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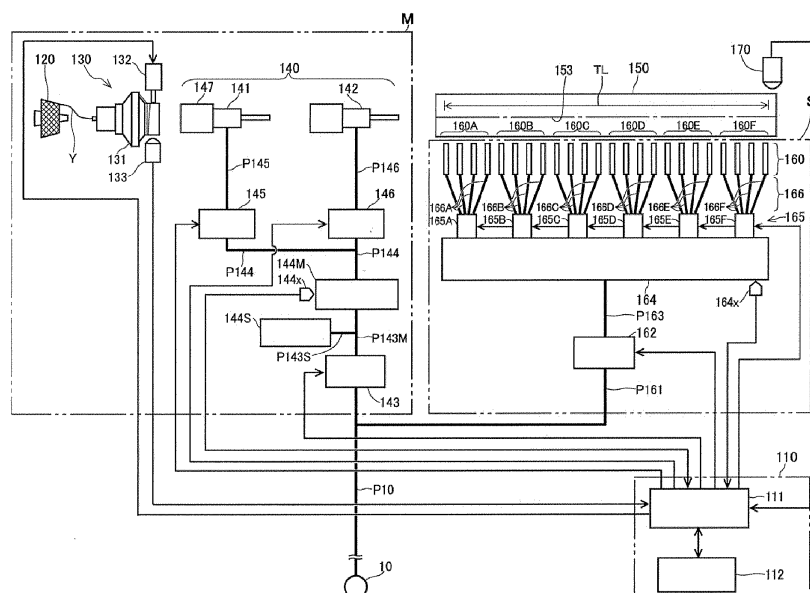
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(54) **WEFT INSERTION APPARATUS OF AIR JET LOOM**

(57) A weft insertion apparatus (100) of an air jet loom includes a first tank (144M) storing compressed air, an electropneumatic regulator (143) regulating a pressure of the compressed air supplied from an air compressor (10) to supply the compressed air having the regulated pressure to the first tank (144M), a nozzle (141, 142) configured to inject the compressed air, a valve (145,

146) connected to the first tank (144M) through a first connecting portion (P144) and supplying the compressed air stored in the first tank (144M) to the nozzle (141, 142), and a second tank (144S) connected to the first tank (144M) through a second connecting portion (P143S, P143Sa, P143Sb, H143MS) that is provided independently from the first connecting portion (P144).

100 **FIG. 1**



Description

BACKGROUND ART

[0001] The present invention relates to a weft insertion apparatus of an air jet loom using compressed air for weft yarn traveling, in particular, a weft insertion apparatus of an air jet loom capable of suppressing a reduction in a pressure of compressed air upon activation of the air jet loom and a fluctuation range of the pressure of the compressed air during operation of the air jet loom.

[0002] An air jet loom weaves fabrics by injecting compressed air to cause each of weft yarns to travel in a direction orthogonal to warp yarns. One of important points to weave fabrics of high quality in this case is to cause each of the weft yarns to arrive at a predetermined weft insertion position with predetermined timing by maintaining the pressure of the compressed air constant.

[0003] Japanese Patent Application Publication No. 2015-86476 discloses a method of regulating a pressure of compressed air in a tank of an air jet loom by using an electropneumatic regulator so that the pressures of the compressed air injected from nozzles of the air jet loom are regulated. The method disclosed in the above Patent Application Publication is aimed at reducing a fluctuation range of the pressure of the compressed air in the tank by suitably setting the lowest limit of the pressure of the compressed air that determines operation timing of an air supply solenoid valve of the electropneumatic regulator.

[0004] However, a rate of reduction in the pressure of the compressed air in the tank increases upon activation of the air jet loom when a volume of the compressed air injected from the nozzles is increased while the pressure of the compressed air in the tank is being regulated by using the electropneumatic regulator.

[0005] FIG. 5 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the nozzles is set to a standard value, whereas FIG. 6 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the same nozzles is set to a maximum value.

[0006] The characteristic shown in FIG. 6 in comparison with the characteristic shown in FIG. 5 clearly reveals a significant reduction in the pressure of the compressed air upon the activation of the air jet loom, which is not seen in FIG. 5. Such a reduction in the pressure of the compressed air upon the activation of the air jet loom is likely to be caused by a delay in replenishment of the compressed air into the tank through the electropneumatic regulator from a supply source of the compressed air such as an air compressor after consumption of a great volume of the compressed air upon the activation of the air jet loom.

[0007] In order to suppress the reduction in the pressure of the compressed air in the tank upon the activation

of the air jet loom, a capacity of the tank may be reduced. FIG. 7 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the nozzles is set to a maximum value with the capacity of the tank reduced to a half of that before the capacity change. A rate α of the reduction in the pressure of the compressed air upon the activation of the air jet loom shown in FIG. 6 is improved to be a smaller rate β of the reduction in the pressure of the compressed air shown in FIG. 7.

[0008] However, a fluctuation range γ of the pressure of the compressed air during operation of the air jet loom shown in FIG. 6 worsens to a greater fluctuation range δ of the pressure of the compressed air during the operation of the air jet loom shown in FIG. 7. In other words, while the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed by reducing the capacity of the tank, the fluctuation range of the pressure of the compressed air during the operation of the air jet loom worsens. In addition, the electropneumatic regulator hardly operates immediately after the activation of the air jet loom and afterward as shown in FIG. 6, whereas the electropneumatic regulator frequently operates for supplying and exhausting the air during the operation of the air jet loom as shown in FIG. 7. The frequent operations of the electropneumatic regulator as shown in FIG. 7 may reduce a service life of the electropneumatic regulator.

[0009] Therefore, it is extremely difficult, in the weft insertion apparatus using the compressed air injected from the nozzles for weft yarn traveling, to suppress both the reduction in the pressure of the compressed air in the tank upon the activation of the air jet loom and the fluctuation range of the pressure of the compressed air during the operation of the air jet loom, at the same time.

[0010] The present invention has been made in view of the above circumstances and is directed to providing a weft insertion apparatus of an air jet loom capable of suppressing reduction in a pressure of compressed air upon activation of the air jet loom and a fluctuation of the pressure of the compressed air during operation of the air jet loom as compared to a conventional one.

SUMMARY

[0011] In accordance with an aspect of the present invention, a weft insertion apparatus of an air jet loom includes a first tank storing compressed air, an electropneumatic regulator regulating a pressure of the compressed air supplied from an air compressor to supply the compressed air having the regulated pressure to the first tank, a nozzle configured to inject the compressed air, a valve connected to the first tank through a first connecting portion and supplying the compressed air stored in the first tank to the nozzle, and a second tank connected to the first tank through a second connecting portion that is provided independently from the first connecting portion.

[0012] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the embodiments together with the accompanying drawings in which:

FIG. 1 is a block diagram illustrating a weft insertion apparatus according to an embodiment of the present invention;

FIG. 2 is a block diagram illustrating a main regulator of the weft insertion apparatus according to the embodiment;

FIG. 3 is a block diagram illustrating a first main tank and a second main tank of the weft insertion apparatus according to the embodiment;

FIGS. 4A to 4C are schematic views each illustrating flow of compressed air associated with the tanks of the weft insertion apparatus according to the embodiment;

FIG. 5 is a graph showing a characteristic of a pressure of compressed air according to a comparative example;

FIG. 6 is a graph showing a characteristic of the pressure of the compressed air according to a comparative example;

FIG. 7 is a graph showing a characteristic of the pressure of the compressed air according to a comparative example;

FIG. 8 is a graph showing a characteristic of the pressure of the compressed air according to the embodiment;

FIG. 9 is a block diagram illustrating the tanks of the weft insertion apparatus of a first modification according to the embodiment;

FIG. 10 is a block diagram illustrating the tanks of the weft insertion apparatus of a second modification according to the embodiment; and

FIG. 11 is a block diagram illustrating the tanks of the weft insertion apparatus of a third modification according to the embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0014] The following will describe a weft insertion apparatus of an air jet loom according to an embodiment of the present invention in detail with reference to the accompanying drawings. In the drawings, identical reference numerals are provided to identical components.

[0015] The following will describe a configuration of a weft insertion apparatus 100 of an air jetloom according to the embodiment, with reference to FIG. 1. FIG. 1 is a block diagram illustrating the weft insertion apparatus

100 of the air jet loom according to the embodiment.

[0016] In the description, regarding a weft insertion direction in which a weft yarn is inserted through a shed of warp yarns and directed, a side from which the weft yarn is inserted is referred to as an upstream side whereas a side to which the weft yarn is directed is referred to as a downstream side. Regarding a direction in which compressed air flows, a side from which the compressed air flows is referred to as an upstream side whereas a side to which the compressed airflows is referred as a downstream side.

[Configuration of weft insertion apparatus 100]

[0017] The weft insertion apparatus 100 illustrated in FIG. 1 mainly includes a control device 110, a main system M, a sub-system S, a reed 150, and an end sensor 170. The weft insertion apparatus 100 illustrated in FIG. 1 includes a single main system M as an example, but may include two or more main systems M, instead.

[0018] The control device 110 includes a CPU 111 and a function panel 112. The CPU 111 performs various kinds of control over the weft insertion apparatus 100 based on an installed control program. The function panel 112 serves as an informing device that provides various kinds of information. The function panel 112 includes a display function and an input function. The display function displays various kinds of information based on instructions from the CPU 111, and the input function transmits the input information to the CPU 111.

[0019] The main system M includes a yarn supply portion 120, a weft yarn length measuring and storing device 130, and a weft insertion nozzle 140. The yarn supply portion 120 is disposed upstream of the weft yarn length measuring and storing device 130 and holds a weft yarn Y. The weft yarn Y held by the yarn supply portion 120 is drawn by the weft yarn length measuring and storing device 130.

[0020] The weft yarn length measuring and storing device 130 includes a weft yarn storing drum 131, a weft yarn unwinding pin 132, and a balloon sensor 133. The weft yarn storing drum 131 draws the weft yarn Y held by the yarn supply portion 120, and winds and stores the weft yarn Y therearound. The weft yarn unwinding pin 132 and the balloon sensor 133 are disposed in the periphery of the weft yarn storing drum 131. The balloon sensor 133 is disposed in line with the weft yarn unwinding pin 132 on a side of the weft yarn storing drum 131 on which the weft yarn Y is unwound.

[0021] The weft yarn unwinding pin 132 unwinds the weft yarn Y stored around the weft yarn storing drum 131, at a loom rotational angle that is preset in the control device 110. The balloon sensor 133 detects the weft yarn Y to be unwound from the weft yarn storing drum 131 during weft insertion and sends a weft yarn unwinding signal to the control device 110. When the control device 110 receives the weft yarn unwinding signal a predetermined number of times, the control device 110 controls

the weft yarn unwinding pin 132 so that the weft yarn unwinding pin 132 is locked. The locked weft yarn unwinding pin 132 locks the weft yarn Y unwound from the weft yarn storing drum 131, which ends the weft insertion of the weft yarn Y. Operation timing of the weft yarn unwinding pin 132 to lock the weft yarn Y is set according to a number of winds of the weft yarn Y of a length corresponding to a weaving width TL to be wound around the weft yarn storing drum 131.

[0022] The control device 110 is set to send an operational signal to lock the weft yarn Y to the weft yarn unwinding pin 132 when the control device 110 receives the weft yarn unwinding signals from the balloon sensor 133 N times, in a case where a length of the weft yarn Y wound around the weft yarn storing drum 131 by N winds corresponds to the weaving width TL. The weft yarn unwinding signal from the balloon sensor 133 corresponds to an unwinding signal to unwind the weft yarn Y from the weft yarn storing drum 131, which is recognized by the control device 110 as unwinding timing or releasing timing of the weft yarn based on a loom rotational angle signal obtained from an encoder.

[0023] The weft insertion nozzle 140 includes a tandem nozzle 141 and a main nozzle 142. The tandem nozzle 141 is configured to inject the compressed air to draw the weft yarn Y from the weft yarn storing drum 131. A brake 147 is disposed upstream of the tandem nozzle 141, and applies a brake on the traveling weft yarn Y before the weft insertion ends.

[0024] The main nozzle 142 is configured to inject the compressed air to insert the weft yarn Y through a weft yarn passage 153 of the reed 150. The main nozzle 142 is connected to a main valve 146 through a pipe P146. The main valve 146 is connected to a first main tank 144M serving as a first tank through a pipe P144 serving as a first connecting portion.

[0025] The tandem nozzle 141 is connected to a tandem valve 145 through a pipe P145. The tandem valve 145 is connected to the first main tank 144M through the pipe P144. The first main tank 144M is common to the tandem valve 145 and the main valve 146. Either one or both of the tandem valve 145 and the main valve 146 may be connected directly to the first main tank 144M, not through the pipe P144. In this case, either one or both of connecting portions of the tandem valve 145 and the main valve 146 to the first main tank 144M serve as the "first connecting portion" of this invention.

[0026] A pressure of the compressed air supplied from an air compressor 10 installed in a fabric weaving factory is regulated by a main regulator 143, and the compressed air having a regulated pressure is supplied to and stored in the first main tank 144M through a pipe P143M. The pipe P143M serves as a supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M. The main regulator 143 is provided by an electropneumatic regulator. A pressure sensor 144x detects a pressure of the compressed air stored in the first main tank 144M, and a detection result is transmitted

to the control device 110. The pressure sensor 144x may be built in the main regulator 143. In this case, the pressure of the compressed air in the first main tank 144M may be estimated by a pressure of the compressed air downstream from the main regulator 143.

[0027] A second main tank 144S serving as a second tank is connected, through a pipe P143S, to the first main tank 144M serving as the first tank. An additional flow passage resistance is given to the pipe P143S serving as a second connecting portion that transfers the compressed air between the first main tank 144M and the second main tank 144S. In other words, the second main tank 144S is connected to the first main tank 144M through the pipe P143S serving as the second connecting portion that is provided independently from the pipe P144 serving as the first connecting portion. In this case, the pipe P143S serving as the second connecting portion is connected to the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 serving as the electropneumatic regulator to the first main tank 144M. The pipe P143S serving as the second connecting portion may be directly connected to the first main tank 144M.

[0028] The reed 150 that includes a plurality of dents is disposed downstream of the weft insertion nozzle 140 of the main system M. The plurality of dents is configured so that a warp yarn passes through a space between any two of the dents adjacent to each other. The weft yarn passage 153 is formed by recessed portions of the dents disposed in vicinities of centers of the dents in an up-down direction. The weft yarn passage 153 allows the weft yarn Y to travel therethrough. A plurality of nozzles serving as sub-nozzles 160 (hereinafter referred to as a plurality of groups of sub-nozzles 160), and the end sensor 170 are disposed along the weft yarn passage 153 of the reed 150.

[0029] The sub-system S includes the plurality of groups of sub-nozzles 160 disposed along the weft yarn passage 153 of the reed 150. The compressed air is injected (hereinafter referred to as "air injection") from the plurality groups of sub-nozzles 160 so that the weft yarn Y travels through the weft yarn passage 153. The plurality of groups of sub-nozzles 160 is divided into, for example, six groups of sub-nozzles 160A to 160F each of which includes four sub-nozzles.

[0030] The plurality of groups of sub-nozzles 160A to 160F is connected to a plurality of sub-valves 165 via a plurality of groups of pipes 166, respectively. The plurality of groups of pipes 166 includes six groups of pipes 166A to 166F, corresponding to the six groups of sub-nozzles 160A to 160F, respectively, and each group of pipes 166A to 166F includes four pipes. The plurality of sub-valves 165 includes sub-valves 165A to 165F so as to correspond to the plurality of groups of pipes 166A to 166F, respectively, and is connected to a common sub-tank 164.

[0031] The sub-tank 164 is connected, via a pipe P163, to a sub-regulator 162. The sub-regulator 162 is connect-

ed to the air compressor 10 via a pipe P161, arranged in parallel with the main regulator 143. Therefore, the sub-tank 164 stores the compressed air of a pressure regulated by the sub-regulator 162. A pressure sensor 164x detects a pressure of the compressed air stored in the sub-tank 164, and a detection result is transmitted to the control device 110. The pressure sensor 164x may be built in the sub-regulator 162. In this case, the pressure of the compressed air in the sub-tank 164 may be estimated by a pressure of the compressed air downstream from the sub-regulator 162.

[0032] The end sensor 170 is disposed on a downstream side of the weft yarn passage 153, at a downward selvage that is located more downward than a downward end of the weaving width TL. The end sensor 170 optically detects the weft yarn Y that arrives in a detection range. In order to detect the weft yarn Y that arrives in the detection range, the end sensor 170 may include a light emitting device, a light receiving device, and a light guiding device. When the end sensor 170 detects the weft yarn Y, the end sensor 170 generates and transmits a weft yarn detection signal to the control device 110. The weft yarn detection signal from the end sensor 170 corresponds to an end arrival signal of the weft yarn Y, which is recognized by the control device 110 as an end arrival timing.

[Configuration and operation of main regulator 143]

[0033] The following will describe a configuration and operations of the main regulator 143 with reference to FIG. 2. FIG. 2 is a block diagram illustrating the main regulator 143 of the weft insertion apparatus 100 according to the embodiment.

[0034] The main regulator 143 is provided by the electropneumatic regulator, and mainly includes an air spring pressure regulator 1431, a pilot valve 1432, an air exhaust valve 1433, an air supply solenoid valve 1434, and an air exhaust solenoid valve 1435.

[0035] The air spring pressure regulator 1431 includes a diaphragm 1431d that is disposed so as to partition an inside of the air spring pressure regulator 1431 into two parts. The air spring pressure regulator 1431 thus includes a primary space 1431a on one side of the diaphragm 1431d and a secondary space 1431b on the other side of the diaphragm 1431d. Depending on a difference in the pressure of the compressed air in the air spring pressure regulator 1431 between the primary space 1431a and the secondary space 1431b, the position of the diaphragm 1431d is shifted to either the primary space 1431a or the secondary space 1431b. The primary space 1431a is connected to the air supply solenoid valve 1434 and the air exhaust solenoid valve 1435 through a pipeline P143a.

[0036] The pilot valve 1432 includes an inlet 1432in disposed on a side of the pilot valve 1432 close to the air compressor 10 and connected to a pipe P10, and an outlet 1432out disposed on a side of the pilot valve 1432

close to the first main tank 144M and connected to the pipe P143M. The pilot valve 1432 is coupled to the diaphragm 1431d of the air spring pressure regulator 1431, and is opened and closed according to the shift in the position of the diaphragm 1431d.

[0037] The pilot valve 1432 is, for example, opened when the pressure of the compressed air in the primary space 1431a is higher than the pressure of the compressed air in the secondary space 1431b and is closed when the pressure of the compressed air in the primary space 1431a is equal to or lower than the pressure of the compressed air in the secondary space 1431b. When the pilot valve 1432 is opened, the inlet 1432in communicates with the outlet 1432out so that the compressed air of a high pressure present on the side of the pilot valve 1432 close to the air compressor 10 is supplied toward the first main tank 144M. The pipe P143M connected to the outlet 1432out of the pilot valve 1432 communicates with the secondary space 1431b through a pipeline P143b.

[0038] The air exhaust valve 1433 includes a pipeline P143c communicating with the secondary space 1431b and an air exhaust port 1433out communicating with the atmosphere. The air exhaust valve 1433 is opened and closed according to the shift in the position of the diaphragm 1431d, like the pilot valve 1432.

[0039] For example, the air exhaust valve 1433 is closed when the pressure of the compressed air in the primary space 1431a balances with or is higher than the pressure of the compressed air in the secondary space 1431b. The air exhaust valve 1433 is opened when the pressure of the compressed air in the secondary space 1431b is higher than the pressure of the compressed air in the primary space 1431a, according to the shift in the position of the diaphragm 1431d. Accordingly, the compressed air in the secondary space 1431b is discharged from the air exhaust port 1433out of the air exhaust valve 1433. In other word, the compressed air present on a side of the pilot valve 1432 close to the outlet 1432out passes through the pipeline P143b, the secondary space 1431b, and the pipeline P143c, to be discharged from the air exhaust port 1433out.

[0040] The air supply solenoid valve 1434 and the air exhaust solenoid valve 1435 are opened and closed individually according to instructions from the control device 110. The air supply solenoid valve 1434 is connected, through the pipeline P143b, to the pipe P10 that is connected to the air compressor 10. When the air supply solenoid valve 1434 is opened, the compressed air having an original pressure is supplied to the primary space 1431a of the air spring pressure regulator 1431 through the pipeline P143a. The air exhaust solenoid valve 1435 includes an air exhaust port 1435out that is open to the outside. When the air exhaust solenoid valve 1435 is opened, the compressed air in the primary space 1431a of the air spring pressure regulator 1431 is discharged from the air exhaust port 1435out to the outside.

[0041] As described above, the main regulator 143 reg-

ulates the pressure of the compressed air in the first main tank 144M by operations of the air spring pressure regulator 1431, the pilot valve 1432, and the air exhaust valve 1433 while the pressure of the compressed air detected by the pressure sensor 144x falls within a predetermined range. In addition, in a case where the pressure of the compressed air detected by the pressure sensor 144x falls outside the predetermined range, the main regulator 143 rapidly regulates the pressure of the compressed air in the first main tank 144M in the following manner: the control device 110 sends an instruction to either the air supply solenoid valve 1434 or the air exhaust solenoid valve 1435 to greatly shift the diaphragm 1431d, and then the great shift of the diaphragm 1431d causes the pilot valve 1432 and the air exhaust valve 1433 to rapidly operate.

[First main tank 144M and second main tank 144S]

[0042] The following will describe the first main tank 144M serving as the first tank and the second main tank 144S serving as the second tank, with reference to FIG. 3. FIG. 3 is a block diagram illustrating the first main tank 144M and the second main tank 144S of the weft insertion apparatus 100 according to the embodiment.

[0043] As illustrated in FIG. 3, the second main tank 144S is connected, through the pipe P143S, to a midpoint of the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M. The pipe P143S is used for connecting the second main tank 144S to the first main tank 144M. The pipe P143S serves as the second connecting portion to which the additional flow passage resistance is given.

[0044] The compressed air having a pressure regulated by the main regulator 143 is supplied through the pipe P143M to be stored in the first main tank 144M, and also supplied through the pipe P143M and the pipe P143S to be stored in the second main tank 144S.

[0045] The weft insertion apparatus 100 may preferably satisfy a relation $V1 < V2$, where $V1$ denotes a capacity of the first main tank 144M and $V2$ denotes a capacity of the second main tank 144S. The weft insertion apparatus 100 may preferably satisfy another relation $Vorg = V1 + V2$, where $Vorg$ denotes a capacity of the main tank of the conventional case.

[0046] The flow passage resistance of the pipe P143S is determined by factors such as a diameter of the pipe, a variation in the diameter of the pipe, a length of the pipe, friction in the pipe, and presence of a curve at a joint portion of the pipe. In other words, with any of the above factors, for example, if the length of the pipe increases, if the diameter of the pipe decreases, if the friction in the pipe increases, if the pipe has a curve, or the like, the flow passage resistance is likely to increase.

[0047] The weft insertion apparatus 100 may preferably satisfy yet another relation $R1 < R2$, where $R1$ denotes a flow passage resistance of the pipe P143M serv-

ing as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M and $R2$ denotes a flow passage resistance of the pipe P143S serving as the second connecting portion connected to the second main tank 144S. In other words, the "additional flow passage resistance is given" to the pipe P143S means that the pipe P143S has a greater flow passage resistance than the pipe P143M has.

10 [Flows of compressed air associated with first main tank 144M and second main tank 144S]

[0048] The following will describe the flows of the compressed air associated with the first main tank 144M and the second main tank 144S with three steps A to C illustrated in FIGS. 4A to 4C. FIGS. 4A to 4C are schematic views each illustrating the flow of the compressed air associated with the first main tank 144M and the second main tank 144S of the weft insertion apparatus 100 according to the embodiment.

[0049] The compressed air from the main regulator 143 is supposed to be supplied through the pipe P143M to be stored in the first main tank 144M and also supplied through the pipe P143M and the pipe P143S to be stored in the second main tank 144S. In this state, the compressed air stored in the first main tank 144M is maintained at a predetermined pressure.

Step A: During air injection from main nozzle 142

[0050] As illustrated in FIG. 4A, the compressed air stored in the first main tank 144M is injected from the main nozzle 142 through the main valve 146, for weft insertion (a1).

[0051] Then, the compressed air from the main regulator 143 is replenished in the first main tank 144M through the pipe P143M (a2). The compressed air stored in the second main tank 144S is replenished into the first main tank 144M through the pipe P143S and the pipe P143M (a3). As a result, the compressed air of a volume corresponding to totaled capacities of the first main tank 144M and the second main tank 144S is injected from the main nozzle 142.

45 Step B: After air injection from main nozzle 142 (1)

[0052] When the air injection from the main nozzle 142 is finished, the compressed air from the main regulator 143 is supplied to the first main tank 144M only through the pipe P143M that has a smaller flow passage resistance than the pipe P143S has (b1), as illustrated in FIG. 4B. In other words, when $R1$ denotes the flow passage resistance of the pipe P143M and $R2$ denotes the flow passage resistance of the pipe P143S, the flow passage resistances are adjusted to satisfy the relation $R1 < R2$.

[0053] At this point, the compressed air is not supplied to the second main tank 144S since the compressed air from the main regulator 143 is unlikely to flow in a direc-

tion toward the pipe P143S that has a greater flow passage resistance than the pipe P143M has. As a result, a reduced pressure of the compressed air in the first main tank 144M after the air injection from the main nozzle 142 is rapidly recovered. Even when the relation between $R1$ and $R2$ is either $R1 = R2$ or $R1 > R2$, the weft insertion apparatus 100 of the embodiment is capable of suppressing reduction in the pressure of the compressed air in the tank upon activation and during operation of the air jet loom, unlike the conventional case where the second main tank 144S is not provided.

[0054] On the other hand, by satisfying the relation $V1 < V2$, where $V1$ denotes the capacity of the first main tank 144M and $V2$ denotes the capacity of the second main tank 144S, the rate of the reduction in the pressure of the compressed air in the first main tank 144M upon the activation of the air jet loom is suppressed smaller than the conventional case. Even when the relation between $V1$ and $V2$ is either $V1 = V2$ or $V1 > V2$, the weft insertion apparatus 100 of the embodiment is capable of suppressing the reduction in the pressure of the compressed air in the tank upon the activation and during the operation of the air jet loom, unlike the conventional case where the second main tank 144S is not provided.

Step C: After air injection from main nozzle 142 (2)

[0055] In response to the recovery of the reduced pressure of the compressed air in the first main tank 144M in Step B described above, the compressed air from the main regulator 143 is supplied through the pipe P143M to be stored in the first main tank 144M (c1) and also supplied through the pipe P143M and the pipe P143S to be stored in the second main tank 144S (c2), as illustrated in FIG. 4C.

[0056] As described above, since the main tank is divided into the first main tank 144M and the second main tank 144S, the compressed air of the volume corresponding to the totaled capacities of the first main tank 144M and the second main tank 144S is allowed to be used for the air injection from the main nozzle 142, which rapidly recovers the reduced pressure of the compressed air in the first main tank 144M after the air injection from the main nozzle 142, prior to the second main tank 144S. As a result, the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed and a fluctuation range of the pressure of the compressed air during operation of the air jet loom is suppressed smaller than that of the conventional case.

[Characteristics of pressure of compressed air]

[0057] The following will describe characteristics of the pressure of the compressed air, with reference to FIGS. 5 to 8. FIGS. 5 to 7 each are graphs showing the characteristics of the pressure of the compressed air according to comparative examples. FIG. 8 is a graph showing the characteristic of the pressure of the compressed air

according to the embodiment. In each of the above FIGS. 5 to 8, the vertical axis shows the pressure of the compressed air in the first main tank 144M and the horizontal axis shows time for the status of the air jet loom from before the operation through the activation to during the operation.

[0058] FIG. 5 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the main nozzle 142 is set to a standard value according to the comparative example of the weft insertion apparatus that includes only a first main tank without a second main tank. In this case, the fluctuation range of the pressure of the compressed air during the operation of the air jet loom is suppressed smaller than those of any of the cases that will be described below. Also, the main regulator 143 of the comparative example uses neither the air supply solenoid valve 1434 nor the air exhaust solenoid valve 1435.

[0059] FIG. 6 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the main nozzle 142 is set to a maximum value according to the comparative example of the weft insertion apparatus that includes only the first main tank without the second main tank. The characteristic in FIG. 6 shows a rate α of the reduction in the pressure of the compressed air, which is a significant reduction, since the air injection from the main valve 146 is repeated in an initial operation upon the activation of the air jet loom. At that time, the main regulator 143 supplies the compressed air to the tank according to the operation of the air supply solenoid valve 1434 in response to repetitive air supply signals sent from the control device 110 to the air supply solenoid valve 1434. This increases a burden on the main regulator 143. In FIG. 6, a fluctuation range γ of the pressure of the compressed air during the operation of the air jet loom is suppressed smaller than the rate α of the reduction in the pressure during the initial operation upon the activation of the air jet loom.

[0060] FIG. 7 shows a characteristic of changes in the pressure of the compressed air in a case where the volume of the compressed air injected from the main nozzle 142 is set to the maximum value with the capacity of the first main tank reduced to a half of that of FIG. 6, according to the comparative example of the weft insertion apparatus that includes only the first main tank without the second main tank. The reduction in the pressure of the compressed air upon the activation of the air injection loom is improved to the rate β in FIG. 7, smaller than the rate α shown in FIG. 6, since the capacity of the first main tank is reduced to a half of that of FIG. 6 and thus the compressed air is quickly replenished into the first main tank.

[0061] On the other hand, the fluctuation of the pressure of the compressed air during the operation of the air jet loom worsens to a fluctuation range δ in FIG. 7, greater than the fluctuation range γ shown in FIG. 6,

caused by reduction of the capacity of the first main tank to a half of that of FIG. 6. In other words, while the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed by reducing the capacity of the tank, the fluctuation range of the pressure of the compressed air during the operation of the air jet loom worsens.

[0062] FIG. 8 is the graph showing the characteristic of the pressure of the compressed air in the first main tank 144M according to the embodiment. In the weft insertion apparatus of the embodiment that includes the first main tank 144M and the second main tank 144S, the totaled capacities of the capacity V1 of the first main tank 144M and the capacity V2 of the second main tank 144S, which is $V1 + V2$, is set to be equal to the capacity Vorg of the first main tank of the weft insertion apparatus of the conventional case shown in FIGS. 6 and 7.

[0063] The reduction in the pressure of the compressed air upon the activation of the air injection loom shown in FIG. 8 is improved to the rate β like the case shown in FIG. 7, smaller than the rate α shown in FIG. 6, since the capacity of the first main tank 144M is reduced to approximately a half of the capacity Vorg of the first main tank of the conventional case and thus the compressed air is quickly replenished into the first main tank 144M. In this case, the main regulator 143 hardly uses the air supply solenoid valve 1434 and the air exhaust solenoid valve 1435, which reduces the burden on the main regulator 143.

[0064] The fluctuation range of the pressure of the compressed air during the operation of the air jet loom shown in FIG. 8 falls within the fluctuation range γ like the case shown in FIG. 6 since the totaled capacities of the capacity V1 of the first main tank 144M and the capacity V2 of the second main tank 144S, which is $V1 + V2$, is set to be equal to the capacity Vorg of the first main tank of the conventional case. In this case, the main regulator 143 hardly uses the air supply solenoid valve 1434 and the air exhaust solenoid valve 1435, which reduces the burden on the main regulator 143.

[0065] The pressure characteristic shown in FIG. 8 plunges as indicated with (a) when the compressed air is injected from the main nozzle 142, surges as indicated with (b) when the compressed air is supplied only to the first main tank 144M, and then gently declines for a short period as indicated with (c) when the compressed air is supplied to the second main tank 144S in addition to the first main tank 144M.

[Modification examples of connection between first main tank 144M and second main tank 144S]

[0066] The following will describe modification examples of connections between the first main tank 144M and the second main tank 144S, with reference to FIGS. 9 to 11.

[0067] FIG. 9 is a block diagram illustrating the first main tank 144M and the second main tank 144S of the

weft insertion apparatus 100 of a first modification example according to the embodiment. As illustrated in FIG. 9, the second main tank 144S is directly connected to the first main tank 144M through a pipe P143Sb that is provided independently from the pipe P144 serving as the first connecting portion, not via the pipe P143M serving as the supply portion that supplies the compressed air to the first main tank 144M from the main regulator 143. In this modification example, the pipe P143Sb serves as the second connecting portion. The second main tank 144S is allowed both to receive the compressed air supplied through the first main tank 144M and to supply the compressed air to the first main tank 144M. In this case, the pipe P143Sb may be provided and arranged regardless of the position of the pipe P143M, which allows flexible arrangement of the second main tank 144S and piping thereto.

[0068] FIG. 10 is a block diagram illustrating the first main tank 144M and the second main tank 144S of the weft insertion apparatus 100 of a second modification example according to the embodiment. As illustrated in FIG. 10, the second main tank 144S is connected, through a pipe P143Sa, to a midpoint of the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M, and is also connected directly to the first main tank 144M through the pipe P143Sb that is provided independently from the pipe P143M. In this case, the compressed air is supplied to the second main tank 144S through the two pipes serving as the second connecting portions, i.e., the pipe P143Sa and the pipe P143Sb, which thus enhances flexibility in regulation of the flow passage resistances between flow passage resistance R2a of the pipe P143Sa and a flow passage resistance R2b of the pipe P143Sb.

[0069] FIG. 11 is a block diagram illustrating the first main tank 144M and the second main tank 144S of the weft insertion apparatus 100 of a third modification example according to the embodiment. As illustrated in FIG. 11, the first main tank 144M and the second main tank 144S partitioned by a partition wall W are integrally formed. The first main tank 144M is directly connected to the second main tank 144S through a communication port H143MS provided in the partition wall W. The communication port H143MS serves as the second connecting portion that connects the first main tank 144M and the second main tank 144S. The communication port H143MS is adjusted to have a diameter so as to obtain the flow passage resistance R2 that is greater than the flow passage resistance R1 of the pipe P143M. The communication port H143MS may be provided by a communication pipe. In this case, a tank having a capacity equivalent to that of the conventional case may be partitioned by the partition wall W into the first main tank 144M and the second main tank 144S, and thus the configuration and arrangement of an existing weft insertion apparatus may be used.

[Advantageous effects obtained by embodiment]

[0070] The above-described embodiment of the present invention offers the following advantageous effects.

[0071] The weft insertion apparatus 100 of the air jet loom according to the present invention includes the first main tank 144M serving as the first tank that stores the compressed air, the main regulator 143 that regulates the pressure of the compressed air supplied from the air compressor 10 and supplies the regulated compressed air to the first main tank 144M, the main nozzle 142 configured to inject the compressed air stored in the first main tank 144M, the main valve 146 that is connected to the first main tank 144M through the pipe P144 serving as the first connecting portion and supplies the compressed air stored in the first main tank 144M to the main nozzle 142, and the second main tank 144S that is connected to the first main tank 144M through the pipe P143S serving as the second connecting portion that is provided independently from the first connecting portion.

[0072] Since the tank is divided into the first main tank 144M and the second main tank 144S, the compressed air of the volume corresponding to the totaled capacities of the first main tank 144M and the second main tank 144S may be used for the air injection from the main nozzle 142, which rapidly recovers the reduced pressure of the compressed air in the first main tank 144M after the air injection from the main nozzle 142, prior to the second main tank 144S. As a result, the rate of the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed and the fluctuation range of the pressure of the compressed air during the operation of the air jet loom is suppressed smaller than that of the conventional case.

[0073] The pipe P143S serving as the second connecting portion is connected to the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M. In other word, the second main tank 144S is connected, through the pipe P143S serving as the second connecting portion, to a midpoint of the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M. In this case, the second main tank 144S is allowed both to receive the compressed air supplied from the main regulator 143 and to supply the compressed air to the first main tank 144M. As a result, the rate of the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed and the fluctuation range of the pressure of the compressed air during the operation of the air jet loom is suppressed smaller than that of the conventional case.

[0074] The pipe P143Sb serving as the second connecting portion is directly connected to the first main tank 144M. In other word, the second main tank 144S is directly connected to the first main tank 144M through the pipe P143Sb serving as the second connecting portion,

not via the pipe P143M that supplies the compressed air from the main regulator 143 to the first main tank 144M. In this case, the second main tank 144S is allowed both to receive the compressed air supplied through the first main tank 144M and to supply the compressed air to the first main tank 144M. As a result, the rate of the reduction in the pressure of the compressed air upon the activation of the air jet loom is suppressed and the fluctuation range of the pressure of the compressed air during the operation of the air jet loom is suppressed smaller than that of the conventional case.

[0075] By satisfying the relation $V1 < V2$ where $V1$ denotes the capacity of the first main tank 144M and $V2$ denotes the capacity of the second main tank 144S, the rate of the reduction in the pressure of the compressed air in the first main tank 144M upon the activation of the air jet loom is suppressed smaller than the conventional case.

[0076] By satisfying the relation $R1 < R2$ where $R1$ denotes the flow passage resistance of the pipe P143M serving as the supply portion that supplies the compressed air from the main regulator 143 to the first main tank 144M and $R2$ denotes the flow passage resistance of the pipe P143S that supplies the compressed air to the second main tank 144S, the reduced pressure of the compressed air in the first main tank 144M by the air injection from the main nozzle 142 is rapidly recovered, prior to the second main tank 144S, and the reduction in the pressure of the compressed air is suppressed.

[0077] The main tank includes the first main tank 144M and the second main tank 144S in the above-described embodiment. Likewise, the sub-tank 164 may include a first sub-tank and a second sub-tank.

[0078] A weft insertion apparatus (100) of an air jet loom includes a first tank (144M) storing compressed air, an electropneumatic regulator (143) regulating a pressure of the compressed air supplied from an air compressor (10) to supply the compressed air having the regulated pressure to the first tank (144M), a nozzle (141, 142) configured to inject the compressed air, a valve (145, 146) connected to the first tank (144M) through a first connecting portion (P144) and supplying the compressed air stored in the first tank (144M) to the nozzle (141, 142), and a second tank (144S) connected to the first tank (144M) through a second connecting portion (P143S, P143Sa, P143Sb, H143MS) that is provided independently from the first connecting portion (P144).

Claims

1. A weft insertion apparatus (100) of an air jet loom, comprising:

a first tank (144M) storing compressed air;
an electropneumatic regulator (143) regulating a pressure of the compressed air supplied from an air compressor (10) to supply the com-

pressed air having the regulated pressure to the first tank (144M);

a nozzle (141, 142) configured to inject the compressed air; and

a valve (145, 146) connected to the first tank (144M) through a first connecting portion (P144) and supplying the compressed air stored in the first tank (144M) to the nozzle (141, 142); **characterized in that**

a second tank (144S) is connected to the first tank (144M) through a second connecting portion (P143S, P143Sa, P143Sb, H143MS) that is provided independently from the first connecting portion (P144).

2. The weft insertion apparatus (100) of the air jet loom according to claim 1, **characterized in that** the second connecting portion (P143S, P143Sa) is connected to a supply portion (P143M) that supplies the compressed air from the electropneumatic regulator (143) to the first tank (144M).
3. The weft insertion apparatus (100) of the air jet loom according to claim 1, **characterized in that** the second connecting portion (P143Sb, H143MS) is directly connected to the first tank (144M).
4. The weft insertion apparatus (100) of the air jet loom according to any one of claims 1 to 3, **characterized in that** a relation $V1 < V2$ is satisfied, where V1 denotes a capacity of the first tank (144M) and V2 denotes a capacity of the second tank (144S).
5. The weft insertion apparatus (100) of the air jet loom according to any one of claims 1 to 4, **characterized in that** a relation $R1 < R2$ is satisfied, where R1 denotes a flow passage resistance of a supply portion (P143M) that supplies the compressed air from the electropneumatic regulator (143) to the first tank (144M) and R2 denotes a flow passage resistance of the second connecting portion (P143S, P143Sa, P143Sb, H143MS).

FIG. 1

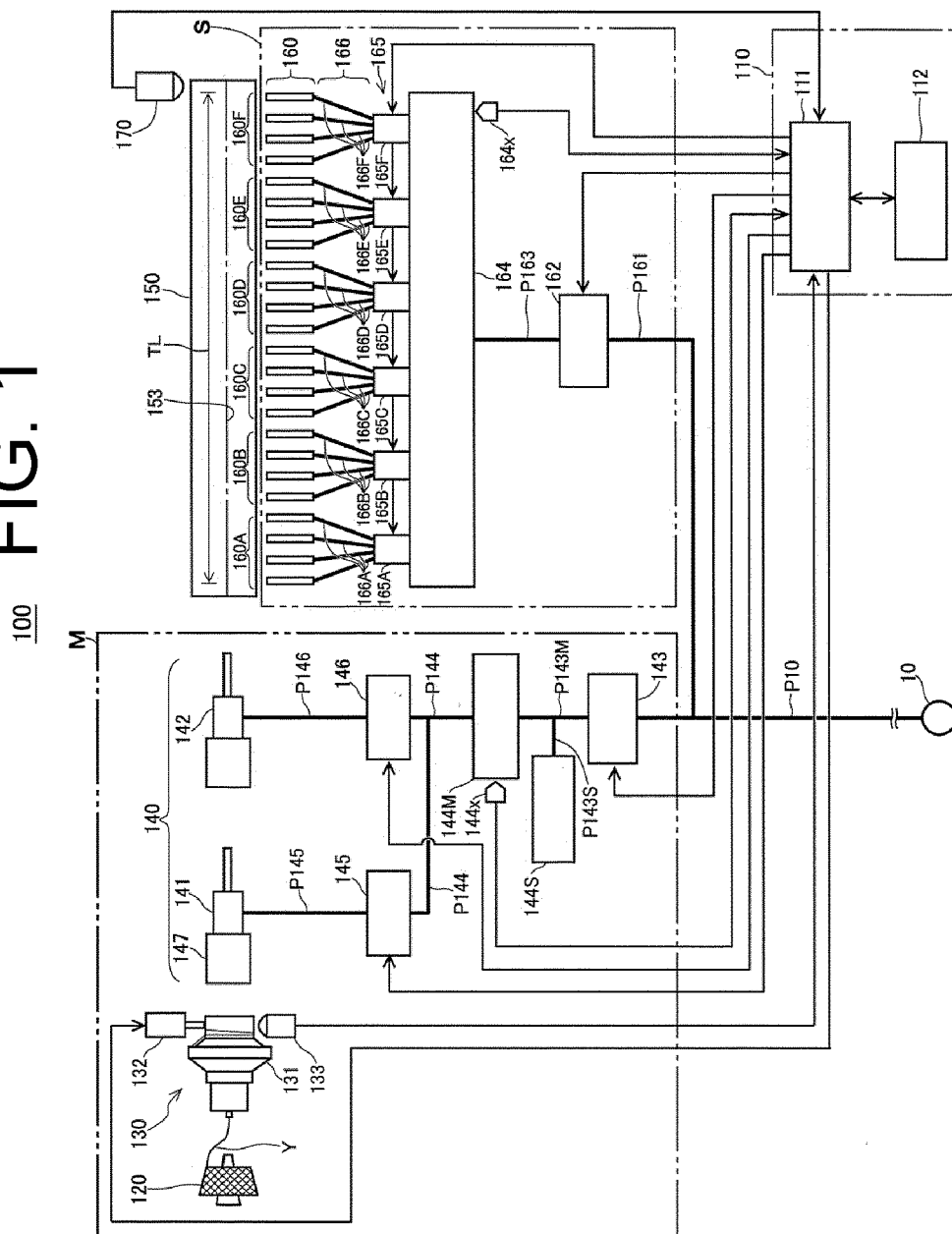


FIG. 2

143

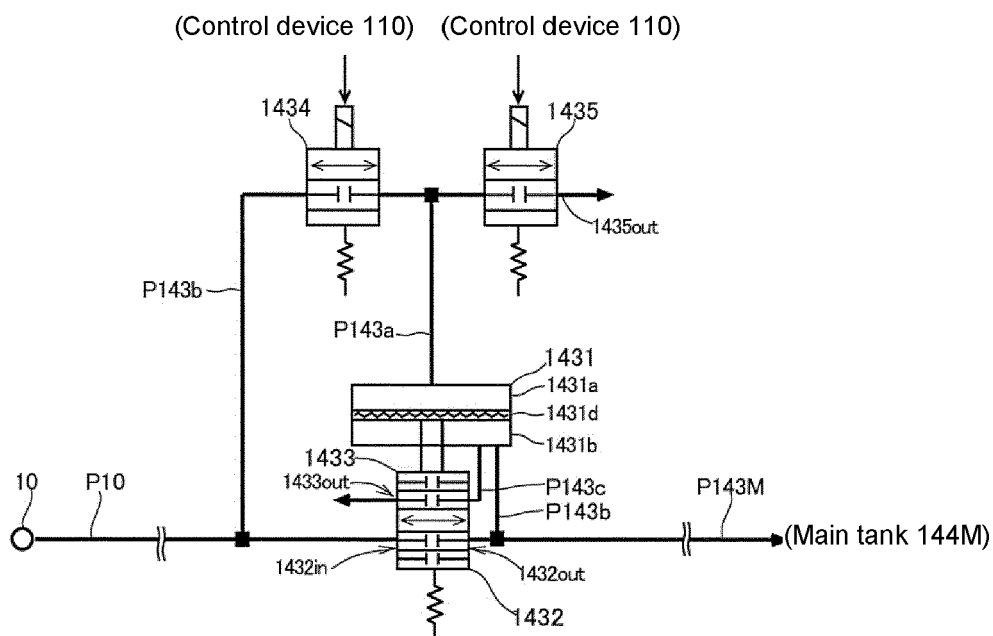


FIG. 3

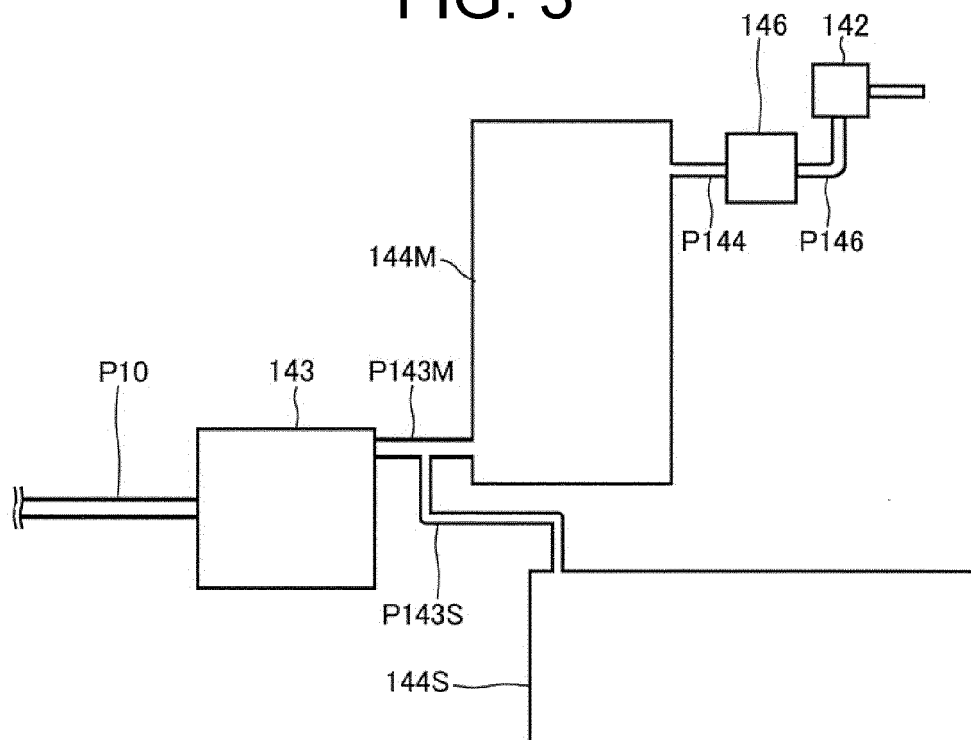


FIG. 4A

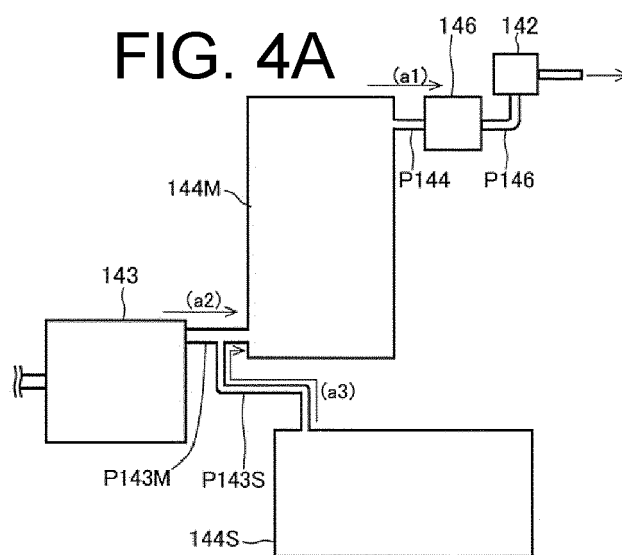


FIG. 4B

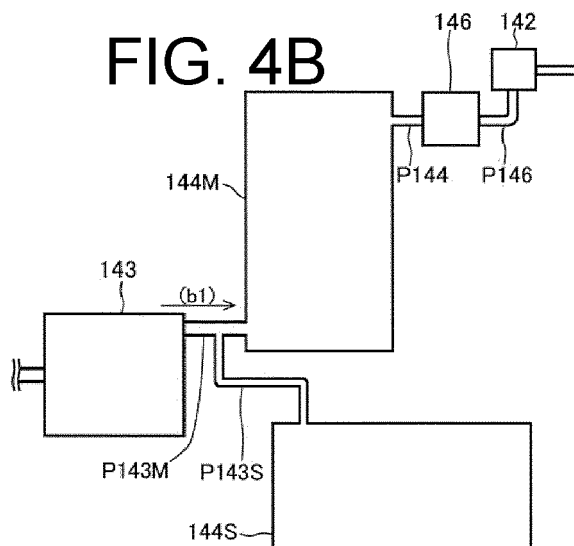


FIG. 4C

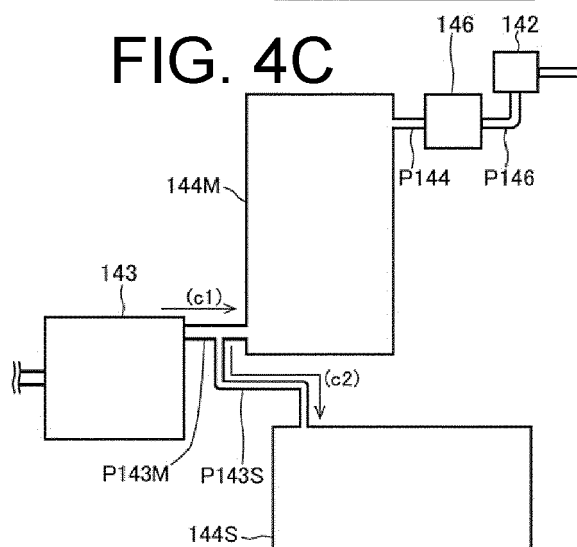


FIG. 5 (Background Art)

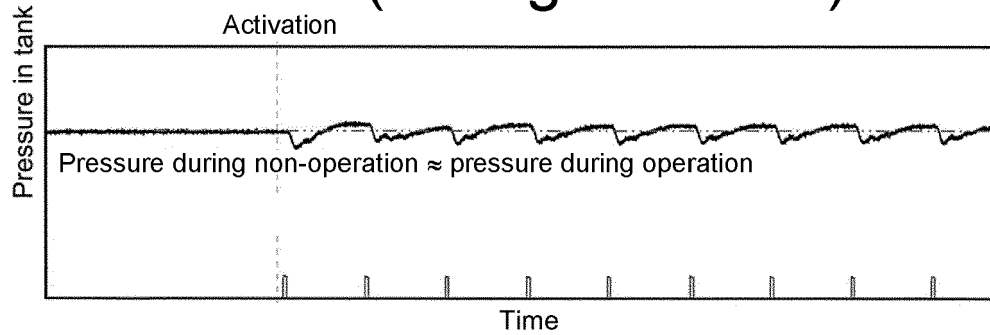


FIG. 6 (Background Art)

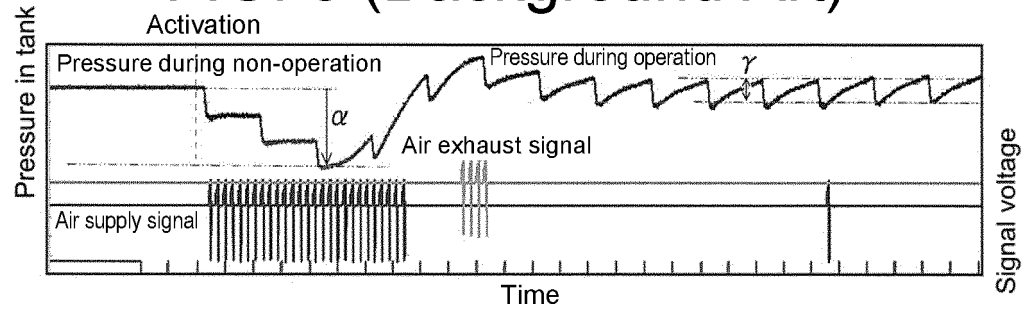


FIG. 7 (Background Art)

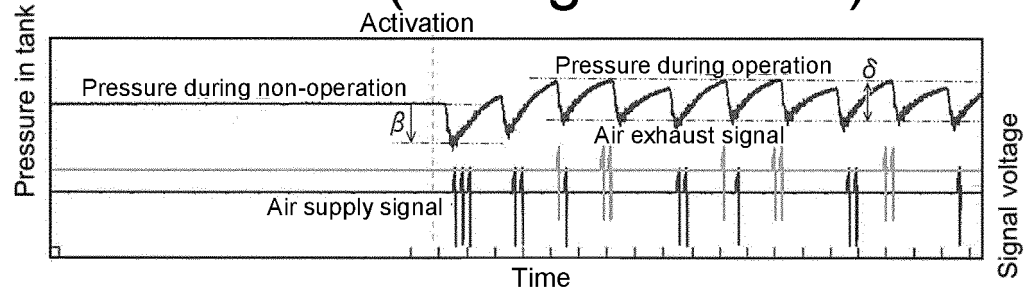


FIG. 8

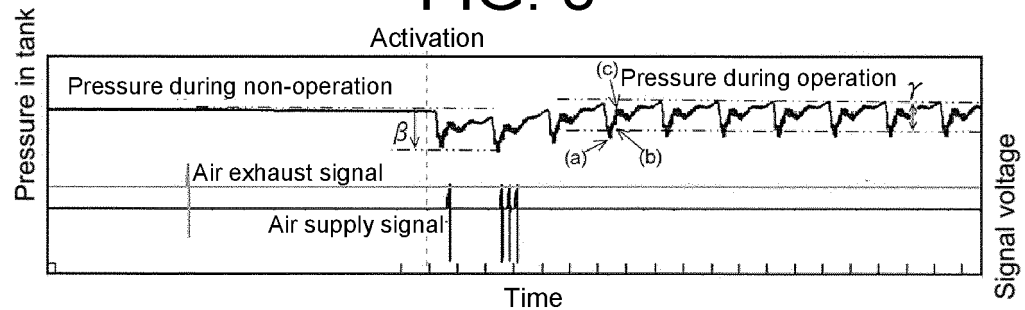


FIG. 9

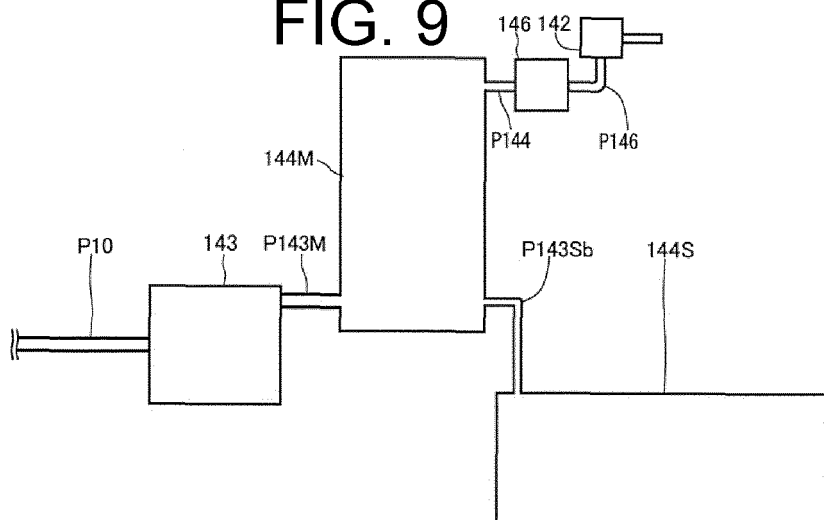


FIG. 10

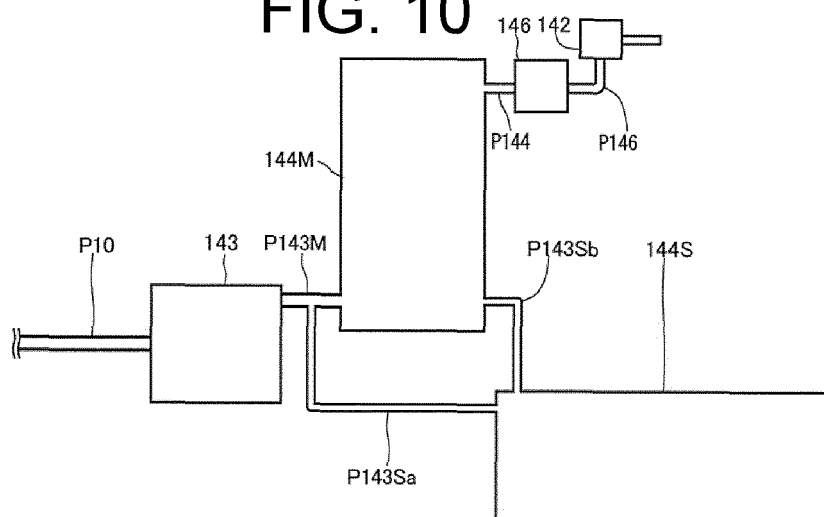
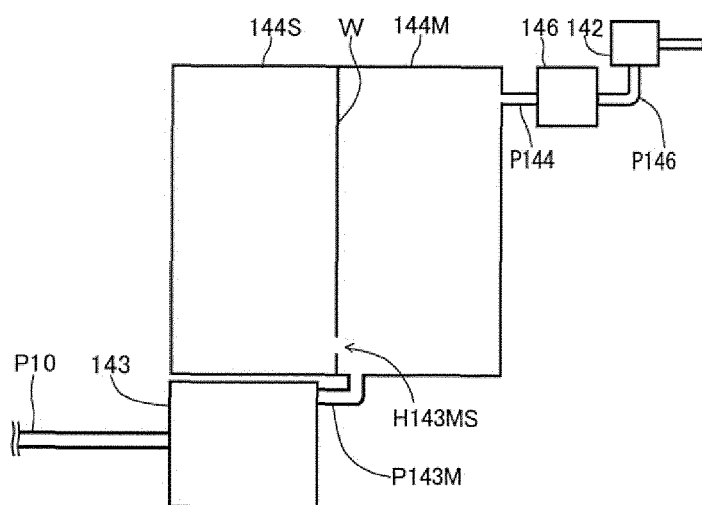


FIG. 11





EUROPEAN SEARCH REPORT

Application Number

EP 21 21 6249

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EPO FORM 1503 03.82 (P04C01)

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 352 869 B1 (PICANOL [BE]) 27 November 2013 (2013-11-27)	1, 2, 4	INV. D03D47/30
A	* paragraph [0029] - paragraph [0032] * * figure 2 *	3, 5	
X	US 4 932 442 A (ISHIDO TAKAO [JP] ET AL) 12 June 1990 (1990-06-12)	1	
A	* figure 6 * * column 5, line 34 - line 66 *	2-5	
X	US 4 967 806 A (IMAMURA SHUICHIRO [JP] ET AL) 6 November 1990 (1990-11-06)	1, 2	TECHNICAL FIELDS SEARCHED (IPC) D03D
A	* figure 1 * * column 6, line 19 - line 37 *	3-5	
The present search report has been drawn up for all claims			
Place of search Munich			
Date of completion of the search 30 May 2022		Examiner Hausding, Jan	
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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30-05-2022

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