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(54) ## LIQUID DISCHARGE HEAD AND RECORDING DEVICE

(57) A liquid discharge head includes a flow channel member including a first surface and a second surface located opposite to the first surface, and a pressurizer located on the first surface. The flow channel member includes a first discharge hole and a second discharge hole located in the second surface, a first individual flow channel connected to the first discharge hole, a first pressurizing chamber located upstream of the first discharge hole in the first individual flow channel, a second individual flow channel connected to the second discharge hole, a second pressurizing chamber located upstream of the second discharge hole in the second individual flow channel, and a manifold commonly connected to an upstream side of the first individual flow channel and an upstream side of the second individual flow channel. The first individual flow channel includes a first communication flow channel connecting the first pressurizing chamber and the first discharge hole. The second individual flow channel includes a second communication flow channel connecting the second pressurizing chamber and the second discharge hole. The second pressurizing chamber is located closer to the manifold than the first pressurizing chamber in a plan view. A width of at least part of the second communication flow channel is different from a width of the first communication flow channel.

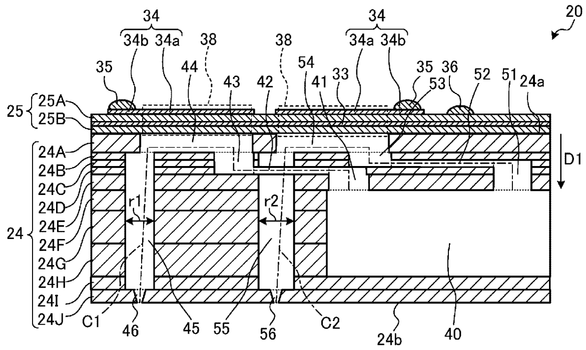

FIG. 5

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Description

TECHNICAL FIELD

[0001] The disclosed embodiments relate to a liquid discharge head and a recording apparatus.

BACKGROUND OF INVENTION

[0002] Inkjet printers and inkjet plotters utilizing an inkjet recording method are known as printing apparatus. A liquid discharge head for discharging a liquid is mounted in such a printing apparatus using an inkjet method.

[0003] Such a liquid discharge head includes a plurality of discharge holes, a plurality of pressurizing chambers respectively connected to the plurality of discharge holes, and a manifold commonly connected to the plurality of pressurizing chambers. The plurality of pressurizing chambers include a pressurizing chamber relatively far from the manifold and a pressurizing chamber relatively close to the manifold (for example, see Patent Document 1).

CITATION LIST

PATENT LITERATURE

[0004] Patent Document 1: JP 2005-35291 A

SUMMARY

[0005] A liquid discharge head according to an aspect of an embodiment includes a flow channel member including a first surface and a second surface located opposite to the first surface, and a pressurizer located on the first surface. The flow channel member includes a first discharge hole and a second discharge hole located in the second surface, a first individual flow channel connected to the first discharge hole, a first pressurizing chamber located upstream of the first discharge hole in the first individual flow channel, a second individual flow channel connected to the second discharge hole, a second pressurizing chamber located upstream of the second discharge hole in the second individual flow channel, and a manifold commonly connected to an upstream side of the first individual flow channel and an upstream side of the second individual flow channel. The first individual flow channel includes a first communication flow channel connecting the first pressurizing chamber and the first discharge hole. The second individual flow channel includes a second communication flow channel connecting the second pressurizing chamber and the second discharge hole. The second pressurizing chamber is located closer to the manifold than the first pressurizing chamber in a plan view. A width of at least part of the second communication flow channel is different from a width of the first communication flow channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a side view schematically illustrating a printer according to an embodiment.
FIG. 2 is a plan view schematically illustrating a printer according to an embodiment.
FIG. 3 is an exploded perspective view illustrating an overall configuration of a liquid discharge head according to an embodiment.
FIG. 4 is an enlarged plan view of a head main body according to an embodiment.
FIG. 5 is a schematic cross-sectional view of the head main body according to an embodiment.
FIG. 6 is an enlarged view of a region surrounded by a dash-dotted line in FIG. 4.
FIG. 7 is a view for illustrating a variation in amount of displacement between a first pressurizing chamber and a second pressurizing chamber.
FIG. 8 is a view illustrating an example of a relationship between a width of a second communication flow channel and a discharge speed of the liquid discharged from a second discharge hole.
FIG. 9 is a view illustrating specific examples of diameters of holes in a manifold plate.
FIG. 10 is a schematic cross-sectional view of a head main body according to another embodiment 1.
FIG. 11 is a schematic cross-sectional view of a head main body according to another embodiment 2.
FIG. 12 is an enlarged plan view of a head main body according to another embodiment 3.

DESCRIPTION OF EMBODIMENTS

[0007] Embodiments of a liquid discharge head and a recording apparatus disclosed in the present application will be described below with reference to the accompanying drawings. The present disclosure is not limited by the following embodiments. Note that the drawings are schematic and that the dimensional relationships between elements, the proportions of the elements, and the like may differ from the actual ones. There may be differences between the drawings in terms of dimensional relationships, proportions, and the like.

[0008] In the embodiments described below, expressions such as "constant", "orthogonal", "perpendicular", and "parallel" may be used, but these expressions do not mean exactly "constant", "orthogonal", "perpendicular", and "parallel". In other words, it is assumed that the above expressions allow for deviations in manufacturing accuracy, installation accuracy, or the like.

Printer Configuration

[0009] Using FIGs. 1 and 2, description will be given of an overview of a printer 1 serving as an example of a recording apparatus according to an embodiment. FIG. 1

is a side view schematically illustrating the printer 1 according to an embodiment. FIG. 2 is a plan view schematically illustrating the printer 1 according to an embodiment.

[0010] As illustrated in FIG. 1, the printer 1 includes a paper feed roller 2, guide rollers 3, an applicator 4, a head case 5, a plurality of transport rollers 6, a plurality of frames 7, a plurality of liquid discharge heads 8, transport rollers 9, a dryer 10, transport rollers 11, a sensor 12, and a collection roller 13.

[0011] The printer 1 further includes a controller 14 configured to control each part of the printer 1. The controller 14 controls the operation of the paper feed roller 2, the guide rollers 3, the applicator 4, the head case 5, the plurality of transport rollers 6, the plurality of frames 7, the plurality of liquid discharge heads 8, the transport rollers 9, the dryer 10, the transport rollers 11, the sensor 12, and the collection roller 13.

[0012] By landing droplets on a printing sheet P, the printer 1 records images and characters on the printing sheet P. The printing sheet P is wound around the paper feed roller 2 in a drawable state before use. The printer 1 conveys the printing sheet P from the paper feed roller 2 to the inside of the head case 5 via the guide rollers 3 and the applicator 4.

[0013] The applicator 4 uniformly applies a coating agent over the printing sheet P. This can perform surface treatment on the printing sheet P, improving the printing quality of the printer 1.

[0014] The head case 5 houses the plurality of transport rollers 6, the plurality of frames 7, and the plurality of liquid discharge heads 8. The inside of the head case 5 is formed with a space separated from the outside except for a part connected to the outside such as parts where the printing sheet P enters and exits.

[0015] As required, the controller 14 controls at least one of controllable factors of the internal space of the head case 5, such as temperature, humidity, and air pressure. The transport rollers 6 convey the printing sheet P near the liquid discharge heads 8 inside the head case 5.

[0016] The frames 7 are rectangular flat plates and are positioned above and close to the printing sheet P to be conveyed by the transport rollers 6. As illustrated in FIG. 2, the plurality of frames 7 (e.g., four) are provided inside the head case 5 such that the longitudinal direction thereof is orthogonal to the conveying direction of the printing sheet P. The plurality of frames 7 are disposed at predetermined intervals along the conveying direction of the printing sheet P.

[0017] In the following description, the conveying direction of the printing sheet P may be referred to as "sub scanning direction", and the direction orthogonal to the sub scanning direction and parallel to the printing sheet P may be referred to as "main scanning direction".

[0018] A liquid, for example, ink, is supplied to the liquid discharge heads 8 from a liquid tank (not illustrated). Each liquid discharge head 8 discharges the liquid supplied from the liquid tank.

[0019] The controller 14 controls the liquid discharge heads 8 based on data of an image, characters, or the like to discharge the liquid toward the printing sheet P. The distance between each liquid discharge head 8 and the printing sheet P is, for example, approximately 0.5 to 20 mm.

[0020] Each of the liquid discharge heads 8 is fixed to the frame 7. For example, each of the liquid discharge heads 8 is fixed to the frame 7 at both end portions in the longitudinal direction. Each of the liquid discharge heads 8 is fixed to the frame 7 such that its longitudinal direction is parallel to the main scanning direction.

[0021] That is, the printer 1 according to the embodiment is a so-called line printer in which the liquid discharge heads 8 are fixed inside the printer 1. Note that the printer 1 according to the embodiment is not limited to a line printer and may also be a so-called serial printer.

[0022] A serial printer is a printer employing a method of alternately performing an operation of recording while moving the liquid discharge heads 8 in a manner to reciprocate or the like in a direction intersecting (e.g., substantially orthogonal to) the conveying direction of the printing sheet P and an operation of conveying the printing sheet P.

[0023] As illustrated in FIG. 2, the plurality of (e.g., five) liquid discharge heads 8 are provided in one frame 7. FIG. 2 illustrates an example in which two liquid discharge heads 8 are arranged in front of the sub scanning direction and three liquid discharge heads 8 are arranged behind the sub scanning direction, and the liquid discharge heads 8 are arranged in the sub scanning direction such that the centers of the liquid discharge heads 8 do not overlap with each other.

[0024] The plurality of liquid discharge heads 8 provided in one frame 7 form a head group 8A. Four head groups 8A are positioned along the sub scanning direction. The liquid discharge heads 8 belonging to the same head group 8A are supplied with ink of the same color. As a result, the printer 1 can perform printing with four colors of ink using the four head groups 8A.

[0025] The colors of the ink discharged from the respective head groups 8A are, for example, magenta (M), yellow (Y), cyan (C), and black (K). The controller 14 can print a color image on the printing sheet P by controlling the respective head groups 8A to discharge the plurality of colors of ink onto the printing sheet P.

[0026] Note that a surface treatment may be performed on the printing sheet P, by discharging a coating agent from the liquid discharge head 8 onto the printing sheet P.

[0027] Furthermore, the number of the liquid discharge heads 8 included in one head group 8A and the number of the head groups 8A mounted in the printer 1 can be changed as appropriate in accordance with printing targets and printing conditions. For example, when the color to be printed on the printing sheet P is a single color and the range of the printing can be covered by a single liquid discharge head 8, only a single liquid discharge head 8 may be provided in the printer 1.

[0028] The printing sheet P printed inside the head case 5 is conveyed to the outside of the head case 5 by the transport rollers 9 and passes through the inside of the dryer 10. The dryer 10 dries the printing sheet P printed. The printing sheet P dried by the dryer 10 is transported by the transport rollers 11 and then collected by the collection roller 13.

[0029] In the printer 1, by drying the printing sheet P with the dryer 10, it makes it possible to suppress bonding, or rubbing of an undried liquid, between the printing sheets P overlapped with each other and rolled at the collection roller 13.

[0030] The sensor 12 includes a position sensor, a speed sensor, a temperature sensor, or the like. Based on information from the sensor 12, the controller 14 can determine the state of each part of the printer 1 and control each part of the printer 1.

[0031] In the above-described printer 1, the printing sheet P is used as the printing target (i.e., the recording medium), but the printing target in the printer 1 is not limited to the printing sheet P, and a rolled cloth or the like may be used as the printing target.

[0032] Furthermore, instead of directly conveying the printing sheet P, the printer 1 described above may have a configuration in which the printing sheet P is put on a conveyor belt and conveyed. By using the conveyor belt, the printer 1 can perform printing on a sheet of paper, a cut cloth, wood, a tile, or the like as a printing target.

[0033] Furthermore, the printer 1 described above may discharge a liquid containing electrically conductive particles from the liquid discharge heads 8, printing a wiring pattern or the like of an electronic device.

[0034] Furthermore, the printer 1 described above may discharge liquid containing a predetermined amount of liquid chemical agent or liquid containing the chemical agent from the liquid discharge heads 8 onto a reaction vessel or the like to produce chemicals.

[0035] The printer 1 described above may also include a cleaner for cleaning the liquid discharge heads 8. The cleaner cleans the liquid discharge heads 8 by, for example, a wiping process or a capping process.

[0036] The wiping process is, for example, a process of removing liquid attached to a second surface 24b (see FIG. 3) of a flow channel member 24 (see FIG. 3), which is an example of a surface of a portion onto which the liquid is discharged, by rubbing the second surface 24b with a flexible wiper.

[0037] The capping process is a process for removing clogging on a first discharge hole 46 (see FIG. 5) and a second discharge hole 56 (see FIG. 5) by covering, with a cap, the portion where the liquid is discharged, and repeating the discharge of liquid. First, a cap is provided in a manner to cover the second surface 24b of the flow channel member 24 which is an example of the portion from which the liquid is discharged (this process is referred to as capping). This forms a substantially sealed space between the second surface 24b and the cap. The discharge of liquid is then repeated in such a sealed space. As a result, liquid with a viscosity higher than that in a normal state, foreign matter, or the like clogging the first discharge hole 46 and the second discharge hole 56 can be removed.

Configuration of Liquid Discharge Head

[0038] FIG. 3 is an exploded perspective view illustrating an overall configuration of the liquid discharge head 8 according to an embodiment.

[0039] As illustrated in FIG. 3, the liquid discharge head 8 includes a head main body 20, a reservoir 21, an electrical board 22, and a head cover 23. The head main body 20 includes the flow channel member 24, a piezoelectric actuator substrate 25, a signal transmitter 26, and a drive IC 27.

[0040] The flow channel member 24 of the head main body 20 has a substantially flat plate shape and includes a first surface 24a, which is one main surface, and the second surface 24b located opposite to the first surface 24a. The first surface 24a has an opening 40a (see FIG. 4), and liquid is supplied into the flow channel member 24 from the reservoir 21 through the opening 40a.

[0041] A plurality of first discharge holes 46 (see FIG. 4) and a plurality of second discharge holes 56 (see FIG. 4) through which liquid is discharged onto the printing sheet P are located in the second surface 24b. Furthermore, a flow channel through which liquid flows from the first surface 24a to the second surface 24b is formed inside the flow channel member 24. Details of the flow channel member 24 will be described later.

[0042] The piezoelectric actuator substrate 25 is located on the first surface 24a of the flow channel member 24. The piezoelectric actuator substrate 25 includes a plurality of displacement elements 38 (see FIG. 5). The displacement element 38 is an example of a pressurizer. The piezoelectric actuator substrate 25 will be described in detail later.

[0043] Two signal transmitters 26 are electrically connected to the piezoelectric actuator substrate 25. Each signal transmitter 26 includes a plurality of the drive integrated circuits (ICs) 27. Note that, in FIG. 3, one of the signal transmitters 26 is omitted for ease of understanding.

[0044] The signal transmitter 26 supplies a signal to each displacement element 38 of the piezoelectric actuator substrate 25. The signal transmitter 26 is formed of, for example, a flexible printed circuit (FPC) or the like.

[0045] The drive IC 27 is provided in the signal transmitter 26. The drive IC 27 controls driving of each displacement element 38 in the piezoelectric actuator substrate 25.

[0046] Note that the head main body 20 has a discharge surface from which the liquid is discharged and an opposite surface located on a side opposite to the discharge surface. In the following description, the discharge surface is described as the second surface 24b of the flow channel member 24 and the opposite surface is described as the first surface 24a of the flow channel member 24.

[0047] The reservoir 21 is located on the opposite surface side of the head main body 20 and is in contact with the first surface 24a excluding the piezoelectric actuator substrate 25. The reservoir 21 includes an opening 21a at each of both end portions thereof in the main scanning direction. The reservoir 21 has a flow channel therein, and is supplied with liquid from the outside through an opening 21a. The reservoir 21 has a function of supplying the liquid to the flow channel member 24 and a function of storing the liquid to be supplied.

[0048] The electrical board 22 is provided in a standing manner on a surface on the side of the reservoir 21 opposite to the head main body 20. A plurality of connectors 28 are located on an end portion of the electrical board 22 on the reservoir 21 side. An end portion of the signal transmitter 26 is housed in each connector 28.

[0049] Connectors 29 for power supply are located on an end portion of the electrical board 22 on the side opposite to the reservoir 21. The electrical board 22 distributes current, supplied from the outside via the connector 29, to the connectors 28 and supplies the current to the signal transmitter 26.

[0050] The head cover 23 is located on the opposite surface side of the head main body 20 and covers the signal transmitter 26 and the electrical board 22. Thus, the liquid discharge heads 8 can seal the signal transmitter 26 and the electrical board 22.

[0051] The head cover 23 includes an opening 23a. The connector 29 of the electrical board 22 is inserted to be exposed to the outside, through the opening 23a.

[0052] The drive IC 27 is in contact with an interior side surface of the head cover 23. The drive IC 27 is pressed against the interior side surface of the head cover 23, for example. As a result, heat generated by the drive IC 27 can be dissipated (radiated) through a contact portion on the side surface of the head cover 23.

[0053] Note that the liquid discharge head 8 may further include a member other than the member illustrated in FIG. 3.

Configuration of Head Main Body

[0054] Next, the configuration of the head main body 20 according to an embodiment will be described with reference to FIGs. 4 to 6. FIG. 4 is an enlarged plan view of the head main body 20 according to an embodiment, FIG. 5 is a schematic cross-sectional view of the head main body 20 according to an embodiment, and FIG. 6 is an enlarged view of a region surrounded by a dash-dotted line in FIG. 4.

[0055] As illustrated in FIG. 4, the head main body 20 includes the flow channel member 24 and the piezoelectric actuator substrate 25. The flow channel member 24 includes a supply manifold 40, a plurality of first pressurizing chambers 44, a plurality of second pressurizing chambers 54, the plurality of first discharge holes 46, and the plurality of second discharge holes 56. The supply manifold 40 is one example of a manifold.

[0056] The plurality of first pressurizing chambers 44 and the plurality of second pressurizing chambers 54 are connected to the supply manifold 40. The plurality of first discharge holes 46 are connected to the plurality of first pressurizing chambers 44, respectively. The plurality of second discharge holes 56 are connected to the plurality of second pressurizing chambers 54, respectively.

[0057] The first pressurizing chambers 44 and the second pressurizing chambers 54 open to the first surface 24a (see FIG. 5) of the flow channel member 24. Furthermore, the first surface 24a of the flow channel member 24 has the opening 40a that is connected to the supply manifold 40. Liquid is supplied from the reservoir 21 (see FIG. 2) to the inside of the flow channel member 24 through the opening 40a.

[0058] In the example illustrated in FIG. 4, the head main body 20 includes four supply manifolds 40 located inside the flow channel member 24. The supply manifold 40 has an elongated shape extending along the longitudinal direction of the flow channel member 24. The opening 40a is located in the first surface 24a of the flow channel member 24 at either end of the supply manifold 40.

[0059] The plurality of first pressurizing chambers 44 and the plurality of second pressurizing chambers 54 are formed in the flow channel member 24 in a two-dimensionally spreading manner. The first pressurizing chambers 44 and the second pressurizing chambers 54 are hollow regions having a substantially diamond-shaped planar shape with rounded corners. The first pressurizing chambers 44 and the second pressurizing chambers 54 open to the first surface 24a of the flow channel member 24, and are closed when the piezoelectric actuator substrate 25 is joined to the first surface 24a.

[0060] The first pressurizing chambers 44 form a first pressurizing chamber row arranged in the longitudinal direction of the flow channel member 24 (supply manifold 40), and the second pressurizing chambers 54 form a second pressurizing chamber row arranged in the longitudinal direction of the flow channel member 24 (supply manifold 40). The first pressurizing chambers 44 belonging to the first pressurizing chamber row and the second pressurizing chambers 54 belonging to the second pressurizing chamber row adjacent to the first pressurizing chamber row are alternately disposed.

[0061] One pressurizing chamber group includes two rows of first pressurizing chamber rows and two rows of second pressurizing chamber rows connected to one supply manifold 40. In the example illustrated in FIG. 4, the flow channel member 24 includes four pressurizing chamber groups.

[0062] Moreover, the relative arrangement of the first pressurizing chambers 44 and the second pressurizing chambers 54 is the same among the pressurizing chamber groups, with the pressurizing chamber groups arranged while being slightly shifted from each other in the longitudinal direction.

[0063] The first discharge holes 46 and the second discharge holes 56 are disposed at positions outside regions, of the flow channel member 24, facing the supply manifold 40. Thus, none of the first discharge holes 46 and the second discharge holes 56 overlap the supply manifold 40 in a perspective plane of the flow channel member 24 as viewed from the first surface 24a side.

[0064] Furthermore, in a plan view, the first discharge holes 46 and the second discharge holes 56 are disposed to be within a region in which the piezoelectric actuator substrate 25 is mounted. One group of the first discharge holes 46 and the second discharge holes 56 occupies a region of approximately the same size and shape as the piezoelectric actuator substrate 25.

[0065] Droplets are discharged through the first discharge holes 46 and the second discharge holes 56 by displacing the displacement elements 38 (see FIG. 5) of the corresponding piezoelectric actuator substrate 25.

[0066] As illustrated in FIG. 5, the supply manifold 40 and the first discharge hole 46 are connected to each other via a first connection flow channel 41, a first aperture 42, a first supply flow channel 43, the first pressurizing chamber 44, and a first communication flow channel 45.

[0067] That is, the flow channel member 24 includes a first individual flow channel C1 including the first connection flow channel 41, the first aperture 42, the first supply flow channel 43, the first pressurizing chamber 44, and the first communication flow channel 45. In the first individual flow channel C1, the first connection flow channel 41 is located near the supply manifold 40 and the first communication flow channel 45 is located near the first discharge hole 46, in a flow direction of the liquid.

[0068] Note that when a direction from the first surface 24a toward the second surface 24b is defined as a first direction D1, the first connection flow channel 41 extends in the first direction D1, the first aperture 42 extends in a direction perpendicular to the first direction D1, and the first supply flow channel 43 extends in the first direction D1. In addition, the first pressurizing chamber 44 extends in a direction perpendicular to the first direction D1, and the first communication flow channel 45 extends in the first direction D1.

[0069] Similarly, the supply manifold 40 and the second discharge hole 56 are connected to each other via a second connection flow channel 51, a second aperture 52, a second supply flow channel 53, the second pressurizing chamber 54, and a second communication flow channel 55.

[0070] That is, the flow channel member 24 includes a second individual flow channel C2 including the second connection flow channel 51, the second aperture 52, the second supply flow channel 53, the second pressurizing chamber 54, and the second communication flow channel 55. In the second individual flow channel C2, the second connection flow channel 51 is located near the supply manifold 40 and the second communication flow channel 55 is located near the second discharge hole 56, in the flow direction of the liquid.

[0071] Note that the second connection flow channel 51 extends in the first direction D1, the second aperture 52 extends in a direction perpendicular to the first direction D1, and the second supply flow channel 53 extends in the first direction D1. In addition, the second pressurizing chamber 54 extends in a direction perpendicular to the first direction D1, and the second communication flow channel 55 extends in the first direction D1.

[0072] The first individual flow channel C1 includes the first aperture 42 provided upstream of the first pressurizing chamber 44 and having a width narrower than other portions. With the width narrower than the other portions of the first individual flow channel C1, the first aperture 42 has a high flow channel resistance.

[0073] As a result, in the embodiment, the pressure generated in the first pressurizing chamber 44 can be suppressed from escaping to the supply manifold 40, instead of being directed to the first discharge holes 46. Therefore, according to the embodiment, the liquid can be efficiently discharged from the first discharge holes 46.

[0074] The second individual flow channel C2 includes the second aperture 52 provided upstream of the second pressurizing chamber 54 and having a width narrower than other portions. With the width narrower than the other portions of the second individual flow channel C2, the second aperture 52 has a high flow channel resistance.

[0075] As a result, in the embodiment, the pressure generated in the second pressurizing chamber 54 can be suppressed from escaping to the supply manifold 40, instead of being directed to the second discharge holes 56. Therefore, according to the embodiment, the liquid can be efficiently discharged from the second discharge holes 56.

[0076] As illustrated in FIG. 5, the flow channel member 24 has a layered structure in which a plurality of plates are stacked. These plates include a cavity plate 24A, a base plate 24B, aperture plates 24C and 24D, a supply plate 24E, manifold plates 24F, 24G, and 24H, a cover plate 24I, and a nozzle plate 24J layered in this order from the first surface 24a of the flow channel member 24.

[0077] Note that FIG. 5 illustrates an example of the layered structure of the plates according to an embodiment, and there is no need to be particularly limited to the example illustrated in FIG. 5. For example, manifold plates 24F, 24G, and 24H may be formed by stacking three or more plates. The cover plate 24I may be formed by stacking a plurality of plates.

[0078] A large number of holes are formed in the plates constituting the flow channel member 24, and the supply manifold 40, the first individual flow channel C 1, and the second individual flow channel C2 are formed inside the flow channel member 24, with the large number of holes connected to each other.

[0079] In the embodiment, by setting the thickness of these plates to about 10 to 300 μm, the holes can be formed with increased accuracy.

[0080] The first individual flow channel C1 includes the first communication flow channel 45 provided downstream of the first pressurizing chamber 44 and connecting the first pressurizing chamber 44 and the first discharge hole 46. In addition, the second individual flow channel C2 includes the second communication flow channel 55 provided downstream of the second pressurizing chamber 54 and connecting the second pressurizing chamber 54 and the second discharge hole 56.

[0081] Here, in the embodiment, as illustrated in FIG. 6, the second pressurizing chamber 54 is located closer to the supply manifold 40 than the first pressurizing chamber 44 in a plan view. That is, in the embodiment, in a plan view, the first pressurizing chamber 44 is relatively far from the supply manifold 40, and the second pressurizing chamber 54 is relatively close to the supply manifold 40. In the example of FIG. 6, in a plan view, the first pressurizing chamber 44 is located away from the supply manifold 40 and does not overlap the supply manifold 40, but the second pressurizing chamber 54 has a portion overlapping the supply manifold 40.

[0082] In the embodiment, as illustrated in FIGs. 5 and 6, the width of the second communication flow channel 55 is different from the width of the first communication flow channel 45. For example, the width of the second communication flow channel 55 is larger than the width of the first communication flow channel 45.

[0083] Incidentally, in the liquid discharge head 8, the second pressurizing chamber 54 relatively close to the supply manifold 40 has lower rigidity than the first pressurizing chamber 44 relatively far from the supply manifold 40, and is likely to be displaced by pressurization from the displacement element 38. In this way, since there is a variation in an amount of displacement between the first pressurizing chamber 44 and the second pressurizing chamber 54, there may be a variation in a discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56.

[0084] FIG. 7 is a view for illustrating a variation in amount of displacement between the first pressurizing chamber 44 and the second pressurizing chamber 54. FIG. 7 illustrates amounts of displacement of the first pressurizing chambers 44 belonging to the first pressurizing chamber rows and amounts of displacement of the second pressurizing chambers 54 belonging to the second pressurizing chamber rows.

[0085] Row numbers illustrated in FIG. 7 are numbers indicating positions of the first pressurizing chamber row and the second pressurizing chamber row in a width direction of the flow channel member 24, and for example, numbers 1 to 16 are assigned as row numbers sequentially from the left side to eight rows of first pressurizing chamber rows and eight rows of second pressurizing chamber rows illustrated in FIG. 4. The row numbers 1, 4, 5, 8, 9, 12, 13, and 16 correspond to the first pressurizing chamber rows, and the row numbers 2, 3, 6, 7, 10, 11, 14, and 15 correspond to the second pressurizing chamber rows. Column numbers illustrated in FIG. 7 are numbers indicating positions of the first pressurizing chambers 44 belonging to the first pressurizing chamber rows and the second pressurizing chambers 54 belonging to the second pressurizing chamber rows in the longitudinal direction of the flow channel member 24.

[0086] As illustrated in FIG. 7, the second pressurizing chamber 54 relatively close to the supply manifold 40 has a larger amount of displacement than the first pressurizing chamber 44 relatively far from the supply manifold 40. In this way, when there is a variation in the amount of displacement between the first pressurizing chamber 44 and the second pressurizing chamber 54, the discharge speed of liquid in the second discharge hole 56 connected to the second pressurizing chamber 54 is higher than that in the first discharge hole 46 connected to the first pressurizing chamber 44. As a result, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 is impaired.

[0087] Therefore, in the embodiment, as illustrated in FIGs. 5 and 6, by making the width of the second communication flow channel 55 larger than the width of the first communication flow channel 45, the discharge speed of liquid is made uniform between the first discharge hole 46 and the second discharge hole 56.

[0088] FIG. 8 is a view illustrating an example of a relationship between the width of the second communication flow channel 55 and the discharge speed of the liquid discharged from the second discharge hole 56. The present inventors changed the width (flow channel width) of the second communication flow channel 55 to supply liquid to the inside of the flow channel member 24 and examined the discharge speed of the liquid discharged from the second discharge hole 56 by simulation. FIG. 8 illustrates a result of such a simulation.

[0089] As illustrated in FIG. 8, the discharge speed of the liquid discharged from the second discharge hole 56 reached the maximum value when the width of the second communication flow channel 55 was about 200 μm, and decreased from the maximum value when the width of the second communication flow channel 55 was smaller or larger than about 200 μm. It is considered that when the width of the second communication flow channel 55 is small, the flow channel resistance of the second communication flow channel 55 becomes high, and the pressure wave generated in the second pressurizing chamber 54 is not efficiently propagated to the second discharge hole 56, leading to a decrease in the discharge speed of the liquid. In addition, it is considered that when the width of the second communication flow channel 55 is large, the pressure wave generated in the second pressurizing chamber 54 is absorbed and attenuated by the liquid, leading to the decrease in the discharge speed of liquid. Note that although not described here, a simulation result similar to that in FIG. 8 is obtained for the discharge speed of the liquid discharged from the first discharge hole 46 in accordance with the change in the width of the first communication flow channel 45.

[0090] In the liquid discharge head 8, the width of the first communication flow channel 45 and the width of the second communication flow channel 55 are generally set so that the discharge speed of the liquid discharged from the discharge holes (the first discharge hole 46 and the second discharge hole 56) becomes a maximum value. For example, in the example of FIG. 8, the width of the first communication flow channel 45 and the width of the second communication flow channel 55 are set in the vicinity of 200 μm, which is a common setting value at which the discharge speed of the liquid becomes the maximum value. By setting the width of the first communication flow channel 45 and the width of the second communication flow channel 55 to the common setting value, theoretically, there would be no variation in the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56. However, actually, as described above, due to the variation in the amount of displacement between the first pressurizing chamber 44 and the second pressurizing chamber 54, the discharge speed of liquid in the second discharge hole 56 is higher than that in the first discharge hole 46. As a result, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 is impaired.

[0091] On the other hand, in the embodiment, by making the width of the second communication flow channel 55 larger than the width of the first communication flow channel 45, the discharge speed of the liquid discharged from the second discharge hole 56 is reduced so as to approach the discharge speed of the liquid discharged from the first discharge hole 46. Therefore, according to the embodiment, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be improved.

[0092] Note that although the width of the second communication flow channel 55 is larger than the width of the first communication flow channel 45 in the embodiment, the width of the second communication flow channel 55 may be smaller than the width of the first communication flow channel 45. In short, it is sufficient that the width of the second communication flow channel 55 is different from the width of the first communication flow channel 45. In addition, the entire width of the second communication flow channel 55 is not necessarily required to be different from the width of the first communication flow channel 45. For example, a width of part of the second communication flow channel 55 may be different from the width of the first communication flow channel 45, and a width of another part of the second communication flow channel 55 may be the same as the width of the first communication flow channel 45. In short, it is sufficient that a width of at least part of the second communication flow channel 55 is different from the width of the first communication flow channel 45.

[0093] In addition, in the embodiment, the width of the second communication flow channel 55 may be larger than the width of the first communication flow channel 45 by 0.5% to 2.5%. For example, when the width of the first communication flow channel 45 is about 200 μm, the width of the second communication flow channel 55 is preferably larger than the width of the first communication flow channel 45 by about 1 to 5 μm. Accordingly, it is possible to suppress an excessive decrease in the discharge speed of the liquid discharged from the second discharge hole 56. Therefore, according to the embodiment, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be further improved.

[0094] In addition, in the embodiment, as illustrated in FIG. 5, in each of the manifold plates 24F, 24G, and 24H, a diameter r2 of the hole for forming the second communication flow channel 55 is preferably larger than a diameter r1 of the hole for forming the first communication flow channel 45.

[0095] FIG. 9 is a view illustrating specific examples of diameters of holes in the manifold plate 24H. FIG. 9 illustrates the diameter r1 of the hole for forming the first communication flow channel 45 and the diameter r2 of the hole for forming the second communication flow channel 55. The row numbers illustrated in FIG. 9 are numbers indicating positions of the holes for forming the first communication flow channels 45 and the holes for forming the second communication flow channels 55 in the width direction of the flow channel member 24. The same numbers as the row numbers of the corresponding first pressurizing chamber rows and second pressurizing chamber rows are assigned to the holes as row numbers. The row numbers 1, 4, 5, 8, 9, 12, 13, and 16 correspond to the holes for forming the first communication flow channel 45, and the row numbers 2, 3, 6, 7, 10, 11, 14, and 15 correspond to the holes for forming the second communication flow channel 55. As illustrated in FIG. 9, in the manifold plate 24H, the diameter r2 of the hole for forming the second communication flow channel 55 is larger than the diameter r1 of the hole for forming the first communication flow channel 45. Note that although not described here, in each of the manifold plates 24F and 24G, the diameter r2 of the hole for forming the second communication flow channel 55 is larger than the diameter r1 of the hole for forming the first communication flow channel 45. That is, in each of the manifold plates 24F, 24G, and 24H, the diameter r2 of the hole for forming the second communication flow channel 55 is larger than the diameter r1 of the hole for forming the first communication flow channel 45. Accordingly, the first communication flow channel 45 and the second communication flow channel 55 can be easily formed in the flow channel member 24 by aligning and stacking the manifold plates 24F, 24G, and 24H so that the respective holes communicate with each other.

[0096] In addition, in the embodiment, as illustrated in

FIG. 5, a thickness of each of the manifold plates 24F, 24G, and 24H may be larger than thicknesses of the other plates included in the plurality of plates constituting the flow channel member 24. For example, in the embodiment, the respective thicknesses of the manifold plates 24F, 24G, and 24H are larger than those of the other plates, such as the cavity plate 24A. Since the respective thicknesses of the manifold plates 24F, 24G, and 24H are larger than those of the other plates, a volume of the second communication flow channels 55 in the manifold plates 24F, 24G, and 24H can be made larger than a volume of the second communication flow channels 55 in the other plates. As a result, the pressure wave generated in the second pressurizing chamber 54 is absorbed and efficiently attenuated by the liquid in the second communication flow channels 55 in the manifold plates 24F, 24G, and 24H, so that an adjustment range of the discharge speed of the liquid discharged from the second discharge holes can be widened. Therefore, according to the embodiment, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be further improved.

[0097] In addition, in the embodiment, as illustrated in FIG. 5, in each of the manifold plates 24F, 24G, and 24H and other plates, the diameter r2 of the hole for forming the second communication flow channel 55 is preferably larger than the diameter r1 of the hole for forming the first communication flow channel 45. For example, in each of the base plate 24B, the aperture plates 24C and 24D, the supply plate 24E, and the cover plate 24I, the diameter r2 of the hole for forming the second communication flow channel 55 is larger than the diameter r1 of the hole for forming the first communication flow channel 45. Accordingly, it is possible to increase not only the volume of the second communication flow channels 55 in the manifold plates 24F, 24G, and 24H but also the volume of the second communication flow channels 55 in the other plates. Therefore, the pressure wave generated in the second pressurizing chamber 54 is absorbed and efficiently attenuated by the liquid in the second communication flow channels 55 in the manifold plates 24F, 24G, and 24H and other plates, so that the adjustment range of the discharge speed of the liquid discharged from the second discharge holes 56 can be widened. Therefore, according to the embodiment, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be further improved.

[0098] A description will be further given on other portions of the head main body 20. As illustrated in FIG. 5, the piezoelectric actuator substrate 25 includes piezoelectric ceramic layers 25A and 25B, a common electrode 33, an individual electrode 34, a connection electrode 35, a dummy electrode 36, and a surface electrode 37 (see FIG. 4).

[0099] In addition, the piezoelectric actuator substrate 25 includes the piezoelectric ceramic layer 25B, the common electrode 33, the piezoelectric ceramic layer 25A, and the individual electrode 34 stacked in this order.

[0100] Each of the piezoelectric ceramic layers 25A and 25B extends across the plurality of first pressurizing chambers 44 and second pressurizing chambers 54. The piezoelectric ceramic layers 25A and 25B each have a thickness of about 20 μm. For example, the piezoelectric ceramic layers 25A and 25B are made of a lead zirconate titanate (PZT)-based ceramic material having ferroelectricity.

[0101] The common electrode 33 is formed over substantially the entire surface in a surface direction in a region between the piezoelectric ceramic layer 25A and the piezoelectric ceramic layer 25B. Thus, the common electrode 33 overlaps all of the first pressurizing chambers 44 and the second pressurizing chambers 54 in the region facing the piezoelectric actuator substrate 25.

[0102] The thickness of the common electrode 33 is approximately 2 μm. For example, the common electrode 33 is made of a metal material such as an Ag-Pd-based material.

[0103] The individual electrode 34 includes a main body electrode 34a and an extraction electrode 34b. The main body electrode 34a is located in a region, on the piezoelectric ceramic layer 25A, facing the first pressurizing chambers 44 and the second pressurizing chambers 54. The main body electrode 34a is one size smaller than each first pressurizing chamber 44 and each second pressurizing chamber 54, and has a shape substantially similar to that of the first pressurizing chamber 44 and the second pressurizing chamber 54.

[0104] The extraction electrode 34b is extracted from the main body electrode 34a to be outside the region facing the first pressurizing chambers 44 and the second pressurizing chambers 54. The individual electrode 34 is made of, for example, a metal material such as an Au-based material.

[0105] The connection electrode 35 is located on the extraction electrode 34b, and is formed to have a convex shape with a thickness of approximately 15 μm. The connection electrode 35 is electrically connected to an electrode provided to the signal transmitter 26 (see FIG. 3). The connection electrode 35 is made of, for example, silver-palladium, including glass frit.

[0106] The dummy electrode 36 is located on the piezoelectric ceramic layer 25A and is located so as not to overlap various electrodes such as the individual electrode 34. The dummy electrode 36 connects the piezoelectric actuator substrate 25 and the signal transmitter 26 to each other, and increases the connection strength.

[0107] Furthermore, the dummy electrode 36 uniformizes the distribution of the contact positions between the piezoelectric actuator substrate 25 and the signal transmitter 26, and stabilizes the electrical connection. The dummy electrode 36 is preferably made of a material equivalent to that of the connection electrode 35, and is preferably formed in a process equivalent to that of the connection electrode 35.

[0108] The surface electrode 37 illustrated in FIG. 4 is formed on the piezoelectric ceramic layer 25A and at a position not interfering with the individual electrode 34. The surface electrode 37 is connected to the common electrode 33 through a via hole formed in the piezoelectric ceramic layer 25A.

[0109] With this configuration, the surface electrode 37 is grounded and maintained at the ground electric potential. The surface electrode 37 is preferably made of a material equivalent to that of the individual electrode 34, and is preferably formed in a process equivalent to that of the individual electrode 34.

[0110] A plurality of the individual electrodes 34 are individually electrically connected to the controller 14 (see FIG. 1) via the signal transmitter 26 and wiring, in order to individually control the potentials of each individual electrode 34. Then, when the individual electrode 34 and the common electrode 33 are set to different potentials and an electric field is applied in a polarization direction of the piezoelectric ceramic layer 25A, a part applied with the electric field in the piezoelectric ceramic layer 25A operates as an active part that is distorted by the piezoelectric effect.

[0111] That is, in the piezoelectric actuator substrate 25, portions of the individual electrode 34, the piezoelectric ceramic layers 25A and 25B, and the common electrode 33 facing the first pressurizing chambers 44 and the second pressurizing chambers 54 function as the displacement elements 38.

[0112] Then, unimorph deformation of such displacement elements 38 results in the first pressurizing chambers 44 and the second pressurizing chambers 54 being pressed. Then, the liquid is discharged from the first discharge holes 46 and the second discharge holes 56.

[0113] Next, a drive procedure of the liquid discharge head 8 according to the embodiment will be described. The individual electrodes 34 are set to a higher potential (hereinafter, also referred to as high potential) than the common electrode 33 in advance. Then, with the controller 14, each time a discharge request is made, the individual electrodes 34 are set to the same potential as the common electrode 33 (hereinafter referred to as low potential), and then are again set to the high potential at a predetermined timing.

[0114] Thus, at the timing when the individual electrodes 34 shift to the low potential, the piezoelectric ceramic layers 25A and 25B return to their original shape, and the volume of the first pressurizing chambers 44 and second pressurizing chambers 54 increases over that in the initial state, that is, the state with the high potential.

[0115] In this process, a negative pressure is applied to the first pressurizing chamber 44 and the second pressurizing chamber 54. As a result, liquid in the supply manifold 40 is sucked into the inside of the first pressurizing chamber 44 and the second pressurizing chamber 54.

[0116] Then, the piezoelectric ceramic layers 25A and 25B deform so as to protrude toward the first pressurizing chamber 44 and the second pressurizing chamber 54 at the timing when the individual electrodes 34 are again set to the high potential.

[0117] That is, the first pressurizing chamber 44 and the second pressurizing chamber 54 have a positive pressure as a result of the decreasing volume of the first pressurizing chamber 44 and the second pressurizing chamber 54. Thus, the pressure of the liquid inside the first pressurizing chamber 44 and the second pressurizing chamber 54 rises, and droplets are discharged from the first discharge holes 46 and the second discharge holes 56.

[0118] That is, the controller 14 supplies a drive signal including pulses based on the high potential to the individual electrodes 34 in order to discharge the droplets from the first discharge holes 46 and the second discharge holes 56. The pulse width need only be an acoustic length (AL), corresponding to a length of time required for pressure waves to propagate from the first connection flow channel 41 to the first discharge hole 46 (or from the second connection flow channel 51 to the second discharge hole 56).

[0119] With this configuration, when the inside of the first pressurizing chambers 44 and the second pressurizing chambers 54 transitions from the negative pressure state to the positive pressure state, both the pressures under the states are combined, so that the droplets can be discharged with higher pressure.

[0120] In addition, for gradient printing, the gradient is expressed based on the number of droplets continuously discharged from the first discharge holes 46 and the second discharge holes 56, that is, the amount (volume) of droplets adjusted based on the number of times the droplets are discharged. Thus, the droplets are discharged by a number of times corresponding to the designated gradient to be expressed, through the first discharge holes 46 and the second discharge holes 56 corresponding to the designated dot region.

[0121] In general, when the liquid discharge is continuously performed, an interval between the pulses that are supplied to discharge the droplets may be set to the AL. Due to this, a period of a residual pressure wave of pressure generated in discharging the droplets discharged earlier matches a period of a pressure wave of pressure to be generated in discharging droplets to be discharged later.

[0122] Thus, the residual pressure wave and the pressure wave are superimposed, whereby the droplets can be discharged with a higher pressure. Note that in this case, the speed of the droplets to be discharged later increases, and the landing points of the plurality of droplets become closer.

Various Other Embodiments of Head Main Body

[0123] Various other embodiments of the head main body 20 according to the embodiment will be described with reference to FIGs. 10 to 12. FIG. 10 is a schematic cross-sectional view of the head main body 20 according to another embodiment 1.

[0124] Note that, in the various other embodiments below, redundant explanations are omitted, with parts that are the same as those in the embodiment described above denoted by the same reference numerals.

[0125] As illustrated in FIG. 10, in another embodiment 1, at least one manifold plate of the manifold plates 24F, 24G, and 24H and the other manifold plates have different diameters of holes for forming the second communication flow channel 55. For example, a diameter r21 of the hole for forming the second communication flow channel 55 in the manifold plates 24F and 24G is larger than a diameter r22 of the hole for forming the second communication flow channel 55 in the manifold plate 24H. Accordingly, since the volume of the second communication flow channel 55 in the manifold plates 24F, 24G, and 24H can be finely adjusted, an adjustment range of the discharge speed of the liquid discharged from the second discharge hole 56 can be widened. Therefore, according to another embodiment 1, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be further improved.

[0126] In addition, in another embodiment 1, central axes of the holes (holes for forming the second communication flow channels 55) of the manifold plates 24F, 24G, and 24H coincide with each other. Accordingly, even in a case where the diameters of the holes (holes for forming the second communication flow channels 55) of the manifold plates 24F, 24G, and 24H are different from each other, the liquid can be caused to flow along the central axes of the holes in the second communication flow channels 55. Therefore, according to another embodiment 1, it is possible to suppress disturbance of the flow of the liquid in the second communication flow channels 55.

[0127] FIG. 11 is a schematic cross-sectional view of the head main body 20 according to another embodiment 2.

[0128] As illustrated in FIG. 11, in another embodiment 2, the manifold plates 24F, 24G, and 24H are different from each other in the diameter of the hole for forming the second communication flow channel 55. Accordingly, since the volume of the second communication flow channel 55 in the manifold plates 24F, 24G, and 24H can be finely adjusted, the adjustment range of the discharge speed of the liquid discharged from the second discharge hole 56 can be widened. Therefore, according to another embodiment 2, the uniformity of the discharge speed of liquid between the first discharge hole 46 and the second discharge hole 56 can be further improved.

[0129] In addition, in another embodiment 2, the diameters of the holes (holes for forming the second communication flow channels 55) of the manifold plates 24F, 24G, and 24H decrease as a position of the hole (hole for forming the second communication flow channel 55) in the first direction D1 approaches the second surface 24b. That is, the diameter r22 of the hole of the manifold plate 24G is smaller than the diameter r21 of the hole of the manifold plate 24F, and the diameter r23 of the hole of the manifold plate 24H is smaller than the diameter r22 of the hole of the manifold plate 24G. Accordingly, since the volume of the second communication flow channel 55 in the manifold plates 24F, 24G, and 24H can be gradually decreased toward the downstream side of the liquid, the flow velocity of the liquid in the second communication flow channel 55 can be increased toward the second discharge hole 56. Therefore, according to another embodiment 2, the discharge of air or foreign matter from the second discharge holes 56 can be promoted.

[0130] In addition, in another embodiment 2, similarly to another embodiment 1, the central axes of the holes (holes for forming the second communication flow channels 55) of the manifold plates 24F, 24G, and 24H coincide with each other. Therefore, according to another embodiment 2, similarly to another embodiment 1, it is possible to suppress the disturbance of the flow of the liquid in the second communication flow channels 55.

[0131] FIG. 12 is an enlarged plan view of a head main body 20 according to another embodiment 3.

[0132] As illustrated in FIG. 12, in the flow channel member 24 of the head main body 20 according to another embodiment 3, the position of the first pressurizing chamber 44 is different from that in the embodiment. Specifically, in a plan view, the first pressurizing chamber 44 is located closer to the supply manifold 40 as a whole than in the embodiment, and has a portion overlapping the supply manifold 40.

[0133] In another embodiment 3, an area of the portion of the first pressurizing chamber 44 overlapping the supply manifold 40 is smaller than an area of the portion of the second pressurizing chamber 54 overlapping the supply manifold 40 in a plan view. With this configuration, the first pressurizing chamber 44 and the second pressurizing chamber 54 can be disposed in the flow channel member 24 with high space efficiency. Thus, according to another embodiment 3, the flow channel member 24 can be downsized, whereby the head main body 20 can be downsized.

[0134] Although an embodiment of the present disclosure has been described above, the present disclosure is not limited to the embodiment described above, and various changes can be made without departing from the spirit of the present disclosure. For example, in the above-described embodiment, an example in which the flow channel member 24 includes the plurality of layered plates has been described, but the flow channel member 24 is not limited to the case of including the plurality of stacked plates.

[0135] For example, the flow channel member 24 may be configured with the supply manifold 40, the first individual flow channel C1, the second individual flow channel C2, and the like formed by etching.

[0136] As described above, a liquid discharge head (for example, the liquid discharge head 8) according to an embodiment includes a flow channel member (for example, the flow channel member 24) including a first surface (for example, the first surface 24a) and a second surface (for example, the second surface 24b) located opposite to the first surface, and a pressurizer (for example, the displacement element 38) located on the first surface. The flow channel member includes a first discharge hole (for example, the first discharge hole 46) and a second discharge hole (for example, the second discharge hole 56) located in the second surface, a first individual flow channel (for example, the first individual flow channel C1) connected to the first discharge hole, a first pressurizing chamber (for example, the first pressurizing chamber 44) located upstream of the first discharge hole in the first individual flow channel, a second individual flow channel (for example, the second individual flow channel C2) connected to the second discharge hole, a second pressurizing chamber (for example, the second pressurizing chamber 54) located upstream of the second discharge hole in the second individual flow channel, and a manifold (for example, the supply manifold 40) commonly connected to an upstream side of the first individual flow channel and an upstream side of the second individual flow channel. The first individual flow channel includes a first communication flow channel (for example, the first communication flow channel 45) connecting the first pressurizing chamber and the first discharge hole. The second individual flow channel includes a second communication flow channel (for example, the second communication flow channel 55) connecting the second pressurizing chamber and the second discharge hole. The second pressurizing chamber is located closer to the manifold than the first pressurizing chamber in a plan view. A width of at least part of the second communication flow channel is different from a width of the first communication flow channel. Therefore, according to the liquid discharge head of the embodiment, the uniformity of the discharge speed of liquid can be improved.

[0137] In addition, a width of at least part of the second communication flow channel may be larger than a width of the first communication flow channel. Thus, according to the liquid discharge head of the embodiment, since the discharge speed of the liquid discharged from the second discharge hole can be reduced so as to approach the discharge speed of the liquid discharged from the first discharge hole, the uniformity of the discharge speed of liquid can be improved.

[0138] In addition, the width of at least part of the second communication flow channel may be larger than the width of the first communication flow channel by 0.5% to 2.5%. As a result, according to the liquid discharge head of the embodiment, since it is possible to suppress an excessive decrease in the discharge speed of the liquid discharged from the second discharge hole, the uniformity of the discharge speed of liquid can be further improved.

[0139] In addition, the flow channel member may have a layered structure in which a plurality of plates are stacked. The plurality of plates may include a plurality of manifold plates (for example, the manifold plates 24F, 24G, and 24H) each having a plurality of holes for forming a manifold, a first communication flow channel, and a second communication flow channel. In each of the plurality of manifold plates, a diameter (for example, the diameter r2) of a hole for forming the second communication flow channel may be larger than a diameter (for example, the diameter r1) of a hole for forming the first communication flow channel. Thus, according to the liquid discharge head of the embodiment, the first communication flow channel and the second communication flow channel can be easily formed in the flow channel member by aligning and stacking the plurality of manifold plates so that the holes communicate with each other.

[0140] In addition, a thickness of each of the plurality of manifold plates may be thicker than thicknesses of the other plates included in the plurality of plates. Thus, according to the liquid discharge head of the embodiment, since a pressure wave generated in the second pressurizing chamber is absorbed and efficiently attenuated by the liquid in the second communication flow channel in the plurality of manifold plates, an adjustment range of the discharge speed of the liquid discharged from the second discharge hole can be widened.

[0141] In addition, at least one manifold plate of the plurality of manifold plates and the other manifold plates may have different diameters of holes for forming the second communication flow channel. With this configuration, according to the liquid discharge head of the embodiment, since the volume of the second communication flow channel in the plurality of manifold plates can be finely adjusted, the adjustment range of the discharge speed of the liquid discharged from the second discharge hole can be widened.

[0142] In addition, the plurality of manifold plates may be different from each other in the diameter of the hole for forming the second communication flow channel. With this configuration, according to the liquid discharge head of the embodiment, since the volume of the second communication flow channel in the plurality of manifold plates can be finely adjusted, the adjustment range of the discharge speed of the liquid discharged from the second discharge hole can be widened.

[0143] When a direction from the first surface toward the second surface is defined as a first direction (for example, the first direction D1), the diameters of the holes of the plurality of manifold plates may decrease as the position of the hole in the first direction approaches the second surface. Therefore, according to the liquid discharge head of the embodiment, the discharge of air or foreign matter from the second discharge holes can be promoted.

[0144] Further, central axes of the holes of the plurality of manifold plates may coincide with each other. Thus, according to the liquid discharge head of the embodiment, it is possible to suppress disturbance of the flow of the liquid in the second communication flow channels.

[0145] In addition, the plurality of plates may include other plates (for example, the base plate 24B, the aperture plates 24C and 24D, the supply plate 24E, and the cover plate 24I) different from the plurality of manifold plates and having a plurality of holes for forming the first communication flow channel and the second communication flow channel. In each of the plurality of manifold plates and the other plates, a diameter of the hole for forming the second communication flow channel may be larger than a diameter of the hole for forming the first communication flow channel. With this configuration, according to the liquid discharge head of the embodiment, since the pressure wave generated in the second pressurizing chamber is absorbed and attenuated by the liquid in the second communication flow channel in the plurality of manifold plates and the other plates, the adjustment range of the discharge speed of the liquid discharged from the second discharge hole can be widened.

[0146] Further effects and other embodiments can be readily derived by those skilled in the art. Thus, the broader aspects of the present invention are not limited to the specific details and representative embodiment illustrated and described above. Accordingly, various changes can be made without departing from the spirit or scope of the general inventive concepts defined by the appended claims and their equivalents.

REFERENCE SIGNS

[0147]

1 Printer
8 Liquid discharge head
14 Controller
20 Head main body
24 Flow channel member
24A Cavity plate
24B Base plate
24C, 24D Aperture plate
24E Supply plate
24F, 24G, 24H Manifold plate
24I Cover plate
24J Nozzle plate
25 Piezoelectric actuator substrate
38 Displacement element
40 Supply manifold
41 First connection flow channel
42 First aperture
43 First supply flow channel
44 First pressurizing chamber
45 First communication flow channel
46 First discharge hole
51 Second connection flow channel
52 Second aperture
53 Second supply flow channel
54 Second pressurizing chamber
55 Second communication flow channel
56 Second discharge hole
C1 First individual flow channel
C2 Second individual flow channel
D1 First direction

Claims

1. A liquid discharge head comprising:

    a flow channel member comprising a first surface and a second surface located opposite to the first surface; and
    a pressurizer located on the first surface,
    wherein the flow channel member comprises:

        a first discharge hole and a second discharge hole located in the second surface;
        a first individual flow channel connected to the first discharge hole;
        a first pressurizing chamber located upstream of the first discharge hole in the first individual flow channel;
        a second individual flow channel connected to the second discharge hole;
        a second pressurizing chamber located upstream of the second discharge hole in the second individual flow channel; and
        a manifold commonly connected to an upstream side of the first individual flow channel and an upstream side of the second individual flow channel,

    the first individual flow channel comprises a first communication flow channel connecting the first pressurizing chamber and the first discharge hole,
    the second individual flow channel comprises a second communication flow channel connecting the second pressurizing chamber and the second discharge hole,
    the second pressurizing chamber is located closer to the manifold than the first pressurizing chamber in a plan view, and
    a width of at least part of the second communication flow channel is different from a width of the first communication flow channel.

2. The liquid discharge head according to claim 1, wherein the width of at least part of the second communication flow channel is larger than the width of the first communication flow channel.

3. The liquid discharge head according to claim 2, wherein the width of at least part of the second communication flow channel is larger than the width of the first communication flow channel by 0.5% to 2.5%.

4. The liquid discharge head according to claim 2 or 3, wherein

the flow channel member has a layered structure in which a plurality of plates are stacked,
the plurality of plates comprises a plurality of manifold plates each having a plurality of holes for forming the manifold, the first communication flow channel, and the second communication flow channel, and
in each of the plurality of manifold plates, a diameter of a hole for forming the second communication flow channel is larger than a diameter of a hole for forming the first communication flow channel.

5. The liquid discharge head according to claim 4, wherein a thickness of each of the plurality of manifold plates is thicker than thicknesses of other plates included in the plurality of plates.

6. The liquid discharge head according to claim 4 or 5, wherein at least one manifold plate of the plurality of manifold plates and the other manifold plates have different diameters of holes for forming the second communication flow channel.

7. The liquid discharge head according to claim 4 or 5, wherein in the plurality of manifold plates, diameters of holes for forming the second communication flow channel are different from each other.

8. The liquid discharge head according to claim 7, wherein when a direction from the first surface toward the second surface is defined as a first direction, the diameters of the holes of the plurality of manifold plates decrease as a position of the hole in the first direction approaches the second surface.

9. The liquid discharge head according to any one of claims 6 to 8, wherein central axes of the holes of the plurality of manifold plates coincide with each other.

10. The liquid discharge head according to claim 4, wherein

the plurality of plates comprise other plates different from the plurality of manifold plates and have a plurality of holes for forming the first communication flow channel and the second communication flow channel, and
in each of the plurality of manifold plates and the other plates, a diameter of the hole for forming the second communication flow channel is larger than a diameter of the hole for forming the first communication flow channel.

11. A recording apparatus comprising the liquid discharge head according to any one of claims 1 to 10.

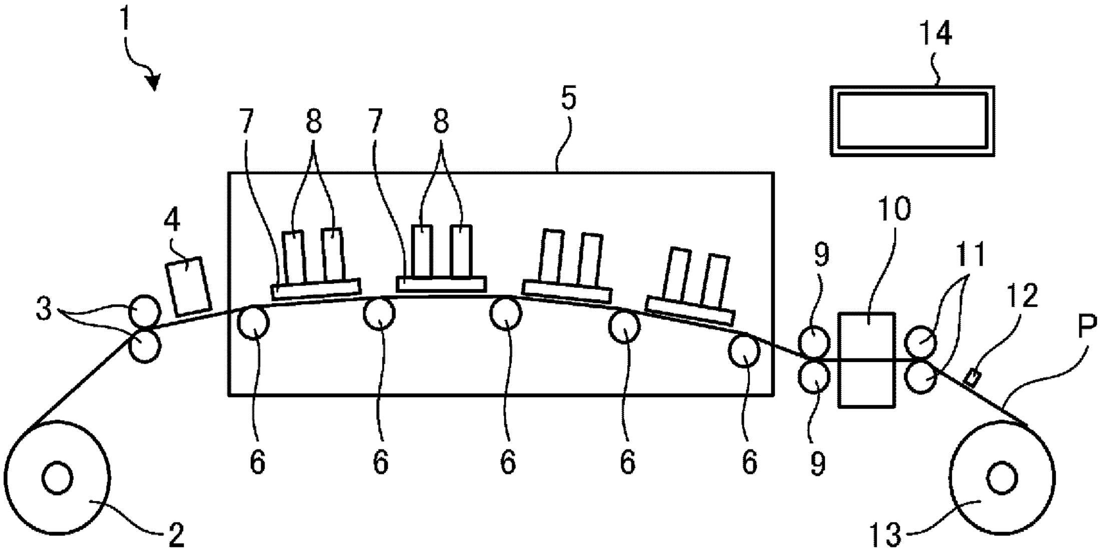
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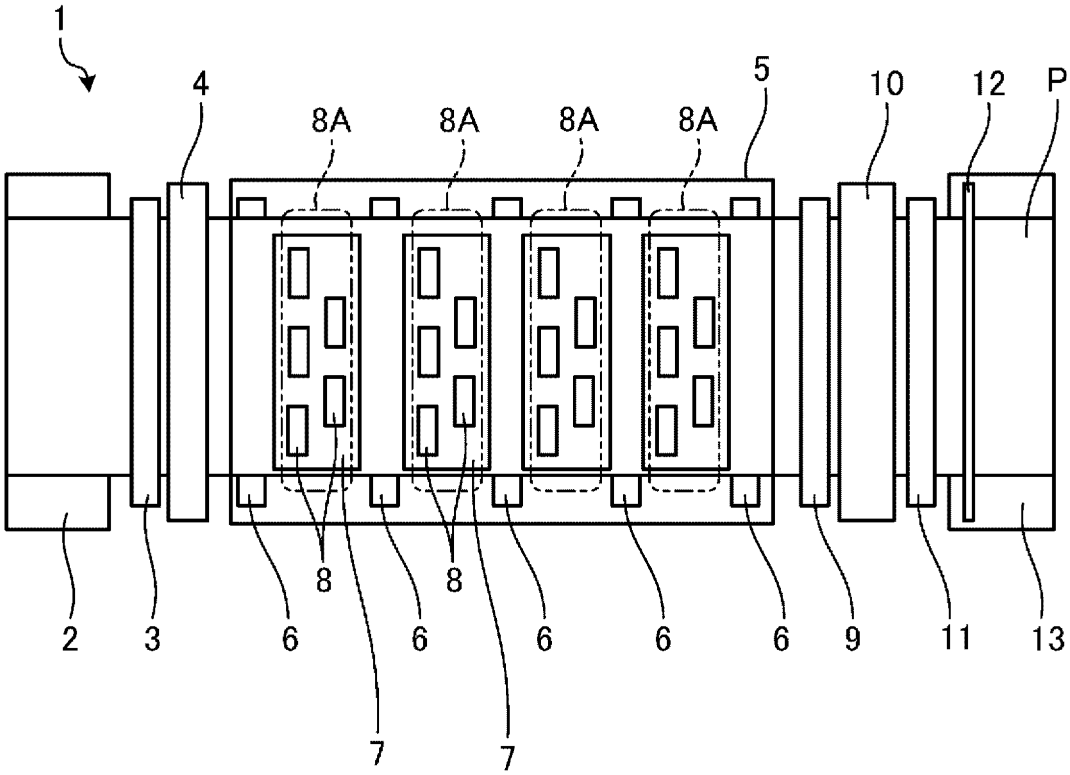
FIG. 1


1
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7

FIG. 2

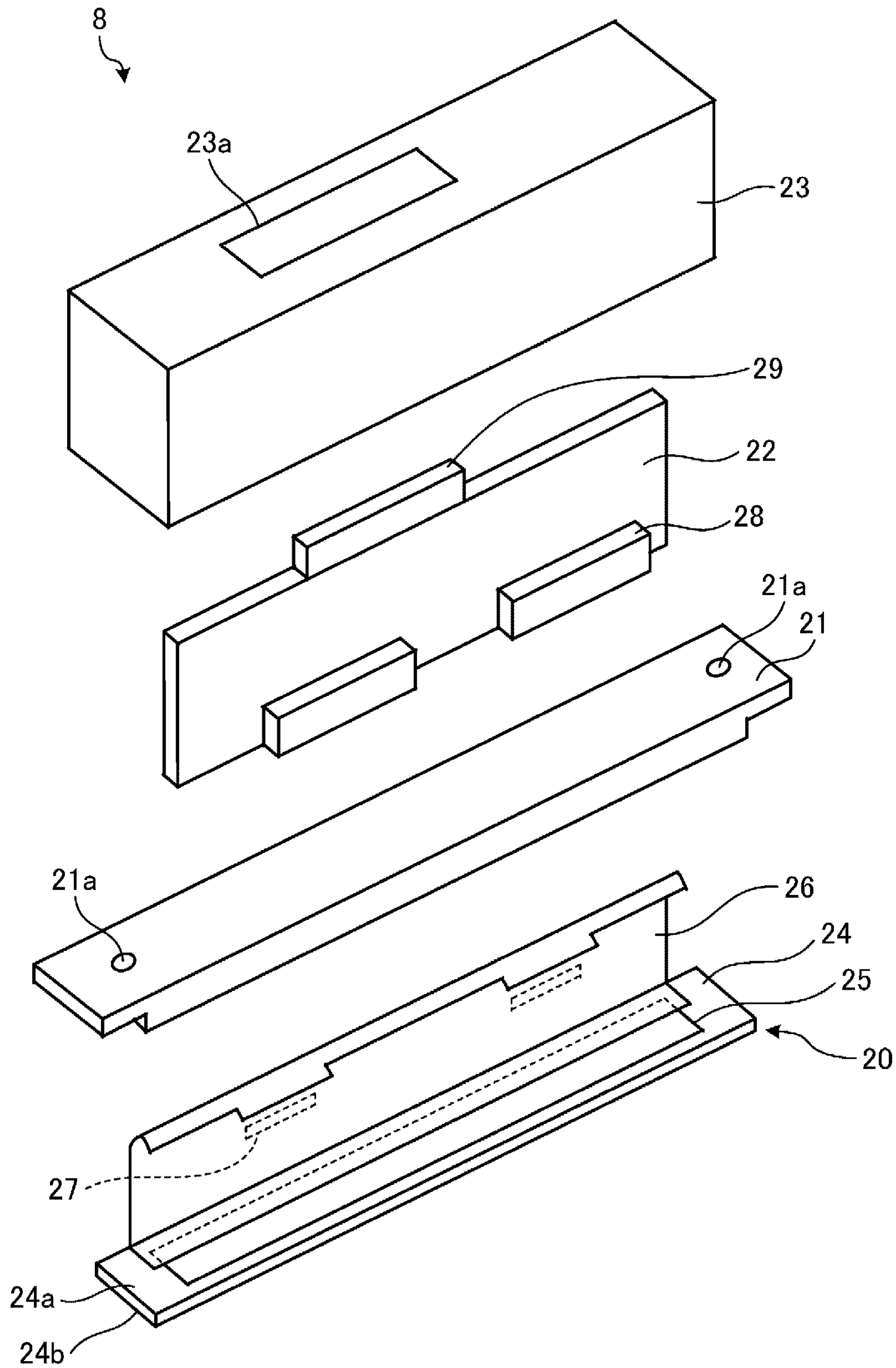


FIG. 3

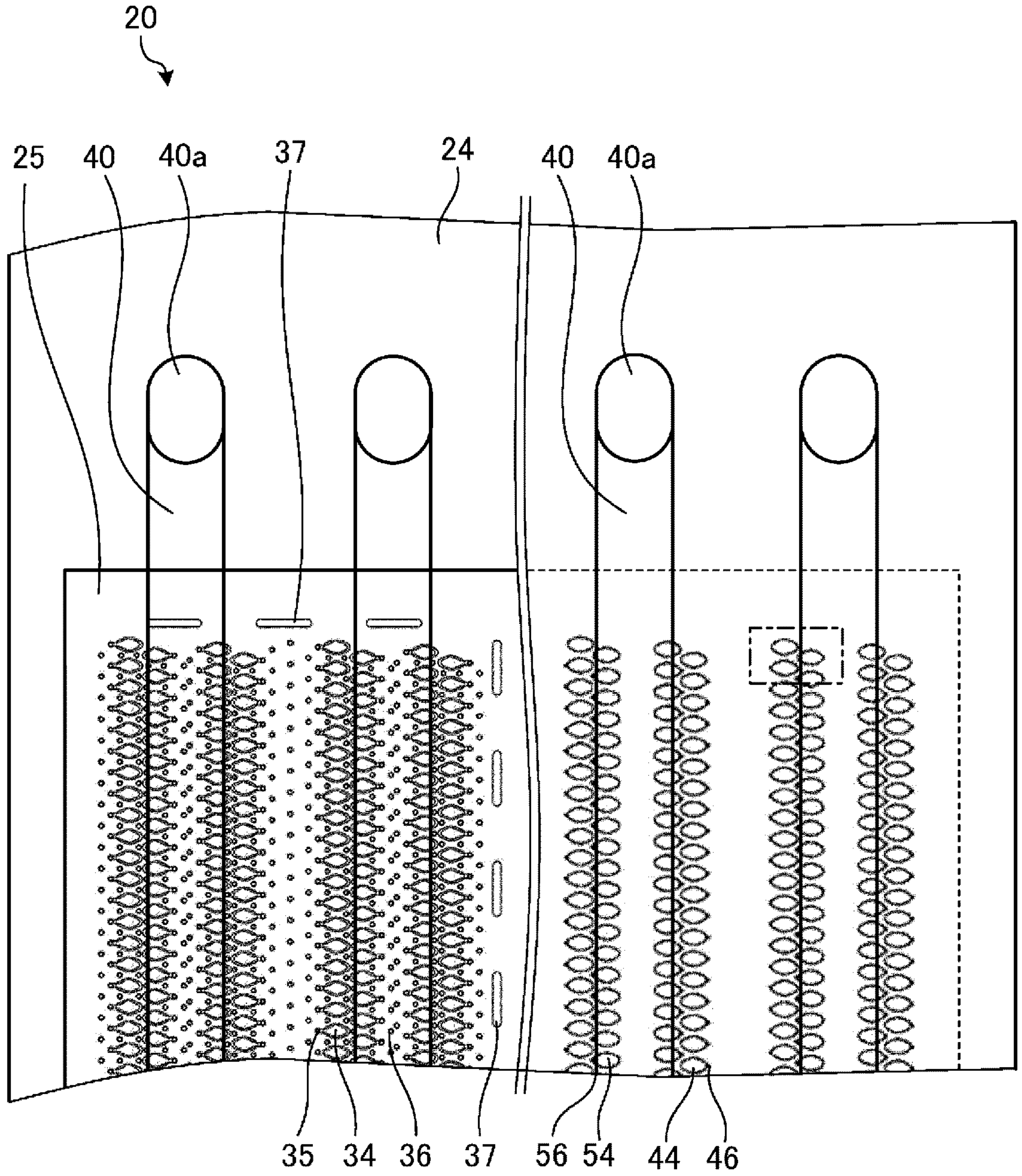
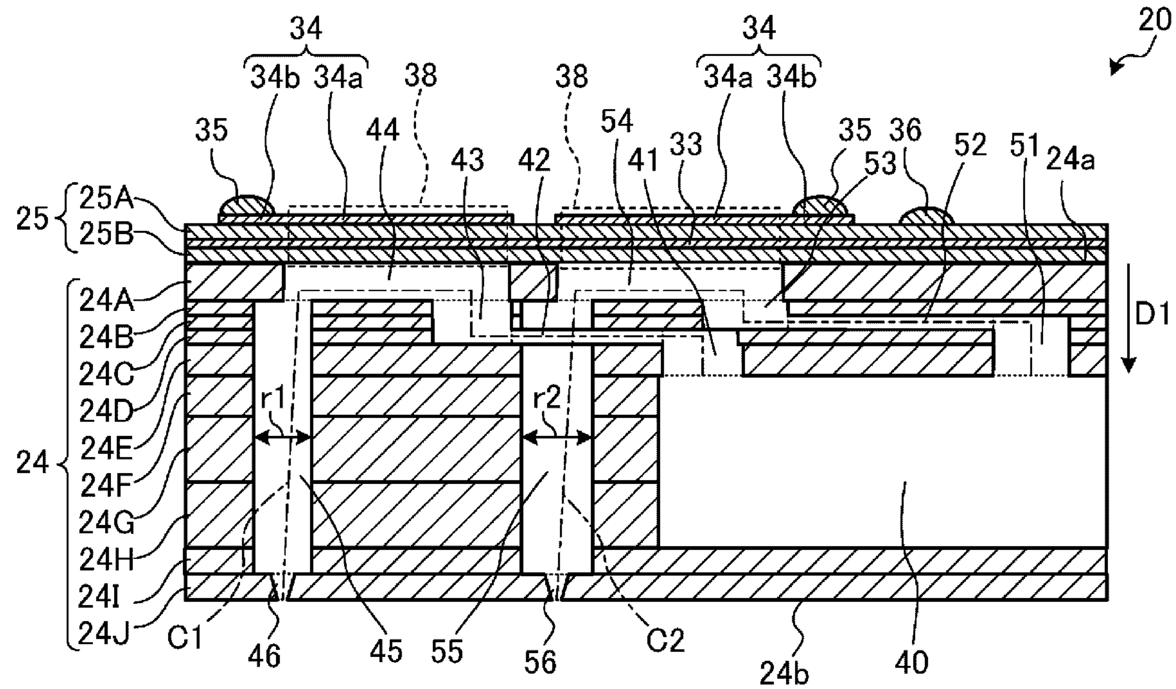


FIG. 4



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34
34b 34a
38
38
34
34a 34b
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35 36
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52
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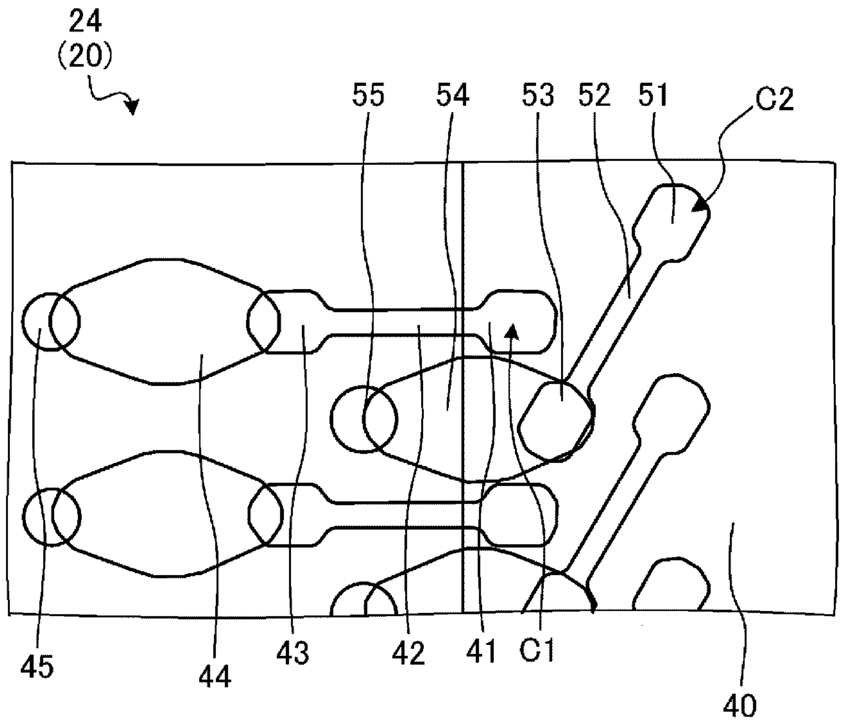
24a
25
25A
25B
24A
24B
24C
24D
24E
24F
24G
24H
24I
24J
24
D1
r1
r2
C1
46
45
55
56
C2
24b
40

FIG. 5



24
(20)
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54
53
52
51
C2
45
44
43
42
41
C1
40

FIG. 6

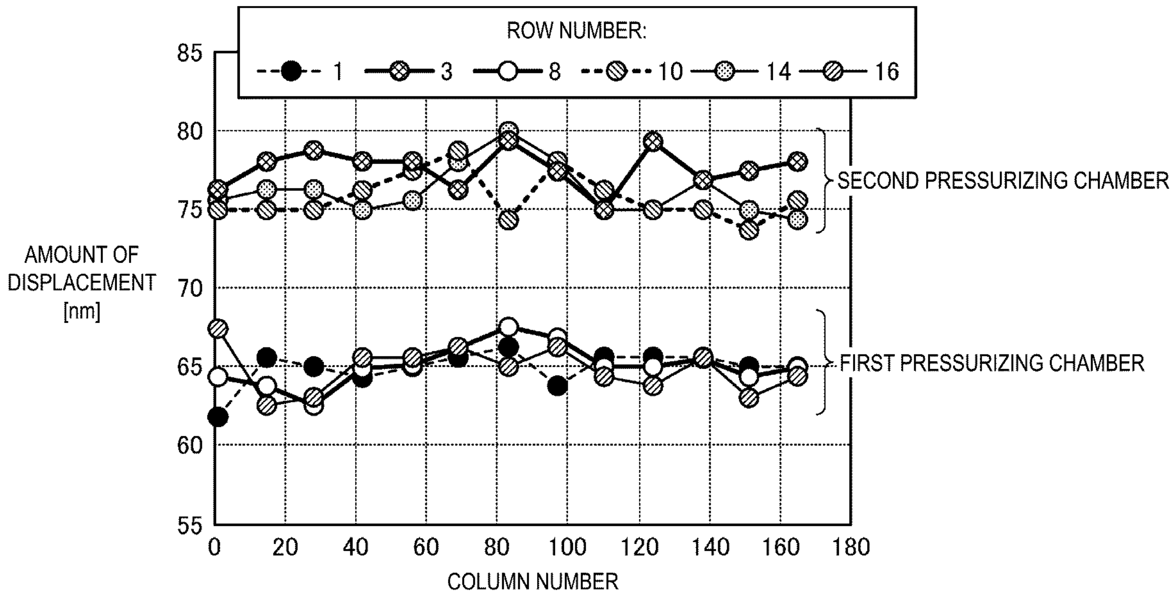

ROW NUMBER:
1
3
8
10
14
16
85
80
75
70
65
60
55
AMOUNT OF DISPLACEMENT [nm]
0
20
40
60
80
100
120
140
160
180
COLUMN NUMBER
SECOND PRESSURIZING CHAMBER
FIRST PRESSURIZING CHAMBER

FIG. 7

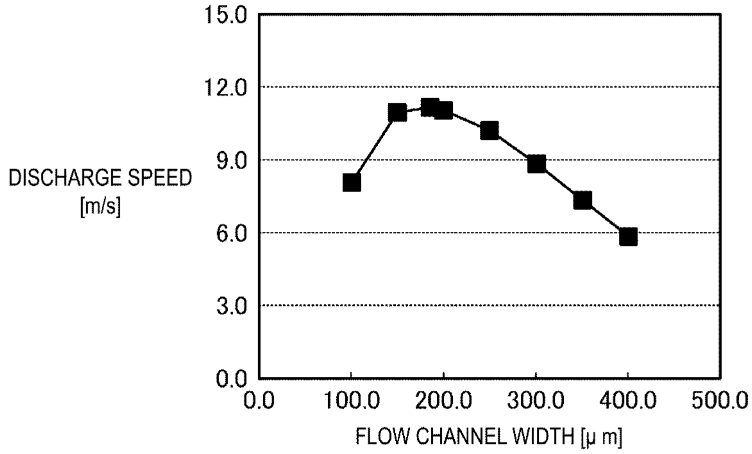

15.0
12.0
9.0
6.0
3.0
0.0
DISCHARGE SPEED [m/s]
0.0
100.0
200.0
300.0
400.0
500.0
FLOW CHANNEL WIDTH [μ m]

FIG. 8

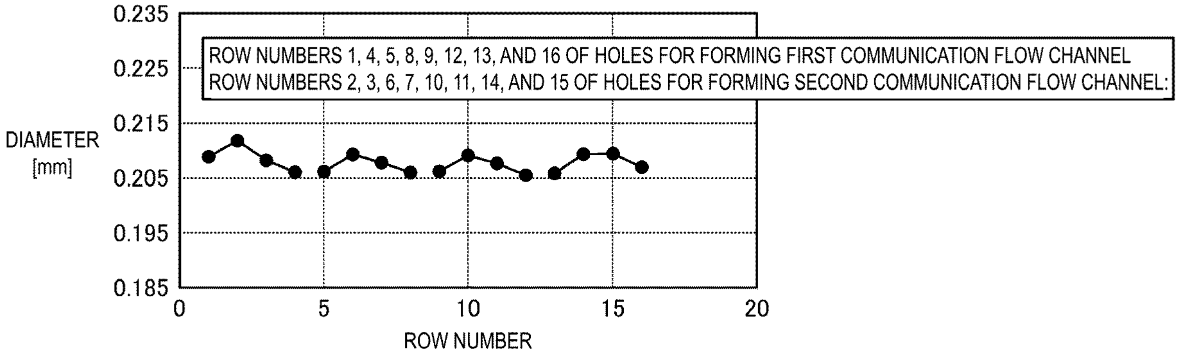
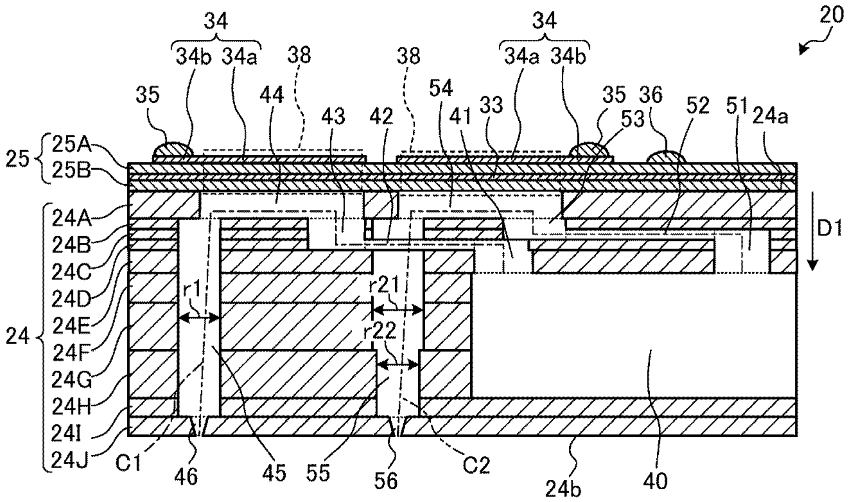

0.235
0.225
0.215
0.205
0.195
0.185
DIAMETER [mm]
0
5
10
15
20
ROW NUMBER
ROW NUMBERS 1, 4, 5, 8, 9, 12, 13, AND 16 OF HOLES FOR FORMING FIRST COMMUNICATION FLOW CHANNEL
ROW NUMBERS 2, 3, 6, 7, 10, 11, 14, AND 15 OF HOLES FOR FORMING SECOND COMMUNICATION FLOW CHANNEL:

FIG. 9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24a
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25A
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24B
24C
24D
24E
24F
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24J
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r1
r21
r22
D1
C1
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56
C2
24b
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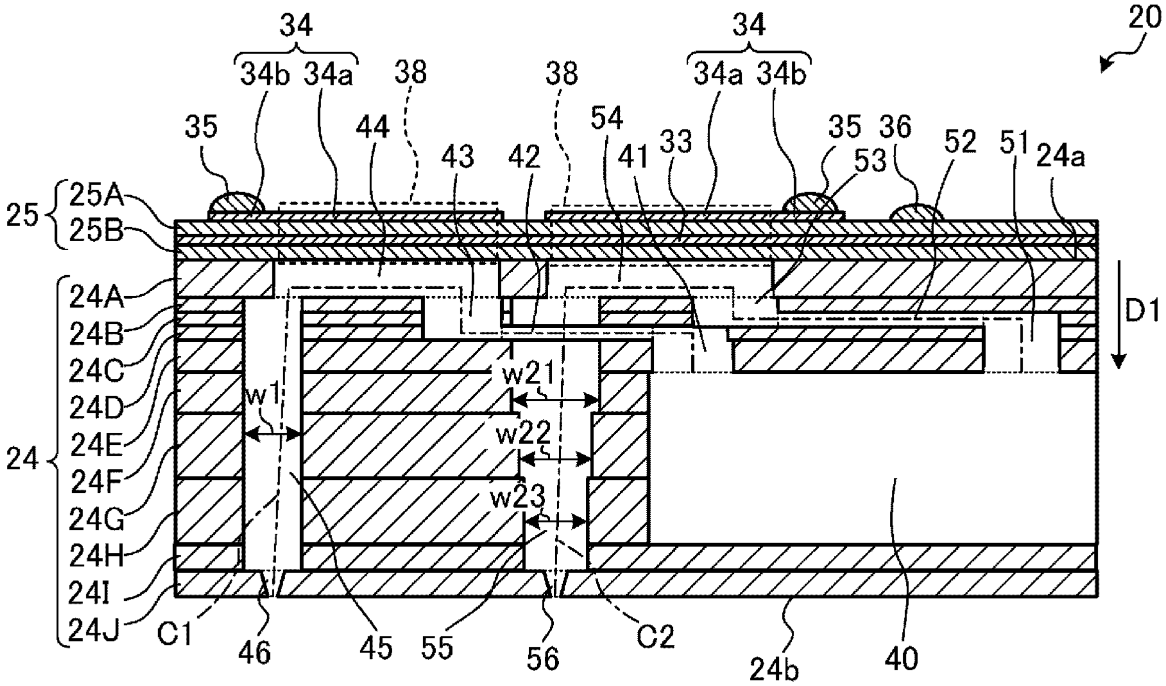
FIG. 10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24B
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24F
24G
24H
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w1
w21
w22
w23
C1
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45
55
56
C2
24b
40

FIG. 11

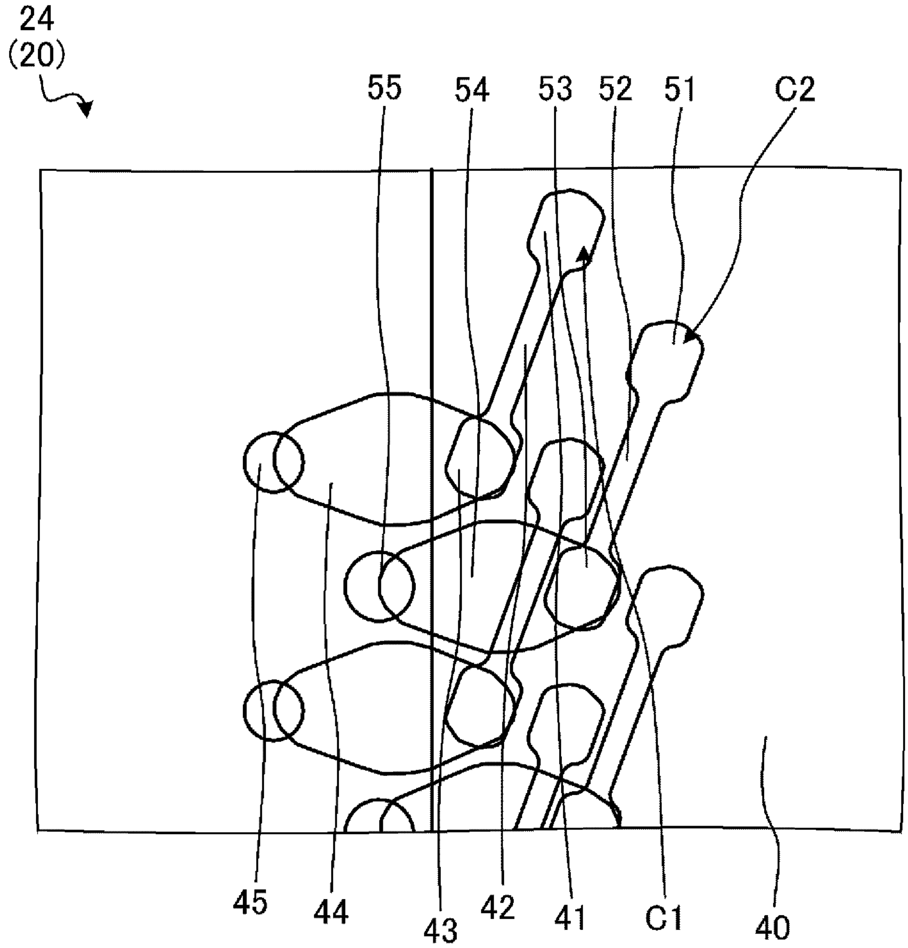

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2023/011941**

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/14(2006.01)i
FI: B41J2/14 305; B41J2/14 501; B41J2/14 603

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J2/01-2/215

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2020-138433 A (KYOCERA CORP) 03 September 2020 (2020-09-03) entire text, all drawings	1-11
A	JP 2020-168811 A (BROTHER IND LTD) 15 October 2020 (2020-10-15) entire text, all drawings	1-11
A	JP 2019-010758 A (CANON KK) 24 January 2019 (2019-01-24) entire text, all drawings	1-11

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 April 2023	**09 May 2023**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/011941

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2020-138433 A	03 September 2020	(Family: none)	
JP 2020-168811 A	15 October 2020	US 2020/0316942 A1 entire text, all drawings	
JP 2019-010758 A	24 January 2019	US 2019/0001672 A1 entire text, all drawings EP 3421241 A1 CN 109203678 A KR 10-2019-0002324 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2005035291 A **[0004]**