June 22, 1948. J. L. RAY 2,443,747

TURBINE MOUNTING

Filed Aug. 14, 1943 2 Sheets-Sheet 1

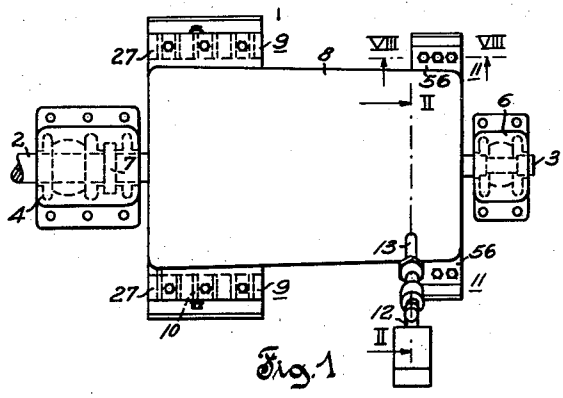


Fig. 1

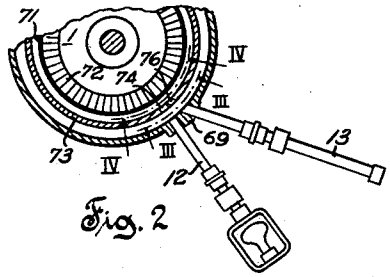


Fig. 2

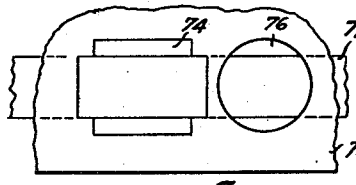


Fig. 3

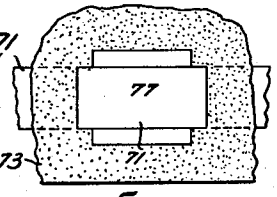


Fig. 4

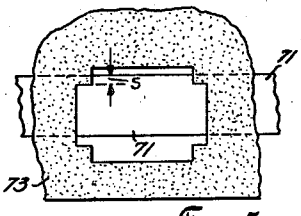


Fig. 5

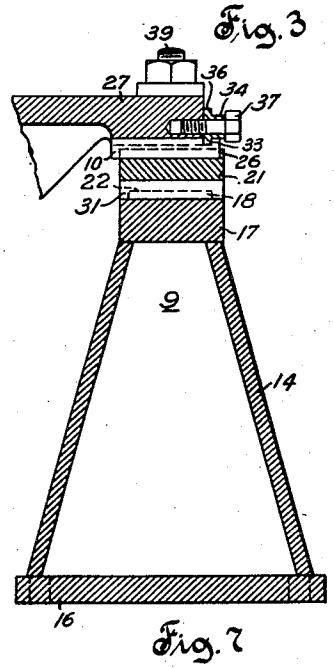


Fig. 7

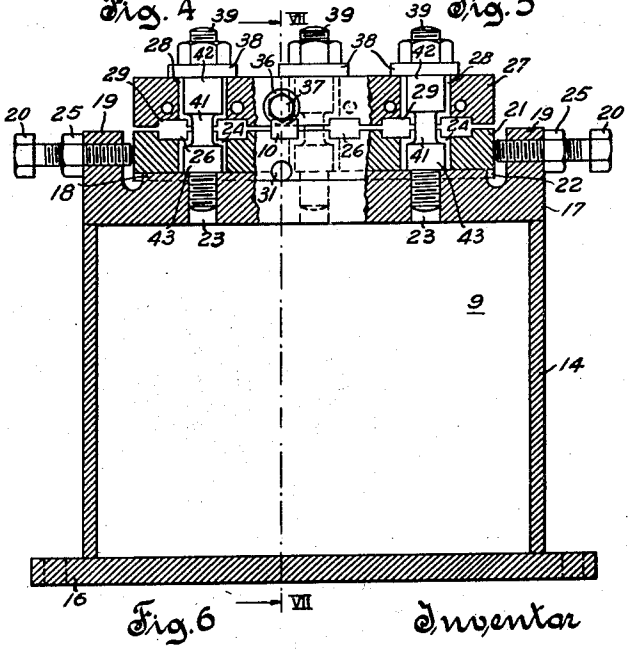


Fig. 6

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TURBINE MOUNTING

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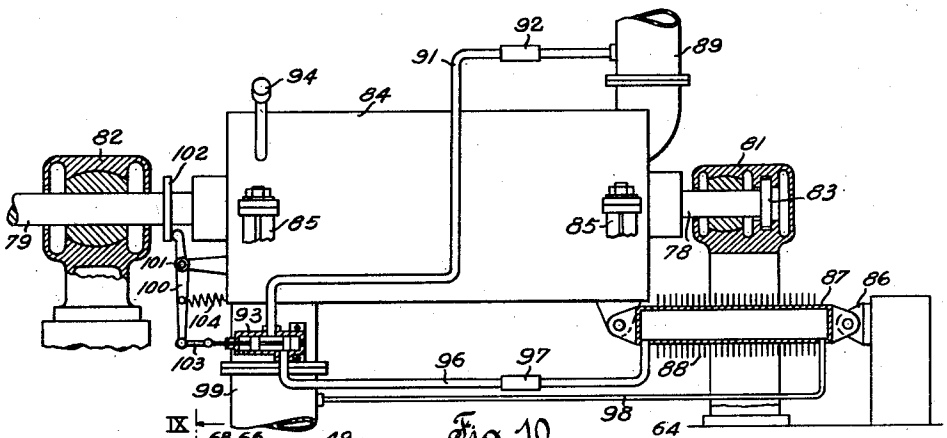


Fig. 10

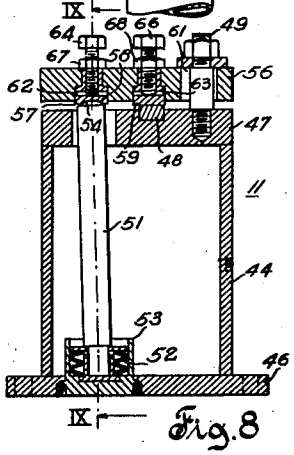


Fig. 8

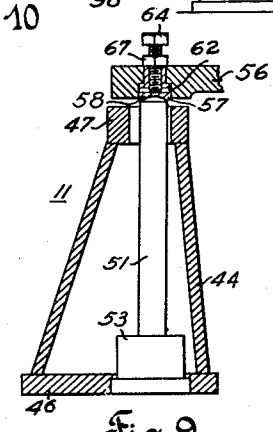


Fig. 9

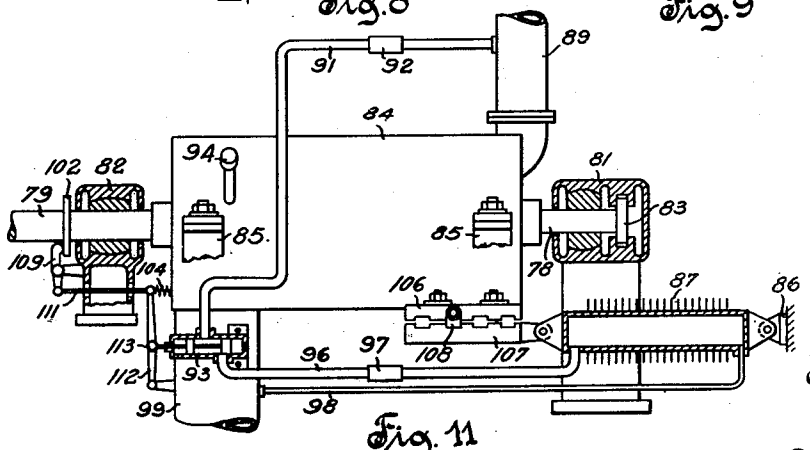


Fig. 11

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TURBINE MOUNTING

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Application August 14, 1943, Serial No. 498,717

8 Claims. (Cl. 253—39)

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This invention relates to high temperature elastic fluid turbines and its primary object is to provide in a support for such turbines means correlatable to effect substantially the same longitudinal expansion for both the spindle and casing, thereby eliminating the necessity of axially adjusting the spindle relative to the casing each time the turbine is placed in operation in order to maintain the clearance between stationary and moving parts within predetermined limits.

Another object of this invention is to provide in a support for such turbines means operative to maintain the rate of longitudinal expansion for both the spindle and casing and the clearance between the stationary and moving parts substantially equal and uniform, respectively, at all times irrespective of the rapidity and extent of load change.

In accordance with this invention, one or more of the above stated objects may be accomplished in whole or in part in any high temperature turbine structure simply by embodying therein combinations of two or more of the following features: (1) supports mounting axially spaced end portions of the spindle and casing elements with the portions of the elements at one end of the turbine immovable axially and with the portions of the elements at the other end of the turbine substantially free for independent axial movement as the spindle and casing elements expand and contract longitudinally relative to their immovable portions, (2) means for detecting any appreciable difference in the extent to which the free end portions of the spindle and casing elements move axially, (3) means for varying the axial distance between the immovable and free end portions of the spindle and/or casing element an amount commensurate with the detected difference in axial movement, and (4) means responsive to a relative axial movement of adjacent free end portions of the spindle and casing for relatively bodily moving said elements in a manner substantially equalizing the rate at which said free end portions move axially.

The invention accordingly consists of various details of construction, combinations of elements, and arrangements of parts as is more fully set forth in the detailed description and appended claims, reference being had to the accompanying drawings, in which:

Fig. 1 is a plan view of a turbine structure embodying the invention;

Fig. 2 is a partial section taken on line II—II of Fig. 1;

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Fig. 3 is an enlarged view taken on line III—III of Fig. 2;

Fig. 4 is an enlarged view taken on line IV—IV of Fig. 2;

Fig. 5 is a view similar to Fig. 4 illustrating a relative axial displacement of the spindle and casing;

Fig. 6 is an enlarged front elevation of the left-hand casing support shown in Fig. 1 with parts broken away to better show the construction;

Fig. 7 is a partial section taken on line VII—VII of Fig. 6;

Fig. 8 is a section taken on line VIII—VIII of Fig. 1;

Fig. 9 is a section taken on line IX—IX of Fig. 8;

Fig. 10 is a side elevation of a modified structure embodying the invention; and

Fig. 11 is a side elevation of another modified structure embodying the invention.

Referring to Figs. 1 and 2 of the drawings, it is seen that a turbine structure embodying the invention may include a spindle 1 having shaft portions 2 and 3 rotatably supported in bearings 4 and 6 with the portion 2 provided with a collar 7 rendering said portion immovable axially relative to the bearing 4 and with the portion 3 substantially free to slide axially in bearing 6 as the spindle expands and contracts longitudinally relative to its fixed end or shaft portion 2, a casing 8 surrounding the blade carrying portion of spindle 1, a pair of identical supports 9 which are fixedly connected with opposite side portions of casing 8 adjacent the bearing 4 and which include an axially displaceable connector 10 for selectively varying the axial distance from the opposite end of the casing to its points of connection with the supports 9, a pair of identical supports 11 slidably mounting the opposite end of the casing 8 for substantially free axial movement as the casing expands and contracts longitudinally relative to its points of fixed connection with the supports 9, and means comprising a light projecting tube 12 and a sight tube 13 for detecting any appreciable difference in the extent to which adjacent free end portions of the spindle and casing move axially as they expand and contract longitudinally.

Referring particularly to Figs. 6 and 7, it is seen that each of the supports 9 may include a pedestal structure 14 comprising a base portion 16 adapted to be bolted or otherwise firmly secured to a suitable foundation or other structure (not shown), a relatively long and narrow top

portion 17 embodying an approximately coextensive central raised portion or track 18 and upwardly extending apertured end flanges 19 which are spaced a slight distance from the adjacent ends of said track, and a relatively long and narrow block 21 which is slidably mounted on track 18 for movement longitudinally thereof by means of a coextensive track receiving recess 22 in its bottom surface. Track 18 is provided with an alined series of longitudinally spaced internally threaded apertures 23 and block 21 is also provided with a series of similarly arranged larger apertures 24. In addition, the top surface of block 21 is provided with a series of transversely extending longitudinally spaced keyway forming slots 26 which intersect opposite side portions of the apertures 24. Opposite side portions of the casing 8 are provided with a laterally extending flange or projection 27 which is in turn provided with a series of apertures 28 and with a series of keyway forming slots 29 which are similar in size and arrangement to the apertures 24 and the slots 26, respectively, in the block 21. Flanges 19 are provided with tap bolts 20 and lock nuts 25 for positioning and retaining block 21 with its apertures 24 and keyway forming slots 26 in substantial alinement with the apertures 23 and 28 and the slots 29 in the track 18 and projection 27. When this relation has once been established, block 21 may be more firmly secured against longitudinal movement by boring and inserting a pin or key member 31 as shown.

The casing flange or projection 27 is spaced from and supported on block member 21 by means of a single key member or connector 10 which snugly fits into any of the keyways formed by alined pairs of the slots 26 and 29, thereby providing the sole supporting connection between the casing projection 27 and the pedestal structure 14. Key member 10 may be held in its inserted position by means of a notch 33 in the top side thereof, a cylindrical collar 34 having a flange 36 disposed in said notch and a tap bolt 37 which extends through and securely clamps collar 36 against the casing projection 27. Upward movement of casing projection 27 relative to the pedestal structure 14 is prevented by washers 38 and stud bolts 39 which extend through the washers 38 and the alined apertures 28 and 24 in projection 27 and block 21 and into the internally threaded apertures 23 in the track 18 as is clearly shown in Fig. 6. Stud bolts 39 also function to securely clamp the key 10 between the casing projection 27 and block 21. Stud bolts 39 have an intermediate portion 41 of less diameter than the distance between adjacent keyways in order to permit insertion of the key 32 in any selected one of the keyways after the structure has once been assembled and contiguous portions 42 and 43 of less diameter than the walls of apertures 28 and 24 in order to permit a relative longitudinal adjustment of block 21 and alinement of the keyway forming slots 26 and 29.

In the initial assembly of this structure, the casing is blocked or jacketed to place the projections 27 in substantially the position shown relative to the pedestal structure 14 whereupon the block 21 is adjusted longitudinally to effect exact alinement of the keyway forming slots 26 and 29 whereupon the key 10 is inserted in a selected keyway, the washers placed on the stud bolts 39, the nuts tightened thereon to clamp the key between the projection 27 and block 21, and the key secured in position by means of collar 34 and tap bolt 37 whereupon the blocks or jacks can be removed, thereby leaving the casing supported on the pedestal structure 14 solely by means of a pair of keys 10. When it is desired to insert key 10 in a different keyway, all that has to be done is to loosen the nuts on stud bolts 29, insert a wedge in one of the remaining keyways, and remove the key locking collar 34 and tap bolt 37 whereupon the key can be readily withdrawn and inserted and secured in a different keyway, the wedge removed and the nuts on stud bolts 39 again tightened to complete the operation.

Each of the casing supports 11, attention being directed to Figs. 8 and 9, may include a pedestal structure 44 comprising a base portion 46 adapted to be bolted or otherwise secured to a suitable foundation or other structure (not shown), an apertured top portion 47 embodying therein a pad 48 and a stud bolt 49, and a vertically extending rigid rod 51 which extends through and is of less diameter than the aperture in top portion 47 and has its lower end portion mounted for tilting movement on springs 52 confined in a casing 53 disposed in the base portion 46. The upper end of rod 51 extends slightly beyond the top surface of the pad 48 in top portion 47 and presents a spherical end surface 54. Opposite side portions of the casing 8 are provided with a laterally extending flange or projection 56 which is in turn provided in its bottom surface with a pad 57 presenting a concave seat 58 engaging the spherical end surface 54 on rod 51, with a pad 59 slidably engaging the top surface of pad 48 in top portion 47 and with a stud bolt receiving aperture 61 of greater diameter than stud bolt 49. Pads 57 and 59 are mounted for vertical adjustment in recesses 62 and 63, respectively, by means of tap bolts 64 and 66 and lock nuts 67 and 68, respectively, in order to permit a selected distribution of the loads carried thereby. Preferably the adjustment is such that the major portion of the load is supported on rod 51 and springs 52, which reduces the friction between pads 48 and 59 and thereby the resistance to an axial movement of the casing relative to the supports 11.

The structure thus far described embodies supports mounting axially spaced portions of the spindle and casing elements with the portions of the elements adjacent one end of the turbine immovable axially and with the portions of the elements adjacent the other end of the turbine free for independent axial movement as the elements expand and contract longitudinally relative to their immovable portions and in addition, means for varying the relative lengths of the free end portions of the elements, that is, the length of the portion which is free to expand and contract longitudinally relative to its axially fixed or immovable portions. In other words, the axially immovable or fixed portion of at least one of the elements can be shifted axially relative to its free end and relative to the other element, thus varying the length of the portion which is free to expand and contract longitudinally and thereby the ultimate extent to which the free end of the element or a selected portion adjacent its free end is moved axially in response to such expansion and contraction.

In order to ascertain the direction and the extent of which the point of fixed connection between an element and its support should be shifted axially relatively to its free end portion, it is necessary to provide some means for detecting any appreciable ultimate axial displacement of adjacent free end portions of the elements. In

this connection, attention is directed particularly to Figs. 2, 3, 4 and 5 which illustrate the manner in which a light tube 12 and a sight tube 13 can be combined to indicate any such displacement. Casing 8 is provided with an apertured boss 69 in which tubes 12 and 13 are mounted in such angular relation that their longitudinal axes intersect at a point substantially on the shroud ring 71 of a spindle blade row 72. The interior of casing 8 has mounted thereon for movement therewith a ring element or member 73 which is interposed between shroud ring 71 and the inner ends of the tubes 12 and 13 and which has therein as best shown in Fig. 3 a rectangular aperture 74 alined with tube 12 and an observation aperture 76 alined with tube 13. The light emitted from tube 12 will pass through aperture 74 and project on a circumferential portion of shroud ring 71 a lighted area 77 having the same configuration as aperture 74 as is clearly shown in Fig. 4 in which the stippled surrounding area represents deep shadow. This lighted area can be readily observed at any time simply by sighting through tube 13 and the alined aperture 76, and what will be seen, assuming that the motive fluid is a gas of the type employed in continuous combustion gas turbines and that there has been no relative axial displacement of these opposed free end portions of the spindle and casing, is exactly what is shown in Fig. 4. In this connection, the axial width of the circumferentially spaced end portions of aperture 74 are preferably dimensioned to produce a lighted area having end portions exactly equal in width to the width of the shroud ring 71 as shown in Fig. 4 so that any appreciable axial displacement of the opposed portions of the spindle and casing can be readily detected as indicated in Fig. 5 which illustrates what is seen when the casing expands axially to a greater degree or extent than does the spindle; the difference in axial expansion or movement being indicated by the distance S. If the spindle expanded axially more than the casing, the displacement of the shroud ring relative to the lighted area would be just the opposite of that shown in Fig. 5. In any event, an observed displacement of the shroud ring relative to the lighted area indicates the direction and the extent to which the relative lengths of the free end portions of the elements must be changed in order to eliminate such a displacement.

For example, if with the construction shown in Figs. 1, 2, 6, 7, 8 and 9, the observed displacement is that shown in Fig. 5, the keys 10 in supports 9 would have to be withdrawn and reinserted as previously described in one of the keyways to the right of that shown, the turbine again placed in operation and observations again taken. If no axial displacement was observed, nothing further would have to be done, but if the condition was over or under corrected, the above procedure would be repeated. However, instead of proceeding as just outlined, the actual displacement could be accurately measured and knowing the coefficient of expansion for the casing, the key 10 could then be shifted into a keyway which would change the distance between the key and the point of observation sufficiently to substantially eliminate the observed axial displacement. In this connection, it is preferable to connect the supports 9 to a highly heated portion of the casing in order to avoid a relatively large axial shifting of the point of fixed connection with said supports in order to eliminate the

aforementioned axial displacement of adjacent free end portions of the spindle and casing.

The construction and procedure hereinbefore described eliminates an ultimate axial displacement of adjacent free end portions of the spindle and casing, but it does not necessarily eliminate a relative axial movement of said portions of the spindle and casing during extreme and rapid changes in load since due to differences in the mass and configuration of the spindle and casing elements, that which heats and cools the more rapidly will expand and contract at a greater rate. Consequently, although the ultimate expansion may be made the same for both elements, as previously described, the rate of expansion may be sufficiently different to produce a relative axial movement between adjacent free end portions of the elements and thereby either too much clearance for best efficiency or a rubbing and damaging contact between rotating and stationary parts.

In this connection, attention is directed to the modified construction shown in Fig. 10 which embodies means for eliminating both a relative axial movement and an ultimate axial displacement between adjacent opposed free-end portions of a turbine spindle and casing. In this modification, the turbine structure also embodies spindle shaft portions 78 and 79 rotatably supported in bearings 81 and 82 with the portion 78 provided with a collar 83 rendering same immovable axially relative to the bearing 81 and with the portion 79 substantially free to slide axially in bearing 82 as the spindle expands and contract longitudinally relative to its fixed end or shaft portion 78. However, the opposite end portions of the surrounding casing 84 are slidably mounted on pairs of identical supports 85 (only one support of each pair is shown in the interest of simplicity) which may be of any suitable form such for example as that shown in Figs. 8 and 9. The end of the casing adjacent the bearing 78 is connected with an axially spaced fixed support 86 by a rigid hollow member or strut 87 which may be provided with heat radiating fins 88 and controllably supplied with heated fluid from any suitable source, such as the turbine inlet pipe 89, by means of pipe 91 including a flexible portion 92, a valve 93 which is fixedly mounted on the end portion of the casing embodying a device 94 for detecting any appreciable relative axial movement of the juxtapositioned casing and spindle parts, a pipe 96 which is connected with one end of member 87 and includes a flexible portion 97, and a pipe 98 connecting the opposite end of member 97 with the turbine exhaust pipe 99 or any other suitable point of low pressure. Consequently, when valve 93 is open, heated motive fluid flows through the hollow member 87 and causes the member 87 to expand longitudinally relative to the fixed support 86 and thus slide the casing 84 axially on the supports 85. The extent to which the member 87 expands longitudinally depends upon the quantity and the temperature of the fluid flowing therethrough, and since the quantity of fluid can be controlled by manipulation of valve 93, the length of the member 87 can be selectively varied. For example, if with the parts as shown in Fig. 10 the valve 93 is assumed to be in a partially open position, a further opening of the valve will increase the temperature and thereby the length of member 87, thus bodily moving the casing 84 toward the left from its shown position while a closing movement of the

valve relative to its said partially open position will decrease the temperature and thereby the length of member 87, thus bodily moving the casing 84 toward the right from its said shown position.

Valve 93 is controllably connected with adjacent free end portions of the spindle and casing by means of a lever 100 having an intermediate portion fulcrumed at 101 on the end of casing 84 with one end portion engaging a collar 102 on the spindle shaft portion 79 and with its oppostie end portion pivotally connected with one end of a link 103 which is in turn pivotally connected with the stem of said valve. A tension spring 104 is connected to the lever 100 at a point intermediate its points of connection with the fulcrum 101 and link 103 and acts at all times to maintain the opposite end portion of the lever in engagement with the collar 102. With this construction, a relative axial movement of the spindle and casing causes the lever to pivot on its fulcrum 101 and move valve 93 either toward its fully open or closed position. In this connection, if the casing expands more rapidly than does the spindle, lever 100 will pivot in a clockwise direction and move valve 93 toward its fully closed position, thus decreasing the quantity of fluid passing through member 87 which in turn decreases the temperature and length of same and bodily moves the casing 84 toward the right, while if the spindle expands more rapidly than does the casing, lever 100 will pivot in a counterclockwise direction and move valve 93 toward its fully open position, thus increasing the quantity of fluid passing through member 87 which in turn increases the temperature and length of same and bodily moves the casing 84 toward the left. However, an equal axial movement of the spindle and casing does not affect the degree of valve opening since the valve and lever are mounted on portions of the casing substantially the same distance from its point of connection with the member 87.

The means for detecting a relative axial movement of the spindle and casing, which is indicated as being of the type shown in Figs. 1–5, inclusive, is utilized to determine the initial or normal position of the valve 93 and in this connection, the degree of valve opening is so selected that when the turbine is placed in operation or the load changes gradually, the rate and the extent of longitudinal expansion is the same for both the spindle and casing, the resulting opening and closing movements of the valve 93 will vary the temperature and thereby the axial length of the member 87 sufficiently to bodily move the casing relative to the spindle in a direction substantially equalizing the rate at which adjacent free end portions of the spindle and casing move axially.

The structure illustrated in Fig. 11 differs from that shown in Fig. 10 in only two respects, (1) the manner in which the heated member is connected to the adjacent end of the casing, and (2) the linkage employed for actuating the valve controlling the quantity of fluid flowing into and through the heated member. Consequently, the same numerals are employed to designate the same or similar parts. The difference designated (1) consists in providing the casing 84 with a projection or flange 106 which is similar to the projection 27 shown on casing 8 in Figs. 1, 6 and 7 and in providing the adjacent end of member 87 with a complementary connecting block 107 which is similar to block 21 shown on pedestal structure 14 in Figs. 1, 6 and 7 and which is positively connected to projection 106 on casing 84

by means of key and lock mechanism 108 which is also similar in construction to that shown in Figs. 1, 6 and 7, while the difference designated (2) consists in placing the collar 102 on shaft portion 79 outside the bearing 82, in employing a lever 109 fulcrumed intermediate its ends on the pedestal of bearing 82 with one end engaging collar 102 and with its opposite end pivotally connected with a link 111 which is in turn pivotally connected with one end of a lever 112 having its opposite end fulcrumed on the casing structure at 113 and its intermediate portion connected with the stem of valve 93.

The provision of an adjustable connection between the casing 84 and member 87 as just described permits the distance between the free end of the casing and its point of fixed connection with the member 87 to be selectively changed in order to eliminate an ultimate relative displacement of adjacent free end portions of the spindle and casing with the valve 93 in a selected partially open position. In other words, this construction permits the selected position of valve 93 to be such that only a slight opening or closing movement thereof will immediately result in the casing being moved bodily relative to the spindle a sufficient axial distance to substantially equalize the rate at which the adjacent free end portions of the spindle and casing move axially. The specified difference in the valve actuating linkage is of no material importance as the functioning of the valve and control means therefor is exactly the same as set forth in the detailed description of Fig. 10. Consequently, a further description in this connection is deemed unnecessary for a complete understanding of the invention.

The invention is applicable to all types of elastic fluid turbines, and although the means for detecting a relative axial movement and/or displacement of adjacent free end portions of the spindle and casing as well as other features are particularly applicable to gas turbine installations, it should be understood that it is not intended to limit the invention to the exact details of construction and operation herein shown and described, as various modifications within the scope of the appended claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a turbine structure embodying a spindle and a casing surrounding the spindle, a part fixed on one end portion of said casing and having in its underside a series of axially spaced keyway forming recesses extending approximately at right angles to the longitudinal axis of the turbine, a fixed support disposed in underlying spaced opposed relation to said casing part and having in its upper side a complementary series of keyway forming recesses alined with the recesses in said casing part, a key member disposed in one of the series of axially spaced keyways formed by said alined recesses and constituting the sole supporting connection between said casing part and support, and means mounting the opposite end portion of the casing for substantially free axial movement as the casing expands and contracts longitudinally relative to said fixed support.

2. In combination in a turbine apparatus embodying a spindle and a casing therefor, means fixedly mounting one end portion of the casing comprising a fixed member disposed in opposed adjacent relation with respect to said one portion

of the casing, said one end portion of the casing and fixed member presenting an axially extending series of pairs of opposed parts adapted to be fixedly united, and comprising means positionable for fixedly supportingly uniting any selected pair of said parts, and an additional means mounting the other end portion of said casing for axial movement relative to at least a portion of said additional means as the casing expands and contracts longitudinally in response to changes in temperature.

3. In combination in a turbine apparatus embodying a spindle and a casing therefor, means rotatably supporting axially spaced portions of said spindle with one of said portions immovable axially relative to its support and with the other of said portions substantially free to move axially relative to its support as the spindle expands and contracts longitudinally in response to changes in temperature, means supporting the portion of the casing adjacent said axially immovable portion of the spindle, a fixed structure axially spaced from said adjacent portion of the casing, a member connecting said adjacent portion of the casing with said fixed structure, means mounting the portion of the casing adjacent said axially movable portion of the spindle for axial movement relative to at least a portion of its supporting means as the casing expands and contracts longitudinally in response to changes in temperature, and means including a control responsive to a relative axial movement of adjacent free end portions of the spindle and casing for varying the temperature and thereby the axial length of said member sufficiently to bodily move said casing in a direction substantially equalizing the rate at which adjacent free end portions of the spindle and casing move axially.

4. In combination in a turbine apparatus embodying a spindle and a casing therefor, means rotatably supporting axially spaced portions of said spindle with one of said portions immovable axially relative to its support and with the other of said portions substantially free to move axially relative to its support as the spindle expands and contracts longitudinally in response to changes in temperature, means supporting the portion of the casing adjacent said axially immovable portion of the spindle, a fixed structure axially spaced from said adjacent portion of the casing, a member connecting the adjacent end of said casing with said fixed structure, means mounting the portion of the casing adjacent said axially movable portion of the spindle for axial movement relative to at least a portion of its supporting means as the casing expands and contracts longitudinally in response to changes in temperature, and means for varying the axial length of said member sufficiently to bodily move said casing in a direction substantially equalizing the rate at which adjacent free end portions of the spindle and casing move axially.

5. In combination in a turbine apparatus embodying a spindle and a casing therefor, means rotatably supporting axially spaced portions of said spindle with one of said portions immovable axially relative to its support and with the other of said portions substantially free to move axially relative to its support as the spindle expands and contracts longitudinally in response to changes in temperature, means supporting the portion of the casing adjacent said axially immovable portion of the spindle, a fixed structure axially spaced from said adjacent portion of the casing, a member connecting said adjacent portion of the casing with said fixed structure and including an adjustable element axially shiftable relative to said member and relative to said adjacent portion of the casing for selectively fixedly uniting different axial parts of said adjacent portion of the casing with correspondingly different axial portions of said member, means mounting the portion of said casing adjacent said axially movable portion of the spindle for substantially free axial movement relative to its mounting means as the casing expands and contracts longitudinally in response to changes in temperature, and means including a control responsive to a relative axial movement of adjacent free end portions of the spindle and casing for varying the temperature and thereby the axial length of said member sufficiently to bodily move said casing in a direction substantially equalizing the rate at which adjacent free end portions of the spindle and casing move axially.

6. Turbine apparatus comprising: a spindle element; a casing element for said spindle element; a pair of spindle supports for rotatably supporting said spindle element at axially spaced general planes transverse to the axis of said spindle, one of said spindle supports having associated therewith means for holding said spindle against axial movement with respect to said spindle support and the other of said spindle supports mounting said spindle for substantially free axial movement as said spindle expands and contracts in response to temperature changes thereof; a pair of casing supports for said casing element separate from said spindle supports at axially spaced general planes transverse to the axis of said casing element, one of said casing supports having associated therewith means for holding said casing against axial movement with respect to said casing support and the other of said casing supports mounting said casing for substantially free axial movement as said casing expands and contracts in response to temperature changes thereof; said means for holding said spindle element against axial movement with respect to its associated support and said means for holding said casing element against axial movement with respect to its associated support being structurally separate from and structurally independent of each other; and one of said supports with its associated means which is adapted to hold its respective element against axial movement with respect to its associated support constituting means for adjustably changing in an axial direction the transverse general plane at which said respective element is supported and held against axial movement, such adjustment leaving unchanged the transverse general plane at which the other of said elements is supported and held against axial movement by reason of the aforesaid structural separateness and independence of the respective holding means for said elements.

7. Turbine apparatus comprising: a spindle element; a casing element for said spindle element; a pair of spindle supports for rotatably supporting said spindle element at axially spaced general planes transverse to the axis of said spindle, one of said spindle supports having associated therewith means for holding said spindle against axial movement with respect to said spindle support and the other of said spindle supports mounting said spindle for substantially free axial movement as said spindle expands and contracts in response to temperature changes thereof; a pair of casing supports for said casing element separate from

said spindle supports at axially spaced general planes transverse to the axis of said casing element, one of said casing supports having associated therewith means for holding said casing against axial movement with respect to said casing support and the other of said casing supports mounting said casing for substantially free axial movement as said casing expands and contracts in response to temperature changes thereof; said means for holding said spindle element against axial movement with respect to its associated support and said means for holding said casing element against axial movement with respect to its associated support being structurally separate from and structurally independent of each other; and one of said supports with its associated means which is adapted to hold its respective element against axial movement with respect to its associated support comprising a separately bodily movable member shiftable axially and constituting means for adjustably changing in an axial direction, in accordance with the position of said member, the transverse general plane at which said respective element is supported and held against axial movement, such adjustment leaving unchanged the transverse general plane at which the other of said elements is supported and held against axial movement by reason of the aforesaid structural separateness and independence of the respective holding means for said elements.

8. Turbine apparatus comprising: a spindle element; a casing element for said spindle element; a pair of spindle supports for rotatably supporting said spindle element at axially spaced general planes transverse to the axis of said spindle, one of said spindle supports having associated therewith means for holding said spindle against axial movement with respect to said spindle support and the other of said spindle supports mounting said spindle for substantially free axial movement as said spindle expands and contracts in response to temperature changes thereof; a pair of casing supports for said casing element separate from said spindle supports at axially spaced general planes transverse to the axis of said casing element, one of said casing supports having associated therewith means for holding said casing

against axial movement with respect to said casing support and the other of said casing supports mounting said casing for substantially free axial movement as said casing expands and contracts in response to temperature changes thereof; said means for holding said spindle element against axial movement with respect to its associated support and said means for holding said casing element against axial movement with respect to its associated support being structurally separate from and structurally independent of each other; and one of said supports with its associated means which is adapted to hold its respective element against axial movement with respect to its associated support comprising a heatable member and separate means for supplying heat thereto and constituting means for adjustably changing in an axial direction, in response to change in temperature of said member, the transverse general plane at which said respective element is supported and held against axial movement, such adjustment leaving unchanged the transverse general plane at which the other of said elements is supported and held against axial movement by reason of the aforesaid structural separateness and independence of the respective holding means for said elements.

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