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(71) Applicant: TSUDAKOMA KOGYO KABUSHIKI
KAISHA

Kanazawa-shi Ishikawa-Ken (JP)

(72) Inventor: Yoneda, Hidetomo
Ishikawa-ken (JP)

(74) Representative:

von Samson-Himmelstjerna, Friedrich R.,
Dipl.-Phys. et al

SAMSON & PARTNER

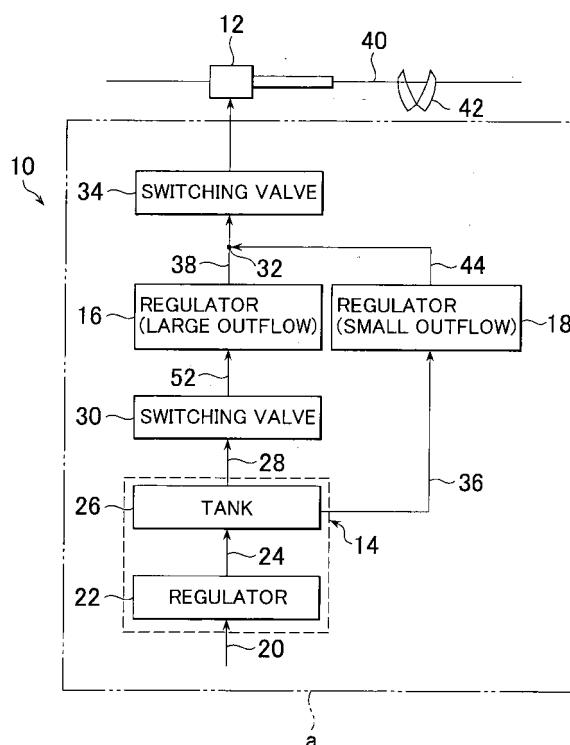
Widenmayerstrasse 5

80538 München (DE)

(54) Air supply apparatus for air jet loom

(57) The air supply apparatus includes a compressed air supply source (14); a first switching valve (30) connected with the compressed air supply source; at least one of first compressed air regulators (16, 58, 138, 140) connected with the first switching valve, in which at least one of the outflow quantity and the pressure of compressed air is set at a predetermined first set value; a second compressed air regulator (18, 68) connected with the compressed air supply source, wherein at least one of the outflow quantity and the pressure of compressed air is set at a second set value different from said first set value, the number of said second compressed air regulator being made equal to that of the first compressed air regulators; and a second switching valve (34, 62, 150, 152) connected with said first and second compressed air regulators, wherein the number of said second switching valves is made equal to or more than that of said first compressed air regulator. The second switching valve is connected with main nozzle (12, 50, 124, 126). The first switching valve is opened in a predetermined first period at the weft inserting time, and the second switching valve is opened in said first period as well as in the second period different from said first period.

FIG. 1



Description**BACKGROUND OF THE INVENTION**

5 1. Field of the Invention

[0001] The present invention is related to an air supply apparatus for supplying the air to a weft inserting nozzle, especially a main nozzle of an air jet loom.

10 2. Description of the Prior Art

[0002] A apparatus and technique for supplying the air to the main nozzle of the air jet loom are made known through various publications. Patent document 1 (p. 8, Fig. 1) is one of such publications and will be referred to as "Reference 1" or "Ref. 1" hereinafter.

15 **[0003]** According to this prior art (Ref. 1), the air supply apparatus as disclosed therein includes the first compressed air regulator (Ref. 1, Fig. 1, reference numeral 4), an air tank (Ref. 1, Fig. 1, reference numeral 5) connected with the first compressed air regulator, the first switching valve (Ref. 1, Fig. 1, reference numeral 6) connected with the air tank and at the same time, connected with a main nozzle (Ref. 1, Fig. 1, reference numeral 1), the second switching valve (Ref. 1, Fig. 1, reference numeral 17) connected with the air tank, and the second compressed air regulator (Ref. 1, Fig. 1, reference numeral 18) connected with the second switching valve and at the same time, connected with the main nozzle.

[0004] [Patent document 1] The Japanese Utility Model Public Disclosure No. 1-58678

25 **[0005]** According to the Reference 1, however, it includes the description to the effect that if the present device is applied to a multi-color type loom, each weft inserting nozzle may be provided with the device (see on page 8, lines 14 to 16 of Ref. 1). As will be apparent from this description, if the above-mentioned prior art is applied to a loom having a plurality of main nozzles, the total number of the first and second switching valves is equal to a value obtained by multiplying the number of switching valves (= 2 in case of the above prior art) necessary for one main nozzle by the number of main nozzles. In other word, the total number of the switching valve is proportional to the number of main nozzles.

30 **[0006]** Accordingly, as the number of the main nozzles increase, the space necessary for arranging switching valves can not help being widened and at the same time, the number of pipelines connected with switching valves, compressed air regulators and main nozzles is increased, thereby not only the inside structure of the air supply apparatus but also the control apparatus of the switching valve becoming complex very much.

35 **[0007]** Besides, if the number of pipelines is increased, the total length of them becomes longer, thus the jet pressure loss becoming larger. Furthermore, if the number of switching valves is increased, there is a possibility that electric troubles take place often in the control apparatus of switching valves, which would possibly makes the weft inserting unstable.

SUMMARY OF THE INVENTION

40 **[0008]** Accordingly, an object of the invention is to stabilize the weft inserting operation of the air jet loom by simplifying constitutional machines and tools like the switching valve and others which are indispensable for performing the weft inserting.

45 **[0009]** In view of defects in the prior art air supply apparatus as described above, i.e., inventor of this invention, have made every effort to develop a new air supply apparatus applicable to various air jet looms. What we aim at is for example an air supply apparatus which makes it possible not only to simplify the piping from the compressed air supply source to the main nozzle, but also to easily convert an air supply apparatus of the one type into that of the other type, for example, from a mono-color air jet loom to a multi-color air jet loom or vice versa. In other words, what we direct to is an air supply apparatus that can be used in common by an air jet loom of any type. As the results of our efforts, we now propose several new type air supply apparatus as follows.

50 **[0010]** The first air supply apparatus according to the invention includes: a compressed air supply source; a first switching valve connected with the compressed air supply source; at least one first compressed air regulators connected with the first switching valve, wherein at least one of the outflow quantity and the pressure of compressed air is set at a predetermined first set value; a second compressed air regulator connected with the compressed air supply source, wherein at least one of the outflow quantity and the pressure of the compressed air is set at a second set value different from the first set value, the number of the second compressed air regulator being equal to that of the first compressed air regulators; and a second switching valve connected with the first and second compressed air regulators, wherein the number of the second switching valves is made equal to or more than that of the first compressed air

regulator. The second switching valve is connected with main nozzle, the first switching valve is opened in a predetermined first period at the weft inserting time, and the second switching valve is opened in the first period as well as in the second period different from the first period.

[0011] Here, an expression "a predetermined first period at the weft inserting time" includes a predetermined period within the weft inserting period (i.e. from the start of the weft inserting to the end of it) as well as a whole period of the weft inserting.

[0012] In the first air supply apparatus, the second set value of the second compressed air regulator is set at a value lower than the first set value of the first compressed air regulator. If the second set value being set like the above, both of the first and second switching valves are opened in the first period. Accordingly, the compressed air from the compressed air supply source passes through the first compressed air regulator and is then jetted from the main nozzle in the state where the outflow quantity or the pressure of the compressed air is large. Besides, in the second period, as the first switching valve is closed while the second switching valve is opened, the compressed air from the compressed air supply source passes through the second compressed air regulator and is then jetted from the main nozzle in the state where the outflow quantity or the pressure of the compressed air is small. In short, the outflow quantity or the pressure of the compressed air jetted from the second switching valve can be changed by opening or closing only the first switching valve.

[0013] The effect of the first air supply apparatus is remarkably shown when increasing the number of main nozzles arranged in the air jet loom from one to more than two. That is, in order to increase the number of main nozzles, the first air supply apparatus may prepare branch lines connected with the output side of the first switching valves, two or more first and second compressed air regulators and the second switching valves, and connect each of first compressed air regulators with each of branch lines. Or the first air supply apparatus may prepare two or more branch lines receiving the output from the first and second compressed air regulators and branching off in each of two or more second switching valves, and connect each of second switching valves with each of main nozzles different from each other.

[0014] Accordingly, the first air supply apparatus installed in the air jet loom having two or more main nozzles can use the first switching valve as a common switching valve. In other words, if the first air supply apparatus is installed in the air jet loom having a plurality of main nozzles, the outflow quantity or the pressure of the compressed air jetted from the second switching valve can be changed by opening or closing only the common first switching valve. Because of this, comparing with the prior art air supply apparatus, the number of expensive switching valves in use can be effectively reduced, which leads to cost reduction as well as simplification of piping. Furthermore, reduction in the number of switching valves makes it possible to reduce electric trouble in the control apparatus, and simplification of piping makes it possible to reduce the loss in the jet pressure.

[0015] The second air supply apparatus according to the invention includes: a compressed air supply source; at least one of compressed air regulators connected with the compressed air supply source; and a switching valve connected with the compressed air regulator as well as with a main nozzle on the basis of one-to-one correspondence. The switching valve opens in the first period that is a predetermined period at the time of the weft inserting by means of the main nozzle as well as in the second period different from the first period, and the compressed air regulator controls at least one of the outflow quantity and the pressure of the compressed air supplied to the switching valve in correspondence with the first and second periods.

[0016] The second air supply apparatus is provided with the compressed air regulator capable of controlling the outflow quantity or the pressure of the compressed air. Because of this, the number of switching valves and compressed air regulator can be reduced comparing with the prior art air supply apparatus. Furthermore, reduction in the number of switching valves and compressed air regulators makes it possible to reduce the number of pipelines connecting them with each other, thus simplification of piping being realized.

[0017] The third air supply apparatus according to the invention includes: a compressed air supply source; and at least one of compressed air regulators connected with the compressed air supply source as well as with a main nozzle on the basis of one-to-one correspondence. The compressed air regulator controls at least one of the outflow quantity and the pressure of the compressed air supplied to the main nozzle based on the rotational angle as set in advance of the main shaft.

[0018] In the third air supply apparatus, as the compressed air regulator controls at least one of the outflow quantity and the pressure of the compressed air supplied to the main nozzle based on the rotational angle as set in advance of the main shaft, the compressed air from the compressed air supply source is outputted to the main nozzle via the compressed air controller capable of continuously controlling the outflow quantity or the pressure of the compressed air.

[0019] As the third air supply apparatus is provided with the compressed air controller capable of continuously controlling the outflow quantity or the pressure of the compressed air based on the rotational angle of the main shaft, the number of switching valves and the compressed air regulators can be reduced comparing with the prior art air supply apparatus, thus the jet control of the compressed air jetted from the switching valve being controlled only by the compressed air controller.

[0020] Reduction in the number of switching valves and compressed air regulators makes it possible to reduce the

number of pipelines connecting them with each other, thus the piping being simplified very much. Furthermore, reduction in the number of switching valves and compressed air regulators also simplifies the control function of the switching valve and the compressed air regulator as well.

[0021] The first through the third air supply apparatus further include piping for supplying the compressed air for use in full-time jetting to a main nozzle from the compressed air supply source. The value of the flow quantity or the pressure of the compressed air supplied to the main nozzle for use in full time jetting is preferably set at a value smaller than the set value of the compressed air regulator. In this way, the small quantity of the compressed air comes to be always jetted from the main nozzle. In other words, the compressed air comes to always flow inside the main nozzle in the weft inserting direction (i.e. direction from the weft storage unit side toward the side of the leading end portion of the weft). Therefore, the weft staying inside the main nozzle is prevented from coming out therefrom.

[0022] The first through the third air supply apparatus further include piping for connecting the second switching valve corresponding to a main nozzle with one or more auxiliary main nozzles for assisting the flight of weft at the time of the weft inserting. Auxiliary main nozzles are arranged between the main nozzle and the weft storage unit. With this arrangement, the weft as stored in the weft storage unit can be smoothly sent out toward the inside of the main nozzle, thereby the weft inserting being carried out surely.

[0023] In the first through the third air supply apparatus, the compressed air regulator includes at least one of throttle a valve and a regulator. Besides, the compressed air supply source includes at least one of a pressure source, an auxiliary compressed air regulator, and a compressed air tank.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Fig. 1 is a piping circuit diagram for use in an air supply apparatus according to the first embodiment of the invention.

Fig. 2 is a timing chart of the air supply apparatus as shown in Fig. 1.

Fig. 3 is a piping circuit diagram for use in an air supply apparatus according to the second embodiment of the invention.

Fig. 4 is a timing chart of the air supply apparatus as shown in Fig. 3.

Fig. 5 is a piping circuit diagram for use in an air supply apparatus according to the third embodiment of the invention.

Fig. 6 is a piping circuit diagram for use in an air supply apparatus according to the fourth embodiment of the invention.

Fig. 7 is one part of a piping circuit diagram for use in an air supply apparatus according to the fifth embodiment of the invention.

Fig. 8 is the other part of a piping circuit diagram as shown in Fig. 7, for use in an air supply apparatus according to the fifth embodiment of the invention.

Fig. 9 is a piping circuit diagram for use in an air supply apparatus according to the sixth embodiment of the invention.

Fig. 10 is a timing chart of the air supply apparatus as shown in Fig. 9.

Fig. 11 is a piping circuit diagram for use in an air supply apparatus according to the seventh embodiment of the invention.

Fig. 12 is a piping circuit diagram for use in an air supply apparatus according to the eighth embodiment of the invention.

Fig. 13 is a timing chart of the air supply apparatus as shown in Fig. 12.

Fig. 14 is a timing chart of the air supply apparatus according to the ninth embodiment of the invention.

Fig. 15 is a timing chart of the air supply apparatus according to the tenth embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] In Figs. 1, 3, 5, 6, 7, 8, 9 and 11 as will be explained in the following, each of arrowheads indicate the flow direction of the compressed air.

[0026] [First Embodiment: Air Supply Apparatus for Mono-Color Air Jet Loom]

[0027] Referring to Figs. 1 and 2, an air supply apparatus 10 is applicable to an air jet loom of the mono-color type having a single main nozzle 12

[0028] The air supply apparatus 10 uses a piping circuit including a piping unit "a" which connects two compressed air regulators 16 and 18 in parallel between a compressed air supply source 14 and the main nozzle 12. These compressed air regulators 16 and 18 are used at the weft inserting time and at the weft cutting time, respectively.

[0029] The compressed air supply source 14 includes a pressure source (not shown) such as a compressor, an

auxiliary compressed air regulator (referred to as "auxiliary regulator" hereinafter) 22 connected with the air outlet of the above pressure source through a pipeline 20, and a compressed air tank (merely referred to as "tank" hereinafter) 26.

[0030] A pipeline 28 extending from one of air outlets of the tank 26 is connected with the main nozzle 12, passing through a switching valve 30, the compressed air regulator 16, a confluent line 32 and a switching valve 34 in this order. Another pipeline 36 extending from another air outlet of the tank 26 is connected with the confluent line 32 located on the pipeline 38 extending from the compressed air regulator 16 through the compressed air regulator 18.

[0031] The auxiliary regulator 22 adjusts the pressure of the compressed air stored in the tank 26 while compressed air regulators 16 and 18 adjust the outflow quantity of the compressed air. The compressed air regulator 16 sets the outflow quantity of the compressed air therefrom at a little bit larger value while the air regulator 18 sets the outflow quantity of the compressed air therefrom at a value little bit smaller than the set value of the compressed air regulator 16.

[0032] The air jet loom provided with the air supply apparatus 10 operates as follows.

[0033] The compressed air supplied from the tank 26 is jetted from the main nozzle 12 toward a weft 40 lying inside the main nozzle 12, thereby the weft 40 coming to fly in the weft inserting direction (from the left to the right in Fig. 1).

[0034] The flying weft 40 is cut in a predetermined timing by a cutter 42 arranged on the yarn feeding side between the main nozzle 12 and a woven fabric (not shown), the predetermined timing being described later.

[0035] The jet operation of the air supply apparatus 10 is carried out, for example, according to a timing chart as shown in Fig. 2. This figure additionally shows the operation of cutter 42 on the yarn feeding side.

[0036] The weft inserting jet, which means an angular range within which the jetting is to be carried out by the main nozzle 12 at the weft inserting time (first period) during the air jet loom operation, is carried out in a weft inserting jet range M between 80° and 160° in terms of the crank angle θ . Cutting of the weft 40 is carried out in a cutting range between a crank angle θ of 20° and a value in the vicinity of it. The cutting jet, which means an angular range within which the jetting is to be carried out by the main nozzle 12 at the weft cutting time (second period) during the air jet loom operation, is carried out in a weft cutting jet range C between 340° and 30° in terms of the crank angle θ , including the above cutting range.

[0037] At the weft inserting jet time, switching valves 30 and 34 are opened at the same time. At the weft cutting jet time, however, the switching valve 30 is not opened while the switching valve 34 is opened.

[0038] The weft cutting jet is carried out for preventing the weft 40, which still remains on the yarn feeding side after being cut by the cutter 42 and projects the leading end of it from the main nozzle 12 in the weft inserting direction, from being withdrawn from the main nozzle 12 due to reaction against the tension given to the weft 40 at the reed beating-up time.

[0039] In other words, a large outflow quantity of the compressed air is required in order to let the weft 40 fly. In compliance with this requirement, in the weft inserting range M, both of switching valves 30 and 34 are opened and the outflow quantity of the compressed air is adjusted by the compressed air regulators 16 and 18, respectively. Then, the compressed air as adjusted by these regulators flows through two pipelines 38 and 44 to meet each other at the confluent line 32.

[0040] With this, a large quantity of the compressed air is supplied to the switching valve 34 and is also supplied to the main nozzle 12 by opening the switching valve 34, thereby the weft 40 being surely blown off by the compressed air jetted from the main nozzle 12.

[0041] When the weft 40 is cut off by the cutter 42, it sometimes happens that the weft 40 gets away from the main nozzle 12 due to reaction against the tension acting on the weft 40. In order to prevent this situation from happening, at the weft cutting time, the switching valve 30 is close while the switching valve 34 is opened, thus the small quantity of the compressed air as adjusted by the compressed air regulator 18 being jetted from the main nozzle 12. In this way, the weft 40 is prevented from being withdrawn from the main nozzle 12.

[0042] [Second Embodiment: Air Supply Apparatus for 2-Color Air Jet Loom]

[0043] Referring to Figs. 3 and 4, an air supply apparatus 46 is applicable to an air jet loom of the 2-color type and uses a piping circuit including a piping unit "b" in addition to the piping unit "a" of the air supply apparatus 10. The piping unit "b" connects the compressed air supply source 14 with the main nozzle 50 for flying another weft 48.

[0044] The air supply apparatus 46 includes a branch line 54 arranged on the pipeline 52 between the switching valve 30 and the compressed air regulator 16 in the piping unit "a". In the piping unit "b", a pipeline 56 extending from this branch line 54 is further extended downstream from the branch line 54 and is connected with the main nozzle 50 via a compressed air regulator 58, a confluent line 60, and a switching valve 62 in this order. A pipeline 64 extending from the third air outlet of the tank 14 is connected with the confluent line 60 arranged on a pipeline 66 extending from the compressed air regulator 58 through a compressed air regulator 68.

[0045] In other words, the compressed air regulators 58 and 68 are connected with the pipeline 56 extending from the branch line 54 and the pipeline 64 extending from the third air outlet of the tank 26, respectively. As a result, the compressed air regulators 58 and 68 come to be connected in parallel with each other between the tank 26 and the confluent line 60.

[0046] In the air supply apparatus 46, the compressed air regulators 58 and 68 are set such that the outflow quantity of the compressed air from each of them becomes the same as that from each of the compressed air regulators 16 and 18. That is, the outflow quantity of the compressed air from the compressed air regulator 58 is set at a little bit larger value while the outflow quantity of the same from the compressed air regulator 68 is set at a value a little bit smaller than the set value of the compressed air regulator 58.

[0047] Respective outflow quantities from the compressed air regulators 16, 58 and 18, 68 may be set at the same set values. Besides, Respective outflow quantities from the compressed air regulators 16, 58 and 18, 68 may be set at set values different from each other based on the characteristics of the wefts 40 and 48.

[0048] As described above, the air supply apparatus 46 for use in the 2-color air jet loom is provided with the piping unit "b" for use in another main nozzle 50 in addition to the piping unit "a" in the air supply apparatus 10, the piping unit "b" including the pipeline 56 extending from the branch line 54, the pipeline 64 extending from the tank 26, the compressed air regulator 58 and 68 connected in parallel between the tank 26 and the confluent line 60, and the switching valve 62.

[0049] In other words, in the air supply apparatus 46, the switching valve 30 is owned in common by any pipeline extending toward main nozzles 12 and 50 from the tank 26. Accordingly, as the air supply apparatus 46 has the pipeline units "a" and "b" which owns the switching valve 30 in common, there is no need for the switching valve to be prepared in proportion to the number of the main nozzles, thus the number of the switching valves being reduced comparing with the prior art air supply apparatus.

[0050] Here, it is assumed that there are three air supply apparatus of which each is required to supply the compressed air to three air jet looms having 2-main nozzle, 4-main nozzle, and 6-main nozzle, respectively. Table 1 shows the relation between the number of main nozzles and the number of switching valves needed at the weft inserting time as well as at the weft cutting time. As shown by the Table 1, the number of switching valves to be arranged for the weft inserting between the main nozzle and the compressed air regulator becomes equal to the number of main nozzles regardless of the air supply apparatus according to the invention and the prior art. However, in case of the weft cutting, the number of switching valves to be arranged for the weft cutting between the compressed air supply source and the compressed air regulator is reduced to only one regardless of the number of main nozzles. Accordingly, even if the number of main nozzles is increased, increase in the total number of switching valves in the air supply apparatus 10 can be effectively suppressed comparing with the prior art.

Table 1

SORT OF SWITCHING VALUE	NOS. OF MAIN NOZZLE	NECESSARY NOS. OF SWITCHING VALUE	
		PRIOR ART	INVENTION
FOR WEFT INSERTING	2	2	2
	4	4	4
	6	6	6
FOR CUTTING	2	2	1
	4	4	
	6	6	

[0051] The jet operation of the air supply apparatus 46 is carried out, for example, according to a timing chart as shown in Fig. 4.

[0052] Similar to the air supply apparatus 10, the main nozzle carries out the weft inserting jet within the weft inserting jet range M, that is, within the range of the crank angle θ . Besides, as the air supply apparatus 46 is used in the 2-color air jet loom, either main nozzle 12 or 50 corresponding to the objective weft to be weft-inserted carries out the weft inserting jet within the weft inserting jet range M in every weft inserting cycle.

[0053] First of all, in the weft inserting jet range M of the first cycle as shown in Fig. 4, the switching valves 30 and 34 are opened in the state where the switching valve 62 is closed. In this state, a large outflow quantity of the compressed air is jetted from the main nozzle 12, thereby the weft 40 being blown off accurately in the weft inserting direction. At this time, the outflow quantity of the compressed air from the compressed air regulators 16 and 18 is respectively adjusted so as to be suitable for the flight of the weft 40.

[0054] In the next, in the weft cutting jet range C of first cycle as shown in Fig. 4, the switching valve 34 is opened in the state where the switching valves 30 and 62 are closed. In this state, a small outflow quantity of the compressed air is jetted from the main nozzle 12 and the weft 40 is cut off by the cutter 42. At this time, the outflow quantity of the compressed air from the compressed air regulator 18 is adjusted so as to be suitable for cutting the weft 40.

[0055] Furthermore, in the weft inserting jet range M of the second cycle as shown in Fig. 4, the switching valves 30 and 62 are opened in the state where the switching valve 34 is closed. In this state, a large quantity of the compressed air is jetted from the main nozzle 50, thereby the weft 48 being blown off from the main nozzle 50 accurately in the weft inserting direction. At this time, the outflow quantity of the compressed air from the compressed air regulators 58 and 68 are respectively adjusted so as to be suitable for the flight of the weft 48.

[0056] Still further, in the weft cutting jet range C of the second cycle as shown in Fig. 4, the switching valve 62 is opened in the state where the switching valves 30 and 34 are closed. In this state, a small quantity of the compressed air is jetted from the main nozzle 50 and the weft 48 is cut off by a cutter 70 arranged between main nozzle 50 and a fabric under the semi-woven condition. However, the weft 48 may be cut by the cutter 42 in place of the cutter 70. At this time, the outflow quantity of the compressed air from the compressed air regulator 68 is adjusted so as to be suitable for cutting the weft 48.

[0057] In the example as shown in Fig. 4, the air supply apparatus 46 repeats the operation in the first and second cycles as described above.

[0058] In the air supply apparatus 46, the outflow quantity of the compressed air jetted from main nozzles 12 and 50 can be adjusted separately by means of compressed air regulators 16 and 58 for use in the weft inserting as well as by compressed air regulators 18 and 68 for use in the weft cutting in response to wefts 40 and 48. Thus, the air supply apparatus 46 can be used not only for the weft inserting of the same kind of weft but also for the weft inserting of the different kinds of wefts. Accordingly, the air jet loom adopting the air supply apparatus 46 can increase the number of kinds of wefts which the air jet loom can deal with.

[0059] [Third Embodiment: Air Supply Apparatus for 2-Color Air Jet Loom]

[0060] Referring to Fig. 5, an air supply apparatus 72 is applicable to an air jet loom of the 2-color type and uses a piping circuit including a piping unit "c" in addition to the piping unit "a" of the air supply apparatus 10. The piping unit "c" is connected with the main nozzle 50 for blowing off the weft 48.

[0061] In the air supply apparatus 72, a pipeline 74 acting as a branch line is connected with the confluent line 32 of the air supply apparatus 10 (Fig. 1), thus the confluent line 32 being used as a confluent/branch line 76. The pipeline 74 is connected with the main nozzle 50 through the switching valve 62. In the air supply apparatus 72, however, it may be possible to connect the pipeline 74 acting as a branch line with a pipeline extending from the confluent line 32 of the air supply apparatus 10 to the main nozzle 12, thereby making the vicinity of the confluent line 32 and the pipeline 74 act as a confluent/branch line 76.

[0062] As the switching valve 62 is directly connected with the confluent/branch line 76 without passing through compressed air regulators 58, 68 as shown in Fig. 3, the outflow quantity of the compressed air supplied to the switching valve 62 becomes almost equal to that which is supplied to the switching valve 34. Accordingly, the air supply apparatus 72 is suitably applicable to an air jet loom of the type wherein the same kind of the wefts 40 and 48 are weft-inserted from the main nozzles 12 and 50, respectively.

[0063] The air supply apparatus 72 has neither the compressed air regulator 58 nor 68 as shown in Fig. 3. Accordingly, the piping circuit of the air supply apparatus 72 is much simplified comparing with the air supply apparatus 46. Besides, it may be allowed that either the compressed air regulator 58 or 68 is used in common.

[0064] The jet operation of the air supply apparatus 72 is carried out, for example, according to a timing chart as shown in Fig. 4.

[0065] [Fourth Embodiment: Air Supply Apparatus with Auxiliary Main Nozzle for 2-Color Air Jet Loom]

[0066] Referring to Fig. 6, an air supply apparatus 78 uses a piping circuit which includes the piping units "a" and "b" of the air supply apparatus 46 (Fig. 3), the piping units "d" and "e" which are connected with compressed air regulators 80 and 82 for use in full-time jetting, respectively, and at the same time, it uses a duplex main nozzle 84 having two main nozzles 12 and 50.

[0067] A pipeline 86 which extends from the tank 26 to compressed air regulators 18 and 68 and acts as a common flow channel, branches off in compressed air regulators 18 and 68 through a branch line 88. Pipelines 44 and 90 extending from respective air outlets of compressed air regulators 18 and 68 are connected with confluent lines 32 and 60, respectively.

[0068] A branch line 92 is arranged on the pipeline 86 between the tank 26 and the branch line 88. Pipelines 94 and 96 extending from this branch line 92 are respectively connected, though compressed air regulators 80 and 82, with confluent lines 102 and 104 which are respectively arranged on pipelines 98, 100 between switching valves 34, 62 and main nozzles 12, 50.

[0069] The piping circuit of the air supply apparatus 78 includes branch lines 106, 108 arranged on pipelines 98, 100 extending from branch lines 102, 104 to main nozzles 12, 50. Pipelines branching off and extending in one direction from branch lines 106, 108 are respectively connected with main nozzles 12 and 50 while the pipelines 110, 112 extending in the other direction are connected with auxiliary main nozzles 114 and 116, respectively.

[0070] Accordingly, the air supply apparatus 78 includes piping units "d" and "e" which supply the compressed air supplied from the tank 26 to the main nozzles 12, 50 as well as the auxiliary main nozzles 114, 116 through compressed

air regulators 80 and 82.

[0071] According to the piping circuit of the air supply apparatus as described above, it becomes possible for main nozzles 12, 50 and auxiliary nozzles 114, 116 to carry out the full-time jetting of the compressed air, of which the outflow quantity is adjusted by the compressed air regulators 80 and 82. Accordingly, wefts 40 and 48 inserted into main nozzles 12, 50 and auxiliary main nozzles 114, 116 as well are prevented from being withdrawn from main nozzles 12, 50 and auxiliary main nozzles 114 and 116 in the direction opposite to the weft inserting direction.

[0072] The regulators 80 and 82 are set such that their set values become smaller than the set value of every compressed air regulator 16, 58, 18 and 68. However, the set value of compressed air regulators 80 and 82 may be set at a value equal to the set value of any one of compressed air regulators 16, 58, 18 or 68.

[0073] In the air supply apparatus 78, the piping circuit between the compressed air supply source 14 and main nozzles 12, 50 includes the following three minor piping circuits as arranged in parallel. That is: (1) the first minor piping circuit for use in weft inserting, which is made up of the common switching valve 30, compressed air regulators 16, 58 as adjusted so as to give a large outflow quantity, and switching valves 34, 62; (2) the second minor piping circuit for use in weft cutting, which is made up of compressed air regulators 18 and 68 as adjusted so as to give a small outflow quantity and switching valves 34 and 62; and (3) the third minor piping circuit for use in full-time jetting which is made up of compressed air regulators 80 and 82 as adjusted so as to give a very small outflow quantity.

[0074] In the air supply apparatus 78 like above, minor piping circuits having the compressed air supply source 14 and compressed air regulators 18, 68 and 80, 82 have a common pipeline 86. Accordingly, the piping circuit of the air supply apparatus 78 is simplified to a great extent.

[0075] In Fig. 6, branch lines 54, 88, 92, 106 and 108 as indicated by a black circle (dot) have no check valve. On the other hand, confluent lines 32, 60, 102 and 104 as indicated by a black triangle have a check valve for blocking up a flow (reverse flow) to corresponding compressed air regulators 16, 18, 58, 68, 80 and 82.

[0076] As shown in Fig. 6, no compressed air regulator is included in the piping formed between confluent lines 102, 104 and the branch lines 106 and 108 respectively connected with auxiliary main nozzles 114, 116 as well as with main nozzles 12, 50. Accordingly, the air supply apparatus 78 may additionally have the function of measuring the pressure of the compressed air within the piping in the area indicated by a dotted line surrounding each of confluent lines 102 and 104, and of adjusting the outflow quantity of the compressed air at compressed air regulators 16, 18, 58, 68, 80 and 82 on the basis of the above measured pressure.

[0077] In the air jet loom provided with the air supply apparatus 78, wefts 40 and 48 are inserted into main nozzles 12 and 50 through auxiliary main nozzles 114 and 116, respectively, and are jetted from auxiliary main nozzles 114 and 116 toward the duplex main nozzle 84 as soon as the switching valves 34 and 62 are opened.

[0078] The jet timing of the compressed air from auxiliary main nozzle 114 and 116 is the same as that from main nozzles 12 and 50. The compressed air jet from auxiliary main nozzle 114 and 116 and main nozzles 12 and 50 as well is carried out according to the timing chart as shown in Fig. 4, for instance.

[0079] [Fifth Embodiment: Air Supply Apparatus with Auxiliary Main Nozzle for 4-Color Air Jet Loom]

[0080] Referring to Figs. 7 and 8, an air supply apparatus 118 is applicable to an air jet loom of the 4-color type having 4 main nozzles as well as 4 auxiliary main nozzles corresponding thereto. The air supply apparatus 118 uses a piping circuit which includes piping units "f" and "g" respectively connected with main nozzles 124, 126 as well as with auxiliary main nozzles 128, 130 for use in the weft inserting of wefts 120 and 122, in addition to piping units "a", "b", "d" and "e" of the air supply apparatus 78 as shown in Fig. 6. (signs "a", "b", "d" and "e" are shown in neither Fig. 7 nor 8).

[0081] Piping units "f" and "g" has a branch line 132 on the pipeline extending from the switching valve 30 to the branch line 52. Pipelines 134 and 136 extending downstream from this branch line 132 are connected with main nozzles 124 and 126, respectively, via compressed air regulators 138, 140, confluent lines 142, 144, branch lines 146, 148, switching valves 150, 152, and confluent lines 154, 156, respectively, in this coder.

[0082] In the fourth embodiment as shown in Fig. 6, auxiliary main nozzles 114, 116 are connected, through pipelines 110, 112, with branch lines 106, 108 arranged on pipelines 98, 100 extending from switching valves 34, 62. Instead of this, in the fifth embodiment as shown Figs. 7 and 8, auxiliary main nozzles 114, 116 are connected, through switching valves 166, 168, with pipelines 170, 172 extending from branch lines 162, 164 arranged on pipelines 158, 160 between confluent lines 32, 60 and switching valves 34, 62.

[0083] On one hand, auxiliary main nozzles 128, 130 are connected respectively with pipelines 178, 180, which extend from branch lines 146, 148 through switching valves 174, 176.

[0084] Pipelines 186, 188, which extend from branch lines 182, 184 arranged on pipelines 44, 90 between compressed air regulators 18, 68 and confluent lines 32, 60, are connected respectively with confluent lines 142, 144 arranged on pipelines 134, 136 between compressed air regulators 138, 140 and branch lines 146, 148.

[0085] Pipelines 194, 196, which extend from branch lines 190, 192 arranged on pipelines 94, 96 between compressed air regulator 80, 82 and branch lines 102, 104, are connected respectively with confluent lines 154, 156, which are arranged on pipeline 134, 136 between switching valves 150, 152 and main nozzles 124, 126.

[0086] Similarly, in the air supply apparatus 118, the piping circuit between the compressed air supply source 14 and main nozzles 12, 50, 124, 126 and the compressed air supply source 14 includes the following three minor piping circuits as arranged in parallel. That is: (1) the first minor piping circuit for use in weft inserting which is made up of the common switching valve 30, compressed air regulators 16, 58, 138 and 140 as adjusted so as to give a large outflow quantity, and switching valves 34, 62, 150 and 152; (2) the second minor piping circuit for use in the weft cutting which is made up of compressed air regulators 18 as adjusted so as to give a small outflow quantity and used in common by main nozzles 12, 124, compressed air regulators 68 as adjusted so as to give a small outflow quantity and used in common by main nozzles 50 and 126; and switching valves 34, 62, 150 and 152; and (3) the third minor piping circuit for use in full-time jetting which is connected through compressed air regulators 80 and 82 as adjusted so as to give a very small outflow quantity.

[0087] Similarly, in the air supply apparatus 118, the piping circuit between auxiliary main nozzles 114, 116, 128 and 130 and the compressed air supply source 14 includes the following three minor piping circuits as arranged in parallel. That is: (1) the first minor piping circuit for use in the weft inserting which is made up of the common switching valve 30, compressed air regulators 16, 58, 138 and 140 as adjusted so as to give a large outflow quantity, and switching valves 166, 168, 174 and 176; (2) the second minor piping circuit for use in the weft cutting which is made up of the compressed air regulators 18 as adjusted so as to give a small outflow quantity and used in common by auxiliary main nozzles 114, 128, and the compressed air regulators 68 as adjusted so as to give a small outflow quantity and used in common by auxiliary main nozzles 116, 130, and switching valves 166, 168, 174 and 176; and (3) the third minor piping circuit for use in full-time jetting which is connected through compressed air regulators 80 and 82 adjusted so as to give a very small outflow quantity.

[0088] In the above air supply apparatus 118, the set value of compressed air regulators 138 and 140 is set at a value equal to those of the compressed air regulators 16 and 58. However, the set value of compressed air regulators 138 and 140 may be set at a value different from the set value of the compressed air regulators 16 and 58 in response to the characteristics of wefts 120 and 122 if needed.

[0089] For example, assuming that the air supply apparatus 118 makes the main nozzle carry out one round of its jet operation in the period equivalent to the first and second cycles as shown in Fig. 4, the main nozzles 12, 50 carry out their jet operation in the first round while the main nozzles 124, 126 carry out their jet operation in the second round. Besides, auxiliary main nozzles carry out their jet operation so as to meet the jet operation of the corresponding main nozzles at any time.

[0090] The jet timing of auxiliary main nozzles 114, 116, 128 and 130 can be made independent of that of main nozzles 12, 50, 124 and 126 by opening or shutting switching valves 166, 168, 174 and 176. The jet range of auxiliary main nozzles 114, 116, 128 and 130 corresponding to switching valves 166, 168, 174 and 176 is preferably within the range of $80^\circ \sim 120^\circ$ in terms of the crank angle θ .

[0091] As described above, each of air supply apparatus 46, 72, 78 and 118 can be formed by adding a predetermined piping circuit to the piping unit "a" of the air supply apparatus 10. Accordingly, the air jet loom of the mono-color type can be converted into the air jet loom of the multi-color type with ease. Furthermore, it becomes possible to simplify the piping circuit structure between the compressed air supply source 14 and the main nozzle.

[0092] [Sixth Embodiment: Air Supply Apparatus for Mono-Color Air Jet Loom]

[0093] Referring to Figs. 9 and 10, an air supply apparatus 198 uses a piping unit "h" as a piping circuit, the piping unit "h" being provided with a compressed air regulator 200 of the variable type wherein the effluent quantity of the compressed air is variably controlled at any time when needed.

[0094] The air supply apparatus 198 is an air supply apparatus for use in an air jet loom of the mono-color type having only one main nozzle 202. The piping circuit of the air supply apparatus 198 includes a pressure source (not shown), a regulator 204, a tank 206, a compressed air regulator 200, and a switching valve 210, which are connected in series with each other in this order toward the downstream side with the help of a plurality of necessary pipelines 212. The regulator 204 and the tank 206 constitute a compressed air supply source 208. The switching valve 210 is connected with the main nozzle 202 through the pipeline 212.

[0095] Besides, the air supply apparatus 198 further includes a pipeline 218 for use in full-time jetting, which extends from a compressed air supply source for use in full-time jetting (not shown) and is connected, via a regulator 214, with a confluent line 216 arranged between the switching valve 210 and the main nozzle 202. The compressed air for use in full-time jetting may be obtained from the compressed air supply source 208 by connecting the pipeline 218 therewith and using the compressed air supply source 208 in common.

[0096] The jet operation of the air supply apparatus 198 is carried out according to the timing chart as shown in Fig. 10, for instance. In other words, the weft inserting jet from the main nozzle 202 is carried out in the weft inserting jet range M of $80^\circ \sim 160^\circ$ in terms of the crank angle θ . The weft cutting jet is carried out in the weft cutting jet range C of $340^\circ \sim 30^\circ$ in terms of the crank angle θ .

[0097] Accordingly, the switching valve 210 is opened in the weft inserting jet range M as well as in the weft cutting jet range C. On one hand, the compressed air regulator 200 makes the outflow quantity of the compressed air large

or small in correspondence with the weft inserting jet range M and the weft cutting jet range C. The outflow quantity of the compressed air from the compressed air regulator 200 is adjusted in a moment based on a signal from a command device (not shown) having received the data as to the crank angle θ .

[0098] As the pipeline 218 for use in the full-time jetting is connected directly with the main nozzle 202, the main nozzle 202 jets the compressed air of which the pressure is always adjusted by the regulator 214, regardless of the crank angle θ . The pipeline 218 for use in the full-time jetting and the regulator 214 may be omitted.

[0099] In the piping circuit of the air supply apparatus 198, the number of switching valves 214 is reduced comparing with that in the piping circuit of the air supply apparatus 10 as shown in Fig. 1, thus the entire structure of the piping circuit being simplified.

[0100] [Seventh Embodiment: Air Supply Apparatus for 2-Color Air Jet Loom]

[0101] Referring to Fig. 11, an air supply apparatus 220 is applicable to an air jet loom of the 2-color type and uses a piping circuit including a newly added main nozzle 222. The air supply apparatus 220 is an air supply apparatus for use in an air jet loom of the 2-color type converted from the air supply apparatus 198.

[0102] A pipeline 224 extending from the tank 206 of the compressed air supply source 208 is connected in series with the main nozzle 222 via a compressed air regulator 226, a switching valve 228, and a confluent line 230 in this order. In other words, switching valves 210, 228 are connected respectively with compressed air regulators 200, 226 as well as with main nozzles 202, 222 on the basis of one-to-one correspondence.

[0103] A pipeline 234 extending from a branch line 232 arranged on the pipeline 218 between the regulator 214 and the confluent line 216 is connected with the confluent line 230 arranged on the pipeline 224 between the switching valve 228 and the main nozzle 222.

[0104] The air supply apparatus 220 is able to separately adjust the outflow quantity of the compressed air jetted from main nozzles 202, 222 by variously changing the respective set value on the outflow quantity of the compressed air from compressed air regulators 200, 226. Accordingly, the air jet loom provided with the air supply apparatus 220 makes it possible to carry out the weft inserting with different wefts.

[0105] In the air supply apparatus 220, if weaving is performed with the same sort of wefts, it is preferable that the respective set values of the outflow quantity of the compressed air from compressed air regulators 200, 226 are set at a value identical to each other. In this case, the piping circuit of the air supply apparatus 220 is changed such that the compressed air regulator 226 is omitted and the pipeline 224 is changed so as to connect itself with the main nozzle 222 and the compressed air regulator 200 via the switching valve 228. In this way, the number of the compressed air regulators in the piping circuit of the air supply apparatus 220 can be reduced and is further simplified.

[0106] [Eighth Embodiment: Air Supply Apparatus for Mono-Color Air Jet Loom]

[0107] Referring to Figs. 12 and 13, an air supply apparatus 236 is applicable to an air jet loom of the mono-color type. In this air supply apparatus, a pipeline 244 extending from a compressed air supply source 242 is connected with a main nozzle 248 through a compressed air controller 246 capable of controlling the outflow quantity of the compressed air from zero up to the maximum outflow quantity. Accordingly, setting the outflow quantity of the compressed air at zero takes the same effect as shutting off the outflow of the compressed air by closing the switching valve.

[0108] The compressed air controller 246 adjusts the outflow quantity of the compressed air supplied from the compressed air supply source 242 based on a command signal from a command device 254, which receives the output signal from an encoder 252 measuring the rotational angle of the main shaft 250. The adjusted outflow quantity of the compressed air is supplied to the main nozzle 248.

[0109] The command device 254 obtains a crank angle θ based on the rotational angle of the main shaft 250 and outputs the command signal based on the crank angle θ . The encoder 252 measures the rotational angle of the main shaft 250 but it may measure the crank angle θ directly instead of measuring the rotational angle of the main shaft 250.

[0110] The jet operation of the air supply apparatus 236 is carried out according to the timing chart as shown in Fig. 13, for instance. The compressed air controller 246 continuously changes the outflow quantity from the compressed air supply 242 based on the crank angle θ , that is, a predetermined large outflow quantity in the weft inserting range M, a predetermined small outflow quantity in the weft cutting range C, and a predetermined very small outflow quantity for full-time jetting, as the other range than the above.

[0111] [Ninth Embodiment: Air Supply Apparatus for Mono-Color Air Jet Loom]

[0112] Referring to Fig. 14, the air supply apparatus 236 as shown in Fig. 12 can variously change the timing of jetting the compressed air.

[0113] At the weft inserting time, in the first half range M1 of the weft inserting range M, as the weft inserting has to be carried out by using the main nozzle 248 only, the outflow quantity of the compressed air to be jetted from the main nozzle 248 has to be large.

[0114] Comparing with this, being inserted into the warp shed, the weft is carried through the inside of the warp shed with compressed air jetted from the main nozzle 248 as well as from subnozzles (not shown). Therefore, the outflow quantity of the compressed air used by the main nozzle 248 may be allowed to be small.

[0115] Therefore, the air supply apparatus 236 controls the compressed air controller 246 such that the outflow

quantity of the compressed air used by the main nozzle 248 is controlled in two steps, to put it more concretely, the outflow quantity of the compressed air for use in the weft inserting is made large in the first half range M1 of the weft inserting range M while in the latter half range M2 of the weft inserting range M, the outflow quantity is made smaller than that in the first half range M1.

[0116] However, if the outflow quantity is improperly or abruptly reduced in the latter half range M2, there is a possibility that the weft inserting error might take place depending on the using condition of the weft. In order to avoid this, therefore, the air supply apparatus 236 may control the compressed air controller 246 such that the outflow quantity used by the main nozzle 248 is changed not in two steps but in three or more steps, or on the non-step basis, in other words, on the continuous basis.

[0117] Besides, the command device 254 may instruct the compressed air controller 246 to reduce the outflow quantity of the compressed air to zero while the weft inserting is finished (e.g. the range of $240^{\circ} \sim 340^{\circ}$ in terms of the crank angle θ in Fig. 14). In this way, it becomes possible to reduce the whole quantity of the compressed air consumed by the air supply apparatus 236.

[0118] [Tenth Embodiment: Air Supply Apparatus for 2-Color Air Jet Loom]

[0119] As shown in Fig. 15, the air supply apparatus 256 is applicable to an air jet loom of the 2-color type and is made up of the piping circuit of the air supply apparatus 236 as shown in Fig. 12 and a new pipeline connected with a main nozzle 258 for use in the weft inserting.

[0120] This new pipeline 260 extending from the compressed air supply source 242 is connected with the main nozzle 258 through a compressed air controller 262.

[0121] Receiving command signals for use in main nozzle 248 and 258, the command device 254 outputs them to compressed air controllers 246 and 262, respectively.

[0122] Similarly, in case of applying the air supply apparatus 256 to 3 or more-color air jet loom, three or more pipelines having the compressed air controller one each are prepared so as to correspond to the number of main nozzles on the one-to-one basis and separately connected with the compressed air supply source 242. In this case, the compressed air controller may be used in common.

[0123] [Other Embodiments]

[0124] It would not be necessary to newly explain that the air supply apparatus according to the 6th through 10th embodiments may be provided with the auxiliary main nozzle as described in connection with the 4th and 5th embodiments.

[0125] In all the embodiments as described above, it would be also unnecessary to newly describe that a check valve may be placed on the outlet side of the compressed air regulator and the compressed air controller.

[0126] In all the embodiments as described above, it has been described that the outflow quantity of the compressed air is set by the compressed air regulator and the compressed air controller. It may be possible, however, that instead of the outflow quantity of the compressed air, the pressure of the same is set by the compressed air regulator and the compressed air controller. Furthermore, the compressed air regulator and the compressed air controller for use in setting the outflow quantity may coexist with the compressed air regulator and the compressed air controller for use in setting the pressure. Still further, the compressed air regulator and the compressed air controller are set by other means, for example, the throttle angle, the opening degree, and so forth.

[0127] Besides, in the above embodiments, the second period is described as a period for use in the weft cutting while the air jet loom is in operation, but it may be possible to use the second period as a period for use in the full-time jetting while the air jet loom is pausing. On the other hand, it is described that the jet operation is carried out in the first period as a predetermined period within the inserting period (i.e. period from the start to the end of the weft inserting), but it is possible for the jet operation to be carried out over the entire weft inserting period.

[0128] While various embodiments of the invention have been shown and described in the above with reference to the accompanying drawings, the invention is not limited to those embodiments. Various changes and modifications will be possible without departing from the gist of the invention.

Claims

1. An air supply apparatus for an air jet loom comprising:

a compressed air supply source (14);

a first switching valve (30) connected with said compressed air supply source;

at least one of first compressed air regulators (16, 58, 138, 140) connected with said first switching valve, in which at least one of the outflow quantity and the pressure of compressed air is set at a predetermined first set value;

a second compressed air regulator (18, 68) connected with said compressed air supply source, wherein at

least one of the outflow quantity and the pressure of compressed air is set at a second set value different from said first set value, the number of said second compressed air regulator being made equal to that of said first compressed air regulators; and

a second switching valve (34, 62, 150, 152) connected with said first and second compressed air regulators, wherein the number of said second switching valves is made equal to or more than that of said first compressed air regulator,

wherein said second switching valve is connected with main nozzle (12, 50, 124, 126), said first switching valve is opened in a predetermined first period at the weft inserting time, and the second switching valve is opened in said first period as well as in the second period different from said first period.

2. An air supply apparatus as claimed in claim 1 further comprising a branch line (54) connected with the output side of said first switching valve (30),

wherein two or more of said first and second compressed air regulators (16, 18, 58, 68, 138, 140) and second switching valves (34, 62, 150, 152) are provided and each of said plural first compressed air regulators is connected with said branch line.

3. An air supply apparatus as claimed in claim 1 further comprising a branch line (76) which receives respective outputs from said first and second compressed air regulators (16, 18, 58, 68, 138, 140) and branches off in each of said two or more second switching valves (34, 62, 150, 152),

wherein each of said second switching valves is connected with each of main nozzles (12, 50, 124, 126) which are different from each other.

4. An air supply apparatus for use in an air jet loom comprising:

a compressed air supply source (208);

at least one of compressed air regulators (200, 226) connected with said compressed air supply source; and a switching valve (210, 228) connected with said compressed air regulator as well as with a main nozzle (202, 222) on the basis of one-to-one correspondence,

wherein said switching valve opens in the first period that is a predetermined period at the weft inserting time by the main nozzle as well as in the second period different from said first period, and said compressed air regulator controls at least one of the outflow quantity and the pressure of the compressed air supplied to said switching valve in correspondence with said first and second periods.

5. An air supply apparatus for use in an air jet loom comprising:

a compressed air supply source (242); and

at least one of compressed air regulator (246, 262) connected with said compressed air supply source as well as with a main nozzle (248, 258) on the basis of one-to-one correspondence

wherein said compressed air regulator controls at least one of the outflow quantity and the pressure of the compressed air supplied to said main nozzle based on the rotational angle as set in advance of the main shaft (250).

6. An air supply apparatus as claimed in any one of claims 1 through 5 further comprising piping (86) for supplying the compressed air for use in full-time jetting to a main nozzle (12, 50, 124, 126, 202, 222, 248, 258) from said compressed air supply source (14, 208, 242).

7. An air supply apparatus as claimed in any one of claims 1 through 6 further comprising piping (86) for connecting said second switching valve (34, 62, 150, 152) corresponding to the main nozzle (12, 50, 124, 126, 202, 222, 248, 258) with at least one of auxiliary main nozzles (114, 116, 128, 130) for assisting the flight of weft at the weft inserting time.

8. An air supply apparatus as claimed in any one of claims 1 through 7, wherein said compressed air regulator comprises at least one of a throttle valve and a regulator.

9. An air supply apparatus as claimed in any one of claims 1 through 8, wherein said compressed air supply source (14, 208, 242) comprises at least one of a pressure source, an auxiliary compressed air regulator (22, 204, 238)

and a compressed air tank (26, 206, 240).

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FIG. 1

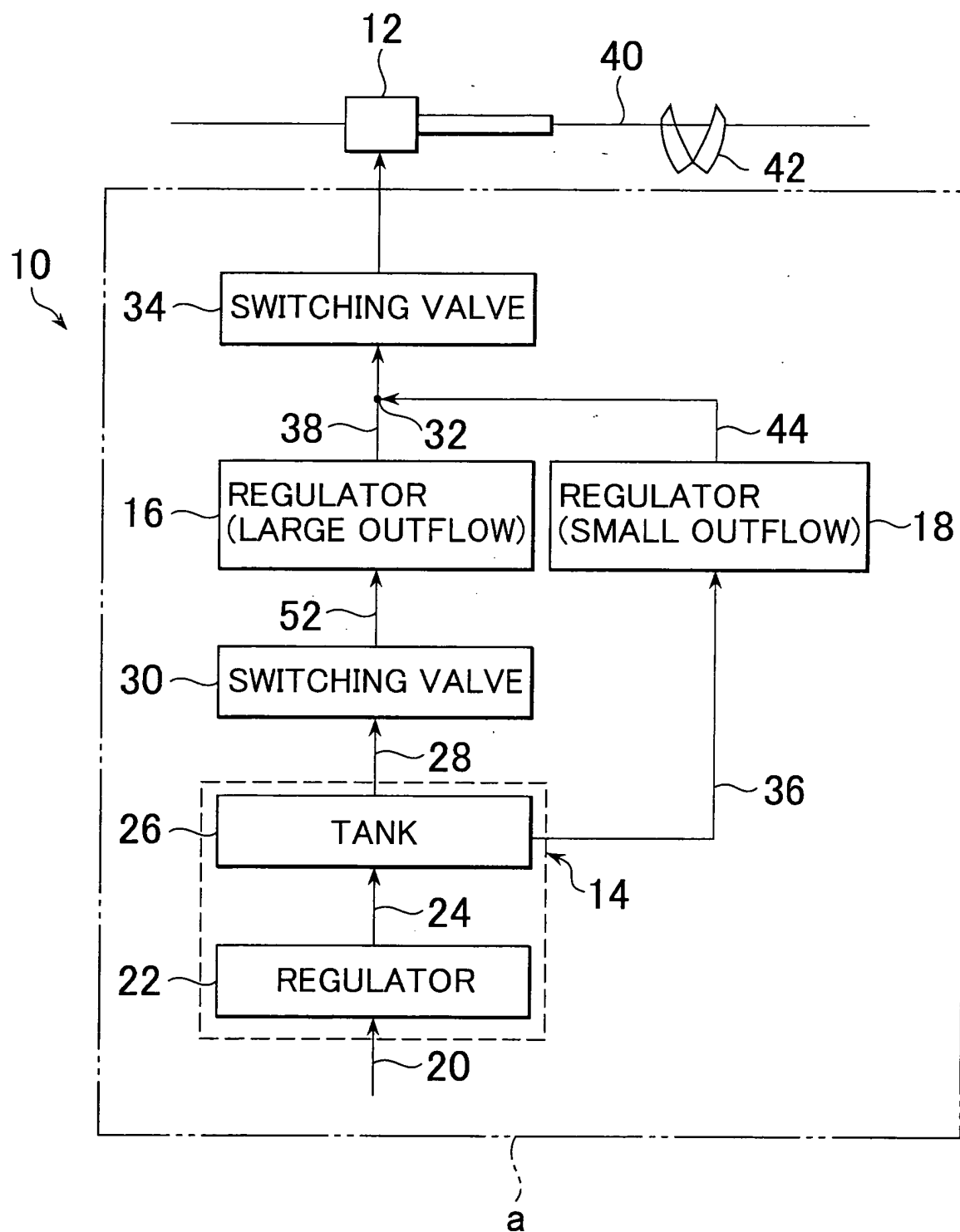


FIG. 2

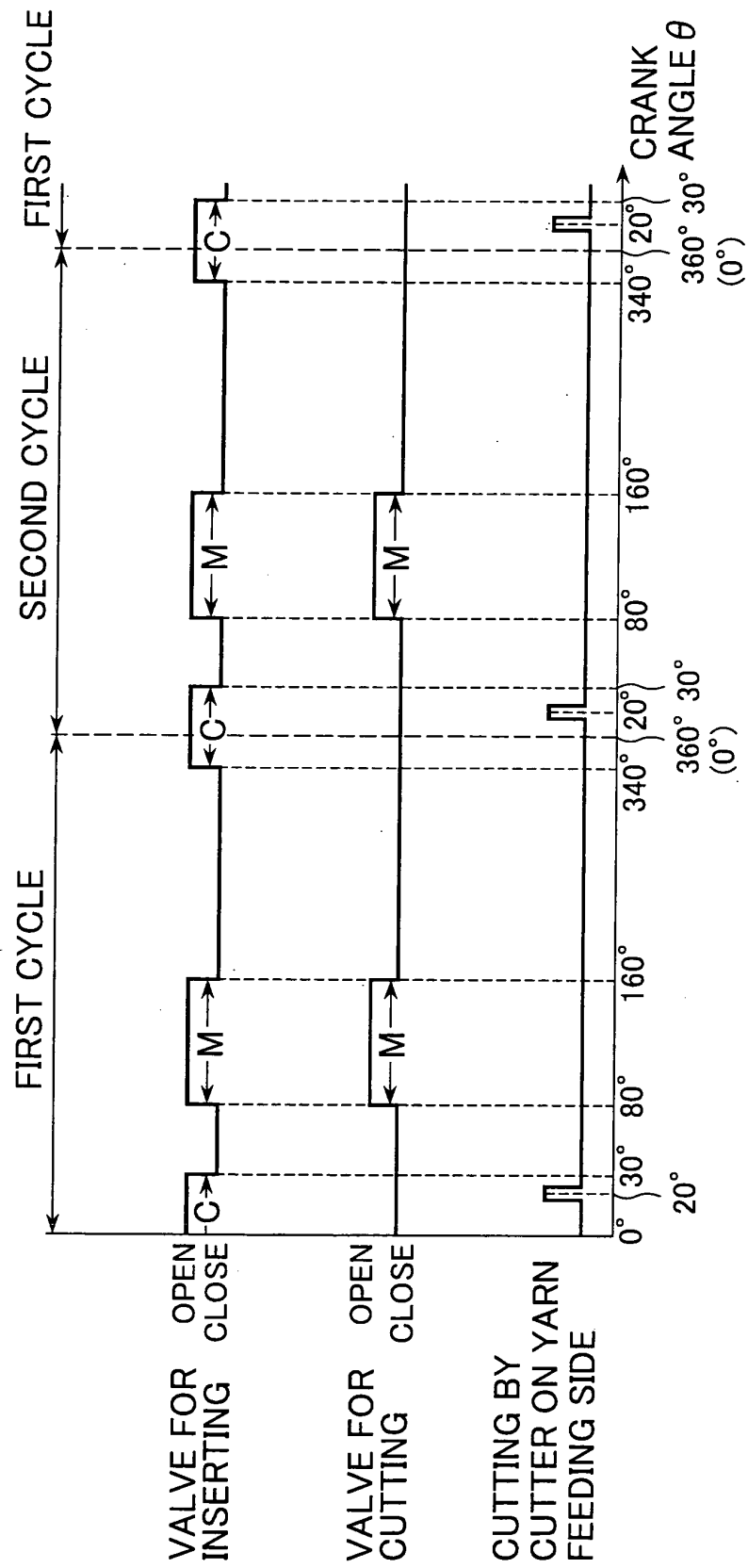


FIG. 3

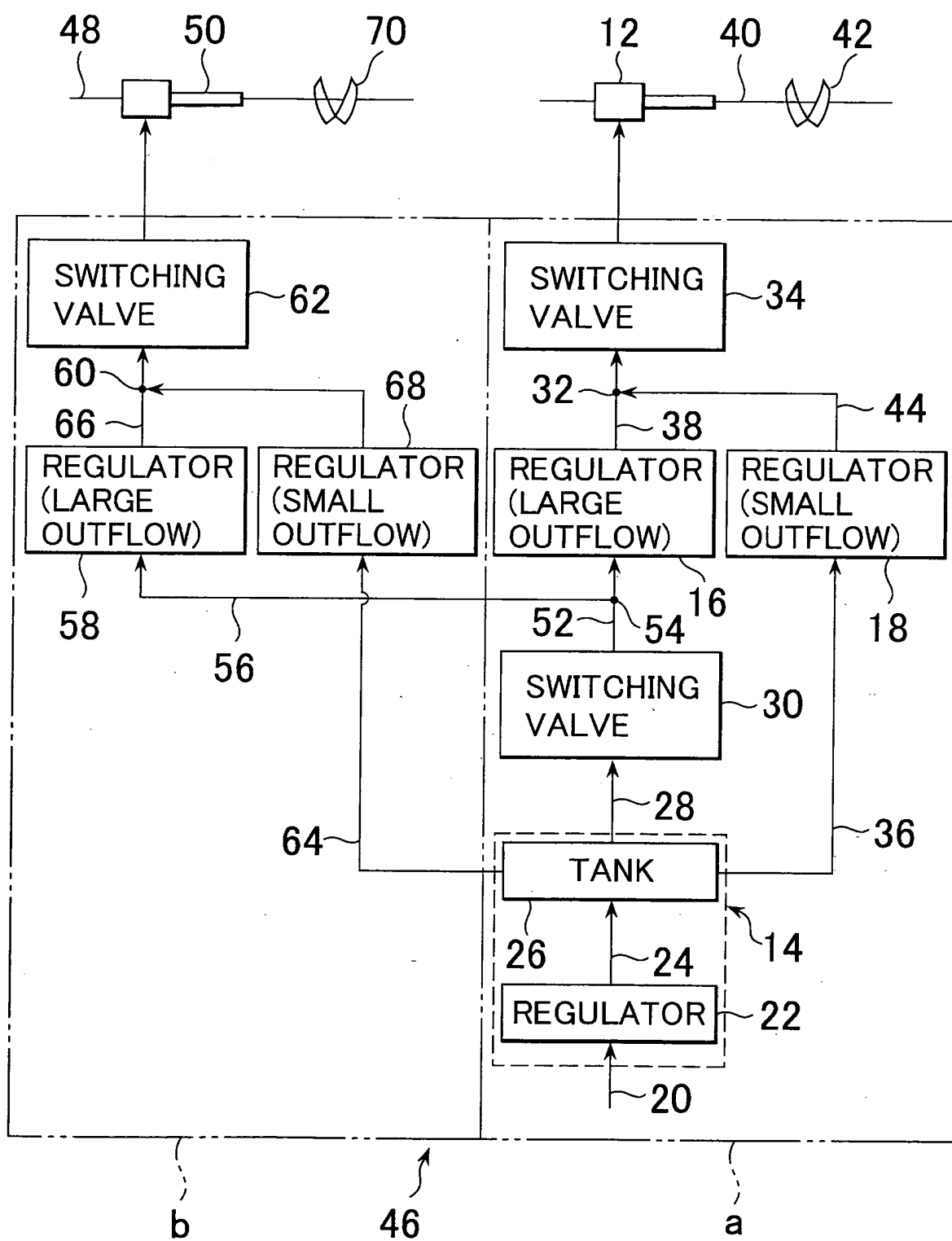


FIG. 4

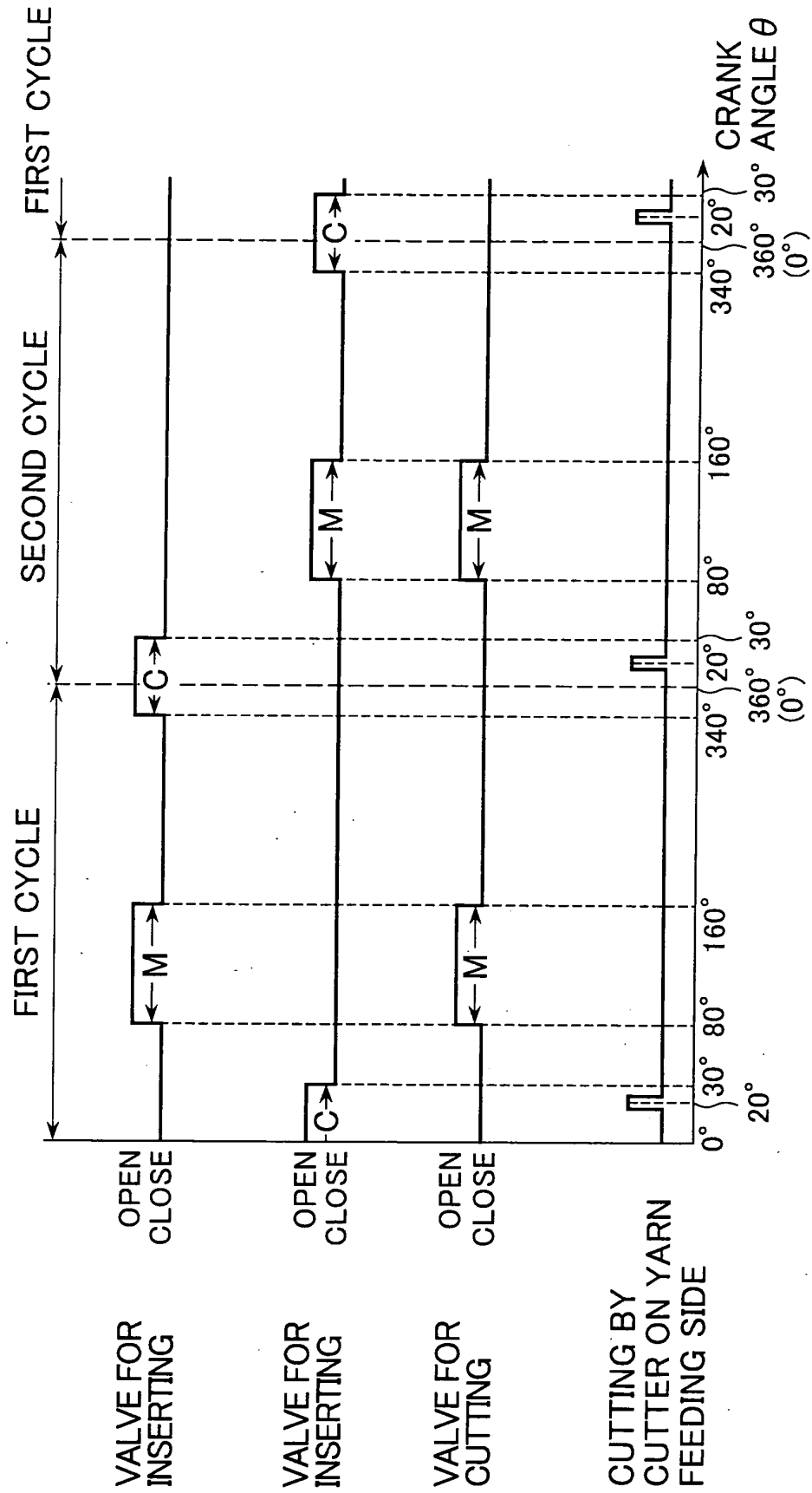


FIG. 5

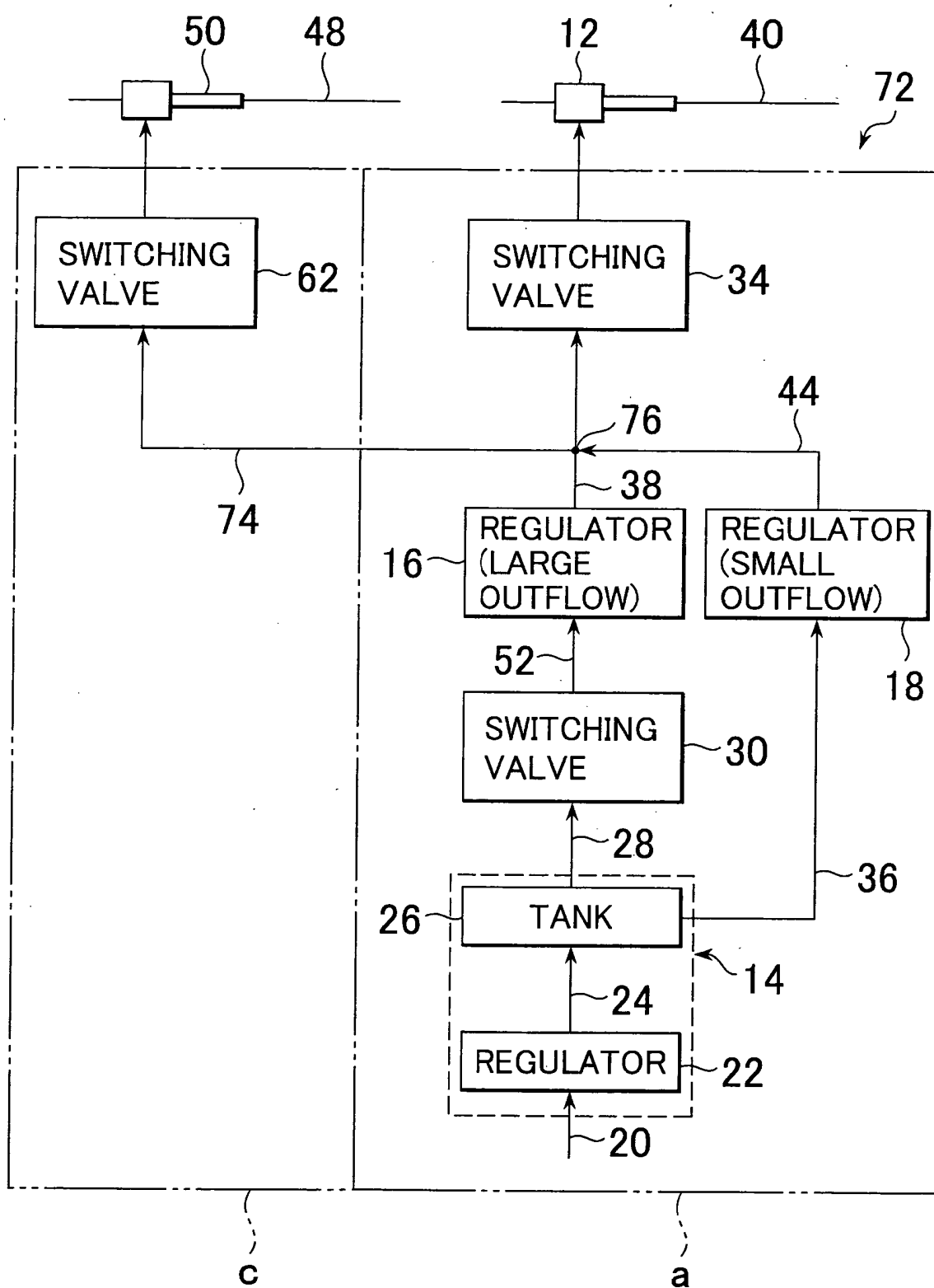


FIG. 6

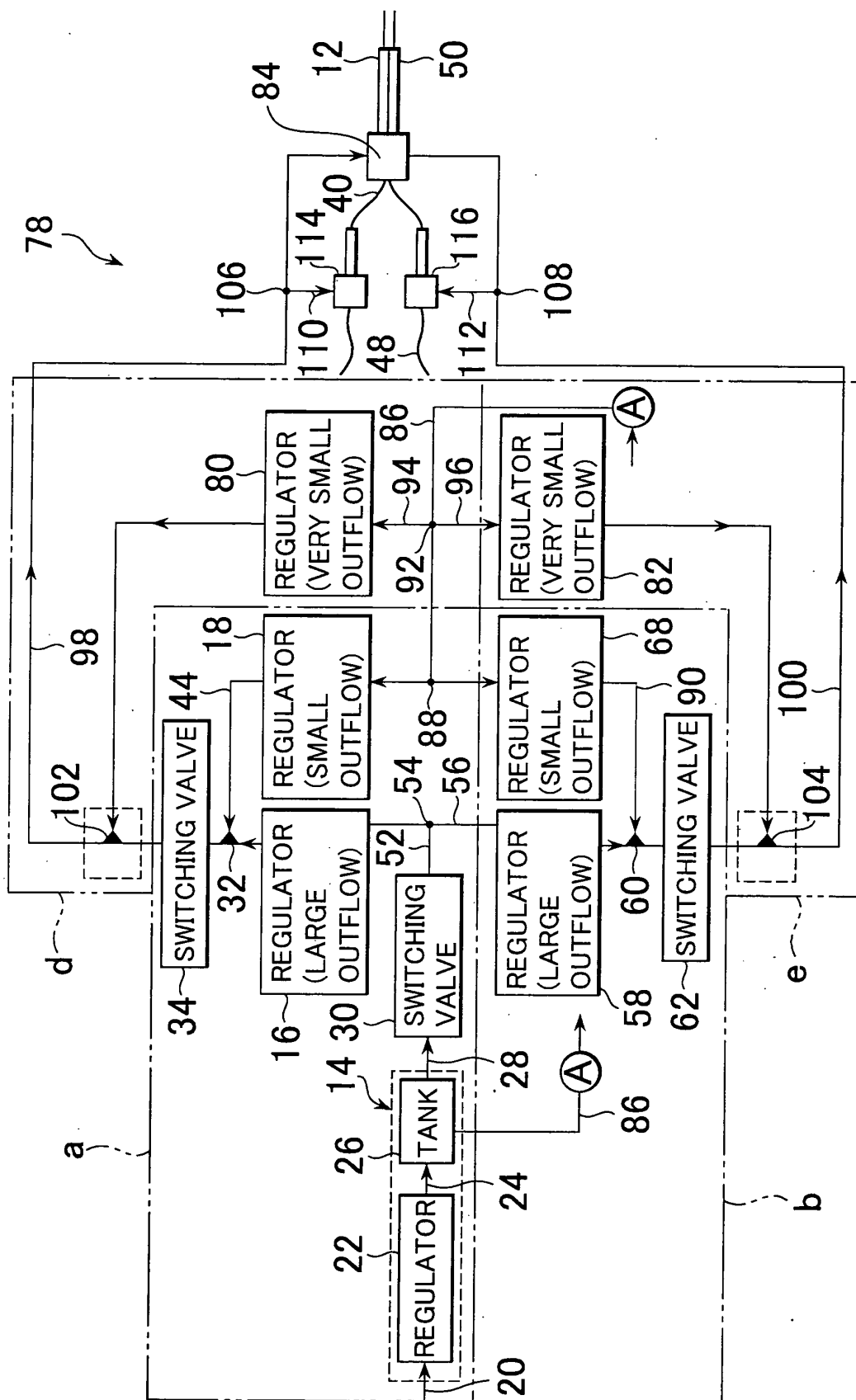


FIG. 7

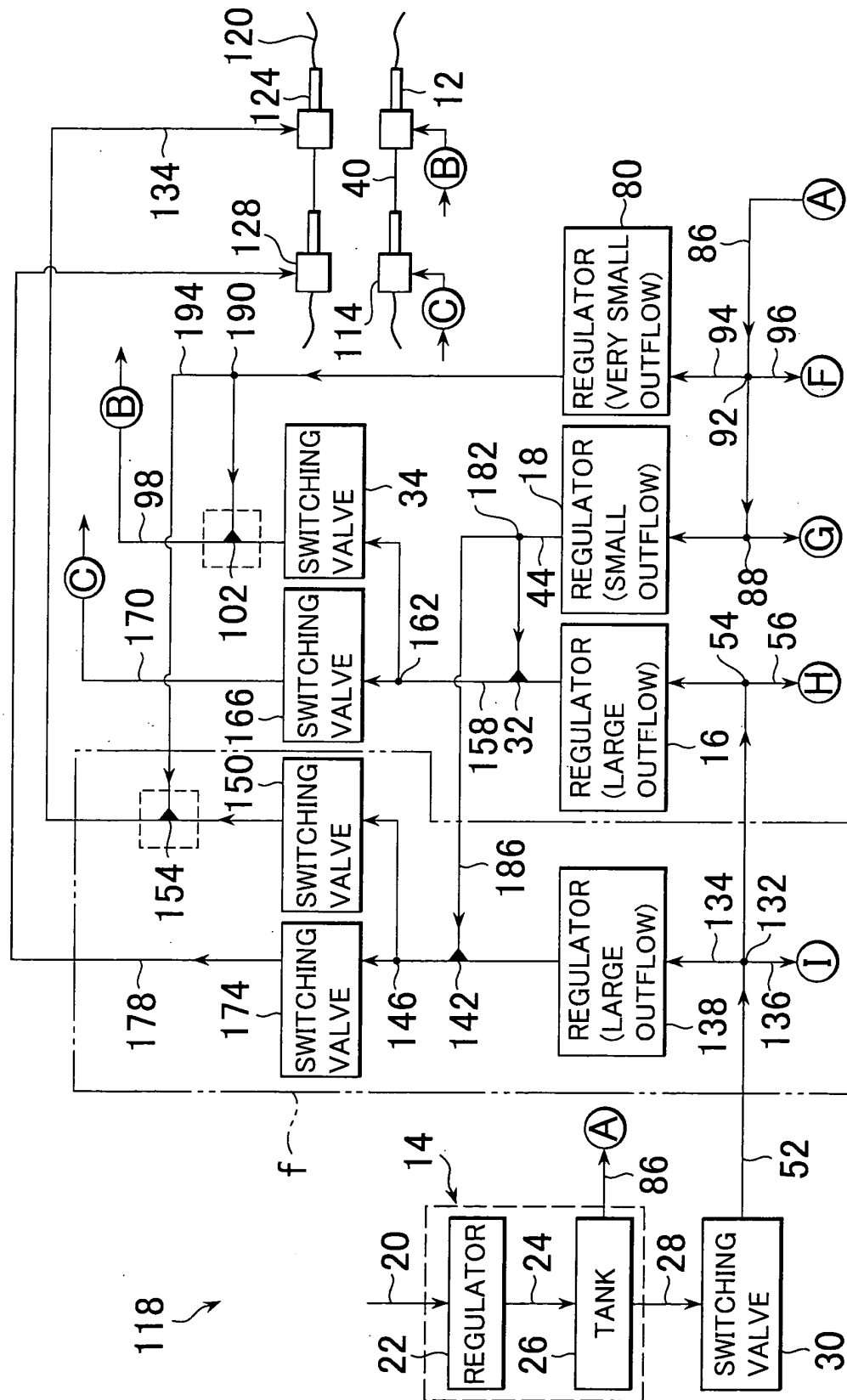


FIG. 8

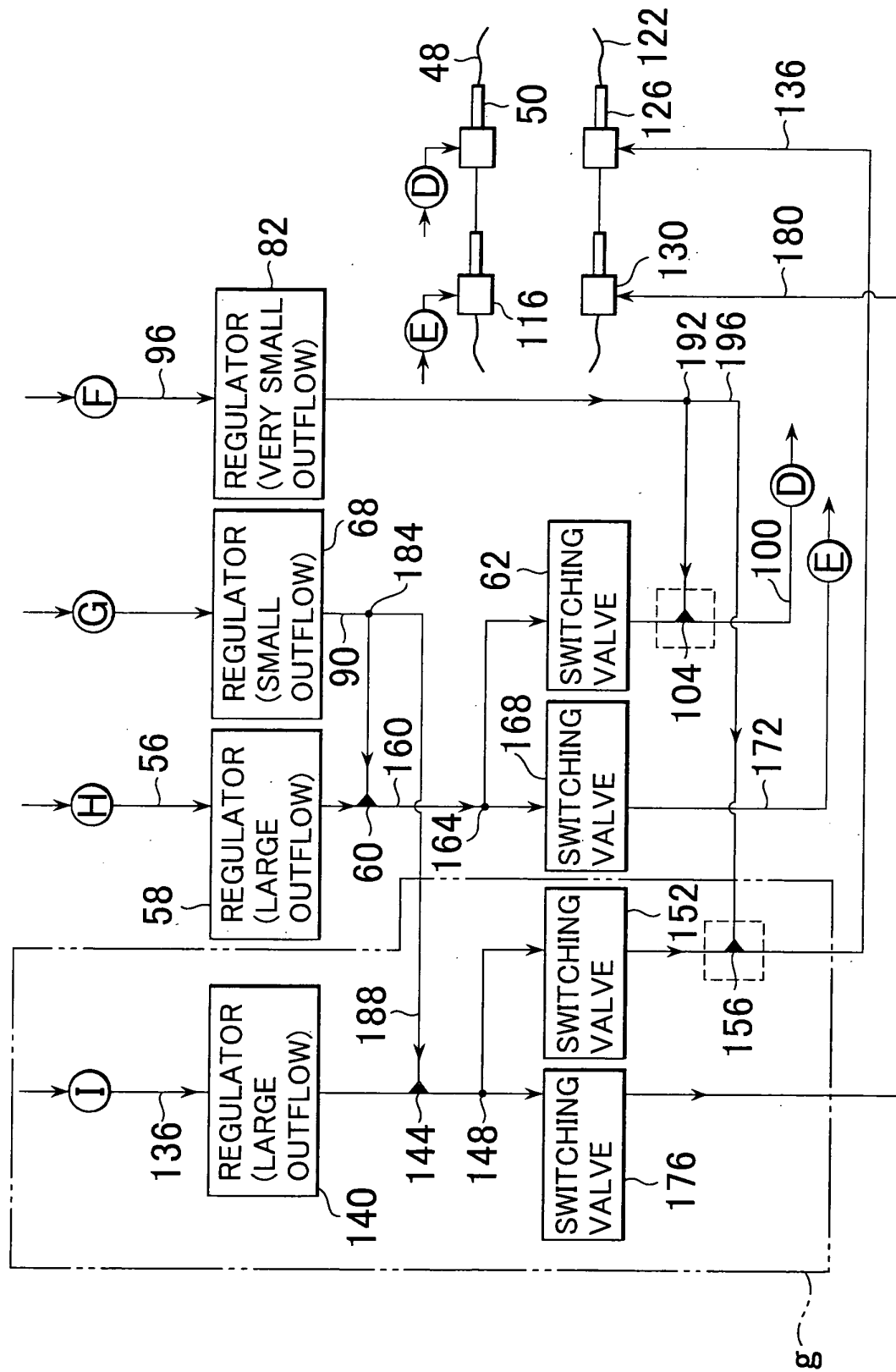


FIG. 9

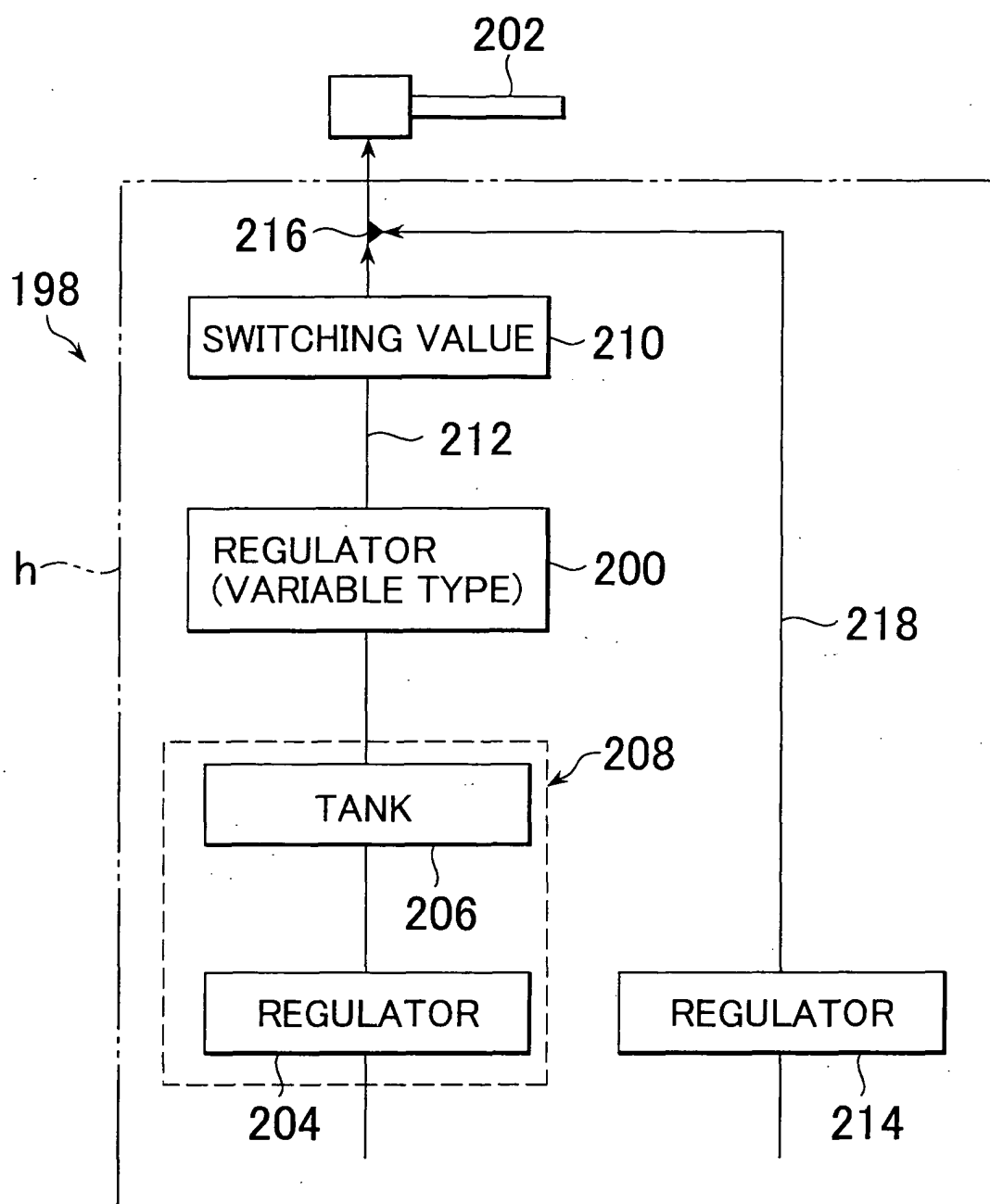


FIG. 10

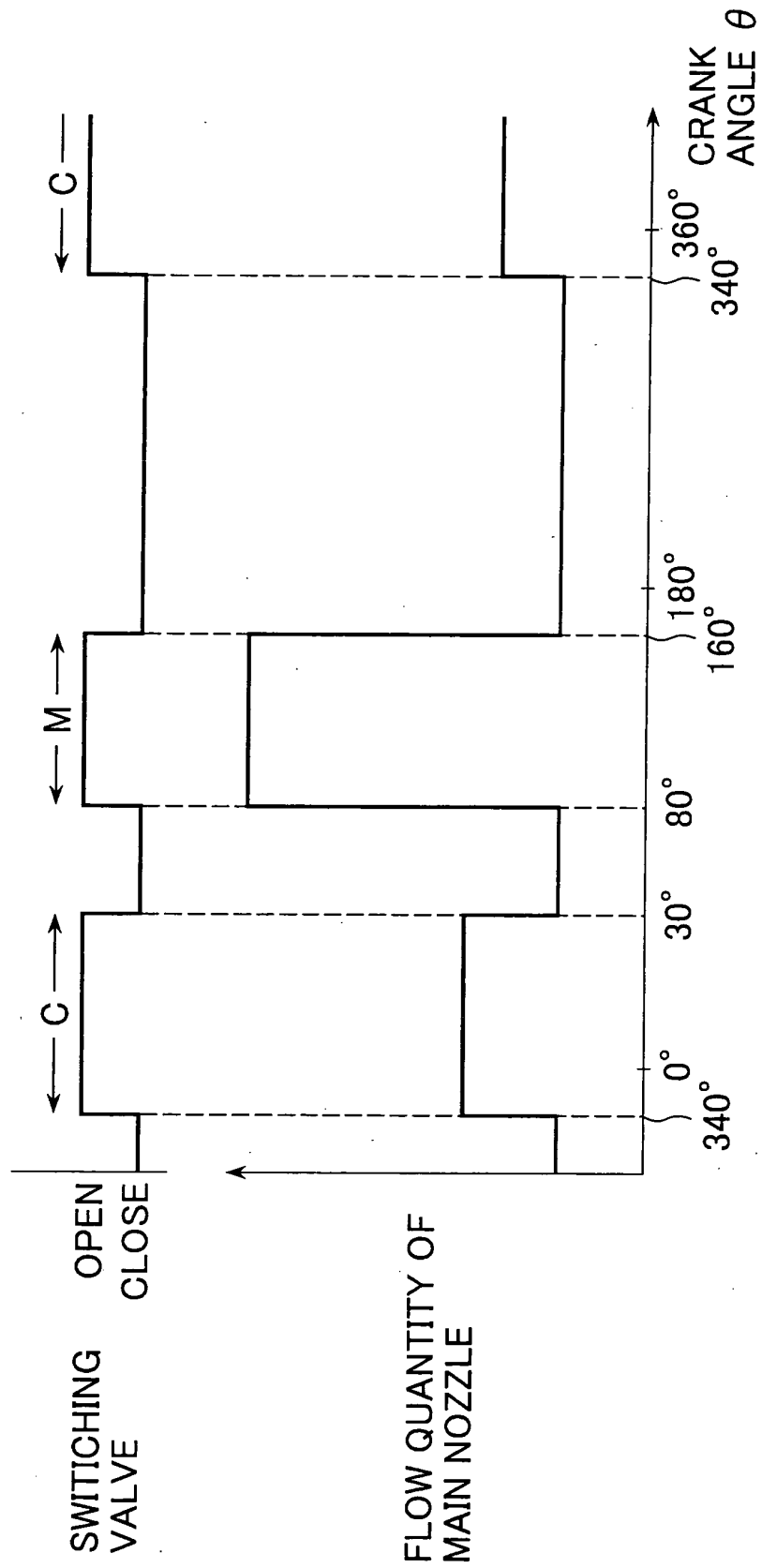


FIG. 11

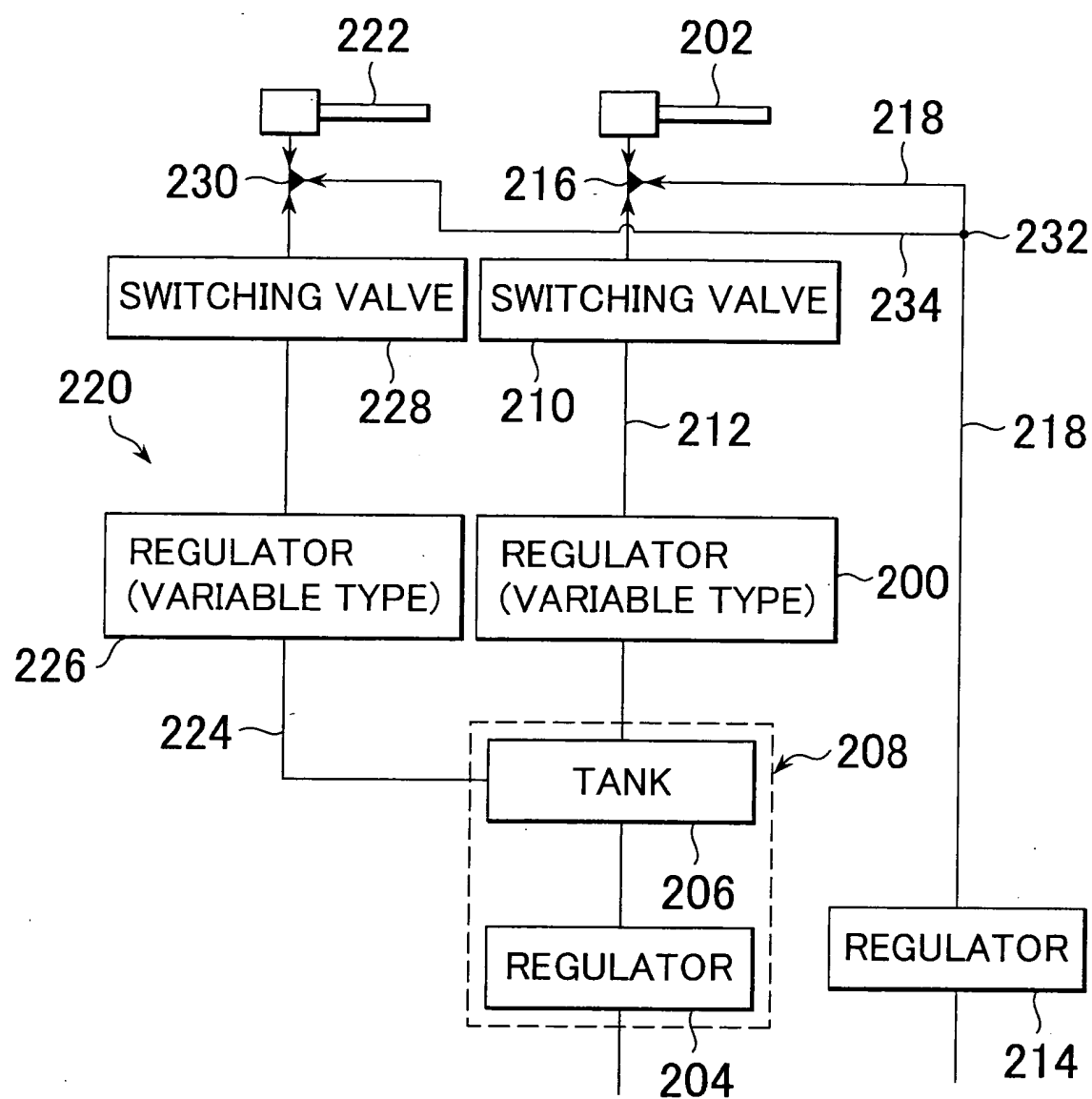


FIG. 12

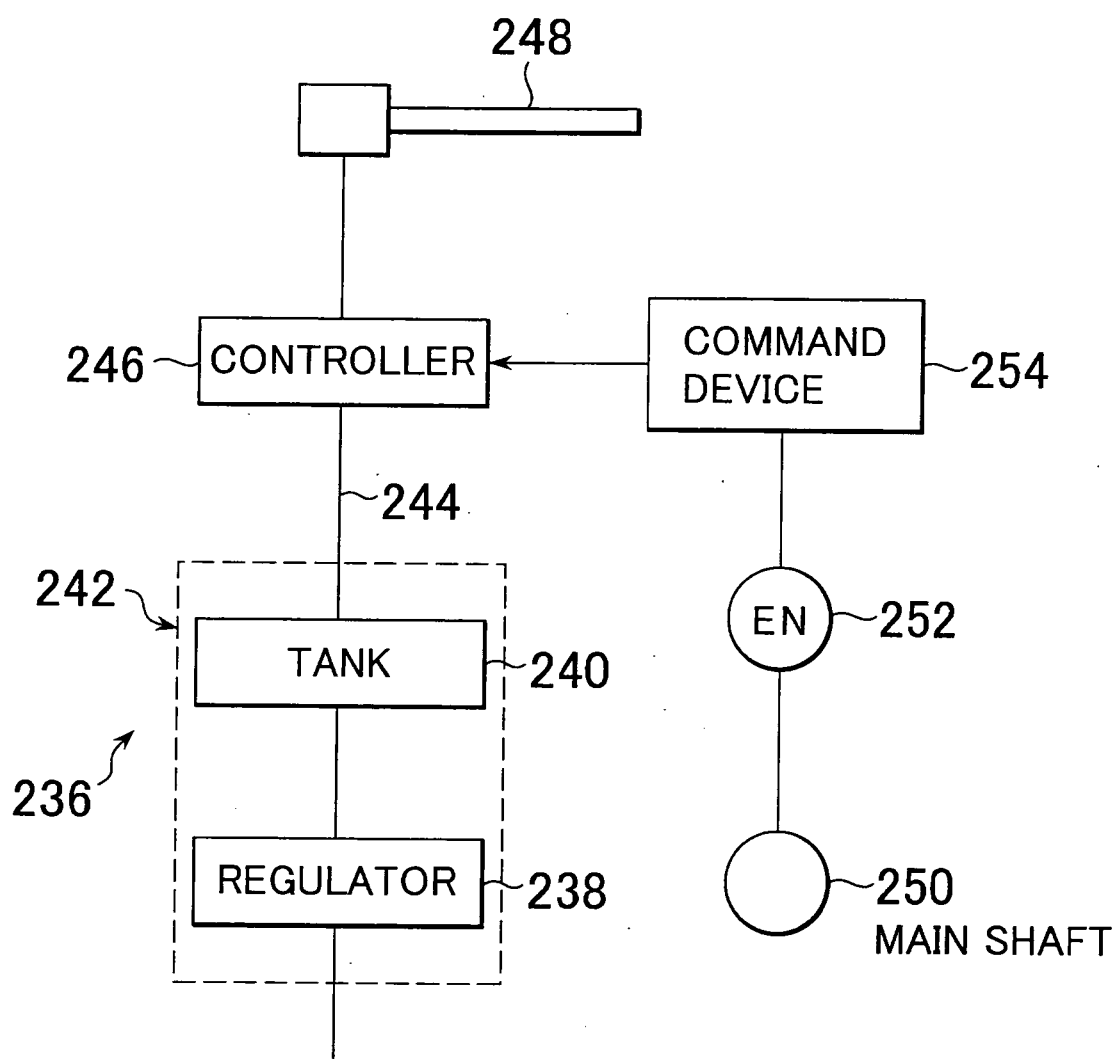


FIG. 13

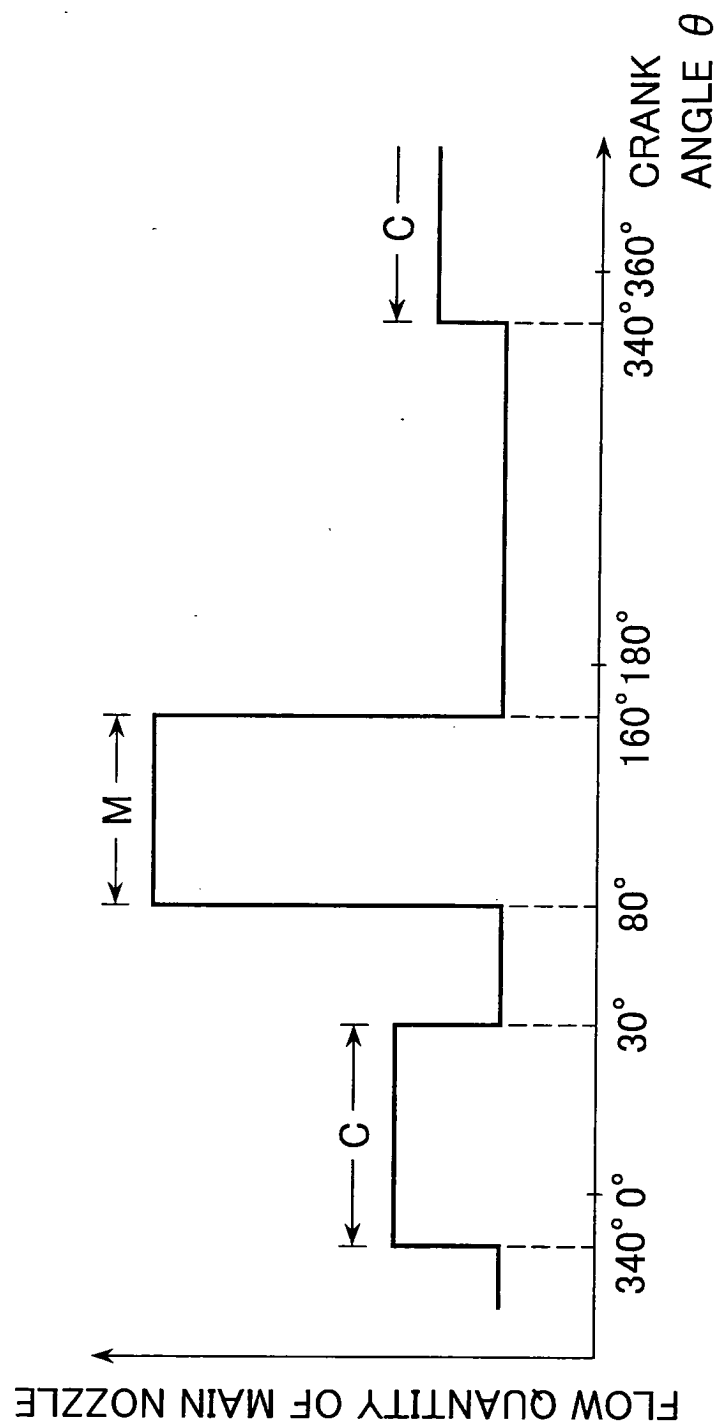


FIG. 14

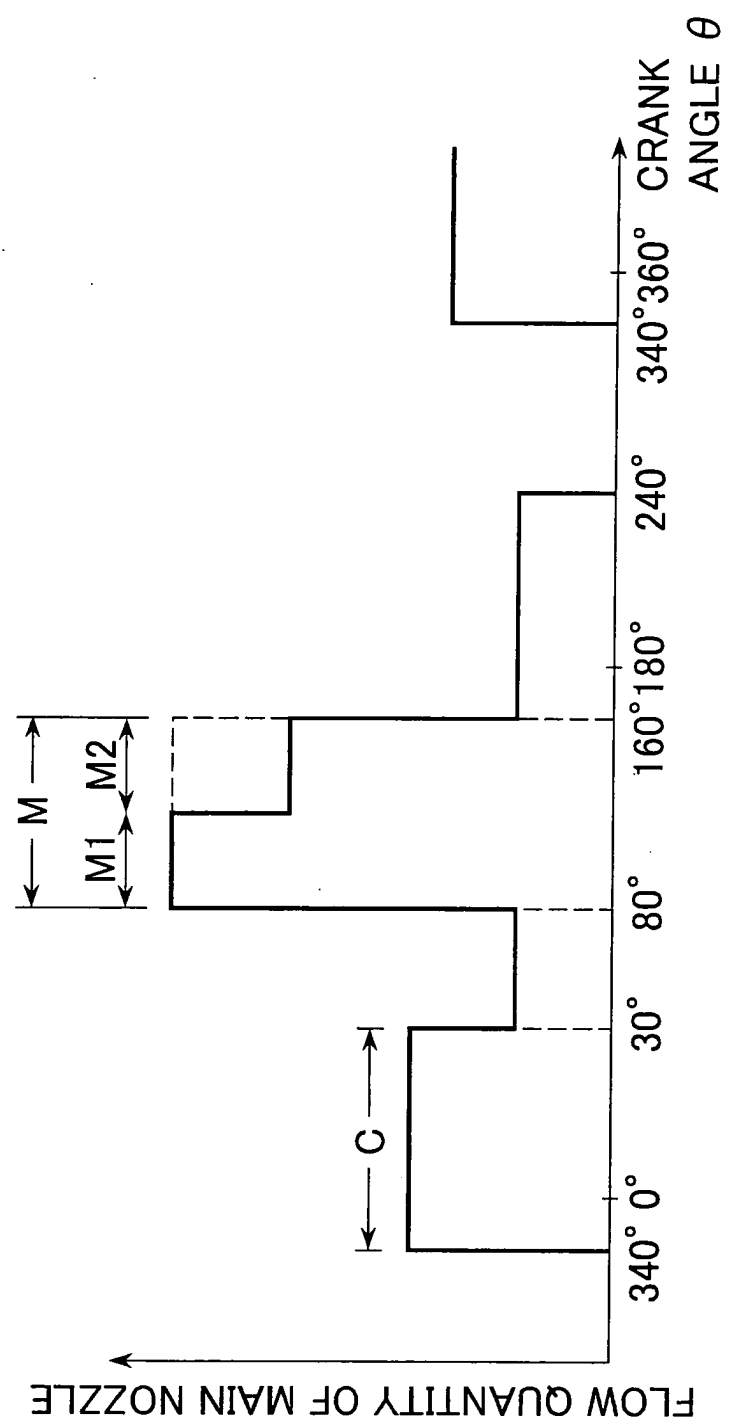


FIG. 15

