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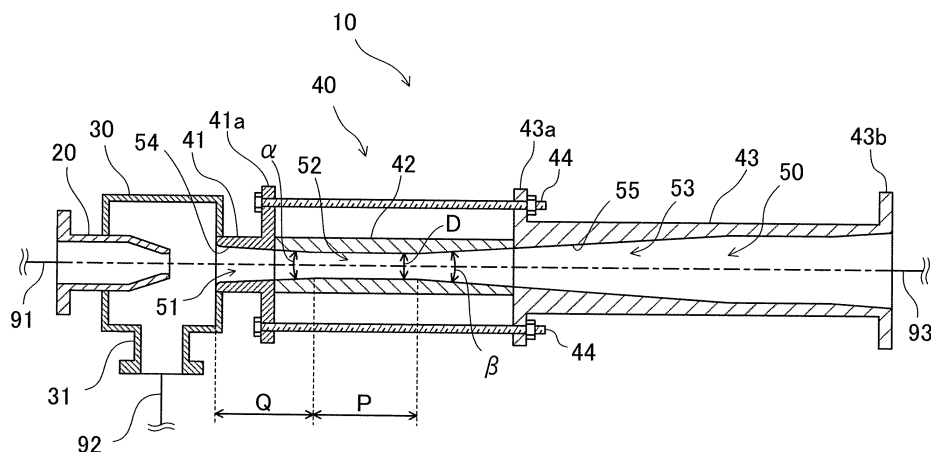
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(54) **EJECTOR, EJECTOR PRODUCTION METHOD, AND METHOD FOR SETTING OUTLET FLOW PATH OF DIFFUSER**

(57) An ejector 10 includes a nozzle 20, a suction chamber 30, and a diffuser 40. An outlet flow path 50 includes a narrowed flow path 51 having a first tapered surface 54 narrowed toward downstream, a parallel flow path 52 having a constant sectional area, and a parallel flow path 52 having a second tapered surface 55 expanded toward downstream. The diffuser 40 further includes

an attachment 42 configured to change the dimensions of the outlet flow path 50. The attachment 42 changes the dimensions of the outlet flow path 50 such that the ratio of the tapered angle α of the first tapered surface 54 to the tapered angle β of the second tapered surface 55 is higher as the sectional area, i.e., the inner diameter D, of the parallel flow path 52 is smaller.

FIG.1



Description

FIELD

[0001] The technique disclosed herein relates to an ejector configured to suck second fluid by negative pressure generated by ejection of first fluid to discharge the second fluid together with the first fluid, the method for manufacturing the ejector, and the method for setting an outlet flow path of a diffuser used for the ejector.

BACKGROUND

[0002] For example, a general ejector is disclosed in Patent Document 1. In this ejector, negative pressure (pressure drop) is generated by ejection of first fluid (drive fluid) from an injection port, and second fluid (drive target fluid) is sucked by the negative pressure. Then, the first fluid and the second fluid are mixed and discharged from a diffuser (an outlet). An expanded flow path (a flow path whose flow path sectional area increases toward a downstream side) is provided at the diffuser. When the fluid mixture of the first fluid and the second fluid flows in the expanded flow path, the velocity of the fluid mixture decreases, and the pressure of the fluid mixture increases. The fluid mixture discharged from the ejector as described above is supplied to, e.g., an apparatus on the downstream side of the ejector.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Patent Publication No. 2000-356305

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] In the above-described ejector, a discharge pressure might change due to, e.g., a change in operation conditions (the usage amount or usage pressure of the fluid mixture) of the apparatus as a steam supply destination. For example, when the operation of temporarily decreasing the usage amount of the fluid mixture in the apparatus as the supply destination or temporarily increasing the usage pressure is performed, the discharge flow rate of the ejector decreases, and the discharge pressure increases. When the discharge pressure becomes too high, the second fluid is less sucked, and eventually, the suction flow rate of the second fluid significantly decreases. In this case, an ejector configured so that a sufficient suction flow rate of second fluid can be ensured until the highest possible discharge pressure has been demanded.

[0005] Performance of the ejector such as the discharge pressure of the fluid mixture and the suction flow

rate of the second fluid varies according to the specifications, i.e., the dimensions, of the flow path of the diffuser. Note that various dimensions of the flow path of the diffuser influence the performance of the ejector, and for this reason, a change in the dimensions of the diffuser might lower the performance of the ejector.

[0006] The technique disclosed herein has been made in view of the above-described situation, and an object of the technique is to reduce degradation of the performance of the ejector upon a simultaneous change of an upper discharge pressure limit for ensuring a second fluid suction flow rate.

SOLUTION TO THE PROBLEMS

[0007] The ejector disclosed herein includes a nozzle configured to eject first fluid, a suction chamber configured to house the nozzle and to suck second fluid by negative pressure generated by ejection of the first fluid from the nozzle, and a diffuser including an outlet flow path and configured to mix and discharge the first fluid and the second fluid of the suction chamber. The outlet flow path includes a narrowed flow path having a first tapered surface narrowed toward downstream, a parallel flow path connected to a downstream end of the narrowed flow path and having a constant sectional area, and an expanded flow path connected to a downstream end of the parallel flow path and having a second tapered surface expanded toward downstream. The diffuser further includes a changing unit configured to change the dimensions of the outlet flow path. The changing unit changes the dimensions of the outlet flow path such that the ratio of the tapered angle of the first tapered surface to the tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is smaller.

[0008] Moreover, the method for manufacturing the ejector as disclosed herein includes the setting step of setting the dimensions of the outlet flow path, and the preparation step of preparing the diffuser having the dimensions of the outlet flow path set at the setting step. At the setting step, the dimensions of the outlet flow path are set such that the ratio of the tapered angle of the first tapered surface to the tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is smaller.

[0009] Further, the method for setting the outlet flow path of the diffuser as disclosed herein includes the step of setting the sectional area of the parallel flow path, and the step of setting the dimensions of the outlet flow path such that the ratio of the tapered angle of the first tapered surface to the tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is smaller.

EFFECT OF THE INVENTION

[0010] According to the above-described ejector, while

the upper discharge pressure limit for ensuring the suction flow rate of the second fluid can be changed, degradation of the performance of the ejector can be reduced upon such a change.

[0011] According to the above-described method for manufacturing the ejector, the ejector can be provided, which is configured to reduce degradation of the performance of the ejector upon a simultaneous change of the upper discharge pressure limit for ensuring the suction flow rate of the second fluid.

[0012] According to the above-described method for setting the outlet flow path of the diffuser, the ejector can be realized, which is configured to reduce degradation of the performance of the ejector upon a simultaneous change of the upper discharge pressure limit for ensuring the suction flow rate of the second fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

[FIG. 1] FIG. 1 is a schematic view of a configuration of an ejector according to an embodiment.

[FIG. 2] FIG. 2 is a graph of a relationship between a discharge pressure and a suction flow rate.

[FIG. 3] FIG. 3 is a schematic sectional view of a diffuser to which a first attachment is attached.

[FIG. 4] FIG. 4 is a schematic sectional view of a diffuser to which a second attachment is attached.

DESCRIPTION OF EMBODIMENTS

[0014] Hereinafter, an exemplary embodiment will be described in detail with reference to the drawings.

[0015] An ejector 10 is a steam ejector configured to suck low-pressure steam (second fluid) by ejection of high-pressure steam (first fluid), thereby mixing and discharging these types of steam. That is, in the ejector 10, the high-pressure steam is drive fluid, and the low-pressure steam is suction fluid. The ejector 10 includes a nozzle 20, a suction chamber 30, and a diffuser 40.

[0016] An inflow pipe 91 connected to a high-pressure steam supply source is connected to the nozzle 20. The nozzle 20 is configured to eject the supplied high-pressure steam. A tip end portion of the nozzle 20 is housed in the suction chamber 30.

[0017] A low-pressure steam suction port 31 is provided at the suction chamber 30. Using negative pressure (pressure drop) generated by ejection of the high-pressure steam from the nozzle 20, the low-pressure steam is sucked into the suction chamber 30 through the suction port 31. That is, in the suction chamber 30, suction force for sucking the low-pressure steam is generated by the negative pressure generated by a jet pump effect of the high-pressure steam. A suction pipe 92 connected to a

low-pressure steam supply source is connected to the suction port 31.

[0018] The diffuser 40 is connected to the suction chamber 30. The diffuser 40 is configured to mix and discharge the high-pressure steam ejected to the suction chamber 30 and the low-pressure steam sucked into the suction chamber 30. An outflow pipe 93 connected to a steam mixture supply destination is connected to a downstream end of the diffuser 40.

[0019] The diffuser 40 has a divided structure including an upstream portion 41, an attachment 42, and a downstream portion 43. An upstream end of the upstream portion 41 is connected to the suction chamber 30. A flange 41a is provided at a downstream end of the upstream portion 41. A first flange 43a is provided at an upstream end of the downstream portion 43, and a second flange 43b is provided at a downstream end of the downstream portion 43. The downstream portion 43 is connected to the outflow pipe 93 through the second flange 43b. The attachment 42 is sandwiched between the upstream portion 41 and the downstream portion 43. The flange 41a of the upstream portion 41 and the first flange 43a of the downstream portion 43 are fastened with bolts 44, and in this manner, the attachment 42 is held by the upstream portion 41 and the downstream portion 43. That is, the attachment 42 can be replaced by loosening of the fastened bolts 44. The attachment 42 is one example of a changing unit.

[0020] An outlet flow path 50 of the high-pressure steam and the low-pressure steam is formed at the diffuser 40, the outlet flow path 50 communicating with the suction chamber 30. The outlet flow path 50 includes a narrowed flow path 51, a parallel flow path 52, and an expanded flow path 53 in this order from an upstream side. The section of the outlet flow path 50 is in a substantially circular shape. The diffuser 40 decreases the velocity of the steam mixture and increases the pressure of the steam mixture when the steam mixture flows in the expanded flow path 53.

[0021] An upstream end of the narrowed flow path 51 opens to the suction chamber 30. The upstream end of the narrowed flow path 51 faces a downstream end of the nozzle 20 in the suction chamber 30. The sectional area, i.e., the inner diameter, of the narrowed flow path 51 gradually decreases toward a downstream side. That is, the narrowed flow path 51 has a first tapered surface 54 narrowed toward the downstream side. The parallel flow path 52 is connected to a downstream end of the narrowed flow path 51. The parallel flow path 52 is a flow path having a constant sectional area, i.e., a constant inner diameter. The parallel flow path 52 is a portion having the smallest inner diameter in the outlet flow path 50, and forms a so-called throat portion. The expanded flow path 53 is connected to a downstream end of the parallel flow path 52. The sectional area, i.e., the inner diameter, of the expanded flow path 53 gradually increases toward the downstream side. That is, the expanded flow path 53 has a second tapered surface 55 expanded toward the

downstream side.

[0022] The narrowed flow path 51 is formed from the upstream portion 41 to the attachment 42. The parallel flow path 52 is formed at the attachment 42. The expanded flow path 53 is formed from the attachment 42 to the downstream portion 43. That is, at least an upstream end portion of the narrowed flow path 51 is formed at the upstream portion 41. At least a downstream end portion of the narrowed flow path 51, the parallel flow path 52, and at least an upstream end portion of the expanded flow path 53 are formed at the attachment 42. At least a downstream end portion of the expanded flow path 53 is formed at the downstream portion 43.

[0023] In the ejector 10 configured as described above, the high-pressure steam flowing in the inflow pipe 91 is ejected to the suction chamber 30 through the nozzle 20, and the low-pressure steam is sucked into the suction chamber 30 through the suction port 31 by ejection of the high-pressure steam. Then, the high-pressure steam and the low-pressure steam in the suction chamber 30 are mixed together, and are discharged from the diffuser 40. The steam discharged from the diffuser 40 is supplied to an apparatus on the downstream side. The flow velocity of the steam mixture reaches about a sound velocity at the parallel flow path 52 of the diffuser 40. Thereafter, when the steam mixture flows in the expanded flow path 53, the velocity of the steam mixture is decreased, and the pressure of the steam mixture is increased.

[0024] The discharge pressure of the ejector 10 might increase according to an operation status or a specification change of the apparatus as the steam supply destination. However, as illustrated in FIG. 2, there is an upper discharge pressure limit (this discharge pressure will be hereinafter referred to as a "maximum discharge pressure") for ensuring a low-pressure steam suction flow rate in the ejector 10. When the discharge pressure increases beyond the maximum discharge pressure P_{max} , a suction pressure also starts increasing. Eventually, the flow velocity in the parallel flow path 52 decreases as compared to the sound velocity, and a noncritical state is brought. Accordingly, the suction pressure increases to a value substantially equal to the discharge pressure. That is, when the discharge pressure exceeds the maximum discharge pressure P_{max} , the low-pressure steam suction flow rate decreases rapidly.

[0025] The maximum discharge pressure P_{max} can be changed according to the specifications, i.e., the dimensions, of the outlet flow path 50. The diffuser 40 is configured such that the dimensions of the outlet flow path 50 is changeable by replacement of the attachment 42.

[0026] For example, it is conceivable that the inner diameter D of the parallel flow path 52 is decreased in order to increase the maximum discharge pressure P_{max} . With a decrease in the inner diameter D of the parallel flow path 52, the flow velocity of the steam mixture in the parallel flow path 52 increases, and therefore, a critical state of the pressure in the parallel flow path 52 is easily en-

sured.

[0027] However, when only the inner diameter D of the parallel flow path 52 is changed, not only the maximum discharge pressure P_{max} cannot be increased, but also performance of the ejector 10 cannot be maintained. For example, the low-pressure steam suction flow rate might significantly decrease while the maximum discharge pressure P_{max} is increased. Conversely, the maximum discharge pressure P_{max} might decrease. That is, the performance of the ejector 10 relates to various dimensions of the outlet flow path 50, and other dimensions of the parallel flow path 52 than the inner diameter D need to be changed.

[0028] For these reasons, in the ejector 10, the dimensions of the outlet flow path 50 are set such that the ratio (hereinafter referred to as a "tapered angle ratio") α/β of the tapered angle α of the first tapered surface 54 to the tapered angle β of the second tapered surface 55 is higher as the sectional area, i.e., the inner diameter D , of the parallel flow path 52 is smaller.

[0029] Specifically, the inner diameter D of the parallel flow path 52 is set smaller for a higher target maximum discharge pressure. Moreover, for reducing degradation of the performance of the ejector 10, the tapered angles α , β are set such that the tapered angle ratio α/β is higher as the inner diameter D is smaller.

[0030] In the diffuser 40, the upstream portion 41 and the downstream portion 43 are not replaceable. Thus, the entire length of the attachment 42, the inner diameter of the narrowed flow path 51 at an upstream end of the attachment 42, and the inner diameter of the expanded flow path 53 at a downstream end of the attachment 42 are not changed. Thus, according to a change in the inner diameter D , the tapered angle α of a portion of the first tapered surface 54 formed at the attachment 42 and the tapered angle β of a portion of the second tapered surface 55 formed at the attachment 42 are changed. Unless otherwise stated, the "tapered angle α " and the "tapered angle β " will hereinafter mean the tapered angles of the tapered surface portions formed at the attachment 42.

[0031] The tapered angle α of the first tapered surface 54 is changed greater for a smaller inner diameter D . In this case, the tapered angles α , β are set such that the tapered angle ratio α/β is higher as the inner diameter D is smaller. That is, in a case where at least one of the tapered angles α , β needs to increase as the inner diameter D gets lower, the tapered angle α is more increased, and an increase in the tapered angle β is suppressed.

[0032] For example, in a case where both of the tapered angles α , β increase as the inner diameter D gets lower, the tapered angles α , β are set such that the increase rate of the tapered angle α (i.e., the tapered angle α after change/the tapered angle α before change) is greater than the increase rate of the tapered angle β (i.e., the tapered angle β after change/the tapered angle β before change).

[0033] In this manner, degradation of the performance of the ejector 10 is reduced. Specifically, the tapered an-

gle α of the first tapered surface 54 and the tapered angle β of the second tapered surface 55 might influence turbulence of the flow of the steam mixture. Greater angles result in more flow turbulence due to separation. Greater flow turbulence results in lower performance of the ejector 10. In the diffuser 40, the tapered angle β of the expanded flow path 53 more influences flow turbulence as compared to the tapered angle α of the narrowed flow path 51. Thus, in a case where the tapered angles α , β need to increase as the inner diameter D of the parallel flow path 52 gets lower, the tapered angle α is more greatly changed, and an increase in the tapered angle β is suppressed. In this manner, worsening of flow turbulence can be reduced, and degradation of the performance of the ejector 10 can be reduced.

[0034] In addition, for further reducing degradation of the performance of the ejector 10, the length P of the parallel flow path 52 is set shorter for a smaller inner diameter D. Specifically, the length P of the parallel flow path 52 is set to satisfy the following expression (1), i.e., in proportion to the inner diameter D.

$$P = M \times D \dots (1),$$

where M represents a constant.

[0035] That is, even in a case where the dimensions of the parallel flow path 52 are changed, the expression (1) is satisfied before and after change. In other words, P/D is substantially equal between before and after change.

[0036] Note that as a result of a larger tapered angle α for a smaller inner diameter D, the length Q of the narrowed flow path 51 is also shorter as the inner diameter D gets smaller.

[0037] Moreover, the length of the expanded flow path 53 is set to such a value that the performance of the ejector 10 is not influenced even when the lengths of the narrowed flow path 51 and the parallel flow path 52 are changed.

[0038] FIG. 3 is a schematic sectional view of the diffuser 40 to which a first attachment 42A is attached, and FIG. 4 is a schematic sectional view of the diffuser 40 to which a second attachment 42B is attached.

[0039] The first attachment 42A has the parallel flow path 52 whose inner diameter D is d1. In this case, the length p1 of the parallel flow path 52 is $M \times d1$. Moreover, the length of the narrowed flow path 51 is q1. The tapered angle α_1 of a portion of the first tapered surface 54 formed at the first attachment 42A is the same as the tapered angle α_0 of a portion of the first tapered surface 54 formed at the upstream portion 41. The tapered angle β_1 of a portion of the second tapered surface 55 formed at the first attachment 42A is the same as the tapered angle β_0 of a portion of the second tapered surface 55 formed at the downstream portion 43.

[0040] On the other hand, the second attachment 42B has the parallel flow path 52 whose inner diameter D is d2. In this case, the length p2 of the parallel flow path 52 at the second attachment 42B is $M \times d2$. Moreover, the length of the narrowed flow path 51 is q2. The tapered angle α_2 of a portion of the first tapered surface 54 formed at the second attachment 42B is greater than the tapered angle α_0 of the portion of the first tapered surface 54 formed at the upstream portion 41. The tapered angle β_2 of a portion of the second tapered surface 55 formed at the second attachment 42B is greater than the tapered angle β_0 of the portion of the second tapered surface 55 formed at the downstream portion 43.

[0041] The inner diameter d2 of the parallel flow path 52 of the second attachment 42B is smaller than the inner diameter d1 of the parallel flow path 52 of the first attachment 42A, and therefore, the parallel flow path 52 of the second attachment 42B is shorter than the parallel flow path 52 of the first attachment 42A.

[0042] In this case, in association with a smaller inner diameter d2 than the inner diameter d1, the tapered angle α_2 of the first tapered surface 54 of the second attachment 42B is greater than the tapered angle α_1 of the first tapered surface 54 of the first attachment 42A, and the tapered angle β_2 of the second tapered surface 55 of the second attachment 42B is greater than the tapered angle β_1 of the second tapered surface 55 of the first attachment 42A. In this case, the tapered angle ratio α_2/β_2 of the second attachment 42B is greater than the tapered angle ratio α_1/β_1 of the first attachment 42A. That is, when the inner diameter D is changed from d1 to d2, the increase rate of the tapered angle α is greater than the increase rate of the tapered angle β .

[0043] Note that in association with an increase in the tapered angle α , the length Q of the narrowed flow path 51 decreases from q1 to q2.

[0044] As described above, the inner diameter d2 of the parallel flow path 52 of the second attachment 42B is smaller than that of the first attachment 42A, and therefore, the maximum discharge pressure Pmax of the diffuser 40 into which the second attachment 42B is incorporated is higher than that in the case of incorporating the first attachment 42A. In this case, the tapered angle α is more increased, and an increase in the tapered angle β is suppressed. In this manner, degradation of the performance of the ejector 1 is reduced. Specifically, the tapered angle α of the first tapered surface 54 and the tapered angle β of the second tapered surface 55 are increased, and therefore, flow turbulence might occur. However, the tapered angle α of the first tapered surface 54 is more increased, and an increase in the tapered angle β of the second tapered surface 55 is suppressed. Thus, worsening of flow turbulence can be reduced. As a result, the maximum discharge pressure Pmax can be increased with a sufficient suction flow rate being ensured. Note that the inner diameter D of the parallel flow path 52 is decreased, and therefore, the low-pressure steam suction flow rate is slightly decreased.

[0045] Note that from a different point of view, the portion of the first tapered surface 54 formed at the upstream portion 41 and the portion of the second tapered surface 55 formed at the downstream portion 43 are not changed, and therefore, the tapered angle ratio α_2/β_2 at the second attachment 42B is, with reference to the tapered angle α_0 at the upstream portion 41 and the tapered angle β_0 at the downstream portion 43, greater than the tapered angle ratio α_0/β_0 at the upstream portion 41 and the downstream portion 43. That is, in a case where at least one of the tapered angles α , β of the attachment 42 is greater than the tapered angles α_0 , β_0 at the upstream portion 41 and the downstream portion 43, the tapered angle α is more increased as compared to the tapered angle β , and an increase in the tapered angle β is suppressed.

[0046] Further, the relationship of the expression (1) is maintained before and after change in the dimensions of the outlet flow path 50. That is, p_2/d_2 is substantially equal to p_1/d_1 . This also reduces degradation of the performance of the ejector 1.

[0047] As a result, the low-pressure steam suction flow rate can be ensured even when the discharge pressure of the ejector 10 increases due to the operation status or the specification change of the apparatus as the steam supply destination.

[0048] Subsequently, the method for manufacturing the above-described ejector 1 will be described.

[0049] Specifically, the method for manufacturing the ejector 1 includes the setting step of setting the dimensions of the outlet flow path 50, and the preparation step of preparing the diffuser 40 having the dimensions set at the setting step.

[0050] At the setting step, the inner diameter D and the length P of the parallel flow path 52, the tapered angle α of the first tapered surface 54, and the tapered angle β of the second tapered surface 55 at the attachment 42 are set. At this step, the tapered angles α , β are set such that the tapered angle ratio α/β is higher as the sectional area, i.e., the inner diameter D, of the parallel flow path 52 is smaller.

[0051] For example, the inner diameter D (i.e., the sectional area) of the parallel flow path 52 is set so that the target maximum discharge pressure can be realized. With the inner diameter D, the length P of the parallel flow path 52 is set based on the expression (1). Then, the tapered angles α , β are set such that the tapered angle ratio α/β is higher as the inner diameter D is smaller. A relationship among the inner diameter D and the tapered angles α , β is obtained in advance. With the inner diameter D, the corresponding tapered angles α , β are set.

[0052] When the length P of the parallel flow path 52 and the tapered angles α , β are set, the length of the narrowed flow path 51 and the length Q of the expanded flow path 53 are inevitably determined from the entire length of the attachment 42.

[0053] At the preparation step, the diffuser 40 having

the dimensions of the outlet flow path 50 set at the setting step is prepared. For example, the attachment 42 having the dimensions of the outlet flow path 50 set at the setting step is produced. Alternatively, the attachment 42 suitable for the operation status or the specifications of the apparatus as the steam supply destination is selected from multiple attachments 42 having different inner diameters D of the narrowed flow path 51 and having a greater tapered angle ratio α/β for a smaller inner diameter D.

[0054] The method for manufacturing the ejector 1 further includes an assembly step. At the assembly step, the nozzle 20, the suction chamber 30, and the diffuser 40 are assembled together. Specifically, the nozzle 20 and the upstream portion 41 of the diffuser 40 are attached to the suction chamber 30. Then, the attachment 42 and the downstream portion 43 are attached to the upstream portion 41 with the attachment 42 being sandwiched between the upstream portion 41 and the downstream portion 43.

[0055] Alternatively, in a case where a new ejector 10 is manufactured by replacement of the attachment 42 of the already-assembled ejector 10, the attachment 42 having a smaller inner diameter D and a greater tapered angle ratio α/β than those before replacement is prepared at the preparation step. Such an attachment 42 is newly produced, or is selected from multiple attachments 42. Then, the attachment 42 of the ejector 10 is replaced with the attachment 42 prepared at the preparation step.

[0056] As described above, the ejector 10 includes the nozzle 20 configured to eject the high-pressure steam (the first fluid), the suction chamber 30 configured to house the nozzle 20 and to suck the low-pressure steam (the second fluid) by the negative pressure generated by ejection of the high-pressure steam from the nozzle 20, and the diffuser 40 having the outlet flow path 50 and configured to mix and discharge the high-pressure steam and the low-pressure steam of the suction chamber 30. The outlet flow path 50 includes the narrowed flow path 51 having the first tapered surface 54 narrowed toward the downstream side, the parallel flow path 52 connected to the downstream end of the narrowed flow path 51 and having the constant sectional area, and the expanded flow path 53 connected to the downstream end of the parallel flow path 52 and having the second tapered surface 55 expanded toward the downstream side. The diffuser 40 further includes the attachment 42 (the changing unit) configured to change the dimensions of the outlet flow path 50. The attachment 42 changes the dimensions of the outlet flow path 50 such that the ratio α/β of the tapered angle α of the first tapered surface 54 to the tapered angle β of the second tapered surface 55 is higher as the sectional area of the parallel flow path 52 is smaller.

[0057] According to this configuration, the dimensions of the outlet flow path 50 are changed by the attachment 42. Upon such a change, when the sectional area, i.e., the inner diameter D, of the parallel flow path 52 is

changed, the maximum discharge pressure $P_{\max}$ of the ejector 10 can be changed. In this case, the dimensions of the outlet flow path 50 are set such that the tapered angle ratio α/β is higher as the sectional area of the parallel flow path 52 is smaller. That is, in a case where at least one of the tapered angles α, β needs to be increased in response to a decrease in the sectional area of the parallel flow path 52, the tapered angle α is more increased, and an increase in the tapered angle β is suppressed. In this manner, the maximum discharge pressure $P_{\max}$ of the ejector 10 can be changed. In addition, flow disturbance due to an increase in the tapered angles α, β can be reduced, and degradation of the performance of the ejector 10 can be reduced.

[0058] Moreover, the attachment 42 changes the dimensions of the outlet flow path 50 such that the length P of the parallel flow path 52 is shorter as the sectional area of the parallel flow path 52 is smaller.

[0059] According to this configuration, not only the sectional area but also the length P of the parallel flow path 52 are changed. Thus, while degradation of the performance of the ejector 1 can be further reduced, the maximum discharge pressure $P_{\max}$ can be changed.

[0060] More specifically, the attachment 42 changes the dimensions of the outlet flow path 50 such that the length P of the parallel flow path 52 is changed in proportion to the inner diameter D of the parallel flow path 52.

[0061] According to this configuration, a relationship between the inner diameter D and the length P is held constant before and after change in the dimensions of the parallel flow path 52. Thus, while degradation of the performance of the ejector 1 can be reduced, the maximum discharge pressure $P_{\max}$ can be changed.

[0062] Further, part of the diffuser 40 is formed from the replaceable attachment 42. The attachment 42 includes at least part of the narrowed flow path 51, the parallel flow path 52, and at least part of the expanded flow path 53. The dimensions of the outlet flow path 50 are changed by replacement of the attachment 42.

[0063] That is, the diffuser 40 is configured such that the attachment 42 is replaceable. The outlet flow paths 50 with different dimensions are formed at multiple attachments 42. In comparison among the attachments 42 with different sectional areas, i.e., different inner diameters D , of the parallel flow path 52, the tapered angle ratio α/β at the attachment 42 with a smaller inner diameter D is greater than the tapered angle ratio α/β at the attachment 42 with a greater inner diameter D . As a result, the maximum discharge pressure $P_{\max}$ of the ejector 10 can be changed by replacement of the attachment 42 without the need for replacement of the entirety of the diffuser 40, and degradation of the performance of the ejector 10 can be reduced. Moreover, it is not necessary to replace the entirety of the ejector 10, and therefore, the dimensions of the outlet flow path 50 can be easily changed.

[0064] In addition, the method for manufacturing the ejector 10 includes the setting step of setting the dimensions of the outlet flow path 50, and the preparation step

of preparing the diffuser 40 having the dimensions of the outlet flow path 50 set at the setting step. At the setting step, the dimensions of the outlet flow path 50 are set such that the ratio α/β of the tapered angle α of the first tapered surface 54 to the tapered angle β of the second tapered surface 55 is higher as the sectional area of the parallel flow path 52 is smaller.

[0065] According to this configuration, while degradation of the performance of the ejector 10 can be reduced, the ejectors 10 with different maximum discharge pressures $P_{\max}$ can be manufactured.

[0066] Moreover, at the preparation step, the diffuser 40 having the outlet flow path 50 set at the setting step is prepared by replacement of the attachment 42 of the diffuser 40 including the replaceable attachment 42.

[0067] That is, the dimensions of the outlet flow path 50 of the diffuser 40 are changed by replacement of the attachment 42. Thus, the dimensions of the narrowed flow path 51 and the parallel flow path 52 can be changed without the need for changing the entirety of the diffuser 40.

[0068] Moreover, the method for setting the outlet flow path of the diffuser 40 includes the step of setting the sectional area of the parallel flow path 52, and the step of setting the dimensions of the outlet flow path 50 such that the ratio α/β of the tapered angle α of the first tapered surface 54 to the tapered angle β of the second tapered surface 55 is higher as the sectional area of the parallel flow path 52 is smaller.

<<Other Embodiments>>

[0069] As described above, the embodiment has been described as an example of the technique disclosed in the present application. However, the technique of the present disclosure is not limited to above, and is also applicable to embodiments to which changes, replacements, additions, omissions, etc. are made as necessary. Moreover, each component described above in the embodiment may be combined to form a new embodiment. Further, the components described in the detailed description with reference to the attached drawings may include not only components essential for solving the problems, but also components not essential for solving the problems and provided for illustrating the above-described technique by an example. Thus, description of the non-essential components in the detailed description with reference to the attached drawings should not be directly recognized as these non-essential components being essential.

[0070] The above-described embodiment may have the following configurations.

[0071] The diffuser 40 has the structure divided into three portions, but may have a structure divided into two portions or four or more portions.

[0072] Moreover, the method for fixing the attachment 42 is not limited to sandwiching between the upstream portion 41 and the attachment 42. As long as the attach-

ment 42 can be fixed, an optional fixing method can be employed.

[0073] Further, the configuration for changing the dimensions of the outlet flow path 50 is not limited to the configuration by the attachment 42. For example, the diffuser may include a deformable mechanism capable of changing the inner diameter. The deformable mechanism may have a tubular wall portion configured to form the outlet flow path 50 and exhibiting flexibility, and multiple pressing members (e.g., bolts) arranged at the outer periphery of the wall portion in a circumferential direction and configured to press the wall portion inward in a radial direction. The wall portion is deformed in such a manner that the wall portion is pressed inward in the radial direction by the pressing member. Accordingly, the inner diameter of the wall portion is decreased. Thus, the inner diameter D, i.e., the sectional area, of the parallel flow path 52 can be changed. Further, multiple sets of the pressing members are provided at different positions of the wall portion in an axial direction thereof, multiple pressing members arranged in the circumferential direction of the wall portion being taken as a single set. That is, depending on at which positions in the axial direction the pressing members are pressed, the length Q of the narrowed flow path 51 can be changed. Furthermore, the tapered angle α of the first tapered surface 54, the length Y of the parallel flow path 52, and the length of the expanded flow path 53 can be changed. Furthermore, the tapered angle β of the second tapered surface 55 can be changed. In other configurations than above, an optional configuration capable of changing the dimensions of the outlet flow path 50 can be employed.

[0074] Further, the diffuser 40 has the divided structure including the attachment 42, but is not limited to above. For example, the diffuser 40 may have an integrated structure. In this case, multiple diffusers 40 each have the outlet flow paths 50 with different dimensions, and each diffuser 40 is configured such that the tapered angle ratio α/β is higher as the inner diameter D is smaller. Among these diffusers 40, the suitable diffuser 40 is selected, and is incorporated into the ejector 10. That is, at the preparation step in the method for manufacturing the ejector 10, the diffuser 40 having the dimensions (the inner diameter D and the tapered angles α , β) of the outlet flow path 50 set at the setting step is selected from multiple diffusers 40, or is newly produced.

[0075] In the examples of FIGS. 3 and 4 as described above, both of the tapered angle α of the first tapered surface 54 and the tapered angle β of the second tapered surface 55 are increased in such a manner that the inner diameter D is decreased from d1 to d2, but the present invention is not limited to these examples. While the tapered angle α increases as the inner diameter D gets smaller, the tapered angle β may be held constant or may decrease. Even in this case, an increase in the tapered angle β is suppressed, and worsening of the flow is reduced.

INDUSTRIAL APPLICABILITY

[0076] The technique disclosed herein is useful for the ejector, the method for manufacturing the ejector, and the method for setting the outlet flow path of the diffuser used for the ejector.

DESCRIPTION OF REFERENCE CHARACTERS

10 [0077]

10	Ejector
20	Nozzle
30	Suction Chamber
40	Diffuser
42	Attachment (Changing unit)
42A	First Attachment (Changing unit)
42B	Second Attachment (Changing unit)
50	Outlet Flow Path
51	Narrowed Flow Path
52	Parallel Flow Path
53	Expanded Flow Path
54	First Tapered Surface
55	Second Tapered Surface
α	Tapered Angle of First Tapered Surface
β	Tapered Angel of Second Tapered Surface
P	Length of Parallel Flow Path

30 Claims

1. An ejector comprising:

a nozzle configured to eject first fluid;
 a suction chamber configured to house the nozzle and to suck second fluid by negative pressure generated by ejection of the first fluid from the nozzle; and
 a diffuser including an outlet flow path and configured to mix and discharge the first fluid and the second fluid of the suction chamber, wherein the outlet flow path includes a narrowed flow path having a first tapered surface narrowed toward downstream, a parallel flow path connected to a downstream end of the narrowed flow path and having a constant sectional area, and an expanded flow path connected to a downstream end of the parallel flow path and having a second tapered surface expanded toward downstream,
 the diffuser further includes a changing unit configured to change a dimension of the outlet flow path, and
 the changing unit changes the dimension of the outlet flow path such that a ratio of a tapered angle of the first tapered surface to a tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is

smaller.

2. The ejector according to claim 1, wherein the changing unit changes the dimension of the outlet flow path such that a length of the parallel flow path is shorter as the sectional area of the parallel flow path is smaller. 5
3. The ejector according to claim 2, wherein the changing unit changes the dimension of the outlet flow path such that the length of the parallel flow path changes in proportion to an inner diameter of the parallel flow path. 10
4. The ejector according to any one of claims 1 to 3, wherein 15
part of the diffuser is formed from a replaceable attachment,
the changing unit is the attachment,
the attachment includes at least part of the narrowed flow path, the parallel flow path, and at least part of the expanded flow path, and
the dimension of the outlet flow path is changed by replacement of the attachment. 20
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5. A method for manufacturing an ejector including a nozzle configured to eject first fluid, a suction chamber configured to house the nozzle and to suck second fluid by negative pressure generated by ejection of the first fluid from the nozzle, and a diffuser including an outlet flow path having a narrowed flow path having a first tapered surface narrowed toward downstream, a parallel flow path connected to a downstream end of the narrowed flow path and having a constant sectional area, and an expanded flow path connected to a downstream end of the parallel flow path and having a second tapered surface expanded toward downstream and configured to mix and discharge the first fluid and the second fluid of the suction chamber, comprising: 30
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 - a setting step of setting a dimension of the outlet flow path; and
 - a preparation step of preparing the diffuser having the dimension of the outlet flow path set at the setting step, 45
 - wherein at the setting step, the dimension of the outlet flow path is set such that a ratio of a tapered angle of the first tapered surface to a tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is smaller. 50
6. The method for manufacturing the ejector according to claim 5, wherein 55
at the preparation step, the diffuser having the outlet flow path set at the setting step is prepared by replacement of a replaceable attachment of the diffus-

er including the attachment.

7. A method for setting an outlet flow path of a diffuser including an outlet flow path having a narrowed flow path having a first tapered surface narrowed toward downstream, a parallel flow path connected to a downstream end of the narrowed flow path and having a constant sectional area, and an expanded flow path connected to a downstream end of the parallel flow path and having a second tapered surface expanded toward downstream and used for an ejector, comprising: 5
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 - a step of setting a sectional area of the parallel flow path; and
 - a step of setting a dimension of the outlet flow path such that a ratio of a tapered angle of the first tapered surface to a tapered angle of the second tapered surface is higher as the sectional area of the parallel flow path is smaller. 15
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FIG.1

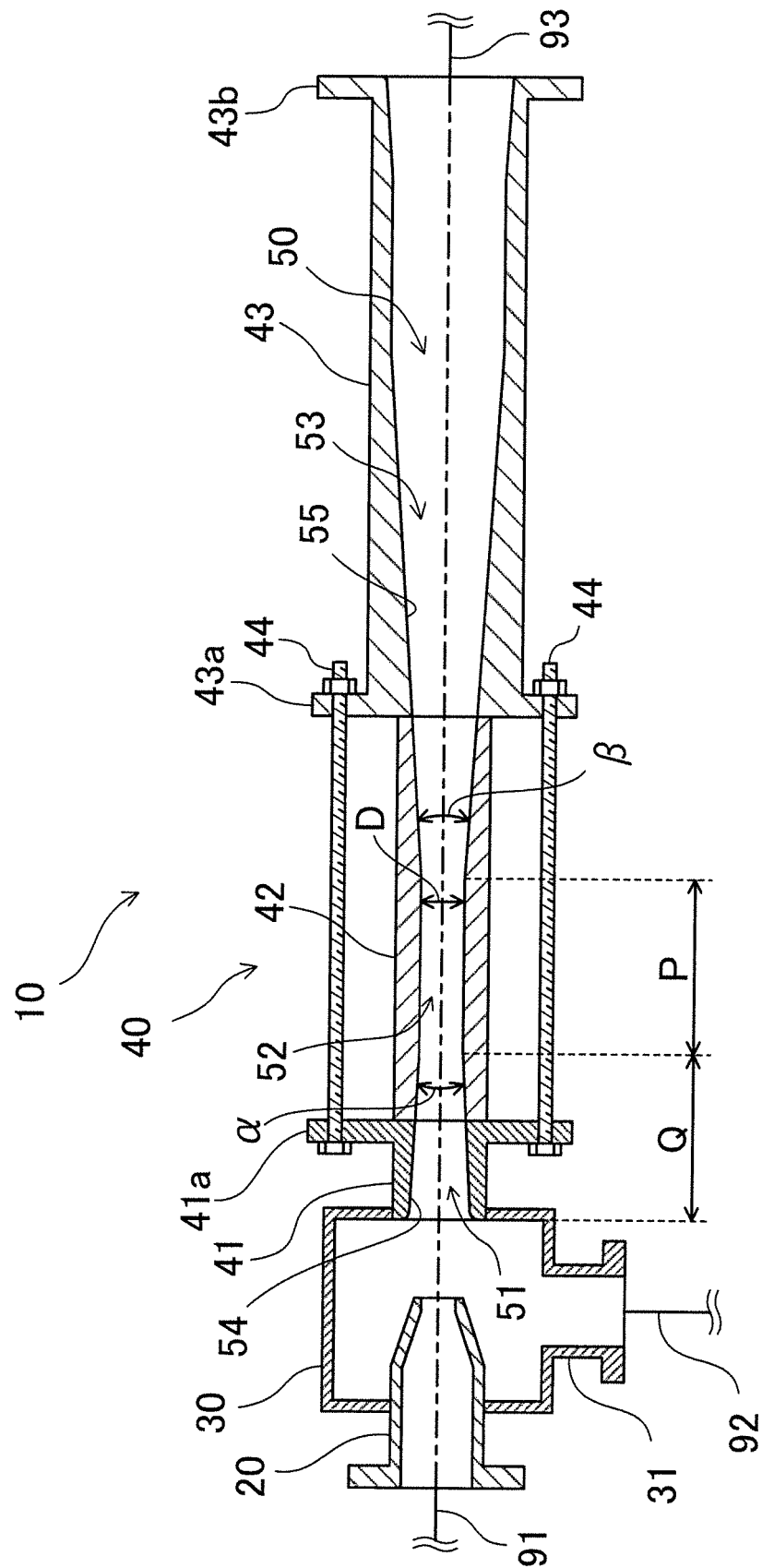


FIG.2

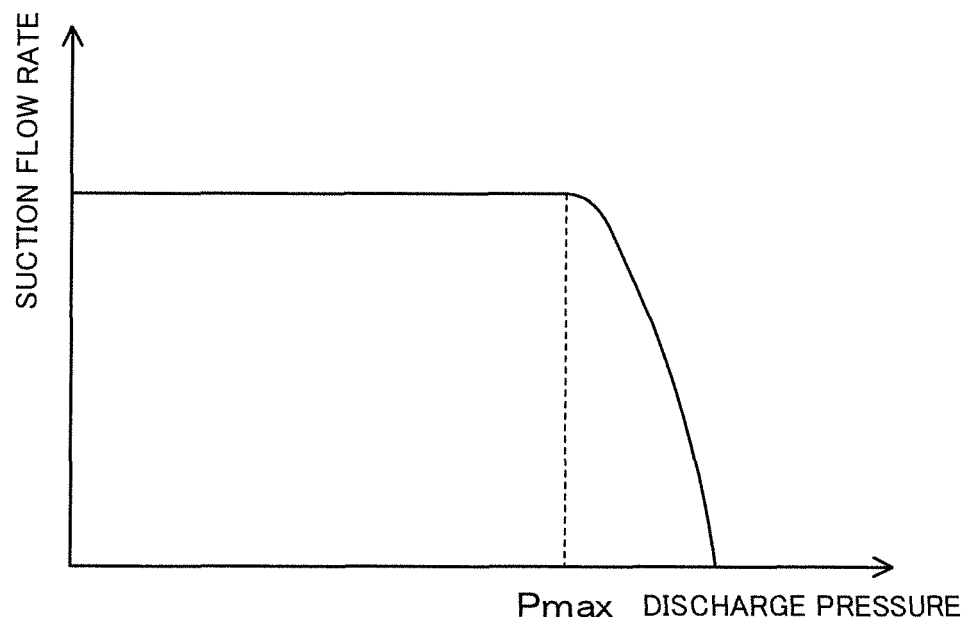


FIG.3

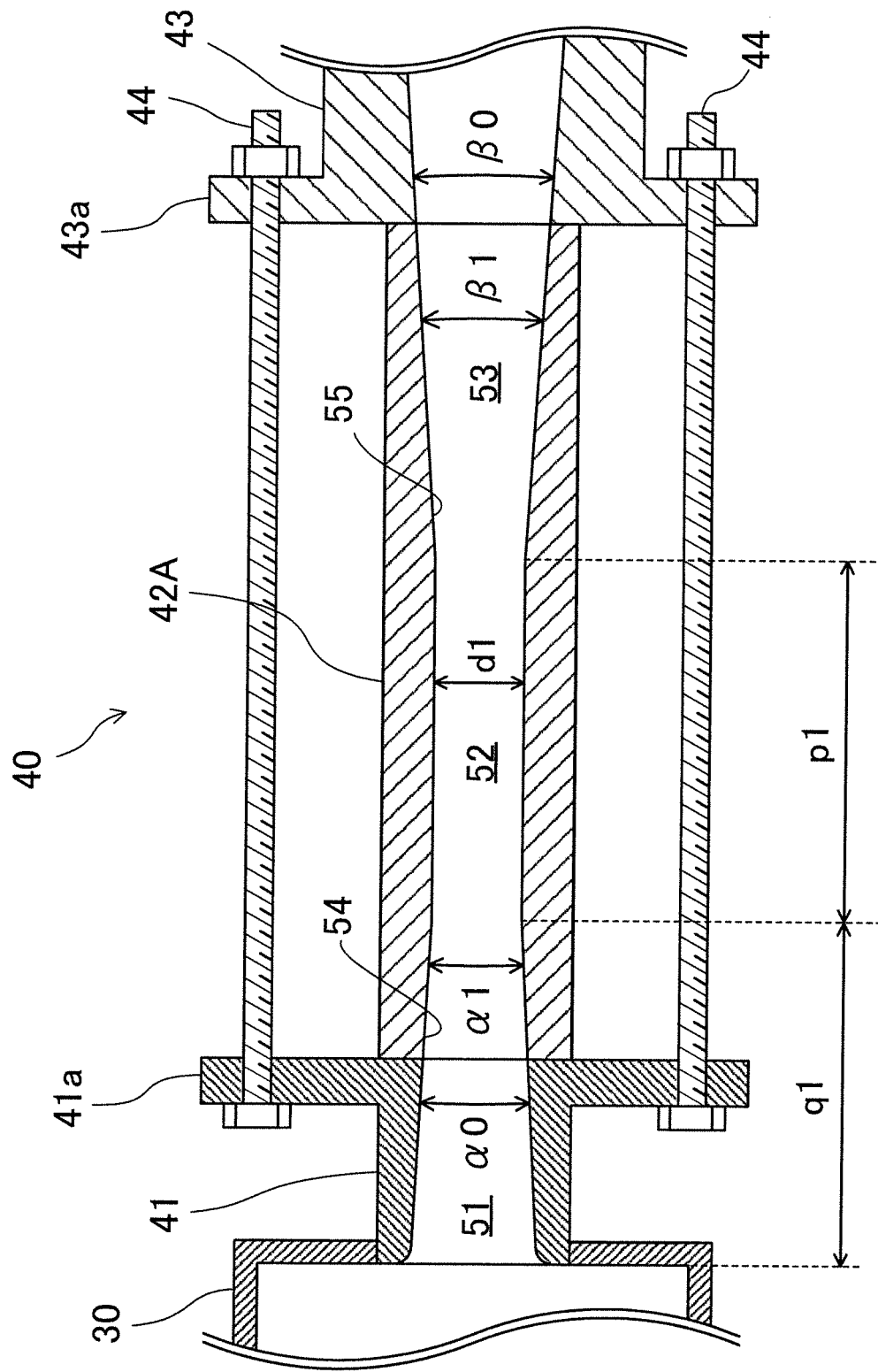
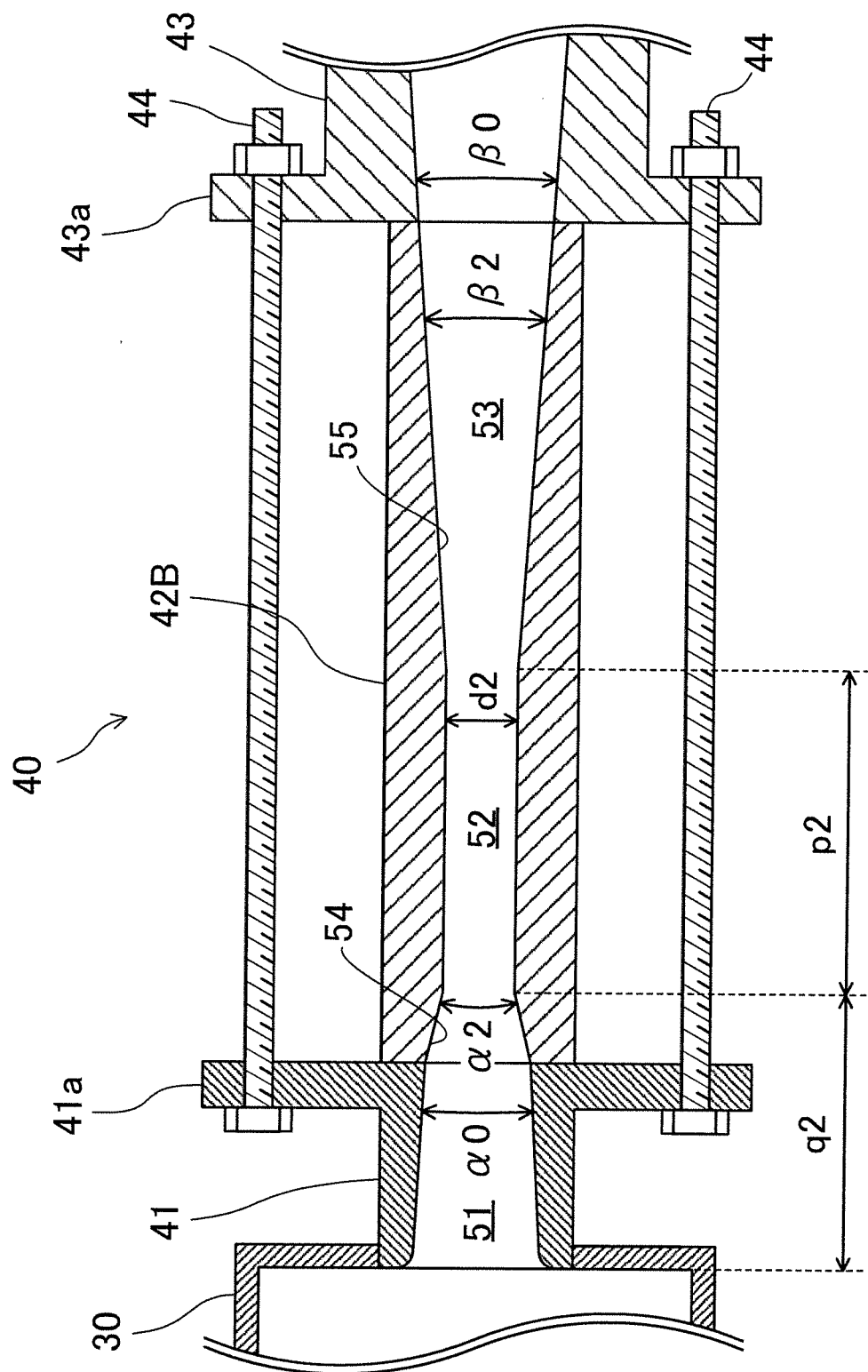


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/005469

A. CLASSIFICATION OF SUBJECT MATTER

F04F5/44 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04F5/44

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6877960 B1 (PRESZ, Jr. Walter M.), 12 April 2005 (12.04.2005), column 3, line 21 to column 5, line 65; fig. 1 to 5 (Family: none)	1-7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 154540/1980 (Laid-open No. 79152/1982) (Kawasaki Steel Corp.), 15 May 1982 (15.05.1982), specification, page 5, line 16 to page 11, line 20; fig. 1 to 3 (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search

07 April 2017 (07.04.17)

Date of mailing of the international search report

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Name and mailing address of the ISA/

Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
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Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/005469

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 135753 C2 (Mitsubishi Heavy Industries, Ltd.), 29 May 1940 (29.05.1940), entire text; all drawings (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000356305 A [0003]