(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 234 092 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.08.2023 Bulletin 2023/35

(21) Application number: **23155016.1**

(22) Date of filing: **06.02.2023**

(51) International Patent Classification (IPC):
B05B 1/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B05B 1/005; B05B 1/002; B05B 1/06

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **24.02.2022 JP 2022026319**

(71) Applicant: **SMC Corporation**
Tokyo 101-0021 (JP)

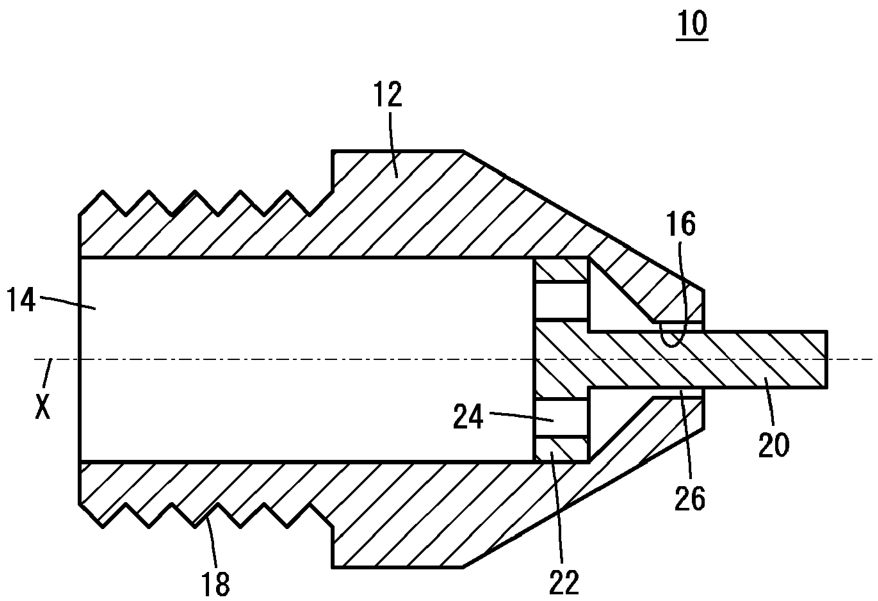
(72) Inventor: **ISHIKAWA, Rikiya**
Ibaraki 300-2493 (JP)

(74) Representative: **Keil & Schaafhausen Patentanwälte PartGmbB**
Friedrichstraße 2-6
60323 Frankfurt am Main (DE)

(54) **AIR NOZZLE**

(57) A shaft core portion (20) is connected to a tubular portion (12) via a connecting portion (22), the shaft core portion is inserted into a small-diameter hole (16) provided at the distal end of the tubular portion, protrudes from the distal end of the tubular portion, and an annular air ejection port (26) is formed by a gap existing between the wall surface of the small-diameter hole and the outer surface of the shaft core portion.

FIG. 1



EP 4 234 092 A1

Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to an air nozzle for injecting air at high pressure.

DESCRIPTION OF THE RELATED ART

[0002] For example, an air nozzle for blowing air onto a workpiece in a production line to remove foreign matters such as dust, chips, and moisture attached to the workpiece has been known. When such an air nozzle is used at high pressure, noise is generated.

[0003] Various techniques have been proposed to reduce noise generated by an air nozzle. For example, JP S58-024182 B2 discloses a fluid nozzle in which a noise-reducing element made of mesh wire fabric is disposed in a centrally located bore of the nozzle, and a passage connecting the centrally located bore of the nozzle to an outer surface thereof is provided. In this fluid nozzle, a back pressure is created on an upstream side of the noise-reducing element, creating a laminar air flow that flows along the outer surface of the nozzle. Drawing in ambient air, this laminar air flow merges with an air stream flowing through the centrally located bore of the nozzle.

[0004] According to the fluid nozzle, because the air stream passing through the centrally located hole of the nozzle passes through the noise-reducing element, the noise is reduced to some extent. Further, because the ambient air induced by the laminar air flow smoothly merges with the air stream passing through the centrally located bore of the nozzle, noise is reduced to some extent.

SUMMARY OF THE INVENTION

[0005] It is known that when high-pressure air is introduced into a tapered nozzle, the air becomes choked in the nozzle and the air is ejected from the tapered nozzle without fully expanding to the atmospheric pressure. This underexpanded jet has a shock cell structure in which shock waves and expansion waves appear alternately. The noise generated when high-pressure air is ejected from the tapered nozzle is closely related to the underexpanded jet. However, air nozzle technology focusing on the underexpanded jet has not yet been sufficiently developed. The technique disclosed in JP S58-024182 B2 did not take the underexpanded jet into consideration.

[0006] The present invention has been made under such circumstances. It is an object of the present invention to provide an air nozzle capable of reducing, as much as possible, noise caused by an underexpanded jet while ensuring a necessary impingement pressure.

[0007] Disclosed is an air nozzle in which a shaft core portion is connected to a tubular portion via a connecting portion, wherein the shaft core portion is inserted into a small-diameter hole provided at the distal end of the tubular portion, the shaft core portion protrudes from the distal end of the tubular portion, and an annular air ejection port is configured by a gap existing between the wall surface of the small-diameter hole and the outer surface of the shaft core portion.

[0008] According to the air nozzle of the present invention, an annular air ejection port is formed by the gap existing between the wall surface of the small-diameter hole of the tubular portion and the outer surface of the shaft core portion, and the shaft core portion protrudes from the distal end of the tubular portion, whereby noise can be reduced while a necessary impingement pressure is acquired.

[0009] The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings, in which a preferred embodiment of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a cross-sectional view of an air nozzle according to a first embodiment of the present invention cut along a plane including an axis of the air nozzle.

FIG. 2 is a view of the air nozzle of FIG. 1 as viewed in a direction along the axis of the air nozzle.

FIG. 3 is a view showing a state in which the air nozzle of FIG. 1 has been attached to a pipe.

FIG. 4A is an external view of a known single-hole nozzle, and FIG. 4B is an external view of a known silencing nozzle.

FIG. 5 is a graph comparing the air nozzle of the present invention with a known single hole nozzle and a known silencing nozzle in terms of noise level.

FIG. 6 is a graph comparing the air nozzle of the present invention with a known single hole nozzle and a known silencing nozzle in terms of impingement pressure.

FIG. 7 is a graph showing the relationship between an axial length of an axial core portion of the air nozzle and the noise level.

FIG. 8 is a graph showing the relationship between the axial length of the shaft core portion of the air nozzle and the impingement pressure.

FIG. 9 is a cross-sectional view of an air nozzle according to a second embodiment of the present invention cut along a plane including an axis of the air nozzle.

FIG. 10 is a cross-sectional view of an air nozzle according to a third embodiment of the present invention cut along a plane including an axis of the air nozzle.

FIG. 11 is a view showing a state in which the air nozzle of FIG. 10 is attached to a manifold by a one-touch fitting.

FIG. 12 is a cross-sectional view of an air nozzle according to a fourth embodiment of the present invention cut along a plane including an axis of the air nozzle.

FIG. 13 is a view of the air nozzle shown in FIG. 12 as viewed from the direction along the axis of the air nozzle.

FIG. 14 is an external view of an air nozzle according to a fifth embodiment of the present invention.

FIG. 15 is a cross-sectional view of the air nozzle shown in FIG. 14 cut along a plane including the axis of the air nozzle.

FIG. 16 is a view of the air nozzle shown in FIG. 14 as viewed from the direction along the axis of the air nozzle.

FIG. 17 is a diagram showing an example in which the air nozzle of FIG. 1 is applied to a blow gun.

DETAILED DESCRIPTION OF THE INVENTION

(First Embodiment)

[0011] An air nozzle 10 according to a first embodiment of the present invention will be described with reference to FIGS. 1 to 3. In the following description, when terms related to the directions of up, down, left, and right are used, they refer to directions in the drawings only for the sake of convenience and do not limit an actual arrangement in any way.

[0012] As shown in FIG. 1, the air nozzle 10 is constituted by a tubular portion 12, a shaft core portion 20, and a connecting portion 22. The shaft core portion 20 has a uniform outer diameter and is connected to the tubular portion 12 via the connecting portion 22 that is disk-shaped. The tubular portion 12, the shaft core portion 20, and the connecting portion 22 are all made of metal. The connecting portion 22 is formed integrally with the shaft core portion 20. The tubular portion 12 that is cylindrical has an air inflow port 14 at its left end and a small-diameter hole 16 at its right end (distal end). The tubular portion 12 has a male screw portion 18 on its outer periphery.

[0013] The shaft core portion 20 is inserted into the small-diameter hole 16 of the tubular portion 12. An annular air ejection port 26 is constituted by a gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20. The left end of the shaft core portion 20 is connected to the center of the connecting portion 22. The shaft core portion 20 protrudes outward from the right end (distal end) of the tubular portion 12 by a predetermined length. The distal end of the shaft core portion 20 has a flat surface. The connecting portion 22 is fixed to the tubular portion 12 by being press-fitted into the tubular portion 12.

[0014] As shown in FIGS. 1 and 2, the connecting portion 22 has a plurality of through holes 24 serving as air flow paths. The plurality of through holes 24 are arranged at equal angles around an axis X of the air nozzle 10. In this embodiment, a total of four through holes 24 are arranged but the number of through holes 24 is arbitrary. As shown in FIG. 3, with a nut 27, the air nozzle 10 is connected and fixed to a pipe 28 for guiding high-pressure air.

[0015] The air flowing into the air inflow port 14 of the air nozzle 10 through the pipe 28 passes through the plurality of through holes 24 of the connecting portion 22 and is then ejected into the atmosphere from the annular air ejection port 26. Air flowing in from the air inflow port 14 at a pressure equal to or higher than a predetermined pressure is not fully expanded up to the atmospheric pressure and is ejected from the air ejection port 26. That is, air flowing in from the air inflow port 14 at a pressure equal to or higher than the predetermined pressure becomes an underexpanded jet flow and is ejected from the air ejection port 26. This underexpanded jet is guided to the outer surface of the shaft core portion 20 and flows around the shaft core portion 20. Thus, it is considered that the vibration of the air is effectively attenuated and noise is reduced.

[0016] The area of the air flow path (the total cross-sectional area of the plurality of through holes 24) at the connecting portion 22 is at least three times as large as the area of the air ejection port 26. As a result, the flow velocity of the air ejected from the air ejection port 26 can be sufficiently increased. The length of a protruding portion of the shaft core portion 20 protruding outward from the right end of the tubular portion 12 (hereinafter, "axial length of the shaft core portion 20") is preferably 3 mm or more and 15 mm or less. The reason for this will be described later.

[0017] Next, the noise level and the impingement pressure of the air nozzle 10 based on experimental results will be described in comparison with a known single-hole nozzle 30 and a known silencing nozzle 32. As shown in FIG. 4A, the single-hole nozzle 30 to be compared is a tapered nozzle having a single ejection port 30a. As shown in FIG. 4B, the silencing nozzle 32 to be compared is a nozzle having four ejection ports 32a, and the four ejection ports 32a are arranged at equal angles around the axis of the nozzle.

[0018] The outer diameter of the shaft core portion 20 of the air nozzle 10 used is 3 mm. The inner diameter of the small diameter hole 16 of the tubular portion 12 of the air nozzle 10 used is about 3.6 mm. Therefore, the area of the air ejection port 26 of the air nozzle 10 is about 4 mm^2. The inner diameter of the ejection port 30a of the single-hole nozzle 30 used is 2 mm. The inner diameter of each ejection port 32a of the silencing nozzle 32 used is 1 mm. That is, the area of the ejection port 30a of the single-hole nozzle 30 and the area of the four ejection ports 32a of the silencing nozzle 32 were set to be equal to the area of the air ejection port 26 of the air nozzle 10. Regarding the axial length of the shaft core portion 20 of the air nozzle 10, seven types of 1 mm, 3 mm, 5 mm, 7.5 mm, 10 mm, 15 mm, and 20 mm were prepared.

[0019] FIG. 5 shows noise levels measured for the air nozzle 10, the single-hole nozzle 30, and the silencing nozzle 32. The horizontal axis represents a gauge pressure of the air measured at the air inlet port of the nozzle (units: MPa). The vertical axis represents the noise level (unit: dB) measured at a predetermined position in the 45° direction with respect to the axis of the nozzle according to the noise measurement method specified in JISB8379. Hereinafter, the gauge pressure of the air measured at the air inlet port of the nozzle is called "immediately preceding pressure".

[0020] As shown in FIG. 5, the noise level of the air nozzle 10 increases as the immediately preceding pressure increases from 0.1 MPa to 0.6 MPa. It can be evaluated that the noise level of the air nozzle 10 is approximately 10 dB or more lower than that of the single-hole nozzle 30 except when the axial length of the shaft core portion 20 is 1 mm, and the noise level of the air nozzle 10 is approximately the same as that of the silencing nozzle 32. It is considered that the air nozzle 10 generates an underexpanded jet when the immediately preceding pressure is 0.1 MPa or more.

[0021] FIG. 6 shows impingement pressures measured for the air nozzle 10, the single-hole nozzle 30, and the silencing nozzle 32. The horizontal axis indicates the immediately preceding pressure (units: MPa). The vertical axis represents the impingement pressure (unit: kPa) measured at a position at a predetermined distance from the ejection port of the nozzle. When the impingement pressure is measured, a plate (not shown) to which a pressure sensor has been attached is prepared, and the plate is disposed vertically below the ejection port of the nozzle in such a way that the distance from the ejection port of the nozzle to the pressure sensor is 40 mm.

[0022] As shown in FIG. 6, the impingement pressure of the air nozzle 10 increases as the immediately preceding pressure increases from 0.1 MPa to 0.6 MPa. The impingement pressure of the air nozzle 10 is greatest when the axial length of the shaft core portion 20 is 3 mm. It can be evaluated that the impingement pressure of the air nozzle 10 is sufficiently larger than that of the silencing nozzle 32 except when the axial length of the shaft core portion 20 is 20 mm.

[0023] According to the above results of the experiments, it can be said that the axial length of the shaft core portion 20 of the air nozzle 10 is preferably not less than 3 mm and not more than 15 mm in order to reduce noise as much as possible and to acquire a necessary impingement pressure. FIG. 7 is a graph showing clearly the relationship between the axial length of the shaft core portion 20 and the noise level by replacing the immediately preceding pressure with the axial length of the shaft core portion 20 in the results of the experiments on the air nozzle 10. FIG. 8 is a graph showing clearly the relationship between the axial length of the shaft core portion 20 and the impingement pressure by replacing the immediately preceding pressure with the axial length of the shaft core portion 20 in the results of the experiments on the air nozzle 10.

[0024] In the above experiments, the outer diameter of the shaft core portion 20 was set to 3 mm and the inner diameter of the small-diameter hole 16 of the tubular portion 12 was set to about 3.6 mm. However, the outer diameter of the shaft core portion 20 and the inner diameter of the small-diameter hole 16 of the tubular portion 12 can be set to various values. As the outer diameter of the shaft core portion 20 and the inner diameter of the small-diameter hole 16 of the tubular portion 12 increase, it is thought that a preferable numerical range of the axial length of the shaft core portion 20 also increases.

[0025] The air nozzle 10 can be applied to a blow gun or various types of valve. FIG. 17 shows an example in which the air nozzle 10 is applied to a blow gun 34. When the operator grasps a handle 36 of the blow gun 34 and pulls a lever 38, air can be ejected from the air nozzle 10 toward the workpiece.

[0026] According to the air nozzle 10 of the present embodiment, the annular air ejection port 26 is constituted by the gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20, and the shaft core portion 20 protrudes from the distal end of the tubular portion 12. Since the underexpanded jet ejected from the annular air ejection port 26 flows around the shaft core portion 20, it is possible to reduce noise while impingement pressure required for the air nozzle 10 is acquired.

(Second Embodiment)

[0027] Next, an air nozzle 40 according to a second embodiment of the present invention will be described with reference to FIG. 9. With respect to the air nozzle 40 according to the second embodiment, components identical or equivalent to those of the air nozzle 10 already described are denoted by the same reference numerals.

[0028] The tubular portion 12 of the air nozzle 40 is constituted by a first tubular portion 12a made of resin and a second tubular portion 12b made of metal. The first tubular portion 12a is fixed to the second tubular portion 12b by press fitting. The shaft core portion 20 and the connecting portion 22 are integrally formed with the first tubular portion 12a by resin molding using, for example, a 3D printer.

[0029] The shaft core portion 20 is connected to the first tubular portion 12a via the connecting portion 22 that is disk-shaped. The second tubular portion 12b has the air inflow port 14 at its left end, and the first tubular portion 12a has the small-diameter hole 16 at its right end. The second tubular portion 12b has the male screw portion 18 on its outer periphery. The shaft core portion 20 is inserted into the small-diameter hole 16 of the first tubular portion 12a. The annular air ejection port 26 is constituted by a gap existing between the wall surface of the small-diameter hole 16 of the first tubular portion 12a and the outer surface of the shaft core portion 20. The shaft core portion 20 projects outward from the right end (distal end) of the first tubular portion 12a.

[0030] The connecting portion 22 has a plurality of through holes 24 serving as air flow paths. As in the case of the first embodiment, the area of the air flow path (the total cross-sectional area of the plurality of through holes 24) at the connecting portion 22 is at least three times as large as the area of the air ejection port 26. A preferable numerical range for the axial length of the shaft core portion 20 is the same as that in the first embodiment.

[0031] In the air nozzle 40 according to the present embodiment, the annular air ejection port 26 is constituted by the gap existing between the wall surface of the small-diameter hole 16 of the first tubular portion 12a and the outer surface of the shaft core portion 20, and the shaft core portion 20 protrudes from the distal end of the first tubular portion 12a. Therefore, it is possible to reduce noise while a necessary impingement pressure is acquired. Further, since the shaft core portion 20 and the connecting portion 22 are integrally formed with the first tubular portion 12a by resin molding, the air flow path structure can be accurately reproduced in comparison with the case where the connecting portion 22 is a separate member from the tubular portion 12.

(Third Embodiment)

[0032] Next, an air nozzle 50 according to a third embodiment of the present invention will be described with reference to FIGS. 10 and 11. With respect to the air nozzle 50 according to the third embodiment, components identical or equivalent to those of the air nozzle 10 already described are denoted by the same reference numerals.

[0033] The air nozzle 50 is constituted by the tubular portion 12, the shaft core portion 20, and the connecting portion 22. The tubular portion 12, the shaft core portion 20, and the connecting portion 22 are integrally formed by resin molding using, for example, a 3D printer. An annular air ejection port 26 is constituted by a gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20. The shaft core portion 20 projects outward from the right end (distal end) of the tubular portion 12.

[0034] The connecting portion 22 has a plurality of through holes 24 serving as air flow paths. As in the case of the first embodiment, the area of the air flow path (the total cross-sectional area of the plurality of through holes 24) at the connecting portion 22 is at least three times as large as the area of the air ejection port 26. A preferable numerical range for the axial length of the shaft core portion 20 is the same as that in the first embodiment. As shown in FIG. 11, the air nozzle 50 is attached to a manifold 54 via, for example, a one-touch fitting 52.

[0035] In the air nozzle 50 according to the present embodiment, the annular air ejection port 26 is formed by the gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20, and the shaft core portion 20 protrudes from the distal end of the tubular portion 12. Therefore, it is possible to reduce noise while a necessary impingement pressure is acquired. Further, since the tubular portion 12, the shaft core portion 20, and the connecting portion 22 are integrally formed by resin molding, the air flow path structure can be accurately reproduced in comparison with the case where the connecting portion 22 is a separate member from the tubular portion 12.

(Fourth Embodiment)

[0036] Next, an air nozzle 60 according to a fourth embodiment of the present invention will be described with reference to FIGS. 12 and 13. With respect to the air nozzle 60 according to the fourth embodiment, components identical or equivalent to those of the air nozzle 10 already described are denoted by the same reference numerals.

[0037] The air nozzle 60 is constituted by the tubular portion 12, the shaft core portion 20, and the connecting portion 22. The tubular portion 12, the shaft core portion 20, and the connecting portion 22 are all made of resin and are integrally molded by a 3D printer or injection molding. The connecting portion 22 is constituted by a plurality of blade portions 62 extending radially from the outer periphery of the shaft core portion 20 to the inner periphery of the tubular portion 12. In this embodiment, a total of three blade portions 62 are arranged at equal angular intervals around the axis X of the air nozzle 60. However, the number of the blade portions 62 is arbitrary.

[0038] The shaft core portion 20 has a uniform outer diameter and is connected to the tubular portion 12 via a plurality of blade portions 62. An annular air ejection port 26 is constituted by a gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20. The shaft core portion 20 projects outward from the right end (distal end) of the tubular portion 12.

[0039] The air flow path 64 at the connecting portion 22 is defined by the inner surface of the tubular portion 12, the side surfaces of the blade portions 62, and the outer surface of the shaft core portion 20 (see FIG. 13). As in the case of the first embodiment, the area of the air flow path at the connecting portion 22 is three times or more larger than the area of the air ejection port 26. A preferable numerical range for the axial length of the shaft core portion 20 is the same as that in the first embodiment.

[0040] According to the air nozzle 60 of the present embodiment, the annular air ejection port 26 is formed by the gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20, and the shaft core portion 20 protrudes from the distal end of the tubular portion 12. Therefore, it is possible to reduce noise while a necessary impingement pressure is acquired. Further, since the connecting portion 22 is constituted by the blade portions 62 extending radially from the outer periphery of the shaft core portion 20 to the inner periphery of the tubular portion 12, a flow path having a large area can be easily acquired at the connecting portion 22.

(Fifth Embodiment)

[0041] Next, an air nozzle 70 according to a fifth embodiment of the present invention will be described with reference to FIGS. 14 to 16. With respect to the air nozzle 70 according to the fifth embodiment, components identical or equivalent to those of the air nozzle 10 already described are denoted by the same reference numerals.

[0042] The air nozzle 70 is constituted by the tubular portion 12, the shaft core portion 20, the connecting portion 22, and a protective portion 74. The tubular portion 12, the shaft core portion 20, the connecting portion 22, and the protective portion 74 are all made of resin and are integrally molded by injection molding. The connecting portion 22 is constituted by a plurality of blade portions 72 extending radially from the outer periphery of the shaft core portion 20 to the inner periphery of the tubular portion 12. The width of the blade portion 72 (the length along the axis X of the air nozzle 70) is not constant but becomes smaller in the vicinity of the shaft core portion 20.

[0043] The shaft core portion 20 is connected to the tubular portion 12 via a plurality of blade portions 72. An annular air ejection port 26 is constituted by a gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20. The shaft core portion 20 projects outward from the right end (distal end) of the tubular portion 12. In this embodiment, the two blade portions 72 extend in opposite directions from the shaft core portion 20 (see FIG. 16). However, the number of the blade portions 72 is arbitrary.

[0044] The protective portion 74 is constituted by a flange portion 76 and a plurality of projecting pieces 78. The annular flange portion 76 extends outward from the outer periphery of the tubular portion 12. The projecting pieces 78 project rightward from the end surface of the flange portion 76. The projecting pieces 78 are disposed around the shaft core portion 20 projecting from the tubular portion 12 and separated from the shaft core portion 20 by a predetermined distance. The projecting pieces 78 extend slightly to the right from the distal end of the shaft core portion 20 (see FIG. 15). The plurality of projecting pieces 78 are arranged at equal angular intervals around the axis X of the air nozzle 70.

[0045] The gaps between the adjacent projecting pieces 78 are of such a size that a human finger cannot enter the gaps. Since the plurality of projecting pieces 78 are arranged around the shaft core portion 20, the shaft core portion 20 is prevented from coming into contact with one or more external entities, and there is no concern that the shaft core portion 20 is damaged. Further, when the operator uses the apparatus to which the air nozzle 70 is applied, there is no possibility that the operator comes into contact with the shaft core portion 20, and the safety of the operator improves. In this embodiment, a total of four projecting pieces 78 are arranged, but the number of projecting pieces 78 may be three or more.

[0046] An air flow path 80 at the connecting portion 22 is defined by the inner surface of the tubular portion 12, the side surfaces of the blade portions 72, and the outer surface of the shaft core portion 20 (see FIG. 16). As in the case of the first embodiment, the area of the air flow path at the connecting portion 22 is three times or more larger than the area of the air ejection port 26. A preferable numerical range for the axial length of the shaft core portion 20 is the same as that in the first embodiment.

[0047] According to the air nozzle 70 of the present embodiment, the annular air ejection port 26 is formed by the gap existing between the wall surface of the small-diameter hole 16 of the tubular portion 12 and the outer surface of the shaft core portion 20, and the shaft core portion 20 protrudes from the distal end of the tubular portion 12. Therefore, it is possible to reduce noise while a necessary impingement pressure is acquired. Further, since the connecting portion 22 is constituted by the blade portions 72 extending radially from the outer periphery of the shaft core portion 20 to the inner periphery of the tubular portion 12, a flow path having a large area can be easily acquired at the connecting portion 22. Further, since the plurality of projecting pieces 78 are disposed around the shaft core portion 20, the protection of the shaft core portion 20 and the safety of the operator can be achieved.

Claims

1. An air nozzle (10, 40, 50, 60, 70) in which a shaft core portion (20) is connected to a tubular portion (12) via a connecting portion (22), wherein
the shaft core portion is inserted into a small-diameter hole (16) provided at a distal end of the tubular portion, the shaft core portion protrudes from the distal end of the tubular portion, and an annular air ejection port (26) is formed by a gap existing between a wall surface of the small-diameter hole and an outer surface of the shaft core portion.

2. The air nozzle according to claim 1, wherein
the connecting portion is disk-shaped and includes a plurality of through holes (24) serving as air flow paths.

3. The air nozzle according to claim 1, wherein
the connecting portion includes a blade portion (62, 72) extending radially from an outer periphery of the shaft core portion to an inner periphery of the tubular

portion, and an air flow path at the connecting portion is defined by an inner surface of the tubular portion, a side surface of the blade portion, and the outer surface of the shaft core portion.

4. The air nozzle according to claim 1, wherein a length of a protruding portion of the shaft core portion that protrudes from the distal end of the tubular portion is 3 mm to 15 mm.

5. The air nozzle according to claim 1, wherein the connecting portion made of metal is integrally formed with the shaft core portion made of metal and is connected and fixed to the tubular portion made of metal.

6. The air nozzle according to claim 1, wherein the tubular portion includes a first tubular portion (12a) made of resin and a second tubular portion (12b) made of metal, and the shaft core portion and the connecting portion are integrally formed with the first tubular portion by resin molding.

7. The air nozzle according to claim 1, wherein the tubular portion, the shaft core portion, and the connecting portion are integrally formed by resin molding.

8. The air nozzle according to claim 1, wherein a protective portion (74) that prevents the shaft core portion from coming into contact with an external entity.

9. The air nozzle according to claim 8, wherein the protective portion includes a flange portion (76) and a plurality of projecting pieces (78), the flange portion expands outward from an outer periphery of the tubular portion, the projecting pieces project from the flange portion, and the projecting pieces are arranged around the shaft core portion projecting from the tubular portion at a predetermined distance from the shaft core portion.

10. The air nozzle according to claim 1, wherein an area of an air flow path at the connecting portion is at least three times as large as an area of the air ejection port.

FIG. 1

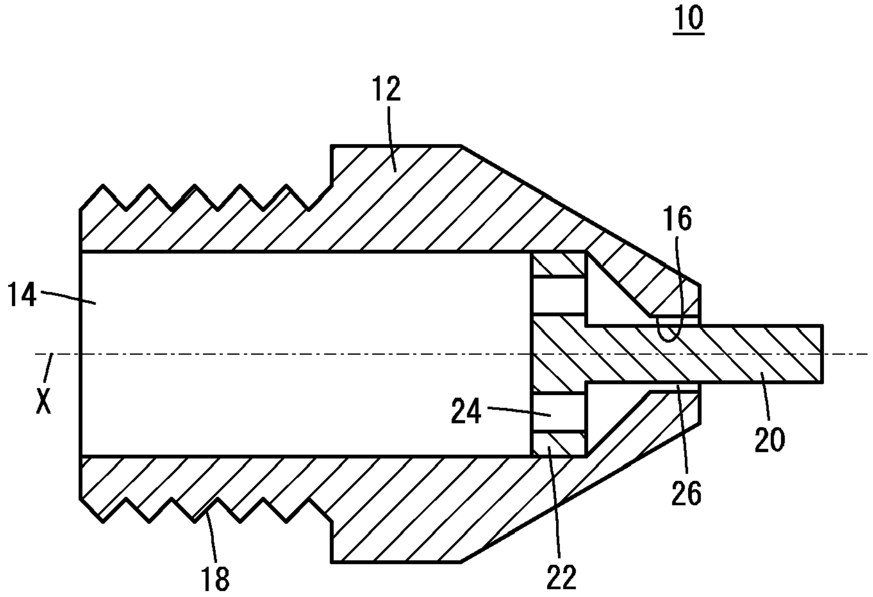


FIG. 2

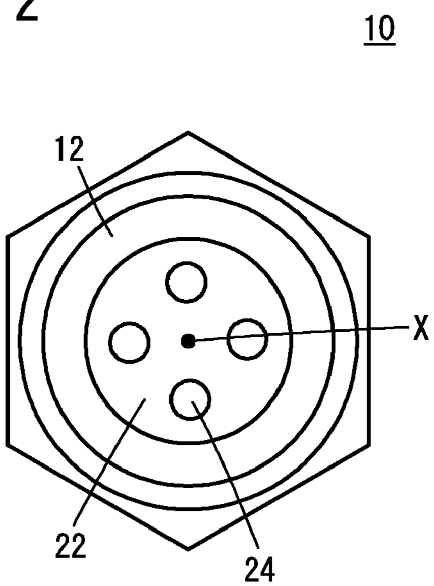


FIG. 3

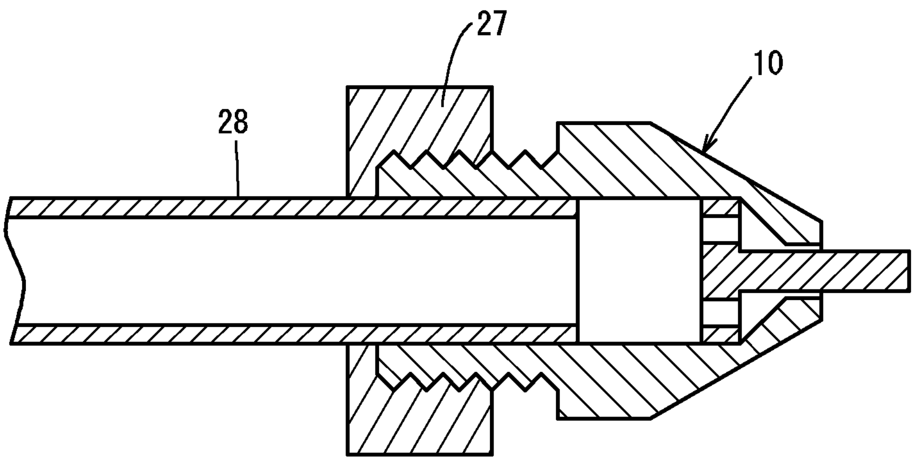


FIG. 4A

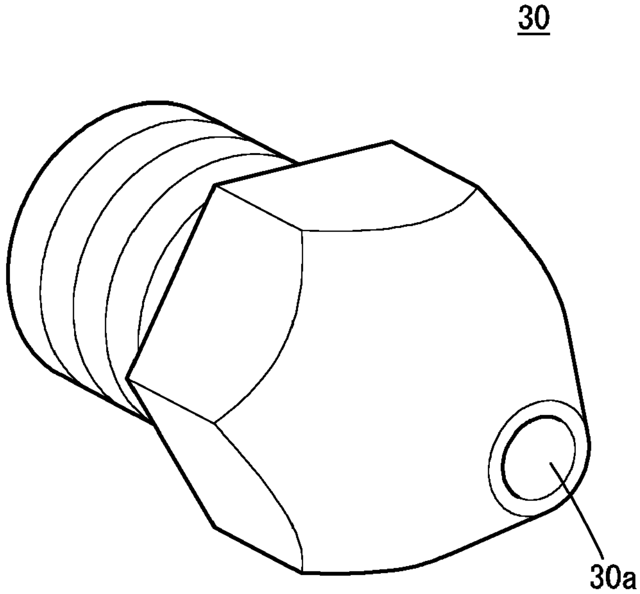


FIG. 4B

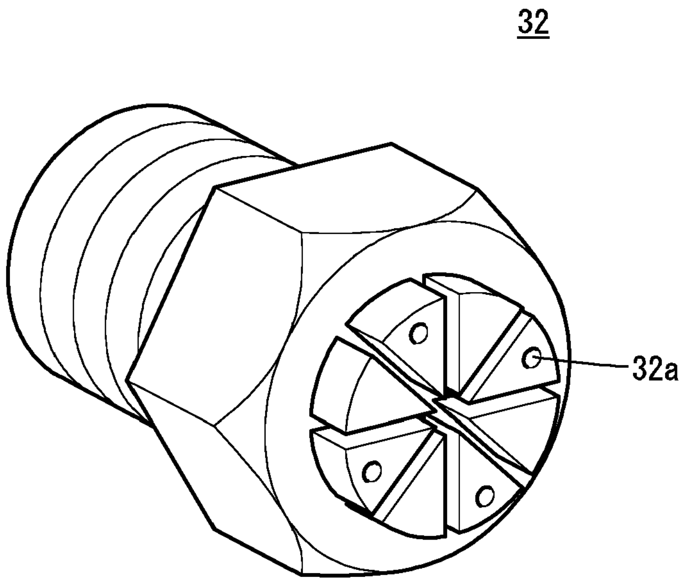


FIG. 5

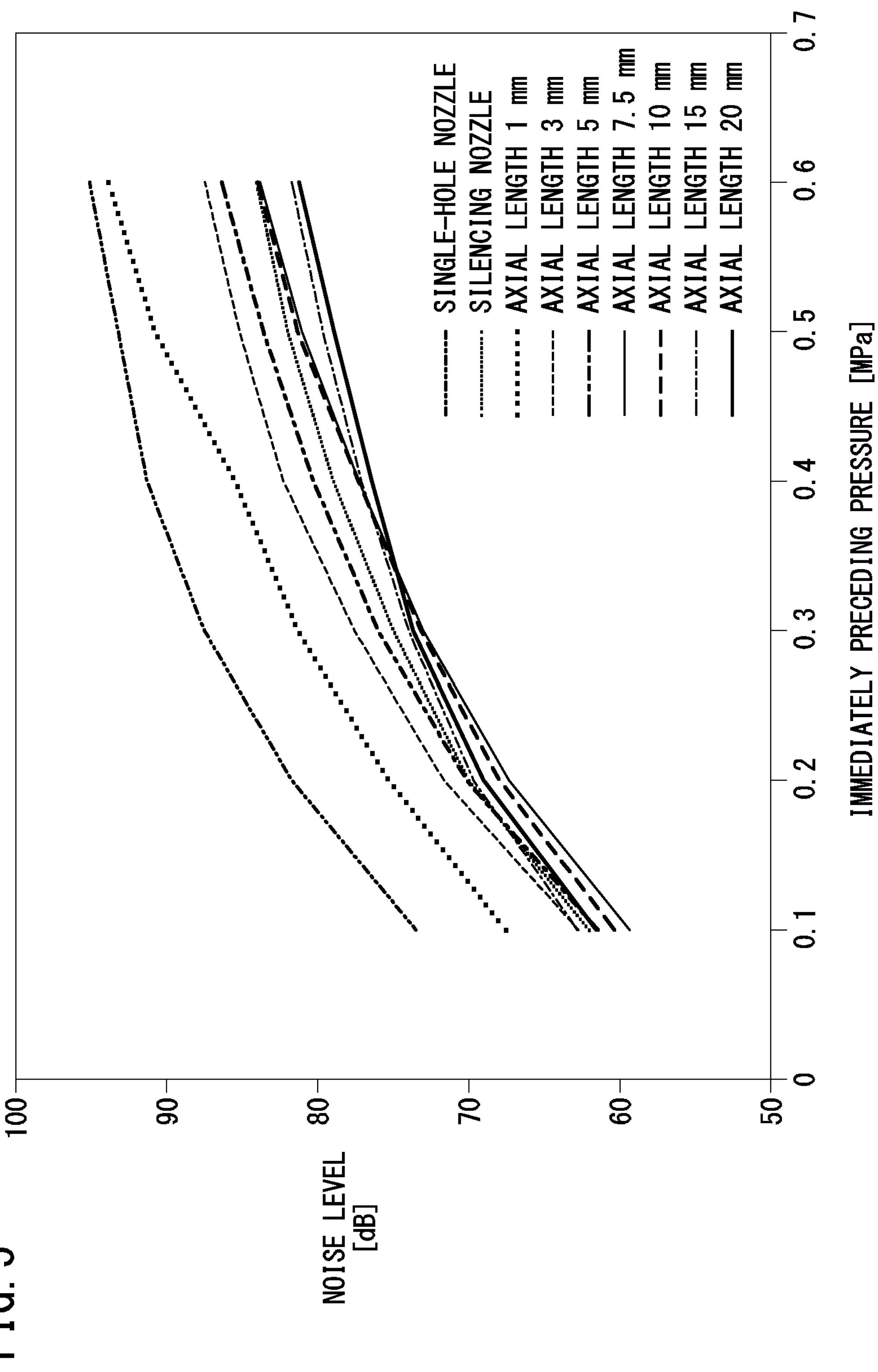

NOISE LEVEL
[dB]
100
90
80
70
60
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
IMMEDIATELY PRECEDING PRESSURE [MPa]
SINGLE-HOLE NOZZLE
SILENCING NOZZLE
AXIAL LENGTH 1 mm
AXIAL LENGTH 3 mm
AXIAL LENGTH 5 mm
AXIAL LENGTH 7.5 mm
AXIAL LENGTH 10 mm
AXIAL LENGTH 15 mm
AXIAL LENGTH 20 mm

FIG. 6

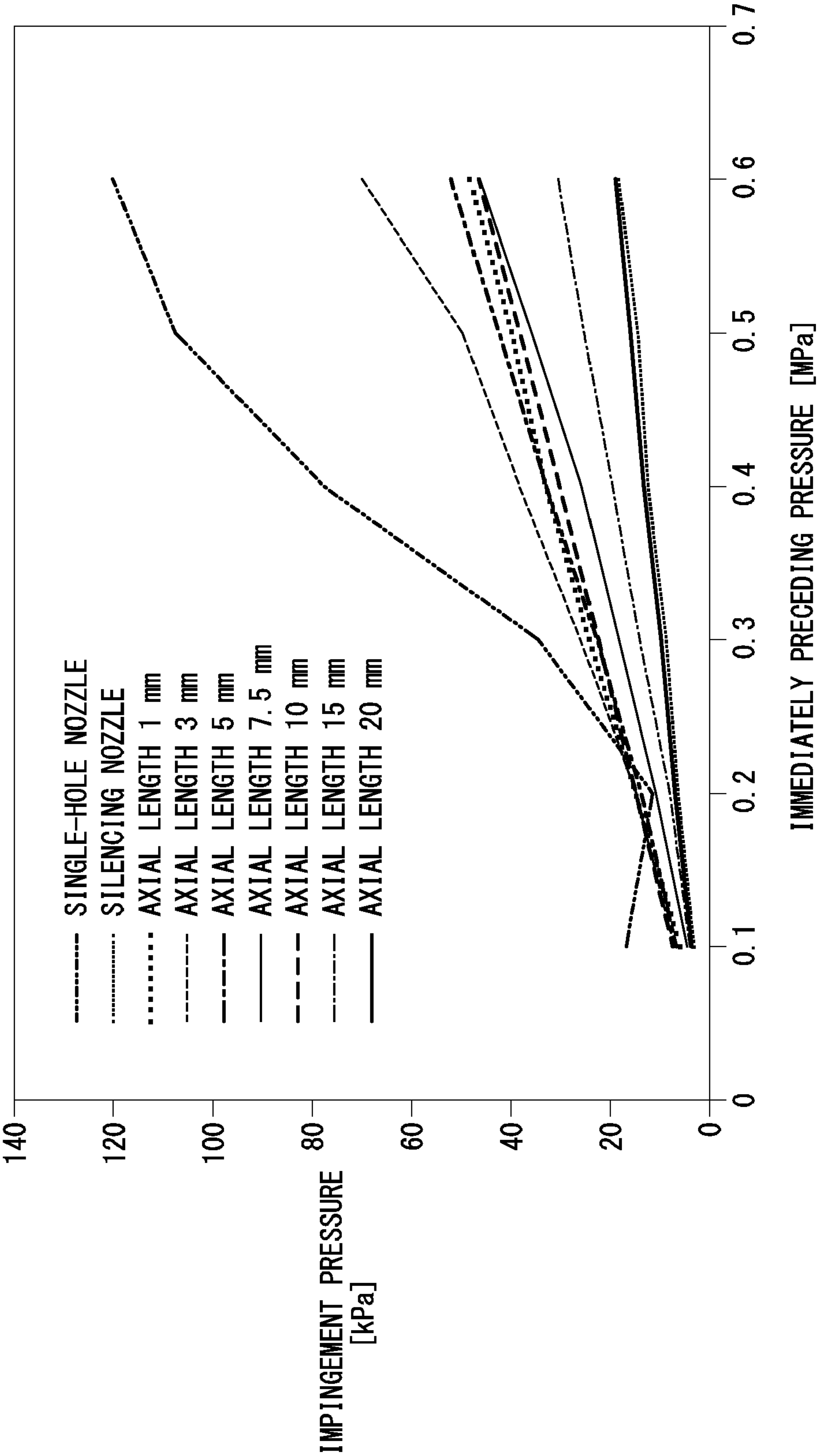

IMPINGEMENT PRESSURE [kPa]
0
20
40
60
80
100
120
140
IMMEDIATELY PRECEDING PRESSURE [MPa]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
SINGLE-HOLE NOZZLE
SILENCING NOZZLE
AXIAL LENGTH 1 mm
AXIAL LENGTH 3 mm
AXIAL LENGTH 5 mm
AXIAL LENGTH 7.5 mm
AXIAL LENGTH 10 mm
AXIAL LENGTH 15 mm
AXIAL LENGTH 20 mm

FIG. 7

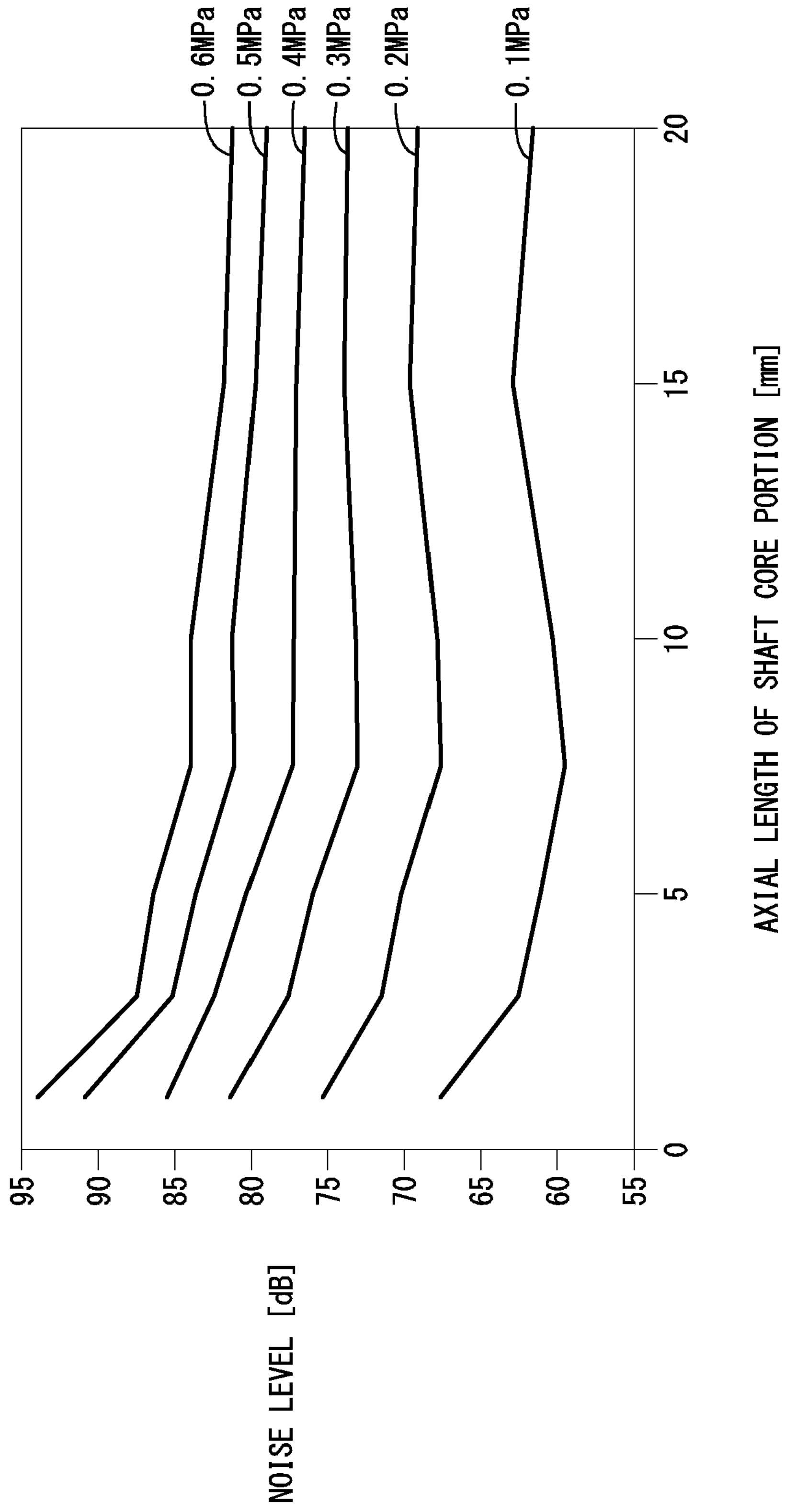

NOISE LEVEL [dB]
95
90
85
80
75
70
65
60
55
0
5
10
15
20
AXIAL LENGTH OF SHAFT CORE PORTION [mm]
0. 6MPa
0. 5MPa
0. 4MPa
0. 3MPa
0. 2MPa
0. 1MPa

FIG. 8

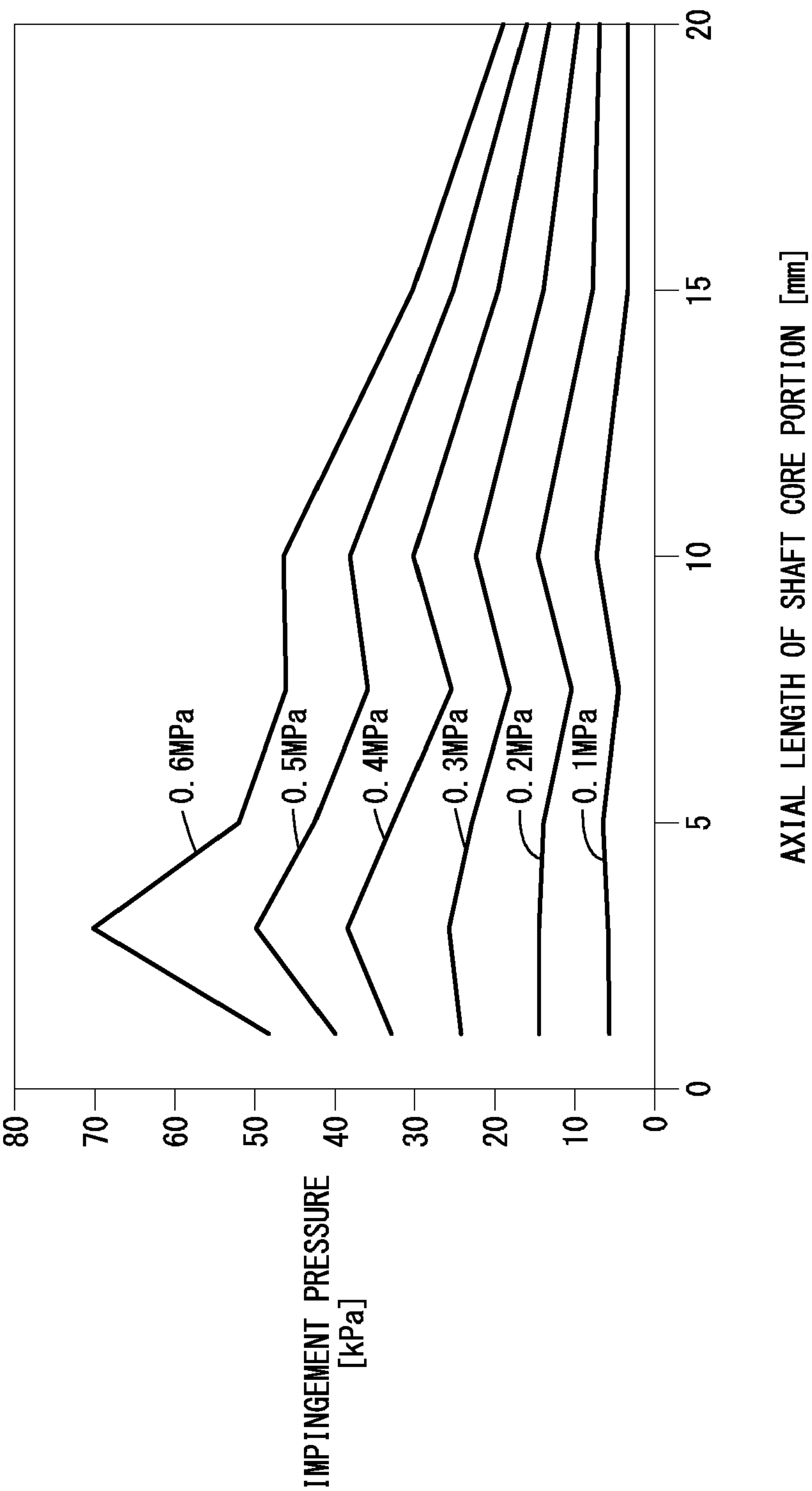

IMPINGEMENT PRESSURE
[kPa]
0
10
20
30
40
50
60
70
80
0
5
10
15
20
AXIAL LENGTH OF SHAFT CORE PORTION [mm]
0. 6MPa
0. 5MPa
0. 4MPa
0. 3MPa
0. 2MPa
0. 1MPa

FIG. 9

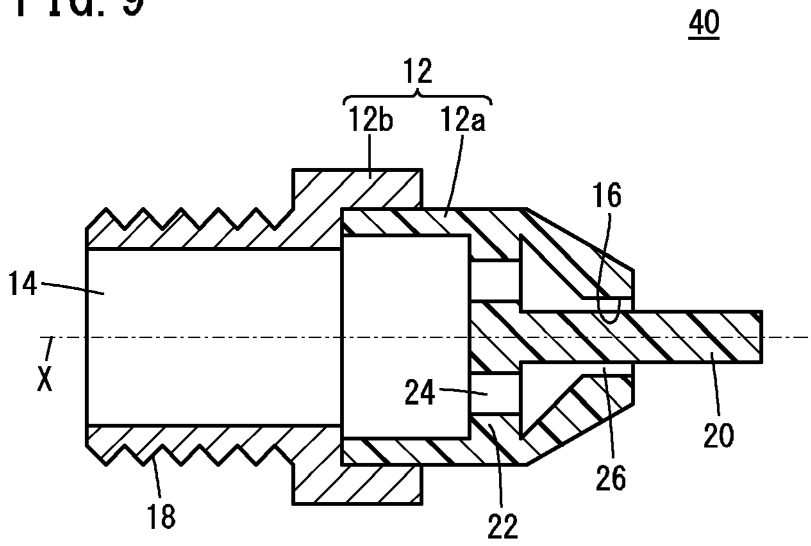


FIG. 10

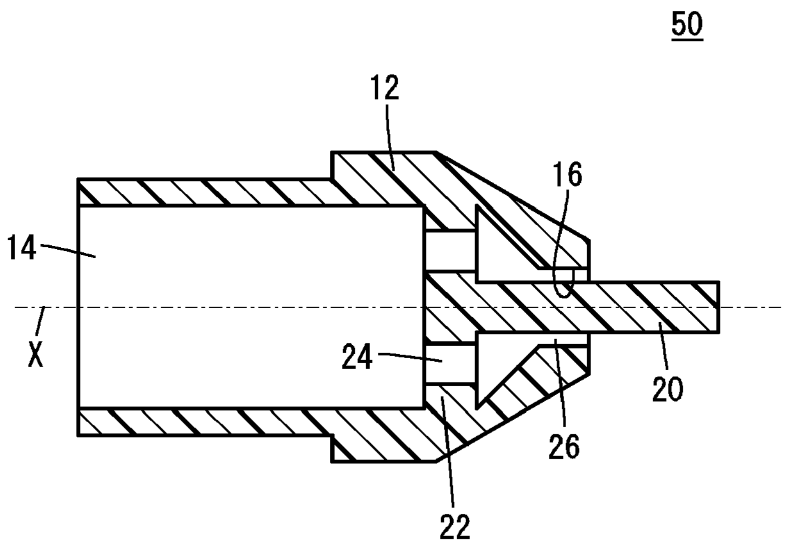


FIG. 11

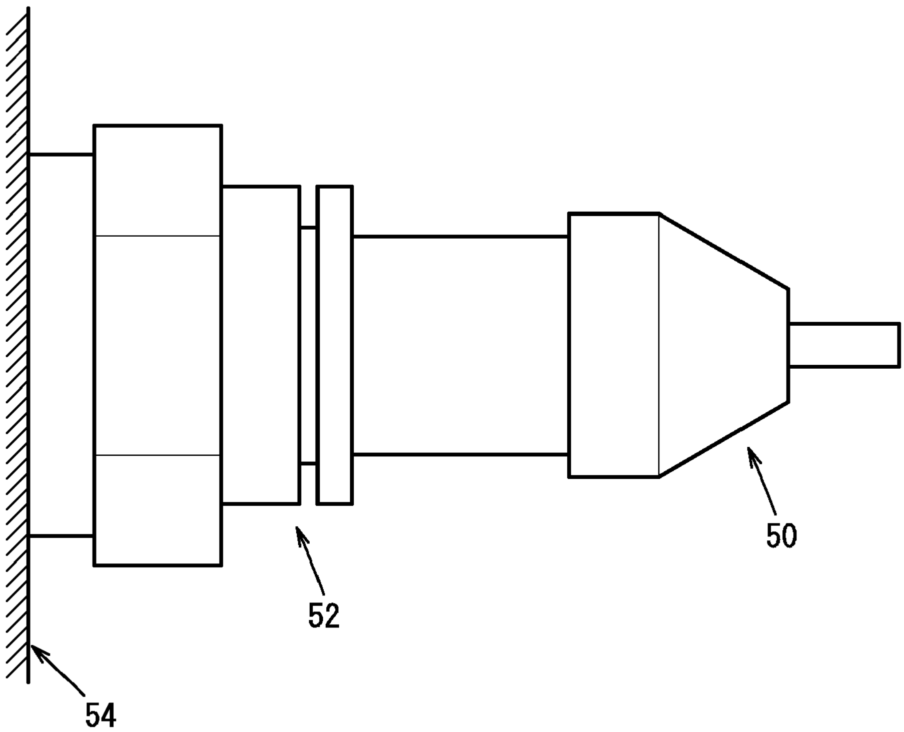


FIG. 12

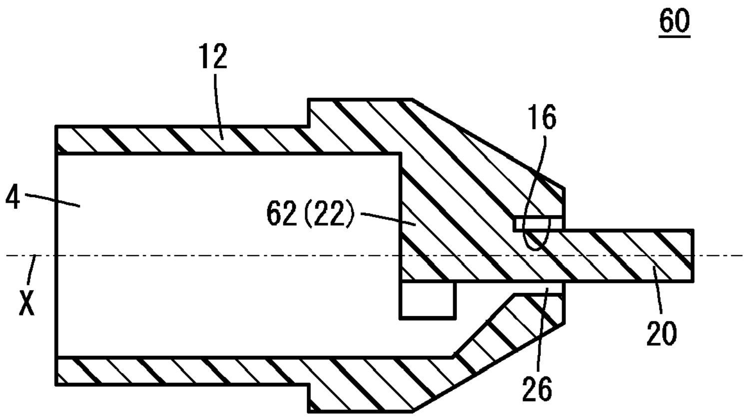


FIG. 13

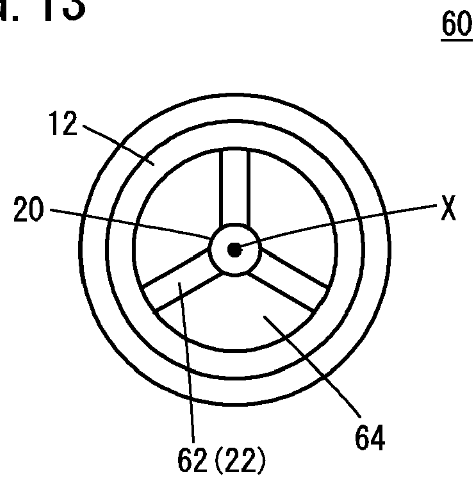


FIG. 14

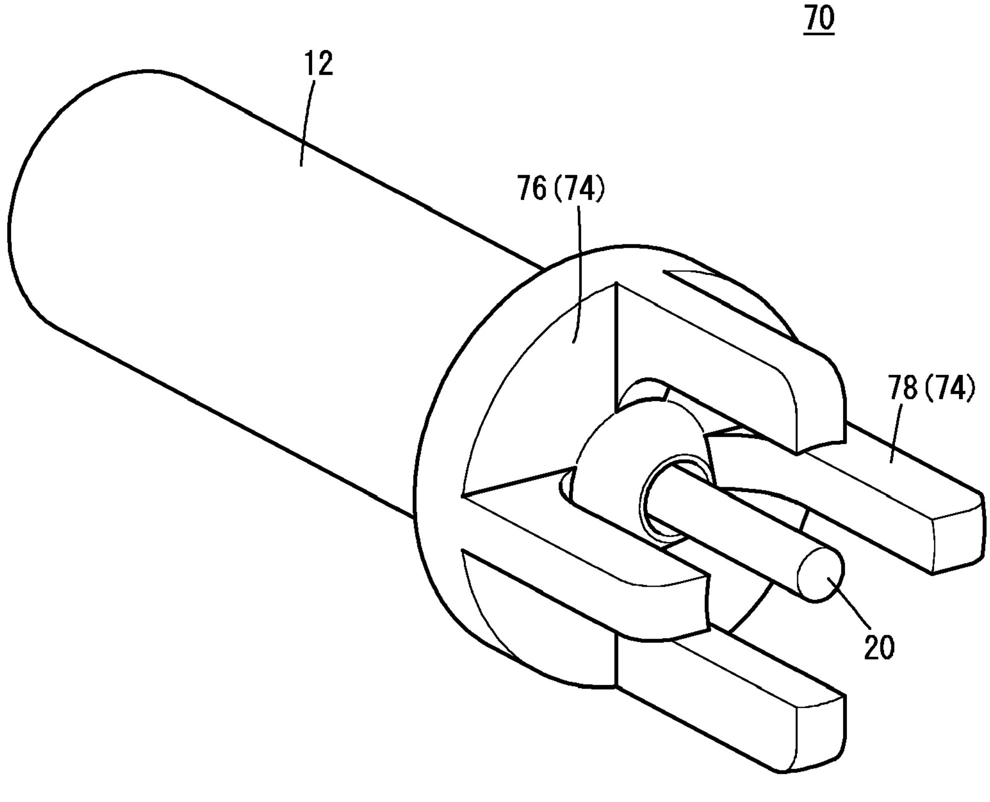


FIG. 15

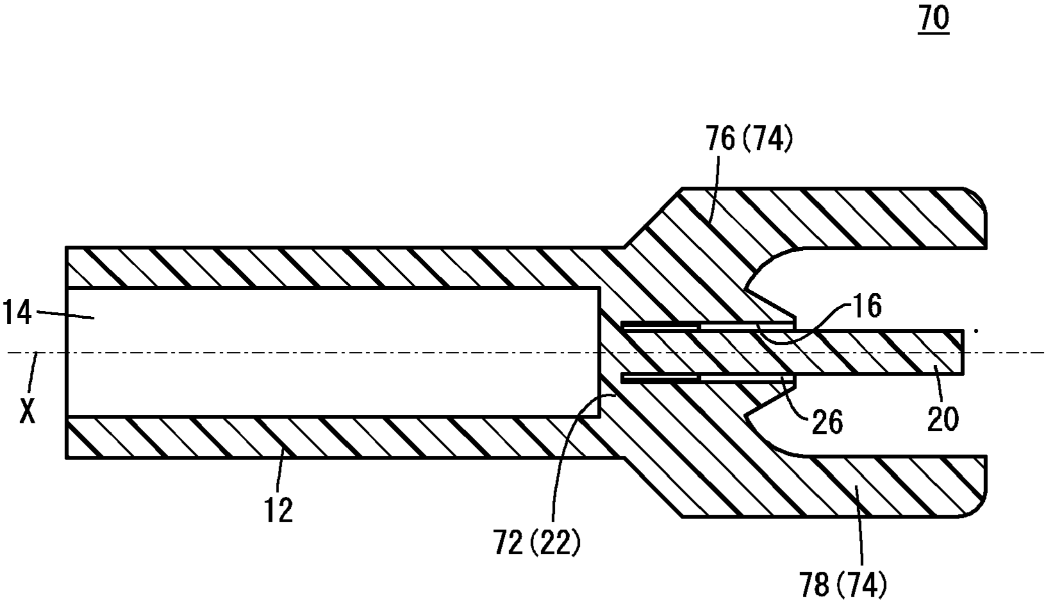


FIG. 16

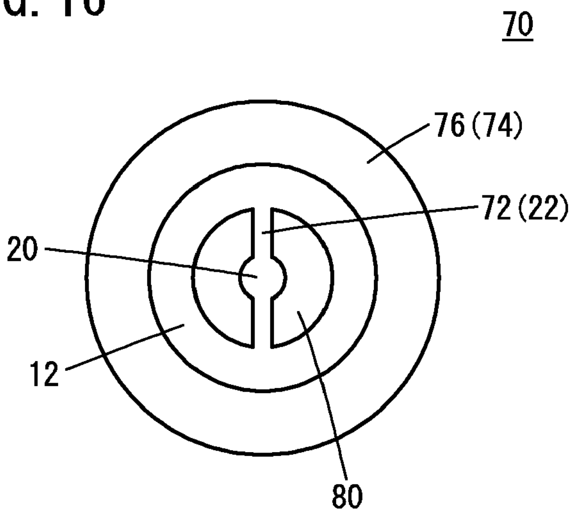
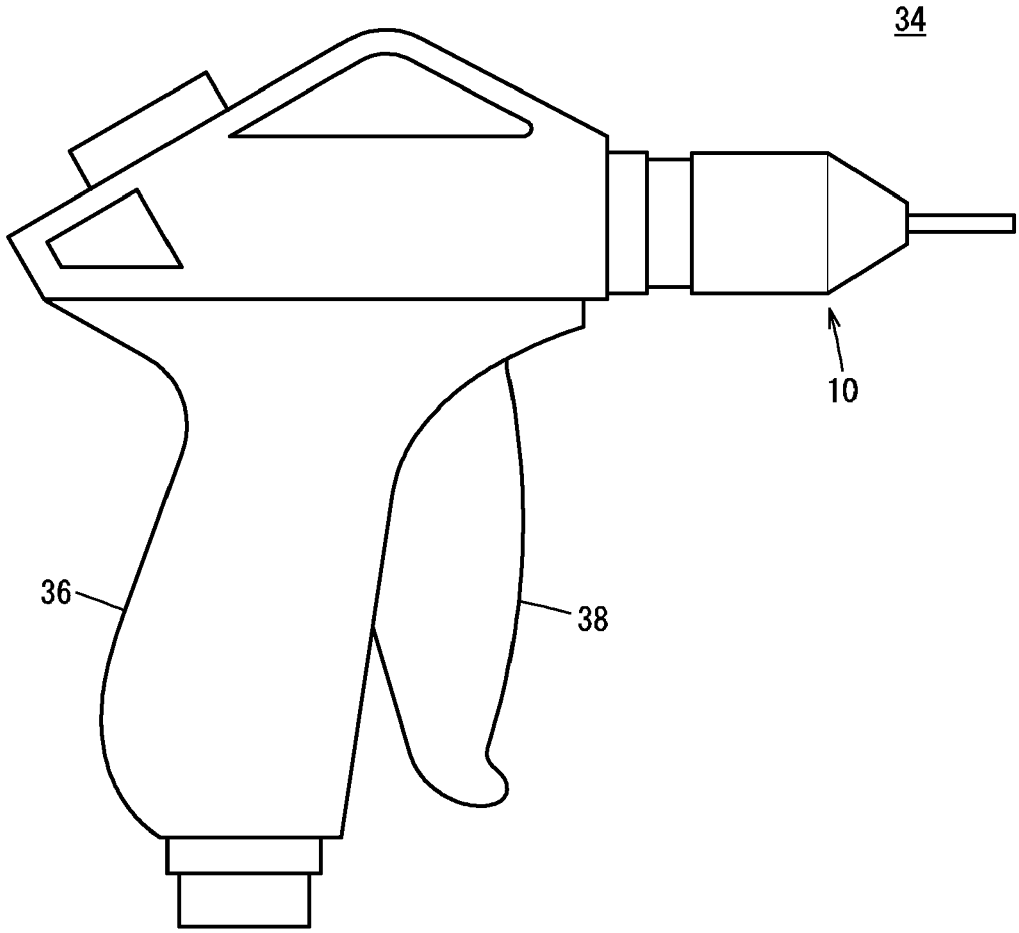


FIG. 17



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 15 5016

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 4 385 728 A (INGLIS LESLIE R ET AL) 31 May 1983 (1983-05-31) * column 2, line 58 - line 62; figures * -----	1,4-7,10 2,3,8,9	INV. B05B1/00
X A	CN 107 511 276 A (JINAN SHENJIAN CHEMICAL TECH CO LTD) 26 December 2017 (2017-12-26) * the whole document * -----	1,2,10 3-9	
A	CN 101 554 622 A (MUZHEN QIU [CN]) 14 October 2009 (2009-10-14) * the whole document * -----	1-10	
A	US 4 431 135 A (KAYE RICHARD G [US]) 14 February 1984 (1984-02-14) * the whole document * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			B05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	6 July 2023	Lindner, Volker

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 15 5016

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-07-2023

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4385728	A	31-05-1983	CA	1185296 A	09-04-1985
			US	4385728 A	31-05-1983
CN 107511276	A	26-12-2017	NONE		
CN 101554622	A	14-10-2009	NONE		
US 4431135	A	14-02-1984	NONE		

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 58024182 B **[0003] [0005]**