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

(11) EP 2 578 360 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.04.2013 Bulletin 2013/15

(51) Int Cl.:
B24B 55/02 *(2006.01)*

(21) Application number: **12185898.9**

(22) Date of filing: **25.09.2012**

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **06.10.2011 GB 201117243**

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(54) Grinding apparatus with a slot nozzle

(57) Apparatus for high speed grinding comprises a grinding wheel having a circumferential grinding surface, a machine for mounting and rotating the grinding wheel about the axis, a coolant supply system including a slot nozzle arranged to direct coolant fluid secantly to the grinding surface, the slot nozzle having an exit with an elongate axis and a short axis wherein the elongate axis is tilted relative to the axis of the grinding wheel.

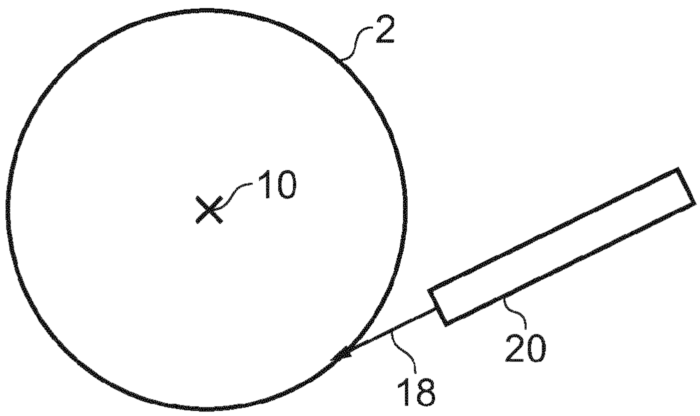

FIG. 3(a)

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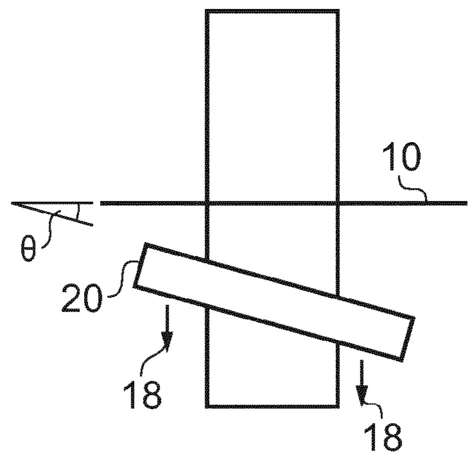

FIG. 3(b)

Description

[0001] The invention relates to a method and apparatus for grinding.

[0002] The present invention seeks to provide an improved method and apparatus for grinding. Grinding apparatus is described in US6123606.

[0003] According to a first aspect of the invention there is provided apparatus for high speed grinding comprises a grinding wheel on an axle having a circumferential grinding surface, a machine for mounting and rotating the grinding wheel about the axle, a coolant supply system including a slot nozzle arranged to direct coolant fluid secantly to the grinding surface, the slot nozzle having an elongate axis and a short axis wherein the elongate axis is parallel to a chord through the grinding wheel and tilted relative to the axis of the grinding wheel.

[0004] By tilting the exit of the slot nozzle an improved flow distribution to the grinding surface is achieved.

[0005] Preferably the elongate axis is tilted between 5 and 20 degrees to the axis of the grinding wheel.

[0006] The slot nozzle may have a length along the elongate axis that is longer than the width of the circumferential grinding surface.

[0007] The extended length provides a flow of coolant over the edges of the grinding surface to further improve cooling of the grinding wheel. Preferably the length of the elongate axis is more than 5% longer than the width of the circumferential grinding surface.

[0008] The machine for mounting and rotating the grinding wheel may be capable of rotating the wheel at peripheral speeds between 10 metres per second and about 80 metres per second.

[0009] The coolant supply system may deliver a jet of liquid from the nozzle at a pressure of between 40 and 70 Bar (4000kPa - 7000kPa).

[0010] Preferably the apparatus further comprises an alignment tool having a first edge for alignment with a side of the grinding wheel, a second edge for alignment with the grinding surface and a third edge for alignment with an edge of the nozzle.

[0011] The tool may be provided by a sheet of material.

[0012] The invention will now be described by way of example only and with reference to the accompanying drawings in which,

Figure 1 is a schematic diagram illustrating an embodiment of the invention;

Figure 2 depicts a nozzle for use in the system of Figure 1;

Figure 3 is a schematic depicting the nozzle of Figure 2 presented to a grinding wheel;

Figure 4 is a diagram of a nozzle, alignment tool and grinding wheel;

Figure 5 is a diagram of a nozzle, further alignment tool and grinding wheel;

Figure 6 depicts a supply pipe for supplying coolant fluid to the nozzle.

[0013] For the purposes of illustrating the principles of a grinding process incorporating the invention, Fig. 1 shows a grinding set-up which comprises a grinding wheel 2 rotating in the direction of arrow 4 while a workpiece 6 is fed past the wheel 2 in the relative direction of arrow 8. In the illustrated example this produces an operation known in the art as "down" grinding in a contact region generally indicated at 9. The invention is found to work just as well with "up" grinding. Essentially the process of the invention is a developed form of the process known as creep-feed grinding, although this may be regarded as something of a misnomer since the enhancement results is very much faster removal of workpiece material.

[0014] The grinding wheel 2 is mounted on a rotary spindle 10 carried by a tool head or chuck 12 which is part of a standard multi-axis machine. The workpiece 6 is held by means of a mounting fixture 14 on a surface mounting table 16. Since, in this embodiment, a "one-pass" grinding process is shown the width of the grinding wheel can be determined by the corresponding width of the ground surface required. We have found no significant variation of results using grinding wheels in a width range of 10 mm to 45 mm providing the surface speed is maintained constant. On the other hand we have found no indication of a width limit and the invention may be expected to be useful regardless of the width of the grinding wheel, other considerations aside.

[0015] The range of values of surface speed for the type of grinding wheel employed is from about 10 metres per second up to about 80 metres per second. Wheels of various diameters gave consistent results providing surface speed was matched with all other parameters. The maximum diameter of grinding wheel used to date is around 220mm, but this upper limit was imposed by physical clearance in the operative region of the machine, rather than by the inherent stability of the wheel construction. Obviously grinding wheels by the nature of their composition and construction possess limitations in terms of maximum rotational speed, depth of cut achievable to name but two, but in this example these did not curtail the operational parameters of the process. Thus, where the machine permits in respect of size, and speed higher figures may be expected to be achieved e.g. up to 400mm or more.

[0016] A jet 18 of liquid coolant, comprising a water soluble oil, is directed through nozzle means 20 at an aiming point 19 on the periphery of wheel 2. The nozzle 20 is the outlet of a closed-loop coolant delivery, collection and filtration system. Spent coolant ejected from the wheel is collected in a sump 22, in the lower part of the machine, and drawn-off through an efficient filtration system 24 to remove debris down to a particle size, typically of at least, about 10 micron.

[0017] Integral with the filtration system 24 is a very high pressure pump system 26 which delivers coolant under pressure through outlet 28 to the delivery nozzle 20. In the illustrated embodiment the coolant supply is delivered via the outlet 28 at a pressure of up to 100 bar (10000kPa), typically between 40 bar and 70 bar (4000 to 7000 kPa), at a flow rate of up to about 130 litres per minute.

[0018] The nozzle 20 is positioned close to the periphery of wheel 2 to deliver the very high pressure jet 18 of coolant at the wheel at a point approximately 45 degrees in advance of the cutting region on workpiece 6. The nozzle is a slot nozzle 20 constructed and arranged to direct a jet 18 of coolant fluid to the periphery of the wheel with the impact point across the full width of the wheel. In the embodiment the nozzle 20 has a jet orifice which is approximately rectangular having a length approximately equal to the width of the wheel 2, but preferably slightly longer, and which is 0.5 mm to 1 mm in depth. This orifice, therefore, directs a jet 18 of coolant in the shape of a sheet or fan at the periphery of the wheel.

[0019] Also, in Figure 1, a pair of radii 30,32 are shown (in chain-line) centred on the wheel spindle 10. A first radius 30 is drawn through the impingement region of the jet 18 on the periphery of the wheel 2, while the second radius 32 is drawn through the contact point between the wheel 2 and the workpiece 6. The included angle between these two radii 30,32 defines the circumferential position of the impact point of jet 18. It will be apparent from the illustration of the present embodiment, which used a wheel diameter of approximately 80 mm at the smaller end of the range, that this included angle is approximately 45 degrees and the jet 18 is in advance of the grinding wheel contact point. Other included angles may be appropriate.

[0020] A more detailed view of the nozzle is shown in Figure 2. As may be observed the nozzle body has an inlet portion 40, a tapering portion 42 and a flow forming portion 44 before the nozzle outlet 46 which offers a consistent laminar flow from the nozzle and helps to reduce the amount of air in the coolant flow and can reduce, where the substrate suffers, tarnishing and oxidation at the grinding point. Figure 2 depicts a perspective view (Fig. 2a) a top view (Fig. 2b) and a side view (Fig. 2c). In an alternative arrangement the inlet portion has a nut or other connecting feature for connecting the nozzle to pipework which supplies the cooling fluid to the nozzle.

[0021] The nozzle may be formed from stainless steel pipe manufactured on customised jaws and aperture former to produce the elongate nozzle shape.

[0022] Figure 3 depicts the preferred alignment of the nozzle 20 to the grinding wheel 2. The nozzle 20 directs the coolant fluid as a jet 18 secantly to the wheel such that it impacts the grinding surface from an angle that is leant relative to the true radius of the wheel. In the most extreme case the jet is directed tangentially to the wheel but normally angle of the nozzle is between 5 and 20 degrees from the tangent. The tem secantly includes the arrangement where the fluid is directed tangentially.

[0023] As shown in Figure 3b the nozzle is presented to grinding wheel to supply coolant to the grinding face which is the circumferential face. It has been found that the orientation of the nozzle relative to the circumferential face is important; not just the secant angle onto the circumferential face but also the angle e of the elongate axis of the nozzle to the axis of the grinding wheel. By arranging the elongate axis of the nozzle at an angle e between 5° and 15°, and preferably at around 10° to the axis of the grinding wheel an improved cooling distribution is achieved.

[0024] Where a particularly wide grinding face is used it may be necessary to use more than one elongate coolant nozzle which may be at different angles relative to each other and to the axis of the grinding wheel. The nozzles may overlap to provide extra coolant to particular regions of the grind face. One or more of the nozzles may be parallel to the axis of the grinding wheel.

[0025] The tip (exit orifice) of the nozzle 20a,20b in use is preferably positioned very close to the peripheral, circumferential surface of the grinding wheel 2. To aid simple alignment of the nozzle a tool may be used as show in Figure 4. The tool 102 has a first datum face 104 to align with a side of the grinding wheel, a second datum face 106 to align with the grinding face of the grinding wheel, a third datum face 107 to locate the axial position of the end of the nozzle relative to the grinding face to ensure overlap and a fourth datum face 108 to align the angle of the elongate nozzle to the axis of the grinding wheel. The tool may be formed from readily available sheet metal offering a simple and elegant solution to what could be a complex and costly set up process.

[0026] A further alignment tool an example of which is shown in Figure 5 may be used which locates the nozzle in its correct secantial or tangential position relative to the edge of the grinding wheel. The tool has an elongate member 110 which is long enough to span the distance between the nozzle 20 and the edge of the grinding wheel 2 and a notched portion 112 which engages with the nozzle. To align the nozzle the notched portion is placed into engagement with the nozzle and the elongate member then the axis of the wheel or the entry to pipework supplying fluid to the nozzle moved till the elongate member is at the desired secantal or tangential angle to the grinding wheel.

[0027] Figure 6 shows top view (Fig. 6a) and a side view (Fig. 6b) for an option of pipework which may be used to supply the cooling fluid to the nozzle. The pipework is made of three separate sections which are joined together, preferably by welding, to avoid significant bending of a full length pipe and fluctuations in bore size at the bending points and weakness in the material. The bends are all kept below 90 degrees so that fluctuations in flow are minimised.

Claims

1. Apparatus for high speed grinding comprises a grinding wheel (2) on an axle having a circumferential grinding surface,

a machine for mounting and rotating the grinding wheel about the axle (10),
a coolant supply system (26,28) including a slot nozzle (46) arranged to direct coolant fluid secantly to the grinding surface,
the slot nozzle having an exit with an elongate axis and a short axis wherein elongate axis is parallel to a chord through the grinding wheel and tilted relative to the axis of the grinding wheel.

2. Apparatus according to claim 1, wherein the elongate axis is tilted between 5 and 20 degrees to the axis of the grinding wheel.

3. Apparatus according to claim 1 or claim 2, wherein the slot nozzle has a length along the elongate axis that is longer than the width of the circumferential grinding surface.

4. Apparatus according to claim 3, wherein the length of the elongate axis is more than 5% longer than the width of the circumferential grinding surface.

5. Apparatus according to any preceding claim, wherein the machine for mounting and rotating the grinding wheel rotates the wheel at peripheral speeds between 10metres per second and about 80 metres per second.

6. Apparatus according to any preceding claim, wherein the coolant supply system delivers a jet of liquid from the nozzle at a pressure of between 40 and 70 Bar (4000 and 7000 kPa).

7. Apparatus according to any preceding claim further comprising an alignment tool having a first edge for alignment with a side of the grinding wheel, a second edge for alignment with the grinding surface and a third edge for alignment with an edge of the nozzle.

8. Apparatus according to claim 7, wherein the tool is provided by a sheet of material.

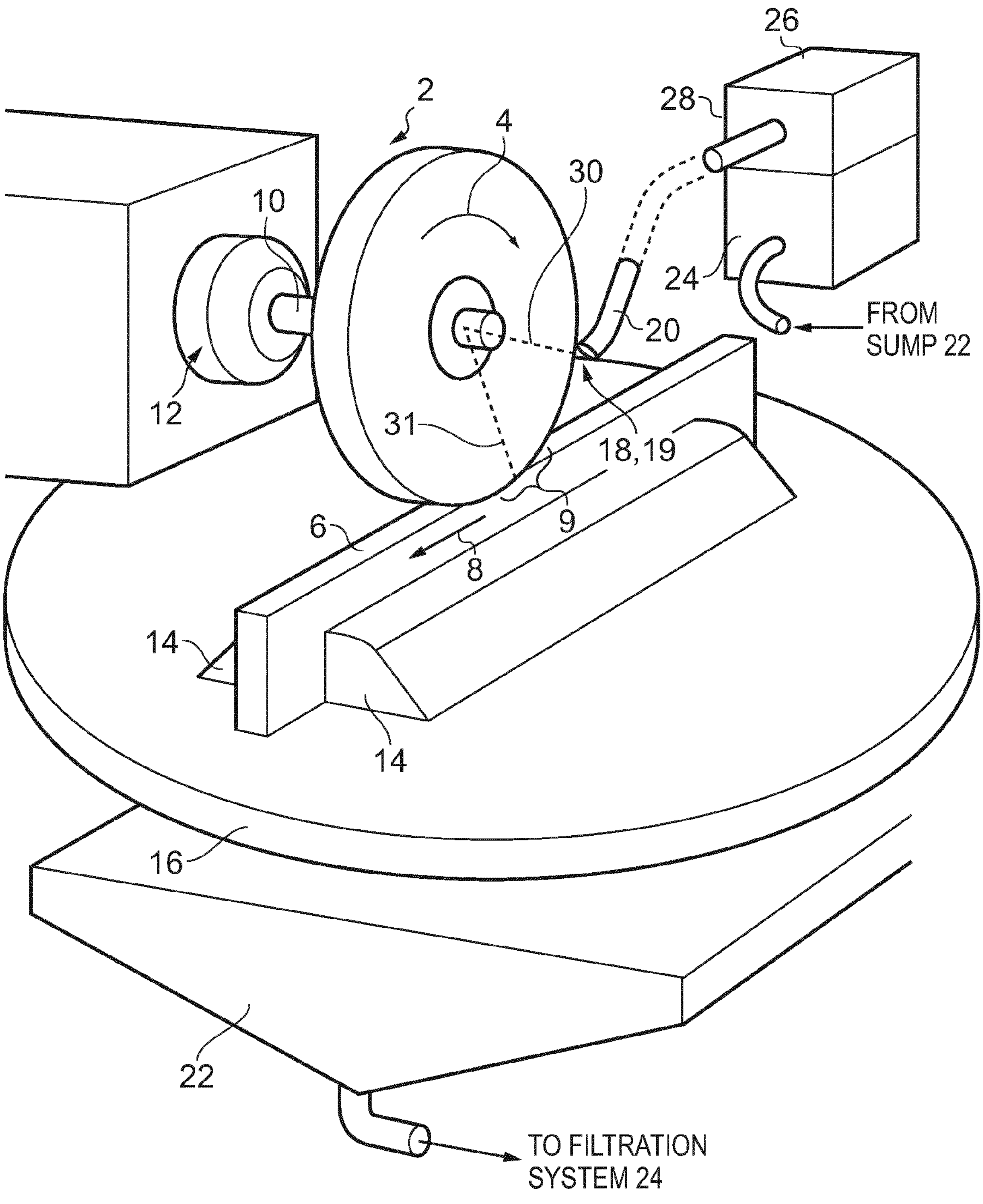
2
4
26
28
30
10
24
20
FROM
SUMP 22
12
31
18,19
9
6
8
14
14
16
22
TO FILTRATION
SYSTEM 24

FIG. 1

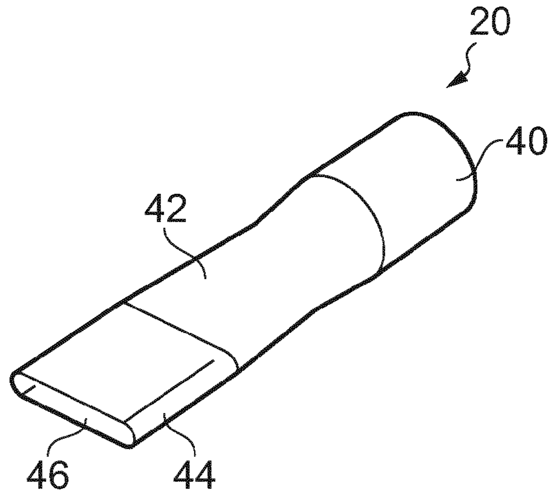

FIG. 2(a)

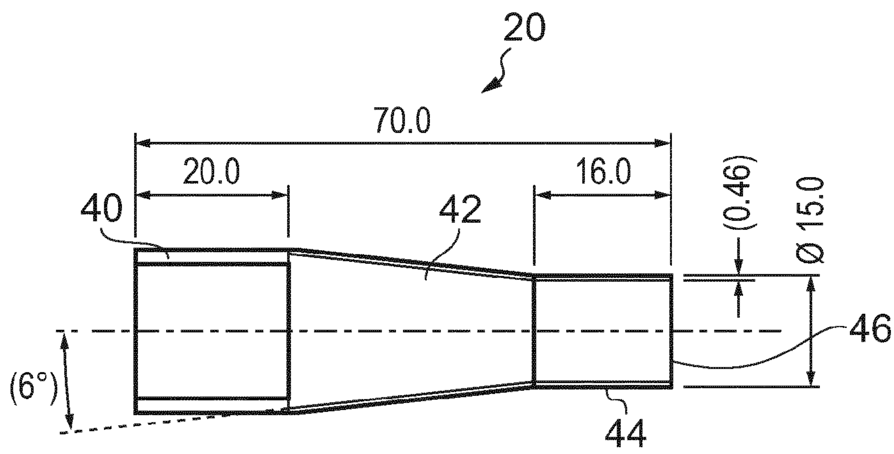

FIG. 2(b)

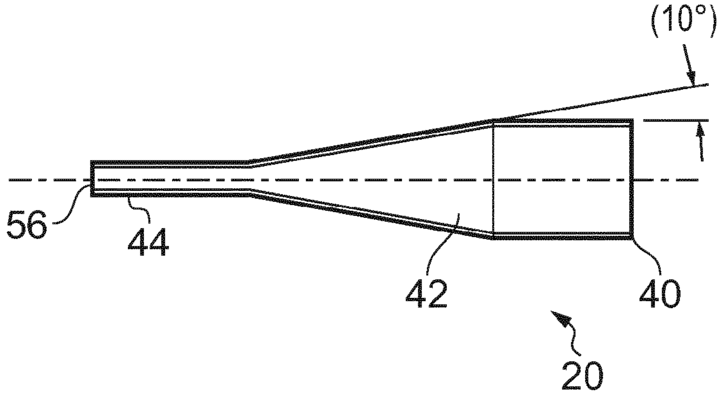

FIG. 2(c)

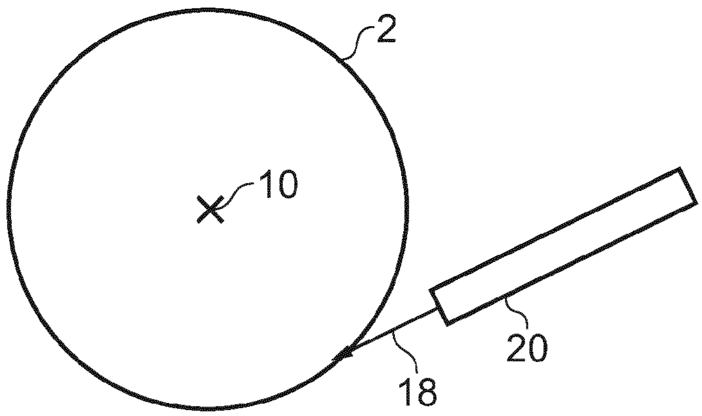

FIG. 3(a)

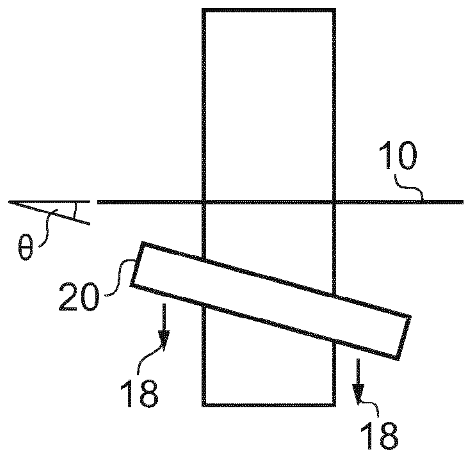

FIG. 3(b)

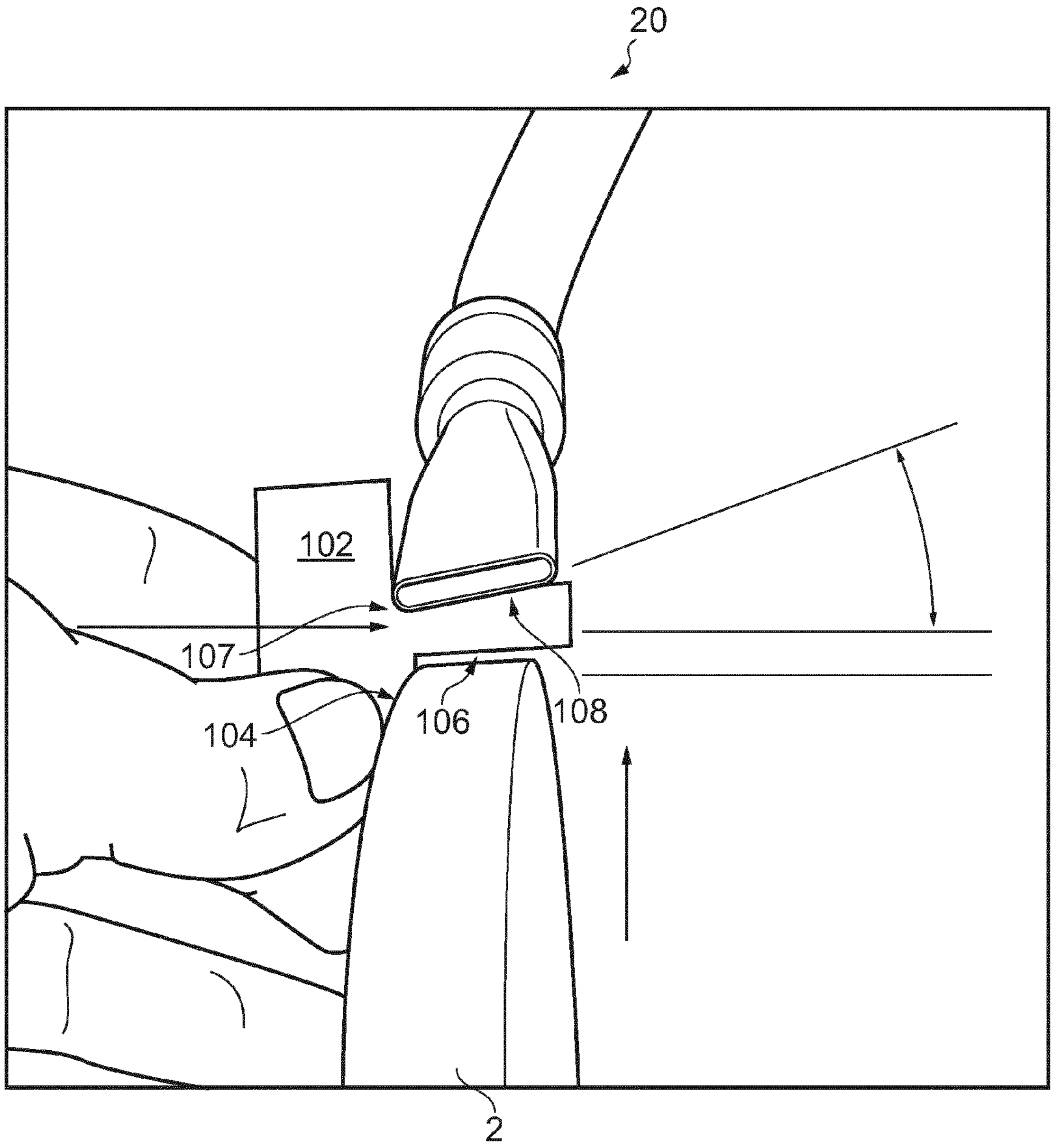

FIG. 4

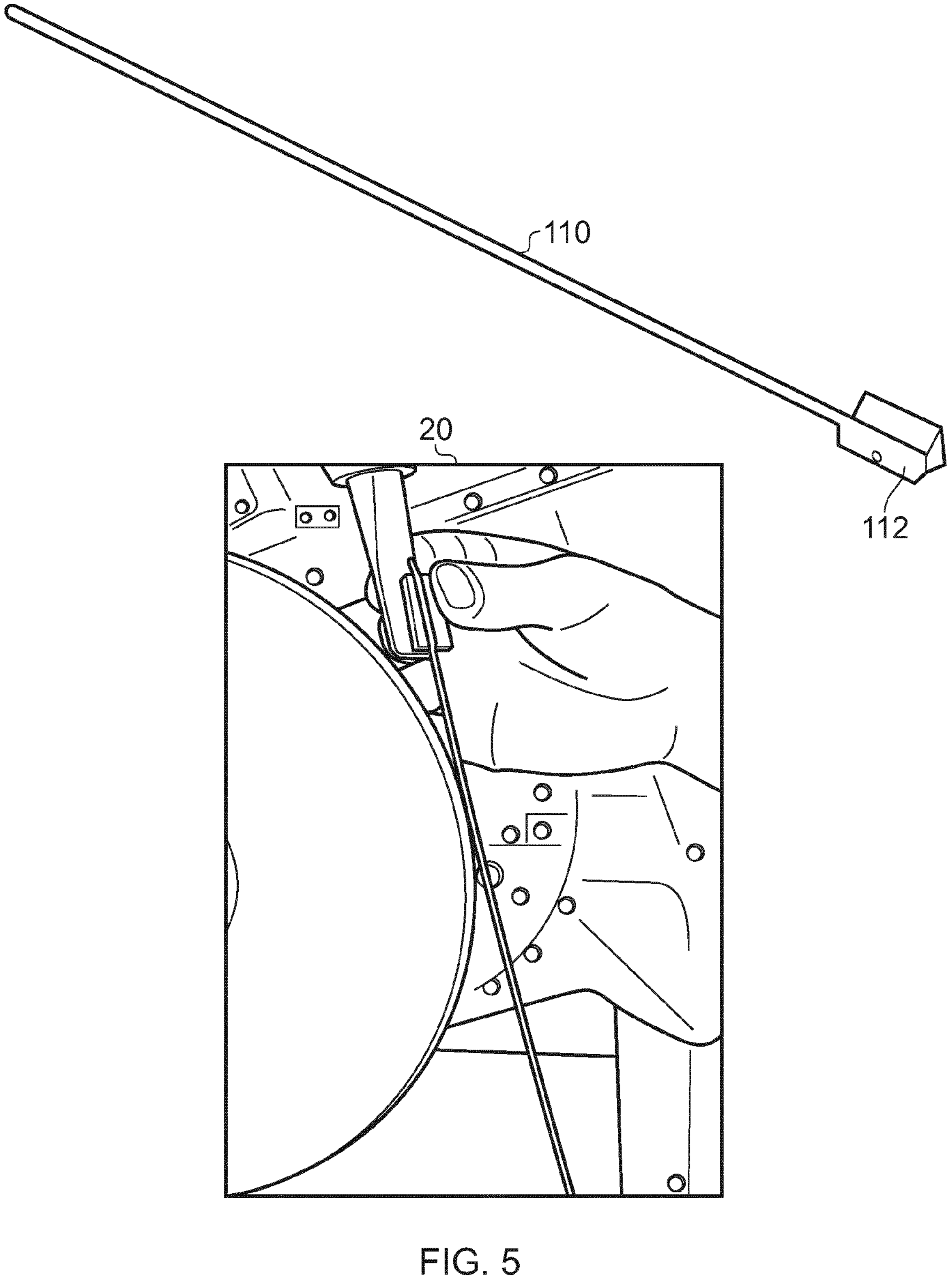

FIG. 5

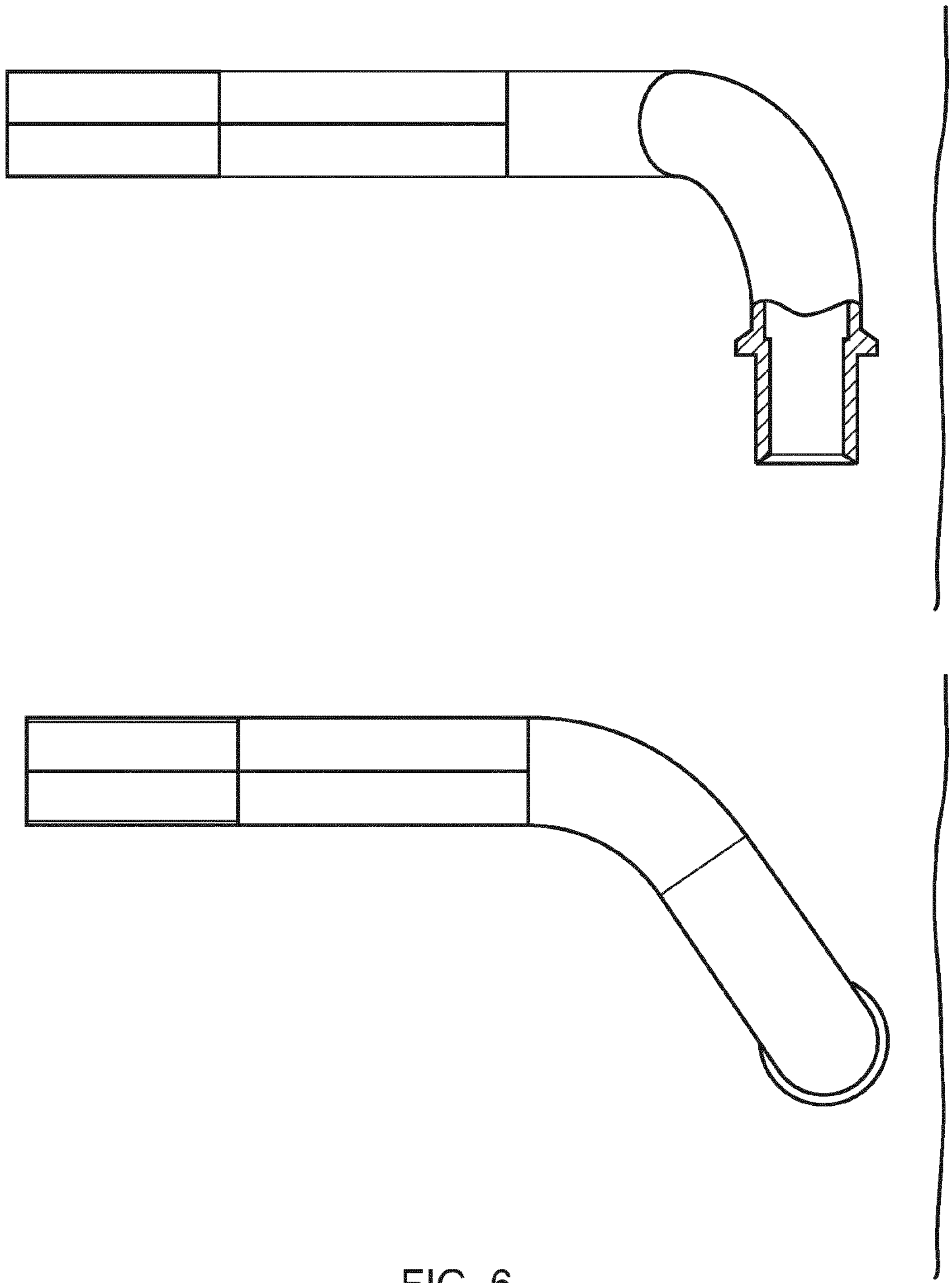

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6123606 A **[0002]**