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LIQUID DISCHARGE HEAD AND LIQUID DISCHARGE APPARATUS

Abstract

A liquid discharge head includes: a nozzle plate having a nozzle from which a liquid is dischargeable in a discharge direction; a valve movable in the discharge direction to open and close the nozzle; a mover to move the valve in the discharge direction between: an open position at which the valve opens the nozzle; and a closed position at which the valve closes the nozzle; a housing to house the valve and the mover, the housing including: a first housing; a second housing coupled to the first housing at a coupling portion between the first housing and the second housing; and a groove on a periphery of the coupling portion of at least one of the first housing or the second housing; and a sealing in the groove to seal a portion between the housing and the valve.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application is based on and claims priority pursuant to 35 U.S.C. § 119 (a) to Japanese Patent Application No. 2024-018689, filed on Feb. 9, 2024, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

Technical Field

[0002] The present embodiment relates to a liquid discharge head and a liquid discharge apparatus.

Related Art

[0003] A liquid discharge head includes a nozzle plate on which a nozzle is formed, a valve that opens and closes the nozzle, a mover that moves the valve between an open position at which the nozzle is opened and a closed position at which the nozzle is closed, a housing including a liquid chamber that stores liquid to be discharged from the nozzle and a mover storage that stores the mover, and a sealing that abuts the housing and the valve and seals between the liquid chamber and the mover storage.

SUMMARY

[0004] In an aspect of the present disclosure, a liquid discharge head is provided that includes: a nozzle plate having a nozzle from which a liquid is dischargeable in a discharge direction; a valve movable in the discharge direction to open and close the nozzle; a mover to move the valve in the discharge direction between: an open position at which the valve opens the nozzle; and a closed position at which the valve closes the nozzle; a housing to house the valve and the mover, the housing including: a first housing; a second housing coupled to the first housing at a coupling portion between the first housing and the second housing; and a groove on a periphery of the coupling portion of at least one of the first housing or the second housing; and a sealing in the groove to seal a portion between the housing and the valve. The groove fixes a position of the sealing in the discharge direction.

Description

BRIEF DESCRIPTIONS OF DRAWINGS

[0005] A more complete appreciation of embodiments of the present disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

[0006] FIGS. **1**A and **1**B are external illustrative views of a liquid ejection head according to an embodiment of the present embodiment;

[0007] FIG. **2** is an entire cross-sectional view of the liquid discharge head;

[0008] FIG. **3** is a diagram for illustrating an arrangement of a heater provided in a first housing;

[0009] FIG. **4** is a schematic configuration diagram illustrating a basic configuration of a liquid discharge module;

[0010] FIG. **5** is an enlarged view of the periphery of a valve through hole of the liquid discharge head of a comparative example;

[0011] FIG. **6** is an enlarged view of the periphery of a valve through hole of the liquid discharge head of the present embodiment;

[0012] FIGS. **7**A and **7**B are diagrams illustrating a state in which the needle valve is moved from a

nozzle closed position to a nozzle open position;
[0013] FIGS. **8**A and **8**B are diagrams for illustrating a parting line of the sealing;
[0014] FIG. **9** is a schematic configuration diagram illustrating an example in which a holding groove is a triangular groove;
[0015] FIG. **10** is a schematic configuration diagram of a liquid discharge head provided with a liquid discharge module according to a modification;
[0016] FIGS. **11**A and **11**B are schematic diagrams illustrating another modification of a liquid discharge module;
[0017] FIG. **12** is a schematic perspective view of a liquid discharge apparatus;
[0018] FIG. **13** is a diagram illustrating an example of a supply apparatus that supplies paint to a plurality of liquid discharge heads provided in the liquid discharge apparatus; and
[0019] FIG. **14** is a diagram illustrating an example of an electrode manufacturing apparatus.
[0020] The accompanying drawings are intended to depict embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that have a similar function, operate in a similar manner, and achieve a similar result.
[0022] Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.
[0023] A best mode for carrying out the present embodiment will be hereinafter described with reference to the drawings. It is to be understood that those skilled in the art can easily change and correct the present embodiment within the scope of claims to form other embodiments, and these changes and corrections are included in the scope of claims. The following description is an example of the best mode of the present embodiment, and does not limit the scope of claims.
[0024] FIGS. **1**A and **1**B are external illustrative views of a liquid discharge head **10** according to an embodiment of the present embodiment. FIG. **1**A is an entire perspective view of the liquid discharge head **10**, and FIG. **1**B is an entire side view of the head.
[0025] In FIGS. **1**A and **1**B, a longitudinal direction of the liquid discharge head **10** (arrangement direction of nozzles **14**) is defined as an X direction, and a lateral direction of the liquid discharge head **10** is defined as a Y direction. A height direction of the liquid discharge head **10** is defined as a Z direction. In the subsequent drawings, the definition of coordinates is similar unless otherwise specified. The height direction is also referred to as "an opening/closing direction of a needle valve **31**", "a moving direction of the needle valve **31**", or "a liquid discharge direction from the nozzle **14**".
[0026] The liquid discharge head **10** is provided with a housing **11** as a housing. The housing **11** includes a first housing **11***a* and a second housing **11***b*. The second housing **11***b* is stacked and joined to the first housing **11***a*. The first housing **11***a* is made of a material having high thermal conductivity such as metal and having high resistance to liquid such as ink, and the second housing **11***b* is made of the same material as the first housing **11***a*. In the present embodiment, the first housing **11***a* and the second housing **11***b* are made of stainless steel (SUS). A material not having high thermal conductivity such as resin may be used as long as an apparatus does not heat the liquid using a heater.
[0027] The first housing **11***a* is provided with heaters **12** as heating units on its front and rear surfaces. The heater **12** can control temperature and heats the first housing **11***a*. The second housing

11*b* is provided with a connector **13** for communication of electric signals on its upper portion.
[0028] FIG. **2** is an entire cross-sectional view of the liquid discharge head **10**, and is a cross-sectional view taken along line A-A of FIG. **1**A.
[0029] The first housing **11***a* holds a nozzle plate **15**. The nozzle plate **15** is provided with a plurality of nozzles **14** for discharging liquid. The plurality of nozzles **14** is arranged in the longitudinal direction of the liquid discharge head **10** (X direction).
[0030] A supply port **16** for supplying liquid such as ink into the head is provided on one end in the X direction of the second housing **11***b*, and a recovery port **18** for ejecting the liquid from the head is provided on the other end in the X direction.
[0031] The first housing **11***a* is provided with a liquid chamber **17** that stores liquid. The supply port **16** is connected to one end in the X direction of the liquid chamber, and the recovery port **18** is connected to the other end in the X direction of the liquid chamber **17**. As indicated by arrow a**1** in the drawing, the liquid supplied from the supply port **16** to one end side in the X direction of the liquid chamber moves inside the liquid chamber **17** to the other end side in the X direction as indicated by arrow a**2** in the drawing. As indicated by arrow a**3** in the drawing, this moves in the recovery port **18** and is ejected from the head.
[0032] A plurality of liquid discharge modules **30** is arranged between the supply port **16** and the recovery port **18**. The number of the liquid discharge modules **30** corresponds to the number of the nozzles **14**, and in this example, a configuration is illustrated in which eight liquid discharge modules **30** corresponding to eight nozzles **14** arranged in one row are provided. The number and arrangement of the nozzles **14** and the liquid discharge modules **30** are not limited to the above description. For example, the number of the nozzles **14** and the number of the liquid discharge modules **30** may be one instead of plural. The number may be eight or larger or smaller. The nozzles **14** and the liquid discharge modules **30** may be arranged in a plurality of rows instead of one row.
[0033] Each liquid discharge module **30** is provided with a needle valve **31** as a valve that opens and closes the nozzle **14** and a piezoelectric element **32** as a mover that moves the needle valve **31**. The piezoelectric element **32** is connected to a drive controller via the connector **13**. When a voltage is applied to the piezoelectric element **32** by the drive controller, the piezoelectric element **32** contracts in the Z direction, the needle valve **31** rises to open the nozzle **14**, and liquid is discharged from the nozzle **14**. When no voltage is applied to the piezoelectric element **32**, the needle valve **31** closes the nozzle **14**. In this state, the liquid is not discharged from the nozzle **14**. As the mover for moving the needle valve **31**, a solenoid may be used.
[0034] A regulation member **20** that regulates upward movement of the liquid discharge module **30** is provided on an upper portion of the liquid discharge module **30**. A housing seal member **19** is provided in a joint portion between the first housing **11***a* and the second housing **11***b* of the supply port **16** and a joint portion between the first housing **11***a* and the second housing **11***b* of the recovery port **18**. In this example, an O-ring is used as the housing seal member, and the O-ring prevents leakage of liquid from the joint portion between the first housing **11***a* and the second housing **11***b*.
[0035] FIG. **3** is a diagram for illustrating the arrangement of the heater **12** provided in the first housing **11***a*. As indicated by a broken line in FIG. **3**, the heaters **12** provided on the front and rear surfaces of the first housing **11***a* are provided in the vicinity of the nozzles **14** so as to cross the plurality of nozzles **14**.
[0036] FIG. **4** is a schematic configuration diagram illustrating a basic configuration of the liquid discharge module **30**.
[0037] In addition to the needle valve **31** and the piezoelectric element **32** described above, the liquid discharge module **30** is mainly provided with a securing member **33**, a holder **35**, and a plug **36**. The holder **35** includes a drive body storage unit **35***a* therein, and stores and holds the piezoelectric element **32** in the drive body storage unit **35***a*. The holder **35** is made of metal such as

stainless steel such as SUS304 or SUS316L. The holder **35** is a frame body in which a plurality of elongated members extending in the longitudinal direction is arranged around the piezoelectric element **32** (for example, four elongated members are arranged at 90° intervals), and the piezoelectric element **32** is inserted into the holder **35** through between the elongated members forming the holder **35**.

[0038] The needle valve **31** is coupled to a leading end portion on the nozzle **14** side of the holder **35**. A bellows portion **35***b* is formed on the nozzle **14** side of the holder **35**, and is elastically expandable/contractable in the longitudinal direction of the piezoelectric element **32**. The bellows portion **35***b* is used to expand and contract the leading end portion on the nozzle side of the holder **35** in the Z direction in the same manner as the piezoelectric element **32** when the piezoelectric element **32** expands and contracts.

[0039] The securing member **33** is coupled to a proximal end side on an opposite side of the nozzle **14** side of the holder **35**. In other words, the securing member **33** is stored in an upper end portion of the second housing **11***b*. The securing member **33** includes a through screw hole **33***a* extending in a radial direction. A positioning screw **60** is screwed into the through screw hole **33***a* from the outside of the second housing **11***b*.

[0040] The positioning screw **60** is inserted into an elongated hole **11***b***1** in the longitudinal direction in the upper end portion of the second housing **11***b*. Therefore, the positioning screw **60** is movable by a predetermined length in the Z direction. The positioning screw **60** is fastened in a state in which the securing member **33** positioned in the Z direction.

[0041] A female screw hole **11***b***2** is formed in an upper end opening of the second housing **11***b*. The plug **36** abutting the regulation member **20** of FIG. **2** is screwed into the female screw hole **11***b***2**. The plug **36** abuts an upper end portion of the securing member **33** positioned in the longitudinal direction by the positioning screw **60** to finally secure the position of the securing member **33**.

[0042] A compression spring **37** is arranged in a lower end portion of the second housing **11***b*. The compression spring **37** biases the piezoelectric element **32** and the holder **35** that holds the piezoelectric element **32** upward.

[0043] The needle valve **31** is formed of a metal material such as stainless steel (SUS), and an elastic member **40** such as rubber is provided in a leading end portion on the nozzle **14** side of the needle valve **31**. When the elastic member **40** of the needle valve **31** is pressed against the nozzle plate **15**, the elastic member **40** is compressed, so that the nozzle **14** is surely closed by the needle valve **31**.

[0044] The first housing **11***a* is provided with a valve through hole **41** through which the needle valve **31** penetrates. In the valve through hole **41**, an annular sealing **34** such as an O-ring is provided to seal such that the liquid in the liquid chamber **17** does not leak, and prevent liquid from entering a piezoelectric element storage unit **330**.

[0045] FIG. **5** is an enlarged view of the periphery of the valve through hole **41** of the liquid discharge head of a comparative example.

[0046] As illustrated in FIG. **5**, in the liquid discharge head of the comparative example, the needle valve **31** is provided with an annular holding groove **31***a* that holds the annular sealing **34**. A groove width (Z-direction length) of the holding groove **31***a* is wider than a wire diameter (thickness) of the sealing **34**, and the sealing **34** was held so as to be movable in the holding groove **31***a* by a predetermined range in the Z direction.

[0047] Therefore, due to a difference between sliding resistance between the sealing **34** and an inner peripheral surface of the valve through hole **41** and sliding resistance between the sealing **34** and a bottom surface of the holding groove **31***a*, the sealing **34** moves in the Z direction together with the needle valve **31** and slides on the inner peripheral surface of the valve through hole **41**, or remains on the spot and slides on the bottom surface of the groove portion during an opening/closing operation of the needle valve **31**. In a case where the sliding resistance in a circumferential direction is not constant, the sealing **34** might be inclined or twisted with respect to the Y direction in the drawing. As a result, a movement resistance during the opening/closing operation of the needle valve **31** varies between the liquid discharge modules **30**, and a movement amount and a moving speed of the needle valve **31** vary. The variation in the movement amount of the needle valve **31** affects a variation in distance between the nozzle **14** and the needle valve **31** when the nozzle **14** is opened, and the variation results in a variation in fluid resistance when the liquid in the liquid chamber **17** flows to the nozzle **14**. Such variation results in a variation in discharge speed and discharge amount per unit time of the liquid discharged from the nozzle **14**. The variation in the moving speed of the needle valve **31** affects a variation in time in which the needle valve **31** is opened, and thus affects a variation in size of a discharge droplet when the opening/closing operation is performed at a high frequency. As a result, there has been a possibility that a discharging performance varies among the nozzles.

[0048] Therefore, in the present embodiment, the sealing **34** is held so as not to be movable in the moving direction of the needle valve **31** (Z direction). Hereinafter, features of the present embodiment are described with reference to the drawings.

[0049] FIG. **6** is an enlarged view of the periphery of the valve through hole **41** of the liquid discharge head **10** of the present embodiment.

[0050] As illustrated in FIG. **6**, in the present embodiment, an upper end of the valve through hole **41** of the first housing **11***a* is cut out, and the second housing **11***b* and the first housing **11***a* form an annular holding groove **44** that holds the annular sealing **34**. A groove width W (Z-direction length) of the holding groove **44** is narrower than a Z-direction length in an uncompressed state of the sealing **34**. Therefore, the sealing **34** of the holding groove **44** is interposed and held between the first housing **11***a* and the second housing **11***b* in the Z direction, which is the moving direction of the needle valve **31**. Accordingly, the sealing **34** is held in the holding groove **44** so as not to be movable in the Z direction. Thus, the first housing **11***a* and the second housing **11***b* can fix the position of the sealing **34** in the Z direction.

[0051] In the present embodiment, it is sufficient that the sealing **34** abuts an outer peripheral surface of the needle valve **31** and the holding groove **44** at a predetermined abutting pressure to seal such that the liquid in the liquid chamber **17** does not leak, and an O-ring, a D-ring, an X-ring, and a T-ring can be applied. The O-ring has a circular or elliptical cross-sectional shape in the cross section of FIG. **6**, the D-ring has a cross-sectional shape similar to an alphabet “D” obtained by cutting out a part of the circular shape with a straight line, and the X-ring and the T-ring have shapes in which grooves and ribs are provided so as to have cross-sectional shapes similar to “X” and “T”. In the present embodiment, the sealing **34** having an intermediate shape between the O-ring and the D-ring is used.

[0052] As a material of the sealing **34**, an elastic member such as rubber, resin, or elastomer is preferable, and other materials may be adopted as long as the ink can be sealed. The material of the sealing **34** is necessary to have characteristics such as chemical resistance and solvent resistance, and examples of the material of the sealing include, for example, perfluoroelastomer (4275B, manufactured by MORISEI KAKO Co., Ltd.).

[0053] The Z direction (needle valve moving direction) length (thickness in the Z direction) of the sealing **34** is preferably 1 mm or more. The sealing **34** has an inner diameter of at least 1 mm and an outer diameter of about 3 mm.

[0054] Sealing between the sealing **34** and the housing **11** is performed by interposing between the first housing **11***a* and the second housing **11***b*. Specifically, the groove width W of the holding groove **44** is made shorter than the thickness in the Z direction of the sealing **34** (in the uncompressed state) so that a crushing ratio in the Z direction of the sealing **34** becomes 15±10%. When the crushing ratio is less than 5%, sealing with the housing is insufficient, and leakage might occur due to a liquid pressure in the liquid chamber. In contrast, when the crushing ratio exceeds 25%, permanent distortion of the sealing might occur.

[0055] When the thickness in the Z direction of the sealing **34** in the uncompressed state is W0 and the thickness in the Z direction in a compressed state, that is, a crushed state is W, the crushing ratio can be obtained by (W0−W)/W0×100(%).
[0056] In such a configuration, it is preferable that an inner diameter d of a bottom surface of the annular holding groove **44**≥the outer diameter of the sealing **34** in the uncompressed state. As a result, it is not necessary to reduce the diameter of the sealing **34** to assemble to the holding groove **44**, and the sealing **34** can be easily assembled to the holding groove **44**.
[0057] By making an outer diameter D of the sliding portion of the needle valve **31** with the sealing **34** larger than the inner diameter of the sealing **34** in the uncompressed state to expand the sealing **34** in diameter (the inner diameter of the sealing in an unexpanded state<the outer diameter D of the sliding portion of the needle valve **31**), the sealing between the sealing **34** and the needle valve **31** is performed. An optimum range of an elongation ratio of the sealing **34** at that time can be set according to the material and shape of the sealing **34**. For example, by setting the elongation ratio of the sealing to ½ or less of the elongation ratio at break, it is possible to satisfactorily seal the sliding portion between the sealing **34** and the needle valve **31**. It is further preferable that the elongation ratio of the sealing **34** is 5% or more and 25% or less. By setting the elongation ratio of the sealing **34** to 5% or more and 25% or less, it is possible to reduce the sliding resistance between the sealing **34** and the needle valve **31** and seal such that the liquid does not leak to the drive body storage unit **35***a* due to the pressure applied to the liquid in the liquid chamber **17**.
[0058] When an inner diameter of the sealing in the unexpanded state of the sealing **34** is set to D0 and an inner diameter in an expanded state of the sealing **34** is set to D1, the elongation ratio can be obtained by (D1−D0)/D0×100(%). The inner diameter D1 in the expanded state of the sealing **34** is equal to the outer diameter D of the sliding portion of the needle valve **31**. Therefore, the elongation ratio may be obtained by (D-D0)/D1×100(%).
[0059] The inner diameter of the sealing **34** may be reduced by crushing of the sealing **34** due to compression of the sealing **34** in the Z direction by the first housing **11***a* and the second housing **11***b*, so that the sealing **34** can contact the needle valve **31** to perform sealing with the needle valve **31**. In such a configuration, the inner diameter of the sealing in the uncompressed state>the outer diameter D of the needle valve can be satisfied, and an assembly work of the sealing **34** and the needle valve **31** can be facilitated.
[0060] As the sealing **34**, it is preferable to use a member a surface of which is coated with a low friction material such as fluorine or silicone and is subjected to a low friction treatment. Here, the low friction material is a material that reduces frictional resistance of the member before coating. Examples of the sealing the surface of which is coated with the low friction material include an SP-treated O-ring (NOK CORPORATION). By using the sealing **34** the surface of which is coated with the low friction material and subjected to a surface low friction treatment, sliding resistance with the needle valve **31** can be reduced. The needle valve **31** can be easily inserted into the sealing **34**, and the assembly work of the sealing **34** and the needle valve **31** can be facilitated.
[0061] A contact portion of the needle valve **31** with the sealing **34** may be coated with the low friction material such as fluorine or silicone to reduce friction. Examples of a coating material for coating the contact portion of the needle valve with the sealing **34** include BICOAT® (YOSHIDA SKT CO., LTD.). In this manner, by applying the low friction treatment to the contact portion of the needle valve **31** with the sealing **34**, the sliding resistance with the sealing **34** can be reduced. The needle valve **31** can be easily inserted into the sealing **34**, and the assembly work of the sealing **34** and the needle valve **31** can be facilitated.
[0062] The contact portion of the needle valve **31** with the sealing **34** may be set to have arithmetic average roughness Ra of 0.1 μm or less by mirror polishing to reduce friction. It is preferable that the arithmetic average roughness Ra is set to 0.1 μm or less by mirror polishing, and then surface treatment for reducing friction such as diamond-like carbon (DLC) coating is further performed, because sliding resistance with the sealing can be made smaller. The arithmetic average roughness

Ra of the contact portion of the needle valve **31** with the sealing **34** may be set to 0.1 μm or less by surface coating.

[0063] The above-described low friction treatment may be applied to a surface of one of the sealing **34** and the needle valve **31**, or the above-described low friction treatment may be applied to both the sealing **34** and the needle valve **31**. Such low friction treatment can reduce sliding resistance generated between the needle valve **31** and the sealing **34** when the needle valve **31** moves. By reducing an absolute value of the sliding resistance, a variation in sliding resistance itself can be reduced. This can reduce a variation in liquid discharging performance.

[0064] FIGS. **7**A and **7**B are diagrams illustrating a state in which the needle valve **31** is moved from a nozzle closed position to a nozzle open position, in which FIG. **7**A illustrates a state in which the needle valve **31** is located at the nozzle closed position, and FIG. **7**B illustrates a state in which the needle valve **31** is located at the nozzle open position.

[0065] In the present embodiment, the sealing **34** is interposed between side surfaces of the holding groove **44**, and the sealing **34** is held in the holding groove **44** so as not to be movable in the Z direction, which is the moving direction of the needle valve **31**. As a result, the sealing **34** slides only on the outer peripheral surface of the needle valve **31** when the needle valve **31** moves. Therefore, the sealing **34** does not slide on an inner wall of the valve through hole **41** in the Z direction. Therefore, in all the liquid discharge modules **30**, the sealing **34** slides only on the needle valve **31**, and a variation in movement resistance during the opening/closing operation of the needle valve **31** between the liquid discharge modules **30** is suppressed. As a result, a variation in the movement amount and the moving speed of the needle valve **31** can be suppressed, and a variation in discharging performance among the nozzles can also be suppressed.

[0066] FIGS. **8**A and **8**B are diagrams for illustrating a parting line **34***a* of the sealing **34**, in which FIG. **8**A illustrates the parting line **34***a* of the sealing **34** of the present embodiment, and FIG. **8**B illustrates the parting line **34***a* of the sealing **34** of the comparative example.

[0067] The parting line **34***a* of the sealing **34** is a protruding portion (also referred to as a burr line) formed when a burr is removed after molding.

[0068] As illustrated in FIG. **8**B, the parting line **34***a* of the sealing **34** is generally formed at the center in a central axis direction of the annular sealing **34** (Z direction in the drawing). However, in such a configuration, a portion of the parting line **34***a* of the sealing **34** abuts the outer peripheral surface of the needle valve **31**. Since a height of the parting line **34***a* is non-uniform, in a case where the parting line **34***a* abuts the needle valve **31**, the abutting pressure between the needle valve **31** and the sealing **34** becomes non-uniform in the circumferential direction, and leakage might occur locally.

[0069] In contrast, in the present embodiment, as illustrated in FIG. **8**A, a structure of a molding die is devised so that the parting line **34***a* is formed at a position not in contact with the side surface (the surface orthogonal to the Z direction) of the holding groove **44** and the needle valve **31** that perform sealing with the housing. As a result, it is possible to suppress the abutting pressure between the needle valve **31** and the sealing **34** from becoming non-uniform in the circumferential direction and the abutting pressure with the side surface of the holding groove **44** from becoming non-uniform in the circumferential direction, and it is possible to suppress the occurrence of local leakage.

[0070] In the present embodiment, the parting line **34***a* of the sealing **34** is not in contact with the housing **11** and the needle valve **31**, but the parting line **34***a* may be lightly brought into contact as long as the abutting pressure in the sealing portion is not affected. In other words, the parting line **34***a* may contact the needle valve **31** or the housing **11** at an abutting pressure sufficiently lower than the abutting pressure in the sealing portion.

[0071] FIG. **9** is a schematic configuration diagram illustrating an example in which the holding groove **44** is a triangular groove.

[0072] As illustrated in FIG. **9**, by forming the holding groove **44** into the triangular groove,

crushing of the sealing **34** outward due to compression in the Z direction by the first housing **11***a* and the second housing **11***b* (crushing in a direction away from the needle valve **31**) is suppressed. As a result, the sealing **34** is crushed in a direction in which the inner diameter further decreases, the abutting pressure of the sealing **34** with the needle valve **31** can be increased, and the sealing with the needle valve **31** can be performed more reliably. Here, the triangular groove is a groove including no bottom surface and having a shape in which at least one of two side surfaces (wall surfaces orthogonal to the Z direction) of the holding groove **44** with which the sealing **34** is in contact is inclined (inclined such that a position in the Z direction of one end of the side surface and a position in the Z direction of the other end are different from each other) in the moving direction (Z direction) of the needle valve **31**. The two side surfaces of the holding groove **44** may be inclined, or either one may be inclined. It is not limited to the triangular groove, and a shape in which at least one side surface of the two side surfaces is inclined in the Z direction such that the groove width W (distance between side surfaces) of the holding groove **44** is gradually narrowed with an increasing distance from the needle valve **31** is sufficient, and for example, the groove with a trapezoidal cross-sectional shape parallel to the Z direction may also be used.
[0073] The holding groove **44** may be provided in any one of the first housing **11***a* and the second housing **11***b*, but the holding groove **44** is preferably formed of the first housing **11***a* and the second housing **11***b*. By forming the holding groove **44** of the first housing **11***a* and the second housing **11***b*, sealing between the first housing **11***a* and the second housing **11***b* can also be performed by the sealing **34**. After the sealing **34** is assembled to the cutout formed in one of the first housing **11***a* and the second housing **11***b*, the second housing **11***b* is assembled to the first housing **11***a*, and the sealing **34** can be compressed in the Z direction. As a result, it is not necessary to press the sealing **34** into the holding groove **44** to assemble, and the sealing **34** can be easily assembled.
[0074] FIG. **10** is a schematic configuration diagram of a liquid discharge head provided with a liquid discharge module **30**A according to a modification.
[0075] As illustrated in FIG. **10**, the liquid discharge module **30**A of this modification includes an arm member **55**, and by amplifying a displacement amount of the piezoelectric element **32** with the arm member **55**, the movement amount of the needle valve **31** is increased.
[0076] A plurality of liquid discharge modules **30**A is alternately arranged in the X direction such that the needle valve **31** sides face each other in two rows in the piezoelectric element storage unit **330** of the second housing **11***b*. The plurality of liquid discharge modules **30** is arranged such that a part of the arm member **55** overlaps as seen in the X direction.
[0077] Here, the alternate arrangement of the liquid discharge modules **30** can be rephrased as a state in which the liquid discharge module in which an actuator **2** is located on one side of the nozzle arrangement and the liquid discharge module in which the actuator **2** is located on the other side of the nozzle arrangement are arranged to face each other, and are arranged in a nozzle arrangement direction (X direction) such that a part of the arm member **3** overlaps each other as seen in the nozzle arrangement direction (X direction).
[0078] The arm member **55** is rotatably supported by a support shaft **55***a*, and includes one end bonded and secured to the holder **35** that holds the piezoelectric element **32** and the other end in contact with an arm receiver **54** secured to the needle valve **31**. A contact portion **55***d* in contact with the arm receiver **54** on the other end of the arm member **55** has a hemispherical shape protruding toward the arm receiver **54** or a half-moon shape as seen in the X direction, and is smoothly in contact with the arm receiver **54** when the arm member **55** rotates.
[0079] On the other end of the arm member **55**, a clearance hole **55***b* through which the needle valve **31** penetrates is formed. An inner diameter of the clearance hole **55***b* is larger than the outer diameter of the needle valve **31** so that the needle valve **31** does not contact the arm member **55** when the arm member **55** rotates.
[0080] An end portion on a side opposite to the nozzle plate side of the needle valve **31** penetrates a spring receiving plate **52**. Between the arm receiver **54** secured to the needle valve **31** and the

spring receiving plate **52**, a compression spring **53** as a biasing unit is provided and biases the needle valve **31** toward the nozzle plate **15** via the arm receiver **54**.

[0081] By biasing the needle valve **31** toward the nozzle plate **15** by the compression spring **53**, the movement of the needle valve **31** between the open position at which the nozzle **14** is opened and the closed position at which the nozzle **14** is closed can be stabilized. The spring receiving plate **52** is attached to a securing member **51** secured to the second housing **11***b*.

[0082] By including the arm member **55**, the piezoelectric element **32**, which is the largest component among components forming the liquid discharge module **30**A, can be arranged on the end side in the Y direction in the piezoelectric element storage unit **330**. As a result, the securing member **51** can be arranged at the center in the Y direction in the piezoelectric element storage unit **330**, and the spring receiving plate **52** can be secured by one securing member **51**. As a result, the liquid discharge head **10** can be downsized.

[0083] In this modification, the liquid discharge modules **30**A are alternately arranged in the X direction such that a part of the arm member **55** overlaps as seen in the X direction. As a result, the liquid discharge head can be downsized in the Y direction as compared with a configuration in which the arm members do not overlap.

[0084] When a securing unit **55***c* is displaced in the Z direction together with the piezoelectric element **32** by the displacement of the piezoelectric element **32**, the arm member **55** rotates about the support shaft **55***a* as a fulcrum. When the arm member **55** rotates by the displacement of the piezoelectric element **32**, the contact portion **55***d* of the arm member **3** raises the arm receiver **54** against a biasing force of the compression spring **53**. As a result, the needle valve **31** rises together with the arm receiver **54**, the nozzle **14** is opened, and a droplet is discharged from the nozzle **14** by the pressure applied to the liquid in the liquid chamber **17**.

[0085] Before the arm member **55** rotates, the top of the contact portion **55***d* is in contact with the arm receiver **54**; however, when the arm member **55** rotates due to the displacement of the piezoelectric element **32**, a contact position of the contact portion **55***d* with the arm receiver **54** shifts to a left side (the other end side of the arm member) in FIG. **10**. As described above, since a contact surface of the contact portion **55***d* with the arm receiver **54** has a circular arc shape as seen in the X direction, the contact position of the contact portion **55***d* with the arm receiver **54** can be smoothly shifted. As a result, the arm member **55** can be smoothly rotated, and the needle valve **31** can be stably displaced. Therefore, a variation in droplets can be suppressed.

[0086] The support shaft **55***a* that supports the arm member **55** is provided closer to the securing unit **55***c* than the center of the arm member **55** in the longitudinal direction (Y direction). As a result, a turning radius of the contact portion **55***d* becomes longer than a turning radius of the securing unit **55***c*, and a displacement amount of the contact portion **55***d* in the Z direction becomes larger than a displacement amount of the securing unit **55***c* in the Z direction. As a result, the displacement amount by which the contact portion **55***d* raises the arm receiver **54** becomes larger than the displacement amount of the piezoelectric element **32** in the Z direction. As a result, the displacement amount of the piezoelectric element **32** is amplified by the arm member **55**, and the movement amount of the needle valve **31** can be increased. Therefore, a gap between the nozzle **14** and the leading end of the needle valve **31** when the needle valve **31** is at the open position can be increased, the liquid easily flows into the nozzle **14**, and a size of the droplet discharged from the nozzle **14** can be increased. Therefore, printing efficiency can be enhanced, and a printing time can be shortened. The piezoelectric element **32** having a small displacement amount can be used, the piezoelectric element **32** can be downsized, and the liquid discharge head **10** can be effectively downsized.

[0087] FIGS. **11**A and **11**B are schematic diagrams illustrating another modification of a liquid discharge module. FIG. **11**A is a schematic configuration diagram illustrating a state in which a needle valve **31** closes a nozzle **14**, and FIG. **11**B is a schematic configuration diagram illustrating a state in which the needle valve **31** opens the nozzle **14**.

[0088] A liquid discharge module **30**B illustrated in FIGS. **11**A and **11**B includes the needle valve **31**, a piezoelectric element **32**, a moving member **61**, a pair of arm members **62**, and a leaf spring member **63**. The moving member **61** includes one end secured to the piezoelectric element **32** and the other end to which the pair of arm members **62** is rotatably attached, and is attached to a holder **35** that holds the piezoelectric element **32** so as to be movable in a Z direction. The pair of arm members **62** is rotatably supported by a support shaft **62***a* attached to the holder **35**.
[0089] By bending a sheet metal made of stainless steel (SUS), the leaf spring member **63** forms a valve connection portion **63***a* connected to the needle valve, a pair of inclined portions **63***b* as elastic deformation portions, and a pair of arm connection portions **63***c*. The needle valve **31** is joined to the valve connection portion **63***a* with an adhesive, and the inclined portions **63***b* extend obliquely upward in the drawing from both ends of the valve connection portion **63***a*. The arm connection portion **63***c* is fitted into a slit portion provided on the arm member **62** and attached to the arm member **62**.
[0090] As illustrated in FIG. **11**A, when the needle valve **31** closes the nozzle **14** (a state in which the needle valve **31** is at the closed position), the pair of inclined portions **63***b* of the leaf spring member **63** elastically deforms as indicated by a broken line in the drawing. As a result, a biasing force that presses the needle valve **31** against the nozzle plate **15** is generated.
[0091] As indicated by a black arrow in FIG. **11**B, when the piezoelectric element **32** is displaced toward the nozzle **14**, the moving member **61** moves toward the nozzle and pushes the pair of arm members **62** toward the nozzle. As a result, the pair of arm members **62** rotates about the support shaft **62***a* as a fulcrum. When the pair of arm members **62** rotates, both ends of the leaf spring member **63** move in a direction separating from each other. As a result, the needle valve **31** is raised to open the nozzle **14**, and the liquid is discharged from the nozzle **14** (corresponding to a state in which the needle valve **31** is at the open position to open the nozzle **14**).
[0092] The liquid discharge head **10** described above is of a valve jet type, and can discharge a highly viscous liquid or a large droplet (having a diameter of several tens to several hundreds μm) toward a discharge target at a distance (several tens mm ahead). The nozzle diameter can be increased, and liquid containing a material having a large particle diameter can be satisfactorily discharged. In this manner, since liquid having high viscosity can be discharged, the liquid discharge head **10** described above is suitable for painting a vehicle body of a vehicle or a truck, a body of an aircraft, a wall surface of a building, and a road surface, and printing an image. This can also be suitably used for forming an electrode of a lithium ion battery mounted on a vehicle body.
[0093] An example of a liquid discharge apparatus including the above-described liquid discharge head **10** will be next described.
[0094] FIG. **12** is a schematic perspective view of a liquid discharge apparatus **100**.
[0095] The liquid discharge apparatus **100** includes a movable frame unit **120** installed to face a liquid discharge target **200**.
[0096] The frame unit **120** is provided with a Y-axis rail **101** extending in a horizontal direction, a plurality of X-axis rails **102** extending in a vertical direction and provided at predetermined intervals, and a Z-axis rail **103** intersecting the X-axis rails **102** and the Y-axis rail **101**.
[0097] Each X-axis rail **102** holds the Y-axis rail **101** such that the Y-axis rail **101** extending horizontally is movable in the X direction (the nozzle arrangement direction of the liquid discharge head and the vertical direction). The Y-axis rail **101** holds the Z-axis rail **103** so that the Z-axis rail **103** is movable in the Y-axis direction. The Z-axis rail **103** holds a carriage **110** such that the carriage **110** is movable in the Z direction.
[0098] The carriage **110** is provided with a head holder **130**. The head holder **130** holds, for example, liquid discharge heads of different colors. For example, a C color liquid discharge head that discharges a cyan paint, an M color liquid discharge head that discharges a magenta paint, a Y color liquid discharge head that discharges a yellow paint, and a K color liquid discharge head that discharges a black paint are held. A W color liquid discharge head that discharges a white paint

may also be held. A liquid discharge head that discharges a clear (transparent) coating material may be held, and coating may be applied simultaneously with printing.

[0099] A first Z-direction driver **140***a* that moves the carriage **110** in the Z direction (the liquid discharge direction and a contact/separation direction with respect to the liquid discharge target **200**) along the Z-axis rail **103** is provided. A Y-direction driver **150** that moves the Z-axis rail **103** in the Y direction (a direction orthogonal to both the liquid discharge direction of the liquid discharge head and the nozzle arrangement direction, and the horizontal direction) along the Y-axis rail **101** is provided. An X-direction driver **160** that moves the Y-axis rail **101** in the X direction (the nozzle arrangement direction of the liquid discharge head and the vertical direction) along the X-axis rail **102** is provided. The Y-axis rail **101** is supported by the X-direction driver **160** held by each Y-axis rail **101**. A second Z-direction driver **140***b* that moves the head holder **130** in the Z direction with respect to the carriage **110** is provided.

[0100] The X-direction driver **160** and the Y-direction driver **150** form a scanner to scan the carriage **110** that mounts the liquid discharge head in the X-axis direction and the Y-axis direction.

[0101] The liquid discharge apparatus **100** discharges paint, which is an example of liquid, from the liquid discharge head provided on the head holder **130** while moving the carriage **110** in the X-axis, Y-axis, and Z-axis directions, and performs drawing on the liquid discharge target **200**. The movement of the carriage **110** and the head holder **130** in the Z direction is not necessarily parallel to the Z direction, and may be oblique movement as long as the movement includes at least a component in the Z direction. In a case where the number of nozzle rows of the liquid discharge head is one, it is possible to hold by the carriage **110** so as to be inclinable with respect to the X direction of the liquid discharge head, and a nozzle pitch may be made variable.

[0102] FIG. **13** is a diagram illustrating an example of a supply apparatus **170** that supplies paint as liquid to a plurality of liquid discharge heads **10** provided in the liquid discharge apparatus **100**.

[0103] The supply apparatus **170** is provided with tanks **172***a* to **172***d* as sealed containers storing paints **171***a* to **171***d* discharged from liquid discharge heads **10***a* to **10***d* held by the head holder **130**, respectively.

[0104] The tank **172** and the supply port **16** (refer to FIGS. **1**A and **1**B) of the liquid discharge head **10** are connected to each other via a tube **173**. In contrast, the tank **172** is connected to a compressor **176** via a pipe **175** including an air regulator **174**. The compressor **176** supplies pressurized air to the tank **172**. As a result, the paint in the liquid discharge head **10** is in a pressurized state, and when the needle valve **8** as described above is opened, the paint is discharged from the nozzle **14**.

[0105] Although a surface shape of the liquid discharge target **200** is illustrated as a plane in FIG. **13**, the surface shape of the liquid discharge target **200** may be a surface close to vertical, such as a vehicle body of a vehicle or a truck, or a body of an aircraft, or a surface having a large curvature radius.

[0106] FIG. **14** is a diagram illustrating an example of an electrode manufacturing apparatus **700** as a liquid discharge apparatus provided with the liquid discharge head according to the present embodiment.

[0107] The electrode manufacturing apparatus **700** includes a discharge process unit **710** and a heating process unit **730**. The discharge process unit **710** performs a process of applying a liquid composition onto a printing base material **704** including a discharge target to form a liquid composition layer. The heating process unit **730** performs a heating process of heating the liquid composition layer to obtain an electrode mixture layer.

[0108] The printing base material **704** on which the liquid composition layer is formed is not particularly limited as long as this is a target on which a layer including an electrode material is formed, and can be appropriately selected according to an object. For example, there is an electrode substrate (current collector), an active material layer, and a layer including a solid electrode material.

[0109] The discharge process unit **710** may directly discharge the liquid composition to form the layer including the electrode material as long as this can form the layer including the electrode material on the printing base material **704**. It is possible to indirectly discharge the liquid composition to form the layer including the electrode material.

[0110] The heating process unit **730** is a process of heating the liquid composition discharged onto the printing base material **704** in the discharge process unit **710**. The liquid composition layer can be dried by heating.

[0111] The electrode manufacturing apparatus **700** is provided with a conveyance unit **705** that conveys the printing base material **704**, and the conveyance unit **705** conveys the printing base material **704** at a preset speed in an order of the discharge process unit **710** and the heating process unit **730**. A method for manufacturing the printing base material **704** including the discharge target such as an active material layer is not particularly limited, and a known method can be appropriately selected. The discharge process unit **710** is provided with a printing apparatus **281***a* provided with the liquid discharge head **10** of the present embodiment that discharges the liquid composition onto the printing base material **704**. A storage container **281***b* that stores the liquid composition, and a supply tube **281***c* that supplies the liquid composition stored in the storage container **281***b* to the printing apparatus **281***a* are provided.

[0112] The storage container **281***b* stores a liquid composition **707**, and the discharge process unit **710** discharges the liquid composition **707** from the printing apparatus **281***a* to apply the liquid composition **707** onto the printing base material **704** to form a liquid composition layer in a thin film shape. The storage container **281***b* may be integrated with the manufacturing apparatus for the electrode mixture layer, or may be detachable from the manufacturing apparatus for the electrode mixture layer. The container may be used to be added to a storage container integrated with the manufacturing apparatus for the electrode mixture layer or a storage container detachable from the manufacturing apparatus for the electrode mixture layer.

[0113] The storage container **281***b* and the supply tube **281***c* can be optionally selected as long as the liquid composition **707** can be stably stored and supplied.

[0114] The heating process unit **730** includes a heater **703**, and includes a solvent removal process of heating and drying a solvent remaining in the liquid composition layer by the heater **703** to remove. Thus, the electrode mixture layer can be formed. The heating process unit **730** may perform a solvent removal process under reduced pressure.

[0115] The heater **703** is not particularly limited, and can be appropriately selected according to a purpose, and examples thereof include a substrate heater, an IR heater, and a warm air heater, and they may be combined. Heating temperature and time can be appropriately selected according to a boiling point of the solvent included in the liquid composition **707** and a film thickness to be formed.

[0116] When the liquid discharge head **10** of the present embodiment is used as the electrode manufacturing apparatus **700**, the liquid composition can be discharged to a target place of the discharge target. The electrode mixture layer can be suitably used as, for example, a part of the configuration of an electrochemical element. The configuration other than the electrode mixture layer in the electrochemical element is not particularly limited, and a known configuration can be appropriately selected, and examples thereof include a positive electrode, a negative electrode, and a separator, for example.

[0117] Although the present embodiment has been described above, the present embodiment is not limited to the above-described embodiment, and various changes can be made without departing from the gist of the present embodiment.

[0118] In the above description, an example in which a voltage is applied to a drive body such as the piezoelectric element **32** to open and close the needle valve **31** has been described. However, the present embodiment is not limited thereto, and the needle valve **31** may be opened and closed by pneumatic pressure or hydraulic pressure. In this case, a drive pulse generated by the drive controller is a drive waveform for driving a pressurizing mechanism by pneumatic pressure or hydraulic pressure at a set pressure.

[0119] A liquid discharge head includes: a nozzle plate having a nozzle from which a liquid is dischargeable in a discharge direction; a valve movable in the discharge direction to open and close the nozzle; a mover to move the valve in the discharge direction between: an open position at which the valve opens the nozzle; and a closed position at which the valve closes the nozzle; a housing to house the valve and the mover, the housing including: a first housing; a second housing coupled to the first housing at a coupling portion between the first housing and the second housing; and a groove on a periphery of the coupling portion of at least one of the first housing or the second housing; and a sealing in the groove to seal a portion between the housing and the valve, and the groove fixes a position of the sealing in the discharge direction.

[0120] In the liquid discharge head, the sealing has an elastic member, and the first housing and the second housing compress the sealing at a crushing ratio of 5 to 25%.

[0121] In the liquid discharge head, the sealing is a mold member, and the sealing has a parting line not in contact with the valve.

[0122] In the liquid discharge head, the sealing is a mold member, the sealing has: a parting line in contact with the valve or the housing with a first pressure; and a sealing portion in contact with the valve or the housing with a second pressure larger than the first pressure.

[0123] In the liquid discharge head, the sealing has an annular shape, the groove has an annular shape to hold the sealing, the first housing and the second housing compress the sealing in the groove at the coupling portion in the discharge direction, the sealing has an outer diameter in an uncompressed state in which the sealing is not compressed by the first housing and the second housing, and the groove has an inner diameter equal to or larger than the outer diameter of the sealing.

[0124] In the liquid discharge head, the sealing has an inner diameter in an uncompressed state in which the sealing is not compressed by the first housing and the second housing, the valve has a contact portion contacting with the sealing, and the contact portion of the valve has an outer diameter larger than the inner diameter of the sealing in the uncompressed state.

[0125] In the liquid discharge head, the first housing has a first face in the coupling portion, the second housing has a second face, facing the first face in the discharge direction, in the coupling portion, the first face of the first housing and the second face of the second housing forming a part of the groove, the first face and the second face compress the sealing in the groove at the coupling portion in the discharge direction, at least one of the first face or the second face has an inclination inclined relative to the discharge direction in a cross section parallel to the discharge direction.

[0126] In the liquid discharge head, the valve has a sliding portion slidable with the sealing, and at least one of a surface of the sealing or the sliding portion has a coating to reduce friction between the sliding portion and the sealing.

[0127] In the liquid discharge head, the valve has a sliding portion slidable with the sealing, and the sliding portion has an arithmetic average roughness Ra of 0.1 μm or less.

[0128] In the liquid discharge head, the first housing is closer to the nozzle plate than the second housing in the discharge direction, the first housing has a liquid chamber to store a liquid to be discharged from the nozzle, and the second housing includes a mover storage to store the mover.

[0129] A liquid discharge apparatus includes the liquid discharge head and a scanner to move the liquid discharge head.

[0130] In the present application, the “liquid discharge apparatus” is an apparatus provided with the liquid discharge head or the liquid discharge unit obtained by integrating functional parts and mechanisms with the liquid discharge head, the apparatus that drives the liquid discharge head to discharge the liquid. The integration includes a combination in which the liquid discharge head and the functional parts and mechanisms are secured to each other through fastening, bonding, and engaging, and a combination in which one is movably held by the other. The liquid discharge head may be detachably attached to the functional parts and mechanisms.

[0131] There also is the liquid discharge unit in which the liquid discharge head and the head tank are integrated and the liquid discharge unit in which the liquid discharge head and the head tank are connected to each other with a tube to be integrated. Here, a unit including a filter may be added between the liquid discharge head and the head tank of the liquid discharge unit.

[0132] Examples of the liquid discharge unit include the unit in which the liquid discharge head and a carriage are integrated, and the liquid discharge unit in which the liquid discharge head, the carriage, and the scan moving mechanism are integrated. Examples of the liquid discharge unit include the liquid discharge unit in which the liquid discharge head is movably held by a guide member that forms a part of the scan moving mechanism, and the liquid discharge head and the scan moving mechanism are integrated.

[0133] Examples of the liquid discharge unit include the liquid discharge unit in which a cap member as a part of a maintenance recovery mechanism is secured to the carriage to which the liquid discharge head is attached, and the liquid discharge head, the carriage, and the maintenance recovery mechanism are integrated. Examples of the liquid discharge unit include the liquid discharge unit in which a tube is connected to the liquid discharge head to which the head tank or flow path parts are attached, and the liquid discharge head and a supply mechanism are integrated. Liquid in a liquid reservoir source is supplied to the liquid discharge head through this tube.

[0134] The scan moving mechanism includes a guide member single body. The supply mechanism includes a tube single body and a loading unit single body.

[0135] The “liquid discharge apparatus” includes not only an apparatus that can discharge liquid to a material on which liquid can adhere but also an apparatus that discharges liquid toward gas or into liquid.

[0136] The “liquid discharge apparatus” may include a unit regarding feeding, conveyance, and ejection of a material on which liquid can adhere, a pretreatment apparatus, and a post-treatment apparatus.

[0137] The “liquid discharge apparatus” may be, for example, an image forming apparatus to form an image on a sheet by discharging ink, or a stereoscopic fabrication apparatus (three-dimensional fabrication apparatus) to discharge fabrication liquid to a powder layer in which powder material is formed in layers to fabricate a stereoscopic fabrication object (three-dimensional fabrication object).

[0138] The “liquid discharge apparatus” is not limited to an apparatus to discharge liquid to visualize meaningful images, such as letters or figures. For example, an apparatus to form meaningless images or fabricate three-dimensional images is also included.

[0139] The “material on which liquid can adhere” is the above-described liquid discharge target, and means a material to which the liquid can at least temporarily adhere and to which the liquid adheres and adheres, a medium to which the liquid adheres and permeates. Specific examples include recording media such as a sheet, recording paper, a recording sheet, a film, and a cloth, electronic components such as an electronic substrate and a piezoelectric element, and media such as a powder layer, an organ model, and a testing cell, and include any material on which liquid can adhere, unless particularly limited.

[0140] Examples of the “material on which liquid can adhere” include any materials on which liquid can adhere even temporarily such as paper, thread, fiber, fabric, leather, metal, plastic, glass, wood, and ceramic.

[0141] The “liquid discharge apparatus” may be an apparatus in which the head unit and the material on which the liquid can adhere move relative to each other; however, the liquid discharge apparatus is not limited to this. Specific examples include a serial type apparatus that moves the head unit, and a line type apparatus that does not move the head unit.

[0142] Examples of the “liquid discharge apparatus” further include a treatment liquid applying apparatus to discharge treatment liquid to a sheet for applying the treatment liquid to a sheet

surface to reform the sheet surface. There also is an injection granulation apparatus for injecting composition liquid in which raw materials are dispersed in a solution through a nozzle hole to granulate fine particles of the raw material.
[0143] Although preferred embodiments of the present embodiment have been described above, the present embodiment is not limited to such specific embodiments, and unless particularly limited in the above description, various modifications and changes can be made without departing from the scope of the gist of the present embodiment recited in claims.
[0144] According to the present embodiment, it is possible to suppress variations in the amount and speed of droplets discharged from the nozzle.
[0145] The above-described embodiments are limited examples, and the present disclosure includes, for example, the following aspects having advantageous effects.
Aspect 1
[0146] According to Aspect 1, in a liquid discharge head **10** including a nozzle plate **15** on which a nozzle **14** is formed, a valve such as a needle valve **31** that opens and closes the nozzle **14**, a mover such as a piezoelectric element **32** that moves the valve between an open position at which the nozzle **14** is opened and a closed position at which the nozzle is closed, a housing such as a housing **11** including a liquid chamber **17** that stores liquid to be discharged from the nozzle **14** and a mover storage such as a piezoelectric element storage unit **330** that stores the mover, and a sealing **34** that abuts the housing and the valve and seals between the liquid chamber **17** and the mover storage, the sealing **34** is held by the housing so as not to be movable in a moving direction of the valve.
[0147] In Japanese Patent No. 7310404, the length in the moving direction of the valve of the holding groove provided on the valve is longer than the length of the sealing in the moving direction, and the sealing is movable in the holding groove within a predetermined range in the moving direction. Therefore, the sealing is slidable with respect to both the outer peripheral surface of the valve and the inner wall surface of the housing. Therefore, when the valve opens and closes, the sealing moves together with the valve and slides on the inner wall surface of the housing, or only the valve moves and the sealing slides on the valve, so that a target on which the sealing slides might change. As a result, the movement resistance during opening/closing of the valve varies, the movement amount and the moving speed of the valve vary, and the amount and speed of droplets discharged from the nozzle might vary.
[0148] In contrast, in Aspect 1, since the sealing is held in the housing so as not to be movable in the moving direction of the valve, the sealing slides only on the outer peripheral surface of the valve when the valve opens and closes. As a result, it is possible to suppress the variation of the movement resistance during opening/closing of the valve, and it is possible to suppress the variation in the movement amount and moving speed of the valve. As a result, it is possible to suppress variations in the amount and speed of droplets discharged from the nozzle.
Aspect 2
[0149] According to Aspect 2, in the liquid discharge head **10** of Aspect 1, the sealing **34** is an elastic member, and is held by the housing such as the housing **11** at a crushing ratio of 5 to 25%.
[0150] According to this, as described in the embodiment, the sealing can be satisfactorily performed, and the permanent distortion of the sealing **34** can be suppressed.
Aspect 3
[0151] According to Aspect 3, in the liquid discharge head **10** of Aspect 1 or 2, the sealing **34** is a mold member, and a parting line **34***a* of the sealing **34** is not in contact with the valve such as the needle valve **31** and the housing such as the housing **11**, or an abutting pressure of the parting line **34***a* with the valve or the housing is lower than an abutting pressure of a sealing portion of the sealing **34** with the valve and a sealing portion with the housing.
[0152] According to this, as described with reference to FIGS. **8**A and **8**B, the parting line **34***a* of the sealing **34** can suppress generation of a low abutting pressure at the sealing portion with a

counter member, and local liquid leakage can be suppressed.
Aspect 4
[0153] According to Aspect 4, in the liquid discharge head **10** of any one of Aspects 1 to 3, the sealing **34** has an annular shape, the housing such as the housing **11** includes an annular holding groove **44** that holds the sealing **34**, the sealing **34** is crushed in the moving direction (Z direction) by a pair of side surfaces of the holding groove **44**, and an inner diameter d of a bottom surface of the holding groove **44** is equal to or larger than an outer diameter of the sealing **34** in an uncompressed state.
[0154] According to this, as described in the embodiment, the sealing **34** can be assembled to the holding groove **44** without reducing the diameter, and the sealing **34** can be easily assembled to the holding groove **44**. The sealing **34** is compressed in the moving direction (Z direction) by the side surface of the holding groove **44**, so that the sealing **34** abuts the side surface of the holding groove **44** at a predetermined abutting pressure, and it is possible to satisfactorily seal between the housing and the same.
Aspect 5
[0155] According to Aspect 5, in the liquid discharge head **10** of Aspect 4, an outer diameter D of a contact portion of the valve such as the needle valve **31** with the sealing **34** is shorter than an inner diameter of the sealing in the uncompressed state.
[0156] According to this, as described in the embodiment, the valve such as the needle valve **31** can be easily inserted into the sealing **34**, and the valve and the sealing can be easily assembled. The sealing **34** is compressed in the moving direction (Z direction) by the side surface of the holding groove **44** and crushed in a direction in which the inner diameter of the sealing is shortened, so that the sealing **34** can contact the valve to seal between the valve and the same.
Aspect 6
[0157] According to Aspect 6, in the liquid discharge head **10** of any one of Aspects 1 to 5, the housing such as the housing **11** includes a holding groove that holds the sealing **34**, the sealing **34** is compressed in the moving direction by a pair of side surfaces of the holding groove, and at least one side surface of the pair of side surfaces of the holding groove is inclined in the moving direction in a cross section parallel to the moving direction.
[0158] According to this, the sealing **34** is crushed to the valve side such as the needle valve by the compression by the side surface of the holding groove, and the abutting pressure with the valve can be increased, and the sealing can be satisfactorily performed.
Aspect 7
[0159] According to Aspect 7, in the liquid discharge head **10** of any one of Aspects 1 to 6, at least one of a surface of the sealing **34** or a sliding portion of the valve such as the needle valve **31** with the sealing **34** is coated with a low friction material.
[0160] According to this, it is possible to reduce the sliding resistance with the sealing when the valve such as the needle valve moves.
Aspect 8
[0161] According to Aspect 8, in the liquid discharge head **10** of any one of Aspects 1 to 7, arithmetic average roughness Ra of a sliding portion of the valve such as the needle valve with the sealing of the housing is 0.1 μm or less.
[0162] According to this, the sliding resistance between the sealing and the valve can be reduced when the valve such as the needle valve moves.
Aspect 9
[0163] According to Aspect 9, in the liquid discharge head **10** of any one of Aspects 1 to 8, the sealing **34** is interposed and held in a moving direction (Z direction) by two members (first housing **11***a* and second housing **11***b*) forming the housing such as the housing **11**.
[0164] According to this, sealing between the two members of the housing can also be performed by the sealing **34**. After the sealing **34** is assembled to the cutout formed in any one of the two

members forming the housing, the other member is assembled to the one member, and the sealing **34** can be compressed in the Z direction in the holding groove **44**. As a result, it is not necessary to push the sealing **34** into the holding groove **44** to assemble to the holding groove **44**, and the sealing **34** can be easily assembled.

Aspect 10

[0165] According to Aspect 10, a liquid discharge apparatus including a liquid discharge head uses the liquid discharge head of any one of Aspects 1 to 9 as the liquid discharge head.

[0166] According to this, stable liquid discharge can be performed.

[0167] The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of the present invention.

Claims

1. A liquid discharge head comprising: a nozzle plate having a nozzle from which a liquid is dischargeable in a discharge direction; a valve movable in the discharge direction to open and close the nozzle; a mover to move the valve in the discharge direction between: an open position at which the valve opens the nozzle; and a closed position at which the valve closes the nozzle; a housing to house the valve and the mover, the housing including: a first housing; a second housing coupled to the first housing at a coupling portion between the first housing and the second housing; and a groove on a periphery of the coupling portion of at least one of the first housing or the second housing; and a sealing in the groove to seal a portion between the housing and the valve, wherein the groove fixes a position of the sealing in the discharge direction.

2. The liquid discharge head according to claim 1, wherein the sealing has an elastic member, and the first housing and the second housing compress the sealing at a crushing ratio of 5 to 25%.

3. The liquid discharge head according to claim 1, wherein the sealing is a mold member, and the sealing has a parting line not in contact with the valve.

4. The liquid discharge head according to claim 1, wherein the sealing is a mold member, the sealing has: a parting line in contact with the valve or the housing with a first pressure; and a sealing portion in contact with the valve or the housing with a second pressure larger than the first pressure.

5. The liquid discharge head according to claim 1, wherein the sealing has an annular shape, the groove has an annular shape to hold the sealing, the first housing and the second housing compress the sealing in the groove at the coupling portion in the discharge direction, the sealing has an outer diameter in an uncompressed state in which the sealing is not compressed by the first housing and the second housing, and the groove has an inner diameter equal to or larger than the outer diameter of the sealing.

6. The liquid discharge head according to claim 5, wherein the sealing has an inner diameter in an uncompressed state in which the sealing is not compressed by the first housing and the second housing, the valve has a contact portion contacting with the sealing, and the contact portion of the valve has an outer diameter larger than the inner diameter of the sealing in the uncompressed state.

7. The liquid discharge head according to claim 1, wherein the first housing has a first face in the coupling portion, the second housing has a second face, facing the first face in the discharge direction, in the coupling portion, the first face of the first housing and the second face of the second housing forming a part of the groove, the first face and the second face compress the sealing in the groove at the coupling portion in the discharge direction, at least one of the first face or the second face has an inclination inclined relative to the discharge direction in a cross section parallel to the discharge direction.

8. The liquid discharge head according to claim 1, wherein the valve has a sliding portion slidable

with the sealing, and at least one of a surface of the sealing or the sliding portion has a coating to reduce friction between the sliding portion and the sealing.
9. The liquid discharge head according to claim 1, wherein the valve has a sliding portion slidable with the sealing, and the sliding portion has an arithmetic average roughness Ra of 0.1 μm or less.
10. The liquid discharge head according to claim 1, wherein the first housing is closer to the nozzle plate than the second housing in the discharge direction, the first housing has a liquid chamber to store a liquid to be discharged from the nozzle, and the second housing includes a mover storage to store the mover.
11. A liquid discharge apparatus comprising: the liquid discharge head according to claim 1; and a scanner to move the liquid discharge head.