant, so the temperature of the motive fluid falls to perhaps 750° F. due to increased "throttling." The comparatively thin wall portion 5a now rapidly contracts; and, because of the flow of heat by conduction from the integral flange 6 to the conduit and nozzlebox wall portions 5a, 7, etc., the flange 6 likewise contracts. This contraction of wall 5a causes clearance spaces to open up at 5b, 5c, so that heat is no longer readily conducted from the lean ring 12 to the cooler wall 5a. On the other hand, the ring 12 tends to follow the more gradually falling temperature of the shell portion 2a with which it remains in intimate contact. The result is that the relatively greater radial movement of the threaded end portions of the bolts, as the flange 6 contracts, tends to make the axes of the bolts "lean" at an acute angle to the axis of the conduit 5, by reason of the higher temperature of the lean ring 12. This angularity of the axes of the bolts produces bending stresses which are added to the normal tension stresses imposed on the bolts

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during assembly. The superimposing of these abnormal bending stresses to the normal tension stresses may produce resultant stresses of a magnitude to cause failure of the bolts, usually at the threaded portion where the bolt enters the flange 6.

Accordingly, the invention provides means for insuring that the temperature of the lean ring 12 will more closely follow the temperature of the conduit wall portion 5a, so the ring 12 will expand and contract at generally the same rate as the flange 6. This is accomplished in the following manner:

In accordance with the invention, a special system of cooling passages is associated with the lean ring 12. This includes one or more small steam supply ports 5e extending through the wall of inlet conduit 5 and communicating with the annular recess 5d formed in the inner periphery of the lean ring, as noted above. The lower surface of the lean ring 12 defines a plurality of radially extending grooves identified at 12b in Fig. 1. As shown more specifically in Fig. 2, one of these radial grooves 12b is provided between each pair of adjacent bolt heads. The outer ends of these grooves communicate with the annular recess 13a defined between the periphery of lean ring 12 and the recess 13. To insure that all of the radial grooves 12b are fed equally, the lower inside corner of the ring 12 may be provided with an annular recess identified 5f in Fig. 3. While it may be found unnecessary, this recess 5f will permit circumferential flow to insure completely equal feeding of the grooves 12b.

The method of operation of this system of temperature control passages is as follows.

When hot steam is admitted to the cold turbine, the operation is as described above. That is, the comparatively more rapid expansion of the inlet conduit portion 5 causes the lean ring 12 to be stretched, within its elastic limit, so that the bolt head portions move radially outward at substantially the same rate as the lower threaded end portions. However, when the turbine is being shut down or the load substantially reduced, so that the motive fluid temperature is drastically reduced, the rapid contraction of the inlet conduit wall portion 5a produces the significant clearance spaces at 5b, 5c in Fig. 5, which now complete the circuit through the cooling path so that the comparatively cooler steam supplied through the port 5e flows upwardly through the clearance space 5b, and downwardly through the clearance space 5c, radially out through the grooves 12b and upwardly through the clearance space 13a as shown in Figs. 3, 4 and 5. Thus the lean ring 12 is literally "blanketed" on all sides with the comparatively cooler steam, and it therefore tends to follow rapidly the reduced temperature of the motive fluid. This strong cooling effect on ring 12 causes it to contract at substantially the same rate as the conduit portions 5 and flange 6, and thus eliminates the tendency of the bolts to "lean." The tendency of ring 12 to contract as it cools is so powerful that the ring slides on the annular bottom surface 13b of recess 12a, in spite of the high friction forces imposed by the tension of bolts 11 on this surface.

Thus it will be seen that the invention provides a special temperature control arrangement for the lean ring 12 which insures that, both in the cooling and heating cycle, the axes of the bolts 11 will remain parallel, with no tendency to "lean" so as to create high bending stresses. It will be observed that the flow of cooling steam through the port 5e occurs only during the comparatively brief cooling cycle. As soon as the temperature of the conduit wall 5a becomes equalized with that of the lean ring 12, the clearance spaces at 5b, 5c close so that this cooling flow is discontinued. Thus the arrangement results in no significant loss of thermal efficiency due to discharge of motive fluid through this cooling path.

The special arrangement of the lean ring 12 and the

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cooling system provided for it makes possible the use of a comparatively inexpensive and simple to assemble and disassemble bolted assembly for securing the integral nozzlebox of a high pressure steam turbine to its supporting shell.

It will be apparent that numerous modifications and substitutions of equivalents might be made. The precise configuration of the nozzlebox with its integral inlet conduit 5 could be substantially different than shown in the drawings, and variations in the design of the lean ring 12 and its associated cooling passages may be made. Also, it is obvious that the bolts might be arranged with their heads engaging the under surface of flange 6 and their opposite ends threaded into the lean ring 12. Or, nuts could be used, instead of threading the bolts into the flange 6, as shown. It is of course intended to cover by the appended claims all such modifications as fall within the true spirit and scope of the invention.

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

1. A bolted connection for securing a relatively thin-walled high temperature fluid conduit in a comparatively massive pressure casing wall portion through which the conduit extends comprising the combination of an integral circumferential flange projecting radially from the conduit and having an annular seating area disposed to axially engage an adjacent surface portion on the high pressure side of the casing wall, a plurality of bolts spaced circumferentially around said flange with one end engaged thereby, said bolts being disposed with their axes generally parallel to the axis of the conduit and projecting freely through openings in the casing wall, an annular member spaced axially on the other side of the casing wall from said flange to receive the other ends of the bolts and having surface portions adapted to axially engage an annular surface of the casing wall, said annular member and casing wall defining coolant passages substantially surrounding the annular member, the conduit having at least one wall portion defining a port for supplying fluid from within the conduit to said coolant passages, and the annular member having at least one inner annular surface disposed to normally contact the outer surface of the conduit so as to block communication between said coolant supply port and said coolant passages, whereby upon sudden reduction in temperature of the fluid in the conduit, differential shrinkage of the conduit within the annular member effects flow of the reduced temperature fluid from the conduit through the cooling passages and causes the annular member to change temperature so as to substantially follow contraction of the conduit, whereby the axes of the bolts remain substantially parallel during such temperature drop.

2. A bolted conduit connection in accordance with claim 1 in which the coolant passages for the annular member are formed in part by an inner annular surface portion of the annular member defining a first annular recess communicating with the coolant supply port of the conduit, the outer periphery of the annular member defining a second annular clearance space with adjacent portions of the casing wall, and the abutting surfaces of said annular member and casing wall define a plurality of circumferentially spaced radially extending coolant passages communicating at the outer ends thereof with said second annular clearance space, while the inner ends of said radial passages are disposed to communicate with said first annular recess upon differential shrinkage of the conduit within the annular member.

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3. A bolted nozzlebox construction for use in a high pressure double shell steam turbine having an outer shell containing steam at an intermediate pressure, an inner shell disposed therein in spaced relation, and an integral nozzlebox conducting high pressure steam to the inner shell with an inlet conduit portion disposed through an opening in the inner shell and projecting into a cooperating opening in the outer shell, comprising the combination of a circumferential flange portion projecting radially from the inlet conduit portion of the nozzlebox and having an annular seating area disposed to axially engage in sealing relation an inner surface portion of the inner shell, a plurality of bolts spaced circumferentially around said bolting flange with one end engaged thereby, said bolts projecting freely through openings in the inner shell, an annular member spaced axially on the other side of the inner shell from said flange to receive the other ends of the bolts and having surface portions adapted to axially engage an annular outer surface of the inner shell, said annular member and inner shell defining a coolant flow path substantially surrounding the annular member, and supply means comprising a port defined by the wall of the inlet conduit portion for admitting steam to said flow path from said inlet conduit portion of the nozzlebox, communication between said supply means and cooling flow path being blocked by at least one close-fitting annular surface portion of the annular member engaging the outer surface of the inlet conduit portion, whereby, upon sudden reduction in temperature of the motive fluid, leakage of steam through said cooling path is effected by differential shrinkage of the inlet conduit portion away from the annular member to produce temperature changes in the annular member causing it to substantially follow contraction of the inlet conduit portion, whereby the axes of the bolts remain substantially parallel during such temperature change.

4. A bolted connection for securing a relatively thin-walled high temperature fluid conduit in a comparatively massive casing wall portion through which the conduit extends comprising the combination of an integral circumferential flange projecting radially from the conduit and having an annular seating area disposed to axially engage an adjacent surface portion of the casing wall, a plurality of bolts spaced circumferentially around said flange with one end engaged thereby, said bolts being disposed with their axes generally parallel to the axis of the conduit and projecting freely through openings in the casing wall, an annular member spaced axially on the other side of the casing wall from said flange to receive the other ends of the bolts and having surface portion adapted to engage an annular surface of the casing wall, said annular member and casing wall defining coolant passages in heat exchange relation with the annular member, and means for circulating a cooling fluid through said coolant passages when the temperature of the fluid in said conduit is reduced comprising a flange on said annular member arranged to block off a port defined by said thin-walled fluid conduit, whereby thermal contraction of the annular member causes it to substantially follow contraction of the conduit and the axes of the bolts remain generally parallel during such temperature drop.

References Cited in the file of this patent

UNITED STATES PATENTS

2,649,315

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