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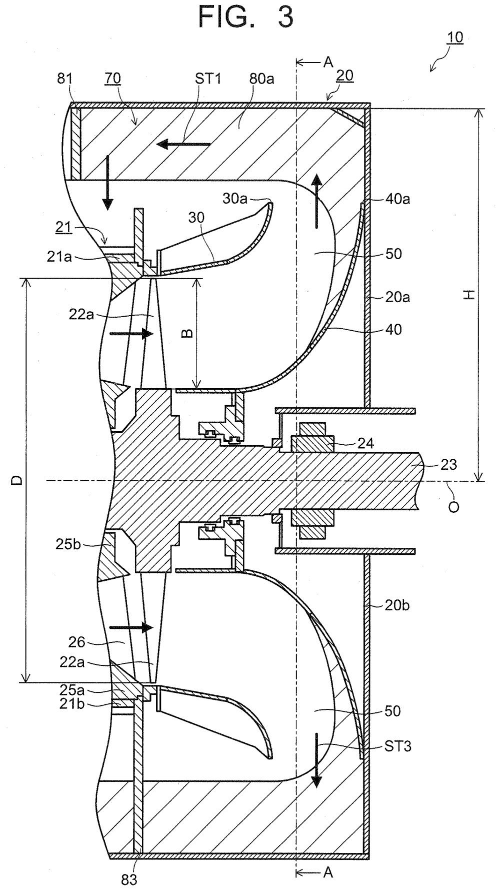
(54) **Steam turbine**

(57) A steam turbine 10 in an embodiment includes: an inner casing 21 surrounding a turbine rotor; an outer casing 20 composed of an upper half side outer casing 20a and a lower half side outer casing 20b; and an annular diffuser 50 through which steam passed through a turbine stage is discharged radially outward. A vertical distance H from a axis of a turbine rotor 23 to an inner wall of the upper half side outer casing 20a, an outermost diameter D of final stage rotor blades 22a, a blade height B of the fmal stage rotor blade 22a, and a distance W between inner walls in vertical and horizontal directions to the axis of the turbine rotor 23, at a bottom portion of the lower half side outer casing 20b forming a discharge port 60, satisfy $(H - D/2)/B \leq 1.7$ and $(W - D)/2B \geq 2$.

FIG. 3



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Description

FIELD

[0001] Embodiments described herein relate generally to a steam turbine.

BACKGROUND

[0002] The thermal efficiency improvement of a steam turbine used in a thermal power plant and the like has been an important task leading to effective use of energy resources and reduction in carbon dioxide (CO_2) emission.

[0003] The thermal efficiency improvement of a steam turbine can be achieved by effectively converting given energy to mechanical work. For this, it is necessary to reduce various internal losses.

[0004] The internal losses in a steam turbine include a profile loss ascribable to the shape of blades, a steam secondary flow loss, a steam leakage loss, a turbine cascade loss based on a steam moisture loss and the like, a passage part loss in passages typified by a steam valve and a crossover pipe, other than cascades, a turbine exhaust loss by a turbine exhaust hood, and so on.

[0005] Among these losses, the turbine exhaust loss is a large loss accounting for 10 to 20% of the total internal losses. The turbine exhaust loss is a loss to occur between an outlet of a final stage and an inlet of a condenser. The turbine exhaust loss is further classified into a leaving loss, a hood loss, an annular area restriction loss, a turn-up loss, and so on. Among them, the hood loss is a pressure loss from an exhaust hood to a condenser, and relies on the type, shape, and size of an exhaust hood including a diffuser.

[0006] Generally, the pressure loss increases in proportion to the square of a flow velocity of steam. For reducing the pressure loss, it is effective to increase the size of an exhaust hood in an allowable range to reduce the flow velocity of steam. However, increasing the size of an exhaust hood is subjected to the restrictions of a manufacturing cost, an installation space of a building, and so on. Increasing the size of an exhaust hood for reducing the hood loss is also subjected to such restrictions. Therefore, it becomes important to make an exhaust hood in a shape with a small pressure loss within a limited size.

[0007] For reducing the pressure loss in an exhaust hood, it is necessary to, in a diffuser, reduce the velocity of steam sufficiently to recover a static pressure and reduce the pressure loss on the downstream side of the diffuser. For this, various examinations have been made in order to reduce the turbine exhaust loss.

[0008] FIG. 13 is a view showing part of a meridian cross section in the vertical direction in an upper half portion of a conventional steam turbine 200. As shown in FIG. 13, steam having passed through a rotor blade 210 forming a final turbine stage is guided to an annular diffuser 213 formed of a steam guide 211 and a bearing cone 212.

[0009] The steam to be discharged from the upper half side of the diffuser 213 flows radially outward in a radial and substantially equal manner as indicated by the arrow in FIG. 13 without directly flowing to an outlet of an exhaust hood. The steam having flowed out from the diffuser 213 flows between an outer casing 214 and an inner casing 215. Particularly, the steam having flowed vertically upward collides with an upper half side flow guide 216 provided on the outer casing 214 of the upper half side and an outer surface of the inner casing 215, and thereby the flow direction is turned downward. Then, the steam having had its flow turned downward is guided to a condenser (not shown) installed below a turbine rotor 217, namely under the steam turbine 200.

[0010] As described above, in the steam turbine 200 in which the exhaust hood guiding the steam to be discharged to the condenser installed below is provided, of the steam having flowed radially outward, the steam having flowed vertically upward in particular collides with the upper half side flow guide 216 and the inner casing 215, and thereby the flow direction is turned downward. Therefore, the steam discharged from the upper half side of the diffuser 213 undergoes a large pressure loss rather than steam discharged from the lower half side of the diffuser 213. Thereby, the pressure loss of the flow of the steam in the exhaust hood increases.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a view showing a meridian cross section in the vertical direction, of a steam turbine in a first embodiment, including a center axis of a turbine rotor.

[0012] FIG. 2 is a perspective view showing part of an exhaust hood in the steam turbine in the first embodiment.

[0013] FIG. 3 is a view showing part of a meridian cross section in the vertical direction, of the exhaust hood in the steam turbine in the first embodiment, including the center axis of the turbine rotor.

[0014] FIG. 4 is a view showing part of a meridian cross section in the horizontal direction, of the exhaust hood in the steam turbine in the first embodiment, including the center axis of the turbine rotor.

[0015] FIG. 5 is a view showing a cross section, taken along A-A in FIG. 3, showing the steam turbine in the first embodiment.

[0016] FIG. 6 is a view showing part of a meridian cross section in the vertical direction, of an exhaust hood in a steam turbine in a second embodiment, including a center axis of a turbine rotor.
[0017] FIG. 7 is a view showing part of a meridian cross section in the horizontal direction, of the exhaust hood in the steam turbine in the second embodiment, including the center axis of the turbine rotor.
[0018] FIG. 8 is a view showing a cross section, taken along B-B in FIG. 6, showing the steam turbine in the second embodiment.
[0019] FIG. 9 is a view showing the relationship between (H - D/2)B and a turbine exhaust loss.
[0020] FIG. 10 is a view showing the relationship between (W - D)/2B and the turbine exhaust loss.
[0021] FIG. 11 is a view showing the relationship between (H - C/2)/B and the turbine exhaust loss.
[0022] FIG. 12 is a view showing the relationship between (W - C)/2B and the turbine exhaust loss.
[0023] FIG. 13 is a view showing part of a meridian cross section in the vertical direction in an upper half portion of a conventional steam turbine.

DETAILED DESCRIPTION

[0024] In one embodiment, a steam turbine having a path to guide steam having passed through a final turbine stage to a condenser provided below. This steam turbine includes: an inner casing surrounding a turbine rotor and composed of an upper half side inner casing and a lower half side inner casing; and an outer casing surrounding the inner casing and composed of an upper half side outer casing and a lower half side outer casing. Further, the steam turbine includes an annular diffuser that is provided on a downstream side of the final turbine stage and through which the steam having passed through the final turbine stage is discharged radially outward.
[0025] Then, a vertical distance H from a center axis of the turbine rotor to an inner wall of the upper half side outer casing, an outermost diameter D of final stage rotor blades forming the final turbine stage, a blade height B of the final stage rotor blade, and a distance W between inner walls in vertical and horizontal directions to the center axis of the turbine rotor, at a bottom portion of the lower half side outer casing forming a discharge port through which the steam is discharged to the condenser, are set so as to satisfy $(H - D/2)/B \leq 1.7$ and $(W - D)/2B \geq 2$.
[0026] Hereinafter, there will be explained embodiments of the present invention with reference to the drawings.

(First embodiment)

[0027] FIG. 1 is a view showing a meridian cross section in the vertical direction, of a steam turbine 10 in the first embodiment, including a center axis O of a turbine rotor 23. FIG. 2 is a perspective view showing part of an exhaust hood 70 in the steam turbine 10 in the first embodiment. Note that in FIG. 2, a state which an outer casing 20 is removed from the steam turbine 10 is shown.
[0028] FIG. 3 is a view showing part of a meridian cross section in the vertical direction, of the exhaust hood 70 in the steam turbine 10 in the first embodiment, including the center axis O of the turbine rotor 23. FIG. 4 is a view showing part of a meridian cross section in the horizontal direction, of the exhaust hood 70 in the steam turbine 10 in the first embodiment, including the center axis O of the turbine rotor 23. FIG. 5 is a view showing a cross section, taken along A-A in FIG. 3, showing the steam turbine 10 in the first embodiment. Note that FIG. 4 is a cross section of the upper half side of the exhaust hood 70 seen from the lower half side. FIG. 5 is shown in a manner that part of the constitution is omitted as a matter of convenience.
[0029] Here, as the steam turbine 10, a double flow exhaust type low-pressure turbine having a downward exhaust type exhaust hood is explained as an example.
[0030] As shown in FIG. 1, in the outer casing 20, an inner casing 21 is provided, and the steam turbine 10 is provided with what is called a double casing structure. The outer casing 20 and the inner casing 21 are each formed in a structure divided into upper and lower two parts by a horizontal plane including the center axis O of the turbine rotor 23. The outer casing 20 is composed of an upper half side outer casing 20a and a lower half side outer casing 20b. The inner casing 21 is composed of an upper half side inner casing 21a and a lower half side inner casing 21b.
[0031] In the inner casing 21, the turbine rotor 23 having rotor blades 22 implanted therein is penetratingly installed. The plural rotor blades 22 are implanted in the circumferential direction to thereby form a rotor blade cascade. A plurality of stages of the rotor blade cascades is provided in the axial direction of the turbine rotor 23. The turbine rotor 23 is rotatably supported by rotor bearings 24. Incidentally, among the rotor blades 22, the rotor blade provided on a final turbine stage is set as a final stage rotor blade 22a here.
[0032] On an inner circumference of the inner casing 21, nozzles (stationary blades) 26 supported by diaphragms 25a and 25b are provided so as to be alternate with the rotor blades 22 in the axis direction of the turbine rotor 23. The plural nozzles 26 are implanted in the circumferential direction to thereby form a nozzle cascade (stationary blade cascade). The nozzle cascade and the rotor blade cascade positioned on the immediately downstream side of the nozzle cascade form one turbine stage. Note that the inner casing 21 is supported by the outer casing 20, for example.

[0033] In the center of the steam turbine 10, an intake chamber 28 into which steam through a crossover pipe 27 is introduced is provided. The steam is introduced into the right and left turbine stages from this intake chamber 28 in a distributed manner.

[0034] As shown in FIG. 1 to FIG. 4, on the downstream side of the final turbine stage, an annular diffuser 50 through which the steam is discharged radially outward is formed by a steam guide 30 of the outer circumference side and a bearing cone 40 of the inner circumference side. Note that inside the bearing cone 40, the rotor bearing 24, and the like are provided.

[0035] As shown in FIG. 3 and FIG. 4, the steam guide 30 and the bearing cone 40 are each formed in a structure divided into upper and lower two parts by the horizontal plane including the center axis O of the turbine rotor 23. For example, the cylindrical steam guide 30 in a bell mouthed and expanded open shape is formed by the steam guide 30 of the upper half side and the steam guide 30 of the lower half side. Similarly, the cylindrical bearing cone 40 in a bell mouthed and expanded open shape is formed by the bearing cone 40 of the upper half side and the bearing cone 40 of the lower half side. Then, the annular diffuser 50 is formed by the cylindrical steam guide 30 and the cylindrical bearing cone 40 provided inside thereof Note that of the steam guide 30, the formation of the upper half side and the formation of the lower half side are the same, and of the bearing cone 40, the formation of the upper half side and the formation of the lower half side are the same.

[0036] As shown in FIG. 3 and FIG. 4, the annular diffuser 50 is preferably formed so that at an outlet of the annular diffuser 50, the flow of the steam may flow radially outward, and for example, an endmost portion 30a of the outlet side of the steam guide 30 may become the same in the horizontal position as an endmost portion 40a of the outlet side of the bearing cone 40. That is, a radial distance from the center axis O of the turbine rotor 23 to the endmost portion 30a and a radial distance from the center axis O of the turbine rotor 23 to the endmost portion 40a are preferably formed equally. The steam having performed expansion work in the turbine stages passes through the previously described annular diffuser 50 to be discharged radially outward from the outlet of the annular diffuser 50.

[0037] As shown in FIG. 2, in a bottom portion of the outer casing 20, a discharge port 60 through which the steam is discharged to a condenser (not shown) provided under the steam turbine 10 is formed. Here, a steam passage where the steam having passed through the final turbine stage flows to be discharged from the discharge port 60 of the outer casing 20 functions as the exhaust hood 70.

[0038] The exhaust hood 70 includes a large space portion surrounded by the upper half side outer casing 20a having an upper half side keel rib 80a and the lower half side outer casing 20b having a lower half side keel rib 80b as shown in FIG. 2 and FIG. 5, for example. Further, on the upper half side outer casing 20a, there is provided an upper half side flow guide 81 turning the steam having flowed vertically upward from the annular diffuser 50 of the upper half side downward.

[0039] On the bottom portion side of the lower half side outer casing 20b, besides the above-described lower half side keel rib 80b, partition parts 82 and 83, and so on are provided. As above, the upper half side keel rib 80a, the lower half side keel rib 80b, the partition parts 82 and 83, and so on are provided, thereby making the exhaust hood 70 in a structure durable against pressing pressure such as outside air pressure.

[0040] Here, as shown in FIG. 3 and FIG. 5, a vertical distance from the center axis O of the turbine rotor 23 to an inner wall of the upper half side outer casing 20a is set to H. As shown in FIG. 3 and FIG. 4, an outermost diameter of the final stage rotor blades 22a forming the final turbine stage is set to D. Here, the outermost diameter D is equal to a diameter of a circle made by blade edges of the final stage rotor blades 22a when the final stage rotor blades 22a rotate. Further, a blade height of the final stage rotor blade 22a is set to B. Here, the blade height B is a distance from a blade root to a blade edge as shown in FIG. 3 and FIG. 4, and functions as a representative dimension indicating an inlet of the exhaust hood 70 (an inlet of the annular diffuser 50).

[0041] The vertical distance H, the outermost diameter D of the final stage rotor blades 22a, and the blade height B of the final stage rotor blade 22a described above are set so as to satisfy the following expression (1).

$$(H - D/2)/B \leq 1.7 \text{ ... Expression (1)}$$

[0042] Further, as shown in FIG. 5, in the bottom portion of the lower half side outer casing 20b, the discharge port 60 through which the steam is discharged to the condenser (not shown) is formed. Then, a distance between inner walls 90a and 90b in the vertical and horizontal directions to the center axis O of the turbine rotor 23, at the bottom portion (the discharge port 60) of the lower half side outer casing 20b is set to W. This distance W, the outermost diameter D of the final stage rotor blades 22a and the blade height B of the final stage rotor blade 22a that are described previously are set so as to satisfy the following expression (2).

$$(W - D)/2B \geq 2 \text{ ... Expression (2)}$$

[0043] That is, the steam turbine 10 is constituted so as to satisfy Expression (1) and Expression (2) described above.

[0044] Here, Expression (1) described above is satisfied, thereby narrowing a vertical upper space between the upper half side outer casing 20a and the upper half side inner casing 21a, which is formed vertically upward. Then, a flow rate of steam ST1 flowing into this space is reduced (see FIG. 5). That is, a flow rate of the steam passing through a gap between the upper half side outer casing 20a and the endmost portion 30a of the downstream side of the steam guide 30 and colliding with the upper half side flow guide 81 and the upper half side inner casing 21a to thereby have its flow turned downward is reduced (see FIG. 3). Therefore, it is possible to reduce, in the exhaust hood 70, a pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side.

[0045] Here, the lower limit value of (H - D/2)B is 0.5 or so due to making the exhaust hood 70 in a structure durable against pressing pressure such as outside air pressure by securing the height of the upper half side keel rib 80a.

[0046] On the other hand, Expression (2) described above is satisfied, thereby enlarging a horizontal direction space between the upper half side outer casing 20a and the upper half side inner casing 21a, which is formed in the horizontal direction. Then, a flow rate of steam ST2 flowing into this space is increased (see FIG. 5). That is, since the flow rate of the steam ST1 is reduced, the flow rate of the steam ST2 flowing into the horizontal direction space is increased. The steam ST2 having flowed into the horizontal direction space is guided to the discharge port 60 of the lower half side outer casing 20b without colliding with the upper half side flow guide 81 and the upper half side inner casing 21a. Therefore, it is possible to reduce, in the exhaust hood 70, the pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side.

[0047] Here, the upper limit value of (W - D)/2B is 4 or so for the reason of preventing occurrence of an enlargement loss caused by sudden enlargement of a channel area with respect to the flow of the steam having flowed out from the annular diffuser 50.

[0048] Incidentally, the steams ST1 and ST2 having flowed out from the annular diffuser 50 of the upper half side flow together with steam ST3 having flowed out from the annular diffuser 50 of the lower half side to be discharged from the discharge port 60 to the condenser (not shown).

[0049] As described above, according to the steam turbine 10 in the first embodiment, as for the steam flowing in the radial direction from the annular diffuser 50 of the upper half side in a radial manner, it is possible to reduce the flow rate of the steam ST 1 flowing into the narrow vertical upper space and to increase the flow rate of the steam ST2 flowing into the large horizontal direction space. This makes it possible to reduce, in the exhaust hood 70, the pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side.

(Second Embodiment)

[0050] FIG. 6 is a view showing part of a meridian cross section in the vertical direction, of an exhaust hood 70 in a steam turbine 11 in the second embodiment, including a center axis O of a turbine rotor 23. FIG. 7 is a view showing part of a meridian cross section in the horizontal direction, of the exhaust hood 70 in the steam turbine 11 in the second embodiment, including the center axis O of the turbine rotor 23. FIG. 8 is a view showing a cross section, taken along B-B in FIG. 6, showing the steam turbine 11 in the second embodiment. Note that FIG. 7 is a cross section of the upper half side of the exhaust hood 70 seen from the lower half side. FIG. 8 is shown in a manner that part of the constitution is omitted as a matter of convenience. Further, the same constituent parts as those of the steam turbine 10 in the first embodiment are denoted by the same reference signs, and a duplicate description will be omitted or simplified.

[0051] In the steam turbine 11 in the second embodiment, as shown in FIG. 6 and FIG. 8, a vertical distance from the center axis O of the turbine rotor 23 to an inner wall of an upper half side outer casing 20a is set to H. As shown in FIG. 6 to FIG. 8, an outermost diameter at an endmost portion 30a of the outlet side (downstream side) of a steam guide 30 forming an outlet of an annular diffuser 50 is set to C. Further, a blade height of a final stage rotor blade 22a is set to B. Here, the blade height B is a distance from a blade root to a blade edge as shown in FIG. 6 and FIG. 7.

[0052] The vertical distance H, the outermost diameter C of the endmost portion 30a, and the blade height B of the final stage rotor blade 22a described above are set so as to satisfy the following expression (3).

$$0.2 \leq (H - C/2)/B \leq 0.85 \text{ ... Expression (3)}$$

[0053] Further, as shown in FIG. 8, in a bottom portion of a lower half side outer casing 20b, a discharge port 60 through which steam is discharged to a condenser (not shown) is formed. Then, a distance between inner walls 90a and 90b in the vertical and horizontal directions to the center axis O of the turbine rotor 23, at the bottom portion (the discharge port 60) of the lower half side outer casing 20b is set to W. This distance W, the outermost diameter C of the endmost portion 30a and the blade height B of the final stage rotor blade 22a that are described previously are set so as to satisfy the following expression (4).

$$1.1 \leq (W - C)/2B \leq 1.8 \text{ ... Expression (4)}$$

[0054] That is, the steam turbine 11 is constituted so as to satisfy Expression (3) and Expression (4) described above.

[0055] Here, as shown in FIG. 6 and FIG. 7, the flow of steam having flowed radially outward from the outlet of the annular diffuser 50 of the upper half side has its flow direction turned at 90 degrees, and the steam flows into a gap between the upper half side outer casing 20a and the endmost portion 30a of the steam guide 30. In the case of this gap being narrow, the flow of the steam having flowed radially outward in a radial manner from the outlet of the annular diffuser 50 of the upper half side does not flow through this gap easily. Thereby, a large pressure loss occurs.

[0056] On the other hand, in the case of the gap between the upper half side outer casing 20a and the endmost portion 30a of the steam guide 30 being large, the distance between the upper half side outer casing 20a and the endmost portion 30a of the steam guide 30 is lengthened. Therefore, the steam having flowed out from the outlet of the annular diffuser 50 of the upper half side diffuses suddenly in a space. Thereby, a pressure loss caused by sudden enlargement of the flow occurs.

[0057] Further, the distance between the outlet of the annular diffuser 50 of the upper half side and an inner wall surface of the upper half side outer casing 20a facing this outlet is long, and thus the inner wall surface of the upper half side outer casing 20a does not function as a flow guide guiding the flow of the steam in a predetermined direction. Therefore, it makes it difficult to turn the flow of the steam having flowed radially outward from the outlet of the annular diffuser 50 of the upper half side at 90 degrees to appropriately let the steam flow into the gap between the upper half side outer casing 20a and the endmost portion 30a of the steam guide 30. Thereby, the flow of the steam is inclined toward the bearing cone 40 side. Therefore, it becomes impossible to effectively use an exhaust area of the discharge port 60, resulting in that the pressure loss increases.

[0058] As above, with regard to the gap between the endmost portion 30a of the steam guide 30 and the upper half side outer casing 20a facing this, an optimal value exists. That is, even when the gap between the endmost portion 30a of the steam guide 30 and the upper half side outer casing 20a facing this is smaller or larger than this optimal value, the pressure loss increases.

[0059] Further, this gap is narrowed as much as possible, thereby making it possible to reduce the flow rate of the steam ST1 colliding with an upper half side flow guide 81 and an upper half side inner casing 21a to thereby have its flow turned downward (see FIG. 8). This makes it possible to reduce, in the exhaust hood 70, the pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side. Therefore, the gap between the endmost portion 30a of the steam guide 30 and the upper half side outer casing 20a facing this is reduced as much as possible to such an extent that the flow of the steam is not hindered, and the range of (H - C/2)/B is set.

[0060] Further, a horizontal direction space between the upper half side outer casing 20a and the upper half side inner casing 21a, which is formed in the horizontal direction, is enlarged to such an extent that a sudden enlargement loss of the flow does not occur, and thereby the flow rate of the steam ST2 flowing into this space is increased (see FIG. 8). That is, since the flow rate of the steam ST1 is reduced, the flow rate of the steam ST2 flowing into the horizontal direction space is increased.

[0061] The steam ST2 having flowed into the horizontal direction space is guided to the discharge port 60 of the outer casing 20 without colliding with the upper half side flow guide 81 and the upper half side inner casing 21a. Therefore, it is possible to reduce, in the exhaust hood 70, the pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side. Based on the description above, the relational expressions of Expression (3) and Expression (4) described above can be obtained.

[0062] As described above, according to the steam turbine 11 in the second embodiment, it is possible to reduce the gap between the endmost portion 30a of the steam guide 30 and the upper half side outer casing 20a facing this as much as possible to such an extent that the flow of the steam is not hindered. Therefore, it is possible to reduce the flow rate of the steam ST1 flowing into the narrow vertical upper space and to increase the flow rate of the steam ST2 flowing into the large horizontal direction space. This makes it possible to reduce, in the exhaust hood 70, the pressure loss of the steam having flowed out from the annular diffuser 50 of the upper half side.

(Evaluation of a turbine exhaust loss)

(1) (H - D/2)B, (W - D)/2B and a turbine exhaust loss

[0063] FIG. 9 is a view showing the relationship between (H - D/2)B and the turbine exhaust loss. FIG. 10 is a view showing the relationship between (W - D)/2B and the turbine exhaust loss. These relationships are results obtained from a model test by a scale model and a numerical analysis.

[0064] Incidentally, in the evaluations according to FIG. 9 and FIG. 10, the turbine exhaust loss was evaluated by changing both values of (H - D/2)B and (W - D)/2B. Concretely, with reducing the value of (H - D/2)/B, the value of(W -

D)/2B was increased. For example, when (H - D/2)/B was 1.7, (W - D)/2B was 2, and with reducing (H - D/2)/B from 1.7, (W - D)/2B was increased from 2.

[0065] As shown in FIG. 9, when the value of (H - D/2)/B exceeds 1.7, the turbine exhaust loss increases rapidly. Further, as shown in FIG. 10, when (W - D)/2B is less than 2, the turbine exhaust loss increases rapidly. Therefore, it is found that (H - D/2)/B is set to 1.7 or less and (W - D)/2B is set to 2 or more, thereby making it possible to reduce the turbine exhaust loss.

(2) (H - C/2)/B, (W - C)/2B and the turbine exhaust loss

[0066] FIG. 11 is a view showing the relationship between (H - C/2)B and the turbine exhaust loss. FIG. 12 is a view showing the relationship between (W - C)/2B and the turbine exhaust loss. These relationships are results obtained in an actual machine.

[0067] Incidentally, in the evaluations according to FIG. 11 and FIG. 12, the turbine exhaust loss was evaluated by changing both values of (H - C/2)/B and (W - C)/2B. Concretely, with increasing the value of (H - C/2)/B, the value of (W - C)/2B was reduced. For example, when (H - C/2)/B was 0.2, (W - C)/2B was 1.8, and with increasing (H - C/2)/B from 0.2, (W - C)/2B was reduced from 1.8. (W - C)/2B when (H - C/2)/B is 0.85 is 1.1.

[0068] As shown in FIG. 11, when (H - C/2)/B is 0.6 or so, a maximum static pressure recovery amount is obtained, and when (H - C/2)/B deviates from the value, the static pressure recovery amount reduces and the turbine exhaust loss increases. Here, according to a normal turbine design standard, a design allowing up to the static pressure recovery amount reduced by 20% from the maximum static pressure recovery amount is made. In FIG. 11, the static pressure recovery amount reduced by 20% from the maximum static pressure recovery amount is indicated by a dotted line. Therefore, it is found that (H - C/2)B is set to not less than 0.2 nor more than 0.85 and (W - C)/2B is set to not less than 1.1 nor more than 1.8, thereby making it possible to obtain the static pressure recovery amount equal to or more than the previously described turbine design standard value and reduce the turbine exhaust loss.

[0069] According to the explained embodiments above, it becomes possible to suppress the pressure loss of the flow of the steam in the exhaust hood and reduce the turbine exhaust loss.

[0070] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Claims

1. A steam turbine having a path to guide steam having passed through a final turbine stage to a condenser provided below, the steam turbine, comprising:

   an inner casing surrounding a turbine rotor and composed of an upper half side inner casing and a lower half side inner casing;
   an outer casing surrounding the inner casing and composed of an upper half side outer casing and a lower half side outer casing; and
   an annular diffuser that is provided on a downstream side of the final turbine stage and through which the steam having passed through the final turbine stage is discharged radially outward, wherein
   a vertical distance H from a center axis of the turbine rotor to an inner wall of the upper half side outer casing, an outermost diameter D of final stage rotor blades forming the final turbine stage, a blade height B of the final stage rotor blade, and a distance W between inner walls in vertical and horizontal directions to the center axis of the turbine rotor, at a bottom portion of the lower half side outer casing forming a discharge port through which the steam is discharged to the condenser, satisfy the following expression (1) and expression (2).

$$(H - D/2)/B \leq 1.7 \ldots \text{Expression (1)}$$

$$(W - D)/2B \geq 2 \ldots \text{Expression (2)}$$

2. A steam turbine having a path to guide steam having passed through a final turbine stage to a condenser provided below, the steam turbine, comprising:

an inner casing surrounding a turbine rotor and composed of an upper half side inner casing and a lower half side inner casing;
an outer casing surrounding the inner casing and composed of an upper half side outer casing and a lower half side outer casing; and
an annular diffuser that is provided on a downstream side of the final turbine stage and is formed by a steam guide and a bearing cone inside the steam guide and through which the steam having passed through the final turbine stage is discharged radially outward, wherein a vertical distance H from a center axis of the turbine rotor to an inner wall of the upper half side outer casing, an outermost diameter C at an endmost portion of the steam guide forming an outlet of the annular diffuser, a blade height B of a final stage rotor blade forming the final turbine stage, and a distance W between inner walls in vertical and horizontal directions to the center axis of the turbine rotor, at a bottom portion of the lower half side outer casing forming a discharge port through which the steam is discharged to the condenser, satisfy the following expression (3) and expression (4).

$$0.2 \leq (H - C/2)/B \leq 0.85 \text{ ... Expression (3)}$$

$$1.1 \leq (W - C)/2B \leq 1.8 \text{ ... Expression (4)}$$

FIG. 1

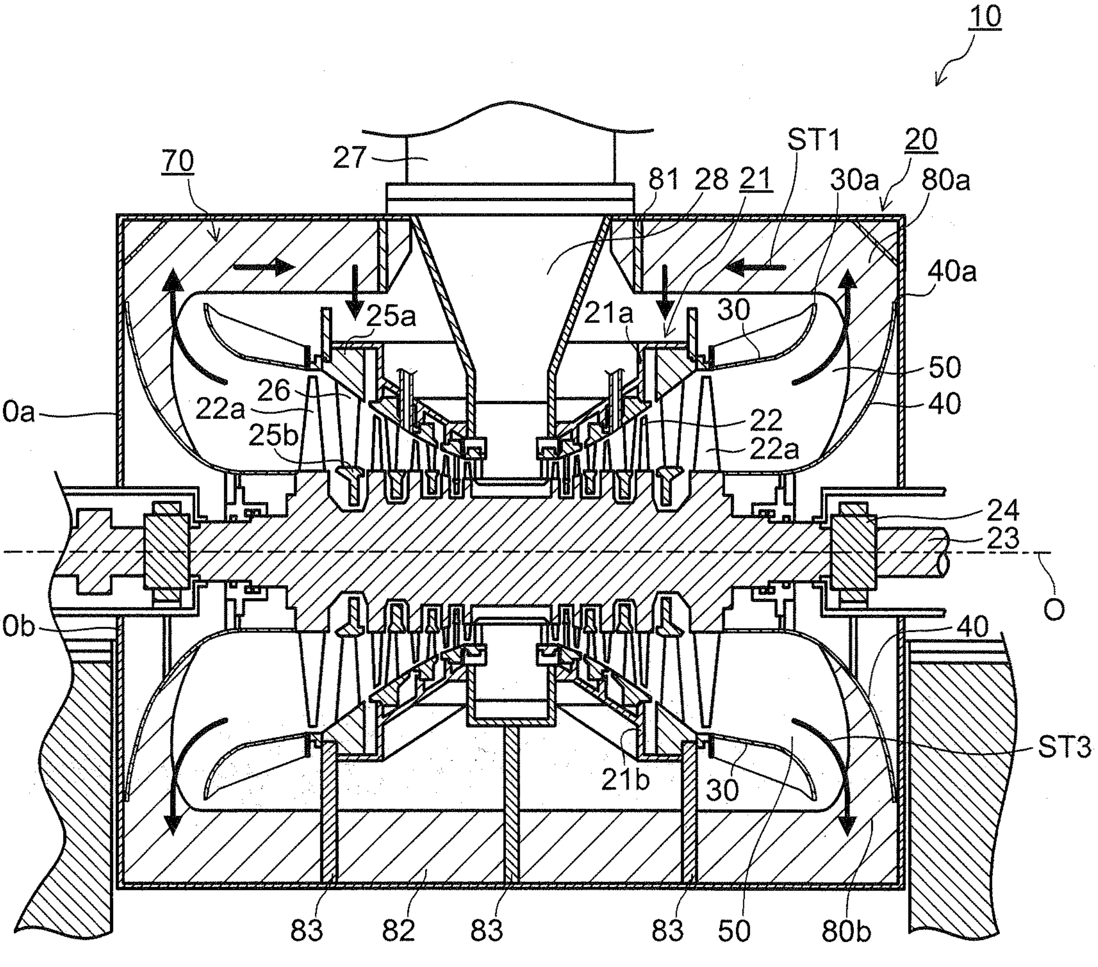

10
70
27
81
28
21
ST1
20
30a
80a
40a
25a
21a
30
50
40
20a
22a
26
25b
22
22a
24
23
O
20b
40
21b
30
ST3
83
82
83
83
50
80b

FIG. 2

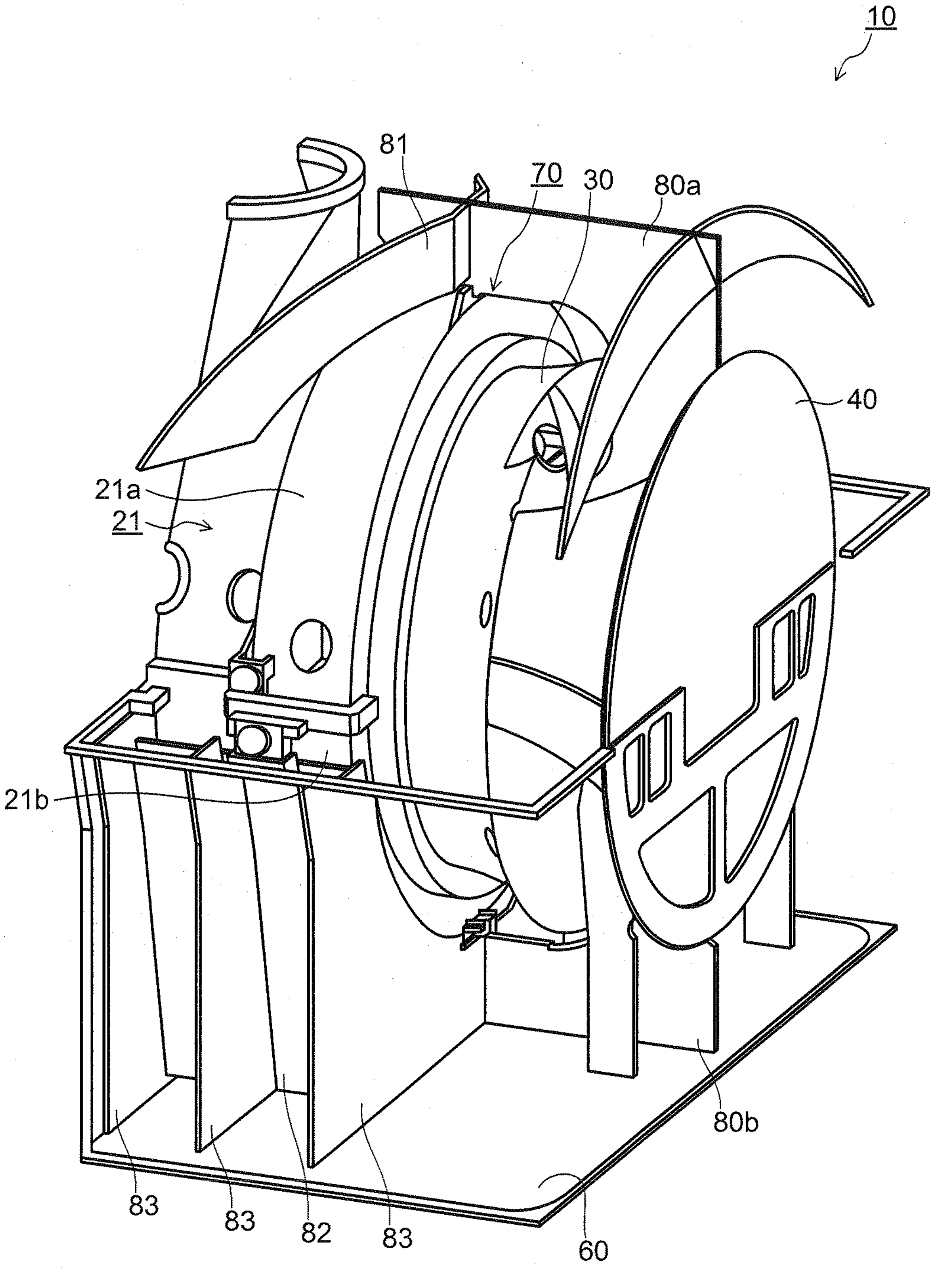


FIG. 3

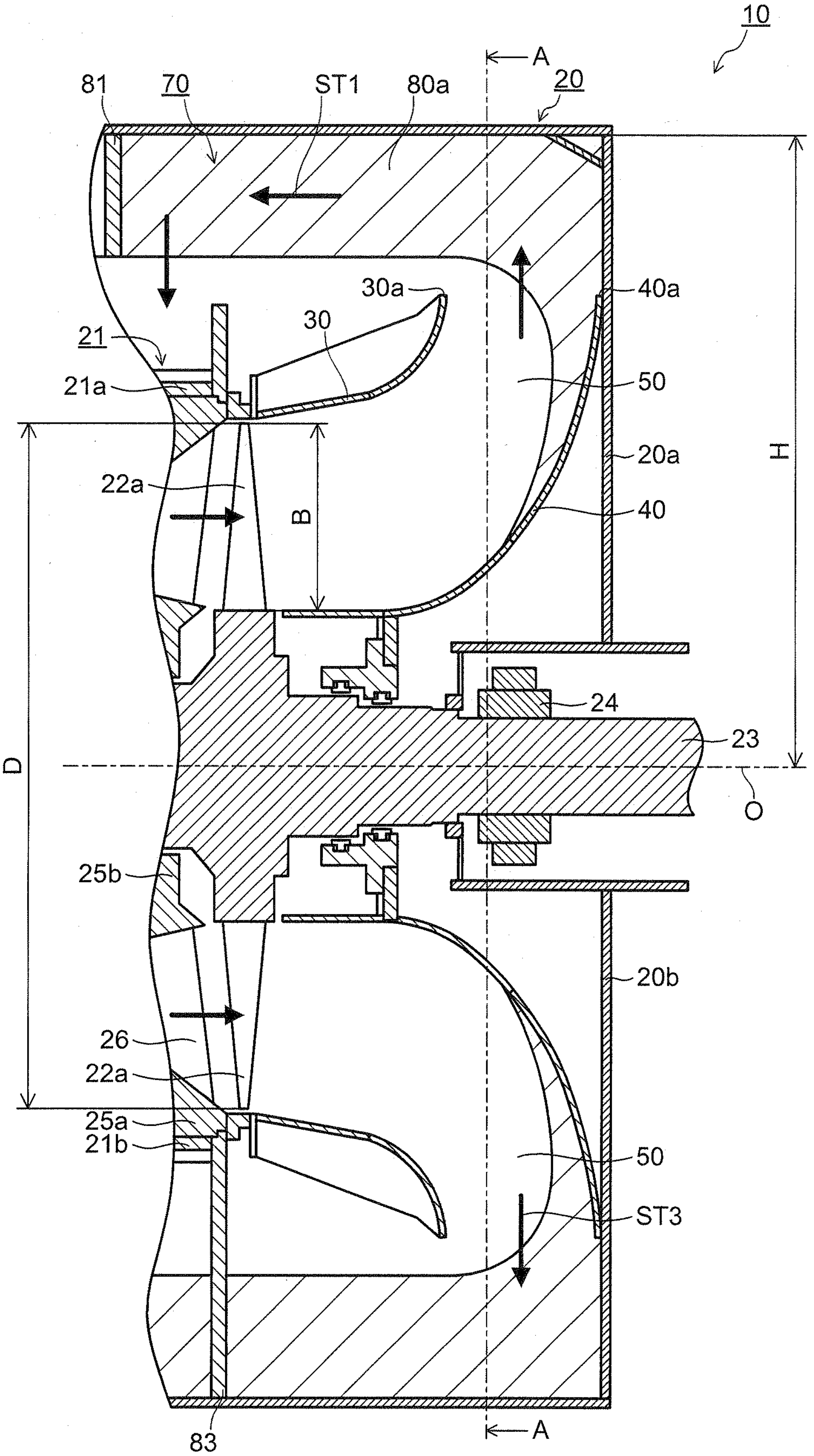

10
A
81
70
ST1
80a
20
30a
40a
30
21
21a
50
20a
H
22a
B
40
24
23
D
O
25b
20b
26
22a
25a
21b
50
ST3
83
A

FIG. 4

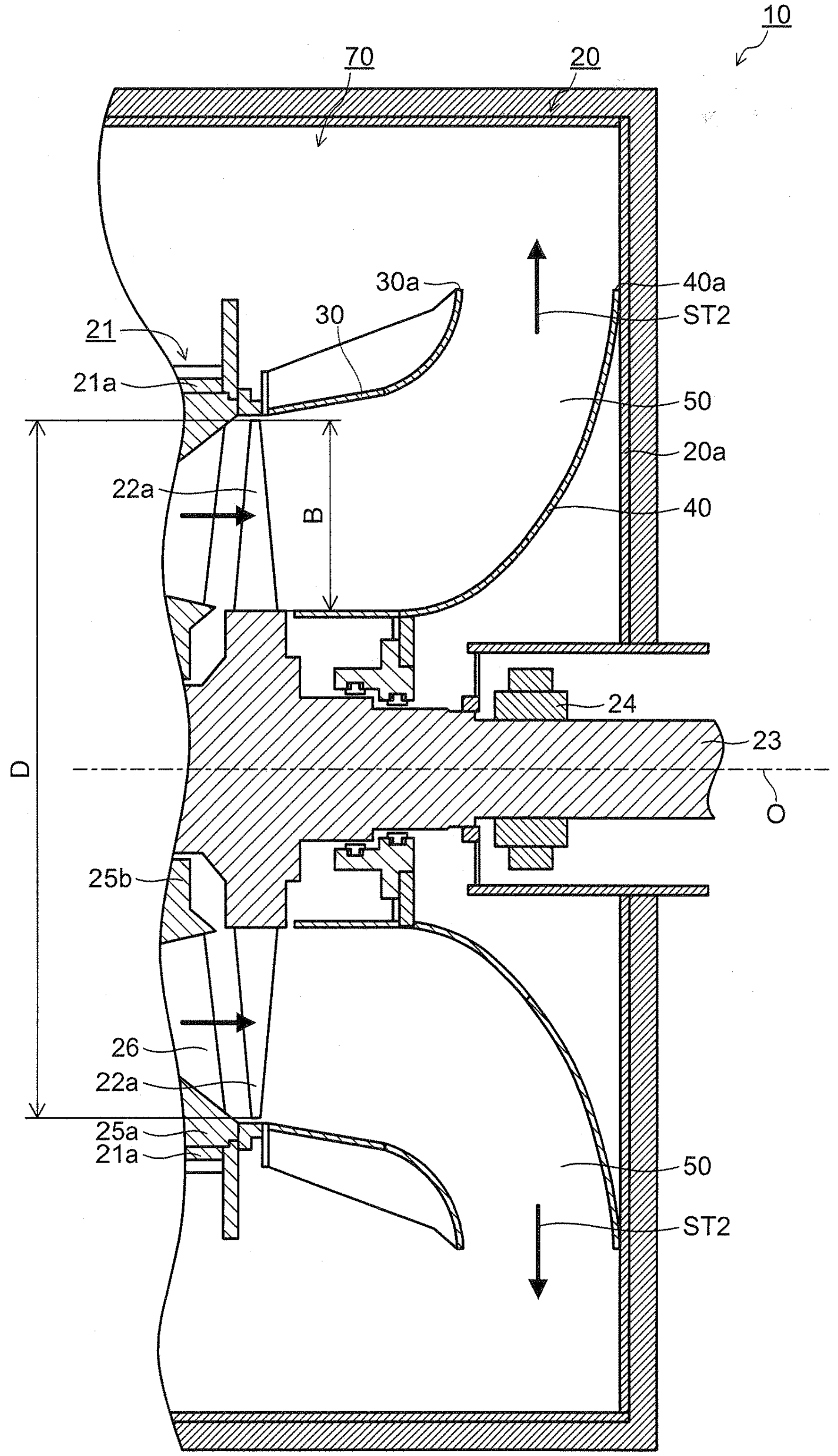

10
70
20
30a
40a
30
ST2
21
21a
50
20a
22a
B
40
24
23
D
O
25b
26
22a
25a
21a
50
ST2

FIG. 5

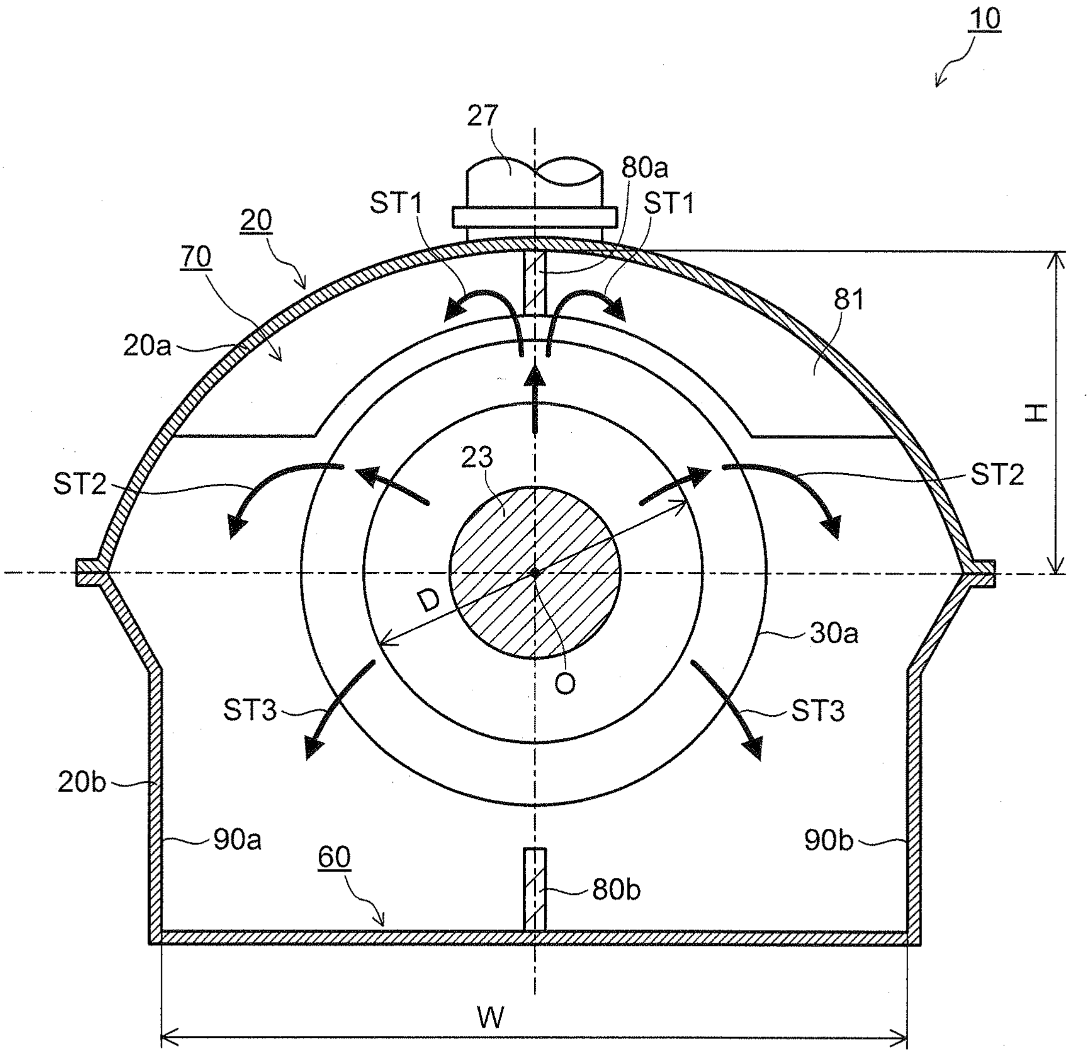

10
27
80a
ST1
ST1
20
70
81
20a
H
23
ST2
ST2
D
30a
O
ST3
ST3
20b
90a
90b
60
80b
W

FIG. 6

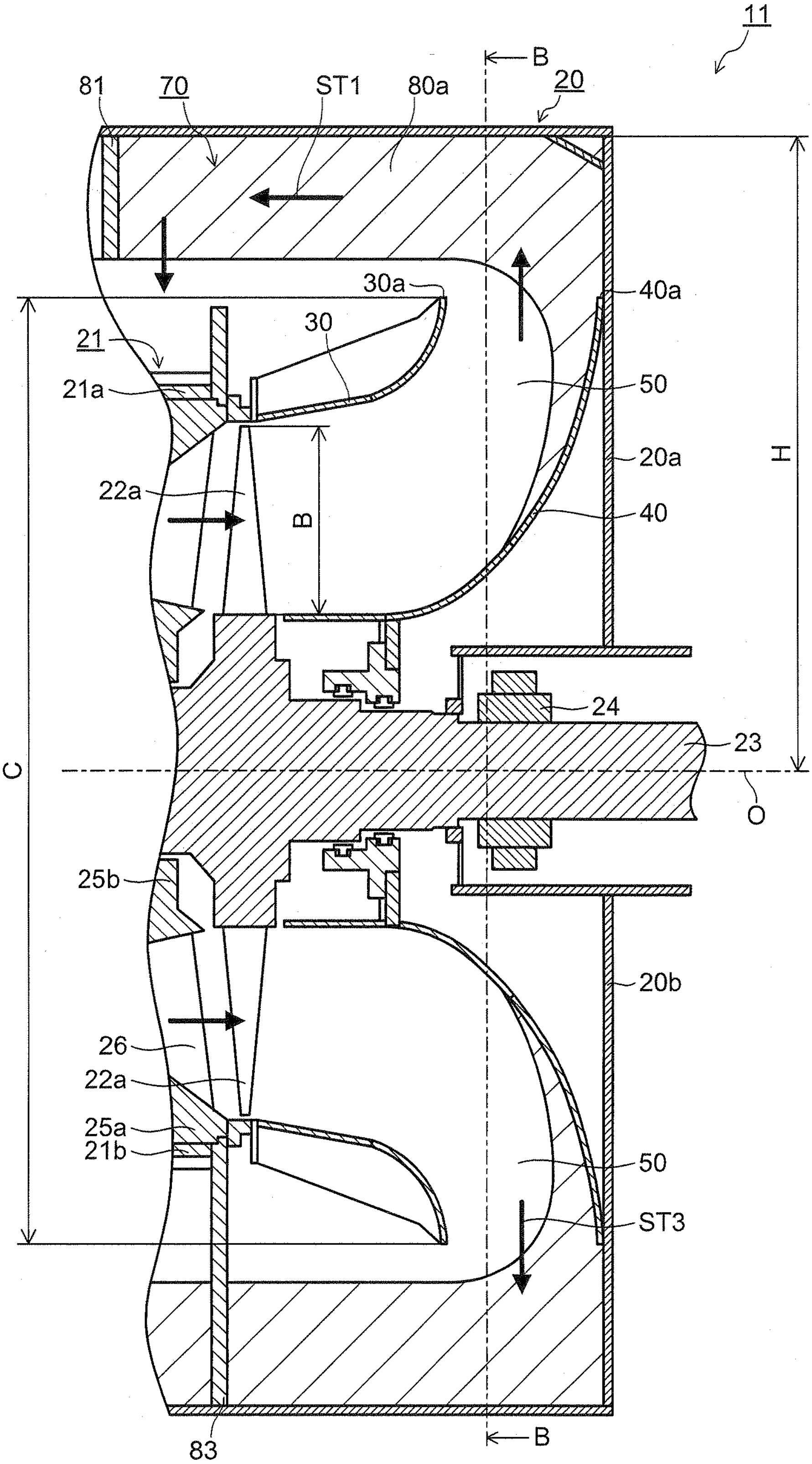

11
B
20
81
70
ST1
80a
30a
40a
30
21
21a
50
20a
22a
B
H
40
C
24
23
O
25b
20b
26
22a
25a
21b
50
ST3
83
B

FIG. 7

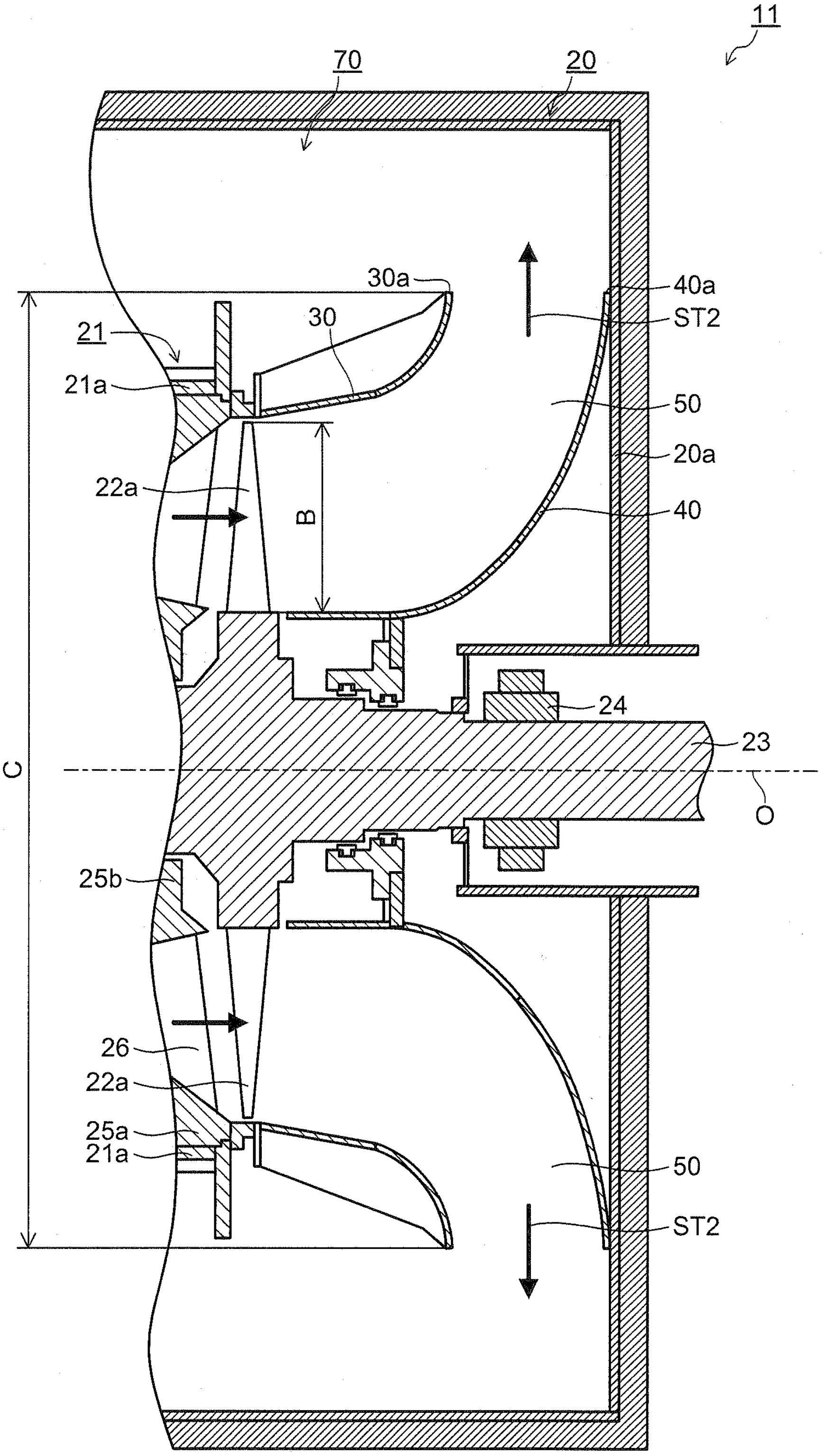

11
70
20
30a
40a
ST2
21
30
21a
50
20a
22a
B
40
24
23
C
O
25b
26
22a
25a
21a
50
ST2

FIG. 8

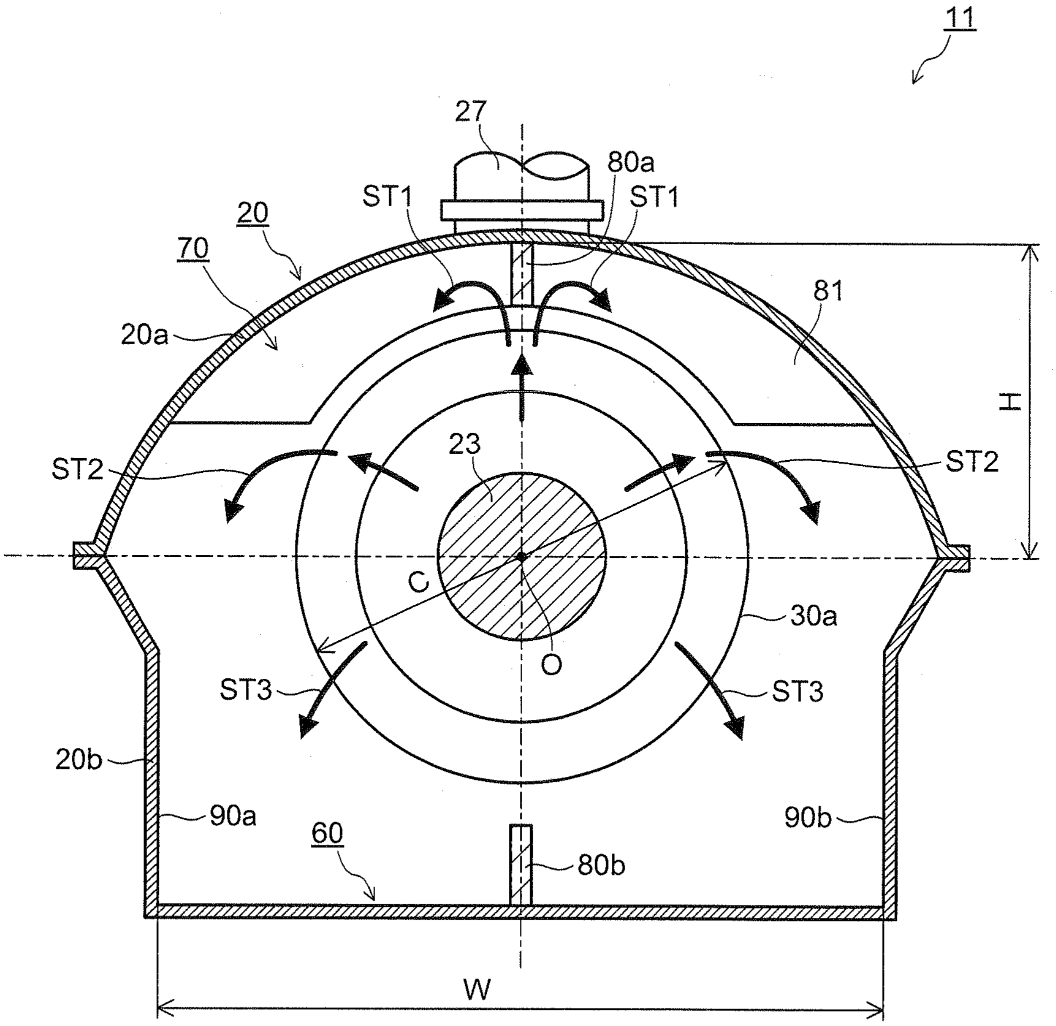

11
27
80a
ST1
ST1
20
70
81
20a
H
23
ST2
ST2
C
30a
O
ST3
ST3
20b
90a
90b
60
80b
W

FIG. 9

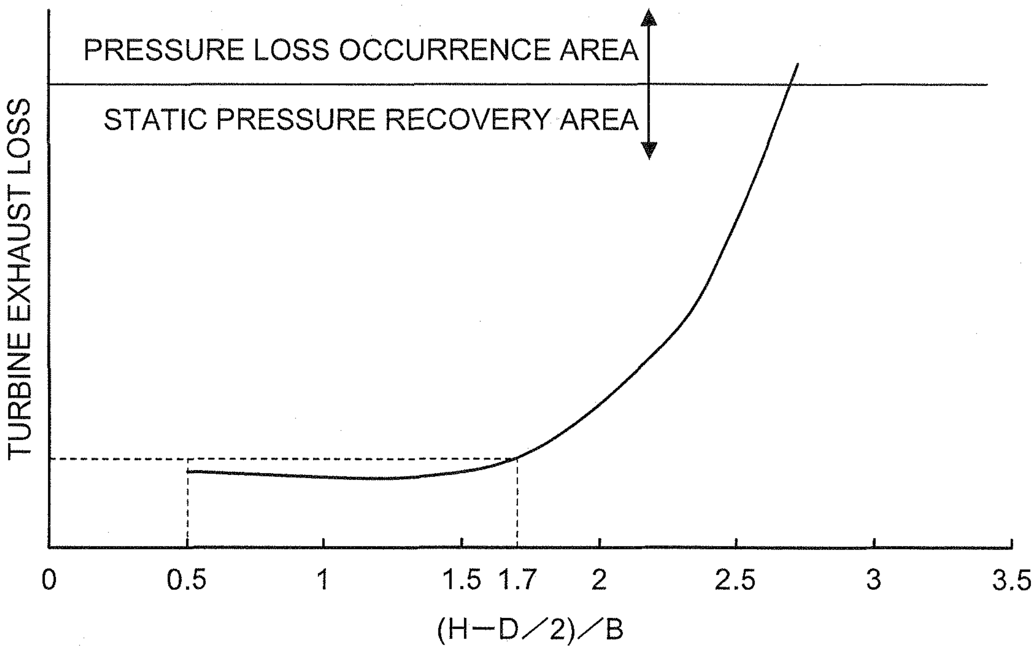

PRESSURE LOSS OCCURRENCE AREA
STATIC PRESSURE RECOVERY AREA
TURBINE EXHAUST LOSS
0
0.5
1
1.5
1.7
2
2.5
3
3.5
(H−D／2)／B

FIG. 10

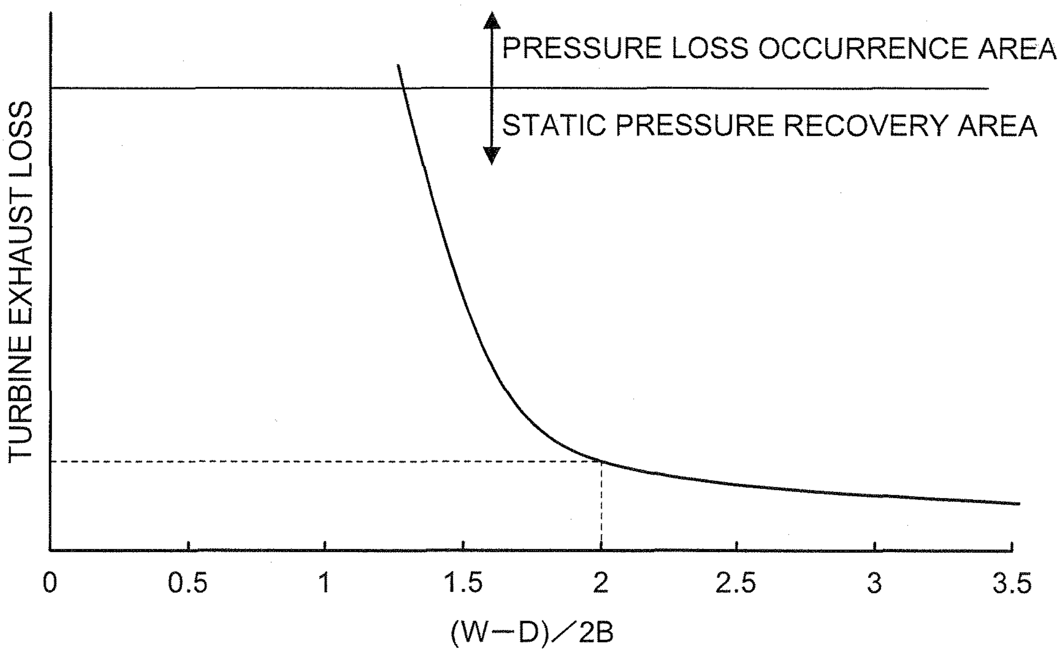

PRESSURE LOSS OCCURRENCE AREA
STATIC PRESSURE RECOVERY AREA
TURBINE EXHAUST LOSS
0
0.5
1
1.5
2
2.5
3
3.5
(W−D)／2B

FIG. 11

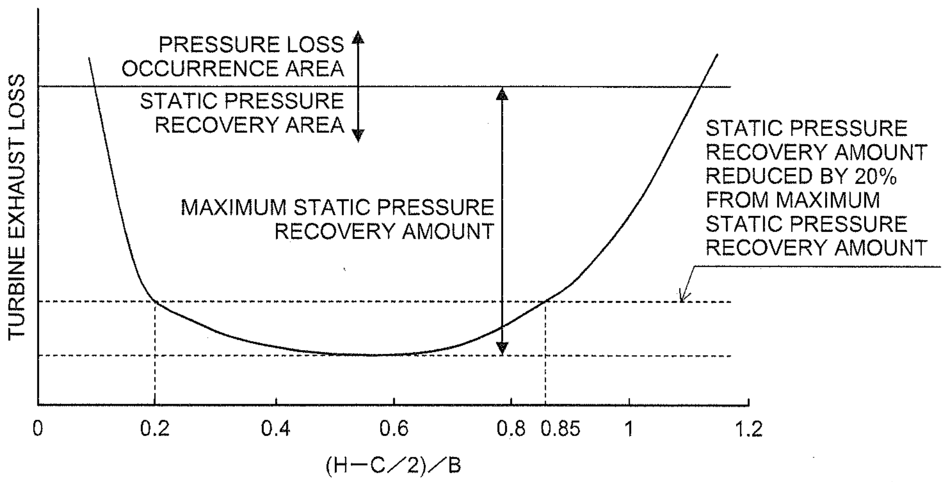
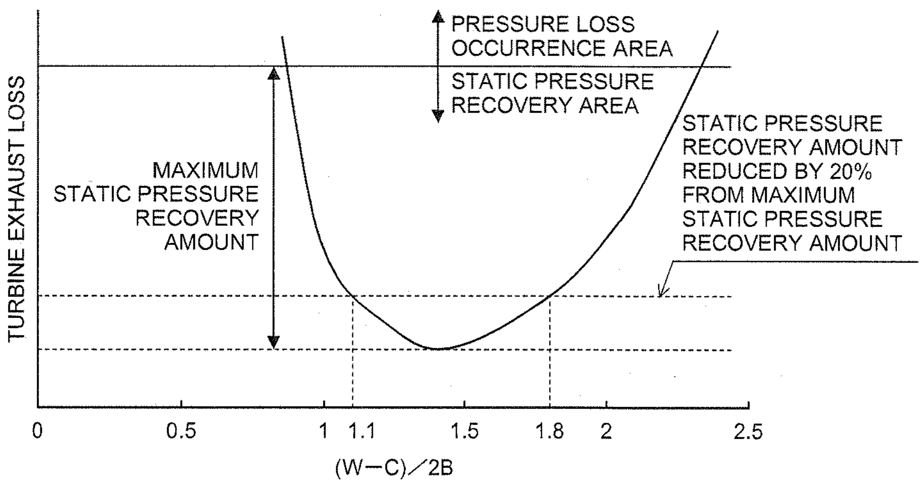

PRESSURE LOSS
OCCURRENCE AREA
STATIC PRESSURE
RECOVERY AREA
MAXIMUM STATIC PRESSURE
RECOVERY AMOUNT
STATIC PRESSURE
RECOVERY AMOUNT
REDUCED BY 20%
FROM MAXIMUM
STATIC PRESSURE
RECOVERY AMOUNT
TURBINE EXHAUST LOSS
0
0.2
0.4
0.6
0.8
0.85
1
1.2
(H−C／2)／B

FIG. 12



PRESSURE LOSS
OCCURRENCE AREA
STATIC PRESSURE
RECOVERY AREA
TURBINE EXHAUST LOSS
MAXIMUM
STATIC PRESSURE
RECOVERY
AMOUNT
STATIC PRESSURE
RECOVERY AMOUNT
REDUCED BY 20%
FROM MAXIMUM
STATIC PRESSURE
RECOVERY AMOUNT
0
0.5
1
1.1
1.5
1.8
2
2.5
(W−C)／2B

FIG. 13