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(54) PARTICLE COLLECTION SYSTEM AND METHOD

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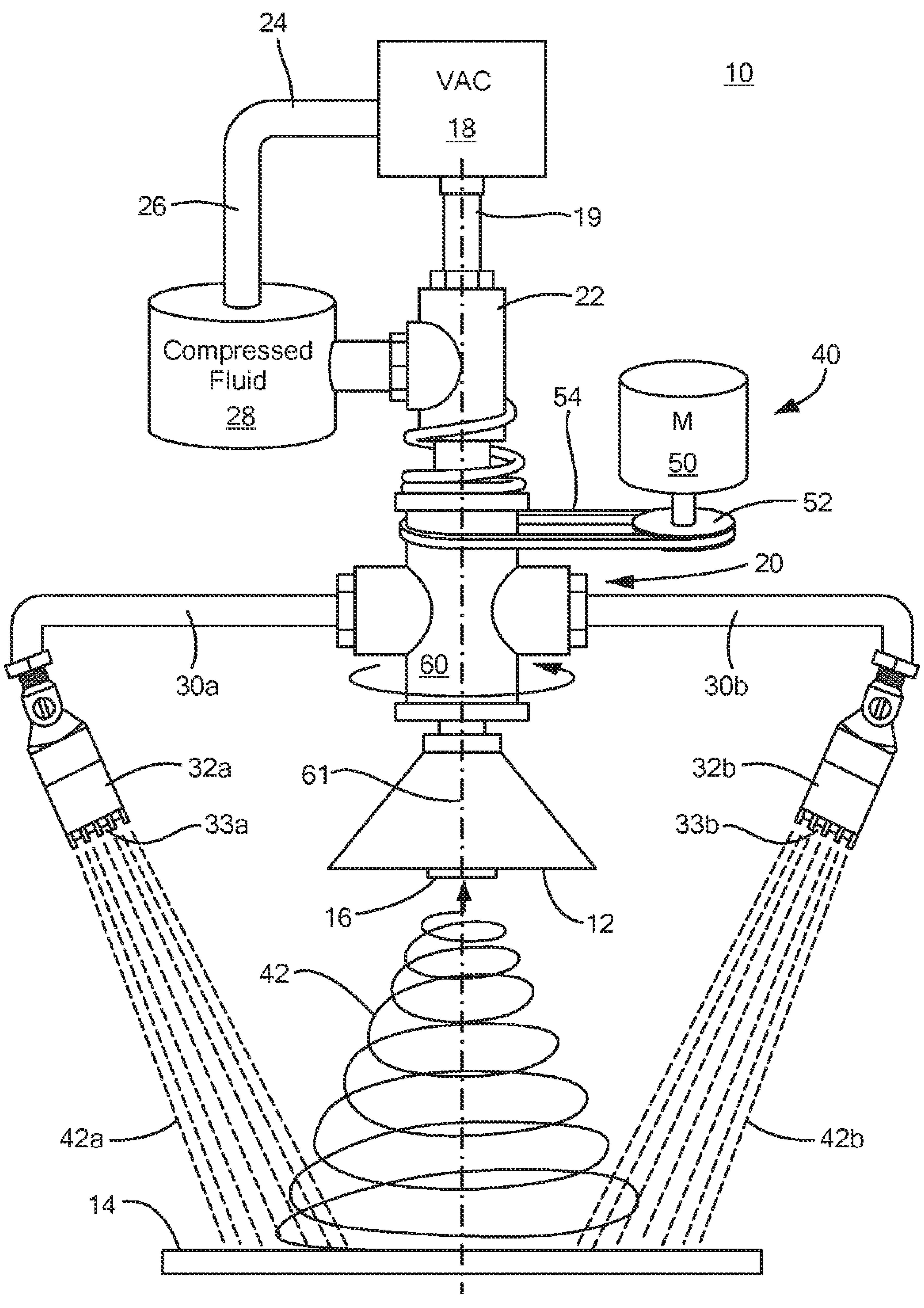
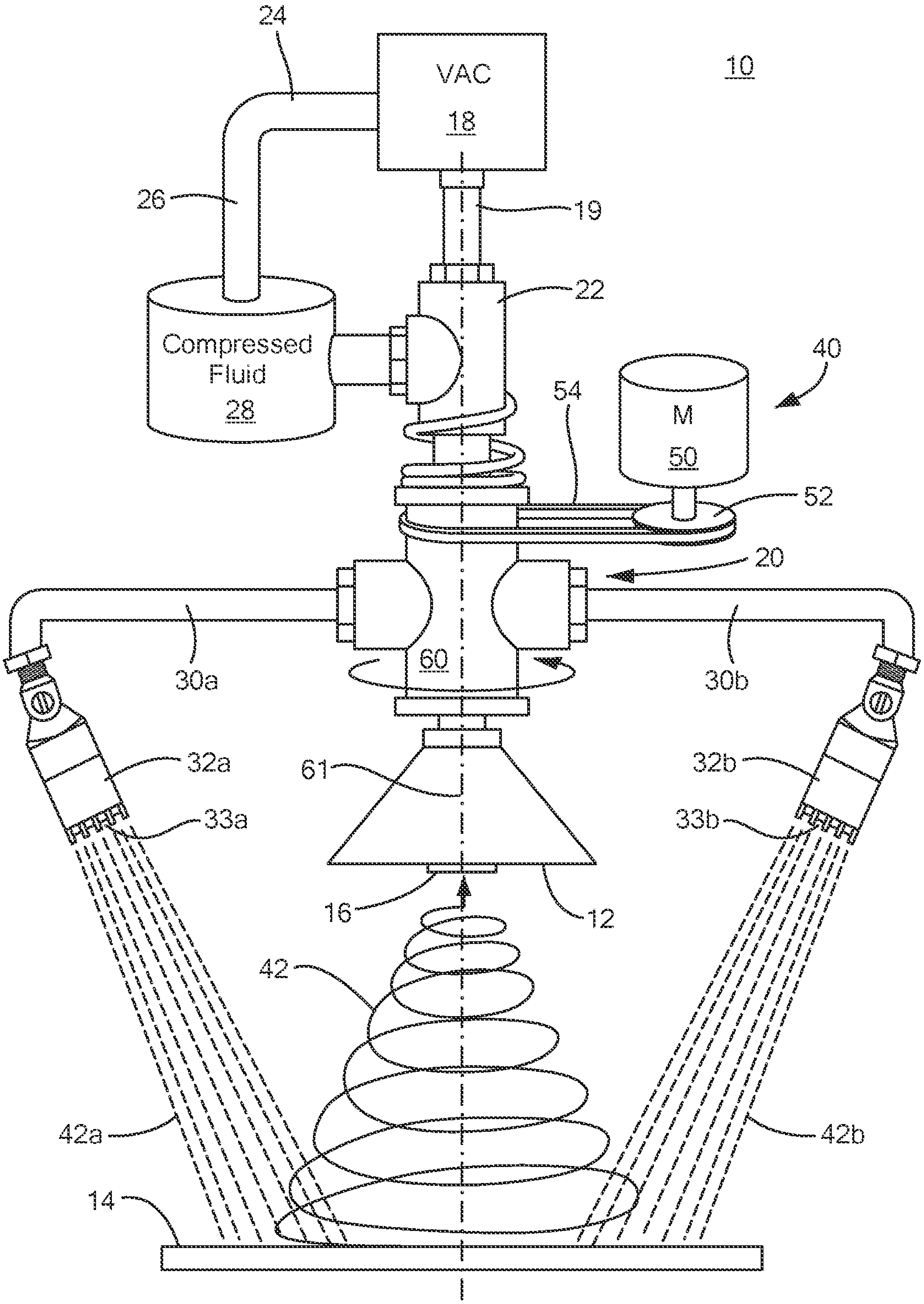
(57) **ABSTRACT**

A particle collection system and method including a collection inlet aimable at a surface from which particles are to be collected, and a rotatable fixture including at least a pair of nozzles about the collection inlet also aimable at the surface and fluidly connected to a source of compressed fluid in order to dislodge particles from the surface. The rotatable fixture is rotated to generate, as the nozzles rotate about the collection inlet, a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet.





24
VAC
18
10
26
19
22
Compressed
Fluid
28
40
54
M
50
52
20
60
30a
30b
32a
32b
61
33a
33b
16
12
42
42a
42b
14

FIG. 1

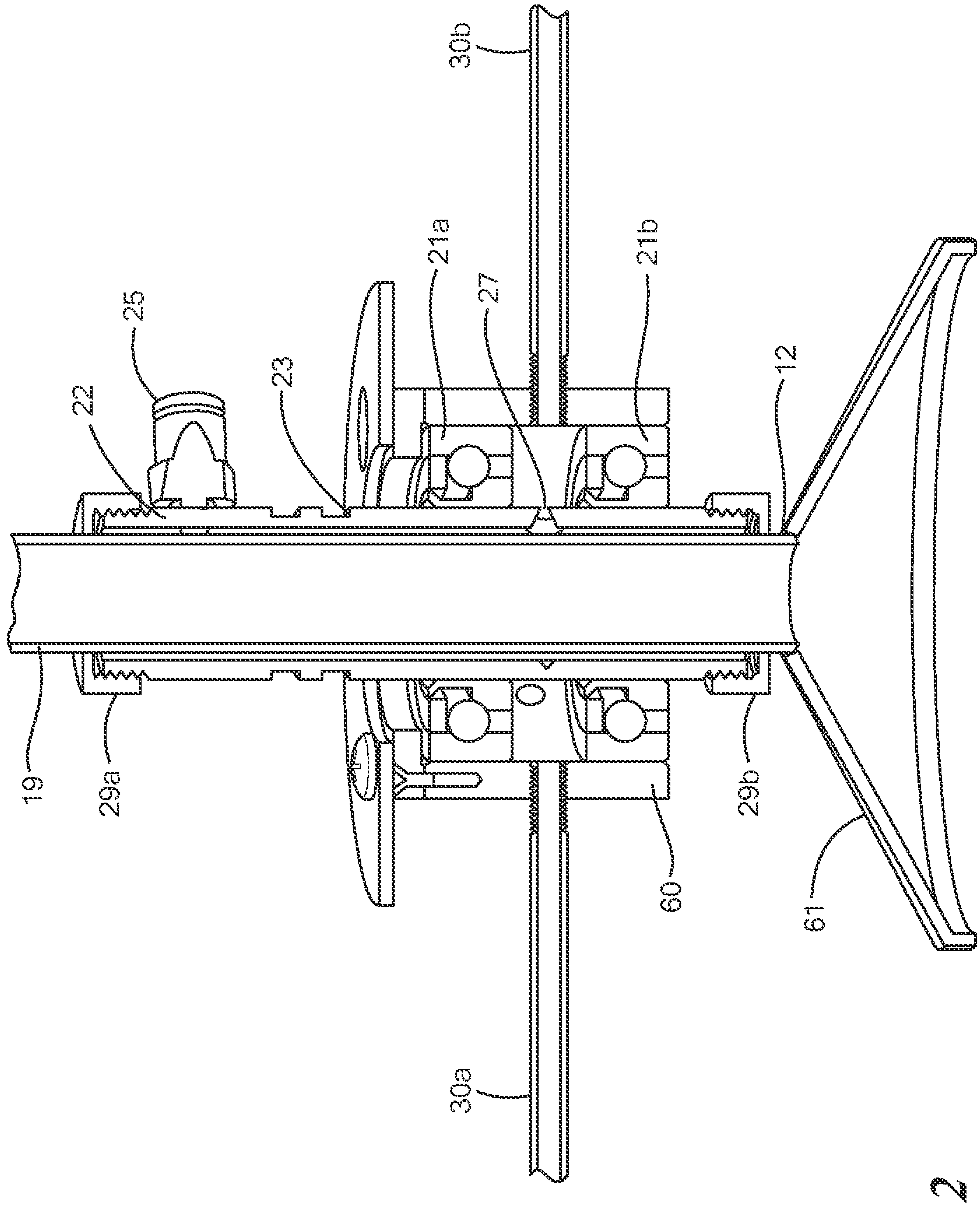


FIG. 2

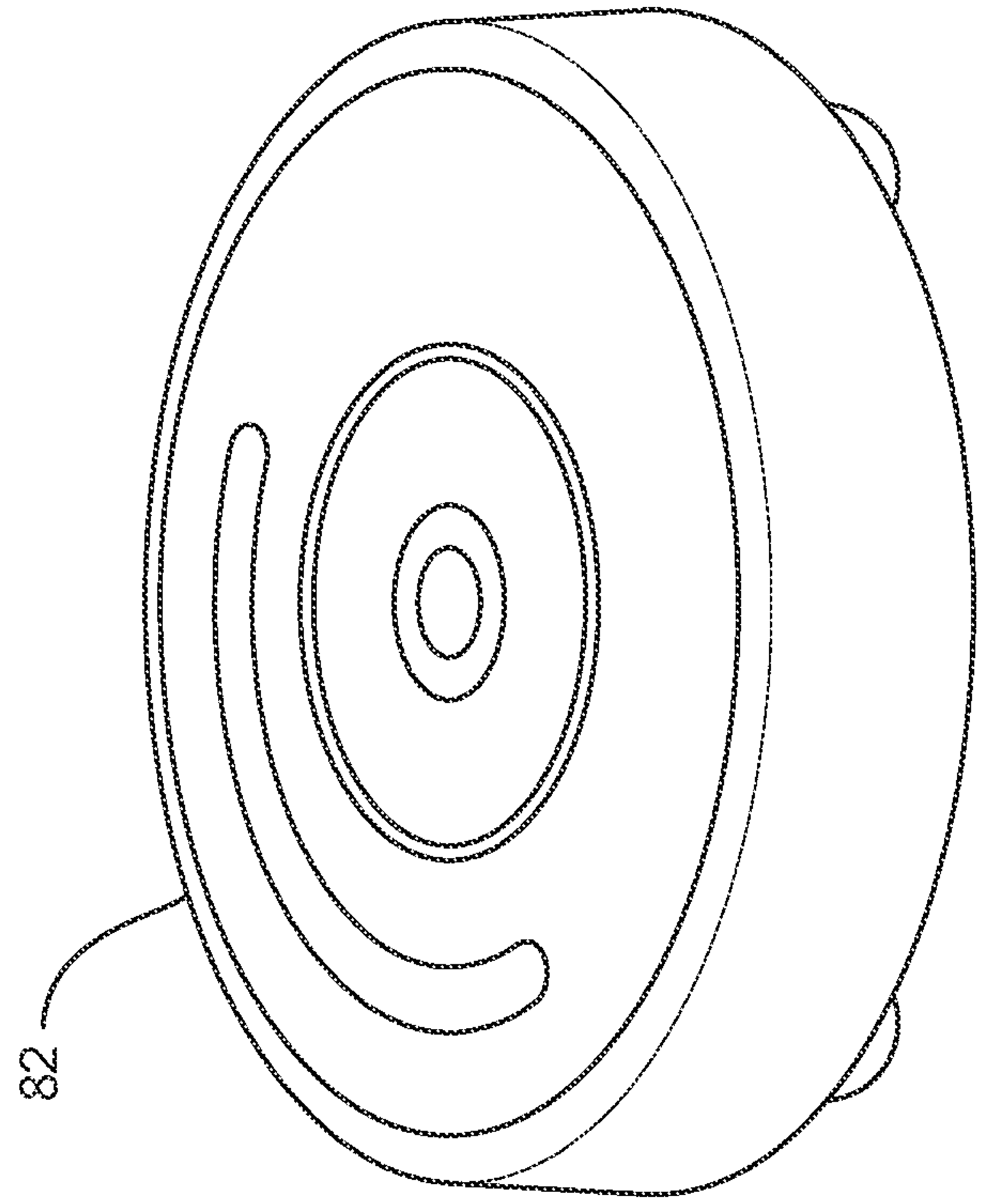


FIG. 4

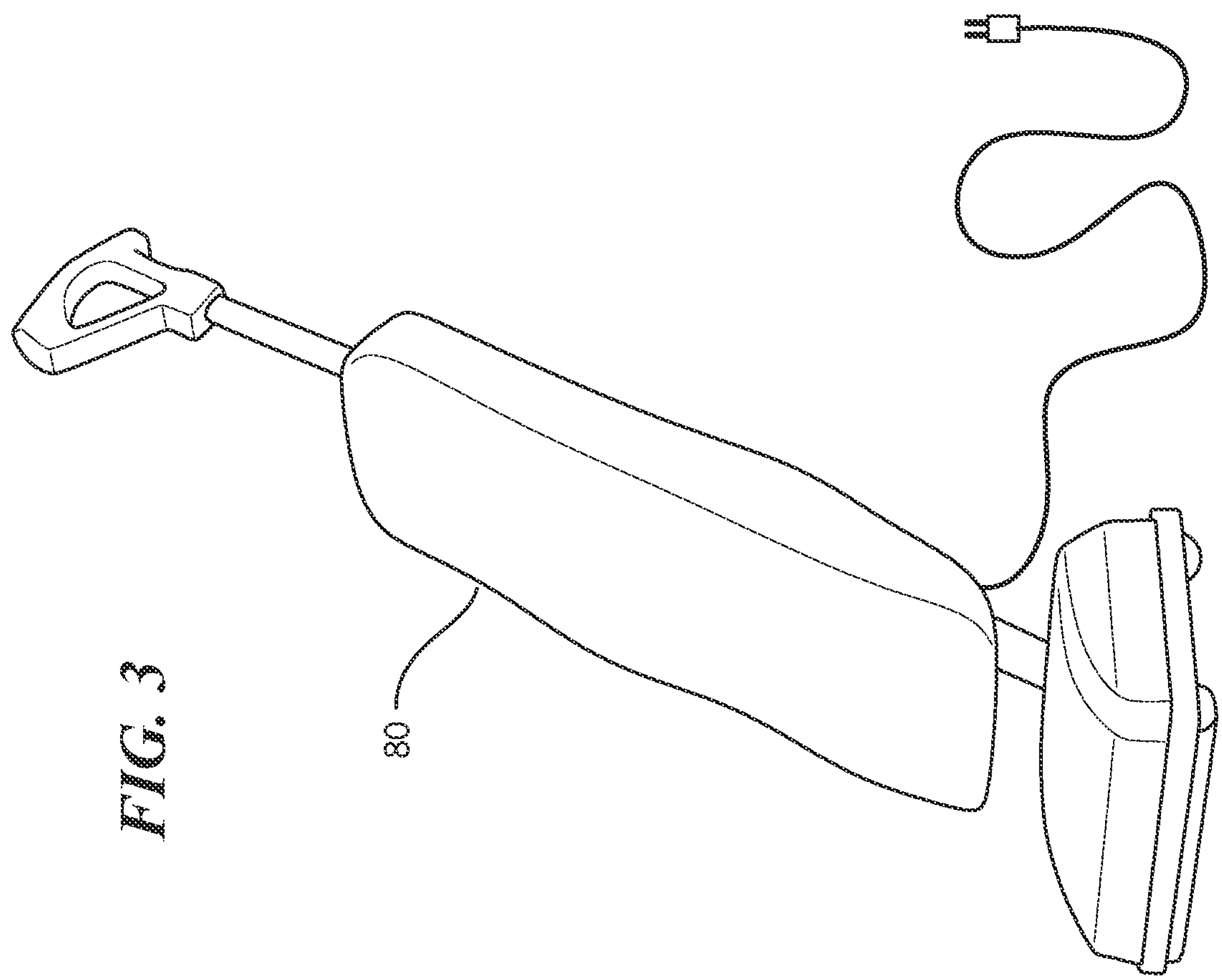


FIG. 3

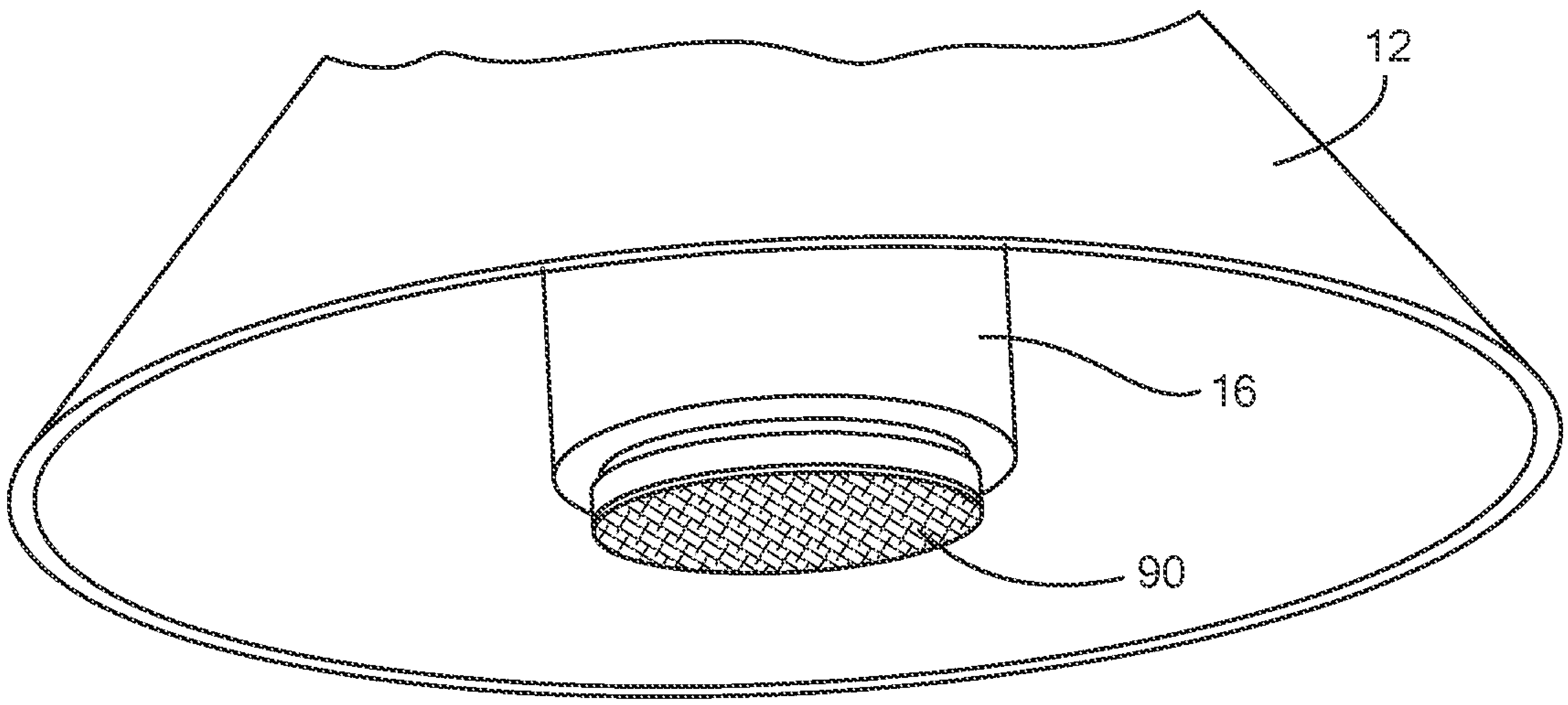


FIG. 5

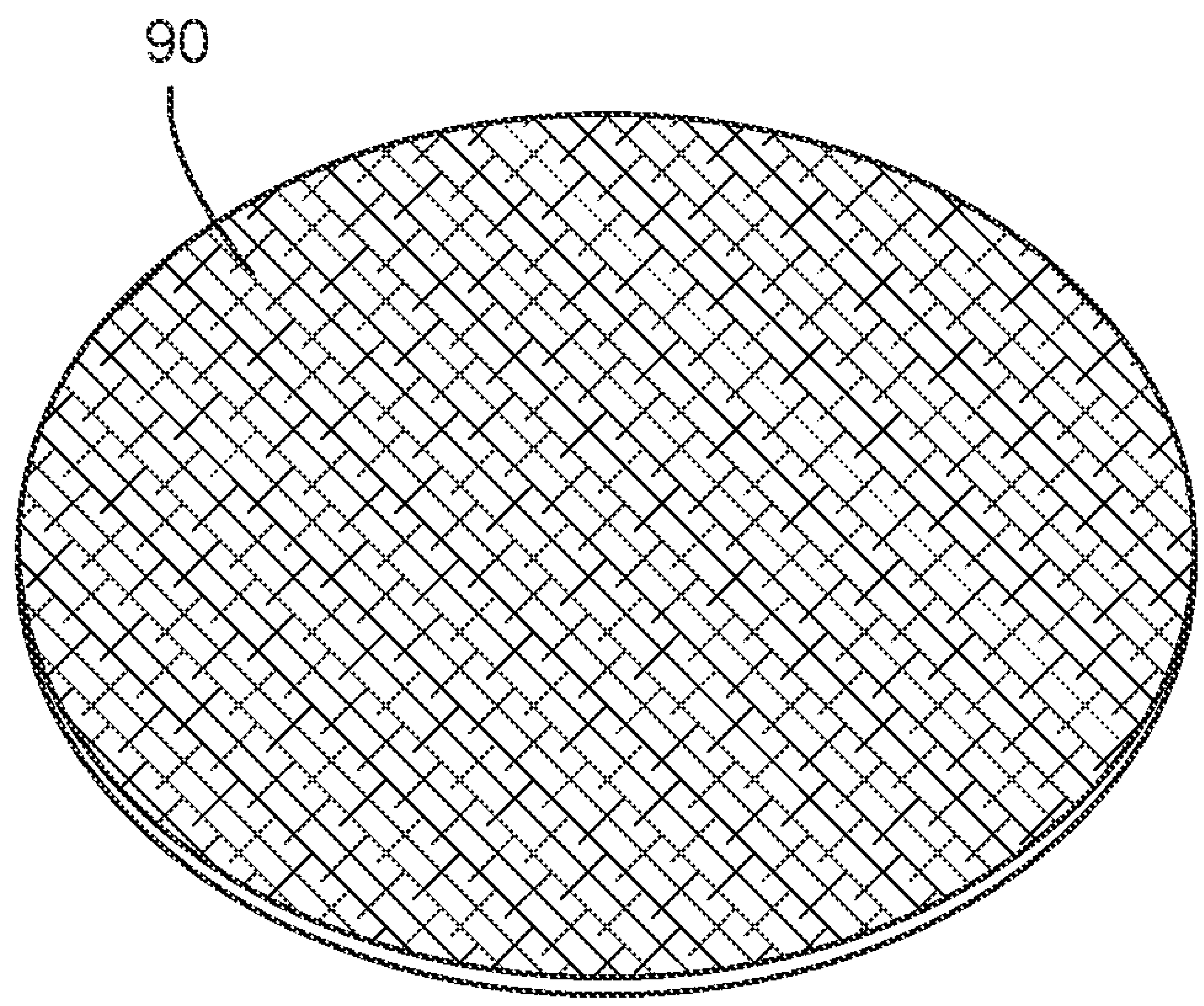


FIG. 6

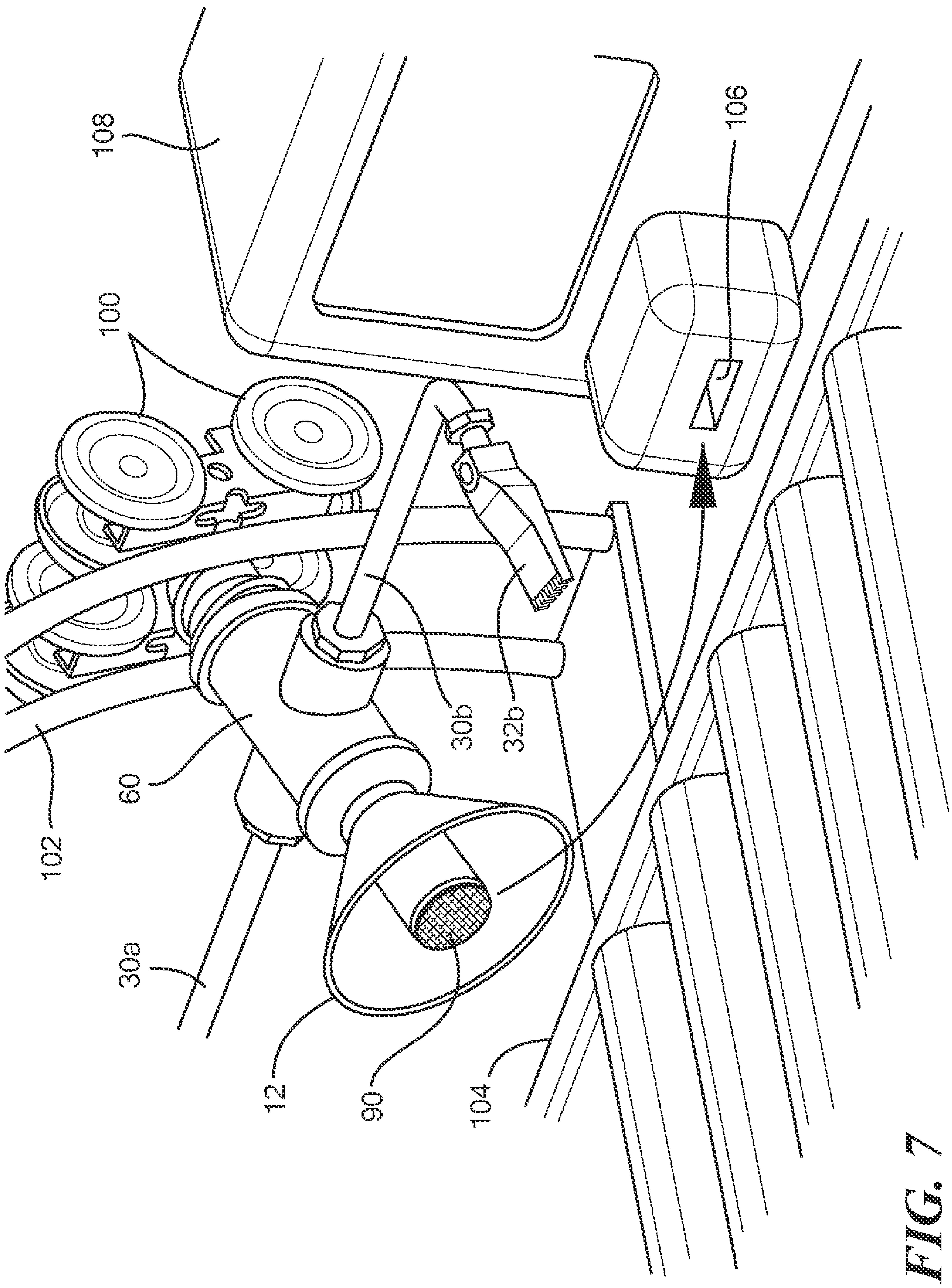


FIG. 7

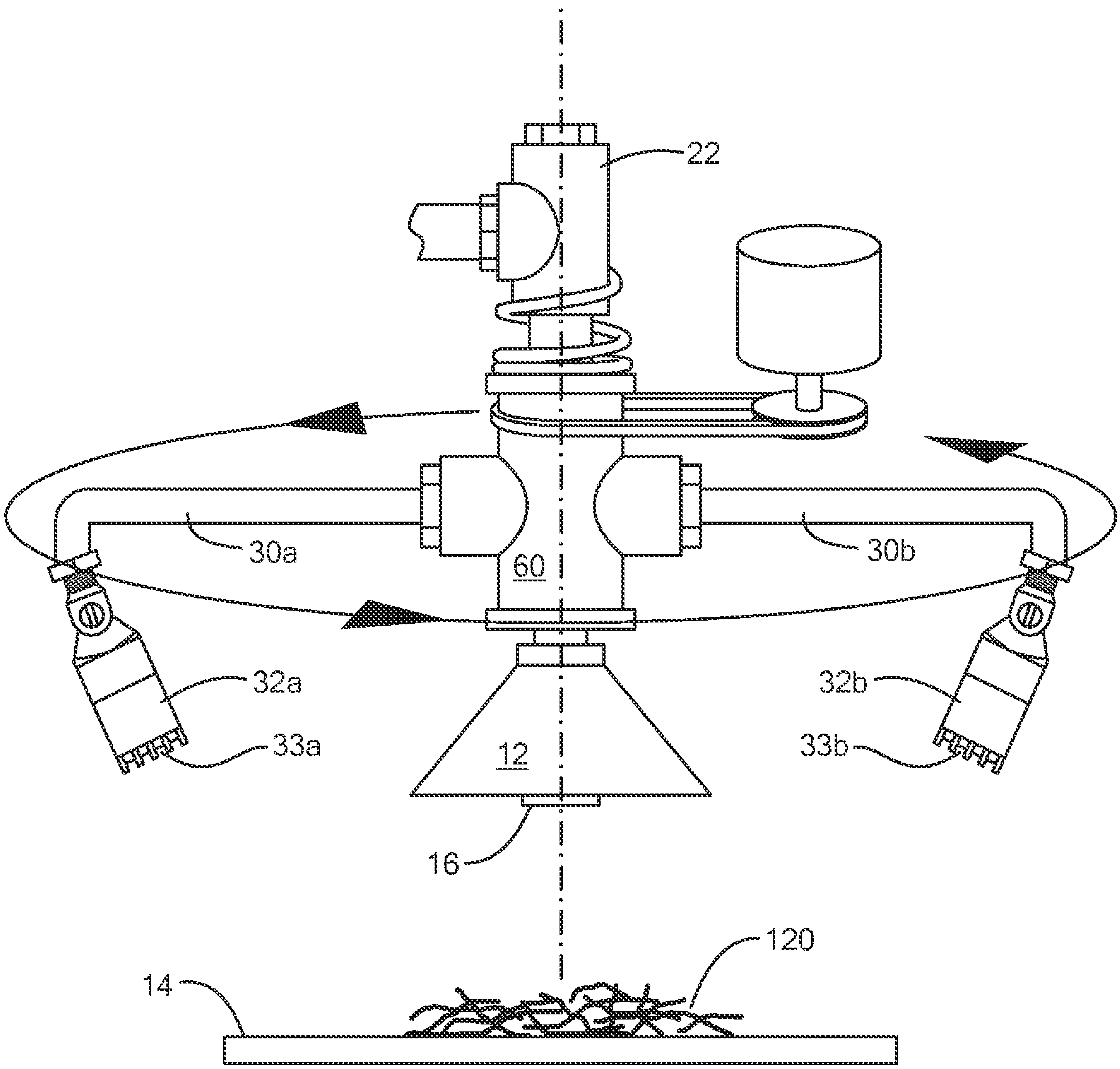


FIG. 8

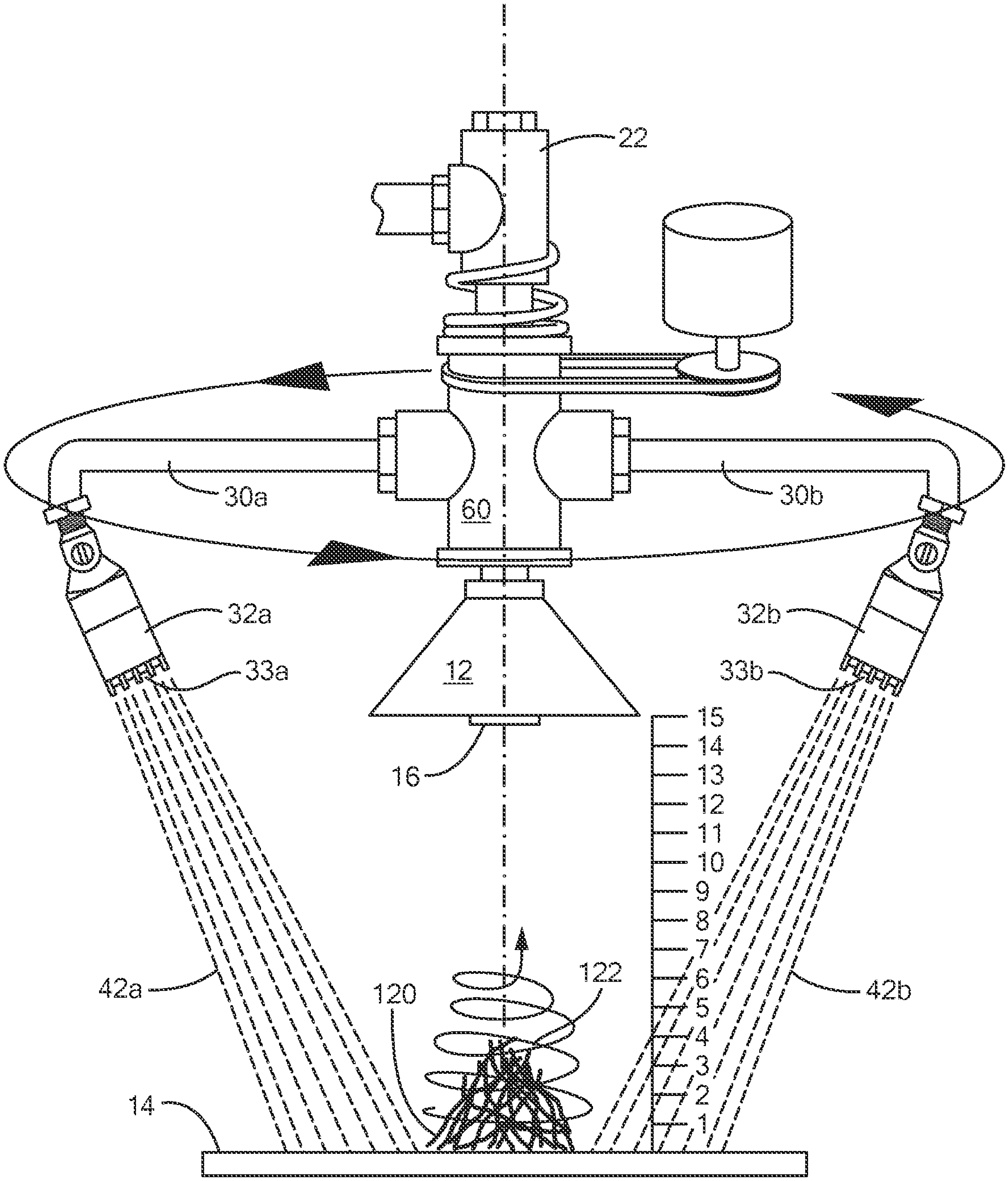

22
30a
30b
60
32a
32b
33a
33b
12
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
42a
42b
120
122
14

FIG. 9

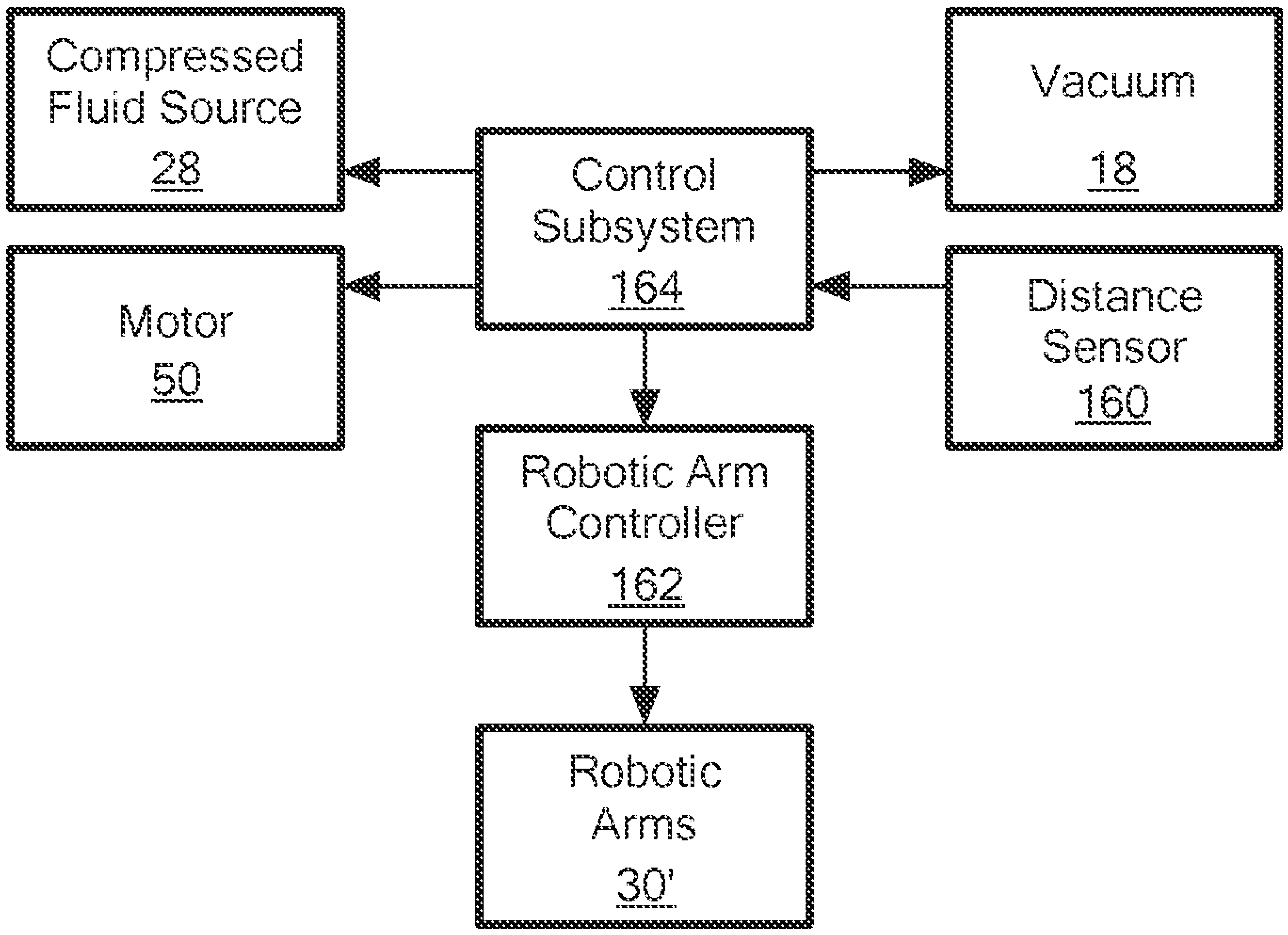

Compressed Fluid Source
28
Control Subsystem
164
Vacuum
18
Motor
50
Distance Sensor
160
Robotic Arm Controller
162
Robotic Arms
30'

FIG. 10

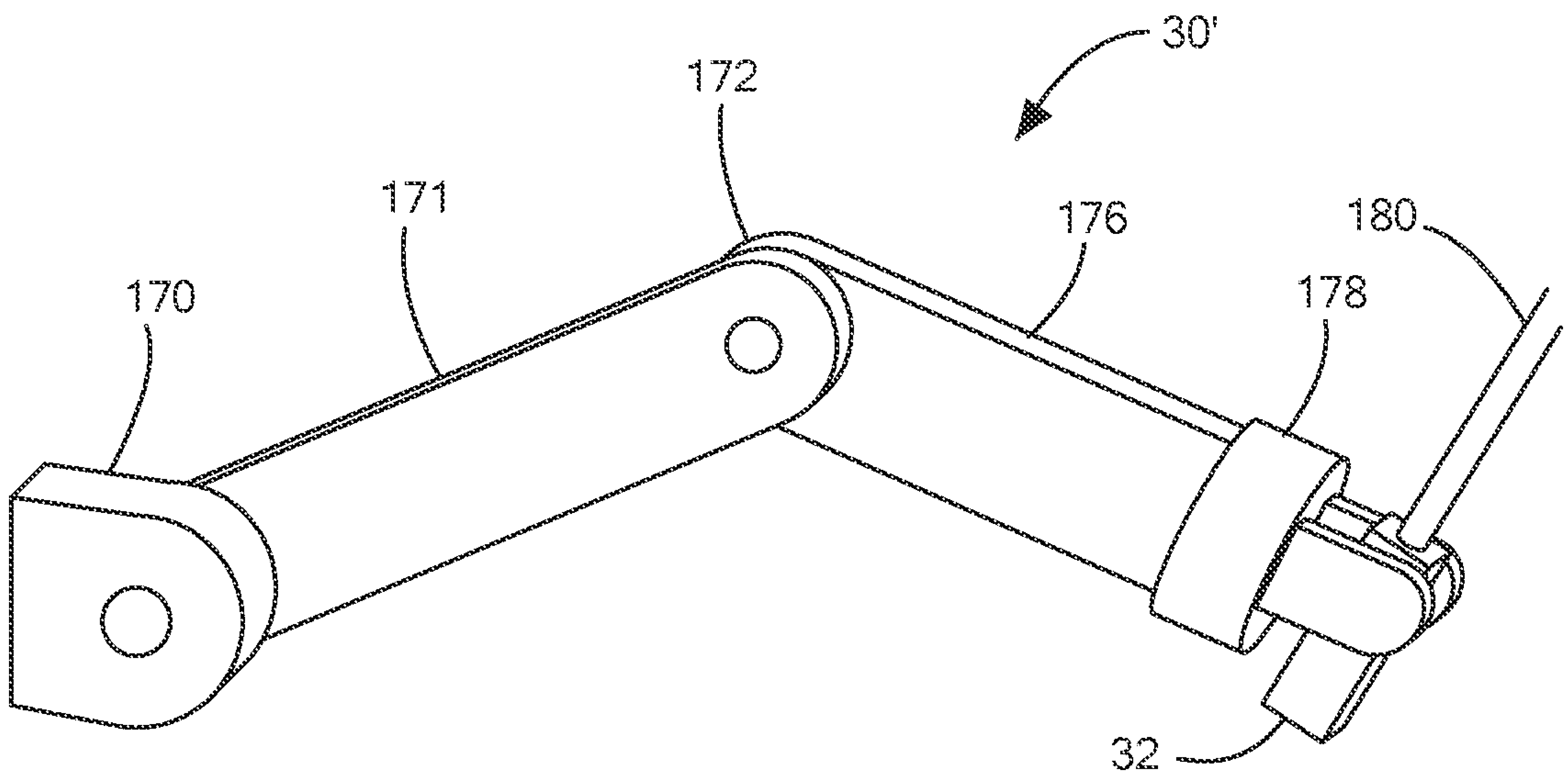

30'
172
171
176
180
170
178
32

FIG. 11

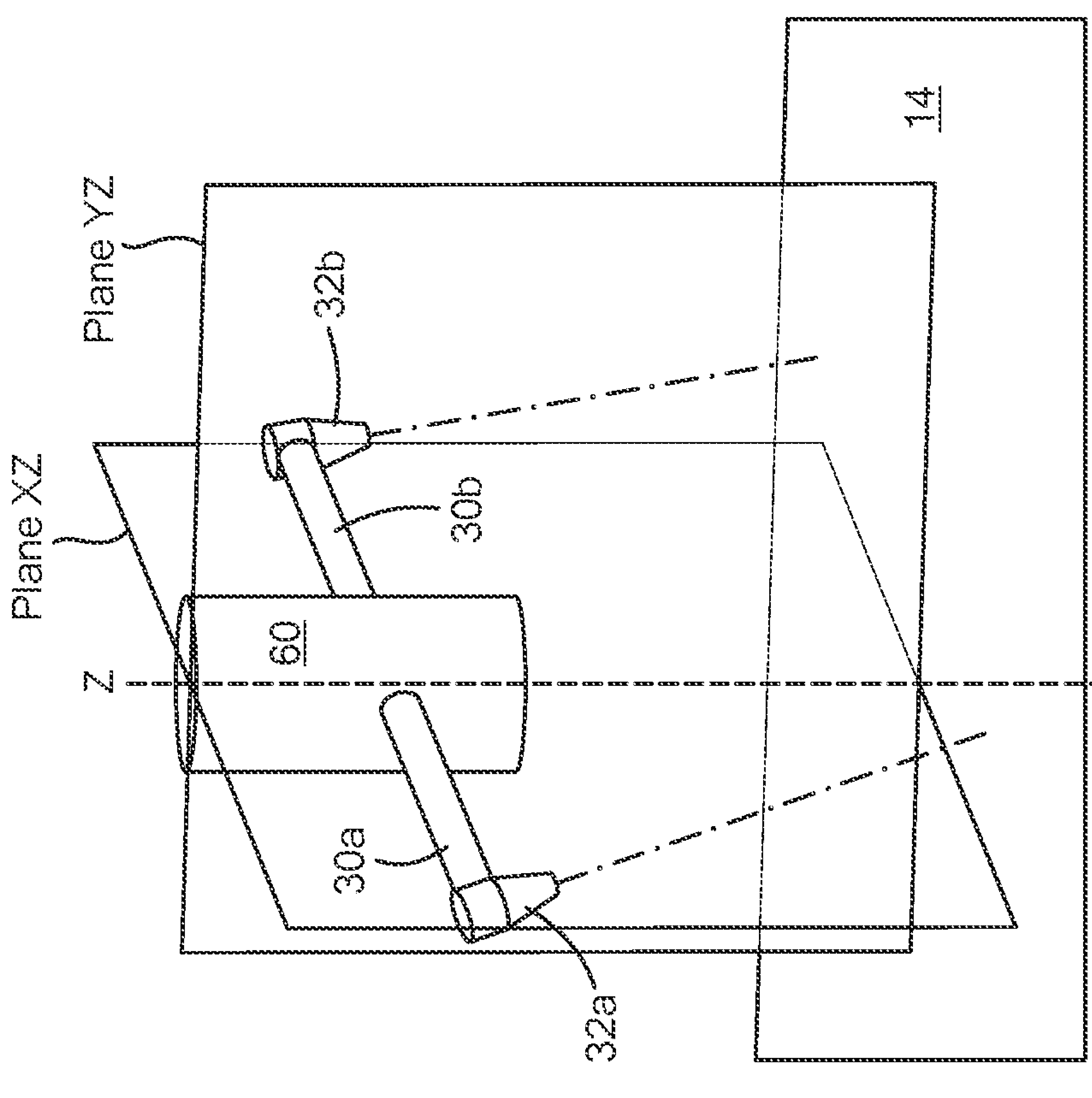


FIG. 12

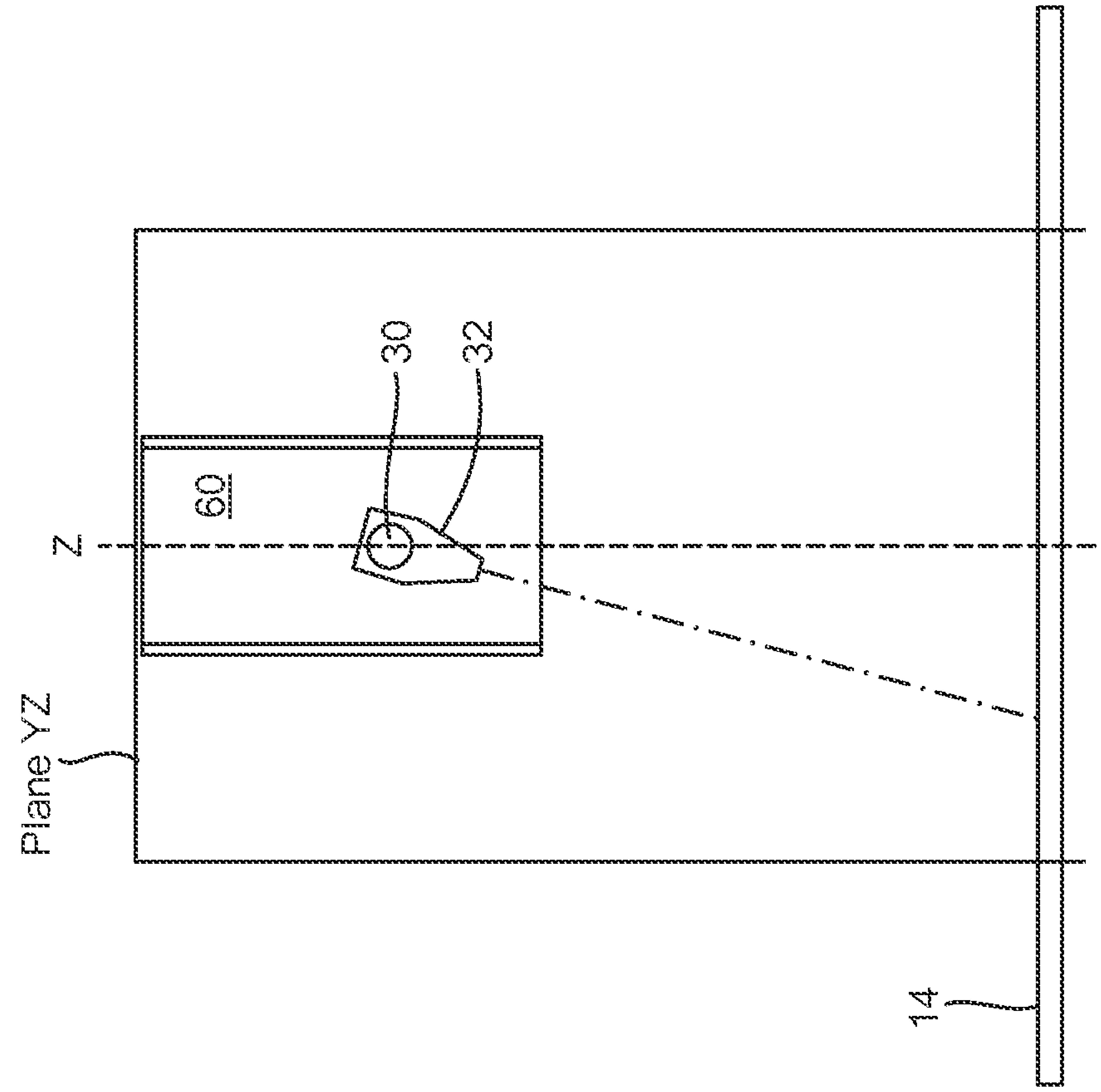


FIG. 13

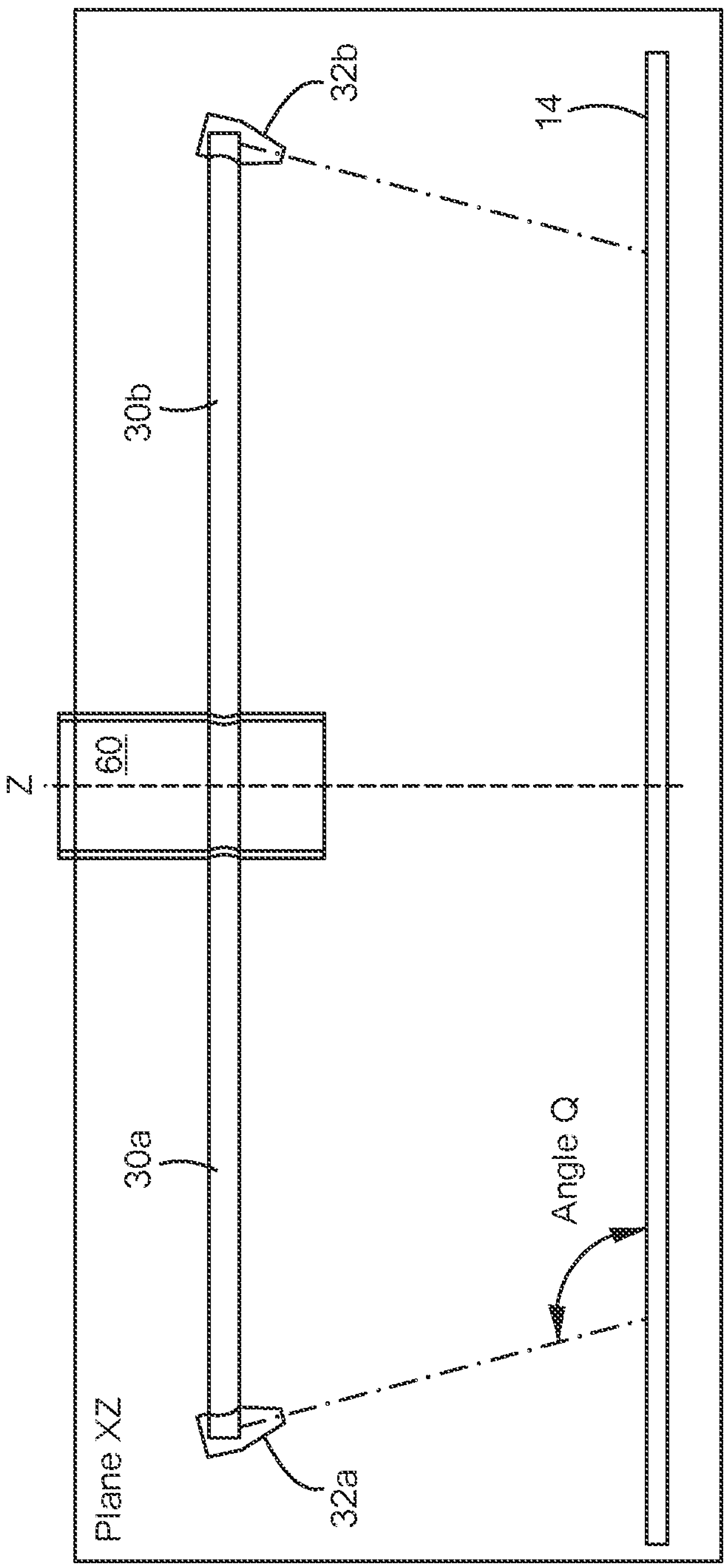

Plane XZ
32b
14
30b
Z
60
30a
Angle Q
32a

FIG. 14

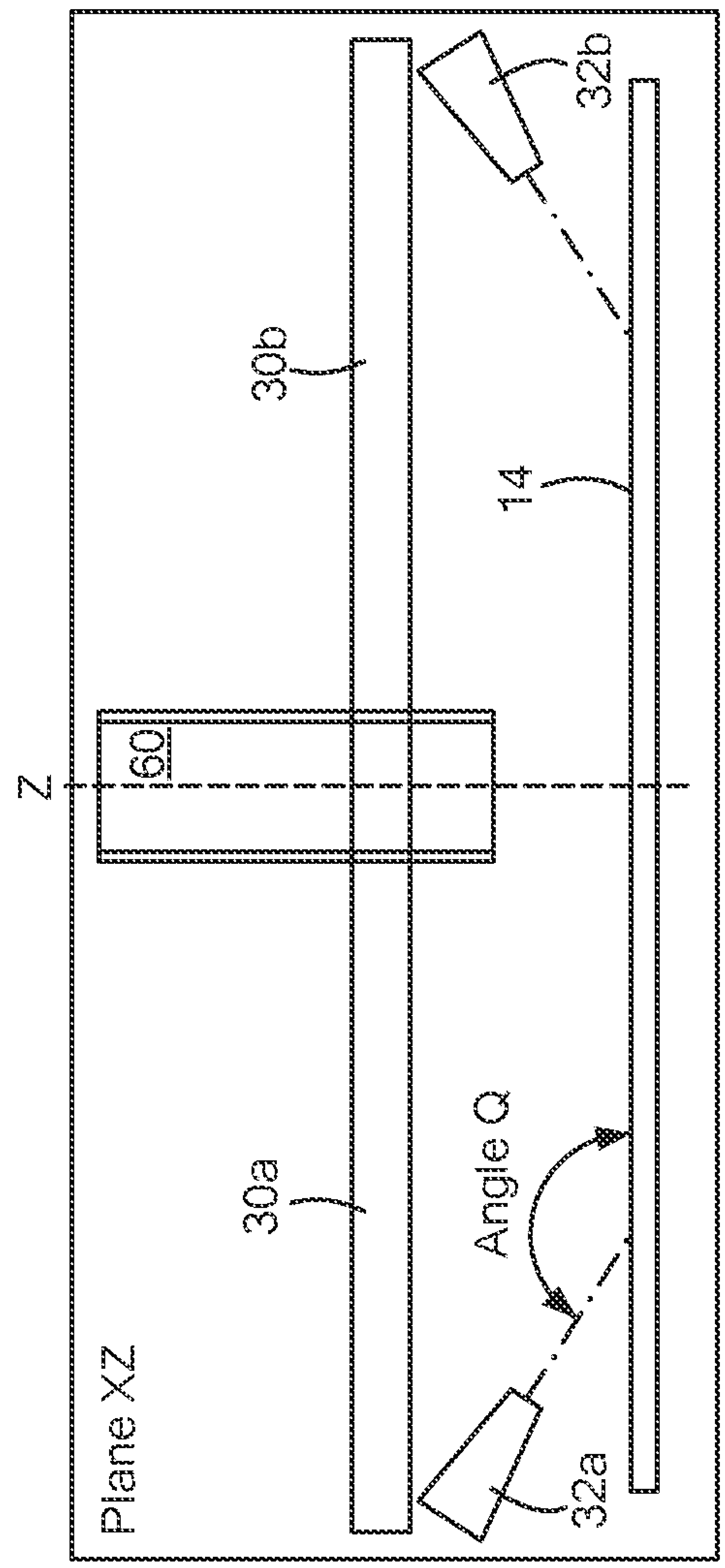

Plane XZ
32b
30b
14
Z
60
30a
Angle Q
32a

FIG. 15

PARTICLE COLLECTION SYSTEM AND METHOD

GOVERNMENT RIGHTS

[0001] This invention was made with U.S. Government support under Contract No. 80NSSC22PB243 awarded by the NASA Shared Service Center (NSSC). The Government has certain rights in the subject invention.

RELATED APPLICATIONS

[0002] This application claims benefit of and priority to U.S. Provisional Application Serial No. 63/318,398 filed Mar. 10, 2022, under 35 U.S.C. §§119, 120, 363, 365, and 37 C.F.R. §1.55 and §1.78, which is incorporated herein by this reference.

FIELD OF THE INVENTION

[0003] This invention relates to particle collection systems and methods.

BACKGROUND OF THE INVENTION

[0004] There are a variety of reasons to dislodge particles from a surface and collect them. The particles can be dust, dirt, or debris collected in order to clean the surface. Or, the surface and particles may be tested by collecting, sampling, and analyzing the particles on the surface (for example powder, grains, or residue) for use in a number of applications including security applications. See for example U.S. Pat. Nos. 3,917,568; 8,816,234; 6,334,365; 5,915,268; 6,708,572; 6,870,155; 6,861,646; 8,469,295; 8,122,756; and 7,576,320 hereby incorporated herein by this reference.

[0005] A vacuum type collector does not work well at any appreciable distance from the surface and/or when the particles are stuck to the surface.

SUMMARY OF THE INVENTION

[0006] In one example, a test bench was used in attempt to collect particles off a surface using a vacuum without success when the vacuum inlet was more than two inches from the surface. Stationary nozzles blowing compressed air towards the surface dislodged the particles from the surface but also scattered them. But, when opposing sets of nozzles were rotated (at, for example, 50_{rpm}), a vortex was created picking up the particles (for example dust or powder) off the surface, and entraining them, and carrying them to the collection chamber optionally connected to a vacuum source. Particles were successfully collected at distances of 5 to 20 inches from the collection chamber to the surface.

[0007] The subject invention, however, in other embodiments, need not achieve all these objectives and the claims hereof should not be limited to structures or methods capable of achieving these objectives.

[0008] Featured is a particle collection system comprising a collection inlet aimable at a surface from which particles are to be collected, a rotatable fixture including at least a pair of nozzles about the collection inlet also aimable at the surface and fluidly connected to a source of compressed fluid in order to dislodge particles from the surface, and a subsystem for rotating the rotatable fixture to generate, as the nozzles rotate about the collection inlet, a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet.

[0009] In one design, the rotatable fixture includes an outwardly extending arm for each nozzle and carrying compressed fluid to the nozzles. The system may further include a vacuum source fluidly connected to the collection inlet.

[0010] In one example, the source of compressed fluid includes an exhaust of the vacuum source.

[0011] The collection inlet can be connected to a conduit and the rotatable fixture rotates about the conduit. Preferably, there are an even number of nozzles in pairs opposing each other. In one example, the nozzles have a slit-like cross sectional opening. The collection inlet may define an axis perpendicular to the surface and the nozzles are angled inwardly with respect to said axis.

[0012] The system may further include a filter token associated with the collector inlet.

[0013] Also featured is a particle collection method comprising aiming a collection inlet at a surface from which particles are to be collected, aiming at least a pair of nozzles oriented about the collection inlet at the surface, providing a compressed fluid to the nozzles in order to dislodge particles from the surface, and rotating the nozzles to generate a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet.

[0014] In one example, the nozzles are fluidly and mechanically coupled to a rotatable fixture via an outwardly extending arm for each nozzle carrying the compressed fluid to the nozzles. The method may further include energizing a vacuum source fluidly connected to the collection inlet.

[0015] The method may further include analyzing the collected particles. In one example, the compressed fluid includes a carrier gas and a metastable species.

[0016] The method may further include providing relative motion between the surface and the collector.

[0017] The method may further include ionizing the surface environment and/or heating the fluid.

[0018] The method may further include adjusting the distance of the nozzles from the collection inlet, adjusting the aiming angle of the nozzles to the surface, and/or sensing the distance from the collection inlet to the surface.

[0019] In one example, a particle collection system includes a collection inlet aimable at a surface from which particles are to be collected, a rotatable fixture including at least a pair of adjustable nozzles about the collection inlet also aimable at the surface and fluidly connected to a source of compressed fluid in order to dislodge particles from the surface; a subsystem for rotating the rotatable fixture to generate, as the nozzles rotate above the collection inlet, a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet, a distance sensor for measuring the distance from the collection inlet to the surface. A controller subsystem is responsive to the distance sensor and is configured to adjust the adjustable nozzles based on the distance from the collection inlet to the surface.

[0020] The controller subsystem can be configured to adjust an angle of the nozzles relative to the surface, to adjust the distance of the nozzles to the surface, to adjust the distance of the nozzles from the collection inlet, to adjust the rate of rotation of the nozzles based on the distance of the collection inlet to the surface by controlling the subsystem, to adjust the pressure of the compressed fluid by controlling the source of pressurized fluid, and/or to adjust the vacuum pressure at the collection inlet by controlling a vacuum source.

[0021] Also featured is a particle collection method including aiming a collection inlet at a surface from which particles are to be collected, aiming at least a pair of nozzles oriented about the collection inlet at the surface, providing a compressed fluid to the nozzles in order to dislodge particles from the surface, rotating the nozzles about the collection inlet to generate a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet, measuring the distance from the collection inlet to the surface, and adjusting the adjustable nozzles based on the distance from the collection inlet to the surface.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0022] Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

[0023] FIG. **1** is a schematic view showing an example of a particle collection system;

[0024] FIG. **2** is a cross sectional view of the system of FIG. **1**;

[0025] FIGS. **3-4** show vacuum cleaner embodiments of the system;

[0026] FIG. **5** shows the addition of a filter token;

[0027] FIG. **6** shows an exemplary filter token;

[0028] FIG. **7** shows an example of a collection system mounted to a conveyance and used in conjunction with an analyzer;

[0029] FIGS. **8-9** show experimental results where no compressed fluid was supplied to the rotating nozzles (FIG. **8**) and where compressed air was supplied to the rotating nozzles;

[0030] FIG. **10** is a block diagram showing an example of a particle collection system with adjustable nozzles and a control subsystem;

[0031] FIG. **11** is schematic view of a robotic arm for a nozzle; and

[0032] FIGS. **12-15** are views showing adjustment of the angle of the nozzles relative to the surface in two planes based on the distance of the collection chamber inlet from the surface.

DETAILED DESCRIPTION OF THE INVENTION

[0033] Aside from the preferred embodiment or embodiments disclosed below, this invention is capable of other embodiments and of being practiced or being carried out in various ways. Thus, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. If only one embodiment is described herein, the claims hereof are not to be limited to that embodiment. Moreover, the claims hereof are not to be read restrictively unless there is clear and convincing evidence manifesting a certain exclusion, restriction, or disclaimer.

[0034] Collection system **10**, FIG. **1** in one example, includes an optional collection chamber **12** about collection inlet **16** aimed at surface **14** upon which lay particles such as smoke, dust, powder, dirt, residue, grains, etc. Conduit **19** extends from optional vacuum source **18** to inlet **16** through rotatable fixture **20** and plenum **22** which is connected to a source of compressed fluid (e.g., a gas such as air, a vapor, steam, etc.). In this example, conduit **19** terminates at inlet **16**. In one example, the exhaust **24** of vacuum source **18** is or is a part of the source **28** of compressed fluid as shown by the dashed lines for conduit **26**. In other examples, the source of compressed fluid is a pressurized tank, an air compressor, or the like.

[0035] Compressed fluid is delivered from source **28** to plenum **22** and then to rotatable fixture **20** which, in this example, includes a pair of opposing arms **30***a*, **30***b* extending from plenum **60** and each fitted with a nozzle **32***a*, **32***b* aimed at surface **14** and configured to a form of fluid discharge spray which strikes surface **14** dislodging particles therefrom. The nozzles can be above, below, laterally adjacent, or otherwise disposed about the inlet. The act of the compressed fluid exiting the nozzles and striking the surface as shown at **42***a*, **42***b* dislodges particles from the surface.

[0036] A motive subsystem is configured to rotate rotatable fixture **20** and arms **30** and nozzles **32** to generate, as the nozzles rotate about inlet **16**, a vortex **42** further dislodging particles from the surface, picking up the particles dislodged from the surface, and entraining the particles and carrying them up to the collection inlet where the optional vacuum source sucks up the particles.

[0037] In one benchtop example, motorized subsystem **40** includes motor **50** driving pulley **52** and belt **54** about rotatable fixture **20** and pulley **52**. But, other designs are possible for rotating fixture **20** including gears, direct drive subsystems, and the like. The rotation also can be produced with a force generated by blowing of a pressurized air or gas.

[0038] Other designs are possible for rotatable fixture **20** as well, including that when nozzles **32***a* and **32***b* are directly attached to the plenum **60** or the nozzles can be lower openings in a rotating plate. In the example shown, plenum **60** is rotatably coupled about fixed conduit **16** via airtight sealed bearings and plenum **60** is fluidly connected to plenum **22** which does not rotate. Rotating arms **30***a*, **30***b* are fluidly and physically coupled between nozzles **32** and plenum **60**.

[0039] Particles are successfully collected at distances of up to 20 inches from collection chamber **12** to surface **14**. In some examples at closer distances, particles were successfully collected even with vacuum source **18** deenergized.

[0040] There are preferably an even number of nozzles in pairs opposing each other. Shown are two nozzles opposing each other and each having a slit-light cross sectional opening **33***a*, **33***b* (with a length to width ratio of at least 25:1) forming a truncated pyramid shaped compressed fluid discharge spray. Other nozzles and spray patterns are possible. Shower head style nozzles with round openings could be used. The collection chamber **12** preferably defines an axis **61** perpendicular or nearly perpendicular to surface **14** and preferably nozzles **32** are angled inwardly with respect to this axis as shown in FIG. **1**.

[0041] As shown in FIG. **2**, in one example, plenum **60** rotates about plenum **22** conduit **23** itself disposed about vacuum conduit **19** via airtight sealed bearings **21***a*, **21***b*. Compressed fluid (e.g., air) enters fitting **25** coupled to conduit **23** and flows between conduit **23** and conduit **19** exiting into rotatable plenum **60** at orifice **27** in conduit **23** and then proceeds into arms **30**a, **30**b and to the nozzles. Conduit **23** is sealed with respect to conduit **19** via nuts **29**a, **29**b with inner O-rings. Other compressed fluid delivery and sealing methods are possible.

[0042] In some examples the particle collection system is configured as a standard vacuum cleaner **80**, FIG. **3**, or robotic vacuum cleaner **82**, FIG. **4**. In other instances, the collector is used to clean dust off space vehicles and/or equipment. The collection system may be adapted to move relative to the surface or the surface may be driven with respect to the collection system via a conveyance, for example. Cleaning solutions can be added to the compressed fluid ejected by the nozzles. The collector may contain a filter, a collection device, a measuring device, a pump, a blower, or a combination of the above. When used for a sample collection, a filter can be placed at the entrance of the inlet. Collected particles can be injected into an analytical device, for example a mass spectrometer, or ion mobility spectrometer. Collected particles can be pre-concentrated before submitting to an analytical tool.

[0043] Filter **90**, FIGS. **5**-**6**, can be constructed from a metal mesh in the form of a filter token. The filter token can be attached to the sampling port using an O-ring.

[0044] The nozzles are preferably arranged in pairs, one opposite the other, mirrored with respect to the axis of rotation. Air, gas or steam coming from the nozzles can be heated by heaters located directly near or inside the nozzles. Also, an air ionizer can be located near the nozzles to remove particles from the surface. The ionizer can be a corona discharge needle or a discharge plate, or tube with dielectric barrier breakdown ionizer.

[0045] The nozzles can be mounted in such a way as to be able to change the distance of their location from the axis of rotation. The nozzles can be mounted in such a way as to be able to change the angles at which the air jet from the nozzle is directed relative to the surface from which the particles are blown off and collected.

[0046] A sensor may be mounted on or near the nozzles and on or near the stationary low-pressure pipe to measure the distance to the surface or object from which the particles are collected. The sensor can be an optical, ultrasonic or capacitive distance sensor. In accordance with the readings of the surface distance sensor, the angular position of the nozzles and their distance to the axis can be changed.

[0047] The collector can be mounted on wheels which will facilitate movement relative to the surface from which the particles are collected. Such movement can be organized along rails or guides. The whole construction can be mounted on a conveyor. The movement on rails or guides can be controlled by a motor. Guides or rails can be arranged in the form of an arch. In this way, particles can be collected from different surfaces of the object. The object from which the particles are collected can move relative to the sampler.

[0048] The cross section of the air jet nozzles can be a circle or a strip. When the nozzles rotate around the axis, the strip nozzle forms a tangent to the circle of rotation.

[0049] The collector can also be used as an ion source for analytical instrumentation like a mass spectrometer or ion mobility spectrometer. Instead of the pressurized air, the nozzles can blow a carrier gas with a metastable species, wherein the metastable species interacts with the reactant gas produce ionized derivatives of the reactant gas. The carrier-gas/reactant-gas/ionized-derivative mixture is directed into contact with the analyte on a surface to form analyte ions, analyte fragment ions, and/or analyte adduct ions, which will be delivered with the collector into the inlet communicating with an entrance of a mass spectrometer or ion mobility spectrometer. A DART ion source as described in U.S. Pat. No. 6,949,741 and U.S. Pat. No. 7,112,785, both incorporated herein by this reference, operate in a configuration where the flow of metastable species is unidirectional with the flow of generated ions injected into the analytical tool. Such a geometry limits the application of DART ion source by analysis of analytes, which can be placed between the source of metastable species and the inlet of the ion source. With the use of the collector as a source of the metastable species, the intake of the analytical tool can be in communication with collector inlet and positioned from 2 to 20 inches away from the analyte.

[0050] There are other areas of technology that require the separation of smoke, dust, particles, powder, grains and other substances from a surface or from a pile and transported over a distance. After transportation, the collected matter can be stored, processed, or thrown away. The invented device can be used for trace particle collection for transportation security applications, particle removing in various technological processes, particle collection for analysis, for industrial hygiene applications, for household hygiene applications, installed on a moving vehicle to collect particles from a surface, and other applications. Other examples include removing smog and particles during welding processes, laser-cutting, and laser scribing procedures. The present disclosure also relates to a method for lifting particles from a surface and carrying them with an airstream.

[0051] The described device has air nozzles rotating around an axis from which a stream of air, steam or gas flows out. Air nozzles create air flows directed towards the surface on which the particles of interest are located. The air flows created by the circular motion of the nozzles around the axis create an impulse effect on the particles located on the surface and blow them away from it. Picked up by the air flow, the particles move towards the center (the axis of rotation of the nozzles) and are picked up by the formed vortex. The vortex delivers the particles to the collector.

[0052] The collector may contain a filter, a collection device, a measuring device, a pump, a blower, or a combination of the above. The sampling port is preferably attached to the low-pressure pipe.

[0053] The number of nozzles rotating around the axis can be 2,4,6 or more. The nozzles are arranged in pairs, one opposite the other, mirrored with respect to the axis of rotation. There could also be an odd number of nozzles.

[0054] Air, gas or steam coming from the nozzles can be heated by heaters located directly near or inside the nozzles. Also, an air ionizer can be located near the nozzles. The ionizer can be a corona discharge needle or a discharge plate, or tube with dielectric barrier breakdown ionizer.

[0055] The nozzles can be mounted in such a way as to be able to change the distance of their location from the axis of rotation. The nozzles can be also mounted in such a way as to be able to change the angles at which the air jet from the nozzle is directed relative to the surface from which the particles are blown off and collected. The change of these angles can be organized by means of electric motors. Laser diodes shining in the direction of the surface can be installed next to the nozzles and used to indicate where the air from the nozzles meets the surface and where particles are collected.

[0056] A sensor may be mounted on or near the nozzles and on or near the stationary low-pressure pipe to measure the distance to the surface or object from which the particles are collected. The sensor can be an optical, ultrasonic, or a capacitive distance sensor.

[0057] In accordance with the readings of the surface distance sensor, the angular position of the nozzles and their distance to the axis can be changed using electric motors.

[0058] Compressed air, gas or steam is preferably supplied to the air nozzles at a pressure of 3 to 200 psi. Compressed air up to 4000 psi can also be used.

[0059] The distance between the nozzles can be from 2 inches to 3 feet. The rotation of the nozzles can be from 2 to 25 revolutions per second. The dimension of the nozzle opening can be from 0.01 mm to 2 mm. The distance from the sampler to the surface from which the particle is collected can be from 1 inch to 5 feet. The large variation in dimensions is explained by the ability to change the size of the device depending on the application.

[0060] The vortex sampler can be installed with rollers **100**, FIG. **7** on a rail **102** over a conveyor **104** in order to inspect articles (e.g., luggage) traveling on conveyor **104**.

[0061] The filter **90** with collected particles can be automatically transferred to a sampling port **106** of chemical analyzer **108**. The chemical analyzer can be an Ion Mobility Spectrometer or a Mass Spectrometer.

[0062] The device demonstrates the ability to "wipe off" and remove various size, weight and material particles from the surface of the inspected object and send them to the sampling port using vortex airflow. When the air flow is turned off, there is no pressure difference between the test object surface and the sampling port. Turning on the air jet (nozzles) creates a strong, directional air flow towards the sampling port. In the sampling port particles are collected on a reusable 1″ OD, filter token. With use of an equipment-specific holder the token can be placed into most ETD swab heaters for following thermal desorption.

[0063] In FIG. **8**, ribbon bunch **120** was glued to surface table **14** and the nozzle arms **30***a*, **30***b* were rotated but no pressurized air was supplied to the nozzles. As shown there was little effect on the ribbon bunch. The result would be the same if pressurized air was supplied to the nozzles but they were not rotated. In contrast, in FIG. **9** pressurized air was supplied to the nozzles, the nozzles were rotated, and now the ribbon bunch was sucked upward towards the collection chamber as shown at **122**. In this experiment, collection chamber was 15″ away from surface **14**. Again, the use of a vacuum source fluidly connected to the collection chamber inlet may be beneficial but is not always necessary.

[0064] In some examples, it is desirable to adjust the angle of the nozzles (in one or more planes), the rate of rotation of the nozzles about the collector inlet, the pressure of the nozzle fluid, the vacuum pressure, the distance of the nozzles from the surface, and/or the distance of the nozzles from the collector inlet depending on a factor such as the distance of the collection inlet from the surface or the type of particle collection technology being employed including the type of particles being collected and the characteristics of the surface.

[0065] In FIG. **10**, distance sensor **160** (e.g., a sonic based detector) measures the distance of the collection chamber inlet to the surface. The nozzle arms in this example could include robotic arms **30′** having various degrees of freedom, for example, the ability to extend or retract, raise and lower, and to change the angle of the nozzles attached to the robotic arms in two planes via robotic arm controller **162**. Control subsystem **164** receives a signal from distance sensor **160** indicative of the distance of the collection chamber inlet from the surface and in response is configured (e.g., programmed) to provide signals to robotic arm controller(s) **162** in order to extend and retract, raise and lower, and/or change the angle of the nozzles in one or more planes. Control subsystem **164** could include a computer, controller(s), application specific integrated circuit(s), or the like.

[0066] Based on the distance of the collection chamber inlet relative to the surface and/or the type of collection technology employed, controller subsystem **164** may also vary the speed of rotation of the nozzles by controlling motor **50** (e.g., between 30-150 rpm (preferably 50-90 rpm)), vary the pressure of the fluid (e.g., between 3-150 psi) by signaling compressed fluid source **28**, and/or vary the vacuum pressure (e.g., between 14.7-4 PSIA) by signaling vacuum pump **18**. For nozzles with a 0.007″ × 0.5″ opening, the optimal pressure was from 30-60 psi for a distance of 2-7″ from the surface. For a greater distance, the pressure should be higher. For floor cleaning applications, the compressed air pressure can be as low as 3 psi. In general, the further the collection chamber inlet is from the surface, the fluid pressure and rotation rate are all increased and the vacuum pressure is decreased. And, the further the collection chamber inlet is from the surface, the angle of the nozzles relative to the surface increase and the distance of the nozzles from the collection chamber inlet increase and the distance of the nozzles from the surface decrease.

[0067] FIG. **11** shows an example of a robotic arm **30′** with rotatable shoulder **170**, elbow **172** between upper arm **174** and forearm **176** and wrist **178** to which nozzle **32** is attached and fed pressurized fluid via conduit **180**. Robotic arms used in wafer processing or material handling may be used.

[0068] As shown in FIGS. **12-15**, the angle Q between the nozzles and the axis of rotation in XZ plane at a large distance to the surface can be from 75-135°. When the distance from the nozzle to the surface reduces, the angle should be increased to up to 165°. In the YZ plane, the angle should be 90 ± 15°. In general, when the distance from the collection chamber inlet to the surface increases, the angle Q in the XZ plane decreases. The nozzles can be pivoted via a robot arm wrist or by using pivoting motors.

[0069] Although specific features of the invention are shown in some drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. The words "including", "comprising", "having", and "with" as used herein are to be interpreted broadly and comprehensively and are not limited to any physical interconnection. Moreover, any embodiments disclosed in the subject application are not to be taken as the only possible embodiments.

[0070] In addition, any amendment presented during the prosecution of the patent application for this patent is not a disclaimer of any claim element presented in the application as filed: those skilled in the art cannot reasonably be expected to draft a claim that would literally encompass all possible equivalents, many equivalents will be unforeseeable at the time of the amendment and are beyond a fair interpretation of what is to be surrendered (if anything), the rationale underlying the amendment may bear no more than a tangential relation to many equivalents, and/or there are many other reasons the applicant cannot be expected to describe certain insubstantial substitutes for any claim element amended.

[0071] Other embodiments will occur to those skilled in the art and are within the following claims.

What is claimed is:

1. A particle collection system comprising:

a collection inlet aimable at a surface from which particles are to be collected;

a rotatable fixture including at least a pair of nozzles about the collection inlet also aimable at the surface and fluidly connected to a source of compressed fluid in order to dislodge particles from the surface; and

a subsystem for rotating the rotatable fixture to generate, as the nozzles rotate about the collection inlet, a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet.

2. The system of claim **1** in which the rotatable fixture includes an outwardly extending arm for each nozzle and carrying compressed fluid to the nozzles.

3. The system of claim **1** further including a vacuum source fluidly connected to the collection inlet.

4. The system of claim **3** in which the source of compressed fluid includes an exhaust of the vacuum source.

5. The system of claim **1** in which the collection inlet is connected to a conduit and the rotatable fixture rotates about the conduit via sealed bearings.

6. The system of claim **1** in which there are an even number of nozzles in pairs opposing each other.

7. The system of claim **1** in which the nozzles have a slit opening.

8. The system of claim **1** in which the collection inlet defines an axis perpendicular to the surface and the nozzles are angled inwardly with respect to said axis.

9. The system of claim **1** further including a filter token associated with the collector inlet.

10. A particle collection method comprising:

aiming a collection inlet at a surface from which particles are to be collected;

aiming at least a pair of nozzles oriented about the collection inlet at the surface;

providing a compressed fluid to the nozzles in order to dislodge particles from the surface; and

rotating the nozzles to generate a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet.

11. The method of claim **10** in which the nozzles are fluidly and mechanically coupled to a rotatable fixture via an outwardly extending arm for each nozzle carrying the compressed fluid to the nozzles.

12. The method of claim **10** further including energizing a vacuum source fluidly connected to the collection inlet.

13. The method of claim **10** in which there are an even number of nozzles in pairs opposing each other.

14. The method of claim **10** in which the nozzles have a slit opening.

15. The method of claim **10** in which the collection inlet defines an axis perpendicular to the surface and the nozzles are angled inwardly with respect to said axis.

16. The method of claim **10** further including analyzing the collected particles.

17. The method of claim **10** in which the compressed fluid includes a carrier gas and a metastable species.

18. The method of claim **10** further including providing relative motion between the surface and the collector.

19. The method of claim **10** further including ionizing the surface environment.

20. The method of claim **10** further including heating the fluid.

21. The method of claim **10** further including adjusting the distance of the nozzles from the collection inlet.

22. The method of claim **10** further including adjusting the aiming angle of the nozzles to the surface.

23. The method of claim **10** further including sensing the distance from the collection inlet to the surface.

24. A particle collection system comprising:

a collection inlet aimable at a surface from which particles are to be collected;

a rotatable fixture including at least a pair of adjustable nozzles about the collection inlet also aimable at the surface and fluidly connected to a source of compressed fluid in order to dislodge particles from the surface;

a subsystem for rotating the rotatable fixture to generate, as the nozzles rotate above the collection inlet, a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet;

a distance sensor for measuring the distance from the collection inlet to the surface; and

a controller subsystem, responsive to the distance sensor, configured to adjust the adjustable nozzles based on the distance from the collection inlet to the surface.

25. The system of claim **24** in which the controller subsystem is configured to adjust an angle of the nozzles relative to the surface.

26. The system of claim **24** in which the controller subsystem is configured to adjust the distance of the nozzles to the surface.

27. The system of claim **24** in which the controller subsystem is configured to adjust the distance of the nozzles from the collection inlet.

28. The system of claim **24** in which the controller subsystem is further configured to adjust the rate of rotation of the nozzles based on the distance of the collection inlet to the surface by controlling the subsystem.

29. The system of claim **24** in which the controller subsystem is further configured to adjust the pressure of the compressed fluid by controlling the source of pressurized fluid.

30. The system of claim **24** further including a vacuum source fluidly connected to the collection inlet.

31. The system of claim **30** in which the controller subsystem is further configured to adjust the vacuum pressure at the collection inlet by controlling the vacuum source.

32. A particle collection method comprising:

aiming a collection inlet at a surface from which particles are to be collected;

aiming at least a pair of nozzles oriented about the collection inlet at the surface;

providing a compressed fluid to the nozzles in order to dislodge particles from the surface;

rotating the nozzles about the collection inlet to generate a vortex dislodging and picking up particles on the surface, entraining the particles, and carrying the particles to the collection inlet;

measuring the distance from the collection inlet to the surface; and

adjusting the adjustable nozzles based on the distance from the collection inlet to the surface.

33. The method of claim **32** including adjusting an angle of the nozzles relative to the surface.

34. The method of claim **32** including adjusting the distance of the nozzles to the surface.

35. The system of claim **32** including adjusting the distance of the nozzles from the collection inlet.

36. The method of claim **32** including adjusting the rate of rotation of the nozzles based on the distance of the collection inlet from the surface.

37. The method of claim **32** including adjusting the pressure of compressed fluid.

38. The method of claim **32** further including fluidly attaching a vacuum source to the collection inlet.

39. The method of claim **37** including adjusting the vacuum pressure at the collection inlet by controlling the vacuum source.

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