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Numata

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(45) **Date of Patent: Aug. 19, 2025**

(54) **POWER TOOL**

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B24B 55/10 (2006.01)
B25F 5/00 (2006.01)
B25F 5/02 (2006.01)

(52) **U.S. Cl.**
CPC ***B24B 23/022*** (2013.01); ***B25F 5/005*** (2013.01); ***B25F 5/008*** (2013.01); ***B25F 5/02*** (2013.01); *B24B 55/102* (2013.01)

(58) **Field of Classification Search**
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USPC 451/359, 449, 541
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,438,634 B2 * 10/2008 Habele B27B 5/32 451/353
7,988,538 B2 * 8/2011 Trautner H02K 9/06 451/344
8,858,301 B2 * 10/2014 Reid B27B 5/30 451/356
2016/0193727 A1 * 7/2016 Takeda B25F 5/008 173/46
2019/0344461 A1 * 11/2019 Kamiya B26B 25/00
2020/0384597 A1 12/2020 Numata

FOREIGN PATENT DOCUMENTS

JP 2020-199627 A 12/2020
KR 200487071 Y1 * 8/2018 ..... B24B 23/02

OTHER PUBLICATIONS

Machine translation of KR-200487071-Y1 (Year: 2018).*

* cited by examiner

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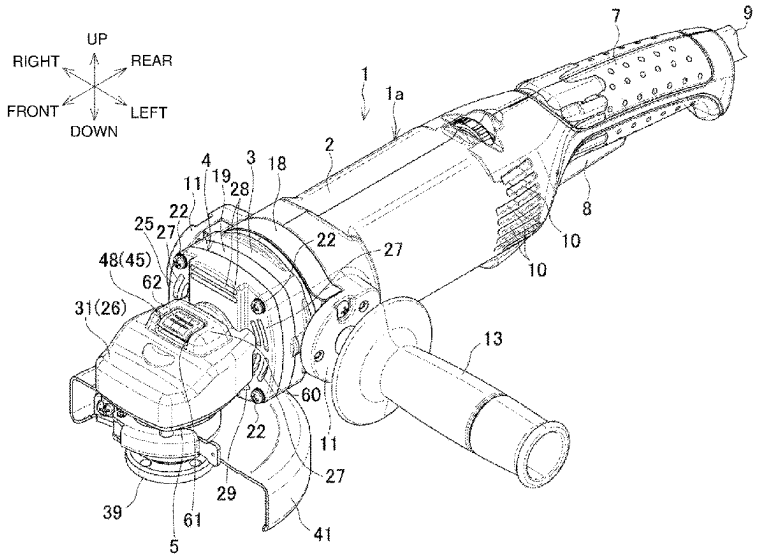
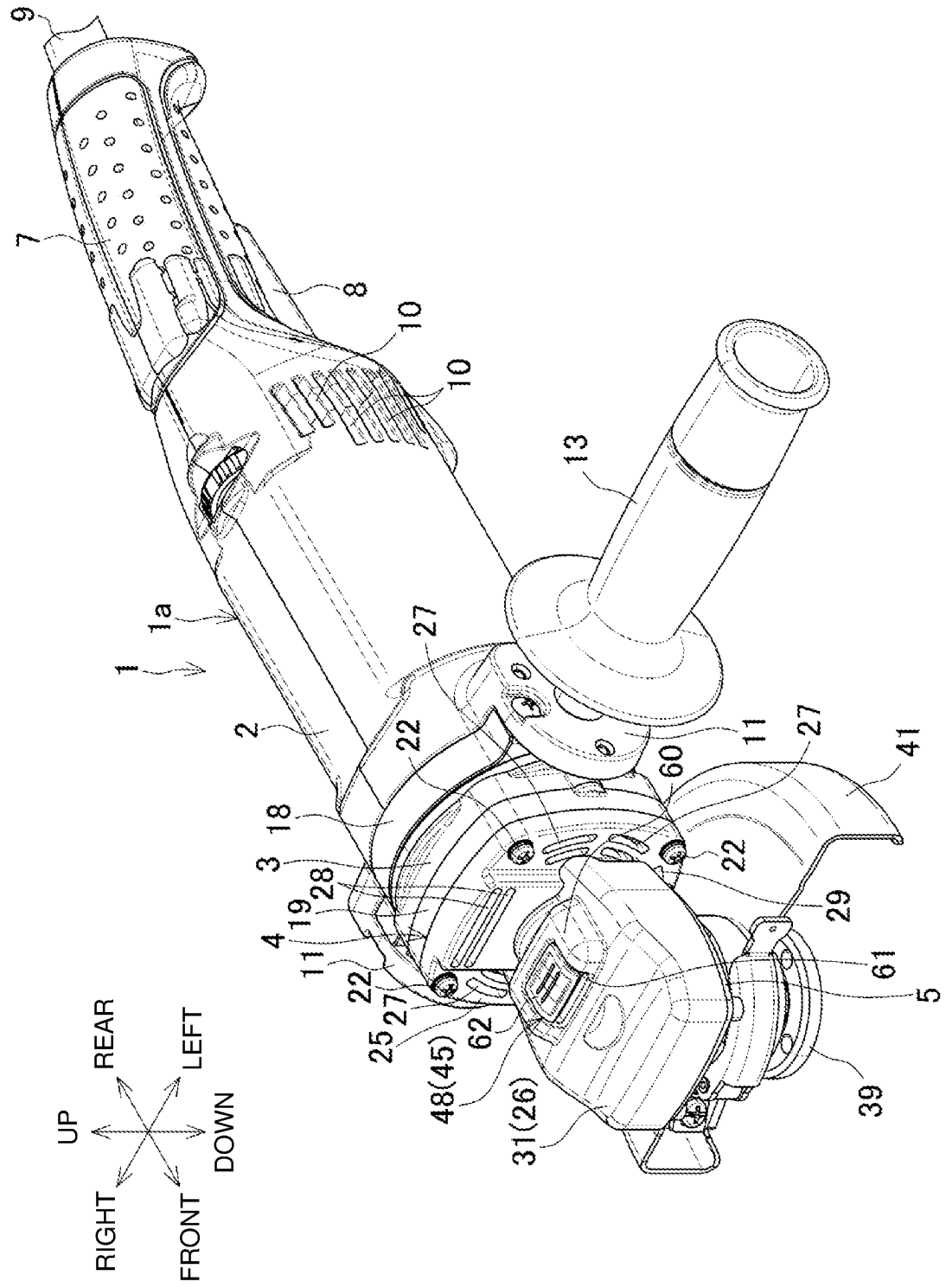
(57) **ABSTRACT**

A grinder includes a locking assembly to lock a spindle in a head housing and has outlets with a large opening area for high cooling efficiency. A grinder includes a main housing accommodating a motor and a fan, a spindle, a locking assembly that locks rotation of the spindle, and a head housing including a joint connected to a front of the main housing, and a compartment accommodating the spindle and the locking assembly. The compartment is laterally less wide than the joint. The locking assembly is located at a middle in a lateral direction of the head housing. The joint has, in a portion of a front surface of the joint, a first outlet at least on a right or a left of the compartment to discharge air for cooling the motor generated from rotation of the fan.

20 Claims, 8 Drawing Sheets

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25
48(45)
62
31(26)
22
29
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5
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UP
REAR
LEFT
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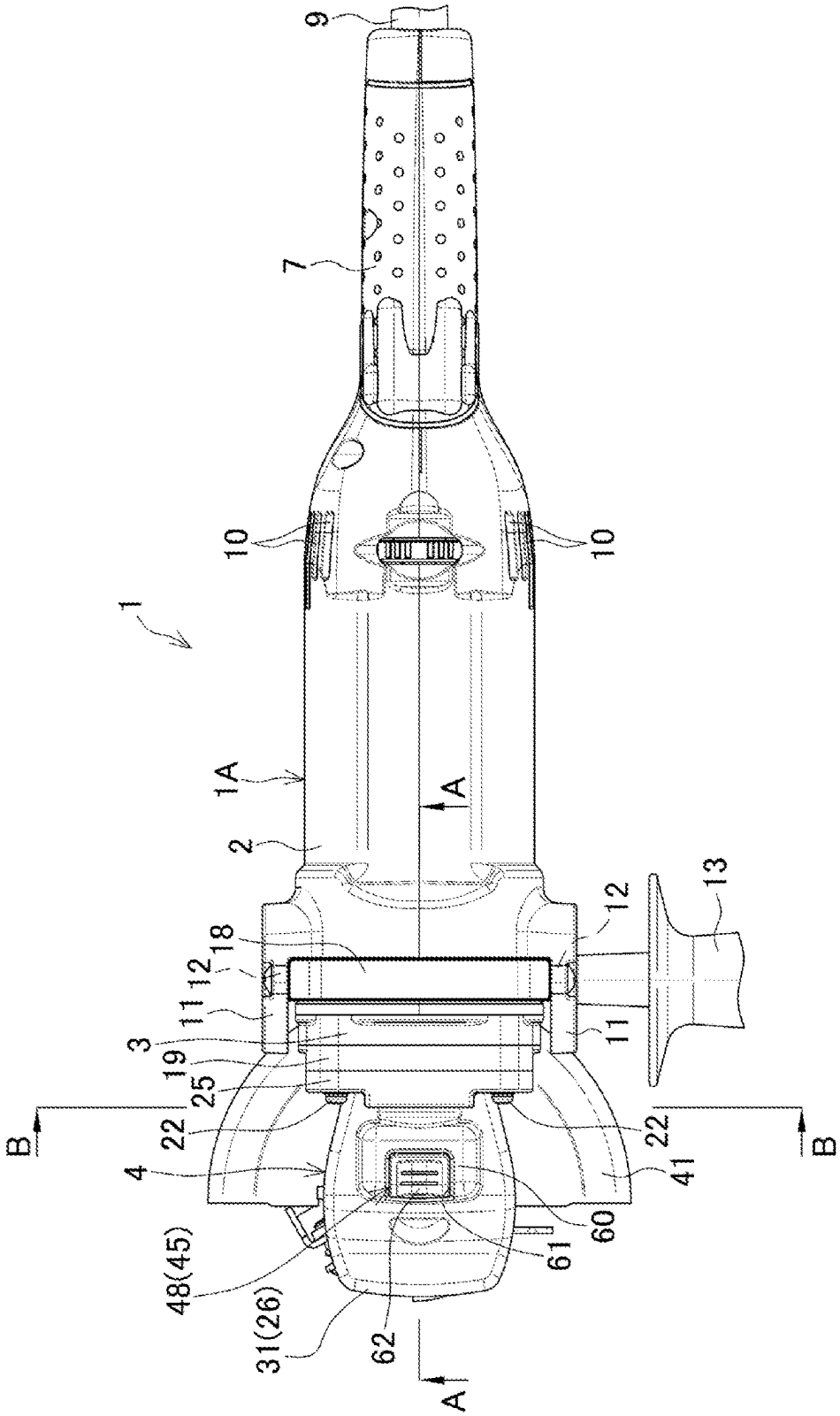
FIG. 1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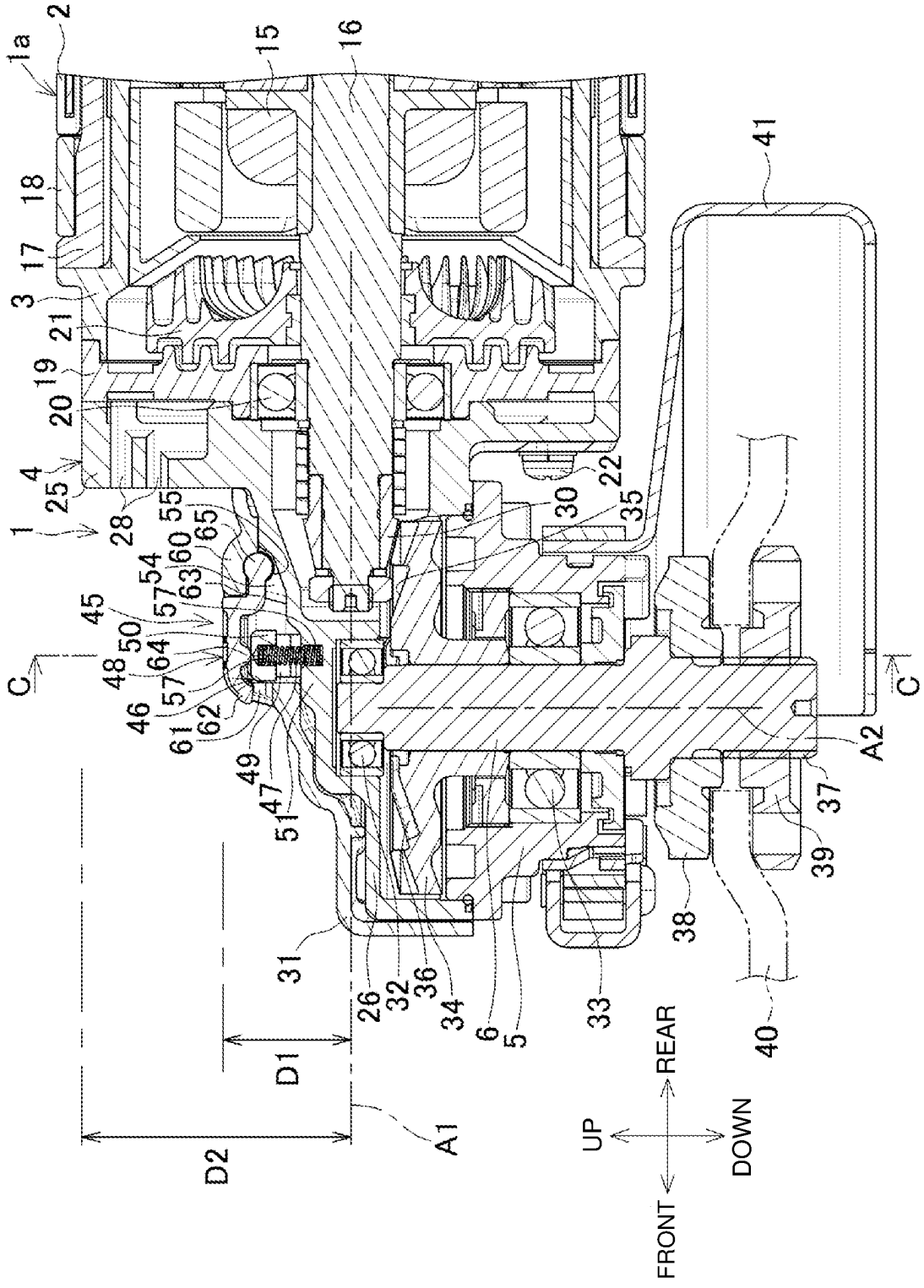
48(45)
31(26)
62
A

FIG. 2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39
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D1
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FIG. 3

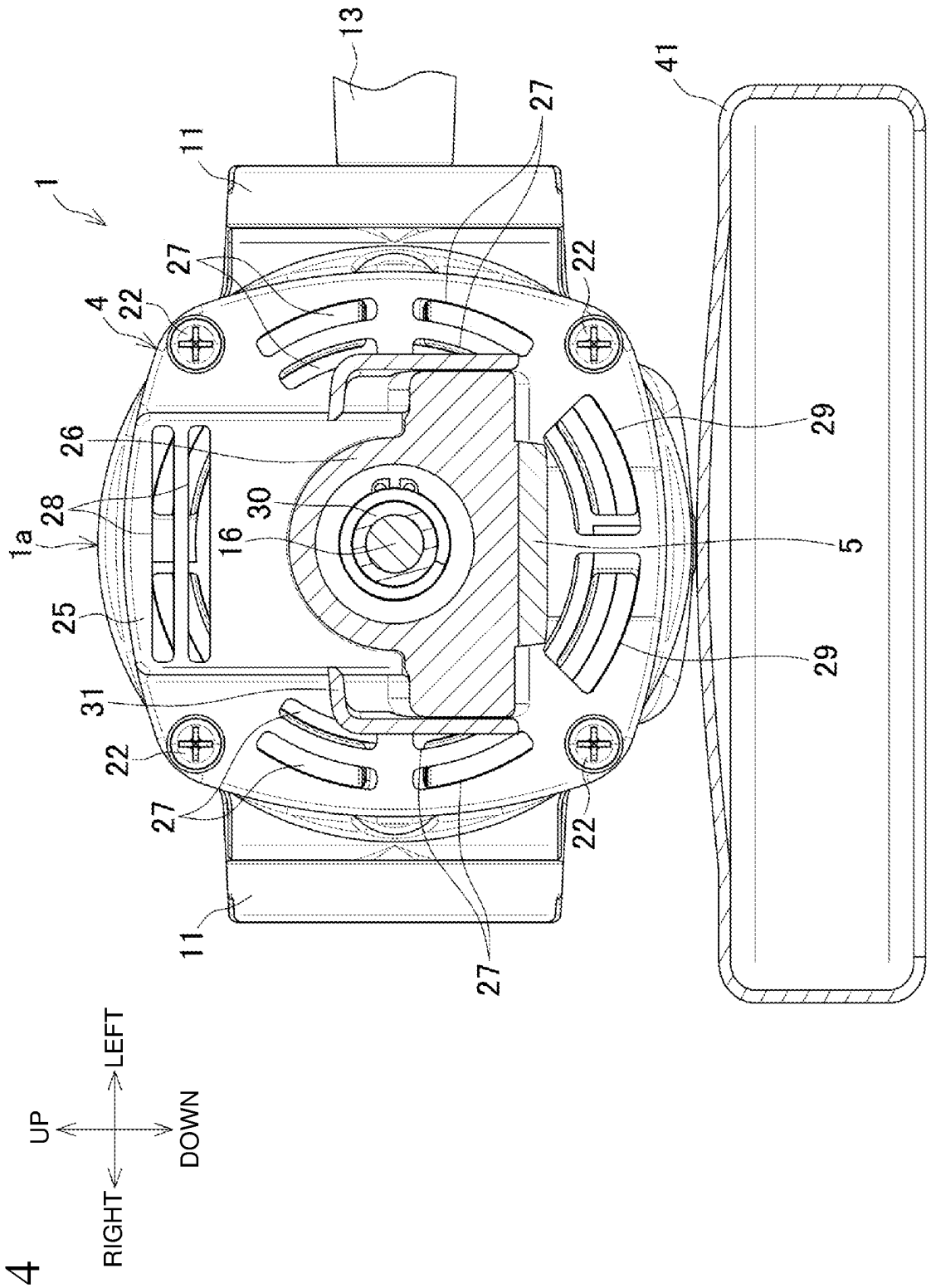
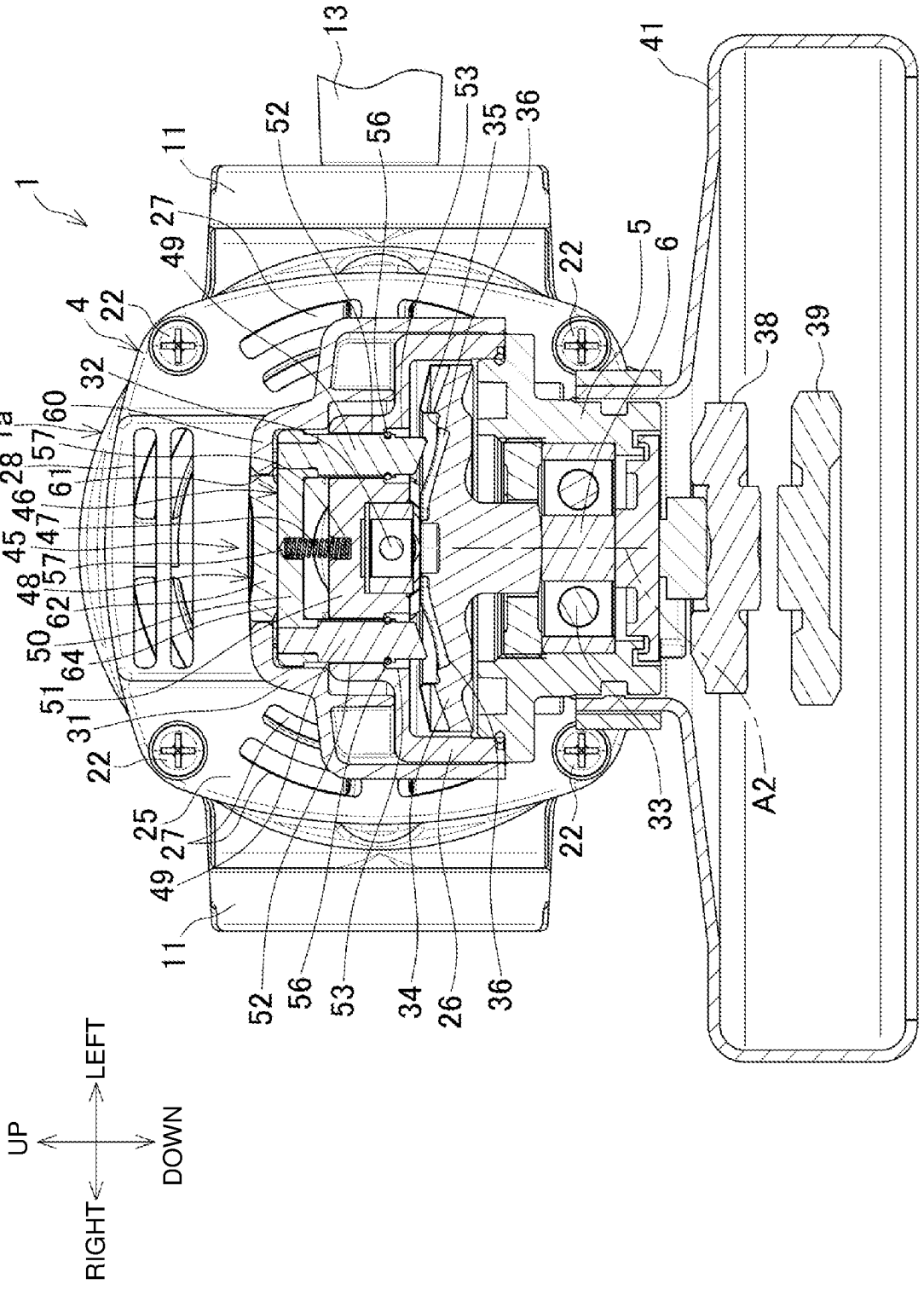


FIG. 4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UP
DOWN
LEFT
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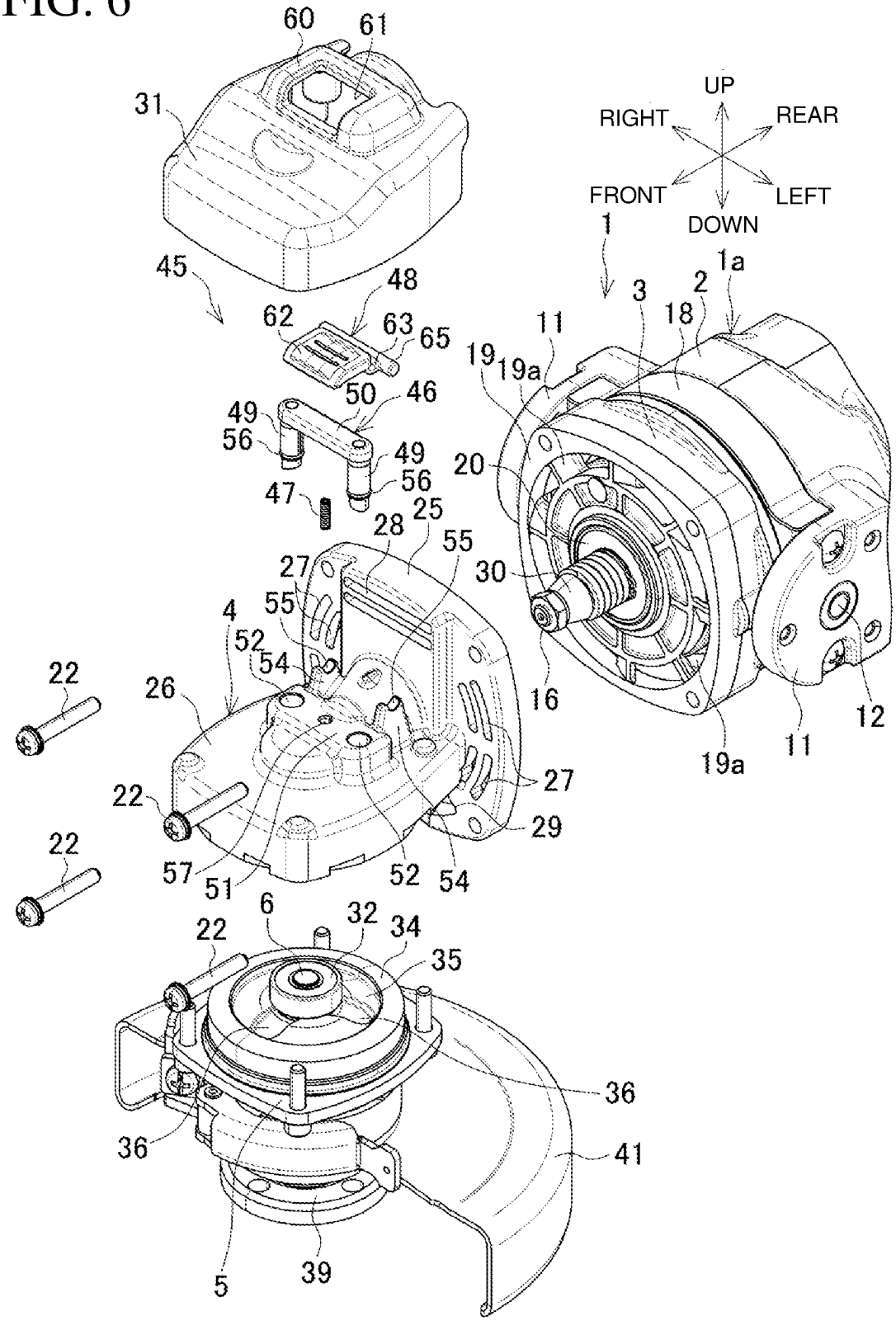
FIG. 5

FIG. 6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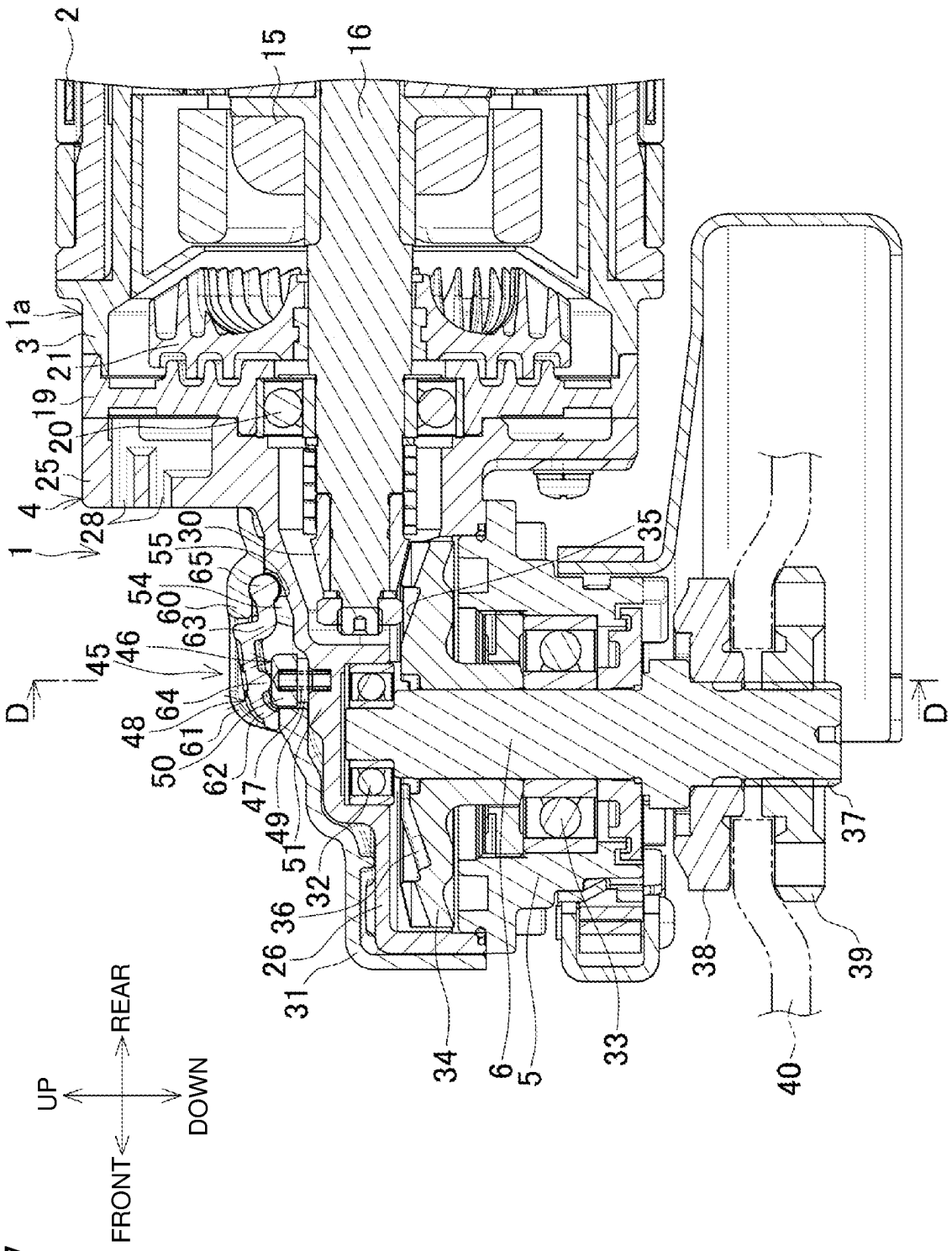
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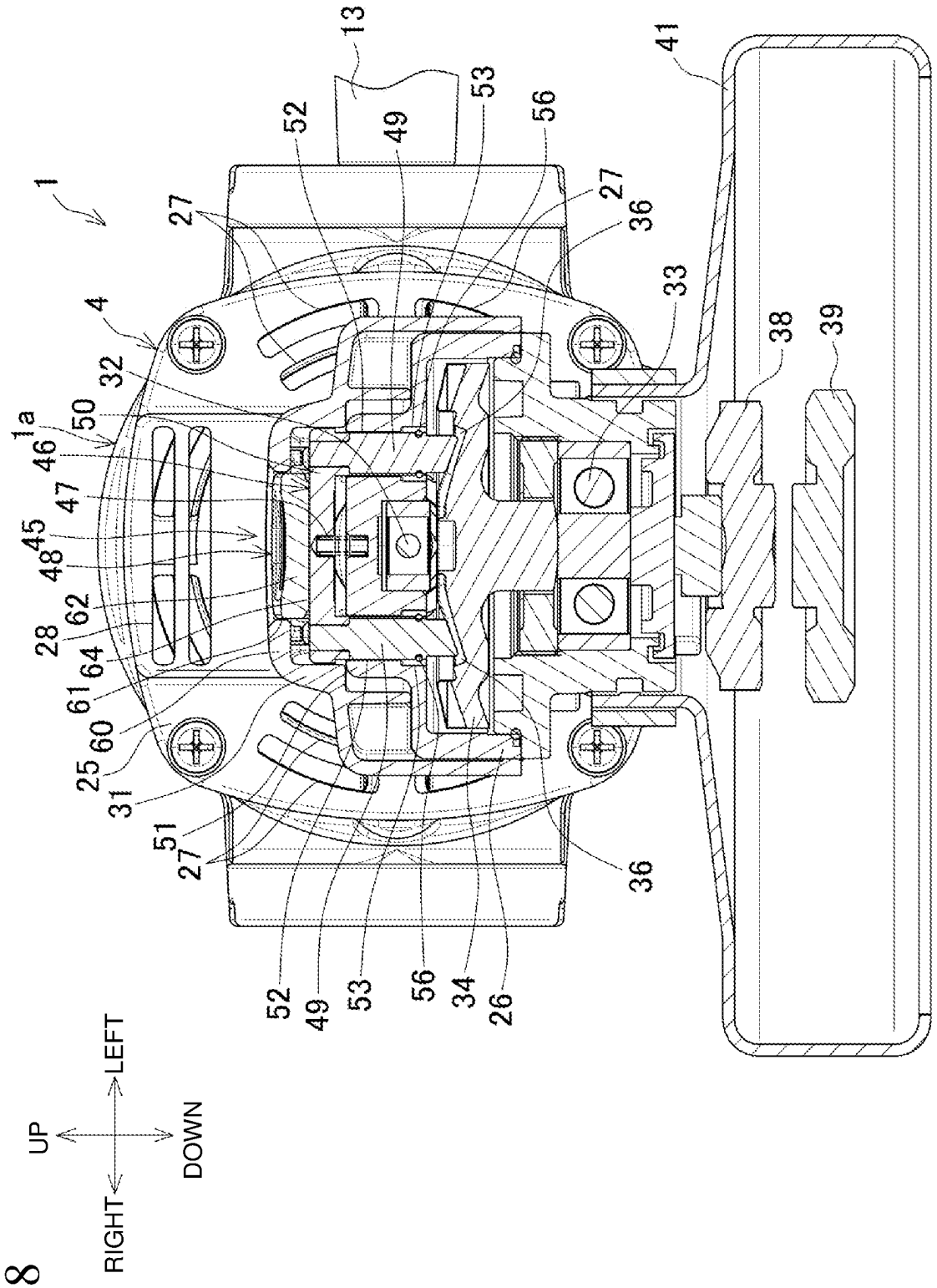
FIG. 7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64
UP
DOWN
LEFT
RIGHT

FIG. 8

POWER TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to Japanese Patent Application No. 2022-032895, filed on Mar. 3, 2022, the entire contents of which are hereby incorporated by reference.

BACKGROUND

1. Technical Field

The present disclosure relates to a power tool such as a grinder including a motor as a power supply.

2. Description of the Background

A grinder includes, for example, a spindle that rotates when driven by a motor. The spindle protruding downward from a housing receives a tip tool such as a grinding disc at its distal end. The grinder can perform an operation such as grinding with the tip tool rotating together with the spindle.

When the tip tool is to be attached to or detached from the grinder, the spindle is locked not to rotate. For example, Japanese Unexamined Patent Application Publication No. 2020-199627 (hereafter, Patent Literature 1) describes a grinder including a gear housing (head housing) accommodating a spindle and bevel gears in front of a main housing accommodating a motor. The gear housing includes a shaft lock (locking assembly). The shaft lock is pressed into the gear housing to have its distal end engaging with recesses in the bevel gears integral with the spindle. This locks the spindle not to rotate.

BRIEF SUMMARY

In Patent Literature 1, the shaft lock is located rightward in the gear housing. A compartment accommodating the spindle and the bevel gears is thus laterally wider to have substantially the same lateral width as its joint to the main housing. In the structure including a fan to cool the motor in the main housing, the gear housing can have outlets for discharging air for cooling the motor above and below the compartment alone. This structure cannot easily increase the opening area of the outlets to cool the motor efficiently.

One or more aspects of the present disclosure are directed to a power tool including a locking assembly to lock a spindle in a head housing and having outlets with a large opening area for high cooling efficiency.

A first aspect of the present disclosure provides a power tool, including:

a motor;

a fan configured to cool the motor;

a main housing accommodating the motor and the fan;

a spindle to which a tip tool is detachably attachable;

a locking assembly configured to lock rotation of the spindle; and

a head housing including

a joint connected to a front of the main housing, and a compartment accommodating the spindle and the locking assembly, the compartment being laterally less wide than the joint,

wherein the locking assembly is located at a middle in a lateral direction of the head housing, and

the joint has, in a portion of a front surface of the joint, a first outlet at least on a right or a left of the compartment to discharge air for cooling the motor generated from rotation of the fan.

The power tool according to the above aspect of the present disclosure includes the locking assembly to lock the spindle in the head housing and has the outlets with a large opening area for high cooling efficiency.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of a grinder.

FIG. **2** is a plan view of the grinder.

FIG. **3** is an enlarged sectional view taken along line A-A in FIG. **2** with a locking member at a non-engagement position.

FIG. **4** is an enlarged sectional view taken along line B-B in FIG. **2**.

FIG. **5** is a sectional view taken along line C-C in FIG. **3**.

FIG. **6** is an exploded perspective view of a gear housing and a locking assembly.

FIG. **7** is an enlarged sectional view corresponding to FIG. **3** with the locking member at an engagement position.

FIG. **8** is a sectional view taken along line D-D in FIG. **7**.

DETAILED DESCRIPTION

Embodiments of the present disclosure will now be described with reference to the drawings.

FIG. **1** is a perspective view of a grinder as an example of a power tool. FIG. **2** is a plan view of the grinder. FIG. **3** is an enlarged sectional view taken along line A-A in FIG. **2**.

A grinder **1** includes a main housing **1***a* including an outer housing **2** and an inner housing **3**. The outer housing **2** and the inner housing **3** are formed from resin. A metal gear housing **4** is connected to the front of the main housing **1***a*. The gear housing **4** is an example of head housing. The gear housing **4** receives a bearing retainer **5** attached to its lower portion. A spindle **6** protrudes downward from the bearing retainer **5**.

The outer housing **2** is a cylinder extending in the front-rear direction. The outer housing **2** includes, in its rear portion, a grip **7** with a smaller diameter. The grip **7** includes a switch lever **8**. The grip **7** has its rear end connected to a power cable **9**. The outer housing **2** has multiple inlets **10** in the right and left side surfaces of its larger diameter portion. The outer housing **2** has handle mounts **11** attached to the right and left side surfaces at its front end. The handle mounts **11** are plates extending laterally outward from the front end of the outer housing **2**, and then protruding frontward. The handle mounts **11** each have a threaded hole **12** (FIGS. **2** and **6**). A side handle **13** is screwed into the threaded hole **12**.

The inner housing **3** accommodates a motor **15**. The motor **15** is held with an output shaft **16** extending in the front-rear direction. A rubber cylinder **17** is externally mounted on the outer circumference of the inner housing **3**. The outer housing **2** holds the inner housing **3** with the rubber cylinder **17** between them. A metal fixing ring **18** is externally mounted on the rubber cylinder **17**. The handle mounts **11** are fastened to the fixing ring **18** with screws.

A partition **19** is located between the inner housing **3** and the gear housing **4**. The output shaft **16** extends through the partition **19** into the gear housing **4**. The partition **19** includes a bearing **20** supporting the output shaft **16**. The output shaft **16** receives a fan **21** behind the partition **19**.

The gear housing **4** includes a joint **25** and a gear compartment **26** that are integral with each other. The joint **25** is rectangular as viewed from the front. The joint **25** has its corners fastened, together with the partition **19**, to the inner housing **3** with four screws **22** from the front.

The gear compartment **26** protrudes frontward from the middle in the vertical and lateral directions of the joint **25**. The gear compartment **26** is rectangular as viewed in plan and has an opening in its lower surface. The gear compartment **26** is laterally less wide than the joint **25**.

As shown in FIG. **4**, the joint **25** has, in portions of the front surface, multiple lateral outlets **27** on the right and left of the gear compartment **26**. Each lateral outlet **27** is arc-shaped. The multiple lateral outlets **27** are laterally symmetrical to one another. The joint **25** has multiple upper outlets **28** in its front surface above the gear compartment **26**. Each upper outlet **28** is elongated in the lateral direction. The joint **25** has multiple lower outlets **29** in its front surface below the gear compartment **26**. Each lower outlet **29** is arc-shaped. In other words, the outlets **27**, **28**, and **29** surround the basal end of the gear compartment **26** as viewed from the front.

The output shaft **16** extends through the joint **25** into the gear compartment **26**. A first bevel gear **30** is fixed to the front end of the output shaft **16** in the gear compartment **26**. The bearing retainer **5** is a cylinder with its upper end having the same shape as the gear compartment **26** as viewed in plan. The bearing retainer **5** is fastened to a lower portion of the gear compartment **26** with screws from below. A front cover **31** is placed on the gear compartment **26** from above. The front cover **31** is formed from resin. The front cover **31** covers the upper surface, the front surface, and the right and left side surfaces of the gear compartment **26**. The front cover **31** is held between the gear compartment **26** and the bearing retainer **5**.

As shown in FIG. **3**, a distance D**1** in the vertical direction from an axis A**1** of the output shaft **16** to the upper end of the gear compartment **26** including the front cover **31** is less than the half of a distance D**2** in the vertical direction from the axis A**1** to the upper end of the joint **25**. The gear compartment **26** including the front cover **31** has smaller dimensions than the joint **25** in the vertical and lateral directions.

The spindle **6** extends in the vertical direction through the gear compartment **26** and the bearing retainer **5**. The spindle **6** has its upper end supported by the bearing **32** held on the gear compartment **26**. The spindle **6** has its intermediate portion supported by the bearing **33** held on the bearing retainer **5**. A second bevel gear **34** is fixed to the spindle **6** above the bearing **33**. The second bevel gear **34** meshes with the first bevel gear **30**. The second bevel gear **34** has its upper surface, except teeth on the outer circumference, defining a conical surface **35** that gradually rises toward the center. As shown in FIGS. **5** and **6**, the conical surface **35** has three recesses **36**. Each recess **36** extends radially outward from the spindle **6** at the center. The three recesses **36** are located at equal intervals in the circumferential direction of the second bevel gear **34**.

The spindle **6** has its lower end extending through the bearing retainer **5** downward. The spindle **6** includes a threaded portion **37** on its lower end. An inner flange **38** is externally mounted on the spindle **6** above the threaded portion **37**. An outer flange **39** is screwed to the threaded portion **37** below the inner flange **38**. With a tip tool **40** (e.g., a grinding disc) held between the inner flange **38** and the outer flange **39**, the outer flange **39** is tightened. This fixes the tip tool **40** to the spindle **6**. The bearing retainer **5** receives a wheel cover **41** that covers the rear upper surface and the rear circumferential surface of the tip tool **40**.

The gear compartment **26** and the front cover **31** include a locking assembly **45**. The locking assembly **45** can restrict the rotation of the spindle **6**. The locking assembly **45** includes a locking member **46**, a coil spring **47**, and an operation button **48**.

The locking member **46** includes two engagement pins **49** and a connector **50**. The engagement pins **49** are located laterally symmetrical about an axis A**2** of the spindle **6** as viewed from the front. Each pin **49** is a rod extending in the vertical direction. The connector **50** is a rod extending in the lateral direction. The engagement pins **49** have their upper ends pressed onto and connected to the right and left ends of the connector **50**. The locking member **46** thus forms an inverted U shape as viewed from the front.

A receiver **51** is raised from the upper surface of the gear compartment **26** behind the axis A**2** of the spindle **6**. The receiver **51** has its upper surface on a plane defined in the front-rear and lateral directions. The receiver **51** is rectangular as viewed in plan. The receiver **51** extends in the lateral direction to cover the bearing **32**. The receiver **51** has a pair of right and left through-holes **52**. Each through-hole **52** extends in the vertical direction. Each through-hole **52** has its lower portion with a larger diameter than its upper portion to define a larger-diameter hole **53**. Each through-hole **52** is open into the internal space of the gear compartment **26**.

A pair of right and left reception plates **54** are located behind the receiver **51**. Each reception plate **54** extends in the front-rear direction on the upper surface of the gear compartment **26**. Each reception plate **54** extends upward. Each reception plate **54** has a semicircular cutout **55** on its upper end.

The right and left engagement pins **49** extend through the through-holes **52** into the gear compartment **26**. The engagement pins **49** and the radially outward ends of the recesses **36** on the second bevel gear **34** are located concentrically as viewed in plan. Each engagement pin **49** has its lower end cut diagonally in conformance with the shape of the conical surface **35** of the second bevel gear **34**. An O-ring **56** is externally mounted on a lower portion of each engagement pin **49**. The O-ring **56** is located inside the larger-diameter hole **53**.

The connector **50** has a blind hole **57** at the middle in the lateral direction of its lower surface. The receiver **51** has a blind hole **57** at the middle in the lateral direction of its upper surface. The blind holes **57** have openings facing each other in the vertical direction. The coil spring **47** has its ends placed in the upper and lower blind holes **57** and are supported in the vertical direction, urging the locking member **46** upward.

The front cover **31** includes, at the middle in the lateral direction of its rear portion, a frame **60** raised upward. The frame **60** is a rectangle elongated in the lateral direction as viewed in plan. The frame **60** defines a space allowing the connector **50** to move vertically between the receiver **51** and the frame **60**. The frame **60** includes an operation window **61** opening outward except the right, left, and rear portions of the frame **60**.

The operation button **48** is located below the frame **60**. The operation button **48** includes a front button portion **62** and a rear support **63** that are integral with each other. The button portion **62** is rectangular as viewed in plan. The button portion **62** has dimensions to be fitted in the operation window **61** in the frame **60**. The button portion **62** has its front portion sloped downward toward the front. A pressing

portion **64** protrudes downward from the lower surface of the button portion **62**. The pressing portion **64** extends in the lateral direction.

The support **63** is connected to the rear end of the button portion **62**. The support **63** extends downward and then bends rearward to be L-shaped as viewed laterally. The support **63** has its rear end integral with a supporting rod **65** extending in the lateral direction.

Attaching the operation button **48** will now be described. The locking member **46** is first attached to the gear compartment **26** together with the coil spring **47**. The supporting rod **65** in the support **63** is then placed on the cutouts **55** on the reception plates **54** in the gear compartment **26**. With the front cover **31** placed in this state, the supporting rod **65** is held between the reception plates **54** and the front cover **31** as shown in FIG. **3**. The operation button **48** is thus supported in a manner swingable in the vertical direction about the supporting rod **65**.

The connector **50** in the locking member **46**, which is urged upward by the coil spring **47**, comes in contact with the pressing portion **64** of the button portion **62** from below. The operation button **48** is thus urged to an upper swing position in FIG. **3** in a normal state. At the upper swing position, the support **63** is in contact with the frame **60** behind the operation window **61**. At the upper swing position, the button portion **62** is located in an upper portion of the operation window **61**.

In this state as shown in FIG. **5**, the locking member **46** is at an uppermost position at which the O-rings **56** on the engagement pins **49** are at the upper ends of the larger-diameter holes **53** of the through-holes **52**. At the uppermost position, the engagement pins **49** have their lower ends located above the recesses **36** on the second bevel gear **34** to be at non-engagement positions at which the engagement pins **49** are not engaged with the recesses **36** in the rotation direction.

The button portion **62** in the operation button **48** is depressed from the upper swing position. As shown in FIG. **7**, the operation button **48** is then swung downward about the supporting rod **65** to be at a lower swing position at which the button portion **62** has its front end in contact with the upper surface of the front cover **31**. With the connector **50** thus pressed downward by the pressing portion **64**, the locking member **46** moves to a lowermost position against an urging force from the coil spring **47**. At the lowermost position as shown in FIG. **8**, the lower ends of the engagement pins **49** are received in the two recesses **36** on the second bevel gear **34** to be at engagement positions at which the engagement pins **49** are engageable with the recesses **36** in the rotation direction.

The switch lever **8** is depressed to turn on a switch (not shown) in the grip **7**. The motor **15** is thus driven to rotate the output shaft **16**. The rotation of the output shaft **16** is transmitted from the first bevel gear **30** to the second bevel gear **34**, and then to the spindle **6**. This rotates the tip tool **40** to, for example, grind a workpiece.

In the gear housing **4** in this state, the locking assembly **45** is located between the axis A**2** of the spindle **6** and the joint **25**, and the distance D**1** is less than the half of the distance D**2**. This structure reduces the height of the gear compartment **26**. The gear compartment **26** and the front cover **31** are thus less likely to obstruct an operator's view. This structure also facilitates operations performed in small spaces.

The fan **21** rotates as the output shaft **16** rotates. This causes outside air to be drawn through the rear inlets **10**. The air flows forward in the inner housing **3** and passes through the motor **15**. The air flows along the outer periphery of the fan **21** into multiple through-holes **19***a* (FIG. **6**) in the partition **19**, and then is discharged forward through the outlets **27**, **28**, and **29** in the joint **25**. This cooling air cools the motor **15**. The outlets **27**, **28**, and **29** in the joint **25** increase the opening area. This structure allows a larger amount of air to flow in the inner housing **3** and thus cools the motor **15** more effectively.

To detach the tip tool **40** for, for example, replacement after the operation is complete, the button portion **62** in the operation button **48** is depressed. The operation button **48** then swings about the supporting rod **65** to the lower swing position in FIGS. **7** and **8**. This causes the locking member **46** to move to the lowermost position against the urging force from the coil spring **47**. In this state, the button portion **62** swings at a position frontward from the supporting rod **65**. The button portion **62** can thus be depressed with a small force against the urging force from the coil spring **47**. The laterally symmetrical engagement pins **49** receive a pressing force from the button portion **62** in a well-balanced manner through the connector **50**. The engagement pins **49** thus smoothly move downward without tilting.

Upon the locking member **46** reaching the lowermost position, the lower ends of the engagement pins **49** engage with the two recesses **36** on the second bevel gear **34**. The locking member **46** thus restricts the rotation of the second bevel gear **34**. With the outer flange **39** loosened using a tool in this state, the tip tool **40** can be replaced.

The two engagement pins **49** in the locking member **46** are engaged with the two recesses **36**. When the outer flange **39** is loosened or tightened, stress in the locking member **46** is thus distributed. In particular, the engagement pins **49** located laterally symmetrical to each other allow uniform distribution of the stress.

This structure improves the strength and the durability of the locking assembly **45**. This structure can also reliably lock the spindle **6** not to rotate. The structure includes the two engagement pins **49**, but includes the single operation button **48**, and thus does not to lower the operability.

When the locking member **46** moves downward, the lower ends of the engagement pins **49** may not align with the recesses **36** and may be in contact with the conical surface **35** of the second bevel gear **34**. In this case, the tip tool **40** may be rotated to rotate the second bevel gear **34**. This changes the positions of the recesses **36** to allow the lower ends of the engagement pins **49** to align with the recesses **36**.

In response to the button portion **62** being released from depressing upon completion of, for example, replacement of the tip tool **40**, the locking member **46** returns to the uppermost position in FIGS. **3** and **5** under the urging force from the coil spring **47**. This separates the engagement pins **49** from the recesses **36**. The operation button **48** is also simultaneously pressed by the connector **50** from below to return to the upper swing position.

The grinder **1** according to the present embodiment includes the motor **15**, the fan **21** that cools the motor **15**, the main housing **1***a* accommodating the motor **15** and the fan **21**, the spindle **6** to which the tip tool **40** is detachably attachable, the locking assembly **45** that locks the rotation of the spindle **6**, and the gear housing **4** connected to the front of the main housing **1***a* and accommodating the spindle **6** and the locking assembly **45**. The gear housing **4** includes the joint **25** connected to the main housing **1***a*, and the gear compartment **26** (compartment) accommodating the spindle **6** and the locking assembly **45**.

The gear compartment **26** is laterally less wide than the joint **25**. The locking assembly **45** is located at the middle in

the lateral direction of the gear housing **4**. The joint **25** has, in the portions of the front surface of the joint **25**, the lateral outlets **27** (first outlet) on the right and the left of the compartment **26** to discharge air for cooling the motor **15** generated from the rotation of the fan **21**.

This structure can increase the opening area of the lateral outlets **27** and can improve cooling efficiency although the gear housing **4** includes the locking assembly **45** to lock the spindle **6**. With the gear compartment **26** downsized, this structure allows grinding performed in relatively small spaces and improves viewability during operation.

The joint **25** has the lateral outlets **27** on the right and the left of the compartment **26** and across the compartment **26**.

The lateral outlets **27** located in a well-balanced manner increase the opening area and improve cooling efficiency.

The joint **25** has, in the portions of the front surface, the upper outlets **28** (second outlet) above the gear compartment **26** and the lower outlets **29** (second outlet) below the gear compartment **26**.

These upper and lower outlets **28** and **29** can increase the opening area together with the lateral outlets **27**.

The spindle **6** has the axis A**2** extending in the vertical direction. The locking assembly **45** is between the axis A**2** of the spindle **6** and the joint **25**.

This structure can reduce the height of the upper end of the gear compartment **26** and can improve viewability although the locking assembly **45** is located at the middle in the lateral direction of the gear housing **4**.

The motor **15** includes the output shaft **16** extending in the front-rear direction. The distance D**1** in the vertical direction from the axis A**1** of the output shaft **16** to the upper end of the gear compartment **26** is less than or equal to half the distance D**2** in the vertical direction from the axis A**1** of the output shaft **16** to the upper end of the joint **25**.

This structure can further reduce the height of the upper end of the gear compartment **26** and can further improve viewability.

The gear compartment **26** and the joint **25** are integral as a single component.

This simplifies the structure to include fewer components.

The gear compartment **26** is formed from metal, and has the surface covered with the front cover **31** (resin).

This structure prevents an operator from directly touching the gear compartment **26** with hands, while maintaining the rigidity of the gear compartment **26**. This improves the operability of the locking assembly **45**.

The threaded holes **12** (an example of the mount) for the side handle **13** are located rearward from the gear housing **4**.

This structure can eliminate the threaded holes in the gear compartment **26** and can thus further downsize the gear compartment **26**. The side handle **13** located rearward from the gear compartment **26** allows an easy operation without being restricted by the position of the side handle **13**, thus improving workability in small spaces.

Modifications of the present disclosure will now be described.

A compartment may be located differently from the compartment in the present embodiment that is located at the middle in the vertical and lateral directions relative to the joint. The compartment may be slightly off the middle in the lateral or vertical direction when the joint has the outlets in at least a right portion or a left portion of the front surface. The shape of the compartment is not limited to the shape in the present embodiment. The compartment may be elongated semicircular or semielliptic as viewed in plan or semicircular as viewed from the front.

The numbers or the shapes of the outlets in the joint are not limited to the numbers or the shapes in the present embodiment. For example, all the outlets may be arc-shaped, elongated circular, circular, or rectangular, or may be shaped with a combination of these.

The lateral outlets may be different from the lateral outlets in the present embodiment that are laterally symmetrical to one another depending on the position and the shape of the compartment. The lateral outlets may be located at least either on the right or left of the compartment.

The upper outlets or the lower outlets, or both may be eliminated.

The distance from the axis of the output shaft to the upper end of the compartment may be half the distance from the axis of the output shaft to the upper end of the joint. With appropriate viewability, these distances may not be defined.

The locking assembly may be at a position other than between the axis of the spindle and the joint. With the outlets in either the right or left portion, the locking assembly may be located, for example, laterally outward from or frontward from the axis of the spindle.

The head housing may not include the joint and the gear compartment that are integral with each other as the gear housing in the present embodiment. The joint and the gear compartment may be connected to each other after being formed separately.

The resin covering the compartment may be formed differently from the front cover in the present embodiment. For example, the resin may be integral with the surface of the compartment by, for example, insert molding. The resin may be eliminated.

The mounts for the side handle are not limited to the threaded holes. The mounts may be located on the side surfaces of the compartment when the compartment is downsized.

The locking assembly may have a structure different from the structure described in the present embodiment. The locking member may include, for example, three or more engagement pins other than the two engagement pins.

The engagement pins may not be located separately in the right and left portions of the head housing. The connector may have its middle protruding upward to be pressed by an operable member.

The engagement pins may be rods shorter than those in the present embodiment. The engagement pins may each have any cross section other than the circular cross section. The engagement pins may not have the sloped lower ends, as appropriate for the shape of the outer surface of the gear. The engagement pins may each be integral with the connector rather than being separate from the connector.

Multiple coil springs may be used. An elastic member other than the coil spring may be used.

The operation button may also have a structure different from the structure of the present embodiment. For example, the operation button may include a circular button as viewed in plan or the supporting rod located frontward, rightward, or leftward from the button. The operation button may move vertically rather than swinging about the supporting rod. The operation button may be eliminated. An operable member may be formed integrally with the upper surface of the locking member to be directly operable.

The locking assembly may have a structure different from the structure of the present embodiment. The locking assembly may have a known structure in which a single engagement pin is urged against the bevel gear to be engaged with the bevel gear and locks the rotation of the spindle.

The grinder may be a direct current (DC) tool powered by a battery pack, rather than an alternating current (AC) tool powered by utility power.

The main housing of the grinder is not limited to the structure of the present embodiment including the outer housing and inner housing. For example, the main housing may include the outer housing alone.

The power tool according to the present embodiment is not limited to the grinder. For example, the structure of the head housing in the present embodiment is applicable to other grinding tools such as a polisher and a sander.

REFERENCE SIGNS LIST

1 grinder
2 outer housing
3 inner housing
4 gear housing
5 bearing retainer
6 spindle
10 inlet
11 handle mount
12 threaded hole
13 side handle
15 motor
16 output shaft
21 fan
25 joint
26 gear compartment
27 lateral outlet
28 upper outlet
29 lower outlet
30 first bevel gear
31 front cover
34 second bevel gear
36 recess
37 threaded portion
38 inner flange
39 outer flange
40 tip tool
45 locking assembly
46 locking member
47 coil spring
48 operation button
A**1** axis of output shaft
A**2** axis of spindle
D**1** distance in vertical direction from axis of output shaft to upper end of front cover
D**2** distance in vertical direction from axis of output shaft to upper end of joint

What is claimed is:

1. A power tool, comprising:
a motor;
a fan configured to cool the motor;
a main housing accommodating the motor and the fan;
a spindle to which a tip tool is detachably attachable;
a locking assembly configured to lock rotation of the spindle; and
a head housing including
a joint connected to a front of the main housing, and
a compartment accommodating the spindle and the locking assembly, the compartment being laterally less wide than the joint,
wherein the locking assembly is located at a middle in a lateral direction of the head housing, and
the joint has, in a portion of a front surface of the joint, a first outlet at least on a right or a left of the compartment to discharge air for cooling the motor generated from rotation of the fan, the first outlet penetrating the joint in a front-rear direction.

2. The power tool according to claim **1**, wherein
the joint has first outlets on the right and the left of the compartment and across the compartment.

3. The power tool according to claim **1**, wherein
the joint has, in a portion of the front surface, a second outlet at least above or below the compartment, the second outlet penetrating the joint in the front-rear direction.

4. The power tool according to claim **1**, wherein
the spindle has an axis extending in a vertical direction, and
the locking assembly is between the axis of the spindle and the joint.

5. The power tool according to claim **4**, wherein
the motor includes an output shaft extending in a front-rear direction, and
a distance in the vertical direction from an axis of the output shaft to an upper end of the compartment is less than or equal to half a distance in the vertical direction from the axis of the output shaft to an upper end of the joint.

6. The power tool according to claim **1**, wherein
the compartment and the joint are integral as a single component.

7. The power tool according to claim **1**, wherein
the compartment comprises metal, and has a surface covered with resin.

8. The power tool according to claim **1**, further comprising:
a mount for a side handle, the mount being located rearward from the head housing.

9. The power tool according to claim **2**, wherein
the spindle has an axis extending in a vertical direction, and
the locking assembly is between the axis of the spindle and the joint.

10. The power tool according to claim **3**, wherein
the spindle has an axis extending in a vertical direction, and
the locking assembly is between the axis of the spindle and the joint.

11. The power tool according to claim **2**, wherein
the compartment and the joint are integral as a single component.

12. The power tool according to claim **3**, wherein
the compartment and the joint are integral as a single component.

13. The power tool according to claim **4**, wherein
the compartment and the joint are integral as a single component.

14. The power tool according to claim **5**, wherein
the compartment and the joint are integral as a single component.

15. The power tool according to claim **2**, wherein
the compartment comprises metal, and has a surface covered with resin.

16. The power tool according to claim **3**, wherein
the compartment comprises metal, and has a surface covered with resin.

17. The power tool according to claim **4**, wherein
the compartment comprises metal, and has a surface covered with resin.

18. The power tool according to claim 5, wherein the compartment comprises metal, and has a surface covered with resin.

19. The power tool according to claim 6, wherein the compartment comprises metal, and has a surface covered with resin.

20. The power tool according to claim 2, wherein the joint has, in a portion of the front surface, a second outlet at least above or below the compartment, the second outlet penetrating the joint in the front-rear direction.

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