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(54) COOLING FLUID SUPPLY STRUCTURE

(57) A cooling fluid supply structure includes: a first supply flow path (101) that extends through a spindle housing (4a) and penetrates a wall of an engagement recess (30d) at the distal end of the spindle housing (4a); a second supply flow path (102) that is formed through in a co-rotation prevention protrusion (25) of a tool unit (20) having a grinding wheel (22) mounted thereon or formed through in the co-rotation prevention protrusion (25) and a casing (24) of the tool unit (20) and communicates at one end opening thereof with a downstream opening of the first supply flow path (101) in an engaged state where the co-rotation prevention protrusion (25) is engaged with the engagement recess (30d); and the third supply flow path (103) that is provided outside the casing (24) of the tool unit (20) and communicates at one end opening thereof with a downstream opening of the second supply flow path (102) with the other end opening thereof located near a surface of the grinding wheel (22).

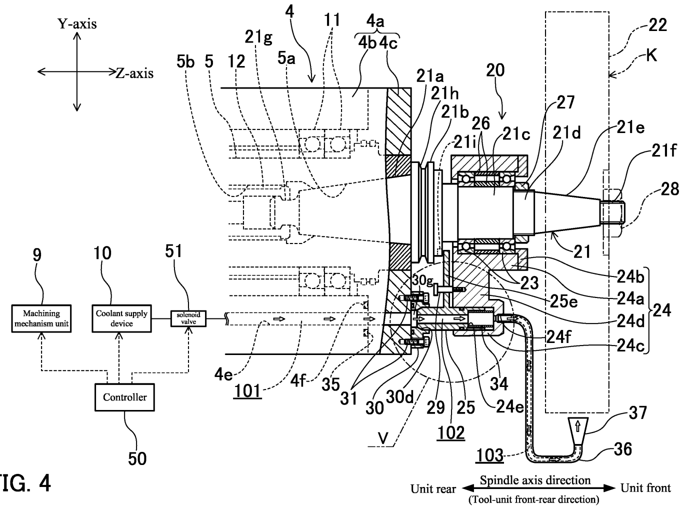

FIG. 4

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Description

Technical Field

[0001] 0001 The present invention relates to a cooling fluid supply structure for supplying a cooling fluid to a surface of a grinding wheel in a machine tool that includes a spindle, to and from which a tool unit having the grinding wheel mounted thereon can be attached and detached, and a spindle housing holding the spindle in a rotatable manner.

Background Art

[0002] 0002 The tool unit that is to be detachably attached to the distal end of the spindle of the machine tool has been known (for example, see Patent Literature 1 listed below). Such a tool unit has a rotary output shaft, a machining tool, a casing, and a co-rotation prevention protrusion. The rotary output shaft is attached in a tapered hole of the spindle so as to rotate integrally with the spindle. The machining tool rotates along with the rotary output shaft. The casing supports the rotary output shaft in a rotatable manner. The co-rotation prevention protrusion is fixed to the casing and is to be engaged with an engagement recess formed in a distal end surface of the spindle housing.

[0003] 0003 When the machining tool is a grinding wheel, a cooling fluid supply structure is needed to suppress heat generation during grinding. Patent Literature 2 listed below discloses an example of such a cooling fluid supply structure. This cooling fluid supply structure discloses an enclosure attached to the casing to enclose the grinding wheel, a spray nozzle mounted on the enclosure to spray coolant into the enclosure, and a coolant pipe connecting the spray nozzle to a coolant supply device. Coolant supplied from the coolant supply device is sprayed into the enclosure from the spray nozzle after flowing through the coolant pipe, so that the heating point on the object to be machined (workpiece) is cooled by the sprayed coolant.

Citation List

Patent Literature

[0004] 0004

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2004-130423
Patent Literature 2: Japanese Utility Model Registration No. 3158872

Summary of Invention

Technical Problem

[0005] 0005 Where the cooling fluid supply structure described in Patent Literature 2 is employed, an operation of connecting the coolant pipe (fluid supply path) to the spray nozzle is required in addition to the operation of attaching the tool unit into the tapered hole of the spindle. This causes the operation time until completion of the coolant supply preparations to become longer.

[0006] 0006 In the cooling fluid supply structure described in Patent Literature 2, the position of the enclosure and the position of the spray nozzle are fixed regardless of the shape of the grinding wheel used. Therefore, there is a problem of inaccurate supply of the coolant (cooling fluid) to the appropriate point (e.g., the heating point on the object to be machined). To address this problem, the spray nozzle could be fixed to the distal end of the coolant pipe, which could enable the position of supply of the coolant as a cooling fluid to be adjusted by changing the routing course for the coolant pipe every time the shape of the grinding wheel is changed due to change of the grinding wheel used or any other cause. In this case, however, the adjustment of the coolant supply position takes long time, which increases the setup time.

[0007] 0007 The present invention has been achieved in view of the above-described circumstances, and an object of the invention is to provide a cooling fluid supply structure which enables an appropriate cooling fluid supply path to be easily established according to the shape of a grinding wheel mounted on a tool unit in conjunction with attachment of the tool unit to a spindle.

Solution to Problem

[0008] 0008 To solve the above-described problem, an aspect of the present invention provides a cooling fluid supply structure for supplying a cooling fluid to a surface of a grinding wheel in a machine tool. The machine tool includes: a spindle having in a distal end surface thereof a tool attachment hole for attaching a tool unit to the spindle; and a spindle housing holding the spindle in a rotatable manner. The spindle housing has at a distal end thereof an engagement recess recessed toward a proximal end of the spindle housing. The tool unit has: a rotary output shaft to be fitted in the tool attachment hole; the grinding wheel rotating along with rotation of the rotary output shaft; a casing holding the rotary output shaft in a rotatable manner; and a co-rotation prevention protrusion fixed to the casing. The co-rotation prevention protrusion is to be engaged with the engagement recess to prevent the casing from rotating in conjunction with rotation of the spindle. The cooling fluid supply structure includes:

a first supply flow path that extends through the spindle housing and penetrates a wall of the engagement recess to supply the cooling fluid toward an inside of the engagement recess;
a second supply flow path that is formed through in the co-rotation prevention protrusion or formed through in the co-rotation prevention protrusion

and the casing and communicates at an opening at one end thereof with a downstream opening of the first supply flow path in an engaged state where the co-rotation prevention protrusion is engaged with the engagement recess; and

a third supply flow path that is provided outside the casing and communicates at an opening at one end thereof with a downstream opening of the second supply flow path with an opening at the other end thereof located near the surface of the grinding wheel to supply the cooling fluid toward the surface of the grinding wheel.

[0009] 0009 This cooling fluid supply structure enables a cooling fluid supply path to the surface of the grinding wheel to be automatically established when the tool unit having the grinding wheel as a machining tool mounted thereon is attached to the spindle. That is to say, the cooling fluid supply path consists of three flow paths, namely, the first supply flow path, the second supply flow path, and the third supply flow path. The first supply flow path is provided on the spindle housing, while the second and third supply flow paths are provided on the tool unit. The first supply flow path penetrates a wall of the engagement recess provided at the distal end of the spindle housing. The second supply flow path is formed through in the co-rotation prevention protrusion of the tool unit or formed through in the co-rotation prevention protrusion and casing of the tool unit. Therefore, when the co-rotation prevention protrusion is brought into engagement with the engagement recess of the spindle housing in attaching the tool unit to the spindle, the downstream opening of the first supply flow path and the one end opening of the second supply flow path are brought into communication with each other. The second supply flow path and the third supply flow path originally communicate with each other regardless of whether or not the co-rotation prevention protrusion is engaged with the engagement recess. Accordingly, the first to third supply flow paths are connected together at once so that the cooling fluid supply path to the surface of the grinding wheel is formed.

[0010] 0010 Therefore, installation and removal of the cooling fluid supply path is easily carried out in conjunction with attachment and detachment of the tool unit to and from the spindle, which can reduce the setup time. Further, setting an appropriate routing course for the third supply flow path, which discharges the cooling fluid toward the grinding wheel, in advance according to the shape of the grinding wheel allows an appropriate cooling fluid supply path to be established according to the shape of the grinding wheel even if the shape of the grinding wheel is changed due to replacement of the tool unit or any other cause. Note that the appropriate cooling fluid supply path according to the shape of the grinding wheel is defined as, for example, but not limited to, a flow path which is able to supply the cooling fluid to the heating point on the workpiece (the point on the workpiece in contact with the grinding wheel). This definition is changed according to the usage of the grinding wheel or any other condition as appropriate.

[0011] 0011 Moreover, since the first supply flow path is formed in the spindle housing, there is no need to additionally provide a piping space for the cooling fluid, which improves space efficiency. Further, since the first supply flow path provided on the spindle and the second supply flow path provided on the tool unit are brought into communication with each other by the co-rotation prevention protrusion provided on the tool unit being brought into engagement with the engagement recess provided on the spindle housing, the co-rotation prevention protrusion also serves as a connector for flow path connection. Therefore, there is neither need to additionally provide a connector for flow path connection on the tool unit nor need to additionally provide an adaptor for connection on a distal end surface of the spindle housing. Accordingly, it is possible to reduce the number of parts, which reduces manufacturing costs.

[0012] 0012 It is preferred that the engagement recess is formed in a mount member provided separately from the spindle housing and mounted on a distal end surface of the spindle housing and the first supply flow path includes a spindle-inside flow path formed in the spindle housing and a spindle-outside flow path formed through in the mount member.

[0013] 0013 In this configuration, the engagement recess to be engaged with the co-rotation prevention protrusion is formed on the mount member that is provided separately from the spindle housing. Therefore, for example, if the position of the co-rotation prevention protrusion is changed due to replacement of the tool unit, the change can be accommodated by only replacing the mount member with another mount member that differs in the position of the engagement recess. Further, the position of the downstream opening of the first supply flow path is easily changed by changing the shape of the spindle-outside flow path formed in the mount member. Therefore, if the position of the second supply flow path formed in the co-rotation prevention protrusion is changed due to replacement of the tool unit, the communication between the first supply flow path and the second supply flow path is easily established by only replacing the mount member with another mount member.

[0014] 0014 It is preferred that the mount member is detachably secured to the distal end surface of the spindle housing via a screw screwed with a screw hole formed in the distal end surface of the spindle housing.

[0015] 0015 This configuration allows for easy replacement of the mount member.

[0016] 0016 It is preferred that the first supply flow path is a linear flow path extending in an axial direction of the spindle.

[0017] 0017 In this configuration, the first supply flow path formed linearly reduces the pipe resistance acting on the cooling fluid in the first supply flow path. Consequently, the cooling fluid is supplied forcefully from the first supply flow path to the second supply flow path connected to the downstream side of the first supply flow path.

[0018] 0018 It is preferred that the second supply flow path is a linear flow path extending in the axial direction of the spindle in the engaged state.

[0019] 0019 In this configuration, the second supply flow path formed linearly reduces the pipe resistance acting on the cooling fluid in the second supply flow path. Consequently, the cooling fluid is supplied forcefully from the second supply flow path to the third supply flow path connected to the downstream side of the second supply flow path.

[0020] 0020 It is preferred that the first supply flow path and the second supply flow path are arranged coaxially with each other and extend linearly in the axial direction of the spindle in the engaged state.

[0021] 0021 In this configuration, since the first supply flow path and the second supply flow path are arranged coaxially with each other, the pipe resistance on the cooling fluid flowing into the second supply flow path from the first supply flow path is reduced. Further, since the first supply flow path and the second supply flow path together form one linear fluid supply path extending in the axial direction of the spindle, the pipe resistance acting on the cooling fluid is significantly reduced as compared with a case where a bent fluid supply path is formed.

[0022] 0022 It is preferred that the third supply flow path is formed by a flexible pipe.

[0023] 0023 This configuration enables the position where the cooling fluid is supplied to the grinding wheel to be freely adjusted by changing the curved shape of the flexible pipe. Consequently, for example, the cooling fluid is accurately supplied to the heating point on the workpiece.

Advantageous Effects of Invention

[0024] 0024 The cooling fluid supply structure according to the present invention includes: the first supply flow path that extends through the spindle housing and penetrates a wall of the engagement recess at the distal end of the spindle housing; the second supply flow path that is formed through in the co-rotation prevention protrusion of the tool unit having a grinding wheel as a machining tool mounted thereon or formed through in the co-rotation prevention protrusion and casing of the tool unit and communicates at the one end opening thereof with the downstream opening of the first supply flow path in the engaged state where the co-rotation prevention protrusion is engaged with the engagement recess; and the third supply flow path that is provided outside the casing of the tool unit and communicates at the one end opening thereof with the downstream opening of the second supply flow path with the other end opening thereof located near the surface of the grinding wheel. This configuration enables an appropriate cooling fluid supply path to be easily established according to the shape of the grinding wheel in conjunction with attachment of the tool unit to the spindle. Consequently, the setup time for replacement of the tool unit can be minimized.

Brief Description of Drawings

[0025] 0025

FIG. 1 is a schematic side view of a machine tool including a coolant supply structure (an example of the cooling fluid supply structure) according to an embodiment of the present invention;

FIG. 2 is a partial cross-sectional view of a spindle head, taken horizontally along the axis of the spindle head;

FIG. 3 is an external perspective view of a tool unit having a grinding wheel mounted thereon;

FIG. 4 is a partial cross-sectional view of the spindle head having the tool unit attached thereto, taken horizontally along the axis of the spindle head;

FIG. 5 is an enlarged view of the circled area V in FIG. 4;

FIG. 6 shows (a) a side view of a mount member and (b) a front view of the mount member as viewed from an engagement recess side;

FIG. 7 is an illustrative diagram for explaining a mount member according to another embodiment of the present invention; and

FIG. 8 is an illustrative diagram for explaining a configuration of a second supply flow path according to another embodiment of the present invention. Description of Embodiments

[0026] 0026 Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

[0027] 0027

<<Embodiment>>

[0028] FIG. 1 is a right side view of a machine tool 1 that includes a coolant supply structure (an example of the cooling fluid supply structure) according to this embodiment. This machine tool 1 is a horizontal machining center and has a bed 2, a column 3, a spindle head 4, a spindle 5, and a table 6. The machine tool 1 is entirely covered by a splash guard 7 that forms the appearance of the machine tool 1. In FIG. 1 that shows the overall view of the machine tool 1, only principal constituent elements of the machine tool 1 are shown.

[0029] 0028 The bed 2 is substantially formed in a T-shape as a whole in plan view. The table 6 is disposed on the bed 2 and is movable in the front-rear direction of the bed 2, i.e., in the direction of Z-axis that is indicated by the horizontal arrow, by being guided by guide rails that are not shown in the drawings. On the table 6, a workpiece W to be machined (shown only in FIG. 1) is set via a pallet P.

[0030] 0029 The column 3 is disposed on the bed 2 and is movable in the direction of X-axis that is horizontally orthogonal to the Z-axis (in the direction perpendicular to the sheet surface of FIG. 1) by being guided by guide rails 8. The column 3 supports the spindle head 4. The spindle head 4 has a spindle housing 4a (see FIG. 2). The spindle housing 4a holds the spindle 5 via bearings 11 such that the spindle 5 is rotatable. A machining tool K is to be detachably attached either via a tool holder or as part of a tool unit 20 (see FIG. 3), which is described later, to the spindle 5. In the following description, unless otherwise indicated, the latter case, i.e., the case where the machining tool K is to be attached as part of the tool unit 20 to the spindle 5, is described.

[0031] 0030 The spindle head 4 is held by the column 3 so as to be movable in the direction of Y-axis that is orthogonal to the X-axis and the Z-axis and indicated by the vertical arrow. Accordingly, the spindle head 4 is movable in an X-Y plane.

[0032] 0031 The column 3 is driven and fed in the X-axis direction by an X-axis feed mechanism (not illustrated). The spindle head 4 is driven and fed in the Y-axis direction by a Y-axis feed mechanism (not illustrated). The table 6 is driven and fed in the Z-axis direction by a Z-axis feed mechanism (not illustrated). The X-axis feed mechanism, the Y-axis feed mechanism, and the Z-axis feed mechanism are each composed of, for example, a combination of a ball screw and a motor. The feed mechanisms, the spindle 5, and a spindle motor (not illustrated) driving the spindle 5 together serve as a machining mechanism unit 9.

[0033] 0032 Under control by a controller 50 (see FIG. 2), the machining mechanism unit 9 changes the relative position between the machining tool K attached to the spindle 5 and the workpiece W set on the table 6, thereby machining the workpiece W into a desired shape. The controller 50 is composed of a computer including a CPU, a ROM, and a RAM. The controller 50 controls the operation of the machining mechanism unit 9 in accordance with an NC program stored on a hard disk or the like.

[0034] 0033 The machine tool 1 further has a coolant supply device 10 (see FIG. 2) that supplies a liquid coolant into the machining area for the purpose of cooling and lubricating the machined portion of the workpiece W and for the purpose of removing chips.

[0035] 0034 The coolant supply device 10 suctions a liquid coolant, which is stored in a storage tank, by means of a supply pump (not illustrated) and supplies the suctioned liquid coolant to the machined portion of the workpiece W. After the supply, the liquid coolant is collected into the storage tank through a return pipe that is connected to the bottom of the bed 2. The coolant supply device 10 is controlled and operated by the controller 50.

[0036] 0035

[Details of spindle structure]

[0037] As shown in FIG. 2, the spindle housing 4a consists of a substantially cylindrical housing body 4b and an end cover 4c. The end cover 4c covers the distal end of the housing body 4b. The end cover 4c has a spigot joint and is attached to the distal end of the housing body 4b from the outside in the axial direction of the housing body 4b.

[0038] 0036 The spindle housing 4a has a through hole 4e formed therein. The through hole 4e is located on the radially outer side of the bearings 11 in the spindle housing 4a and extends throughout the housing body 4b and the end cover 4c in parallel to the axis of the spindle 5. One end of the through hole 4e is connected via a solenoid valve 51 to the coolant supply device 10, while the other end of the through hole 4e is open in a distal end surface of the spindle housing 4a. The solenoid valve 51 is driven by the controller 50 to be opened and closed. When the solenoid valve 51 is energized in the opening direction, the liquid coolant is supplied from the coolant supply device 10 into the through hole 4e. The surface in contact with the end cover 4c of the housing body 4b has an O-ring groove 4f formed therein. The O-ring groove 4f is formed so as to surround the through hole 4e and has an O-ring 35 fitted therein.

[0039] 0037 The spindle 5 is arranged radially inside the housing body 4b and the end cover 4c. The spindle 5 is rotatably supported by the bearings 11 fitted in an inner peripheral surface of the housing body 4b. Two bearings 11 are arranged in each of the distal and proximal sides of the housing body 4b. In FIG. 2, for the purpose of simplicity, only the two bearings 11 arranged in the distal side are shown. The number and arrangement of the bearings 11 are not limited to those mentioned here. The type of the bearing 11 is not limited to a rolling bearing and may be, for example, a sliding bearing.

[0040] 0038 The spindle 5 has a tool attachment hole 5a for attaching the tool unit 20 (see FIG. 3) therein and has a through hole 5b housing a collet 12 for holding the tool unit 20 in the spindle 5.

[0041] 0039 The tool attachment hole 5a is open in a distal end surface of the spindle 5 and has a diameter reduced in a tapered manner from the distal end toward the proximal end of the spindle 5. To attach the tool unit 20 to the spindle 5, a shank 21a of the tool unit 20 is fitted into the tool attachment hole 5a. In this example, the operations of attaching and detaching the tool unit 20 to and from the tool attachment hole 5a are performed automatically by an ATC (Automatic tool changer) device mounted on the machine tool 1; however, the present invention is not limited thereto and, for example, the operations may be performed manually by an operator.

[0042] 0040 The through hole 5b extends coaxially with the spindle 5 in the axial direction of the spindle 5 and communicates with the proximal end of the tool attachment hole 5a. The collet 12 is housed by the through hole 5b so as to be movable in the axial direction of the spindle 5. The collet 12 is connected to a drawbar mechanism that is not shown in the drawings. When the collet 12 is moved toward the proximal end of the spindle

5 by the drawbar mechanism, the collet 12 is closed so that a pull stud 21g of the tool unit 20 is clamped by the collet 12 and the pull stud 21g is pulled toward the proximal end of the spindle 5. Thereby, the shank 21a of the tool unit 20 is firmly fitted in the tool attachment hole 5a so that the tool unit 20 is secured to the spindle 5. To detach the tool unit 20 from the spindle 5, the collet 12 is moved toward the distal end of the spindle 5 by the drawbar mechanism. Thereby, the collet 12 is opened and the clamping of the shank 21a by the collet 12 is released, so that the tool unit 20 can be pulled out of the tool attachment hole 5a.

[0043] 0041 FIG. 3 is a perspective view of an example of the tool unit 20 to be attached to the spindle 5. FIG. 4 is a longitudinal sectional view of the tool unit 20 attached to the spindle 5. In FIGS. 3 and 4, the workpiece W is omitted. In the following description, the distal end side and the proximal end side in the axial direction of the tool unit 20 are defined as the unit front side and the unit rear side, respectively.

[0044] 0042 This tool unit 20 has a grinding wheel 22 as the machining tool K mounted thereon. FIGS. 3 and 4 show an example in which the grinding wheel 22 has a circular plate shape; however, the grinding wheel 22 is not limited to this shape and may have, for example, a conical shape or any other shape. With the tool unit 20 attached to the spindle 5, a cooling flow path for supplying the liquid coolant for cooling to the grinding wheel 22 (see the white arrows in FIG. 4) is formed. This cooling flow path consists of a first supply flow path 101, a second supply flow path 102, and a third supply flow path 103. The supply flow paths 101 to 103 are described in detail later.

[0045] 0043 The tool unit 20 has a rotary output shaft 21, the grinding wheel 22 fixed to the distal end of the rotary output shaft 21, a pair of bearings 23 supporting the rotary output shaft 21 in a rotatable manner, a casing 24 housing the pair of bearings 23, and a co-rotation prevention pin 25 connected to the casing 24.

[0046] 0044 The pair of bearings 23 are spaced apart from each other in the axial direction of the rotary output shaft 21. Between the pair of bearings 23, a spacer 26 that regulates the distance between them is arranged. The number and arrangement of the bearings 23 are not limited to those mentioned here. The type of the bearing 23 is not limited to a rolling bearing and may be, for example, a sliding bearing.

[0047] 0045 The rotary output shaft 21 has a shank 21a, a shaft body 21c, a nut-engaged shaft 21d, a tool mount shaft 21e, and a distal end screw 21f. The shank 21a has a taped shape such that the shank 21a is able to fit into the tool attachment hole 5a of the spindle 5. The shaft body 21c is connected to the distal end of the shank 21a with a flange 21b therebetween. The above-described pair of bearings 23 are to be fitted around the shaft body 21c. The nut-engaged shaft 21d has a nut 27 screwed thereon for securing the pair of bearings 23. The tool mount shaft 21e has a tapered shape and is connected to the distal side of the nut-engaged shaft 21d. The grinding wheel 22 is mounted on the tool mount shaft 21e. The distal end screw 21f is connected to the distal end of the tool mount shaft 21e. A nut 28 for securing the grinding wheel 22 is to be screwed on the distal end screw 21f.

[0048] 0046 The shank 21a has a pull stud 21g connected to the proximal end thereof, which is to be detachably clamped by the above-described collet 12. Various standards are available for the shape of the shank 21a. The example shown in FIG. 3 employs the BBT standard. The shank 21a is not limited to the BBT standard and may employ another standard, e.g., the BT standard or the HSK standard.

[0049] 0047 The flange 21b has a groove 21h, which has a substantially V-shaped cross section, over the entire circumference of an outer peripheral surface thereof. The groove 21h is used when the tool unit 20 is changed automatically by the above-mentioned ATC device. Specifically, in the automatic change of the tool unit 20, a claw of an ATC arm is brought into engagement with the groove 21h for the ATC arm to hold the tool unit 20.

[0050] 0048 The casing 24 has a bearing housing cylinder portion 24a, an end cover portion 24b, a pin holding portion 24c, and a connecting portion 24d. The bearing housing cylinder portion 24a has a cylindrical shape and houses the pair of bearings 23. The end cover portion 24b is attached to one end of the bearing housing cylinder portion 24a in the axial direction of the bearing housing cylinder portion 24a. The pin holding portion 24c is spaced radially outward from the bearing housing cylinder portion 24a and holds the co-rotation prevention pin 25. The connecting portion 24d connects the pin holding portion 24c and the bearing housing cylinder portion 24a to each other.

[0051] 0049 The pin holding portion 24c has a substantially cylindrical shape in appearance. As shown in FIG. 5, the pin holding portion 24c has a guide hole 24e that slidably guides the co-rotation prevention pin 25. The axis of the guide hole 24e extends in parallel to the axis of the rotary output shaft 21. The distance between these two axes is equal to the distance between the axis of the spindle 5 and the axis of the through hole 4e formed in the spindle housing 4a (see FIG. 4). The guide hole 24e is composed of a stop hole that opens to the unit rear side. The co-rotation prevention pin 25 is inserted in the guide hole 24e such that a portion of the distal side of the co-rotation prevention pin 25 protrudes to the unit rear side. The co-rotation prevention pin 25 is guided by the guide hole 24e to move forward and backward in the axial direction thereof. The edge of the distal end of the co-rotation prevention pin 25 is chamfered at approximately 45 degrees.

[0052] 0050 The co-rotation prevention pin 25 has a small-diameter hole 25a and a large-diameter hole 25c formed therethrough in the pin axis direction. The large-diameter hole 25c is connected to the small-diameter hole 25a with a step surface 25b therebetween. The small-diameter hole 25a is open in a distal end surface 25g (an end surface of the protruding side) of the co-rotation prevention pin 25. The large-diameter hole 25c is open in a proximal end surface 25f of the co-rotation prevention pin 25. A compression coil spring 34 is arranged in a compressed state between the step surface 25b and a depth end surface 24i of the guide hole 24e. The co-rotation prevention pin 25 is biased to the unit rear side by this compression coil spring 34.

[0053] 0051 As shown in FIG. 5, the space inside the co-rotation prevention pin 25 and the space between the proximal end surface 25f of the co-rotation prevention pin 25 and the hole bottom in the guide hole 24e are to be filled with the liquid coolant for cooling during grinding, which is described later. The surface dimensions of the co-rotation prevention pin 25 are set such that the pressure of the liquid coolant advances the co-rotation prevention pin 25 to the unit rear side. That is to say, the co-rotation prevention pin 25 satisfies the relationship of A1+A2>A3, where A1 is the area of the step surface 25b, A2 is the area of the proximal end surface 25f, and A3 is the area of the distal end surface 25g. Accordingly, a thrust generated to the unit rear side by the coolant pressure acting on the step surface 25b and proximal end surface 25f of the co-rotation prevention pin exceeds a thrust generated to the unit front side by the coolant pressure acting on the distal end surface 25g of the co-rotation prevention pin 25. This enables the co-rotation prevention pin 25 to be brought into tight contact with an engagement recess 30d of a mount member 30 that is located on the unit rear side of the co-rotation prevention pin 25, so that leakage of the liquid coolant is prevented.

[0054] 0052 The co-rotation prevention pin 25 has an O-ring groove 25d formed in an outer peripheral surface thereof at a surface portion fitting in the guide hole 24e. The O-ring groove 25d has an O-ring 33 fitted therein.

[0055] 0053 The pin holding portion 24c has a through hole 24f formed in a guide end wall 24j thereof that forms the depth end surface 24i of the guide hole 24e. The through hole 24f is formed to be coaxial with the small-diameter hole 25a and large-diameter hole 25c of the co-rotation prevention pin 25. The through hole 24f consists of a narrow hole 24m and a screw hole 24n. The narrow hole 24m is open in the depth end surface 24i of the guide hole 24e. The screw hole 24n is located on the unit front side of the narrow hole 24m and has a female screw for pipe connection formed in an inner peripheral surface thereof. The screw hole 24n is screwed with one end of a flexible pipe 36 that is described later.

[0056] 0054 The co-rotation prevention pin 25 has a protruding plate 25e formed on the outer peripheral surface thereof. The protruding plate 25e protrudes toward the center of rotation of the tool unit 20 (toward the bearing housing cylinder portion 24a). The co-rotation prevention pin 25 is guided in a direction parallel to the axis of the guide hole 24e by a retaining pin 29 that penetrates the protruding plate 25e. The retaining pin 29 is secured by screwing a screw portion formed at the distal end thereof into a screw hole 24k formed in the unit rear side of the connecting portion 24d. By the head of the retaining pin 29 coming into contact with the protruding plate 25e, the amount of movement of the co-rotation prevention pin 25 to the unit rear side is regulated to prevent the co-rotation prevention pin 25 from slipping out of the guide hole 24e.

[0057] 0055 When the tool unit 20 is attached on the spindle 5, the co-rotation prevention pin 25 is engaged with the engagement recess 30d of the mount member 30 that is secured to the spindle housing 4a. This engagement connects the casing 24 of the tool unit 20 to the spindle housing 4a, which is a stationary member, via the co-rotation prevention pin 25 and the mount member 30. Thereby, the casing 24 is prevented from rotating in conjunction with rotation of the spindle 5. Thus, the co-rotation prevention pin 25 functions as the co-rotation prevention protrusion.

[0058] 0056 When the tool unit 20 is not attached to the spindle 5, as shown in FIG. 3, the distal end of the protruding plate 25e connected to the outer peripheral surface of the co-rotation prevention pin 25 is engaged with an engagement groove 21i formed in the flange 21b of the rotary output shaft 21. This engagement groove 21i is located on an outer peripheral portion of the flange 21b and opens to the radially outer side of the flange 21b and to the unit front side. By the engagement of the distal end of the protruding plate 25e with the engagement groove 21i of the rotary output shaft 21, rotation of the casing 24 with respect to the rotary output shaft 21 is prevented. Thus, unnecessary rotation of the casing 24 with respect to the rotary output shaft 21 is prevented, for example, when the tool unit 20 is stored in a tool magazine of the ATC device.

[0059] 0057 When the tool unit 20 is attached to the spindle 5 as shown in FIG. 4, the co-rotation prevention pin 25 is brought into engagement with the engagement recess 30d of the mount member 30 and is moved slightly to the unit front side (to the right side in FIG. 4) against the biasing force of the compression coil spring 34 under the contact reaction force from the engagement recess 30d. Consequently, the distal end of the protruding plate 25e connected to the co-rotation prevention pin 25 moves out of the engagement groove 21i of the rotary output shaft 21, so that the above-described rotation preventing function of the protruding plate 25e is deactivated. This allows the rotary output shaft 21 to rotate independently of the casing 24 while being supported by the casing 24.

[0060] 0058

[Configuration of mount member]

[0061] As shown in FIGS. 5 and 6, the mount member 30 has a bracket 30a and a cylindrical boss 30b. The bracket 30a forms a mounting seat surface. The cylindrical boss 30b is formed to protrude from a surface opposite to the mounting seat surface of the bracket 30a.

[0062] 0059 The mount member 30 has an engagement recess 30d and a communicating hole 30g. The engagement recess 30d is open in an end surface of the cylindrical boss 30b. The communicating hole 30g is continuously connected to the engagement recess 30d and is open in the mounting seat surface. The communicating hole 30g is formed to communicate between the through hole 4e of the spindle housing 4a and the engagement recess 30d when the mount member 30 is mounted on the distal end surface of the spindle housing 4a.

[0063] 0060 The engagement recess 30d consists of a cylindrical hole 30e and a tapered hole 30f. The cylindrical hole 30e is coaxial with the cylindrical boss 30b. The tapered hole 30f is continuously connected to the cylindrical hole 30e and has a diameter reduced toward the mounting seat surface. The cylindrical hole 30e is formed to fit around the outer peripheral surface of the co-rotation prevention pin 25. The tapered hole 30f is formed to fit around the chamfered portion on the distal end of the co-rotation prevention pin 25.

[0064] 0061 The mounting seat surface of the mount member 30 has an O-ring groove 30h formed therein. The O-ring groove 30h is formed so as to surround the communicating hole 30g. The O-ring groove 30h has an O-ring 32 fitted therein.

[0065] 0062 The bracket 30a has a pair of mounting holes 30c formed therein that penetrate the bracket 30a in the thickness direction of the bracket 30a. The pair of mounting holes 30c are symmetrically positioned across the cylindrical boss 30b as viewed in the bracket thickness direction. The mount member 30 is secured to the distal end surface of the spindle housing 4a by bolts 31 inserted through the mounting holes 30c. The distal end surface of the spindle housing 4a has screw holes 4d formed therein that are screwed with the bolts 31. The screw holes 4d may be composed of existing screw holes formed in the distal end surface of the spindle housing 4a. When the mount member 30 is secured to the distal end surface of the spindle housing 4a, the through hole 4e formed in the spindle housing 4a communicates with the engagement recess 30d through the communicating hole 30g of the mount member 30.

[0066] 0063

[Coolant supply structure]

[0067] Next, the coolant supply structure for supplying the liquid coolant as a cooling fluid to the surface of the grinding wheel 22 is described. The white arrows in each figure schematically show the flow of the liquid coolant.

[0068] 0064 As shown in FIG. 4, the coolant supply structure includes a first supply flow path 101, a second supply flow path 102, and a third supply flow path 103.

[0069] 0065 As shown in FIG. 4, the first supply flow path 101 consists of the through hole 4e formed in the spindle housing 4a and the communicating hole 30g formed in the mount member 30. The through hole 4e corresponds to the spindle-inside flow path, while the communicating hole 30g corresponds to the spindle-outside flow path.

[0070] 0066 As shown in FIGS. 4 and 5, the second supply flow path 102 penetrates the co-rotation prevention pin 25 and the guide end wall 24j of the casing 24 in the tool unit 20. Specifically, the second supply flow path 102 consists of the small-diameter hole 25a and large-diameter hole 25c formed in the co-rotation prevention pin 25 and the through hole 24f formed in the guide end wall 24j. The small-diameter hole 25a, the large-diameter holes 25c, and the through holes 24f are arranged linearly and coaxially with each other along the axial direction of the spindle 5. That is to say, the second supply flow path 102 is a linear flow path extending in parallel to the axial direction of the spindle 5. The opening at one end of the second supply flow path 102 communicates with the downstream opening of the first supply flow path 101 (i.e., the downstream opening of the communicating hole 30g). The opening at the other end of the second supply flow path 102 communicates with the third supply flow path 103 that is described below.

[0071] 0067 As shown in FIG. 4, the third supply flow path 103 consists of a flow path in a flexible pipe 36 connected to the through hole 24f and a flow path in a divergent nozzle 37 connected to the distal end of the flexible pipe 36. The flexible pipe 36 extends to the unit front side from the through hole 24f, then bends to the radially outward direction along the side of grinding wheel 22, and then bends to the unit front side and extends to a position close to the outer peripheral surface of the grinding wheel 22. The divergent nozzle 37 is connected to the end at the grinding wheel 22 side of the flexible pipe 36. The divergent nozzle 37 is a flat nozzle having a flow path width increased toward the downstream end thereof and is arranged so as to have a discharge opening near the surface of the grinding wheel 22. Specifically, the divergent nozzle 37 is arranged such that the discharge port thereof faces the outer peripheral surface of the grinding wheel with a predetermined distance therebetween. Note that the predetermined distance is set in a range such that the liquid coolant is supplied toward the heating point on the workpiece W (the point on the workpiece W in contact with the grinding wheel 22). Although the discharge port of the divergent nozzle 37 in this example faces the outer peripheral surface of the grinding wheel 22, the present invention is not limited thereto. The discharge port of the divergent nozzle 37 may face the side of the grinding wheel 22 or may be offset without facing a surface of the grinding wheel 22.

[0072] 0068 In the machine tool 1 having the above-described configuration, when the tool unit 20 is not attached to the spindle 5, as shown in FIG. 2, the first supply flow path 101 is merely open in the vicinity of the distal end of the spindle 5, i.e., the first supply flow path 101 does not function as a path for supplying the liquid coolant. On the other hand, when the tool unit 20 is attached to the spindle 5, as shown in FIG. 4, the co-rotation prevention pin 25 is engaged with the engagement recess 30d of the mount member 30. Through this engagement of the co-rotation prevention pin 25 with the engagement recess 30d, the downstream opening of the first supply flow path 101 (the downstream opening of the communicating hole 30g of the mount member 30) and the upstream opening of the second supply flow path 102 (the upstream opening of the small-diameter hole 25a of the co-rotation prevention pin 25) communicate with each other. The second supply flow path 102 and the third supply flow path 103 are provided in the tool unit 20 and originally communicate with each other. Accordingly, the three supply flow paths 101 to 103 are connected together at once so that a flow path for supplying the liquid coolant from the coolant supply device 10 to a position close to the surface of the grinding wheel 22 (the flow path indicated by the white arrows in FIG. 4) is formed.

[0073] 0069 During grinding by the grinding wheel 22, the solenoid valve 51 is energized in the opening direction under control by the controller 50. Accordingly, the liquid coolant discharged from the coolant supply device 10 flows into the first supply flow path 101 and then flows through the second supply flow path 102 and third supply flow path 103 in the tool unit 20, after which the liquid coolant is supplied to the heating point on the workpiece W (the point on the workpiece W in contact with the grinding wheel 22).

[0074] 0070 In a machining operation performed with a normal tool holder, which does not have the co-rotation prevention pin 25, attached to the spindle 5, the controller 50 recognizes the fact on the basis of analysis of the NC program and energizes the solenoid valve 51 in the closing direction. Therefore, unnecessary spray of the liquid coolant from the distal end of the first supply flow path 101 is prevented during the normal machining operation that does not need the co-rotation prevention pin 25.

[0075] 0071

[Functions and effects in this embodiment]

[0076] As described above, the coolant supply structure according to this embodiment includes: the first supply flow path 101 that extends through the spindle housing 4a and penetrates the wall of the engagement recess 30d at the distal end of the spindle housing 4; the second supply flow path 102 that is formed through in the co-rotation prevention pin 25 and casing 24 of the tool unit 20 and communicates at the one end opening thereof with the downstream opening of the first supply flow path 101 in the engaged state where the co-rotation prevention pin 25 is engaged with the engagement recess 30d; and the third supply flow path 103 that is provided outside the casing 24 of the tool unit 20 and communicates at the one end opening thereof with the downstream opening of the second supply flow path 102 with the other end opening thereof located near the surface of the grinding wheel 22. This configuration enables installation and removal of the coolant supply path to and from the grinding wheel 22 to be easily carried out in conjunction with attachment and detachment of the tool unit 20 to and from the spindle 5. Consequently, the setup time for replacement of the tool unit 20 can be minimized. Further, setting an appropriate routing course for the third supply flow path 103, which discharges the liquid coolant toward the grinding wheel 22, in advance according to the shape of the grinding wheel 22 allows an appropriate coolant supply path to be established according to the shape of the grinding wheel 22 even if the shape of the grinding wheel 22 is changed due to replacement of the tool unit 20 or any other cause.

[0077] 0072 Moreover, the first supply flow path 101 is mostly formed in the spindle housing 4a. Therefore, there is no need to additionally provide a piping space for the liquid coolant, which improves space efficiency. Further, since the first supply flow path 101 provided on the spindle 5 and the second supply flow path 102 provided on the tool unit 20 communicate with each other through engagement of the co-rotation prevention pin 25 provided on the tool unit 20 with the engagement recess 30d, the co-rotation prevention pin 25 also serves as a connector for flow path connection. Accordingly, it is possible to standardize the parts, which reduces costs.

[0078] 0073 The engagement recess 30d is formed in the mount member 30 that is provided separately from the spindle housing 4a and mounted on the distal end surface of the spindle housing 4a. The first supply flow path 101 consists of the through hole 4e as the spindle-inside flow path formed in the spindle housing 4a and the communicating hole 30g as the spindle-outside flow path formed through in the mount member 30.

[0079] 0074 Thus, the engagement recess 30d that is to be engaged with the co-rotation prevention pin 25 is formed in the mount member 30 that is provided separately from the spindle housing 4a. Therefore, for example, if the position of the co-rotation prevention pin 25 is changed due to replacement of the tool unit 20, the change can be accommodated by only changing the shapes of the engagement recess 30d and communicating hole 30g formed in the mount member 30 (see FIG. 7 described later).

[0080] 0075 The mount member 30 is detachably secured to the distal end surface of the spindle housing 4a by the bolts 31 screwed with the screw holes 4d formed in the distal end surface of the spindle housing 4a.

[0081] 0076 This configuration allows for easy replacement of the mount member 30. The screw holes 4d may be composed of existing screw holes formed in the distal end surface of the spindle housing 4a.

[0082] 0077 The first supply flow path 101 is a linear flow path extending in the axial direction of the spindle 5.

[0083] 0078 This configuration reduces the pipe resistance in the first supply flow path 101 because the first supply flow path 101 is formed linearly. Consequently, the liquid coolant is supplied forcefully from the first supply flow path 101 to the second supply flow path 102 connected to the downstream side of the first supply flow path 101.

[0084] 0079 The second supply flow path 102 is formed to extend linearly line in the axial direction of the spindle 5 when the co-rotation prevention pin 25 is engaged with the engagement recess 30d of the mount member 30.

[0085] 0080 This configuration reduces the pipe resistance in the second supply flow path 102 because the second supply flow path 102 is formed linearly. Consequently, the liquid coolant is supplied forcefully from the second supply flow path 102 to the third supply flow path 103 connected to the downstream side of the second supply flow path 102.

[0086] 0081 The first supply flow path 101 and the second supply flow path 102 are arranged coaxially with each other and extend linearly in the axial direction of the spindle 5 when the co-rotation prevention pin 25 is engaged with the engagement recess 30d of the mount member 30.

[0087] 0082 Since the first supply flow path 101 and the second supply flow path 102 are arranged coaxially with each other, the pipe resistance on the liquid coolant flowing into the second supply flow path 102 from the first supply flow path 101 is reduced. Further, since the first supply flow path 101 and the second supply flow path 102 together form one linear fluid supply path, the pipe resistance acting on the liquid coolant fluid can be minimized.

[0088] 0083 The third supply flow path 103 is formed by the flexible pipe 36.

[0089] 0084 This enables the position where the liquid coolant is supplied to the grinding wheel 22 to be freely adjusted by changing the curved shape of the flexible pipe 36. Consequently, the liquid coolant is accurately supplied to the heating point on the workpiece W, which improves the cooling efficiency.

[0090] 0085

<<Other Embodiments>>

[0091] In the above-described embodiment, the tool unit 20 is configured such that the axis of the grinding wheel 22 extends in the same direction as the axis of the spindle 5. However, the present invention is not limited thereto. The tool unit 20 may be configured such that the axis of the grinding wheel 22 intersects the axis of the spindle 5 at a predetermined angle (e.g., 90°). In this case, a gear mechanism should be added in the casing 24 to allow for intersection of the axes of rotation.

[0092] 0086 In the above-described embodiment, the cooling fluid for cooling the grinding wheel 22 is a liquid coolant. However, the present invention is not limited thereto. The cooling fluid may be, for example, a cooling air, an inert gas, or the like.

[0093] 0087 In the above-described embodiment, an example in which the through hole 4e formed in the spindle housing 4a and the co-rotation prevention pin 25 of the tool unit 20 are positioned coaxially with each other is described. However, for example, as shown in FIG. 7, the axis of the co-rotation prevention pin 25 may be offset in the radially outward direction of the spindle housing 4a (to the lower side in FIG. 7) with respect to the axis of the through hole 4e. In this case, the position of the communicating hole 30g formed in the mount member 30 is shifted in the direction absorbing the offset, i.e., in the radially inward direction of the spindle housing 4a (to the upper side in FIG. 6), to allow the through hole 4e and the small-diameter hole 25a in the co-rotation prevention pin 25 to communicate with each other through the communicating hole 30g. Thus, the same functions and effects as those in the above-described embodiment are realized.

[0094] 0088 In the above-described embodiment, the second supply flow path 102 is formed through in the co-rotation prevention pin 25 and guide end wall 24j of the casing 24. However, the present invention is not limited thereto. For example, as shown in FIG. 8, the second supply flow path 102 may be formed through only in the co-rotation prevention pin 25. In the example shown in FIG. 8, the co-rotation prevention pin 25 is fixed to the casing 24. The flexible pipe 36 is connected to the radially outer side (side face) of the co-rotation prevention pin 25 so that the small-diameter hole 25a in the co-rotation prevention pin 25 and the flow path in the flexible pipe 36 communicate with each other.

[0095] 0089 In the above-described embodiment, the first supply flow path 101 can be used for a tool unit having a cutting tool, such as a drill, mounted thereon as the machining tool K. In this case, the liquid coolant supplied to the first supply flow path 101 is supplied to the tip end of the machining tool K by a well-known mechanism, such as a center-through system or a side-through mechanism, by flowing in a flow path formed in the casing or a flow path formed in the rotary output shaft. Thus, the first supply flow path 101 can be used for both the tool unit employing a center-through mechanism or a side-through mechanism and the tool unit 20 according to the above-described embodiment having the grinding wheel 22 mounted thereon so that the coolant supply structure is simplified, which reduces costs.

[0096] 0090 In the above-described embodiment, the co-rotation prevention pin 25 and the casing 24 are formed of separate members. However, the present invention is not limited thereto. The co-rotation prevention pin 25 may be formed integrally with the casing 24.

[0097] 0091 In the above-described embodiment, the engagement recess 30d is formed in the mount member 30 that is provided separately from the spindle housing 4a. However, the present invention is not limited thereto. The engagement recess 30d may be formed directly on the distal end surface of the spindle housing 4a.

[0098] 0092 In the above-described embodiment, the flexible pipe 36 is used to form the third supply flow path 103. However, it is not always necessary to use the flexible pipe 36. A rigid pipe that has a fixed shape may be used instead. Further, the divergent nozzle 37 may be omitted.

[0099] 0093 In the above-described embodiment, the machine tool 1 is a horizontal machining center. However, the present invention is not limited thereto. The machine tool 1 may be, for example, a vertical machining center or a combined machine tool.

[0100] 0094 It should be noted that the foregoing description of the embodiments is not limitative but illustrative in all aspects. One skilled in the art would be able to make variations and modifications as appropriate. The scope of the invention is not defined by the above-described embodiments, but is defined by the appended claims. Further, the scope of the invention encompasses all modifications made from the embodiments within a scope equivalent to the scope of the claims.

Reference Signs List

[0101] 0095

1	Machine tool
4a	Spindle housing
4d	Screw hole
5	Spindle
5a	Tool attachment hole
20	Tool unit
21	Rotary output shaft
22	Grinding wheel
24	Casing
25	Co-rotation prevention pin (co-rotation prevention protrusion)
30	Mount member
30d	Engagement recess
36	Flexible pipe
101	First supply flow path
102	Second supply flow path
103	Third supply flow path

Claims

1. A cooling fluid supply structure for supplying a cooling fluid to a surface of a grinding wheel in a machine tool, the machine tool including: a spindle having in a distal end surface thereof a tool attachment hole for attaching a tool unit to the spindle; and a non-rotatable spindle housing holding the spindle in a rotatable manner, wherein the spindle housing has at a distal end thereof an engagement recess recessed toward a proximal end of the spindle housing, the tool unit has: a rotary output shaft to be fitted in the tool attachment hole; the grinding wheel rotating along with rotation of the rotary output shaft; a casing holding the rotary output shaft in a rotatable manner; and a co-rotation prevention protrusion fixed to the casing, and the co-rotation prevention protrusion is to be engaged with the engagement recess to prevent the casing from rotating in conjunction with rotation of the spindle,
the cooling fluid supply structure comprising:

   a first supply flow path extending through the spindle housing and penetrating a wall of the engagement recess to supply the cooling fluid toward an inside of the engagement recess;
   a second supply flow path formed through in the co-rotation prevention protrusion or formed through in the co-rotation prevention protrusion and the casing and communicating at an opening at one end thereof with a downstream opening of the first supply flow path in an engaged state where the co-rotation prevention protrusion is engaged with the engagement recess; and
   a third supply flow path provided outside the casing and communicating at an opening at one end thereof with a downstream opening of the second supply flow path with an opening at another end thereof located near the surface of the grinding wheel to supply the cooling fluid toward the surface of the grinding wheel.

2. The cooling fluid supply structure according to claim 1, **characterized in that**:

   the engagement recess is formed in a mount member provided separately from the spindle housing and mounted on a distal end surface of the spindle housing; and
   the first supply flow path comprises a spindle-inside flow path formed in the spindle housing and a spindle-outside flow path formed through in the mount member.

3. The cooling fluid supply structure according to claim 2, **characterized in that** the mount member is detachably secured to the distal end surface of the spindle housing via a screw screwed with a screw hole formed in the distal end surface of the spindle housing.

4. The cooling fluid supply structure according to any one of claims 1 to 3, **characterized in that** the first supply flow path is a linear flow path extending in an axial direction of the spindle.

5. The cooling fluid supply structure according to any one of claims 1 to 4, **characterized in that** the second supply flow path is a linear flow path extending in an axial direction of the spindle in the engaged state.

6. The cooling fluid supply structure according to any one of claims 1 to 5, **characterized in that** the first supply flow path and the second supply flow path are arranged coaxially with each other and extend line-

arly in an axial direction of the spindle in the engaged state.

7. The cooling fluid supply structure according to any one of claims 1 to 6, **characterized in that** the third supply flow path is formed by a flexible pipe.

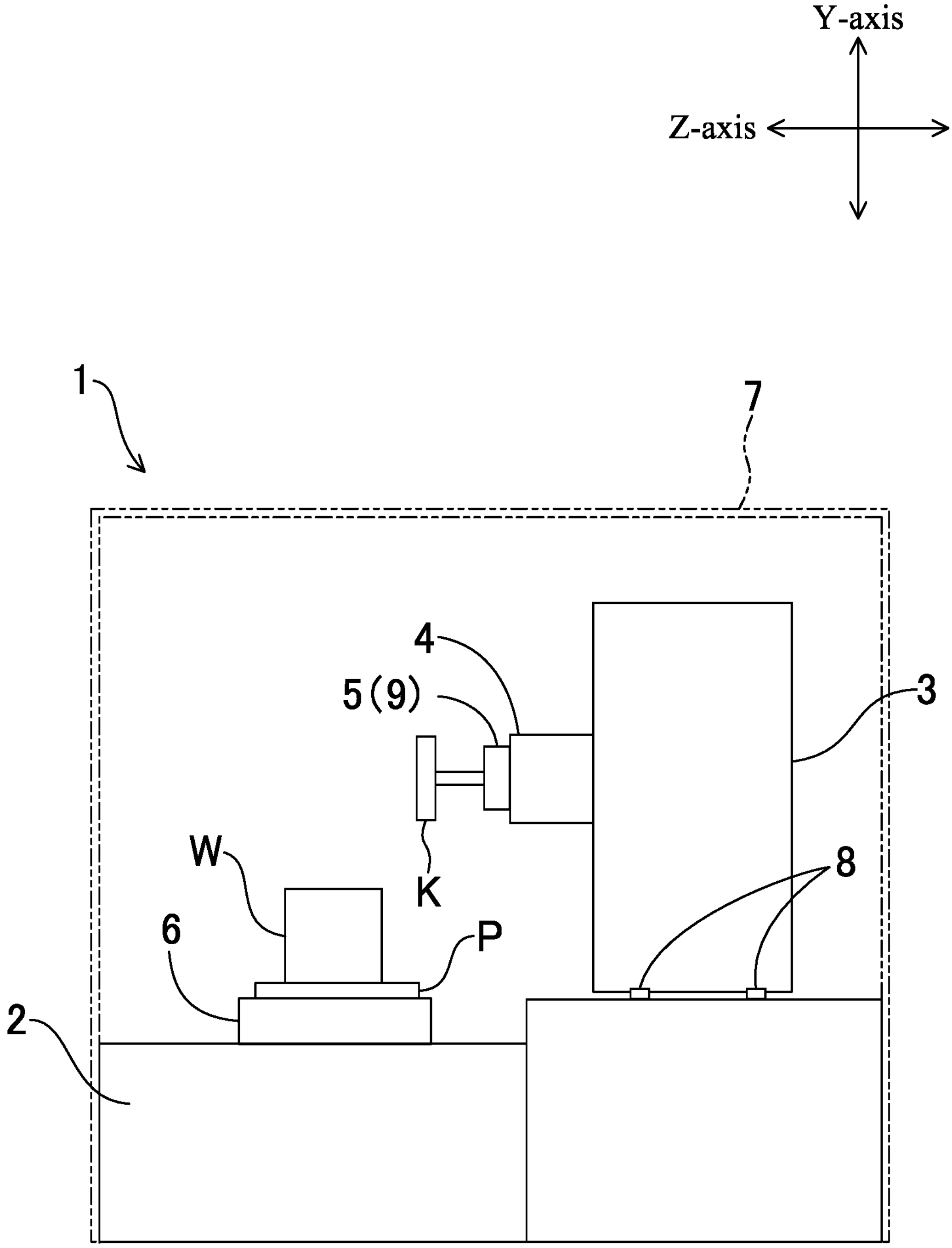


FIG. 1

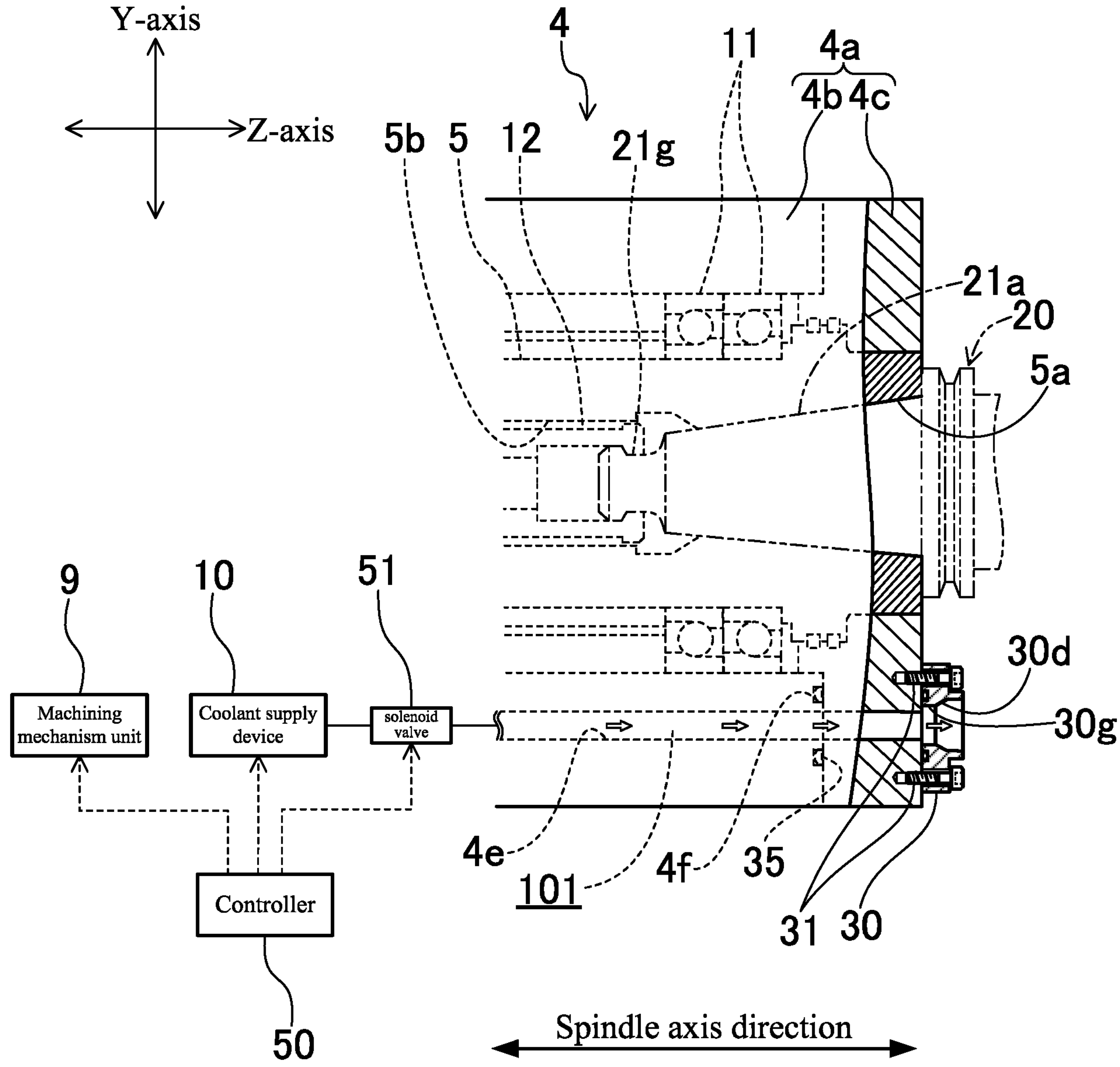

Y-axis
Z-axis
4
11
4a
4b
4c
5b
5
12
21g
21a
20
5a
9
10
51
Machining mechanism unit
Coolant supply device
solenoid valve
Controller
30d
30g
4e
101
4f
35
31
30
50
Spindle axis direction

FIG. 2

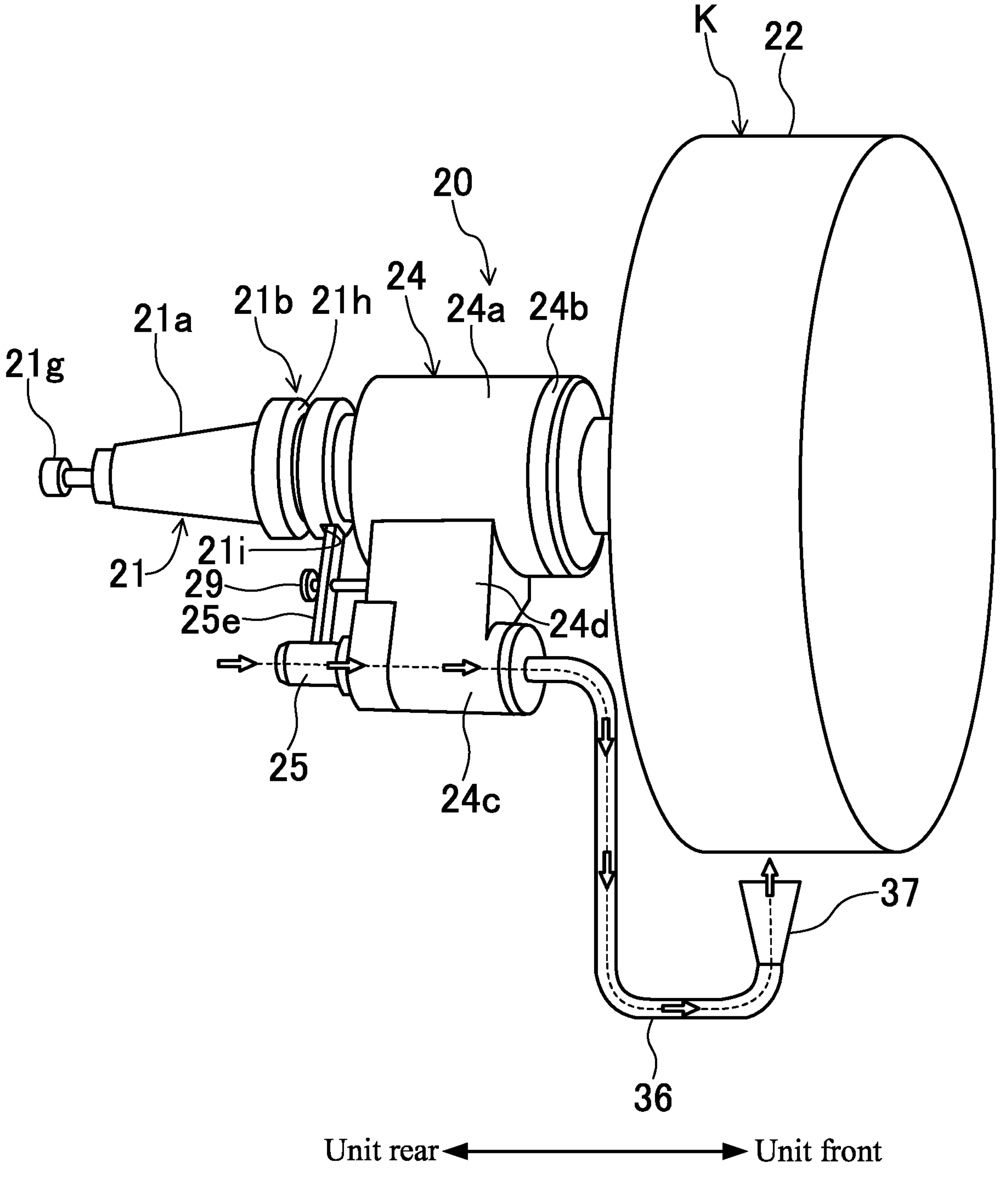
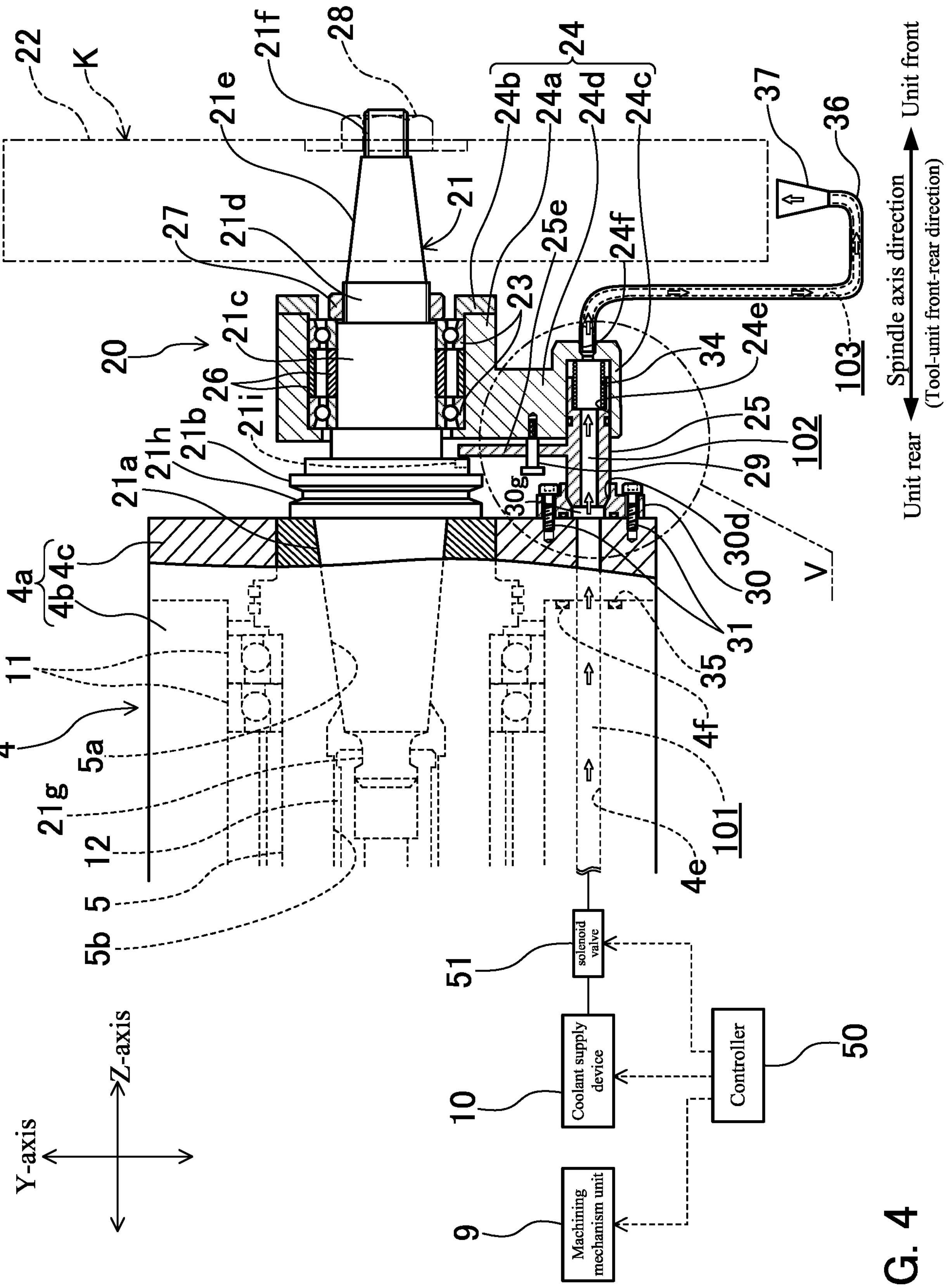
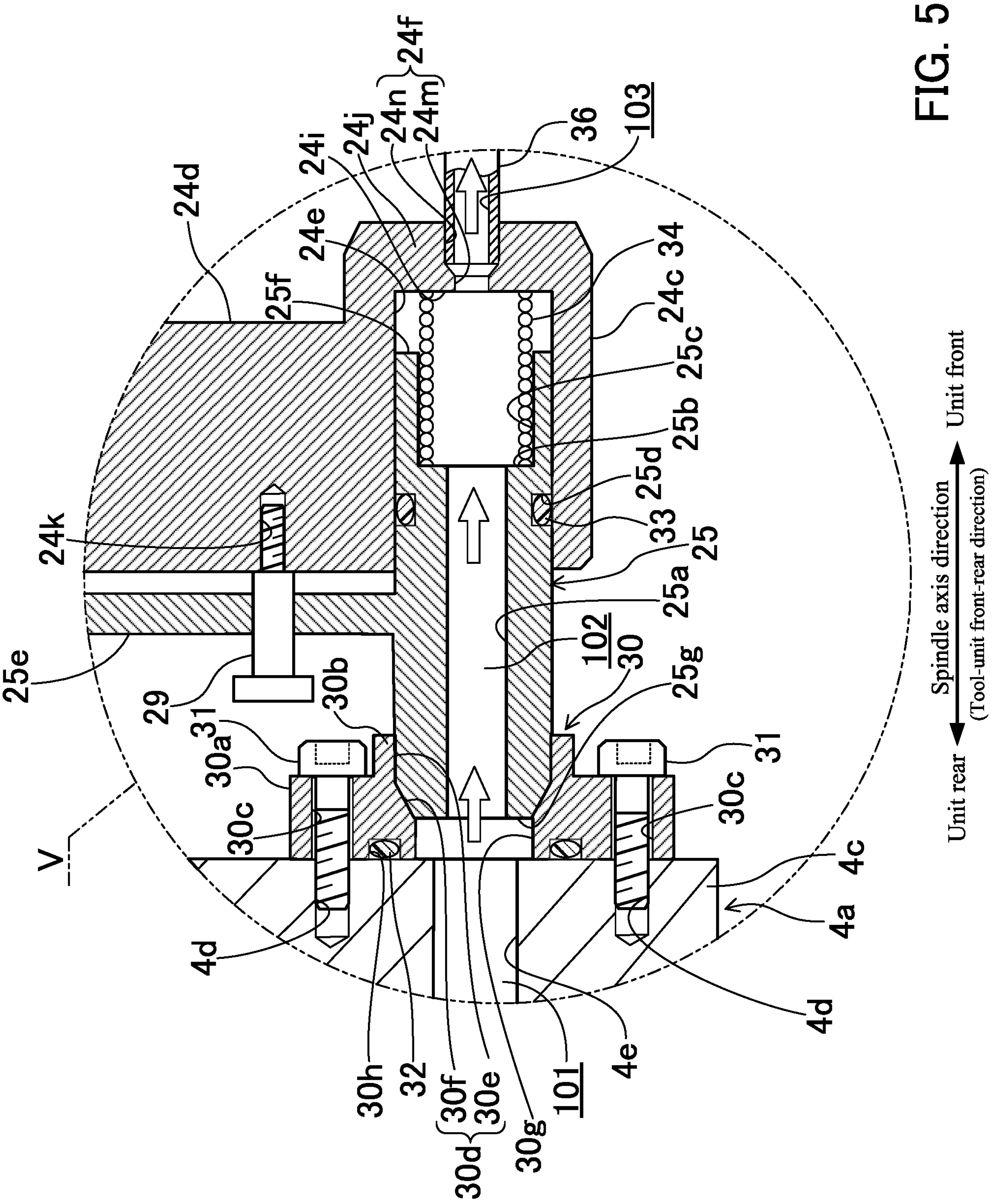

K
22
20
24
21a
21b
21h
24a
24b
21g
21i
21
29
25e
24d
25
24c
37
36
Unit rear
Unit front

FIG. 3



22
K
21f
28
21e
24
24b
24a
24d
24c
21
21d
27
25e
24f
23
20
21c
26
21i
34
24e
25
102
29
30d
30g
21b
21h
21a
4a
4b
4c
30
V
31
35
4f
11
4
5a
21g
12
5
5b
101
4e
37
36
103
Spindle axis direction
(Tool-unit front-rear direction)
Unit front
Unit rear
solenoid valve
51
Coolant supply device
10
Controller
50
Machining mechanism unit
9
Y-axis
Z-axis

FIG. 4



Spindle axis direction
(Tool-unit front-rear direction)
Unit rear
Unit front
V
24d
24e
24i
24j
24n
24m
24f
36
103
34
24c
25f
25c
25b
25d
33
25
25a
24k
25e
29
102
30
30b
31
30a
25g
30c
4c
4a
4d
4e
101
30g
30e
30f
30d
32
30h

FIG. 5

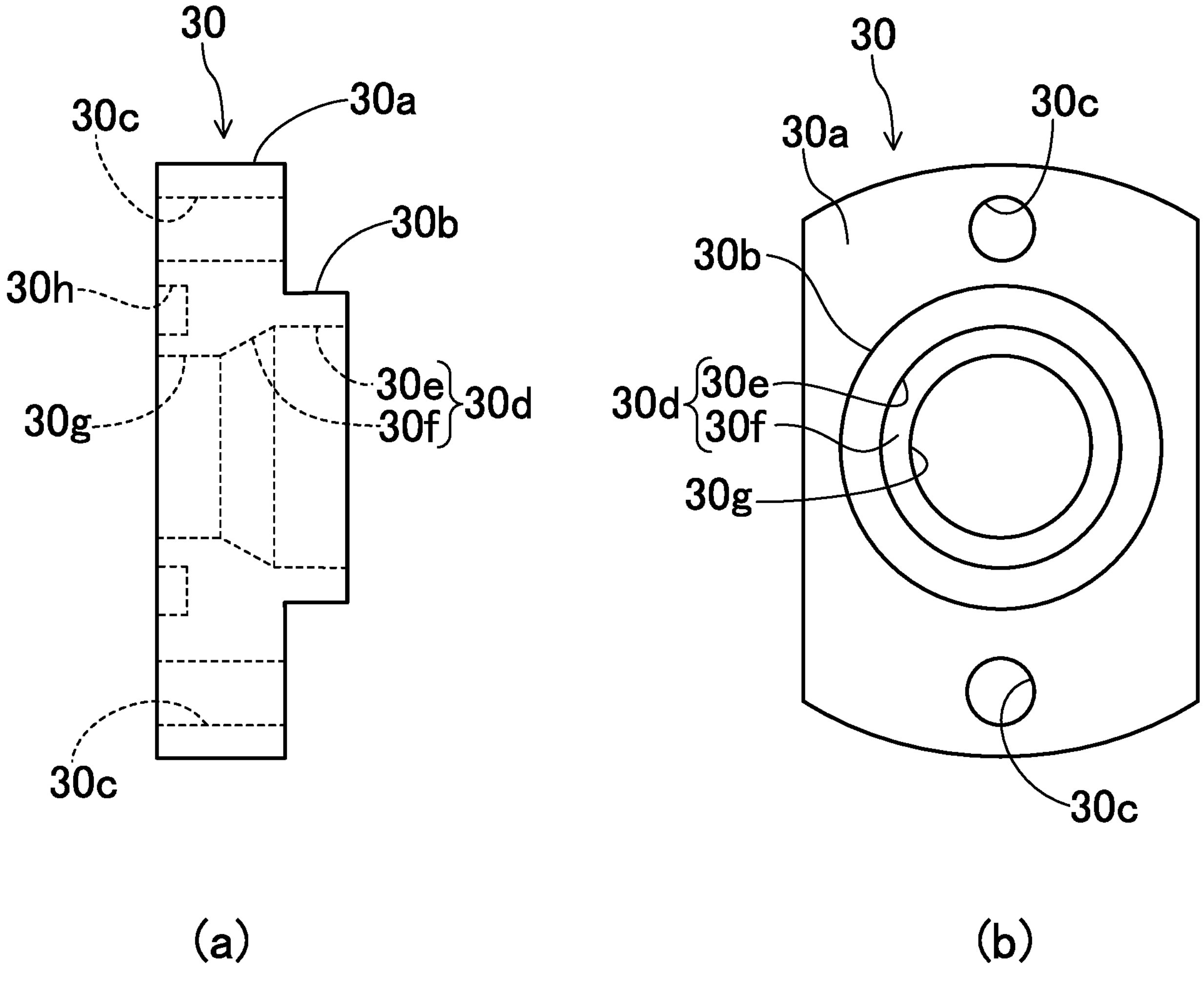
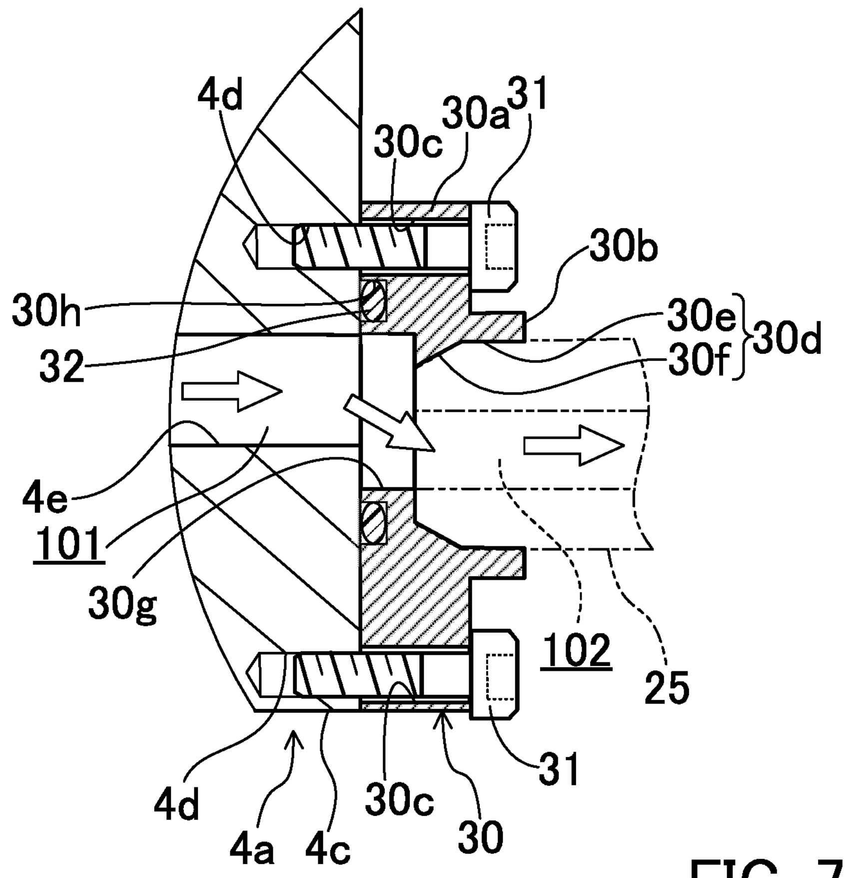

30
30c
30a
30b
30h
30e
30d
30f
30g
30c
(a)
30
30a
30c
30b
30d
30e
30f
30g
30c
(b)

FIG.6


4d
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31
30b
30h
30e
30d
32
30f
4e
101
30g
102
25
4d
30c
30
31
4a
4c

FIG. 7

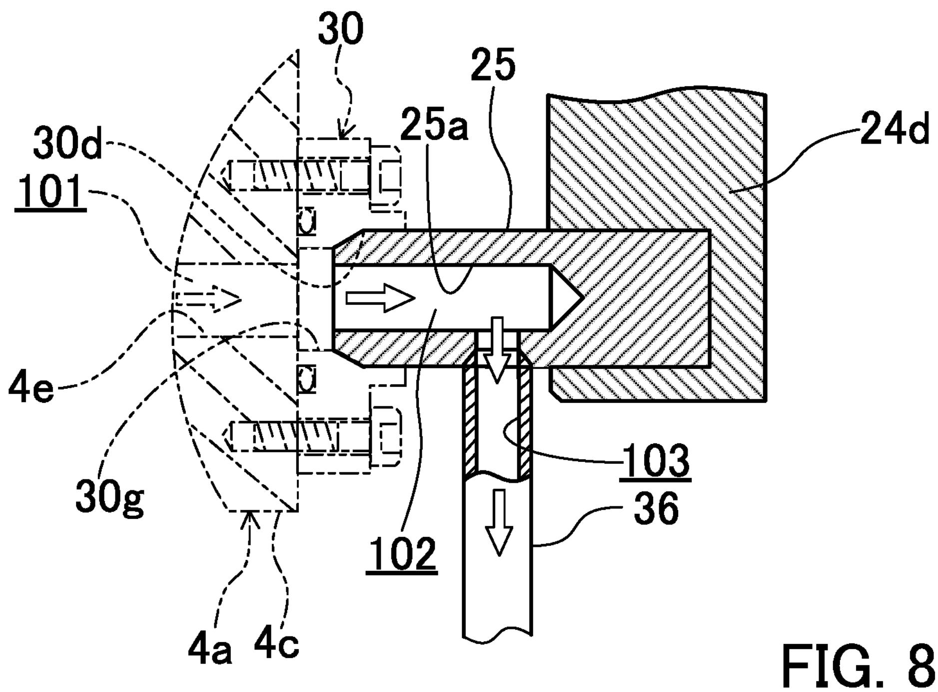
30
25
30d
25a
24d
101
4e
103
36
30g
102
4a
4c

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/007610

A. CLASSIFICATION OF SUBJECT MATTER

B24B 55/02(2006.01)i
FI: B24B55/02 A

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)

B24B55/02

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 3158872 U (NASADA KK) 22 April 2010 (2010-04-22)	1-7
A	JP 2001-121388 A (NSK LTD) 08 May 2001 (2001-05-08)	1-7
A	JP 8-257922 A (SHOWA DENKO KENZAI KK) 08 October 1996 (1996-10-08)	1-7

☐ 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
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"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
11 May 2023	**23 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/JP2023/007610

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 3158872 U	22 April 2010	(Family: none)	
JP 2001-121388 A	08 May 2001	(Family: none)	
JP 8-257922 A	08 October 1996	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004130423 A **[0004]**
- JP 3158872 U **[0004]**