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- (54) Title: PORTABLE SELF-CLEANING AGGREGATE MIXTURE ANALYSIS UNIT

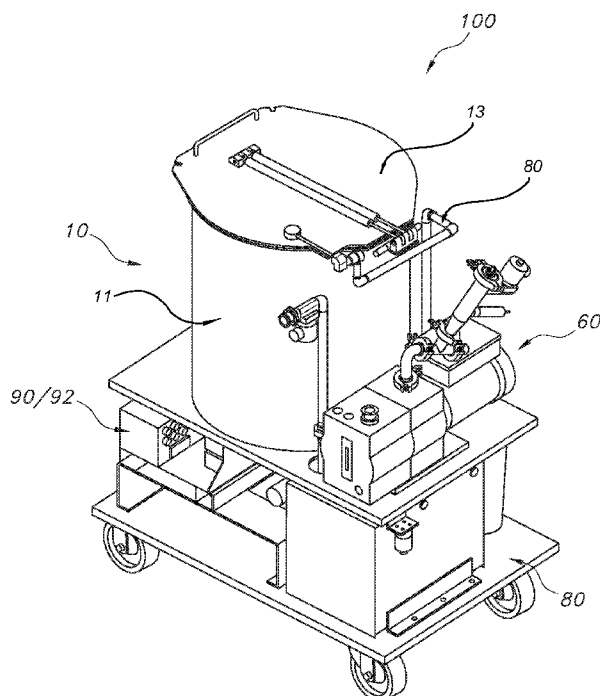


FIG. 1

(57) Abstract: A portable, self-cleaning aggregate mixture analysis device that accepts a sample of an aggregate mixture, separates the sample into particles, analyzes the compositions of the sample, displays results to a user and washes away sample residue, so as to prepare the device for analysis of a subsequent material sample.



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PORTABLE SELF-CLEANING AGGREGATE MIXTURE ANALYSIS UNIT

BACKGROUND INFORMATION

[0001] FIELD OF THE INVENTION

[0002] The invention relates to the field of composition analysis of aggregate materials. Further, the invention relates to equipment that is used to analyze the components of an aggregate particle mixture, such as those that are used to make asphalt concrete.

[0003] DISCUSSION OF PRIOR ART

[0004] Roadways, parking lots, and other surfaces that are intended to be used with wheeled vehicles are often covered in a composite material such as asphalt concrete or flexible pavement. These composite materials are composed of a mixture of variously sized aggregate particles, such as sand, gravel, crushed stone and slag, which are combined with a binder such as asphalt or bitumen. There are a number of well-known composite material mixture formulations, which combine a mixture of different size aggregate particles with various amounts of binders to create the preferred composite material for a specific purpose and to meet various standards and regulations.

[0005] The particle size distribution in the mixture of aggregate particles is one of the most influential characteristics in determining how the composite material will perform as, for example, a pavement material because the particle mixture composition influences the stiffness, stability, durability, permeability, workability, skid resistance and resistance to moisture damage of the pavement. For example, a mixture that does not contain sufficient large sized particles may result in a composite material that lacks stability. Alternatively, a mixture that contains too high

a percentage of large particles may result in a composite material that has poor workability.

[0006] While various aggregate mixture formulations are known, the different formulations are not available as premixed compositions; rather, the various aggregates must be purchased separately and mixed together to obtain the composition that corresponds to a project specification.

[0007] The blending process generally involves combining and mixing an estimated amount of variously sized particles in a mixer, using a scale to weigh the mixture, transporting the mixture to a drying machine to dry the mixture, using a scale to weigh the dry mixture, using a sorting mechanism to sort the aggregate particles by particle size and then using the scale to weigh each size group. Then analyzing weights to determine whether the mixture has the desired composition. These test steps typically result in a cumbersome process that involves numerous machines and that allow for a great deal of human error. And, typically, these tests may only be done in a lab rather than at a mixing site, thus introducing additional delay, cost, and opportunity for human error.

[0008] What is needed, therefore, is a conveniently sized portable test unit that is capable of sorting and analyzing the mixture of aggregates at a worksite. What is further needed is such a test unit that is in a ready-to-use condition after a test has been completed.

BRIEF SUMMARY OF THE INVENTION

[0009] The invention is a portable self-cleaning aggregate material analysis device that accepts a sample of an aggregate particle mixture, captures the weight of the initial sample, dries the sample, and separates and sorts the sample by particle size, and then captures the weight of those particle size groupings to

determine the composition of the sample aggregate mixture, then displays the information to a user, and washes away residual sample material, so that the device is ready to use for a new test.

[0010] The device includes a material analysis chamber that accepts the sample of an aggregate mixture and includes a sorting unit and a weighing mechanism. The weighing mechanism captures the wet weight of the aggregate mixture sample and relays the information to a user via an integrated computer system. A moisture evacuation system is connected to the outside of the material analysis chamber and dries the sample material by evacuating the moisture from the chamber after the wet weight is recorded. The weighing mechanism measures the dry weight of the aggregate mixture sample and relays that data to the computer system. The sorting unit then separates the dry aggregate mixture sample into individual particles and sorts those particles by particle size. The weighing mechanism then captures the weight of each group of particles.

[0011] The sorting unit includes a sieve container that holds a plurality of sieves, the sieve container having an approximately cylindrical sidewall, an open top, and a closed bottom. The sieves are fixed in the horizontal plane within the material analysis chamber, but movable in the vertical plane. The sieves have apertures that are approximately uniformly sized within a single sieve, but that vary between sieves, and are stacked inside the sieve container with the sieve at the top of the stack having the largest apertures and each successively lower sieve having slightly smaller apertures. As the sample material is separated into particles, the particles fall through the sieves having apertures that are larger than the particle size until the particles land in, and are contained by, a sieve having apertures smaller than the particle.

[0012] The sorting unit also includes a vertical oscillation mechanism to facilitate the particles falling through the sieves. This vertical oscillation mechanism includes an oscillator ring having an upper edge that is a vertical displacement contour. The ring is rotatably affixed in the base of the material analysis chamber and is connected to a motor located outside of the material analysis chamber. Actuating the motor causes the oscillator ring to rotate. A plurality of wheels are affixed to the bottom of the sieve container's sidewall and sit on top of the oscillator ring. As the ring rotates beneath the wheels, the displacement contour on the ring forces the sieve container to oscillate in the vertical plane, thereby causing the aggregate particles fall through the sieves that have sieve apertures that are larger than their particle size.

[0013] Following the test, the computer system relays the moisture content of the aggregate mixture and the ratio of particles sizes contained within the sample, the particles are manually removed from the device and a washing system cleans the chamber of all sample material residue to prepare the chamber for further sample material analysis. The device is relatively small and light, such that it is portable and may be transported in the back of an average size pickup truck and easily moved by two or more individuals having average physical capabilities.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention is described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. The drawings are not drawn to scale.

[0015] **FIG. 1** is a perspective view of the device according to the invention.

[0016] **FIG. 2** is a side view of the device.

- [0017] **FIG. 3** is a perspective view of the device encased in a chassis.
- [0018] **FIG. 4** is a perspective view of the chassis with an open lid.
- [0019] **FIG. 5** is a top view of the material analysis chamber with the sieve container.
- [0020] **FIG. 6** is a partial top view of the material analysis chamber without the sieve container.
- [0021] **FIG. 7** is a partial side view of the sieve container showing the wheels, guide posts and the material analysis chamber's oscillating ring.
- [0022] **FIG. 8** is a side view of the sieve containers wheel on the material analysis chamber's oscillating ring.
- [0023] **FIG. 9** is top view of the sieve container showing the inside of the unit.
- [0024] **FIG. 10** is a top view of the sieve container loaded with sieve support rings.
- [0025] **FIG. 11** is a perspective view of the elevator post and gears.
- [0026] **FIG. 12** is a top plan view of a sieve support ring.
- [0027] **FIG. 13** is a top plan view of the sieve.
- [0028] **FIG. 14** is a perspective view of the stepper motors that drive the elevator post and oscillating ring.
- [0029] **FIG. 15** is a partial cut-away view showing the motors connected to the gear and threaded rod.

- [0030] FIG. 16 is a front view of the moisture evacuating unit.
- [0031] FIG. 17 is a side view of the moisture evacuating unit.
- [0032] FIG. 18 is a perspective view of the washing unit.
- [0033] FIG. 19 is a front view of the washing unit.
- [0034] FIG. 20 is a side view of the washing unit.
- [0035] FIG. 21 is a perspective view of a portion of the washing unit showing the water pumps.
- [0036] FIG. 22 is a side view of the computer system contained with the chassis lid.
- [0037] FIG. 23 is a cross-sectional view of the device chamber.
- [0038] FIG. 24 is a perspective view of the ring rack with the rings.
- [0039] FIG. 25 is a perspective view of the ring rack without the rings.
- [0040] FIG. 26 is a side view of the ring rack and weighing mechanism with the weighing mechanism in a lowered position.
- [0041] FIG. 27 is a side view of the ring rack and weighing mechanism with the weighing mechanism in a top position.

DETAILED DESCRIPTION OF THE INVENTION

[0042] The present invention will now be described more fully in detail with reference to the accompanying drawings, in which the preferred embodiments of the invention are shown. This invention should not, however, be construed as limited to

the embodiments set forth herein; rather, they are provided so that this disclosure will be complete and will fully convey the scope of the invention to those skilled in the art.

[0043] **FIGS. 1 – 4** illustrate the portable self-cleaning aggregate mixture analysis unit **100** according to the invention, including a material analysis chamber **10** for holding a sorting unit **30** and weighing unit **49**, each shown in **FIGS. 5 – 11**, a moisture evacuating unit **60**, a washing unit **80**, and a computer control system **90**, which analyzes the contents of aggregate materials, such as used to create asphalt concrete. The material analysis chamber **10** is approximately cylindrical in shape having a sidewall **11** and a lid **13**. In the embodiment shown, all of these components are contained within a chassis **2** that has a chassis lid **4** and is mounted on a movable base that is fitted with wheels or castors, and that is sized so as to be easily portable, for example, in the back of a standard size pickup truck.

[0044] To use the aggregate mixture analysis device **100** a user places an aggregate mixture sample (not shown) into the sorting unit **30** and closes the lid **13**. Closing the lid creates an air tight seal of the material analysis chamber. Most samples contain a small amount of moisture, and the weighing unit **49** is first used to measure the wet weight of the sample. The moisture evacuating unit **60** then uses a vacuum pump **64** to vent the moisture out from the material analysis chamber **10** to dry the sample. The dry weight of the sample is measured and the computer control system **90** calculates the percentage of moisture in the sample, based on the difference of wet to dry weight. The sorting unit **30** then sorts the aggregate mixture by particle size, and the weighing unit **49** weighs each size group. Once the test is completed, a user manually empties the sorting unit **30** and actuates the washing unit **80** to wash away any leftover sample particles and particle residue from the sorting unit **30**.

[0045] **FIGS. 5 – 10** illustrate a first embodiment of the material analysis chamber **10** and the sorting unit **30**. In this embodiment, the material analysis chamber **10** has a plurality of guide tracks **12**, shown in **FIGS. 5** and **6**. The sorting unit **30** includes a sieve container **31**, illustrated in **FIGS. 5**, and **7 – 10**. The container **31** is similar in shape to that of the material analysis chamber **10**, but smaller, and with a plurality of guide posts **46**. This sieve container **31** has a sidewall **32**, a bottom **34**, and an open top **36** and fits into the material analysis chamber **10**, with the guide posts **46** fitting into the guide tracks **12** on the chamber, so as to fix the position of the sieve container **31** in the horizontal plane inside the material analysis chamber.

[0046] The sieve container **31** contains a graduated sieve unit that includes a plurality of screens or sieves **44**, shown in **FIG. 13**, and a corresponding plurality of sieve support rings **42**, shown in **FIG. 12**. Each sieve **44** comprises a sidewall made of a rigid material and a sieve plate **43** constructed of a suitable mesh material that has a plurality of sieve apertures **45**. The sieves **44** are approximately circular in shape and are sized to sit loosely sit on top of the sieve support rings **42**. A series of stepped ring mounts **38** are provided along the inner surface of the container sidewall **32** for supporting the plurality of sieve support rings **42**. The sieve apertures **45** are uniform within a single sieve **44** but vary in size between the sieves **44**, with the sieve **44** at the top of the sieve container **31** having the largest apertures **45** and each successively lower sieve **44** having slightly smaller apertures **45**. The size of the apertures may vary depending on the intended application; however, for example, apertures ranging in size from 19 millimeters to 7.5 microns are often reasonable. The sieves **44** may also sit directly on the stepped ring mounts **38**, however, it is common for some sieve plates **43** to be made of thin materials and in these instances the sieve support rings **42** provide support for the sieve plates **43**.

[0047] The sorting unit **30** has a vertical oscillator **33** that is used to separate the aggregate particles and sort the particles into the plurality of sieves **44**. The vertical

oscillator **33** includes an oscillation ring **14**, shown in **FIGS. 7** and **8**, that is positioned in the bottom of the material analysis chamber **10** and fixedly connected to a first gear **16**, shown in **FIGS. 6** and **11**. The first gear **16** meshes with a second gear **18** that is attached to a first stepper motor **22**, which is shown in **FIG. 14** and **15**, located on the outside of the material analysis chamber **10**. A gear access port **24**, shown in **FIGS. 16** and **17**, provides an opening for the motor **22** to connect to the second gear **18**. The oscillation ring **14** is generally cylindrical in shape and has a top edge that is a vertical displacement contour **26**.

[0048] This vertical oscillation motion is driven by the first stepper motor **22**, the first and second gears, **16** and **18**, and the oscillator ring **14**. Actuating the first stepper motor **22** forces the second gear **18** and the first gear **16** to rotate, which in turn forces the ring **14** to rotate. As the ring **14** rotates, the wheels **48**, which are mounted at fixed positions on the sieve container wall **32** and seated on the vertical displacement contour **26**, are forced up and down, resulting in a vertical oscillation of the sieve container **31**, along with the plurality of sieves **44**. This vertical oscillation agitates the aggregate mixture sample, causing the particles to separate and then, depending on particle size, drop through the successively mounted sieves **44**, so that sample particles that are smaller than the respective sieve aperture **45** fall from one sieve **44** into a lower sieve **44** until they are captured on a sieve having an aperture size smaller than the particular particle size. Any reasonable rotational speed of the ring **14** causes the sample to separate into particles, however, faster speeds cause the sample to separate faster. There are a number of suitable motors, for example, the RKII stepper motor and driver made by MICROSTEP.

[0049] **FIGS. 5, 6, and 11** show an elevator post **28** that is mounted in the center of the material analysis chamber **10** and extends upward through an opening **52** in the sieve container **31**. As shown in **FIG. 13**, each sieve **44** has a slot **47** approximately in the middle of the sieve **44** and that is sized to fit over the elevator

post **28**. In the embodiment shown, the elevator post **28** has an elongate hexagonal shape and the slot **47** a shape that fits over the shaft **28**, such that the sieves **44** are prevented from rotating in a horizontal plane around the elevator post **28**.

[0050] **FIGS. 11 and 15** illustrate a weighing mechanism **49** that is slidably coupled to the elevator post **28**. A second stepper motor **51** drives a threaded rod **52** that extends congruent with a central axis that extends through the elevator post **28** and that is coupled to the weighing mechanism **49**. In the embodiment shown, the weighing mechanism **49** is an elevator disc that contains one or more load cells. A rod access port **53**, shown in **FIGS. 16 and 17**, provides an opening for the motor **51** to connect to the threaded rod **52**. The second stepper motor **51** turns the rod **52** causing the weighing mechanism **49** to rise. As the weighing mechanism **49** reaches each sieve support ring **42**, it lifts each support ring **42** and sieve **44**, stacking the plurality of supports rings **42** and sieves **44** as it travels upward, and calculates the weight of the particle material captured on each sieve **44** by measuring the weight of the stack of sieve rings and sieve plates and subtracting the weight of the sieves **44**, sieve rings **42** and previously weighed particles. The weighing mechanism **49** transmits the information back to the computer control system **90** through an instrumentation feedthrough channel **54**. As the weighing mechanism **49** continues upward, it lifts each successive sieve plate **42** as it travels, transmitting the data to the computer control system **90** as it captures each sieve support ring **42**.

[0051] **FIGS. 16 and 17** illustrate the moisture evacuating unit **60**, which is located outside of the material analysis chamber **10** and is connectable to the sidewall **12** of material analysis chamber **10** by any suitable pipe or tube **62**. The moisture evacuating unit **60** includes a vacuum pump **64** with a moisture vent **65** and a moisture sensor **66**. When the moisture evacuating unit **60** is activated, the pump **64** pulls the moisture from inside the material analysis chamber **10** and past the

moisture sensor **66** and out through the moisture vent **65**. The moisture sensor **66** indicates the current level of moisture being drawn from the material analysis chamber **10** and conveys that data to the computer system **90**. Running the moisture evacuating unit **60** until the moisture sensor **66** indicates that there is no moisture in the sieve container **10** leaves a dry sample stored in the material analysis chamber **10**. Also shown is a solenoid valve **67** and a pressure transducer **69** that help to monitor and control the pressure of the moisture evacuating unit **60** if needed.

[0052] In the embodiment shown, the moisture sensor includes a humidity probe (not shown) within the sensor **66** and a USB feedthrough device **68** that transmits the humidity readings to the computer control system **90**.

[0053] **FIGS. 18 – 21** illustrate the washing unit **80**, which is provided to clean the chamber after it is used, and includes a water tank **82**, a first water pump **83**, second water pump **84**, and water filter **85** and hosing **86/89** to deliver the water to the material analysis chamber **10** and sorting unit **30**. The water tank **82** is filled with clean water (not shown). The first water pump **83** is connected to the water tank **84** and to the water filter **85** by any suitable tubing or hosing **86**, and the water filter **87** is connected to a wide angle nozzle **88** located in the chamber lid **16** by any suitable tubing or hosing **89**. Activating the first water pump **83** delivers water from the water tank **82** to the wide angle nozzle **88** which sprays water throughout the sieve container **31**. The second water pump **84** connects the water tank **82** to a drain pipe **81** in the material analysis chamber **10** and pumps the water out of the material analysis chamber **10** back into the water tank **82** and subsequently, as needed, through the filter **85** to the material analysis chamber **10** for additional washing.

[0054] Referring again to **FIGS 1 – 4** along with **FIG. 22**, the computer system **90** includes an electronics module **92**, a computer **94**, a display unit **96**, and an input

unit **98**, and controls the aggregate mixture analysis device **100**. The input unit may be any suitable data entry and control device such as, for example, a keyboard and mouse or a touch screen. In the embodiment shown, the display unit **96** and the computer **94** are each contained within the chassis lid **4**. The computer **94** connects to the electronics module **92** and the electronics module **92** is connected to the first stepper motor **26**, the second stepper motor **48**, the first water pump **84**, the second water pump **86** and the vacuum pump. The connections may be made by any suitable cable, for example, CATV cables.

[0055] Computer software (not shown) is provided that allows a user to control the aggregate mixture analysis device **100** and calculate and display analysis results.

[0056] **FIGS. 23 – 26** illustrate a second embodiment of the sorting unit **1000** where the sieve container is a ring cage **108** that is affixed to the first gear **16**. A plurality of rings **208** are affixed to the sides of the ring cage **108**. The rings have a smooth bottom edge **302** and a top edge that has a vertical displacement contour **304** that causes vertical oscillation of the ring cage **108** when rotated. The rings **208** and ring cage **108** are generally cylindrical in shape, with the ring cage **108** narrower at the bottom than at the top and with each successive ring **208** having a slightly greater diameter than the ring **208** immediately beneath it. A sieve **44** sits loosely on top of the each of the rings **208**, each successively lower sieve **44** having a smaller sieve size, i.e., smaller apertures **45**.

[0057] As in the first embodiment, actuating the first stepper motor **22** drives the second gear **18** which turns the first gear **16**, causing the ring cage **208** to rotate. The sieves **44** are held in position in the horizontal plane by means of the elevator post **306**. As the rings **208** rotate, the vertical displacement contour **304** causes the sieves to oscillate in the vertical plane, thereby agitating the sample, which causes it

to break into particles. Depending on particle size, the particles drop down through one or more of the sieves **44**, with each successive sieve **44** having smaller size apertures **45**.

[0058] It is understood that the embodiments described herein are merely illustrative of the present invention. Variations in the construction of the portable self-cleaning aggregate mixtures analysis device may be contemplated by one skilled in the art without limiting the intended scope of the invention herein disclosed and as defined by the following claims.

What is claimed is:

Claim 1: A aggregate mixture analysis device for sorting a sample mixture of aggregate particles into separate particles and analyzing composition of the sample, the device comprising:

- a material analysis chamber;

- a sorting unit mounted within the material analysis chamber, the sorting unit including a vertical oscillator and a graduated sieve unit having a plurality of sieves for sorting the separate particles according to particle size;

- an elevator post that is centered and mounted on the bottom of the material analysis chamber and that extends vertically upward from the bottom of the material analysis chamber through the graduated sieve unit;

- a moisture evacuation unit for evacuating moisture from the material in the material analysis chamber;

- a weighing unit mounted on the elevator post for weighing the particles captured on each sieve of the plurality of sieves; and

- a washing unit coupled to the material analysis chamber for cleansing the material analysis chamber of particle residue from the sample of aggregate mixture;

wherein the sample mixture of aggregate particles is placed on the uppermost sieve and the vertical oscillator actuated, thereby causing the sample of aggregate mixture to separate into the separate particles that then, depending on a particle size of each particle, drop through the graduated sieve unit until the particles are captured on one of the plurality of sieves that has an aperture size smaller than the particle size.

Claim 2: The device of claim 1, wherein the graduated sieve unit includes a plurality of sieve support rings that are circular in shape and correspond in number to the

plurality of sieves, and wherein the sieves sit loosely on top of the sieve support rings, and wherein the sorting unit includes a series of stepped ring mounts for holding the sieve support rings.

Claim 3: The device of claim 2, wherein the vertical oscillator includes an oscillation ring that is cylindrical in shape and has a top edge that is a vertical displacement contour, the oscillation ring being attached to a first motor that forces the oscillation ring to rotate, and wherein rotating the oscillation ring forces the graduated sieve unit to oscillate in the vertical plane.

Claim 4: The device of claim 3, further comprising a second motor that is connected to a threaded rod that extends along a central axis in the elevator post and wherein actuating the second motor causes the threaded rod to rotate in a circular direction and raise or lower the weighing mechanism, depending on the direction of rotation, and wherein, as the weighing mechanism rises up, the elevator shaft lifts each sieve support ring and calculates the weight of the particles in the sieve, transmitting the weight to a computer system that is integrated into the aggregate mixture analysis device.

Claim 5: The device of claim 4, further comprising a washing unit that includes a water tank that is connected to a first water pump and a water filter, the first water pump being connected to a tube that connects to a nozzle located inside the material analysis chamber lid;

a drain pipe that connects to the bottom of the material analysis chamber and extends out from the chamber to a second water pump that is connected to the water filter; and

wherein actuating the first water pump deliver waters from the water tank through the nozzle to spray the inside of the material analysis chamber and wherein

actuating the second pump drains water from the bottom of the material analysis chamber through the filter and into the water tank.

Claim 6: The device of claim 5 wherein the material analysis chamber, moisture evacuation unit, washing unit and computer system are enclosed in a chassis having a lid and wheels.

Claim 7: The device of claim 6, wherein the first motor is affixed to the outside of the material analysis chamber and wherein the first motor is connected to a second gear that connects to a first gear that connects to the oscillation ring, and wherein actuating the motor forces the ring to rotate in a circular direction.

Claim 8: The device of claim 1, wherein the sorting unit comprises a ring cage that is placed in the bottom of the material analysis unit and is connected to a first motor, the ring cage having a plurality of sieve support posts, and a plurality of rings each having a top edge that is a vertical displacement contour and a smooth bottom edge and that are affixed to the sieve support posts; and

wherein the sieves are placed on top of the rings and wherein actuating the first motor causes the ring cage to rotate in a circular motion while the elevator post maintains the sieves in a fixed position in the horizontal plane, thereby causing the sieves to oscillate in the vertical plane.

Claim 9: A method of analyzing a sample of an aggregate mixture, the method comprising the steps of:

- a) providing a self-cleaning analysis unit that includes a graduated sieve unit, a vertical oscillator, a weighing unit, a computer and display unit, a moisture evacuation unit, and a washing unit, all incorporated into the portable, self-cleaning analysis unit;

- b) placing the sample into graduated sieve unit;
- c) weighing the sample to obtain a wet weight;
- d) evacuating moisture from the graduated sieve unit to obtain a dry weight;
- e) actuating the vertical oscillator to force the sample to separate into particles that then through the graduated sieve unit until the particles land on one of a plurality of sieves within the graduated sieve unit;
- f) calculating a weight and a composition of each of the plurality of sieves;
- g) removing the particles from the graduated sieve unit; and
- h) actuating the washing unit to cleanse the graduated sieve unit of all particle residue.

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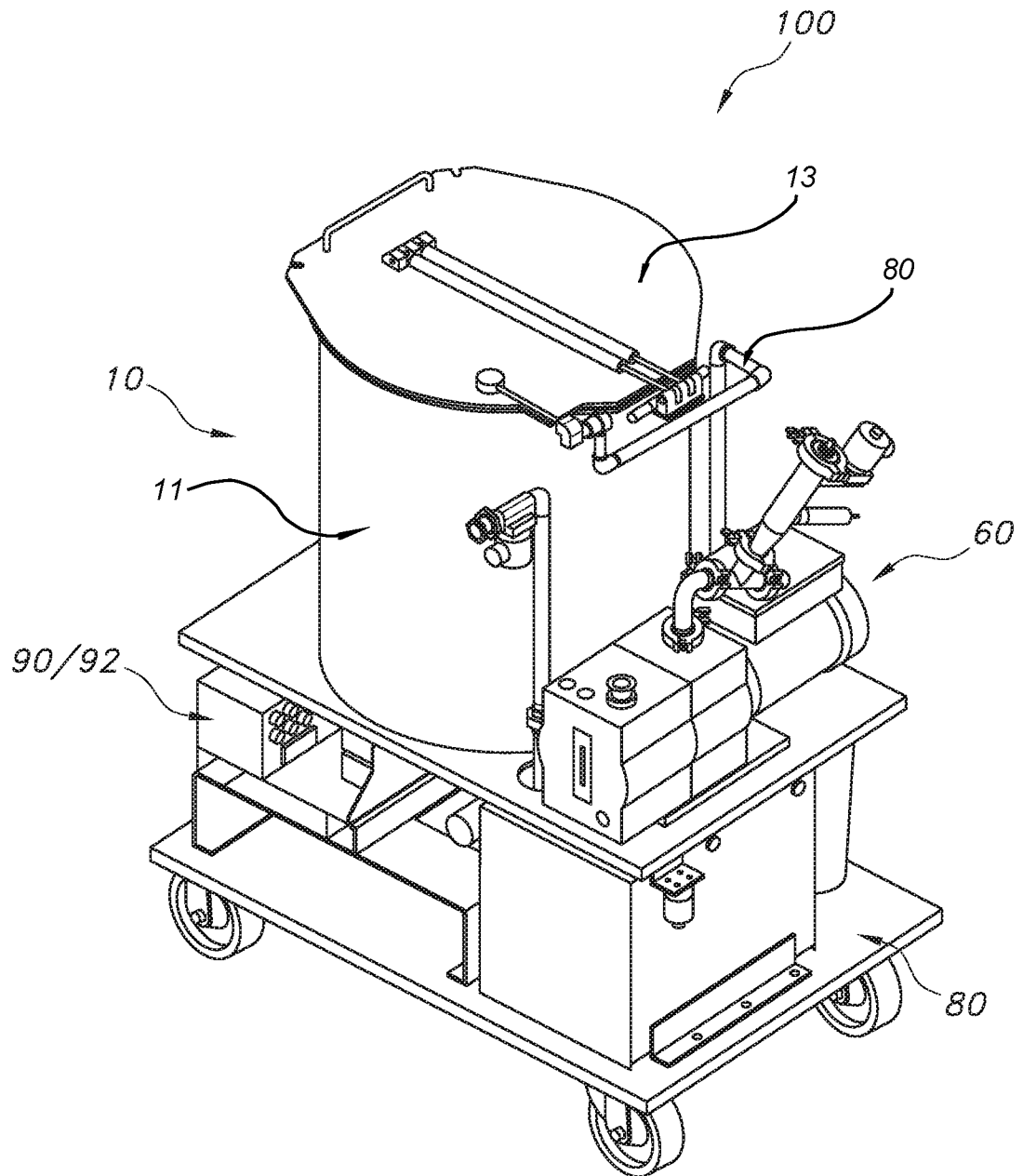


FIG. 1

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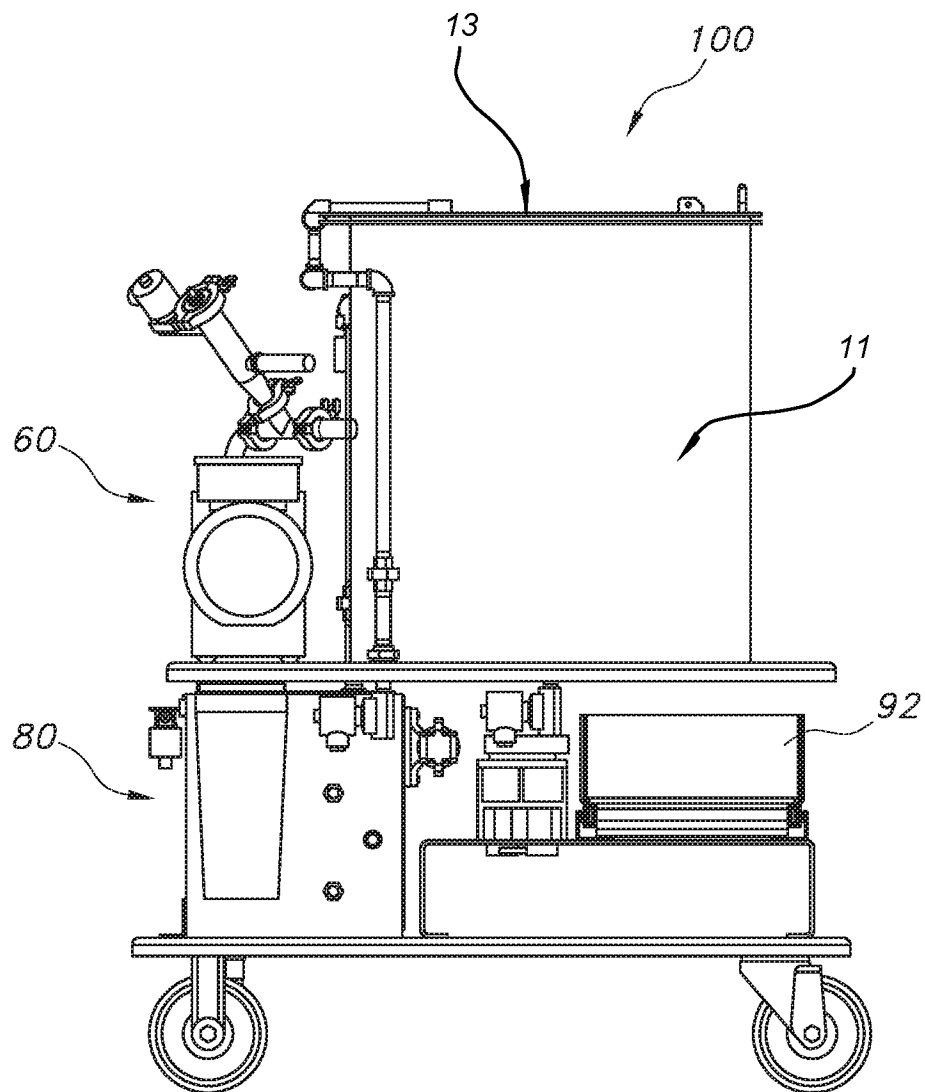


FIG. 2

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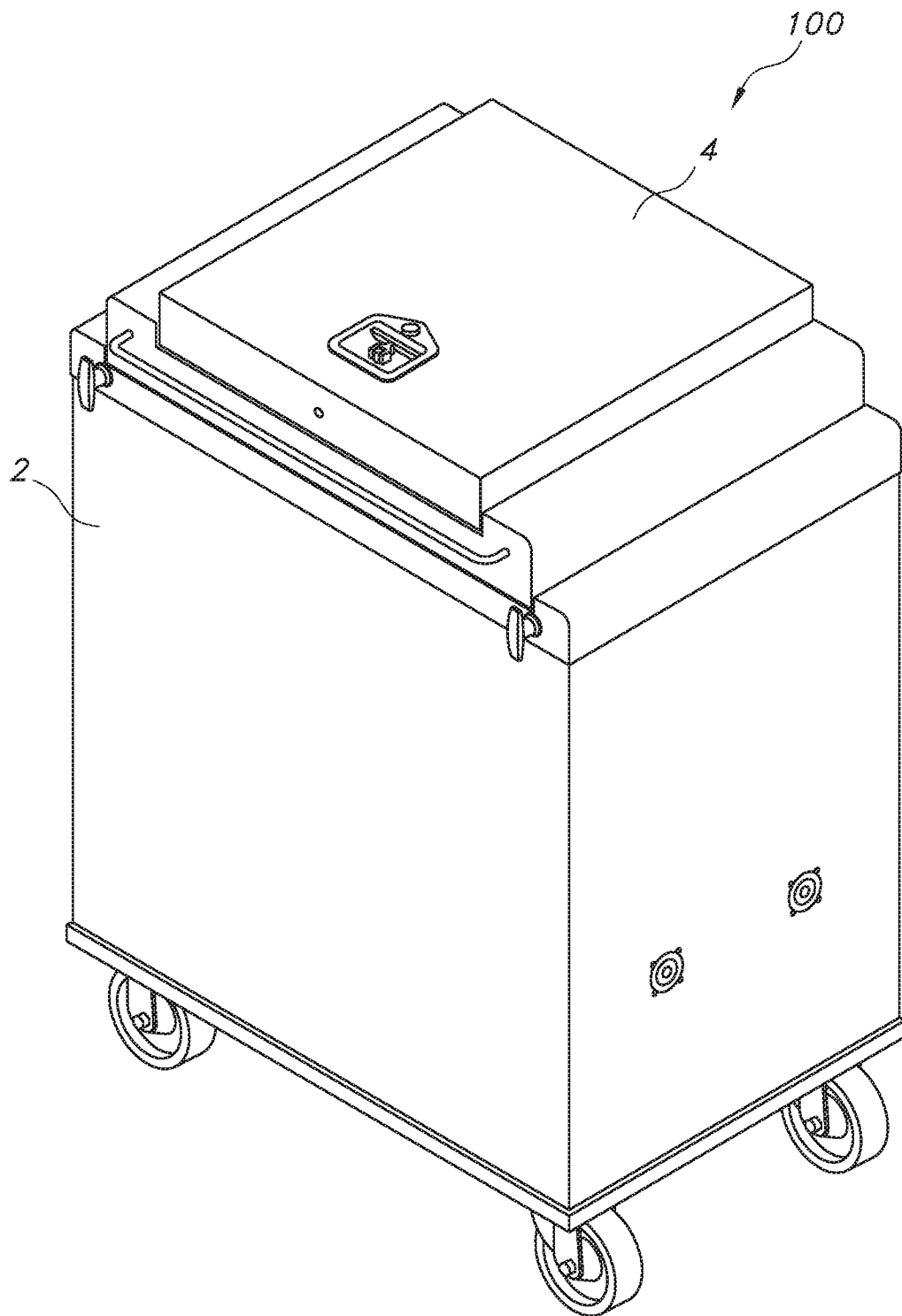


FIG. 3

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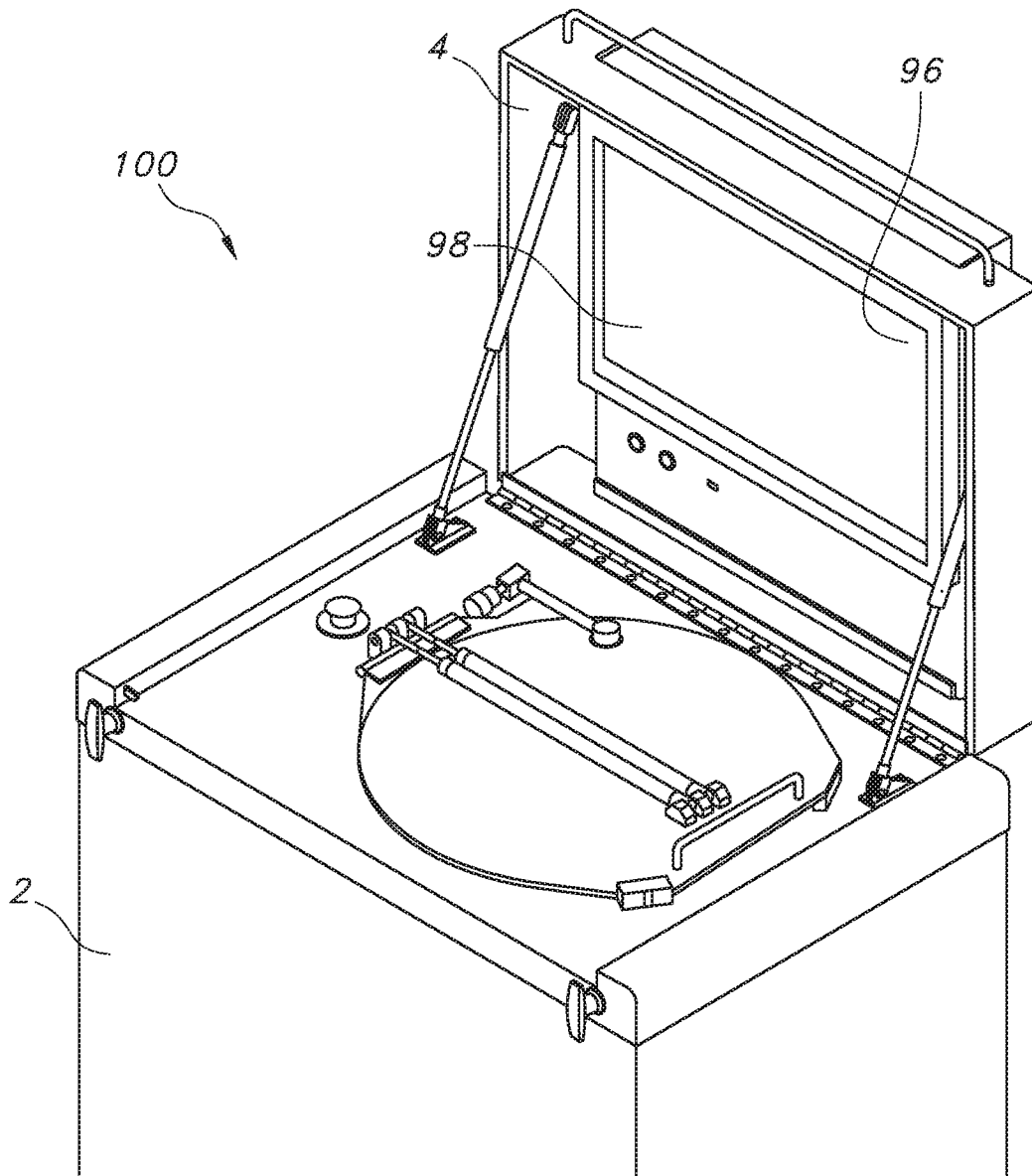


FIG. 4

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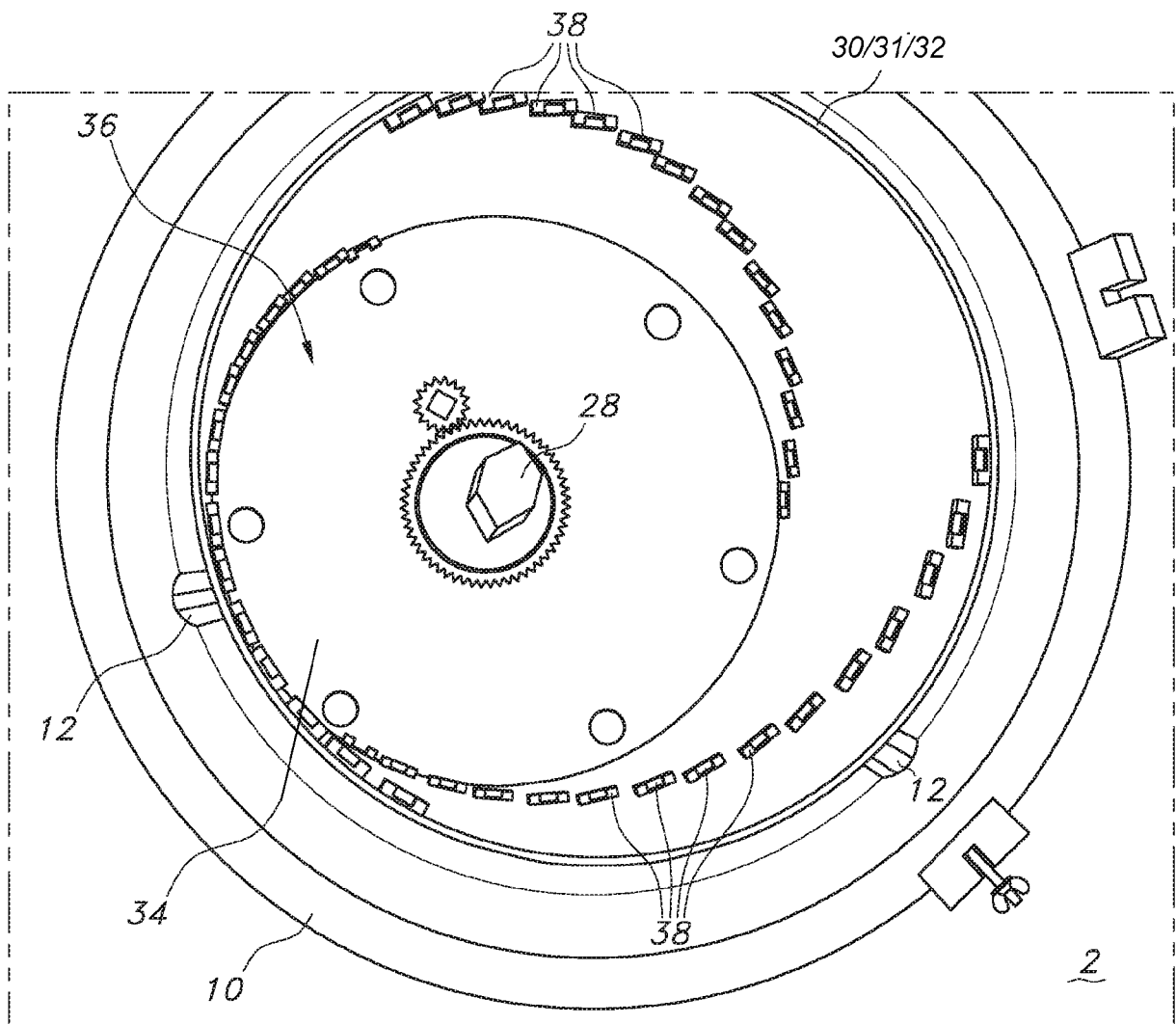


FIG. 5

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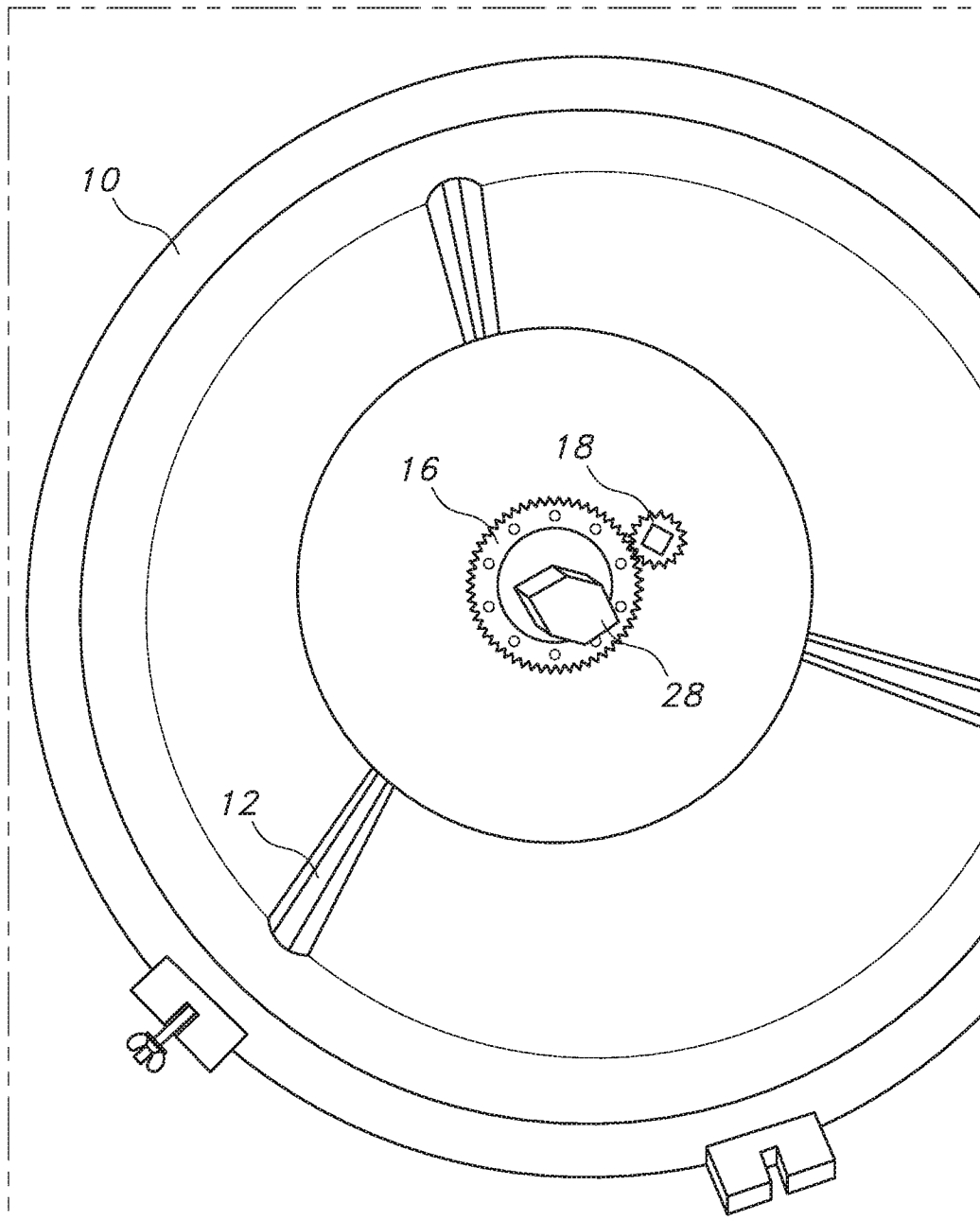


FIG. 6

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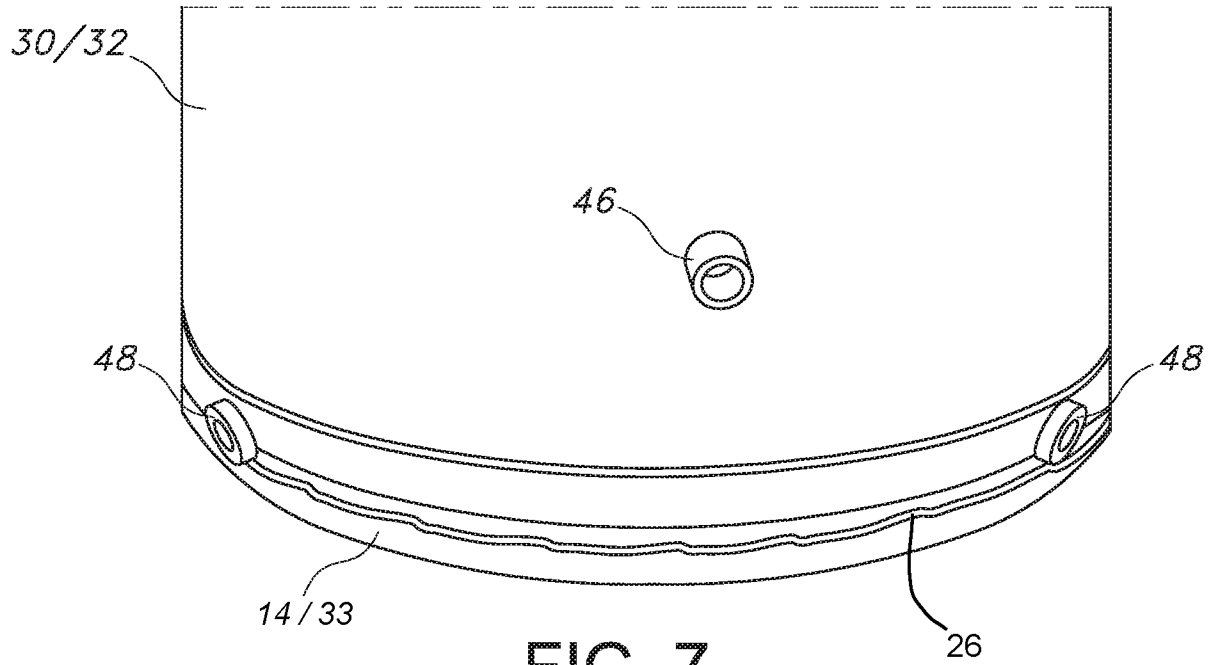


FIG. 7

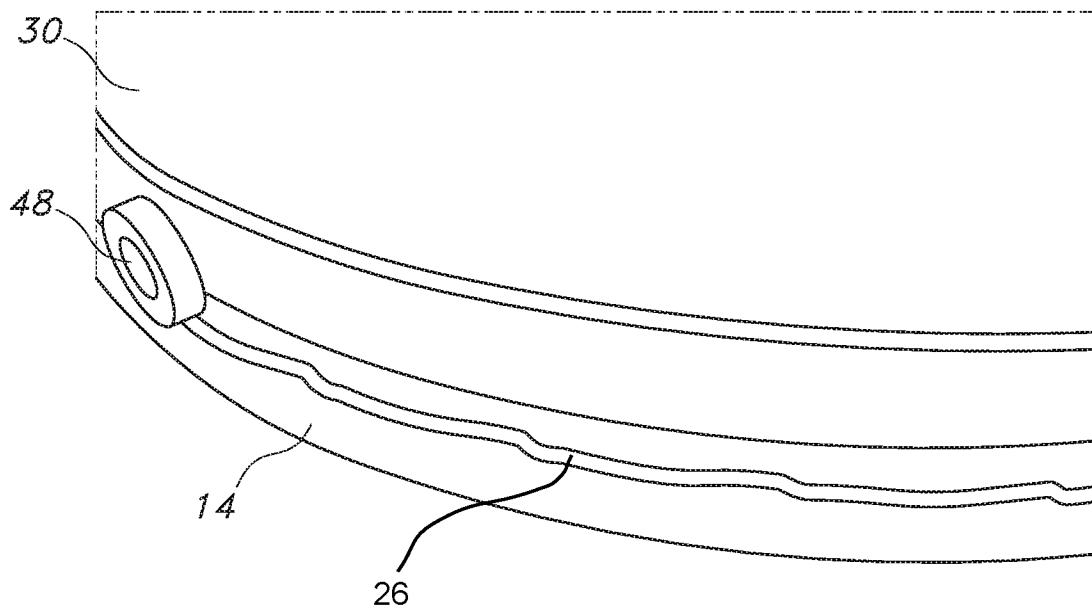


FIG. 8

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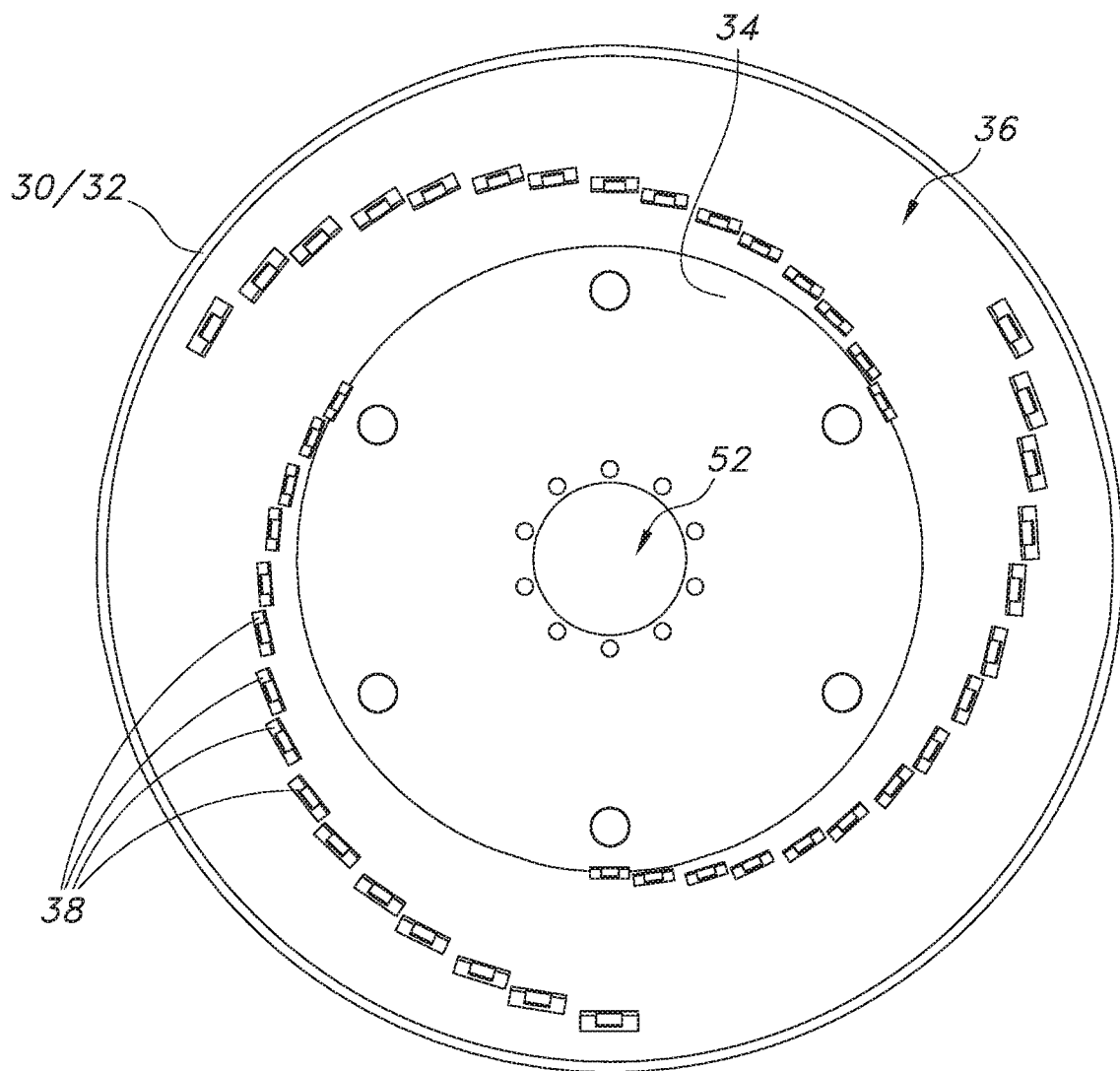


FIG. 9

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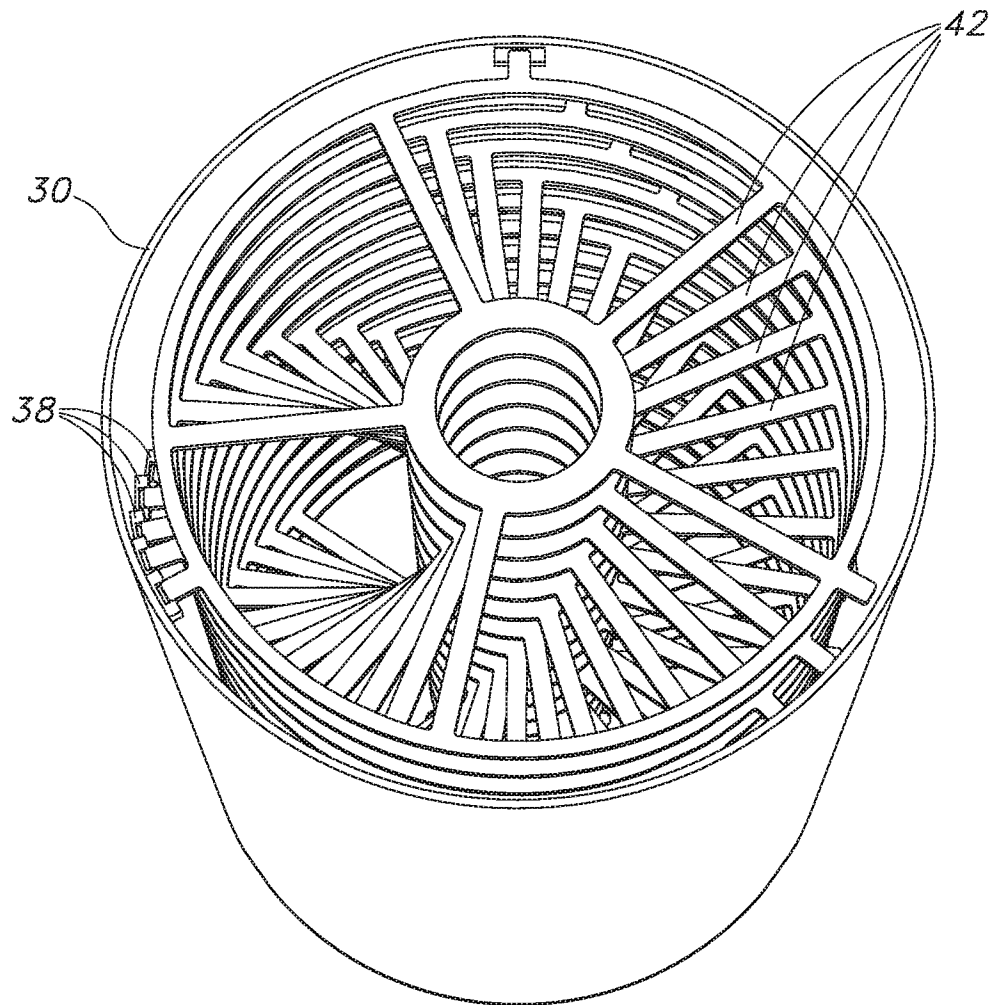


FIG. 10

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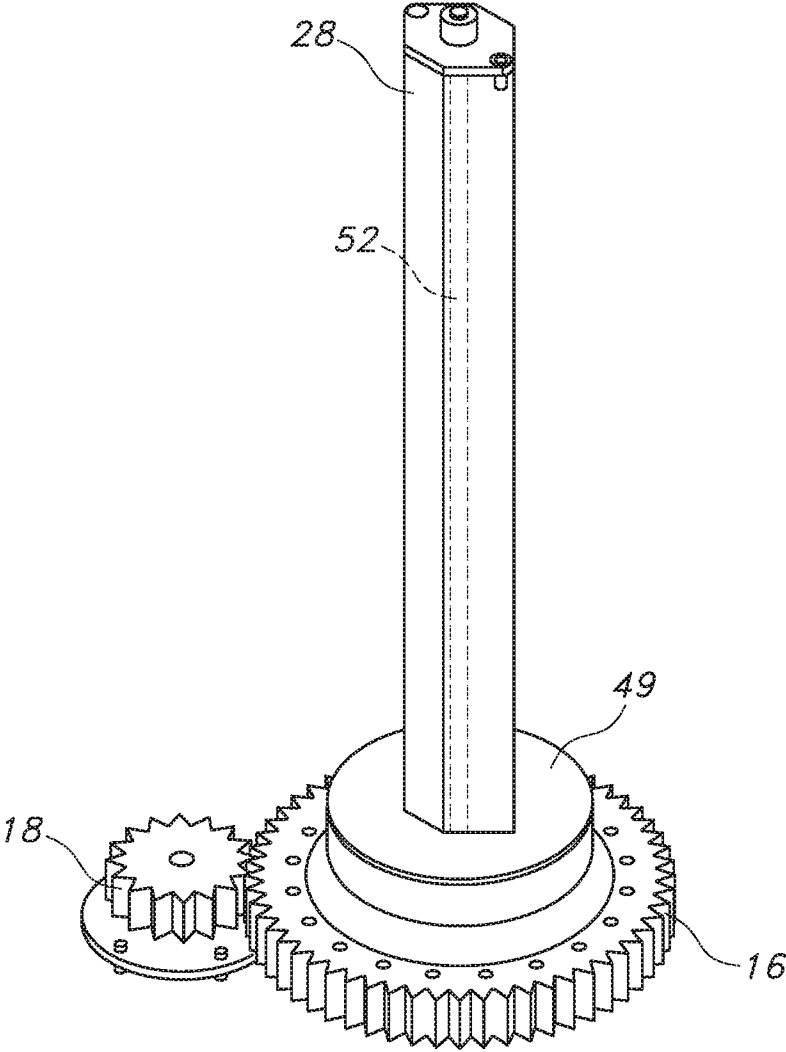


FIG. 11

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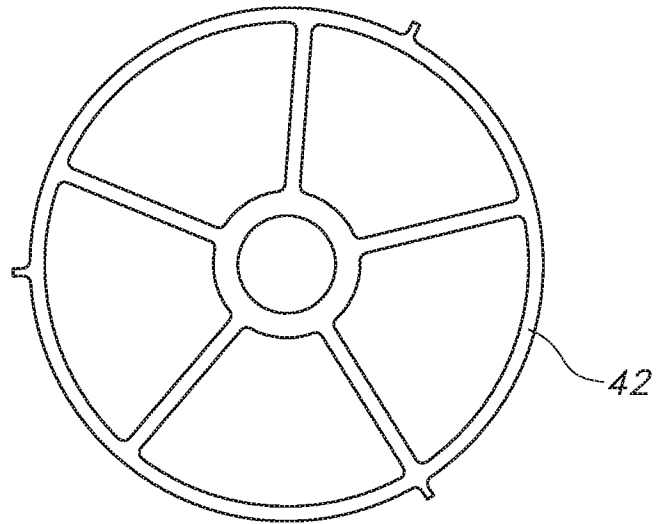


FIG. 12

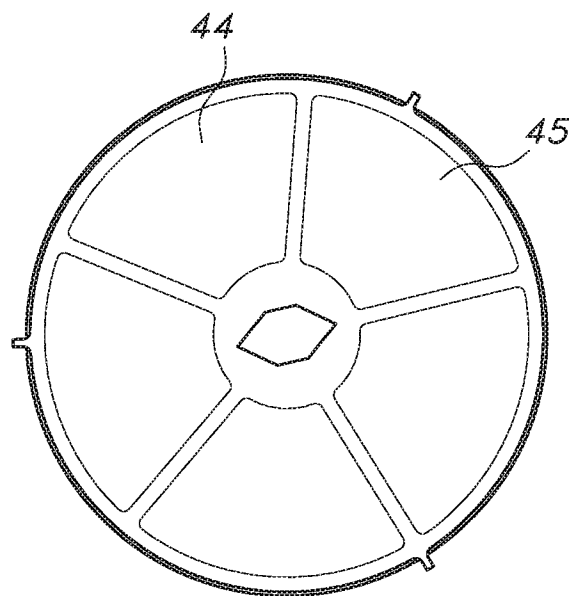


FIG. 13

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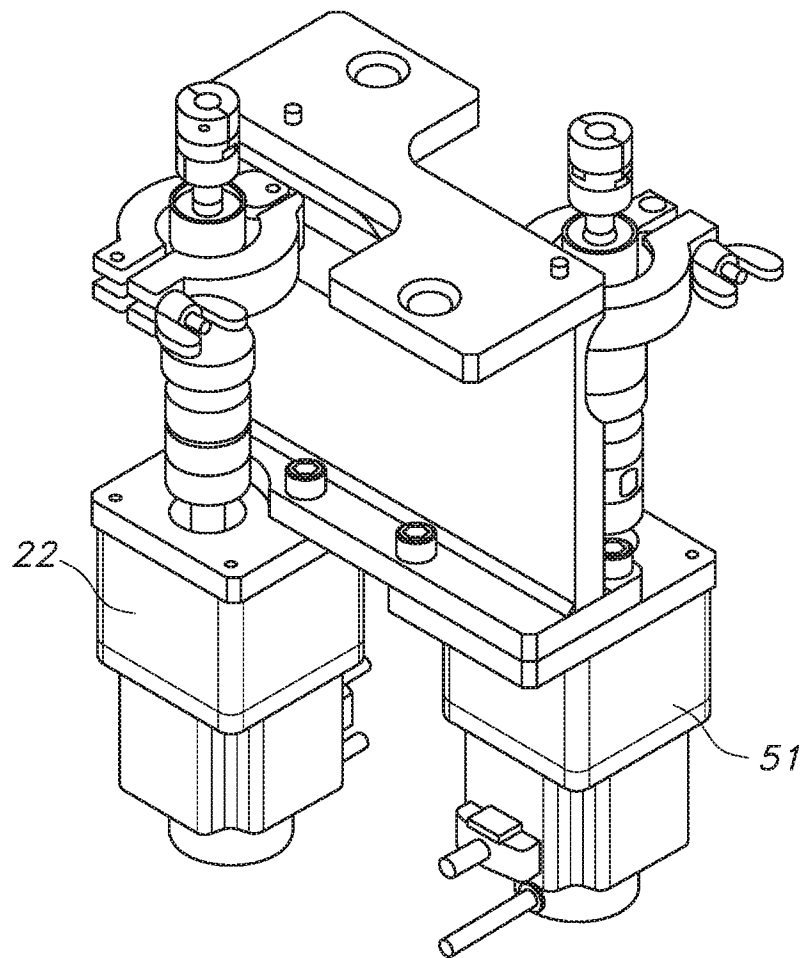


FIG. 14

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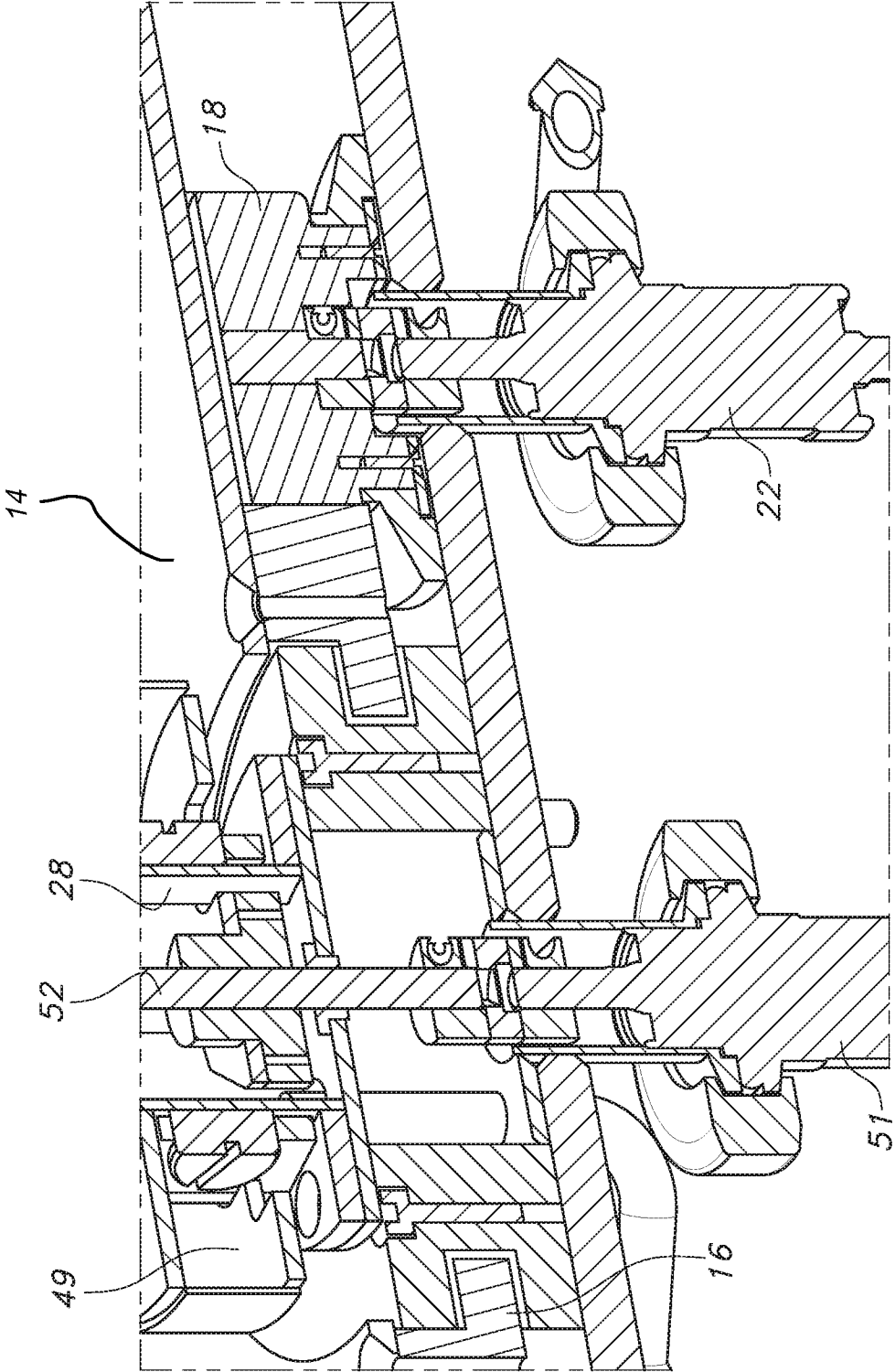


FIG. 15

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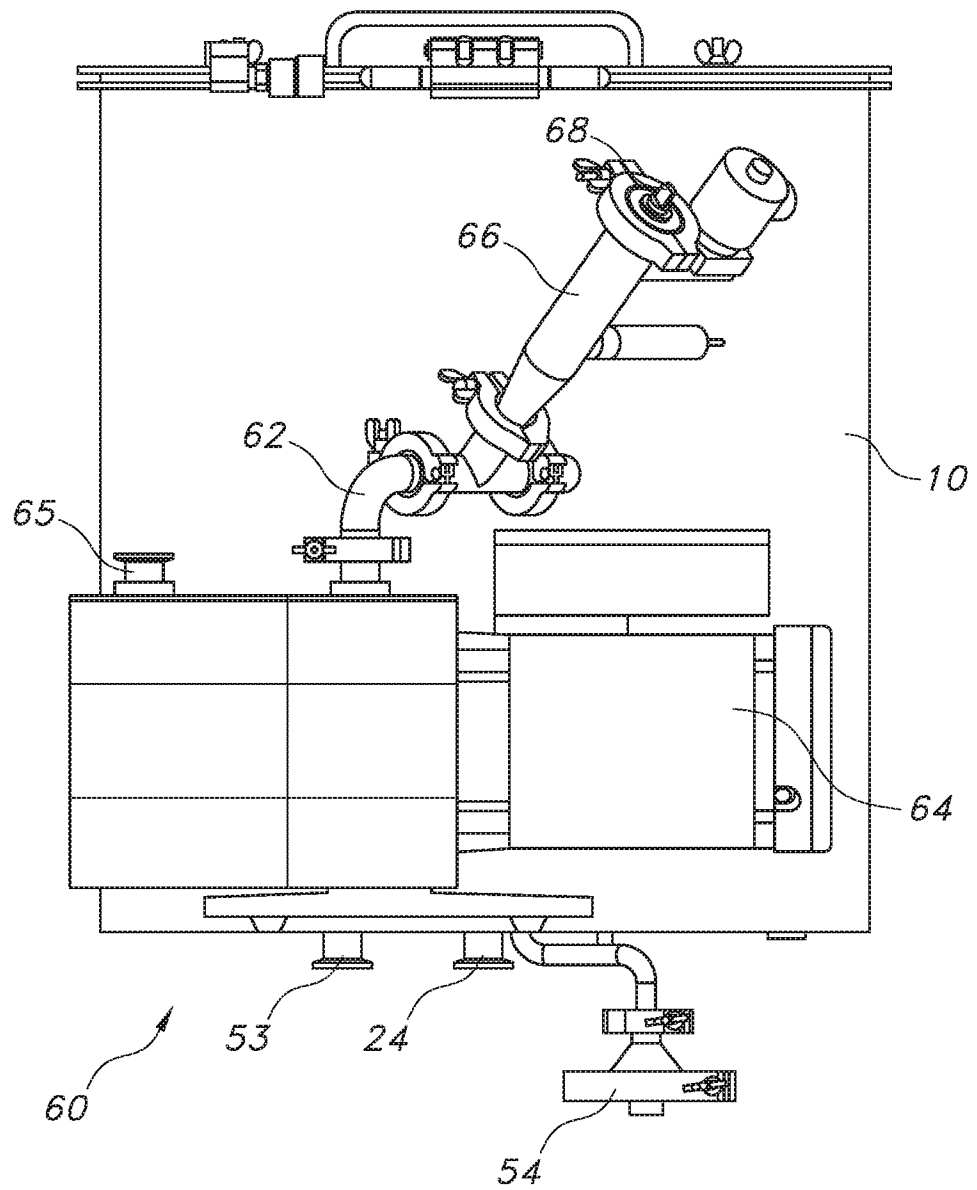


FIG. 16

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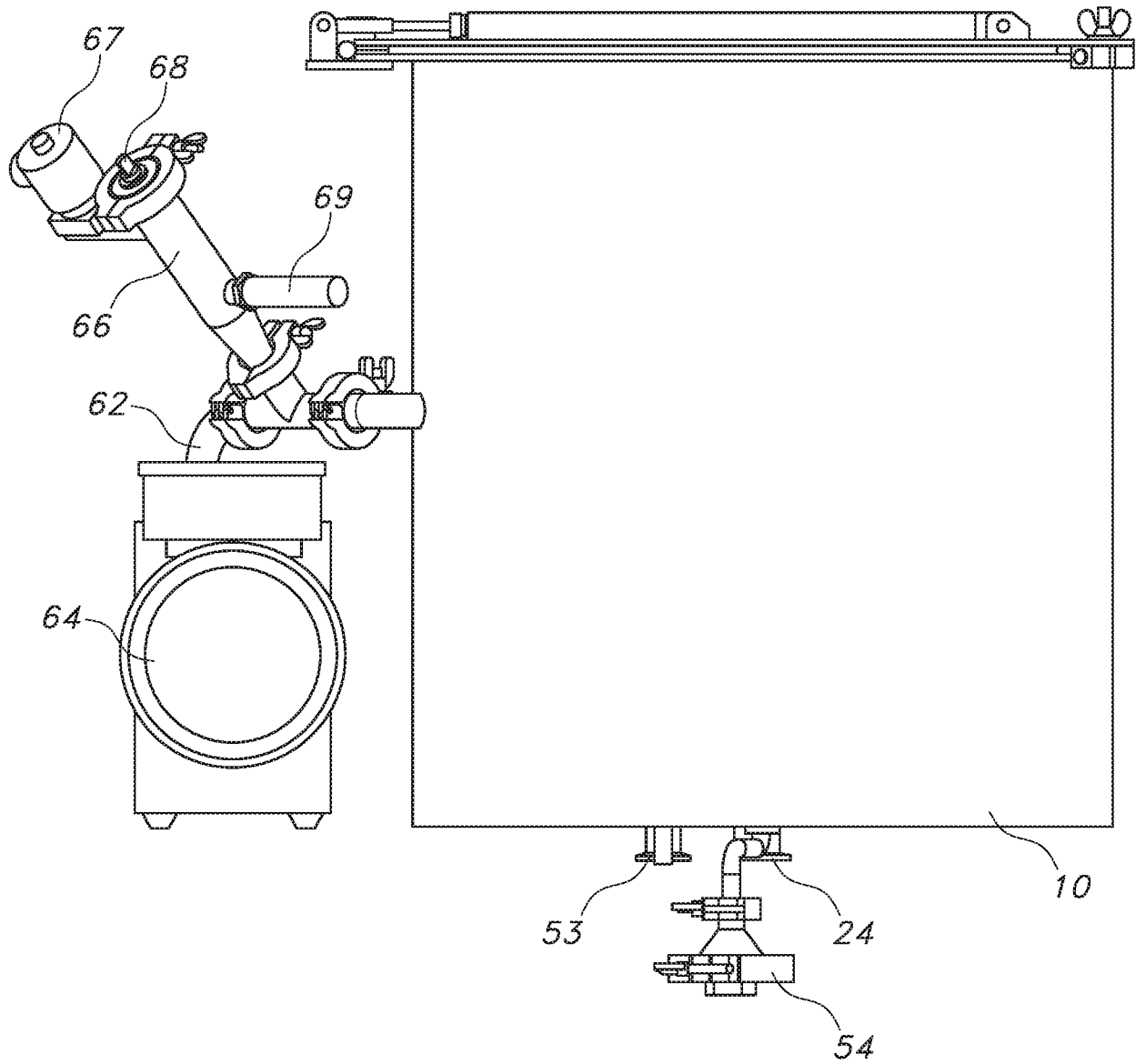


FIG. 17

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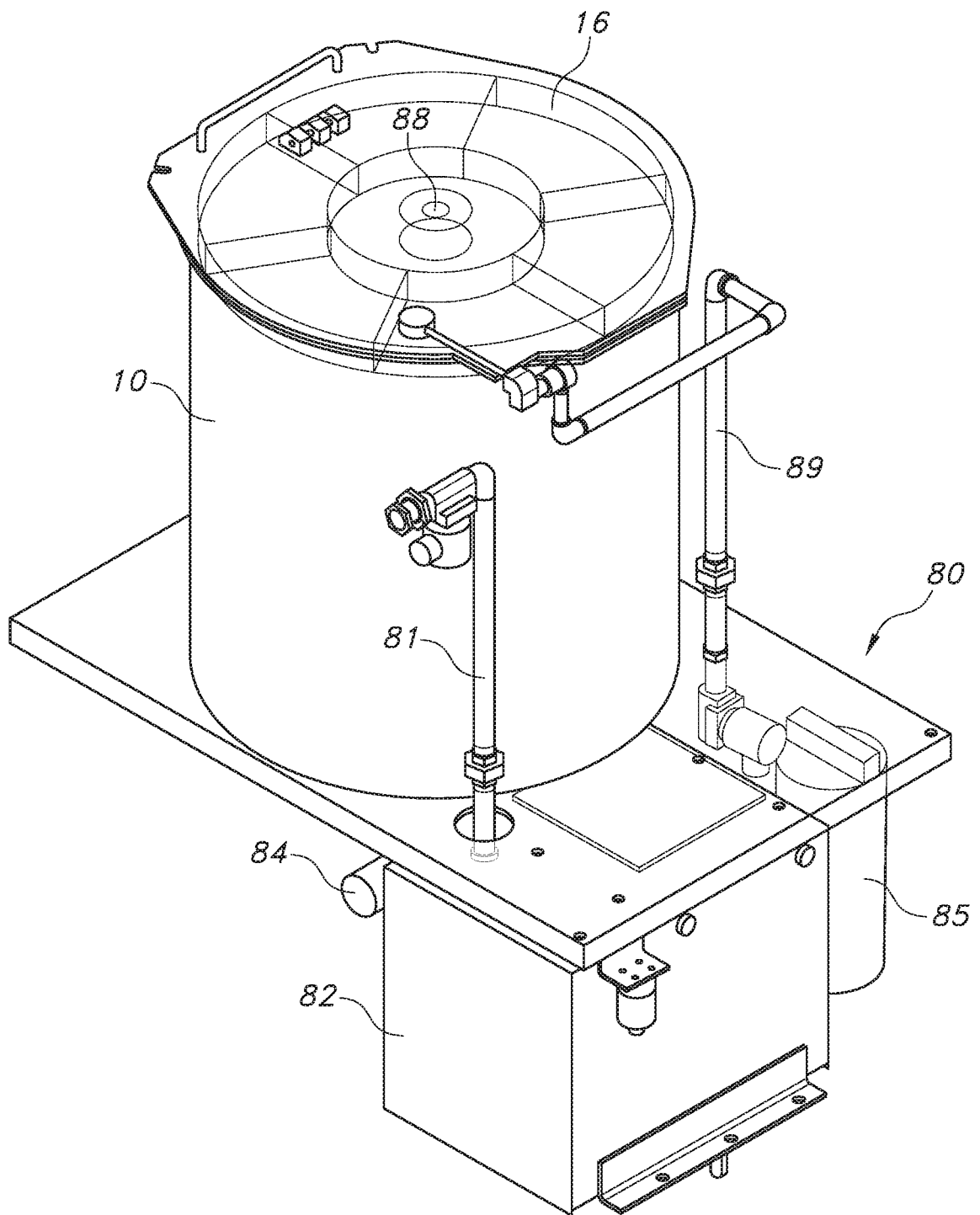


FIG. 18

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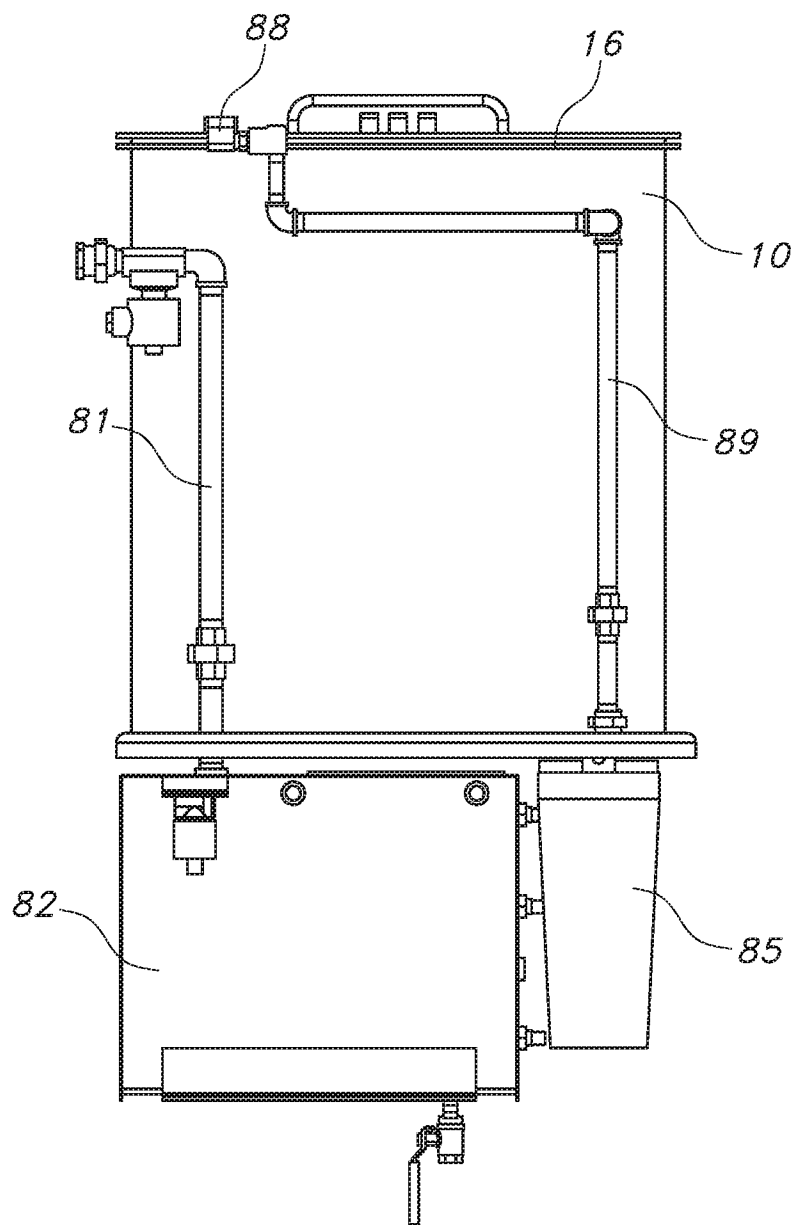


FIG. 19

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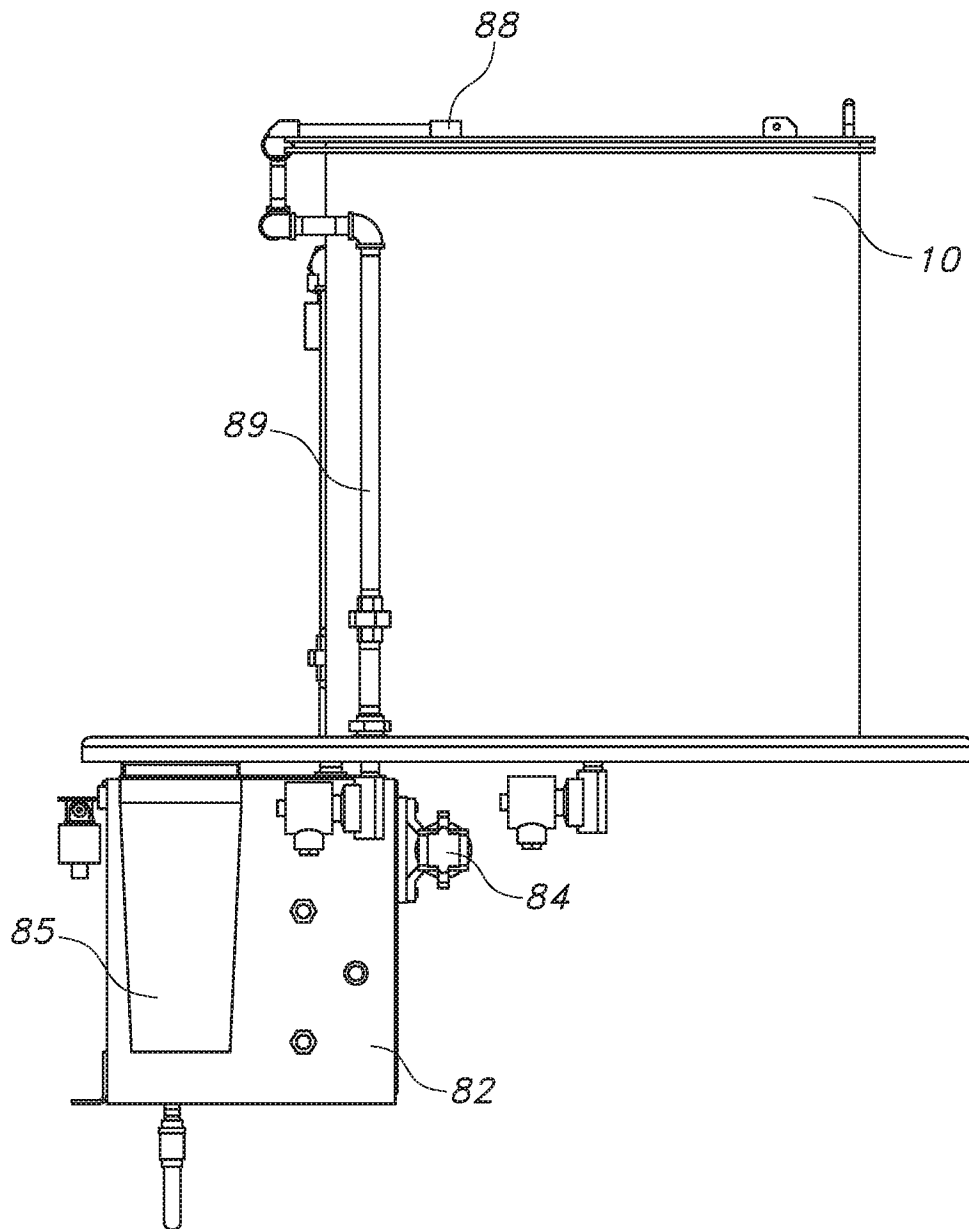


FIG. 20

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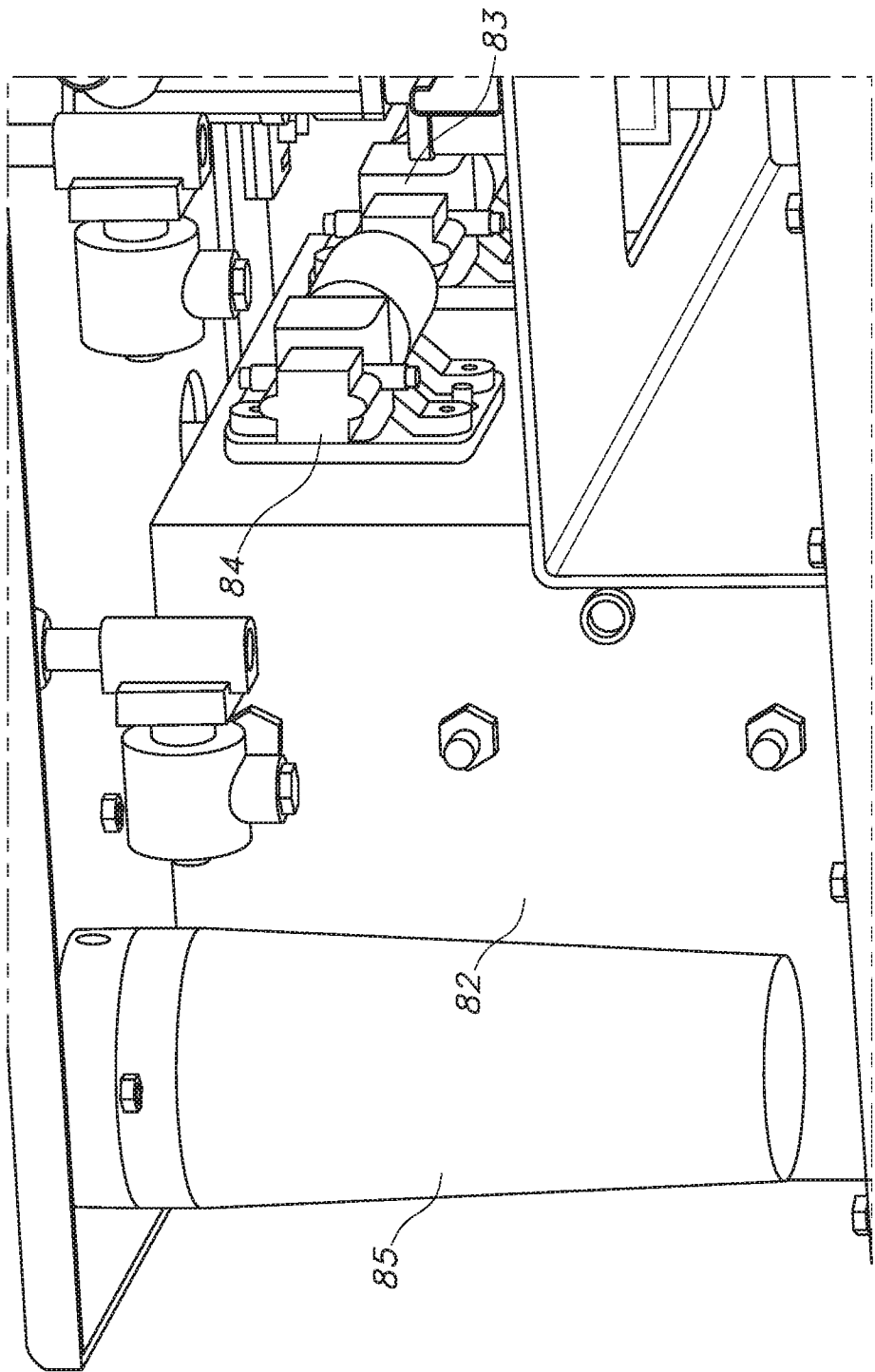


FIG. 21

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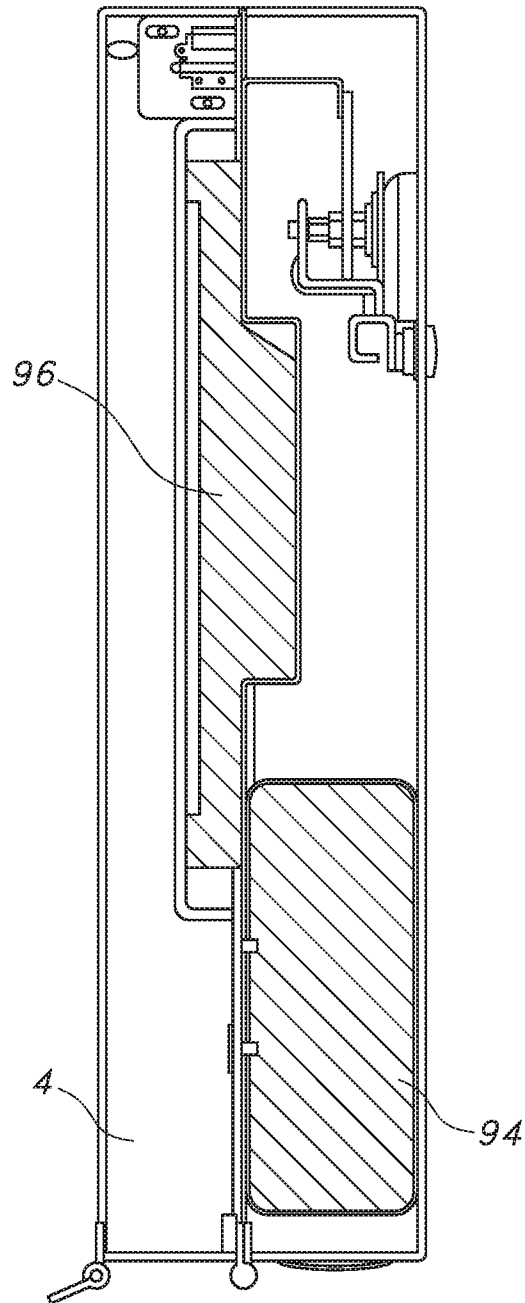


FIG. 22

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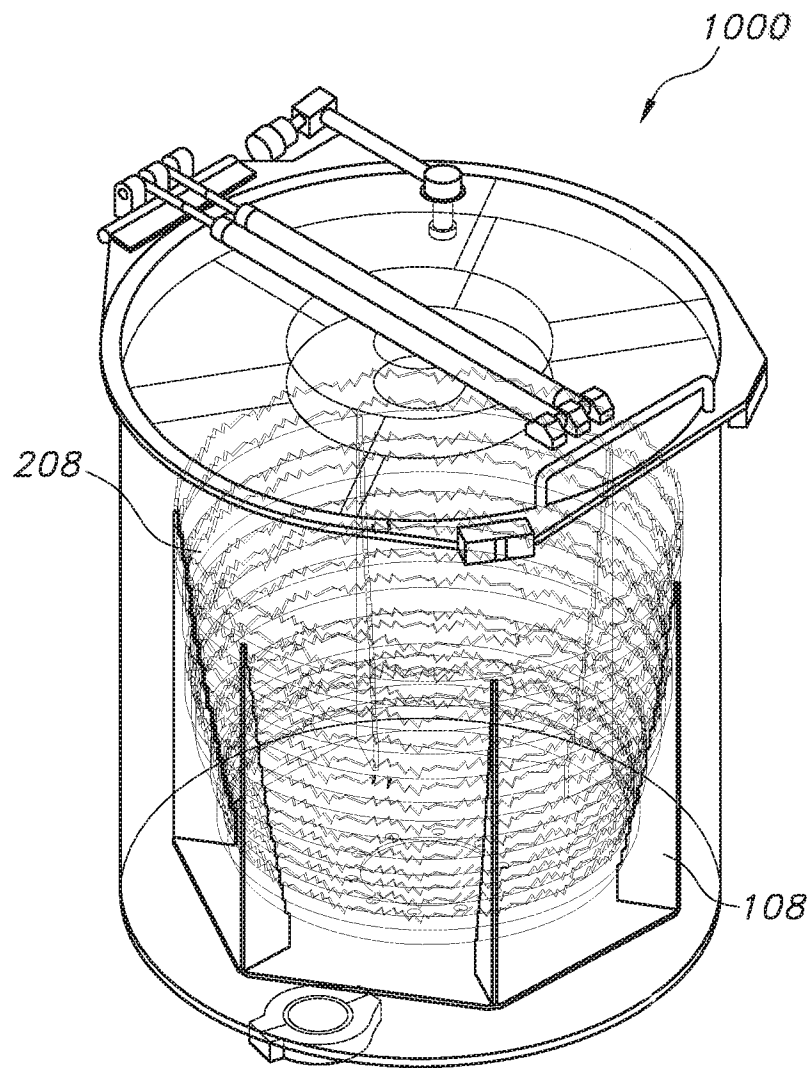


FIG. 23

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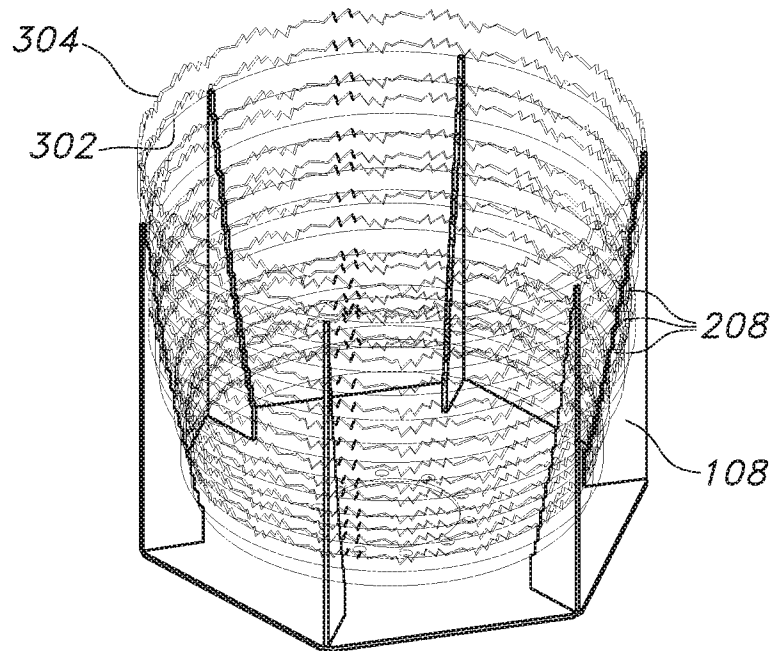


FIG. 24

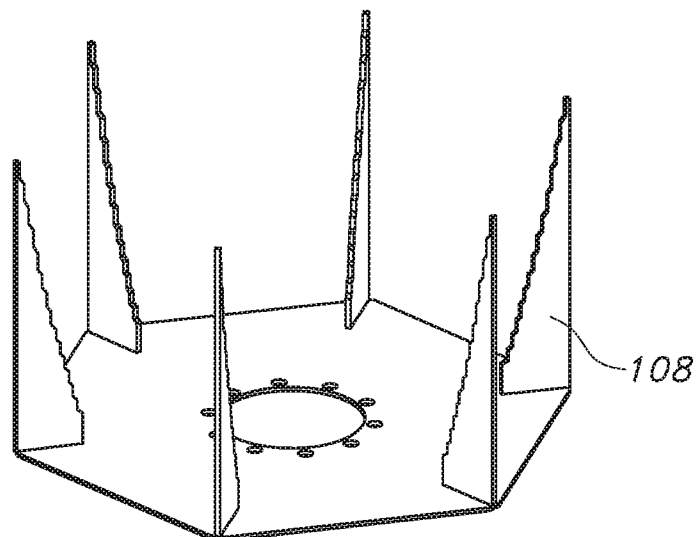


FIG. 25

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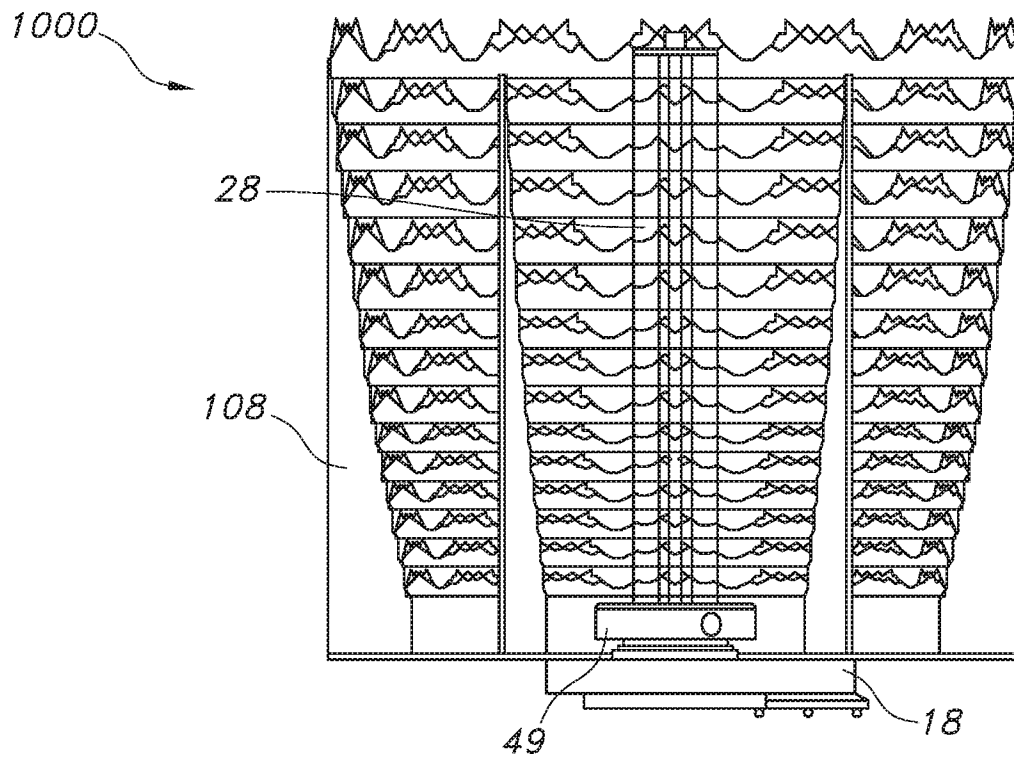


FIG. 26

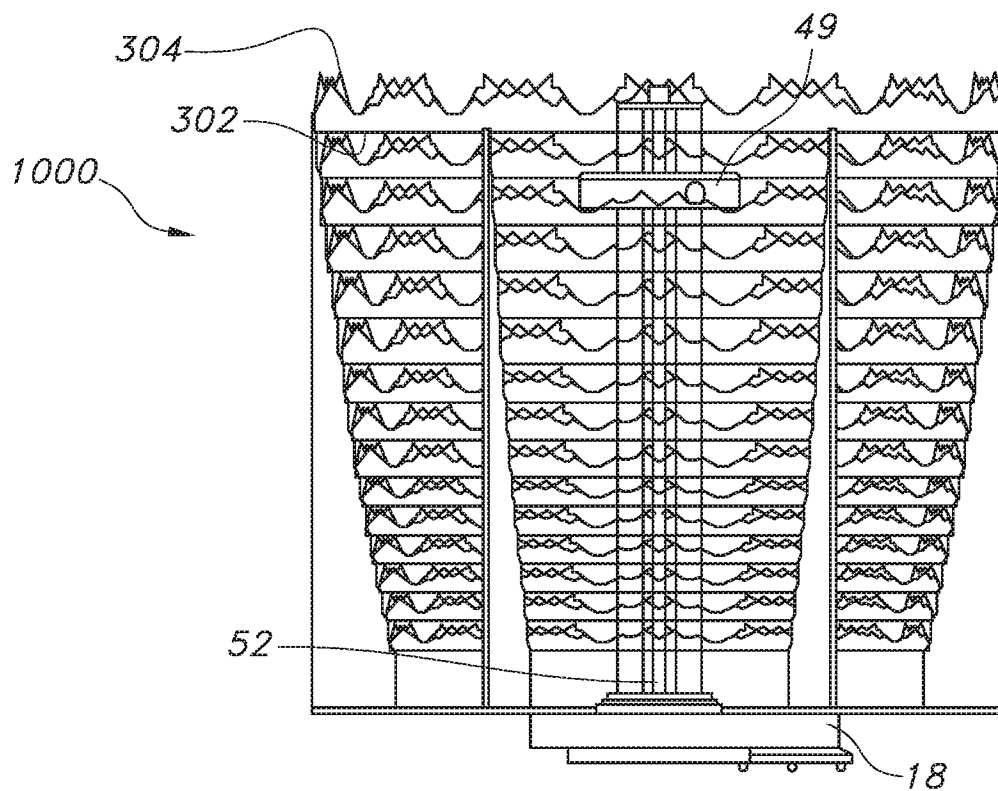


FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/019043**A. CLASSIFICATION OF SUBJECT MATTER****G01N 1/34(2006.01)i, G01N 1/38(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01N 1/34; B02C 13/06; B07B 1/50; G01N 33/00; G01N 33/38; B02C 23/08; B02C 13/286; B07B 1/22; B03B 5/28; B03B 5/56; G01N 1/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: aggregate, particle, mix, clean, oscillation, motor, separate, sieve, portable, sort, chamber and contour

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0011110 A1 (COSTONIS, JOEL F.) 17 January 2008	1-2,9
A	See paragraphs [0032]-[0050] and figures 1, 4, 7.	3-8
Y	KR 10-2007-0052104 A (GEUMGANG CO., LTD.) 21 May 2007	1-2,9
A	See paragraphs [0075], [0089] and figures 3-4.	
A	KR 10-1244089 B1 (GEUMGANG CO., LTD. et al.) 22 March 2013	1-9
A	See abstract; paragraphs [0031]-[0034] and figures 2-3.	
A	US 5082553 A (TANII, MASAO) 21 January 1992	1-9
A	See abstract; column 4, lines 58-68 and figure 3.	
A	US 2014-0353217 A1 (PRESBY PATENT TRUST) 04 December 2014	1-9
A	See abstract; paragraph [0022] and figure 1.	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 May 2017 (10.05.2017)

Date of mailing of the international search report

10 May 2017 (10.05.2017)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/019043

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 2012-109230 A3	08/11/2012
		WO 2012-109230 A4	27/12/2012