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(54) **Title:** CONTINUOUS FLOW SEED TREATER

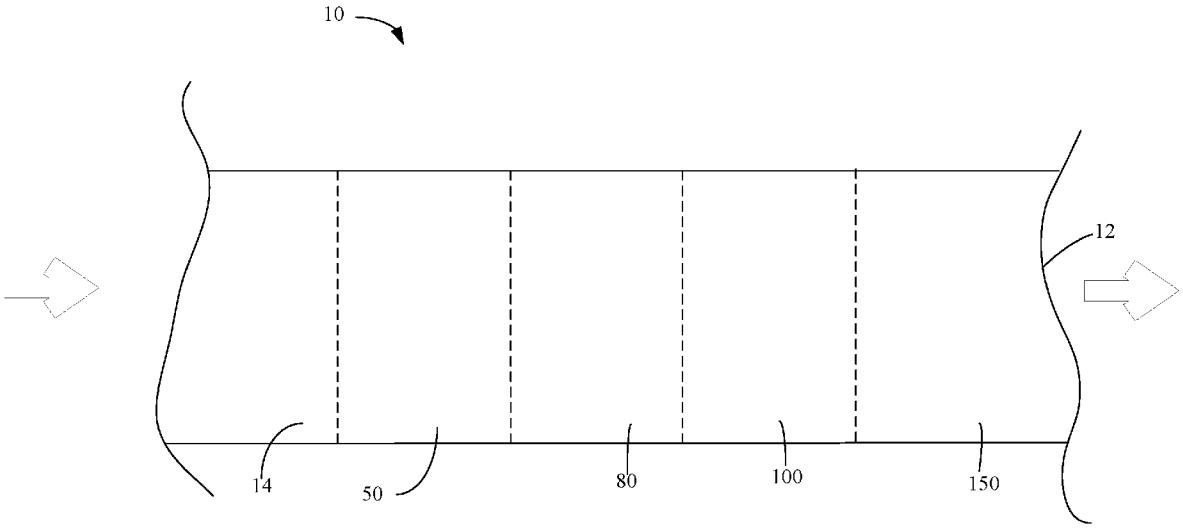

FIG. 1A

(57) **Abstract:** A seed treatment flow path is configured to receive seed and seed treatment and discharge a combination of seed and seed treatment and a valve is configured for controlling seed movement in the flow path, wherein the valve includes a gate operably configured for opening and closing a gate opening. The seed treater also includes a liquid disperser for dispersing at least one liquid type of seed treatment in the flow path, wherein the liquid disperser is disposed downstream of the valve. The seed treater may also include a solid disperser for dispersing at least one solid type of seed treatment in the flow path, wherein the solid disperser is disposed downstream of the valve. The seed treater also includes an actuatable housing for actuating the seed treatment flow path for combinating the inputs into the flow path.

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TITLE: CONTINUOUS FLOW SEED TREATER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 119 to provisional application Serial No. 63/274,594 filed November 2, 2021, which is incorporated by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to a continuous flow seed treater. More particularly, but not exclusively, the present disclosure relates to a continuous flow seed treater for laboratory studies and testing.

BACKGROUND

Commercial, large volume, seed treaters, whether vertical or otherwise, are known; however, such seed treaters do not provide an efficient, economical, and predictable research, testing, and studies platform to assess the viability and scalability of improving seed treatment processes and seed treatment slurries in view of the all the accompanying factors and considerations that impact the study and further development of improved seed treatment processes and seed treatment slurries using known systems and technologies.

Therefore, what is needed is a continuous flow seed treater that addresses the deficiencies in seed treatment processes and slurries along with the industry inhibitors for the continued development and study of seed treatment processes and slurries.

SUMMARY

Therefore, it is a primary object, feature, or advantage of the present disclosure to improve over the state of the art.

It is a further object, feature, or advantage of the present disclosure to provide a continuous seed treater that may be configured to address at least one or more conditions for a seed, a seed treatment, an environment.

It is a still further object, feature, or advantage of the present disclosure to provide a seed treater that is configured to account for seed treatment loss and seed treatment residual in the tumbler.

Another object, feature, or advantage is to provide a seed treater that is configured with a non-planar gate that is electromechanically actuated through a gate opening to vary the seed flow rate through rate while maintaining continuous flow of seed.

Yet another object, feature, or advantage is to provide a seed treater that is configured with a controller for electromechanically controlling the seed flow rate, the liquid dispersion rate, and the solid dispersion rate based at least on one or more conditions.

In at least one exemplary aspect, a seed treater is disclosed. The seed treater includes, for example, a seed treatment flow path configured to receive seed and seed treatment and discharge a combination of seed with seed treatment and a valve in the seed treatment flow path for controlling seed movement, wherein the valve controls a throughput rate of seed introduced into the seed treatment flow path. The seed treater also includes a liquid disperser in the seed treatment flow path for dispersing at least one liquid type of seed treatment at a liquid dispersion rate, wherein the liquid disperser is disposed downstream of the valve. The seed treater may also include a solid disperser in the seed treatment flow path for dispersing at least one solid type of seed treatment at a solid dispersion rate, wherein the solid disperser is disposed downstream of the liquid disperser. The seed treater also includes an actuatable housing within the seed treatment flow path having a rate of operation and an adjustable orientation, wherein the actuatable housing is downstream of the valve for uniformly distributing the at least one liquid type of seed treatment, the at least one solid type of seed treatment, and seed for creating the combination of seed with seed treatment.

In at least one other exemplary aspect, a seed treatment method is disclosed. The seed treatment method includes, for example, such steps as providing a seed treatment flow path configured for receiving seed and seed treatment and discharging a combination of seed with seed

treatment and a valve having a gate and gate opening and controlling a throughput rate of seed into the seed treatment flow path with a valve, wherein at least a portion of the gate is disposed within the gate opening in both open and closed positions. The method also includes dispersing at least one liquid type of seed treatment at a liquid dispersion rate into the seed treatment flow path downstream of the valve. The method may also include dispersing at least one solid type of seed treatment at a solid dispersion rate into the seed treatment flow path downstream of the valve and distributing the combination of seed, the at least one liquid type of seed treatment, and the at least one solid type of seed treatment at a rate of distribution within the seed treatment flow path.

In at least another aspect, a system for continuous treatment of seed is disclosed. The system includes, for example, a seed treatment flow path configured to receive seed and seed treatment and discharge a combination of seed with seed treatment, a valve operably configured to introduce a continuous flow of seed into the seed treatment flow path at a seed throughput rate, and a liquid disperser operably configured to introduce at least one liquid type of seed treatment into the seed treatment flow path at a liquid dispersion rate. The system may also include a solid disperser operably configured to introduce at least one solid type of seed treatment into the seed treatment flow path at a solid dispersion rate and a controller operably configured to control the seed throughput rate, the liquid dispersion rate, and the solid dispersion rate based at least on one or more conditions selected at least from a type of seed and a type of seed treatment.

One or more of these and/or other objects, features, or advantages of the present disclosure will become apparent from the specification and claims that follow. No single aspect need provide each and every object, feature, or advantage. Different aspects may have different objects, features, or advantages. Therefore, the present disclosure is not to be limited to or by any objects, features, or advantages stated herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrated embodiments of the disclosure are described in detail below with reference to the attached drawing figures, which are incorporated by reference herein.

FIGS. 1A-1C are pictorial representations of various configurations a seed treatment flow path in accordance with exemplary aspects of the present disclosure.

FIG. 2 is a perspective view of a seed treater in accordance with an illustrative aspect of the present disclosure.

FIG. 3 is an end perspective view of a seed treater in accordance with an illustrative aspect of the present disclosure.

FIG. 4 is another end perspective view of a seed treater in accordance with an illustrative aspect of the present disclosure.

FIG. 5 is an elevation view of an end of a seed treater in accordance with an illustrative aspect of the present disclosure.

FIG. 6 is an end elevation view of a baffle of the seed treatment flow path in accordance with an illustrative aspect of the present disclosure.

FIG. 7 is an elevation view of a seed hopper, seed flow control system, and seed treatment flow path in accordance with an illustrative aspect of the present disclosure.

FIG. 8 is a perspective view of a seed flow control system and seed treatment flow path in accordance with an illustrative aspect of the present disclosure.

FIG. 9 is a perspective view of a seed flow control system, tumbling system, and seed treatment flow path in accordance with an illustrative aspect of the present disclosure.

FIG. 10 is a top perspective view of a cradle and drive system of the tumbling system in accordance with an illustrative aspect of the present disclosure.

FIG. 11 is an elevation view of a tilt control system of the tumbling system in accordance with an illustrative aspect of the present disclosure.

FIG. 12 is a perspective view of a tilt control system of the tumbling system in accordance with an illustrative aspect of the present disclosure.

FIG. 13 is a perspective view of a control component of the control system for the cradle and drive system in accordance with an illustrative aspect of the present disclosure.

FIG. 14 is a side perspective view of a tumbling system and a treater framework in accordance with an illustrative aspect of the present disclosure.

FIG. 15 is an elevation view of a pumping system of the liquid seed treater system in accordance with an illustrative aspect of the present disclosure.

FIG. 16 is a perspective view of a plumbing configuration of the liquid seed treater system in accordance with an illustrative aspect of the present disclosure.

FIG. 17 is another elevation view of a plumbing configuration of the liquid seed treater system in accordance with an illustrative aspect of the present disclosure.

FIG. 18 is a perspective view of a plumbing configuration and atomizing system in accordance with an illustrative aspect of the present disclosure.

FIG. 19 is a perspective view of a controller of the controller system in accordance with an illustrative aspect of the present disclosure.

FIG. 20 is a top perspective view of actuator system for the seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 21 is a top perspective view of a valve for the seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 22 is a top perspective view of a gate, gate surface, and gate opening for the valve for the seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 23 is another top perspective view of a gate, gate surface, and gate opening for the valve for the seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 24 is an end elevation view of a seed treater and seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 25 is a side elevation view of a seed treater and seed flow control system in accordance with an illustrative aspect of the present disclosure.

FIG. 26 is a top view of a tumbler in accordance with an illustrative aspect of the present disclosure.

FIG. 27 is an end view of a tumbler in accordance with an illustrative aspect of the present disclosure.

FIG. 28 is another end view of a tumbler in accordance with an illustrative aspect of the present disclosure.

FIG. 29 is another side view of a tumbler in accordance with an illustrative aspect of the present disclosure.

FIG. 30 is a front view of a controller and controller housing in accordance with an illustrative aspect of the present disclosure.

FIG. 31 is a side view of a controller and controller housing in accordance with an illustrative aspect of the present disclosure.

FIG. 32 is a top view of a treater framework in accordance with an illustrative aspect of the present disclosure.

FIG. 33 is a side view of a treater framework in accordance with an illustrative aspect of the present disclosure.

FIG. 34 is an end view of a treater framework in accordance with an illustrative aspect of the present disclosure.

FIG. 35 is another end view of a treater framework in accordance with an illustrative aspect of the present disclosure.

FIG. 36 is a front elevation view of a solid seed treater system and control system in accordance with an illustrative aspect of the present disclosure.

FIG. 37 is a side elevation view of a solid seed treater system and control system in accordance with an illustrative aspect of the present disclosure.

FIG. 38 is an end elevation view of a cradle and drive system and tilt controller system in accordance with an illustrative aspect of the present disclosure.

FIG. 39 is a control circuit schematic for a seed treater in accordance with an illustrative aspect of the present disclosure.

FIG. 40 is a flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure.

FIG. 41 is another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure.

FIG. 42 is another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure.

FIG. 43 is another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure.

FIG. 44 is another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure.

DETAILED DESCRIPTION

FIGS. 1A-39 provide various pictorial illustrations for exemplary aspects of a seed treater 10 in accordance with the objects, features, and advantages of the present disclosure. FIGS. 40-44 provide various pictorial illustrations for exemplary aspects of a seed treatment method in accordance with the objects, features, and advantages of the present disclosure.

The present disclosure contemplates many different apparatuses and varying arrangements, methods and systems for a continuous flow seed treater and seed treatment system as well as commercialization and use. Representative applications of methods and systems are described in this section as well as apparatus mechanisms and structures. These examples are provided solely to add context and aid in understanding of the described aspects of the disclosure. It will thus be apparent to one skilled in the art that the described aspects of the disclosure may be practiced without some and/or all of these specific details. In other instances, well known process steps have not been described in detail in order to avoid unnecessarily obscuring the described aspects. Other applications are possible, such that the following examples should not be taken as limiting.

In the following detailed description, references are made to the accompanying drawings, which form a part of the description and show, by way of illustration, specific aspects in accordance with the methods and systems of the present disclosure. Although aspects of the disclosure are described in sufficient detail to enable one skilled in the art to practice the described aspects, it is understood that these examples are not limiting; other aspects may be used, and

changes may be made without departing from the spirit and scope of the described aspects of the disclosure.

It will also be understood that, although the terms first, second, next, lastly, etc. may be used herein to describe various elements, these elements should not be limited by such terms. These terms are only used to distinguish one element from another. For example, a first step could be termed a second step, and, similarly, a second step could be termed a first step, without departing from the spirit and scope of the present disclosure.

The terminology used herein is for the purpose of describing particular aspects of the disclosure only and is not intended to be limiting of the present disclosure. As used in the description of the invention and the appended claims, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. By way of example only, while the singular form of numerous components and steps are described in various aspects of the disclosure herein, it will be apparent that more than one of such components and/or steps can be used to accomplish the same. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, functions, integers, steps, operations, elements, and/or components, but do not preclude the presence and/or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be similarly understood that the terms "including," "include," "includes", "such as" and the like, when used in this specification, are intended to be exemplary and should be construed as including, but not be limited to, all items recited thereafter. As used herein, the term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context.

As used herein, the term "seed" includes seeds of any type of plants, including, but not be limited to, row crops, cereals, grains, oilseeds, fruits, vegetables, turf, forage, ornamental, nuts, tobacco, plantation crops and the like (including, without limitation, cotton and other fiber and hemp and related seeds).

As used herein, the terms "substance" and/or "seed-applied substance" and/or "seed treatment" may include any composition applied to seeds prior to the seeds being planted (e.g.,

when the seed comes in contact with the soil in a field). The seed-applied substance(s) can include active ingredients, other substances, combinations of more than one active ingredient and/or other substances, and/or mixtures having one or more active ingredients and/or one or more other substances. The active ingredients can include any type of substance that causes something to occur (for example, the ingredient(s) in a pesticide that impact the pest, the ingredients in a fungicide that impact the disease and/or plant growth, health and/or vigor, the ingredients in a nematicide that impact the nematode, the ingredients in an inoculant and/or other plant growth and/or health substance that cause the plant to improve its growth, health and/or vigor). The active ingredients can include any past, present and/or future active ingredients and can be chemicals, biologicals (including, without limitation, fungal, bacterial, parasitic, insects and other living organisms), biostimulants, micronutrients, and/or other compositions. Examples of some current potential active ingredients include nitrogen, clothianidin, ipconazole, trifloxystrobin, imidacloprid, metalaxyl, pyraclostrobin, bradyrhizobium, myclobutanil, thiamethoxam, abamectin, mefonoxam, fludioxonil, fipronil, azoxystrobin, cyantraniliprole, Rynaxypyr®, and the like. The other substances typically do not impact the target (for example pest, disease, nematode and/or plant growth, health and/or vigor), but can be helpful to include for a variety of reasons, including, but not be limited to, causing the active ingredients to be at the appropriate levels and/or concentrations to be efficacious but not harmful to the seed and/or plant, helping the active ingredient affix and/or stick to the seed, helping the treated seeds not stick to each other and/or other objects, improving the color of the treated seed (e.g., to indicate the seed is treated with a pesticide), increasing the number and/or amount of active ingredients a seed can absorb and/or otherwise carry and the like. Examples of some of these other substances include polymers, pigments, binders, surfactants, colorants, coatings, and other additives. The seed-applied substances can take any form, including, but not be limited to, wet and dry substances.

FIGS. 1A-1C show pictorial representations of various configurations a seed treatment flow path **12** in accordance with exemplary aspects of the present disclosure. Seed treatment may constitute any of a solid seed treatment, liquid seed treatment, or any other substance that may be applied to a seed along a seed treatment flow path **12** of a seed treater **10.** As shown in FIG. 1A, a seed treater **10** may include a seed flow control system **14**, a liquid seed treater system **50**, a solid seed treater system **80**, a tumbling system **100**, and a control system **150** that may be incorporated on a seed treatment flow path **12**. A seed treatment flow path **12** may be configured to receive seed

and seed treatment and discharge a combination of seed and seed treatment. As shown in FIG. 1A, the seed flow control system **14** may allow seed to enter the seed treatment flow path **12**. In one aspect, the seed flow control system **14** may include a valve **36** which may further include a non-planar gate **42** which could be configured to open and close an opening **46**. Still shown in FIG. 1A, a liquid seed treater system **50** may then disperse at least one liquid seed treatment into the seed treatment flow path **12**, and a solid seed treatment system **80** may then disperse at least one solid seed treatment into the seed treatment flow path **12**. In one aspect, the liquid seed treater system **50** may be downstream of the seed flow control system **14**, and the solid seed treatment system **80** may be downstream of the liquid seed treater system **50**. A tumbling system **100** may be downstream of the seed flow control system **14**, a liquid seed treater system **50**, and a solid seed treater system **80**. However, it is contemplated that various arrangements of the systems could be utilized. A control system **150** may be utilized to control the various systems and their respective components.

The combined seed, at least one liquid seed treatment, and at least one solid seed treatment created from the seed flow control system **14**, the liquid seed treater system **50**, and the solid seed treater system **80** may then be further mixed and/or combined in a tumbling system **100**. The tumbling system **100** is contemplated to be any type of actuatable housing, and may include a variety of components including but not limited to baffles **104**, ridges, heating/cooling elements, sensors, ventilators, discharges, gates, grates, textures or any other conceivable mechanism or design. It is also contemplated that the tumbling system **100** may be made of steel, aluminum, plastic, or any other type of material suitable for mixing materials. The tumbling system **100** may be downstream of the seed flow control system **14**, liquid seed treater system **50**, and solid seed treater system **80**, but it is contemplated that the tumbling system may be arranged elsewhere.

A control system **150** may control the continuous and consistent flow of seed in the seed flow control system **14** into the seed treatment flow path **12**. A control system **150** may further control the dispersing of the at least one liquid type of seed treatment from the liquid seed treater system **50** into the seed treatment flow path **12** based on at least one condition or operating parameter, and control system **150** may also control the dispersing of the at least one solid type of seed treatment from the solid seed treater system **80** into the seed treatment flow path **12** based on at least one condition or operating parameter. Further still, a control system **150** may control the

tumbling of the tumbling system **100** containing the combined seed, liquid, and solid materials in the seed treatment flow path **12** based on at least one condition or operating parameter. The at least one condition or parameter may include any variety of factors stemming from environment, seed, or seed treatment. Environmental factors or conditions may include but are not limited to ambient or environmental temperature, humidity, barometric pressure, thermal barrier properties, or any other environment that may impact a seed or seed treatment on a seed flow path **12**. Seed conditions or characteristics may include but are not limited to seed type, seed sweating, flowability, thermal properties, volume, mass, coat hardness, shape, texture, coat thickness, crude fat, soluble protein, sugar, gibberellins and abscisic acid, adhesiveness, or any other properties of a seed that may require adjustments to the seed flow path **12.** Seed treatment factors may include but are not limited to the substances applied to the seed, such as solid or liquid substances, as well as the seed treatment process itself. Factors relating to substances applied to the seed may include but are not limited to ingredients, flowability, drying factors, temperature effects, viscosity, humidity effects, chemical interactions, wettability, or any other factors of relating to the substances that may be used in a seed treater **10** that may require adjustments to the seed flow path **12** or seed treater **10**. Factors relating to the seed treatment process itself could be seed flow rate, liquid dispersion rate, solid dispersion rate, tumbling rate, tumbling angle, amount of time in tumbler, amount of residual left over on any components of seed treater **10**, or any other factors in the seed treatment process that may require adjustments to the seed flow path **12** or seed treater **10**.

As shown in FIG. 1B, a seed treatment flow path **12** of a seed treater **10** may include a seed flow control system **14**, liquid seed treater system **50**, solid seed treater system **80**, a tumbling system **100**, and a control system **150**. The control system **150** may control the liquid seed treater system **50** to control the dispersion rate of at least one liquid type of seed treatment, and the control system **150** may also control the solid seed treater system **80** to control at least one solid type of seed treatment within the seed treatment flow path **12**. The control system **150** may slow the travel of at least one liquid seed treatment from the liquid seed treater system **50** as well as slow the travel of at least one solid seed treatment from the solid seed treater system **80** through the seed treatment flow path **12**. In other aspects, the control system **150** may speed up the travel of at least one liquid seed treatment from the liquid seed treater system **50** as well as speed up the travel of at least one solid seed treatment from the solid seed treater system **80** on the seed treatment flow path **12**. The combined seed, liquid seed treatment, and solid seed treatment created from a liquid seed treater

system **50** and a solid seed treater system **80** may be further mixed in a tumbling system **100** within the seed treatment flow path **12**. The control system **150** may decrease and/or increase the rate of tumbling in the tumbling system **100** by decreasing and/or increasing the rotations per minute (RPM) of the rate of tumbling. The increase or decrease in the rate of tumbling may be based on at least one condition or operating parameter. Parameters may include but are not limited to environment, seed, and seed treatment. Additionally, the control system **150** may decrease and/or increase the rate of tumbling in the tumbling system **100** by decreasing and/or increasing the number of baffles **104**. Further still, the control system **150** may change the throughput of the combination through the seed treatment flow path **12** by changing an attitude of the seed treatment flow path. Additionally, a control system **150** may detect residual from the combination in the seed treatment flow path by means of a sensor or other conceivable ways to detect residual.

The control system **150** may have a calibration node configured to compare the calculated remaining residue and the calculated treated seed parameters or the at least one condition with the as-treated seed and actual remaining residue and adjust different machine parameters of the seed treatment flow path **12**. In another aspect, the calibration node compares the calculated seed disbursement with the actual seed disbursement. In still another aspect, the calibration node compares the calculated liquid material or seed treatment disbursement with the actual liquid material disbursement or seed treatment disbursement. In yet another aspect, the calibration node compares the calculated solid disbursement with the actual solid disbursement The calibration node can calibrate different machine parameters by making operational adjustments to minimize any differences between the calculated seed treatment data and the measured seed treatment data (i.e., data acquired from one or more operations of one or more nodes/modules for providing and from measuring an as-treated seed and the remaining residue).

The control system **150** may have a data tagging, logging, and storage node. The data tagging, logging and storage node communicates with different parts or aspects of the seed treatment flow path **12** or the seed treater **10** and may be housed in the controller **154**. The data tagging, logging and storage node may receive data from different parts of the seed treatment flow path **12** and tag the data. The tagging allows for data to be easily organized and labeled. The tagging may consist of where the data was acquired, where the data was communicated through, where the data should be stored, or where the data should be communicated to. The data can be

logged and stored in a database. Prior to reaching the data tagging, logging, and storage node, the data may be communicated to a machine learning and artificial intelligence node of the control system **150** and then the data may proceed to the data tagging, logging and storage node. The data tagging, logging, and storage node may contain one or more databases for storing data.

The present disclosure contemplates that many different types of machine learning and artificial intelligence may be employed by the machine learning and artificial intelligence node, and therefore, the one or more machine learning and artificial intelligence layers may include, but are not limited to, k-nearest neighbor (kNN), logistic regression, support vector machines or networks (SVM), linear regression, logistic regression, decision tree, naïve Bayes, K-Means, Random Forest, dimensionality reduction algorithms, gradient boosting algorithms (e.g., GBM, XGBoost, LightGBM, CatBoost), and/or more neural networks. Regardless, the use of machine learning and artificial intelligence in the framework and workflow of the present disclosure enhances the utility of analyzing known and/or collected data and its various components by automatically and heuristically constructing appropriate relationships, mathematical or otherwise, relative to the seed, seed treatment, and environment variables influencing follow-on outcomes such as continuously treating seed and adjustment of amounts and types of inputs into the seed treatment flow path **12**, the seed treater **10**, and processes. The machine learning and artificial intelligence node may be housed in the controller **154** and may be associated with one or more databases. For example, the machine learning and artificially intelligence node may analyze at least one of the one or more seed treatment inputs, the at least one of the one or more seed treater operations, the one or more environmental inputs for treating seed at the controlled rate and converge actual seed treatment results with programmed seed treatment parameters. Such analysis may be alone or performed in combination with one or more points of human inspection, such as by visual inspection and/or conducting one or more tests.

The machine learning and artificial intelligence node may be configured to apply one or more machine learning and artificial intelligence models to the data. For example, in at least one aspect, a machine learning and artificial intelligence node monitors data, such as machine operational data or parameters to, for example, monitor the health, operational accuracy, and to adjust, report problems, and fine tune operations. In one aspect, the machine learning and artificial intelligence node monitors operations of the seed treatment flow path **12** or the seed treater **10** and,

using present, historical, and predictive data tagged, logged, and stored, monitors the health, operational accuracy, and adjusts operations, reports problems, and fine tunes batch processing and accuracy. Measurements taken for identifying, tagging, logging, and storing data based on operation of the seed treatment flow path **12** and modules can be, in at least one aspect, performed and provided, at least in part, by one or more parts or aspects of the seed treatment flow path **12**. The machine learning and artificial intelligence node can calibrate operations of the nodes and/or modules using data from the nodes and modules by making, for example, operational adjustments to minimize any differences between the calculated seed treatment data and the measured seed treatment data (i.e., data acquired from one or more operations of one or more nodes/modules for providing and from measuring an as-treated seed).

As shown in FIG. 1C, a seed treatment flow path **12** of a seed treater **10** may include a seed flow control system **14**, a liquid seed treater system **50**, a solid seed treater system **80**, a tumbling system **100**, and a control system **150**. As shown in FIG. 1C, the seed flow control system **14** may allow seed to enter the seed treatment flow control path **12**. In one aspect, the seed flow control system **14** may include a valve **36** which may be operably configured to introduce a continuous flow of seed into the seed treatment flow path **12** at a seed flow rate. Still shown in FIG. 1C, a liquid seed treater system **50** may then disperse at least one liquid seed treatment into the seed treatment flow path **12** at a liquid dispersion rate, and a solid seed treater system **80** may then disperse at least one solid seed treatment into the seed treatment flow path **12** at a solid dispersion rate. In one aspect, the liquid seed treater system **50** may include a liquid disperser which may be downstream of the seed flow control system **14** which may include a valve **36**, and the solid seed treater system **80** may be downstream of the liquid seed treater system **50**. However, it is contemplated that various arrangements of the systems could be utilized.

The combined seed, at least one liquid seed treatment, and at least one solid seed treatment created from the seed flow control system **14**, the liquid seed treater system **50**, and the solid seed treater system **80** may then be further mixed and/or combined in a tumbling system **100** at a tumbling or mixing rate. The tumbling system **100** is contemplated to be any type of actuatable housing, and may include a variety of components including but not limited to baffles **104**, ridges, heating/cooling elements, sensors, ventilators, discharges, gates, grates, textures or any other conceivable mechanism or design. It is also contemplated that the tumbling system be made of

steel, aluminum, plastic, or any other type of material suitable for mixing materials. The tumbling system **100** may be downstream of the seed flow control system **14**, the liquid seed treater system **50**, and the solid seed treater system **80**, but it is contemplated that the tumbling system **100** may be arranged elsewhere.

A control system **150** may control the continuous and consistent flow of seed in the seed flow control system **14** into the seed treatment flow path **12**. A control system **150** may further control the dispersing of the at least one liquid type of seed treatment from the liquid seed treater system **50** into the seed treatment flow path **12** based on one or more conditions, and control system **150** may also control the dispersing of the at least one solid type of seed treatment from the solid seed treater system **80** into the seed treatment flow path **12** based on one or more conditions. Further still, a control system **150** may control the tumbling of the tumbling system **100** containing the combined seed, liquid, and solid materials in the seed treatment flow path **12** based on one or more conditions. It is further contemplated that control system **150** may be configured to control the seed flow control system **14**, liquid seed treater system **50**, and solid seed treater system **80** at a set rate based on one or more conditions. In other aspects, it is contemplated that a control system **150** may automatically adjust the dispersion rates of the systems individually or in unison based on one or more conditions. In alternative aspects of the present disclosure, the dispersion rates of the systems may be manually adjusted using the control system **150** or rates selected by the control system **150**. The one or more conditions may include a variety of factors stemming from environment, machine operating parameters, seed, liquid materials, solid materials, and seed treatment. The at least one condition or parameter may include any variety of factors stemming from environment, seed, or seed treatment. Environmental factors or conditions may include but are not limited to ambient or environmental temperature, humidity, barometric pressure, thermal barrier properties, or any other environment that may impact a seed or seed treatment on a seed flow path **12**. Seed conditions or characteristics may include but are not limited to seed type, seed sweating, flowability, thermal properties, volume, mass, coat hardness, shape, texture, coat thickness, crude fat, soluble protein, sugar, gibberellins and abscisic acid, adhesiveness, or any other properties of a seed that may require adjustments to the seed flow path **12.** Seed treatment factors may include but are not limited to the substances applied to the seed, such as solid or liquid substances, as well as the seed treatment process itself. Factors relating to substances applied to the seed may include but are not limited to ingredients, flowability, drying factors, temperature

effects, viscosity, humidity effects, chemical interactions, wettability, or any other factors of relating to the substances that may be used in a seed treater **10** that may require adjustments to the seed flow path **12** or seed treater **10**. Factors relating to the seed treatment process itself could be seed flow rate, liquid dispersion rate, solid dispersion rate, tumbling rate, tumbling angle, amount of time in tumbler, amount of residual left over on any components of seed treater **10**, or any other factors in the seed treatment process that may require adjustments to the seed flow path **12** or seed treater **10**.

FIG. 2 shows a perspective view of a seed treater **10** in accordance with an illustrative aspect of the present disclosure. The seed treater **10** may include treater framework **16** for the seed treater **10**. As shown, a seed hopper **18** may be supported by the treater framework **16**, which may be positioned to support a seed treater **10** vertically, but it is contemplated a treater framework may be arranged diagonally, horizontally, or in any other conceivable arrangement to help direct seed flow on a seed treatment flow path **12**. A seed hopper **18** may be positioned to convey seed onto a seed treatment flow path **12**. A conduit **24** may be included in the seed treater **10** to direct seed and seed treatment flow from the seed hopper **18**. A seed treater **10** may also include a tumbling system **100**, which may be located downstream of the seed hopper **18** and connected to conduit **24** of the seed treater **10**.

FIG. 3 shows an end perspective view of a seed treater **10** in accordance with an illustrative aspect of the present disclosure. A seed treater **10** may include a tumbling system **100**. A tumbling system **100** may include a tumbler or drum **101**, and the tumbling system **100** may be supported by the treater framework **16** of the seed treater **10**. The drum **101** may be supported and arranged on a cradle and drive system **110**. The cradle and drive system **110** may also be supported or incorporated onto the treater framework **16** of the seed treater system **10**. As further shown in FIG. 3, a seed treater system **10** may include a cover **20** for collecting discharged materials or otherwise providing protection to the drum **101**.

FIG. 4 shows another end perspective view of a seed treater **10** in accordance with an illustrative aspect of the present disclosure. A seed treater **10** may include a seed flow path **12** that travels through a liquid seed treater system **50**. The liquid seed treater system **50** or the seed flow path **12** may include a shaft **52**, an atomizing wheel **54**, liquid plumbing **56**, and a discharge **58**. An atomizing wheel **54** may be connected to a shaft **52** which may allow the atomizer to rotate at

a rate which may be controlled by a controller **154**. Liquid plumbing **56** may transport and deliver a liquid, such as a liquid type of seed treatment to the atomizer wheel **54** at a discharge **58** to be atomized. An atomizing wheel **54** may be a rotary atomizer and may have a variety of different surfaces for atomizing, such as flat, a vaned disc, cup, slotted wheel, or any other conceivable surface that may be utilized in atomizing a liquid. The atomizer may also be a rotary, pressure swirl, twin fluid atomizer or any other conceivable atomizer or similar mechanism. The atomizing system may be operably configured to receive at least one liquid type of seed treatment from a liquid disperser **58** for atomizing at least one type of liquid type of seed treatment at an atomizing rate. Further, the atomizing rate may be under the operation of a controller **154**. A liquid seed treater system **50** may be operably configured to introduce at least one liquid type of seed treatment in a seed treatment flow path **12** at a liquid dispersion rate, which may be controlled by a controller **154** and/or control system **150**.

The seed treater **10** may be supported by a treater framework **16** and include a tumbling system **100** also supported by a treater framework **16**. As shown in FIG. 4, a tumbling system **100** may include a tumbler or mixing drum **101**, and the drum **101** may be supported and/or arranged on a cradle and drive system **110**, which may also be supported by or attached to a treater framework **16**. The drum **101** of the tumbling system **100** may include an opening **102**. The tumbler opening **102** may be circular in shape as depicted in FIG. 4, but it is contemplated that other shapes may be utilized for the intake of materials. The opening **102** may be an infeed for receiving seed and seed treatment such as the liquid material and/or solid material. The drum **101** may also include one or more baffles **104** which may be utilized to control the mixing of the combined seed and seed treatment. The seed treater system **10** may also include a panel **22** adjacent the opening **102** of the tumbler **101**. A panel **22** may be a removable panel and may provide protection to the drum **101** or prevent undesired movement of the drum **101**. Panel **22** may further be utilized to protect components and mechanisms positioned beneath a drum **101** or prevent injuries for a user of the seed treater **10**.

FIG. 5 shows an elevation view of an end of a seed treater **10** in accordance with an illustrative aspect of the present disclosure. A seed treater **10** may include a seed flow path **12** and a frame **16** to support the seed treater **10** and components of the seed treater **10**. As shown in FIG. 5, a seed treater **10** may include a tumbling system **100**. A tumbling system **100** may be used for

tumbling a combination of seed, at least one liquid type of seed treatment, and at least one solid type of seed treatment within a seed treatment flow path **12**. The tumbling system **100** may include a drum **101** which may include one or more baffles **104** located inside the drum **101** for directing or obstructing the flow of materials in a seed flow path **12**. The drum **101** as shown in FIG. 5 is cylindrical in shape, however, it is contemplated that a drum **101** may be any type of actuatable housing and may be a variety of shapes including but not limited to a sphere, torus, ellipsoid, cone, or any other shape that may allow for different movement or positioning. While baffles **104** may be included on a drum **101** as shown, a drum **101** may be contemplated to utilize ridges, heating/cooling elements, sensors, ventilators, discharges, gates, grates, textures or any other conceivable mechanism or design that can be utilized in conjunction with a drum **101** for a variety of purposes. It may be further contemplated that the drum **101** be made of steel, aluminum, plastic, or any other type of material suitable for mixing materials. Further still, as show in FIG. 5, a drum **101** may include an opening **106** which may be used as an outlet or discharge end for discharging materials from the tumbling system **100** and seed treatment flow path **12**. The opening **106** may be circular in shape as depicted in FIG. 5, but it is contemplated that other shapes may be utilized for discharging materials. As still shown in FIG. 5, additional openings **108** may be included on the drum **101** for discharging materials or ventilation within the drum **101**. The drum **101** may be operably configured to assist in combining a seed and seed treatment within a seed flow path at a tumbling rate. Furthermore, as shown in FIG. 5, a seed treatment flow path **12** travels primarily through the center of a drum **101**, but it is contemplated that different seed treatment flow paths may be utilized in a seed treater **10**.

The drum **101** may be supported and/or arranged on a cradle and drive system **110**, which may also be supported by or attached to frame **16**. The cradle and drive system **110** may include a tilt control system **140** which may be operably configured to control the attitude of the seed treatment flow path **12**. A drum **101** may be operably configured to assist in combining seed and seed treatment within the seed treatment flow path **12** at a tumbling rate, which may be controlled by a controller **154** and/or control system **150**.

FIG. 6 shows an end elevation view of a baffle **104** of the seed treatment flow path **12** in accordance with an illustrative aspect of the present disclosure. As shown in FIG. 6, one or more baffles **104** may be included on a drum **101** of the tumbling system **100**. The baffles **104** may be

used to direct and/or obstruct the mixing of the seed and seed treatment within the drum **101**. A conduit **24** may be utilized to connect the drum **101** of the tumbling system **100** to other components of the seed treater **10** to provide watertight flow of seed and seed treatment in the seed flow control system **12**. An opening **26** between the inner drum **101** and conduit **24** may introduce seed and seed treatment to drum **101.** A drum **101** may also include a damper **28.**

FIG. 7 shows an elevation view of a seed hopper **18**, seed flow control system **14**, and seed treatment flow path **12** in accordance with an illustrative aspect of the present disclosure. The seed hopper **18** may be supported by a treater framework **16** and arranged vertically to be the most upstream in the seed treatment flow path **12** of the seed flow control system **14**. As shown in FIG. 7, the treater framework **16** may be configured to include a shelf for holding materials such as pumps, mixing equipment, or any other equipment deemed necessary for use in a seed flow path **12** of a seed treater **10**. A conduit **24** may be positioned downstream of the seed hopper **18** to assist with and contain the flow of seed and seed treatment in the seed flow path **12**. Liquid plumbing **56** may be included on the seed hopper **18** and may be arranged downstream from top opening of the seed hopper **18**.

A control system **150** may also be included in the seed flow control system **14** and may be contained in a controller housing **152** that may be attached or mounted to a treater framework **16** for ease of access. The control system **150** may include controller **154**, which may be configured for electromechanically controlling a rate for seed and seed treatment operations within a seed flow path **12**. The control system **150** may communicate with one or more remote devices while controlling the rate for seed and seed treatment operations.

FIG. 8 shows a perspective view of a seed flow control system **14** and seed treatment flow path **12** in accordance with an illustrative aspect of the present disclosure. The seed flow control system **14** may be supported by a treater framework **16**. A conduit **24** may be used to assist with the flow of seed and seed treatment in the seed treatment flow path **12** of the seed flow control system **14**. A conduit **24** may be made of aluminum, plastic, concrete, steel, or any other material suitable for assisting with the flow of seed and seed treatment, and a conduit **24** may also be various shapes and sizes such as conical, cylindrical, curved, or any other shape or size conceivable for guiding the direction of seed and seed treatment in a seed treatment flow path **12**.

To prevent leakage of seed or seed treatment in a seed treatment flow path **12**, watertight seals may be used in conjunction with a conduit **24**. As further shown in FIG. 8, a coupler **32** may be used to connect components of seed treater **10** and ensure gaskets are in place when clamping to create watertight seals between a conduit **24** and other components of a seed treater **10**. Additionally, a flange **30** may be utilized to connect a conduit **24** and the opening **102** of the drum **101** of the tumbler system **100**. The flange **30** may be utilized to create a watertight seal between the conduit **24** and the drum **101** to prevent leakage of seed or seed treatment in the seed flow path **12** of the seed treater system **14**.

FIG. 9 illustrates a perspective view of a seed flow control system **14**, tumbling system **100**, and seed treatment flow path **12** in accordance with an illustrative aspect of the present disclosure. The seed flow control system **14** and the tumbling system **100** may be affixed to and/or supported by a treater framework **16**. As shown, the seed flow control system **14** may include a conduit **24** for connecting components of the seed flow control system **14** and to direct the flow of seed and seed treatment within a seed treatment flow path **12**. A coupler **32** may be used to connect components of the seed flow control system **14** and ensure gaskets are in place when clamping to create watertight seals. As shown in FIG. 9, a tumbling system **100** may be positioned downstream of a seed flow control system **14**.

FIG. 10 shows a top perspective view of a cradle and drive system **110** of the tumbling system **100** in accordance with an illustrative aspect of the present disclosure. A tumbler **100** may be operably configured to assist in combining seed and seed treatment within the seed treatment flow path **12** at a tumbling rate, and a controller **154** of a control system **150** may be operably configured to control the tumbling rate of the drum **101**. The cradle and drive system **110** may be affixed to or supported by a cradle frame **126** that may further hold bearings **124**, shafts **120**, and rollers **122**. The cradle and drive support frame **126** may be affixed to or further supported by the main treater framework **16**. The shafts **120** may be inserted through the bearings **124** and may be further inserted through the rollers **122**. As shown in FIG. 10, there four rollers **122** may be positioned on the shaft **124**, however it is contemplated that more rollers **122** or less rollers **122** may be utilized. It is also contemplated that the rollers **122** may be any size or shape that allows for rotation, and rollers **122** may be configured in any combination of differing shapes and sizes e.g. two small rollers used with two large rollers and so forth. FIG. 10 shows the rollers **122** may

be positioned to adjacent and parallel to each other, however, in other aspects the rollers may be positioned in a variety of ways, such as in a circular formation, stair step formation, differing elevations, differing attitudes, or any other arrangement. The cradle and drive system **110** may further include a motor **112**. A motor **112** may be operably connected to a cog **116** which may be connected to a drive member **114** to allow a shaft **120** to rotate. The rollers **122** may be inserted onto the shaft **120** to cause the drum **101** of the tumbling system **100** to rotate or actuate. The drum **101** may be positioned onto the rollers **122** of the cradle and drive system **110** with adjusters **128**. Adjusters **128** may be positioned in a variety of ways to allow for various positions and placements of a drum **101** on the cradle and drive system **110**.

FIG. 11 depicts an elevation view of a tilt control system **140** of the tumbling system **100** in accordance with an illustrative aspect of the present disclosure. A tilt control system **140** may be operably configured to control the attitude of the seed treatment flow path **12** of seed treater **10**. The tilt control system **140** may be removably attached to a treater framework **16**. An actuator **142** may be used in the tilt control system **140** to adjust the tilt and/or attitude of the seed treatment flow path **12**. The control system **150** may adjust to the tilt or attitude. As shown in FIG. 11, an actuator **142** may be a scissor jack and may be adjusted using a ratchet, but it is contemplated that other types of jacks, lifts, or mechanisms could be used to adjust and control tilt and attitude.

FIG. 12 shows a perspective view of a tilt control system **140** of the tumbling system **100** in accordance with an illustrative aspect of the present disclosure. A tilt control system **140** may be operably configured to control the attitude of the seed treatment flow path **12**, and a tumbling system **101** of the tumbling system **100** may be the tilt-controlled vessel. A tilt control system **140** may include a sensor **144** for detecting and monitoring the tilt of the tumbler **101** of the tumbling system **100**. The sensor **144** may be a digital angle gauge or a level gauge, and may be affixed to a cradle frame **126** of the cradle and drive system **110**. The tumbling system **100,** the cradle and drive system **110,** and cradle frame **126** may be supported by or incorporated onto the main treater framework **16**. The sensor **144** may be operatively connected to the control system **150** and may provide data to a control system or be operated by a control system.

FIG. 13 illustrates a perspective view of a control component of the control system **150** for the cradle and drive system **110** in accordance with an illustrative aspect of the present disclosure. A control component may include a control cable **132,** a connector **130**, and a motor **112**. A control

cable **132** may be inserted into a connector **130** of the drum motor **112** to provide power to the motor **112** which may further enable operation of components of the cradle and drive system **110**. The motor **112,** connector **130,** and control cable **132** may be operably connected to a controller **154** of a control system **150**, and may be affixed to a cradle frame **126** of a cradle and drive system **110** which may be affixed to or supported by a treater framework **16**. In other aspects, a motor **112,** connector **130,** and control cable **132** may be positioned in various locations.

FIG. 14 shows a side perspective view of a tumbling system **100** and a treater framework **16** in accordance with an illustrative aspect of the present disclosure. A tumbling system **100** may be used in tumbling a combination of seed, at least one liquid type of seed treatment, and at least one solid type of seed treatment within a seed treatment flow path **12**. A drum **101** may be included in a tumbling system **100**. A drum **101** may include a mounting arm or drum pivot **134** for positioning a drum onto a cradle and drive system **110.** The drum **101** and mounting arms **134** may be supported by adjusters **128** which may be removably attached to a treater framework **16**, and may allow for adjusting the position of the drum **101.** In one aspect, this configuration will allow a tumbler to rest freely upon the cradle and drive system **110** to best allow the tumbler **101** to rotate and/or actuate in a desirable manner. Additionally, a panel **34** may be removably attached to the cradle frame **126** of the cradle and drive system **110** to prevent the tumbler from becoming removed from the treater framework **16**, to contain any materials or debris within the cradle and drive system **110** and tumbling system **100**, to prevent damage to any part of the cradle and drive system **110** or the tumbling system **100**, and as a safety precaution for system operators and injury prevention.

FIG. 15 depicts an elevation view of a pumping system **60** of the liquid seed treater system **50** in accordance with an illustrative aspect of the present disclosure. A pumping system **60** may consist of a liquid pump **60** operably configured to pump at least one liquid type of seed treatment to a liquid discharge or disperser **58**, and a pump **60** may be a peristaltic pump. As shown in FIG. 15, a Masterflex Pump and Easy-Load pump head may be used as a pump **60** and pump housing **62**, respectively, but it is contemplated that other pumps and pump housings may be utilized. Further still, a pumping system **60** may include a power switch for powering on the system, and may further include controls, such as a knob, to control the pumping.

FIG. 16 is a perspective view of a plumbing configuration of the liquid seed treater system **50** in accordance with an illustrative aspect of the present disclosure. A liquid seed treater system **50** may include a discharge **58** in a seed treatment flow path **12** for dispersing at least one liquid type of seed treatment, where the discharge **58** may be located downstream of a valve. A plumbing configuration may include liquid plumbing **56** for transmitting a liquid into a seed treatment flow path **12**. Connected to the liquid plumbing **56** may be a connector **64** for connecting to a pumping system **60** or pump head **62**. A connector may be a nozzle or any other type of connector for plumbing purposes. The plumbing configuration and liquid seed treater system **50** may be incorporated into a hopper **18,** which may be attached to a treater framework **16,** where the plumbing configuration may be downstream of the top of the hopper **18** opening.

FIG. 17 shows another elevation view of a plumbing configuration of the liquid seed treater system **50** in accordance with an illustrative aspect of the present disclosure. In one aspect, the liquid seed treater system **50** may include peristaltically pumping at least one liquid type of seed treatment to a liquid atomizer located within a seed treatment flow path **12**. A pump system **60** may be operably configured to peristaltically deliver at least one liquid type of seed treatment to a discharge or liquid disperser or discharge **58** under operation of a controller 1**54**. The controller 154 may be operatively connected to the control system **150**. As shown in FIG. 17, a liquid seed treater system **50** may include a reservoir **70** which may contain a liquid seed treatment, liquid plumbing **56** which may assist in transporting the liquid seed treatment, and a connector **64** which may connect the liquid plumbing **56** to the seed treater **10**. The liquid plumbing **56** may be connected to the connector **64** and seed treater **10** through a pump housing **62** of a pump **60** which may peristaltically pump at least one type of liquid seed treatment into the seed treatment flow path **12** of the seed treater **10**. A power cable **68** may provide power to the pump **60** which may be controlled by the control system **150**. The liquid seed treater system **50** may be supported by the treater framework **16** and be positioned downstream of a valve **36**.

Also shown in FIG. 17 is a tumbling system **100**, which may include a drum **101**, a cradle frame **126**, and a sensor **144**. The sensor **144** may be a digital angle gauge or a level gauge, and may be affixed to a cradle frame **126** of the cradle and drive system **110** for sensing and indicating the attitude or angle of the cradle and drive system **110**. The tumbling system **100** may be supported by the treater framework **16** and may further be controlled by the control system **150**.

FIG. 18 shows a perspective view of a plumbing configuration and atomizing system in accordance with an illustrative aspect of the present disclosure. A conduit **24** may contain the atomizing system and plumbing configuration in the seed treatment flow path **12**. The atomizing system may include a shaft **52**, an atomizing wheel **54**, liquid plumbing **56**, and a discharge **58**. An atomizing wheel **54** may be connected to a shaft **52** which may allow the atomizer to rotate at a rate which may be controlled by a controller **154**. Liquid plumbing **56** may transport and deliver a liquid, such as a liquid type of seed treatment, to the atomizer wheel **54** at a discharge **58** to be atomized. An atomizing wheel **54** may be a rotary atomizer and may have a variety of different surfaces for atomizing, such as flat, a vaned disc, cup, slotted, or any other conceivable surface that may be utilized in atomizing a liquid. The atomizer may also be a rotary, pressure swirl, twin fluid atomizer, or any other conceivable atomizer or similar mechanism. The atomizing system may be operably configured to receive at least one liquid type of seed treatment from a liquid disperser or discharge **58** for atomizing at least one type of liquid type of seed treatment at an atomizing rate. Further, the atomizing rate may be under the operation of a controller **154** and may also be positioned downstream of a valve **36** on a seed flow path **12.**

FIG. 19 illustrates a perspective view of a controller **154** of the control system **150** in accordance with an illustrative aspect of the present disclosure. A controller **154** may be configured for electromechanically controlling a rate for seed and seed treatment operations within a seed treatment flow path **12**. A controller **154** may also be operably configured to control a seed flow rate, a liquid dispersion rate, and a solid dispersion rate based on at least one or more conditions or operating parameters. The one or more conditions may include, but are not limited to, environment, seed, liquid material, solid material, residue left in the tumbling system **100**, and seed treatment. The at least one condition or parameter may include any variety of factors stemming from environment, seed, or seed treatment. Environmental factors or conditions may include but are not limited to ambient or environmental temperature, humidity, barometric pressure, thermal barrier properties, or any other environment that may impact a seed or seed treatment on a seed flow path **12**. Seed conditions or characteristics may include but are not limited to seed type, seed sweating, flowability, thermal properties, volume, mass, coat hardness, shape, texture, coat thickness, crude fat, soluble protein, sugar, gibberellins and abscisic acid, adhesiveness, or any other properties of a seed that may require adjustments to the seed flow path **12.** Seed treatment factors may include but are not limited to the substances applied to the seed,

such as solid or liquid substances, as well as the seed treatment process itself. Factors relating to substances applied to the seed may include but are not limited to ingredients, flowability, drying factors, temperature effects, viscosity, humidity effects, chemical interactions, wettability, or any other factors of relating to the substances that may be used in a seed treater **10** that may require adjustments to the seed flow path **12** or seed treater **10**. Factors relating to the seed treatment process itself could be seed flow rate, liquid dispersion rate, solid dispersion rate, tumbling rate, tumbling angle, amount of time in tumbler, amount of residual left over on any components of seed treater **10**, or any other factors in the seed treatment process that may require adjustments to the seed flow path **12** or seed treater **10**.

The controller **154** may consist of a controller housing **152** and a gate position indicator **156**. The gate position indicator **156** may show the gate control direct current (DC) voltage, but other aspects may utilize different units or means to display gate position and/or control information. The controller **154** may include a gate position adjuster **158** and auxiliary output switch(es) **168, 170**, and **172**. One of the auxiliary output switches may be a main power switch, and other auxiliary output switches may be switches for operating a variety of components of the seed treater **10**, including but not limited to a liquid seed treater system **50**, a tumbling system **100**, or any other conceivable system or mechanism that may be included in the seed treater **10**. The gate position adjuster **158** may be used as an infeed gate control of the seed treater **10** to allow for precise and controlled or continuous flow of seed or material. The gate position adjuster **158** may consist of a knob, but other means for adjustment may be used such as a gauge, buttons, switches, touch screen, or other conceivable means of adjustment. The gate position indicator **156** and the gate position adjuster **158** may be used in unison to allow for a replicative and consistent setting for seed flow within a seed flow path **12**. The controller **154** or control system **150** may have a communication node or transceiver (not shown) for communicating with remote devices.

The control system **150** and controller **154** may further be configured to electromechanically operate the steps of controlling seed movement in the seed treatment flow path **12** with a valve **36**, dispersing at least one liquid type of seed treatment in the seed treatment flow path **12**, dispersing at least one solid type of seed treatment in a seed treatment flow path **12**, and tumbling the combination with a tumbling system **100**.

According to FIG. 19, the controller **154** may also include a dispersion speed adjuster **162** and a drum speed adjuster **166**. In conjunction with the atomizer dispersion speed adjuster **162**, the controller **154** may include a dispersion speed indicator **160** which may indicate the dispersion speed of a liquid type seed treatment. The dispersion speed may be set using a dispersion speed adjuster **162** to adjust the distribution of at least one liquid or other material(s) onto the seed or other material(s) in the seed treatment flow path **12** via the atomizer **54**, however it is contemplated that liquid and the dispersion rate thereof may be dispersed by another means, including but not limited to a spray nozzle, faucet, or other means. The dispersion speed adjuster **162** may consist of a knob, switch, button(s), touch screen, or other conceivable means of control.

In conjunction with the drum speed adjuster **166**, the controller **154** may include a drum speed indicator **164** which may indicate the drum speed in rotations per minute (RPM), but other aspects may utilize different units to communicate drum speed. The speed of the drum or mixing chamber **101** of the tumbling system **100** may be controlled using the drum speed adjuster **166** to speed up or slow down the mixing that occurs. The drum speed adjuster **166** may consist of a knob, switch, button(s), touch screen, or other conceivable means of control.

FIG. 20 depicts a top perspective view of actuator system for the seed flow control system **14** in accordance with an illustrative aspect of the present disclosure. The actuator system may include a cover **38**. The seed flow control system **14** may further include a valve **36**, gate **42**, and gate surface **44**. The valve **36** in the seed treatment flow path **12** may be utilized to control seed movement, and the valve **36** may include a non-planar gate **42** operably configured for opening and closing a gate opening **46**. The gate **42** may be a non-planar gate with a conical shape, but it is also contemplated that a gate **42** could be a variety of shapes and sizes including but not limited to helix, sphere, torus, cylinder, or any other three-dimensional shape to allow passage of materials through a gate opening **46**. A gate **42** may also be configured to move in a variety of ways for opening and closing a gate opening, such as vertically, horizontally, rotationally, or any other conceivable means of movement. Further, a gate **42** may be made of metal such as steel or aluminum, but it is contemplated that a gate **42** could be made of a variety of different materials such as other metals, plastics or other carbon-based materials, or any other conceivable material utilizable. It is further contemplated that a gate **42** could be incorporated with a variety of textures or additional openings, including but not limited to grates, holes, ridges, crimps, mesh, or others.

FIG. 21 shows a top perspective view of a valve **36** for the seed flow control system **14** in accordance with an illustrative aspect of the present disclosure. Controlling seed movement in a seed treatment flow path **12** may include a valve **36** which may be equipped to at least move a non-planar surface of a gate **42** through a gate opening **46** for increasing or decreasing an occluded portion of a gate opening **46**. A valve **36** may be operably configured to introduce a continuous flow of seed into a seed treatment flow path **12** at a seed flow rate. Further, a valve **36** may control seed movement in a seed flow path **12** in conjunction with a gate **42** which may be configured to have both open and closed positions.

As shown in FIG. 21, a seed flow control system **14** may include a cover **38**. The seed flow control system **14** may consist of a plunger **40**, a gate surface **44**, a gate opening **46**, an inner gate surface **47**, and an outer gate surface **48**. As shown in FIG. 21, a gate **42** may be non-planar or conically shaped. A plunger **40** could be configured to move the gate **42** vertically through a valve **36** which may create an opening for seed or other materials to flow through. Further, the plunger **40** could be configured to be an actuatable plunger via an actuator **39**, which could allow the gate to rotate or actuate while also being enabled to move vertically. FIG. 21 shows a gate **42** may be in a more closed position as a plunger **40** may be adjusted to hold the gate **42** in a more closed position, which may cause valve **36** to also be in a closed position.

FIG. 22 shows a top perspective view of a gate **42**, gate surface **44**, and gate opening **46** for the valve **36** for the seed flow control system **14** in accordance with an illustrative aspect of the present disclosure. Still shown in FIG. 22 is a cover **38** for the seed flow control system **14** to protect components of the seed flow control system **14**. A gate **42** may be a non-planar gate **42** with an inner gate surface **47** and an outer gate surface **48**. A non-planar gate **42** may be conically shaped, and the inner gate surface **47** may be the narrow portion of the conically shaped gate **42** and the outer gate surface **48** may be the wider portion of the conically shaped gate **42**. A gate **42** may be connected to a plunger **40** which may assist in controlling the vertical position of gate **42** to either a predominantly open or closed position. As shown in FIG. 22, a gate gap **49** may be created when a gate **42** is positionally moved, in the present aspect by a plunger **40**, to create space in a gate opening **46** to allow passage of seed or other materials through the valve **36**. Still further shown, FIG. 22 illustrates a gate **42** may be in a predominantly open position as a plunger **40** may be adjusted to hold the gate **42** in a predominantly open position, which may cause valve **36** to also

be predominantly open. Though a plunger **40** is shown in FIG. 22 to assist in adjusting the position of gate **42**, it is contemplated that gate **42** could be positionally adjusted by a variety of means.

FIG. 23 shows another top perspective view of a gate **42**, gate surface **44**, and gate opening **46** for the valve **36** for the seed flow control system in accordance **14** with an illustrative aspect of the present disclosure. Also shown in FIG. 23 is a cover **38** which may be included in the seed flow control system **14** along with a gate opening **44** where a gate may be positioned to allow a valve **36** to be increasingly or decreasingly occluded for the passage of seed or other materials through the seed flow control system **14** and into a seed flow path **12**. The gate **42** may be a non-planar shape, such as a cone, and may include a gate surface **44**, an inner gate surface **47** near the inner portion of the cone shape and an outer gate surface **48** near the outer portion of the cone shape. Further shown in FIG. 23 is a gate gap **49** which may be created by controlling movement or position of a gate **42**. The movement or position of a gate **42** may be controlled by a plunger **40** or an actuator **39**, and the gate **42** may be moved or positioned in various ways including but not limited to vertically, horizontally, rotationally, or any other conceivable ranges of motion. Actuator **39** maybe a linear actuator which may be operably configured to actuate a non-planar surface, such as a gate **42**, through a gate opening **46** of a valve **36**. Further, an actuator **39**, gate **42**, and gate components may be under operation of a controller **154** for controlling a seed flow rate. A gate **42** may be predominantly in an open or closed position, or a partially open or closed position, as illustrated in FIG. 23. According to at least one aspect and FIGs. 21 through 23, at least a portion of a non-planar gate **42** may be disposed within a gate opening **46** in both a closed and open position of a non-planar gate **42**.

FIG. 24 illustrates an end elevation view of a seed treater **10** and seed flow control system **14** in accordance with an illustrative aspect of the present disclosure. A treater framework **16** may support a seed treater **10**. An actuator **39** may be connected to a plunger **40** within a seed hopper **18**. A seed hopper **18** may include a gate **42** and gate opening **46** to allow seed or other materials to pass through to a seed flow path **12**. The gate **42** may be in a predominantly open or predominantly closed position as a plunger **40** and an actuator **39** may raise or lower the gate surface **44** through a gate opening **46**. An actuator **39** may be a linear actuator, though it is contemplated that other types of actuators may be utilized to achieve movement of a gate **42**, including but not limited to rotary, hydraulic, mechanical, electrical, pneumatic, or others. A

predominantly open position of gate **42** may allow seed or other materials to pass through a valve **36** on a seed flow path **12**, whereas a predominantly closed position of gate **42** may prevent seed or other materials to pass through a valve **36**. An actuator **39** may be under operation of a controller **154**.

A shaft **52** and atomizing wheel **54** may be included in the seed treatment flow path **12**, and atomizing wheel **54** may be connected to a shaft **52** which may allow the atomizer to rotate at a rate which may be controlled by a controller **154**. Liquid plumbing **56** may transport and deliver a liquid, such as a liquid type of seed treatment, to the atomizing wheel **54** at a discharge **58** to be atomized. An atomizing wheel **54** may be a rotary atomizer and may have a variety of different surfaces for atomizing, such as flat, a vaned disc, cup, slotted wheel, or any other conceivable surface that may be utilized in atomizing a liquid. The atomizer may also be a rotary, pressure swirl, twin fluid atomizer or any other conceivable atomizer or similar mechanism. As illustrated in FIG. 24, an atomizing wheel **54** may be positioned downstream of a valve **36**, and may help facilitate the dispersion of a liquid, such as a liquid type of seed treater, into a seed flow path **12**. As further illustrated in FIG. 24, a liquid atomizer **54** within a seed flow path **12** may receive at least one liquid type of seed treatment from a liquid disperser **58** for atomizing at least one liquid type of seed treatment within a seed treatment flow path **12**, and may also be positioned downstream of a valve **36**.

A tumbling system **100** and drum **101** may also be included in a seed treater **10**. A conduit **24** may assist in conveying seed and seed treatment on a seed treatment flow path **12** to a drum **101** of a tumbling system **100**. A drum **101** may be an actuatable housing within a seed treatment flow path **12** and may be positioned downstream of a valve **36** controlling seed movement. A drum **101** may have an outer surface, and may include baffles **104** for further controlling seed movement along a seed flow path **12**. A drum **101** may be positioned on rollers **122** which may be incorporated on a cradle frame **126**. The rollers **122** and cradle frame **126** may be utilized to allow a drum **101** to rotate or actuate through a motor/actuator **112** which may facilitate rotation.

FIG. 25 depicts a side elevation view of a seed treater **10** and seed flow control system **14** in accordance with an illustrative aspect of the present disclosure. A treater framework **16** may support the seed treater **10** and all components. An actuator **39** may be operably connected to a plunger **40** within a seed hopper **18**. A seed hopper **18** may include a gate opening **46** which may

allow a gate **42** to increase or decrease occlusion of a gate opening **46**. A gate **42** may have a gate surface **44** and may also be operably attached to a plunger **40** and actuator **39**, which may further be configured to control the position of the gate **42** through a gate opening **46** to achieve various gate positions **43**. Gate positions **43** may include but are not limited to closed, open, partially closed, partially open, predominantly closed, predominantly open, or any other conceivable position to allow seed to continue on a seed treatment flow path **12**. An actuator **39** may be under the operation of a controller **154** to control the position of the gate **42**. As shown in FIG. 25, a gate **42** may be a non-planar gate with a conical shape, but it is also contemplated that a gate **42** could be a variety of shapes and sizes including but not limited to helix, sphere, torus, cylinder, or any other three-dimensional shape to allow passage of materials through a gate opening **46**.

An atomizing wheel **54** and shaft **52** may be located downstream of a valve **36** in a seed treatment flow path **12**, as shown in FIG. 25. An atomizing wheel **54** may be connected to a shaft **52** which may allow the atomizer to rotate at a rate which may be controlled by a controller **154**. Liquid plumbing **56** may transport and deliver a liquid, such as a liquid type of seed treatment to the atomizer wheel **54** at a discharge **58** to be atomized. An atomizing wheel **54** may be a rotary atomizer and may have a variety of different surfaces for atomizing, such as flat, a vaned disc, cup, slotted wheel, or any other conceivable surface that may be utilized in atomizing a liquid. The atomizer may also be a rotary, pressure swirl, twin fluid atomizer or any other conceivable atomizer or similar mechanism. An atomizing wheel **54** may be utilized to disperse at least one liquid type of seed treatment in the seed treatment flow path **12** downstream of a valve **36**, but it is contemplated that other means of liquid dispersion may be utilized, including but not limited to nozzles, ultrasonic nozzles, faucets, spray heads, pressure sprayers, centrifugal sprayers, electrostatic sprayers, or any other means of dispersing liquid.

A conduit **24** may channel seed and seed treatment materials on a seed treatment flow path **12** to a drum **101** of a tumbling system **100**. A drum **101** may include an outer surface **103** and may be supported on a cradle frame **126**. A shaft **120** may be connected to bearings **124** on a cradle frame **126**, and a shaft **120** may be inserted through rollers **122** which hold the drum **101**. The rollers **122** may enable the drum **101** to rotate or actuate. In the present aspect, rollers **122** may be cylindrical in shape, but it is contemplated that the rollers may consist of any other shape that may allow a supported object a range of motion or rotation. Other roller shapes may include but are not

limited to spheres, cones, coils, or any other shape conceivable for allowing movement. Seed and seed treatment may continue along a seed treatment flow path **12** through drum **101** which may further combine seed and seed treatment downstream of a valve **36**.

A tilt control system **140** may also be included in the seed treater **10**. As shown in FIG. 25, a tilt control system may be positioned or affixed to a cradle and drive system **110** on a cradle frame **126**. A tilt control system **140** may be operably configured to control the attitude of the seed treatment flow path **12**, and may adjust the tilt or position of the drum **101** of the tumbling system **100**. The tilt control system **140** may include an actuator **142** to adjust the attitude or tilt of the system. As shown in FIG. 25, an actuator **142** may be a scissor jack, but it is contemplated that various types of actuators may be utilized to adjust attitude.

FIG. 26 shows a top view of a drum or tumbler **101** in accordance with an illustrative aspect of the present disclosure. A tumbler **101** may include an outer surface **103** and openings **102** and **106**. The openings **102** and **106** may receive seed and seed treatment along the seed treatment flow path **12** for passage through the tumbler **101**. Opening **102** may receive seed and seed treatment and may be connected to a conduit **24,** whereas opening **106** may discharge combined seed and seed treatment. Openings **102** and **106** may also be utilized to provide ventilation for a drum **101** and may be the openings through which the seed treatment flow path **12** travels. A tumbler **101** may be operably configured to assist in combining seed and seed treatment within the seed treatment flow path **12** at a tumbling rate, and a controller **154** may be operably configured to control the tumbling rate of the drum or tumbler **101**.

As shown in FIG. 26, a tumbler **101** may include baffles **104** which may further assist in tumbling a combination of seed, at least one liquid type of seed treatment, and at least one solid type of seed treatment within the seed flow path **12**. While baffles **104** may be used as shown in FIG. 26, a tumbler **101** may be contemplated to utilize ridges, heating/cooling elements, sensors, ventilators, discharges, gates, grates, textures or any other conceivable mechanism or design that can be utilized in conjunction with a tumbler **101** for a variety of purposes. It may be further contemplated that the tumbler **101** be made of steel, aluminum, plastic, or any other type of material suitable for mixing materials. Further still, it is contemplated that baffles **104** may consist of a variety of materials such as metals, plastics, rubber, carbon-based materials, or others, and it is also contemplated that baffles **104** may include a variety of textures or surfaces such as grates,

holes, ridges, crimps, fabrics, or other such characteristics that may further alter the tumbling of seed and seed treatment within a drum or tumbler **101**. A tumbler **101** may also include a flange **105** which may be used for attaching a tumbler **101** to a frame such as seed treater frame **16** or cradle frame **126**.

FIG. 27 illustrates an end view of a tumbler **101** in accordance with an illustrative aspect of the present disclosure. As shown in FIG. 27, a tumbler **101** may include an outer surface **103** and a flange **105** for attaching a tumbler **101** to a frame or other supporting element or mechanism. Baffles **104** may be included within the tumbler **101** to further assist in combining seed and seed treatment along a seed treatment flow path **12**. Opening **106** may be a large opening at the end of a tumbler **101** and may be utilized for discharging materials from the tumbler **101**, and opening **106** may be positioned centrally on the end of the tumbler **101**. As shown in FIG. 27, opening **106** may be circular in shape, but it is contemplated that other shapes and sizes may be utilized as an opening **106**. Additional openings **108** may be positioned around the circumference of an end of a tumbler **101**, and may be utilized for ventilation or further discharging materials from the tumbler **101**. Openings **108** may be half circles, but it is contemplated that various other shapes may be utilized as openings **108.**

FIG. 28 shows another end view of a tumbler **101** in accordance with an illustrative aspect of the present disclosure. As shown, a tumbler **101** may include an outer surface **103** and a flange **105** for attaching a tumbler **101** to a frame or other supporting element or mechanism. Baffles **104** may be included within the tumbler **101** to further assist in combining seed and seed treatment along a seed treatment flow path **12**. Opening **102** may be a large opening at the end of a tumbler **101** and may be utilized for channeling materials into the tumbler **101**, and opening **102** may be positioned centrally on the end of the tumbler **101**. As shown in FIG. 27, opening **102** may be circular in shape, but it is contemplated that other shapes and sizes may be utilized as an opening **102**. Additional openings **108** may be positioned around the circumference of an end of a tumbler **101**, and may be utilized for ventilation for materials being combined in the tumbler **101**. Openings **108** may be half circles, but it is contemplated that various other shapes may be utilized as openings **108.**

FIG. 29 shows another side view of a tumbler **101** in accordance with an illustrative aspect of the present disclosure. A tumbler **101** may include an outer surface **103** and openings **102** and

106. The openings **102** and **106** may receive seed, liquid material, solid material, and seed treatment along the seed treatment flow path **12** for passage through the tumbler **101**. However, opening **102** may be an inlet opening to introduce seed and seed treatment into a tumbler **101**, and opening **106** may be an outlet for discharging a combination of seed and seed treatment from a tumbler **101** of seed treater **10**. A tumbler **101** may be operably configured to assist in combining seed and seed treatment within the seed treatment flow path **12** at a tumbling rate, and a controller **154** may be operably configured to control the tumbling rate of the drum or tumbler **101**. A seed treatment flow path **12** may be positioned centrally within the tumbler **101** and follow through the length of tumbler **101**. However, a seed treatment flow path **12** is contemplated to follow an alternate route if a tumbler **101** may be a different size, shape, or have varying internal components that alter the seed treatment flow path **12**.

A shown in FIG. 29, a tumbler **101** may include baffles **104** which may further assist in tumbling a combination of seed, at least one liquid type of seed treatment, and at least one solid type of seed treatment within the seed flow path **12**. While baffles **104** may be used as shown in FIG. 29, a tumbler **101** may be contemplated to utilize ridges, heating/cooling elements, sensors, ventilators, discharges, gates, grates, textures or any other conceivable mechanism or design that can be utilized in conjunction with a tumbler **101** for a variety of purposes. It may be further contemplated that the tumbler **101** be made of steel, aluminum, plastic, or any other type of material suitable for mixing materials. Further still, it is contemplated that baffles **104** may consist of a variety of materials such as metals, plastics, rubber, carbon-based materials, or others, and it is also contemplated that baffles **104** may include a variety of textures or surfaces such as grates, holes, ridges, crimps, fabrics, or other such characteristics that may further alter the tumbling of seed and seed treatment within a drum or tumbler **101**. A tumbler **101** may also include a flange **105** which may be used for attaching a tumbler **101** to a frame such as seed treater framework **16** or cradle frame **126**.

FIG. 30 illustrates a front view of a controller **154** and controller housing **152** in accordance with an illustrative aspect of the present disclosure. The controller **154** may be a part of the controller system **150** and may be enclosed in the controller housing **152.** The controller **154** within the controller housing **152** may be removably attached to the seed treater **10** by means of mounts or holes for attachment or removability. The controller housing **152** may also be opened by means

of a latch, door and hinges, clasps, hooks, belt and loops, fasteners, or other conceivable means of removability or openability.

Further shown in FIG. 30, the controller **154** may include a gate position adjuster **158** and a gate position indicator **156** for displaying the gate control direct current (DC) voltage, but other aspects may utilize different units or means to display gate position and/or control information. The gate position adjuster **158** may be used for the infeed gate control of the seed treater **10** to allow for precise and controlled flow of seed or material. The gate position adjuster **158** may consist of a knob, but other means for adjustment may be used such as a gauge, buttons, switches, touch screen, or other conceivable means of adjustment. The gate position indicator **156** and the gate position adjuster **158** may be used in unison to allow for replicative consistent setting of seed flow along a seed flow path **12**. The controller **154** may also include one or more auxiliary output switches **168, 170**, and **172** which may be utilized to provide power to a pump **60** and/or seed mixing equipment or tumbling system **100.** The auxiliary output switches **168, 170**, and **172** may be flip switches, knobs, buttons, touch screen, or other conceivable means for providing power or operating components of seed treater **10**. Further, the auxiliary output switches **168, 170,** and **172** may be utilized to adjust, control, or provide power to different parts or mechanisms of the seed treater **10**. Auxiliary output switch **172** may be a main power switch to provide power to any and/or all components or mechanisms of the seed treater **10**, and may consist of a knob, switch, button(s), touch screen, or other conceivable means of providing power.

Still further shown in FIG. 30, the controller system **150** may include a dispersion speed adjuster **162** and a drum speed adjuster **166**. In conjunction with the dispersion speed adjuster **162**, the controller **150** may include a dispersion speed indicator **160** which may indicate the dispersion speed in. The dispersion speed adjuster **162** may consist of a knob, switch, button(s), touch screen, or other conceivable means of control. In conjunction with the drum speed adjuster **166**, the controller **150** may include a drum speed indicator **164** which may indicate the drum speed in rotations per minute (RPM), but other aspects may utilize different units to communicate drum speed. The drum speed adjuster **166** may consist of a knob, switch, button(s), touch screen, or other conceivable means of control.

FIG. 31 illustrates a side view of a controller **154** and controller housing **152** in accordance with an illustrative aspect of the present disclosure. As shown in FIG. 31 and as part of the

controller system **150**, the controller housing **152** may include a door or opening **153** which may be removable or otherwise opened by means of a latch, hinges, clasps, hooks, belt and loops, fasteners, or other conceivable means of removability or openability.

FIG. 32 shows a top view of a treater framework **126** in accordance with an illustrative aspect of the present disclosure. A treater framework or cradle frame **126** may be utilized for a cradle and drive system **110**, and may include frame members **136** for supporting components of a cradle and drive system **110**. The members **136** may form a predominantly square shape, but other shapes may be utilized to support components of either a cradle and drive system **110** or other components of a seed treater **10**. A treat framework **126** may include posts **138** which may be arranged vertically to support a drum **101** as well as mounting arms or drum pivots **134** which may be utilized for attaching a drum **101** to the frame or otherwise supporting a drum **101**.

FIG. 33 illustrates a side view of a treater framework **126** in accordance with an illustrative aspect of the present disclosure. As shown, treater framework or a cradle frame **126** may include frame members **136** that may extend outwardly from posts **138** to form an "L" shape as depicted from the side as shown in FIG. 33. Mounting arms or drum pivots **134** may be utilized to support drum **101** on the treater framework **126** in conjunction with the posts **138**.

FIG. 34 shows an end view of a treater framework **16** or **126** in accordance with an illustrative aspect of the present disclosure. A treater framework **16** or **126** may include a cover **20** which may further include an outer panel **23**. A cover **20** or outer panel **23** may be removable from the treater framework **16** or **126**. Additionally, a treater framework **16** or **126** may include adjustment slots **21** for adjusting position of a cover **20** and/or outer panel **23**.

FIG. 35 shows another end view of a treater framework **16** or **126** in accordance with an illustrative aspect of the present disclosure. A treater framework **16** or **126** may include a cover **20** which may further include an outer panel **23**. A cover **20** or outer panel **23** may be removable from the treater framework**16** or **126**. Additionally, a treater framework **16** or **126** may include adjustment slots **21** for adjusting position of a cover **20** and/or outer panel **23**.

FIG. 36 depicts a front elevation view of a solid seed treater system **80** and control system **88** in accordance with an illustrative aspect of the present disclosure. A solid seed treater system **80** may be attached to or supported by a treater framework **16** and may be a solid conveyor

operably configured to convey at least one solid type of seed treatment to a solid disperser, outlet, or opening **86**. As shown in FIG. 36, a solid seed treater system **80** may include a hopper **82** which may receive a solid seed treatment for conveyance through a conduit **84** and an opening or outlet **86.** The outlet **86** may be utilized to disperse at least one solid type of seed treatment in the seed treatment flow path **12** downstream of a valve. A shaft **96** may be connected to an auger **98** for conveying at least on solid type of seed treatment to a solid disperser disposed within the seed treatment flow path **12**, and the shaft **96** may be operably connected to a coupler **97**, where a coupler **97** may be connected to a motor **90** which may be operated by a controller **88**. A motor **90** may be a DC gear motor and may operably enable rotation of the shaft **96** and auger **98** to convey at least one solid seed treatment through a hopper **82** and conduit **84** for dispersion at an opening **86**.

Controller **88** may include controls **92** and **94**, which may include a timer and a rotation speed adjuster for adjusting the rate of rotation of the auger **98**. The rotation rate may be calculated and indicated in rotations per minute (RPM). As shown in FIG. 36, a solid seed treater system **80** may be operably configured to introduce at least one solid type of seed treatment into a seed treatment flow path **12** at a solid dispersion rate. Further shown in FIG. 36, a solid seed treater system **80** may include a vibrator **99** which may be utilized to further assist conveying at least one type of solid seed treatment from the hopper **82** through a conduit **84** for dispersion at an opening **86**.

FIG. 37 illustrates a side elevation view of a solid seed treater system **80** and control system **88** in accordance with an illustrative aspect of the present disclosure. As previously described, a solid seed treater system **80** may be attached to or supported by a treater framework **16**, and could include a motor **90**, coupler **97**, shaft **96**, and auger **98** which may be operably connected and utilized to convey at least one type of solid seed treatment through a conduit **84** and **85** for dispersion at an opening **86** onto a seed treatment flow path **12**. The dispersion rate of solid seed treatment through the solid seed treater system **80** may be controlled by a controller **88**, which may include controls **92** and **94** to control the rotation rate of an auger **98** powered by a motor **90,** and therefore control the dispersion rate of an at least one type of solid seed treatment onto a seed treatment flow path **12**.

FIG. 38 shows an end elevation view of a cradle and drive system **110** and tilt controller system **140** in accordance with an illustrative aspect of the present disclosure. A cradle and drive system **110** may be attached to or supported by a cradle frame **126**, and a cradle frame **126** may include posts **138** along with mounting arms or drum pivots **134** for supporting components of the cradle and drive system **110** as well as a tumbler or drum **101** of a tumbling system **100**. A cradle and drive system **110** may further be attached to or supported by a treater framework **16**. Rollers **122** may be operably configured and connected to a motor/actuator **112** which may control a drive member **114**, allowing rollers **122** to rotate and therefore allow a drum **101** to rotate. The rotation of a drum **101** may be utilized to further tumble the combination of seed, liquid seed treatment, and solid seed treatment along a seed treatment flow path **12**.

A tilt control system **140** may include an actuator **142**, which may be a scissor jack or other mechanism which may be used to adjust attitude. A tilt control system **140** may also incorporate a weighing system **180** which may be operably configured to weigh residual seed treatment within the seed treatment flow path **12** from receiving seed and seed treatment and discharging a combination of seed and seed treatment. A weighing system could include a sensor **182** which may be a load sensor. As shown in FIG. 38, a weighing system **180** may be positioned beneath a tumbling system **100** and drum **101** to accurately weigh the contents of a drum **101**. In one aspect, the tilt control system **140** may be operatively connected to the controller **154** or control system **150**.

A drum **101** may include an opening **102** which may be an inlet or infeed opening for receiving a combination of seed and seed treatment. A flange **105** may be used to connect a conduit **24** to the opening **102** of the drum **101** to assist in conveying the combination of seed and seed treatment into the drum **101** on a seed treatment flow path **12**.

FIG. 39 illustrates a control circuit schematic **154** for a seed treater **10** in accordance with an illustrative aspect of the present disclosure. A control circuit **154** may also include a power supply **174** which may be a 24V power supply or any other appropriate voltage. A control circuit **154** may further include a 24 - 12 volts of direct current (VDC) voltage converter **176** or any other appropriate VDC converter. The control circuit **154** may also include a gate position adjuster **158**, a gate position indicator **156**, a dispersion speed adjuster **162**, and a drum speed adjuster **166.**

Further, the control circuit **154** may include a drum motor **112** and a dispersion motor for pump **60.**

FIG. 40 shows a flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure. A seed treatment method may include the step **200** of providing a seed treatment flow path for receiving seed and seed treatment and discharging a combination of seed and seed treatment. Further, a seed treatment method may include the step **202** of providing a seed flow control valve for controlling the continuous and consistent flow of seed through the seed treatment flow path. A seed treatment method may also include the step **204** of dispersing at least on liquid type of seed treatment into the seed treatment flow path and step **206** of dispersing at least on solid type of seed treatment into the seed treatment flow path. Additionally, a seed treatment method may include the step **208** of tumbling the combination of seed, at least on liquid type of seed treatment, and at least one solid type of seed treatment within the seed treatment flow path. Further still, a seed treatment method may include the step **210** of controlling the continuous and consistent flow of seed into the seed treatment flow path based on at least on condition, and may further include the step **212** of controlling the dispersing of at least one liquid type of seed treatment into the seed treatment flow path based on at least on condition. Further shown in FIG. 40 is the step **214** of controlling the dispersing of at least one solid type of seed treatment into the seed treatment flow path based on at least one condition, as well as the step **216** of controlling the tumbling of the combination within the seed treatment flow path based on at least one condition.

FIG. 41 shows another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure. A seed treatment method may include the step **218** of controlling the continuous and consistent flow of seed through a seed treatment flow path. Further, a seed treatment method may include the step **220** of funneling seed from a seed hopper to a valve having a gate and a gate opening, and also include the step **222** of opening the valve by actuating the gate away from the gate opening. Further still, a seed treatment method may include the step **224** of concentrically increasing a gate gap between the gate opening and gate during opening of the valve, and the step **226** of increasing the rate of passing seed from the hopper through the gate opening and around the gate through the seed treatment flow path. FIG. 41 further shows the step **228** of closing the valve by actuating the gate through the gate opening. As shown

further in FIG. 41, a seed treatment method may include the step **230** of concentrically decreasing a gate gap between the gate opening and gate during closing of the valve, as well as the step **232** of decreasing the rate of passing seed from the hopper through the gate opening and around the gate through the seed treatment flow path. FIG. 41 also shows the step **234** of electromechanically actuating the opening and closing of the gate with a controller.

FIG. 42 shows yet another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure. A seed treatment method may include the step **236** of controlling the dispersing of at least one liquid type of seed treatment in the seed treatment flow path. A seed treatment method may also include the step **238** of plumbing liquid seed treatment form a hopper for dispersing in the seed treatment flow path. As further shown in FIG. 42, a seed treatment method may also include the step **240** of increasing the rate of liquid treatment passing through plumbing by increasing a rate of pumping, as well as the step **242** of decreasing the rate of liquid treatment passing through plumbing by decreasing a rate of pumping. Further still, a seed treatment method may include the step **244** of discharging liquid treatment from plumbing in the seed treatment flow path. Additionally, a seed treatment method may include the step **246** of increasing dispensing of the discharged liquid treatment in the seed treatment flow path by increasing the rate of pumping, as well as the step **248** of increasing the dispersion of the discharged liquid treatment in the seed treatment flow path by increasing a rate of dispersion. As shown in FIG. 42, a seed treatment method may still further include the step **250** of decreasing the dispensing of the discharged liquid treatment in the seed treatment flow path by decreasing the rate of pumping, as well as the step **252** of decreasing the dispersion of the discharged liquid treatment in the seed treatment flow path by decreasing a rate of dispersion.

FIG. 43 shows another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure. As shown, a seed treatment method may include the step **254** of controlling the dispersing of at least on solid type of seed treatment in the seed treatment flow path, and further include step **256** of plumbing solid seed treatment from a hopper for dispersing in the seed treatment flow path. A seed treatment method may also include the step **258** of increasing the rate of solid treatment passing through plumbing by increasing a rate of conveyance, and may also include the step **260** of decreasing the rate of solid treatment passing through plumbing by decreasing a rate of conveyance. Further still, a seed treatment method may

include the step **262** of discharging solid treatment from plumbing in the seed treatment flow path. FIG. 43 further shows a seed treatment method may include the step **264** of increasing dispersion of the discharged solid treatment in the seed treatment flow path by increasing the rate of conveyance, and may also include the step **266** of increasing dispersion of the discharged solid treatment in the seed treatment flow path by increasing a rate of tumbling. Additionally, a seed treatment method may further include the step **268** of decreasing dispensing of the discharged solid treatment in the seed treatment flow path by decreasing the rate of conveyance, and my further include the step **270** of decreasing dispersion of the discharged solid treatment in the seed treatment flow path by decreasing a rate of tumbling.

FIG. 44 shows another flowchart illustrating a seed treatment method in accordance with an illustrative aspect of the present disclosure. A seed treatment method may include the step **272** or controlling a combination of seed, at least one liquid type of seed treatment, and at least one solid type of seed treatment within a seed treatment flow path **12**. A seed treatment method may further include the step **274** of slowing the travel of the combination through the seed treatment flow path **12**. Further, a step **276** of tumbling the combination within the seed treatment flow path **12** may be included in a seed treatment method. Next, a step **278** of decreasing a rate of tumbling by decreasing an RPM of the rate of tumbling may be included in a seed treatment method and may further include the step **280** of decreasing a rate of tumbling be decreasing a number of baffles **104**. A seed treatment method may also include the step **282** of increasing a rate of tumbling by increasing an RPM of the rate of tumbling, and may further include the step **284** of increasing a rate of tumbling by increasing a number of baffles **104**. A step **286** of changing throughput of a combination through the seed treatment flow path **12** by changing an attitude of a seed treatment flow path **12** may be included in a seed treatment method. Finally, a step **288** of detecting residual from a combination in a seed treatment flow path **12** with a sensor may be included in a seed treatment method.

The seed treater **10** of the present disclosure includes, for example, a seed treatment flow path **12** configured to receive seed and seed treatment and discharge a combination of seed with seed treatment. A valve **36** may be positioned in the seed treatment flow path **12** for controlling seed movement. In at least one aspect, the valve **36** controls a throughput rate of seed introduced into the seed treatment flow path **12**. A liquid disperser of the liquid seed treater system **50** may

be disposed in the seed treatment flow path **12** for dispersing at least one liquid type of seed treatment at a liquid dispersion rate. In one aspect, the liquid disperser is disposed downstream of the valve **36**. A solid disperser of the solid seed treater system **80** in the seed treatment flow path **12** may be disposed in the seed treatment flow path **12** for dispersing at least one solid type of seed treatment at a solid dispersion rate. In at least one aspect, the solid disperser is disposed downstream of the liquid disperser. An actuatable housing of the tumbling system **100** within the seed treatment flow path **12** has a rate of operation and an adjustable orientation. In at least one aspect, the actuatable housing is downstream of the valve **36** for uniformly distributing the at least one liquid type of seed treatment, the at least one solid type of seed treatment, and seed for creating the combination of seed with seed treatment. In at least one aspect, the adjustable orientation of the actuatable housing of the tumbling system **100** adjusts a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path **12**. In at least one other aspect, the rate of operation of the actuatable housing of the tumbling system **100** adjusts a rate of the uniform distribution of the at least one liquid type of seed treatment, the at least one solid type of seed treatment, and seed. In at least one additional aspect, the rate of operation of the actuatable housing of the tumbling system **100** is adjusted based on at least one of a type of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the throughput rate of seed, the liquid dispersion rate, the solid dispersion rate, and the adjustable orientation of the tumbling system **100**. In still another aspect, the throughput rate of seed may be adjusted based on at least one of a type of seed, the at least one liquid type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80**, the liquid dispersion rate of the liquid seed treater system **50**, the solid dispersion rate of the solid seed treater system **80**, the rate of operation of the actuatable housing of the tumbling system **100**, and the adjustable orientation of the tumbling system **100**. In yet another aspect, the solid dispersion rate of the solid seed treater system **80** may be adjusted based on at least one of a type of seed, the throughput rate of seed, the at least one liquid type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80**, the liquid dispersion rate of the liquid seed treater system **50**, the rate of operation of the actuatable housing of the tumbling system **100**, and the adjustable orientation of the tumbling system **100**. In at least one other aspect, the liquid dispersion rate of the liquid seed treater system **50** may be adjusted based on at least one of a type of seed, the throughput rate of seed, the at least one liquid

type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80**, the solid dispersion rate of the solid seed treater system **80**, the rate of operation of the actuatable housing of the tumbling system **100**, and the adjustable orientation of the tumbling system **100**.

The seed treatment method of the present disclosure includes, for example, providing a seed treatment flow path **12** configured for receiving seed and seed treatment and discharging a combination of seed with seed treatment and a valve **36** having a gate **42** and gate opening **46**. The method can include the steps of: controlling a throughput rate of seed into the seed treatment flow path **12** with a valve **36**, wherein at least a portion of the gate **42** is disposed within the gate opening **46** in both open and closed positions **43**; dispersing at least one liquid type of seed treatment of the liquid seed treater system **50** at a liquid dispersion rate into the seed treatment flow path **12** downstream of the valve **36**; dispersing at least one solid type of seed treatment of the solid seed treater system **80** at a solid dispersion rate into the seed treatment flow path **12** downstream of the valve **36**; and distributing the combination of seed, the at least one liquid type of seed treatment of the liquid seed treater system **50**, and the at least one solid type of seed treatment of the solid seed treater system **80** at a rate of distribution of the tumbling system **100** within the seed treatment flow path **12**. In at least one other aspect, adjusting a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path **12** may be by adjusting the rate of the distribution of the tumbling system **100**. In still another aspect, adjusting the rate of distribution of the seed of the tumbling system **100**, the at least one liquid type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80** by adjusting a rate of distributing the combination of seed of the tumbling system **100**. In yet another aspect, adjusting the throughput rate of seed may be based on at least one of a type of seed, the at least one liquid type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80**, the liquid dispersion rate of the liquid seed treater system **50**, the solid dispersion rate of the solid seed treater system **80**, and the rate of distribution of the tumbling system **100**. For another aspect, adjusting the rate of distribution of the tumbling system **100** may be based on at least one of a type of seed, the at least one liquid type of seed treatment of the liquid seed treater system **50**, the at least one solid type of seed treatment of the solid seed treater system **80**, the liquid dispersion rate of the liquid seed

treater system **50**, the solid dispersion rate of the solid seed treater system **80**, and the throughput rate of seed.

The system for continuous treatment of seed of the present disclosure includes, for example, a seed treatment flow path **12** configured to receive seed and seed treatment and discharge a combination of seed with seed treatment. The system may include a valve **36** operably configured to introduce a continuous flow of seed into the seed treatment flow path **12** at a seed throughput rate. A liquid disperser of the liquid seed treater system **50** may be operably configured to introduce at least one liquid type of seed treatment into the seed treatment flow path **12** at a liquid dispersion rate. A solid disperser of the solid seed treater system **80** may be operably configured to introduce at least one solid type of seed treatment into the seed treatment flow path **12** at a solid dispersion rate. A controller **154** of the control system **150** may be operably configured to control the seed throughput rate, the liquid dispersion rate of the liquid seed treater system **50**, and the solid dispersion rate of the solid seed treater system **80** based at least on one or more conditions selected at least from a type of seed and a type of seed treatment. A tumbler or drum **101** of tumbling system **100** may also be operably configured to assist in combining seed and seed treatment within the seed treatment flow path **12** at a tumbling rate, wherein the controller **154** is operably configured to control the tumbling rate **166** based at least on one or more conditions selected at least from the type of seed and the type of seed treatment. In at least one aspect, the at least one or more conditions are further selected at least from seed temperature, seed treatment flow path temperature, seed treatment flow path humidity, seed treater environment temperature, and seed treater environment humidity. A weighing system **180** may also be operably configured to weigh residual seed treatment remaining within the seed treatment flow path **12** from receiving seed and seed treatment and discharging a combination of seed with seed treatment. A tilt control system **140** may also be operably configured to control the orientation of the seed treatment flow path **12** for controlling a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path **12**. A pump **60** of the liquid seed treater system **50** may also be operably configured to peristaltically deliver the at least one liquid type of seed treatment to the liquid disperser of the liquid seed treater system **50** under operation of the controller **154** for changing the liquid dispersion rate of the liquid seed treater system **50**. A linear actuator **39** may also be operably configured to actuate at least a portion of the gate **42** being disposed within a gate opening **46** in both open and closed positions **43** under operation of the controller **154** for controlling the

seed throughput rate. A tilt control system **140** may also be operably configured to control the orientation of the seed treatment flow path **12** for controlling a rate of distribution of seed with seed treatment before discharge of the combination of seed with seed treatment from the seed treatment flow path **12**.

The disclosure is not to be limited to the particular aspects described herein. In particular, the disclosure contemplates numerous variations in a continuous flow seed treater. The foregoing description has been presented for purposes of illustration and description. It is not intended to be an exhaustive list or limit any of the disclosure to the precise forms disclosed. It is contemplated that other alternatives or exemplary aspects are considered included in the disclosure. The description is merely examples of embodiments, processes or methods of the disclosure. It is understood that any other modifications, substitutions, and/or additions can be made, which are within the intended spirit and scope of the disclosure.

What is claimed is:

1. A seed treater, comprising:

a seed treatment flow path configured to receive seed and seed treatment and discharge a combination of seed with seed treatment;

a valve in the seed treatment flow path for controlling seed movement, wherein the valve controls a throughput rate of seed introduced into the seed treatment flow path;

a liquid disperser in the seed treatment flow path for dispersing at least one liquid type of seed treatment at a liquid dispersion rate, wherein the liquid disperser is disposed downstream of the valve;

a solid disperser in the seed treatment flow path for dispersing at least one solid type of seed treatment at a solid dispersion rate, wherein the solid disperser is disposed downstream of the liquid disperser; and

an actuatable housing within the seed treatment flow path having a rate of operation and an adjustable orientation, wherein the actuatable housing is downstream of the valve for uniformly distributing the at least one liquid type of seed treatment, the at least one solid type of seed treatment, and seed for creating the combination of seed with seed treatment.

2. The seed treater of claim 1, wherein the adjustable orientation of the actuatable housing adjusts a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path.

3. The seed treater of claim 1, wherein the rate of operation of the actuatable housing adjusts a rate of the uniform distribution of the at least one liquid type of seed treatment, the at least one solid type of seed treatment, and seed.

4. The seed treater of claim 1, wherein the rate of operation of the actuatable housing is adjusted based on at least one of a type of seed, the at least one liquid type of seed treatment, the

at least one solid type of seed treatment, the throughput rate of seed, the liquid dispersion rate, the solid dispersion rate, and the adjustable orientation.

5. The seed treater of claim 1, wherein the throughput rate of seed is adjusted based on at least one of a type of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the liquid dispersion rate, the solid dispersion rate, the rate of operation of the actuatable housing, and the adjustable orientation.

6. The seed treater of claim 1, wherein the solid dispersion rate is adjusted based on at least one of a type of seed, the throughput rate of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the liquid dispersion rate, the rate of operation of the actuatable housing, and the adjustable orientation.

7. The seed treater of claim 1, wherein the liquid dispersion rate is adjusted based on at least one of a type of seed, the throughput rate of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the solid dispersion rate, the rate of operation of the actuatable housing, and the adjustable orientation.

8. A seed treatment method, comprising:

providing a seed treatment flow path configured for receiving seed and seed treatment and discharging a combination of seed with seed treatment and a valve having a gate and gate opening;

controlling a throughput rate of seed into the seed treatment flow path with a valve, wherein at least a portion of the gate is disposed within the gate opening in both open and closed positions;

dispersing at least one liquid type of seed treatment at a liquid dispersion rate into the seed treatment flow path downstream of the valve;

dispersing at least one solid type of seed treatment at a solid dispersion rate into the seed treatment flow path downstream of the valve; and

distributing the combination of seed, the at least one liquid type of seed treatment, and the at least one solid type of seed treatment at a rate of distribution within the seed treatment flow path.

9. The seed treatment method of claim 8, further comprising:

adjusting a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path by adjusting the rate of the distribution.

10. The seed treatment method of claim 8, further comprising:

adjusting the rate of distribution of the seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment by adjusting a rate of distributing the combination of seed.

11. The seed treatment method of claim 8, further comprising:

adjusting the throughput rate of seed based on at least one of a type of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the liquid dispersion rate, the solid dispersion rate, and the rate of distribution.

12. The seed treatment method of claim 8, further comprising:

adjusting the rate of distribution based on at least one of a type of seed, the at least one liquid type of seed treatment, the at least one solid type of seed treatment, the liquid dispersion rate, the solid dispersion rate, and the throughput rate of seed.

13. A system for continuous treatment of seed, comprising:

a seed treatment flow path configured to receive seed and seed treatment and discharge a combination of seed with seed treatment;

a valve operably configured to introduce a continuous flow of seed into the seed treatment flow path at a seed throughput rate;

a liquid disperser operably configured to introduce at least one liquid type of seed treatment into the seed treatment flow path at a liquid dispersion rate;

a solid disperser operably configured to introduce at least one solid type of seed treatment into the seed treatment flow path at a solid dispersion rate; and

a controller operably configured to control the seed throughput rate, the liquid dispersion rate, and the solid dispersion rate based at least on one or more conditions selected at least from a type of seed and a type of seed treatment.

14. The system of claim 13, further comprising:

a tumbler operably configured to assist in combining seed and seed treatment within the seed treatment flow path at a tumbling rate, wherein the controller is operably configured to control the tumbling rate based at least on one or more conditions selected at least from the type of seed and the type of seed treatment.

15. The system of claim 13, wherein the at least one or more conditions are further selected at least from seed temperature, seed treatment flow path temperature, seed treatment flow path humidity, environment temperature, and environment humidity.

16. The system of claim 13, further comprising:

a weighing system operably configured to weigh residual seed treatment remaining within the seed treatment flow path from receiving seed and seed treatment and discharging a combination of seed with seed treatment.

17. The system of claim 13, further comprising:

a tilt control system operably configured to control the orientation of the seed treatment flow path for controlling a rate of discharge of the combination of seed with seed treatment from the seed treatment flow path.

18. The system of claim 13, further comprising:

a pump system operably configured to peristaltically deliver the at least one liquid type of seed treatment to the liquid disperser under operation of the controller for changing the liquid dispersion rate.

19. The system of claim 13, further comprising:

a linear actuator operably configured to actuate at least a portion of the gate being disposed within a gate opening in both open and closed positions under operation of the controller for controlling the seed throughput rate.

20. The system of claim 13, further comprising:

a tilt control system operably configured to control the orientation of the seed treatment flow path for controlling a rate of distribution of seed with seed treatment before discharge of the combination of seed with seed treatment from the seed treatment flow path.

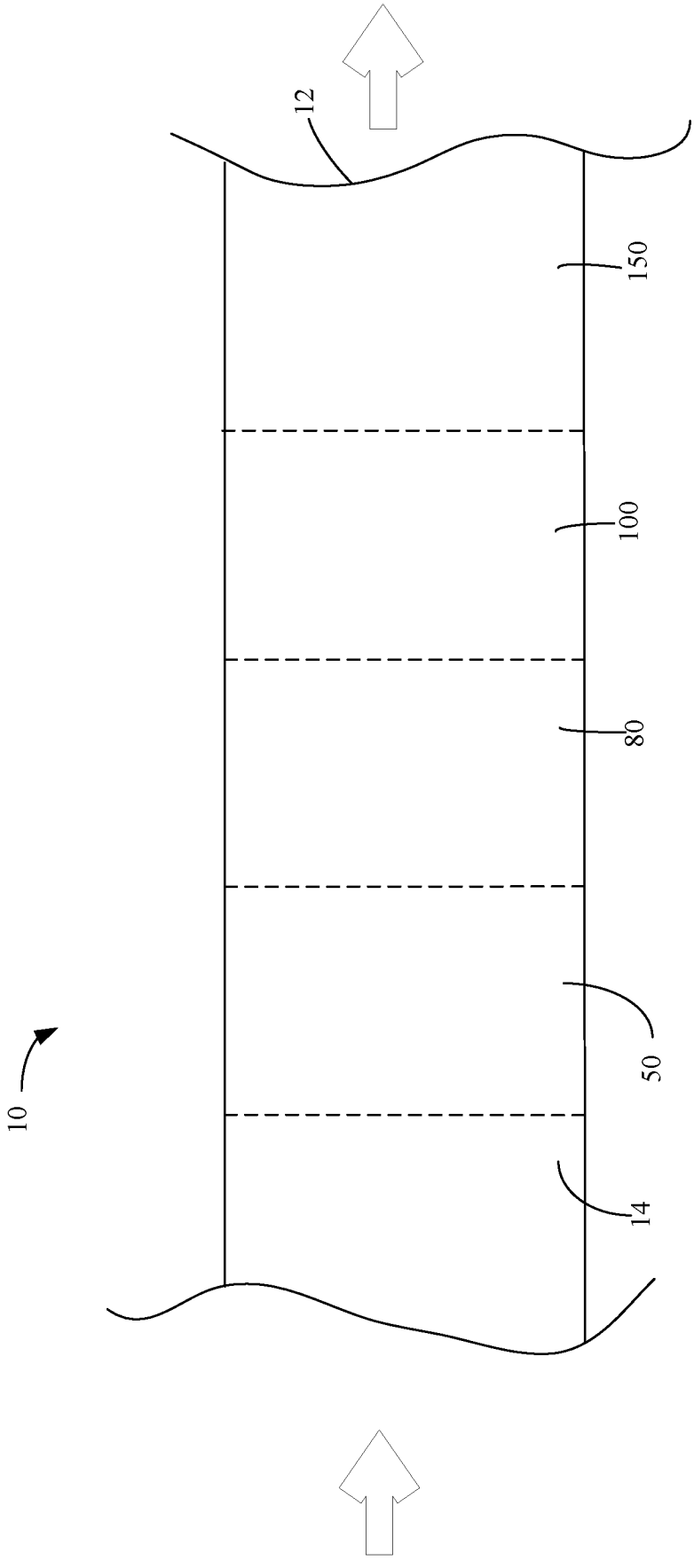

FIG. 1A

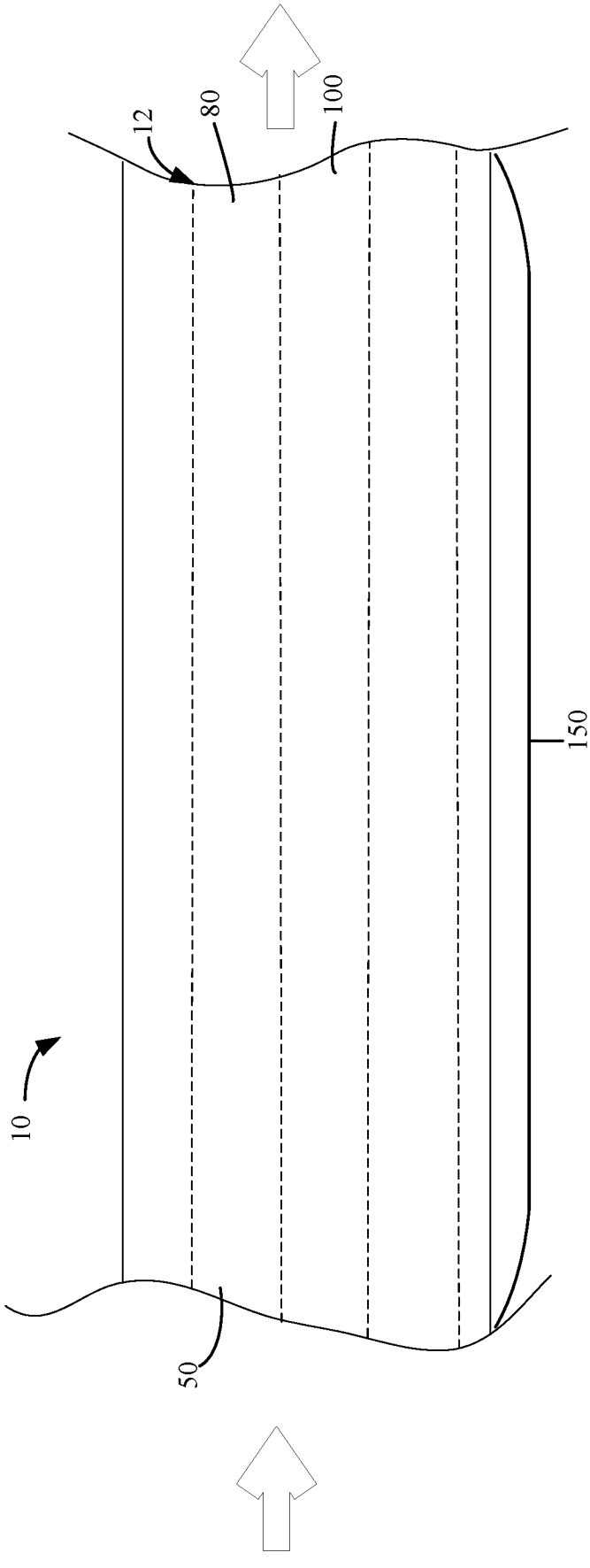

FIG. 1B

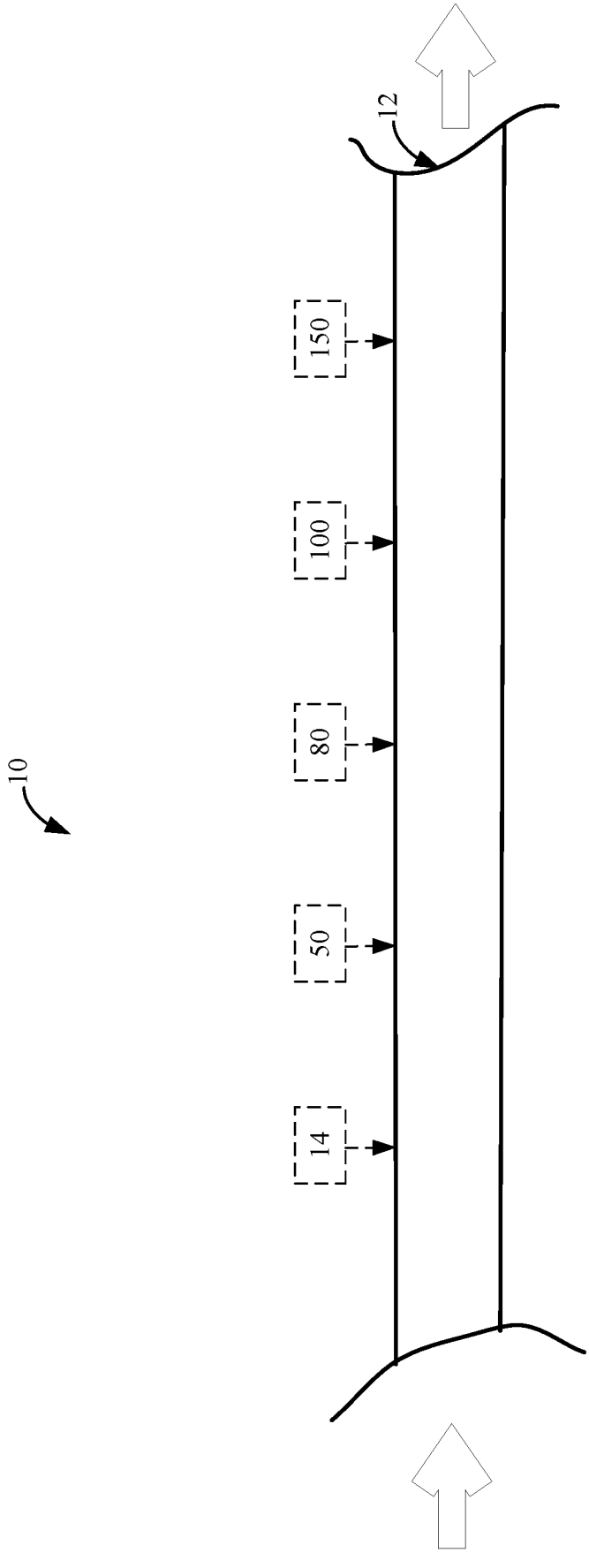

FIG. 1C

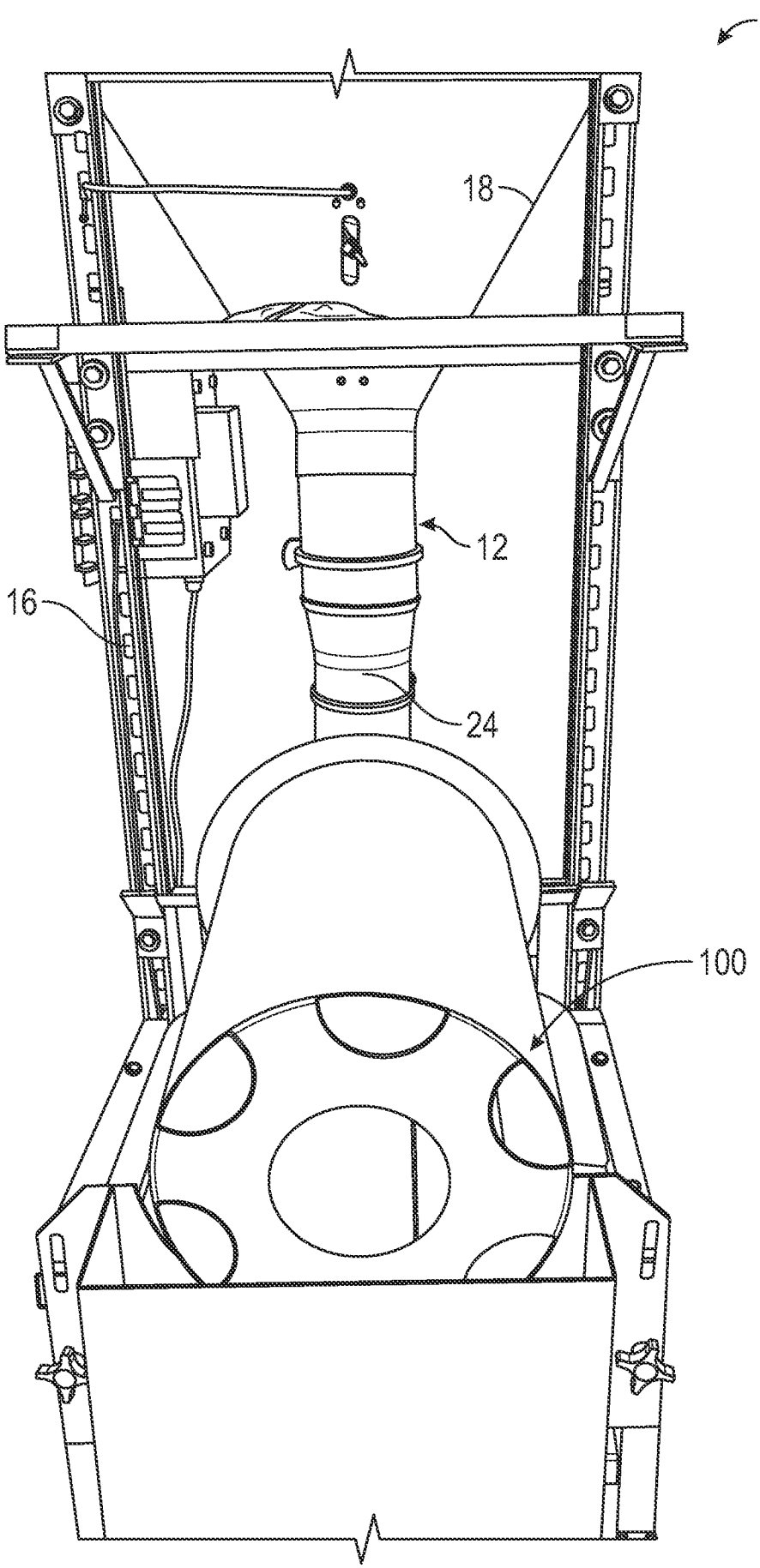

FIG. 2

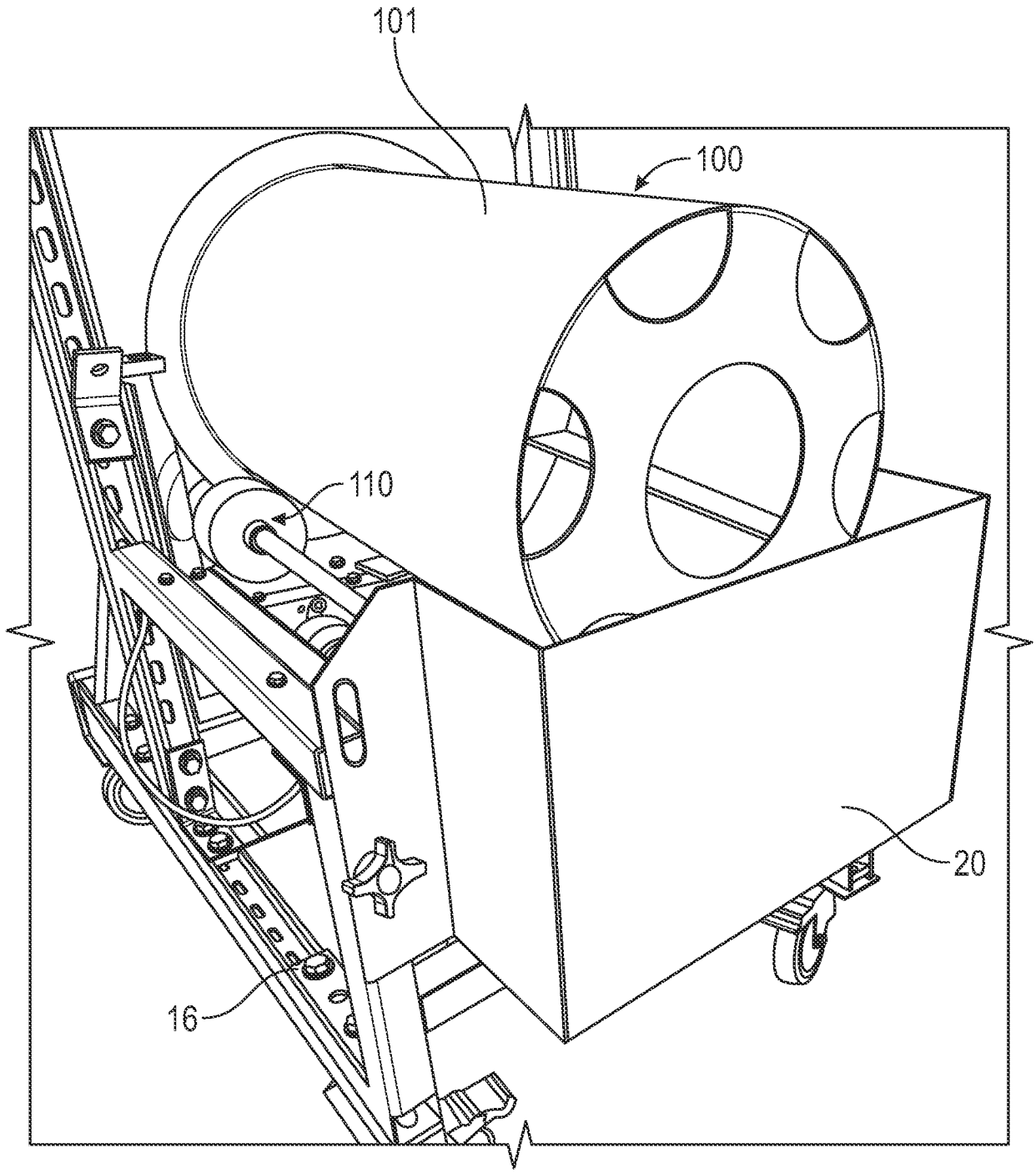

FIG. 3

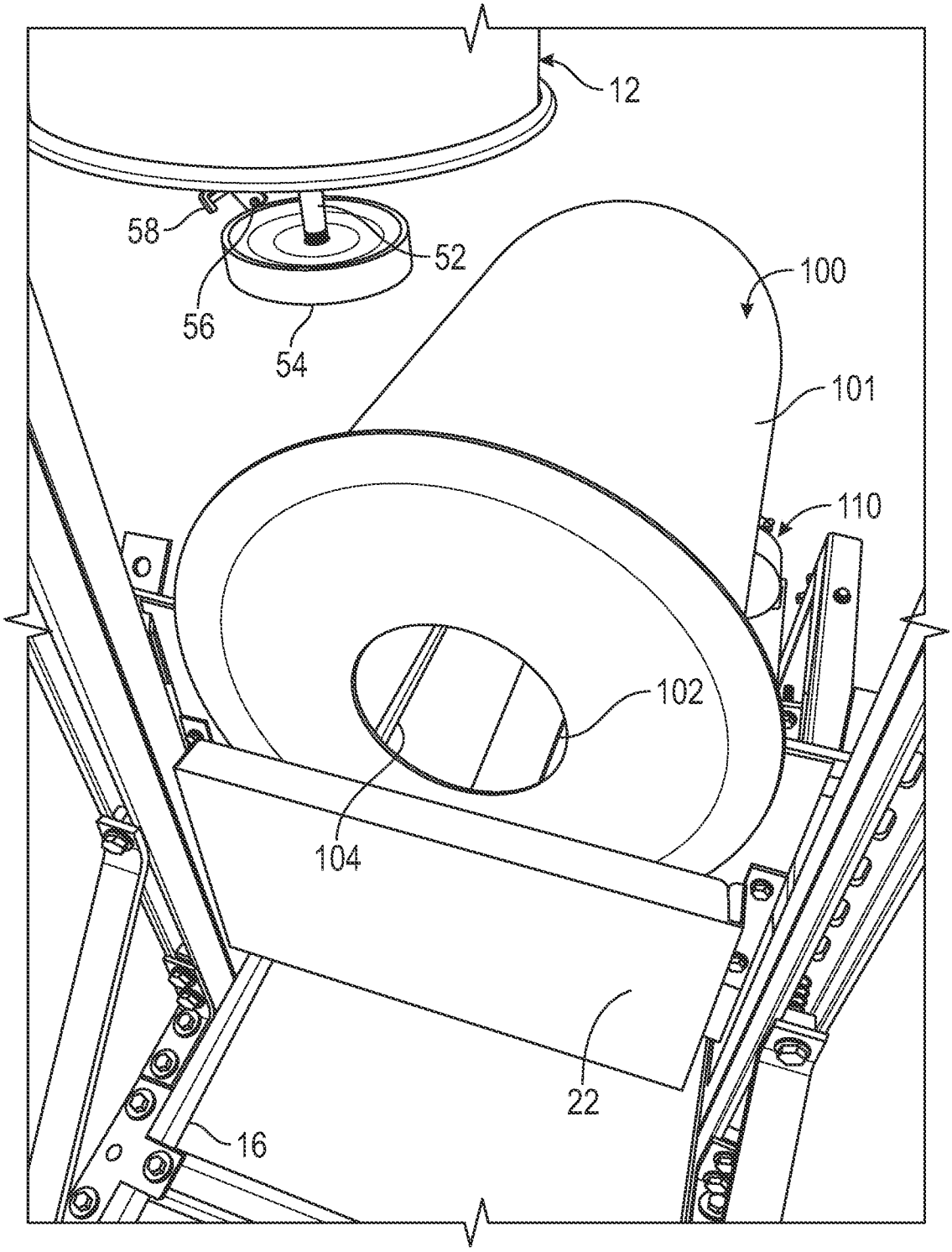

FIG. 4

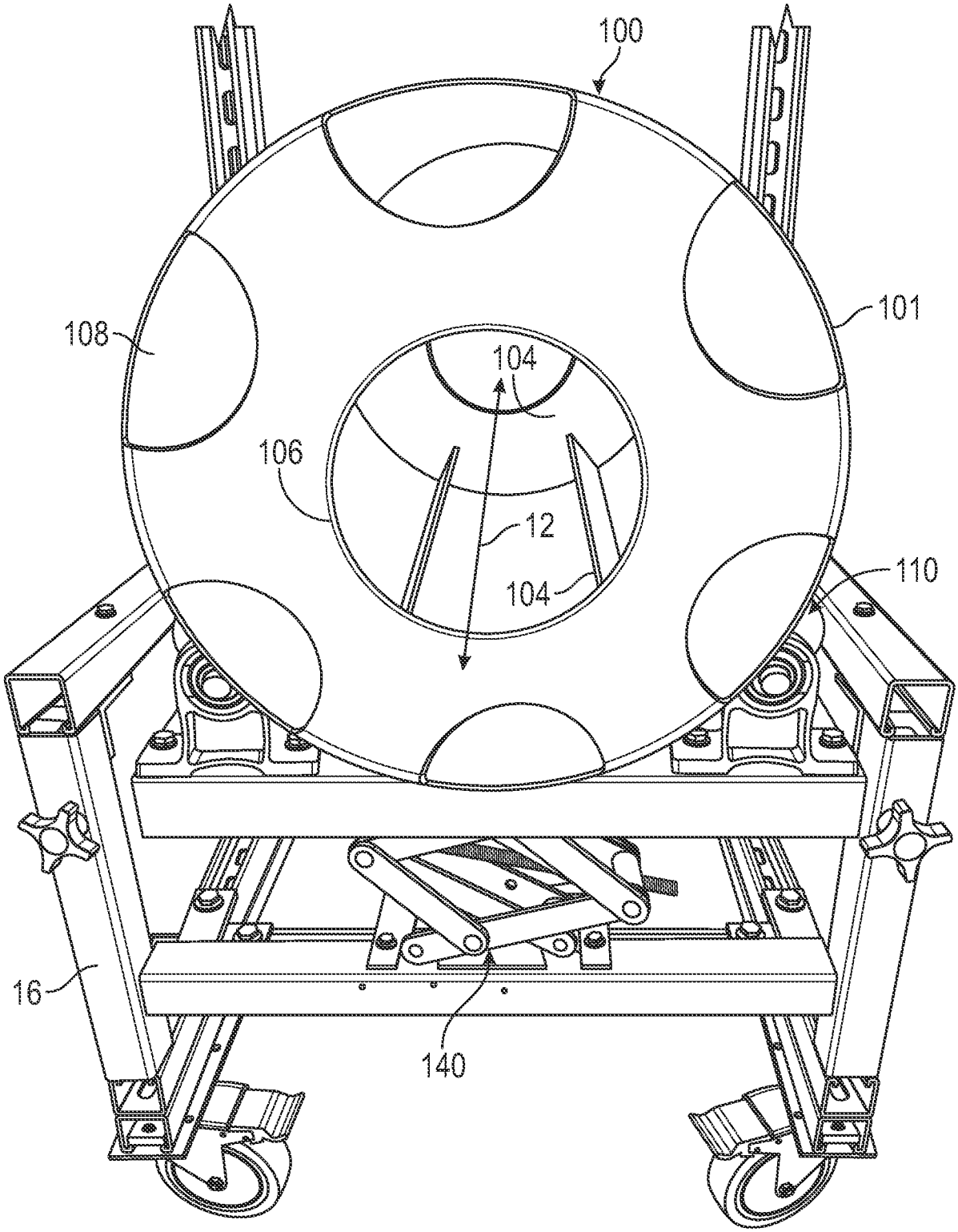

FIG. 5

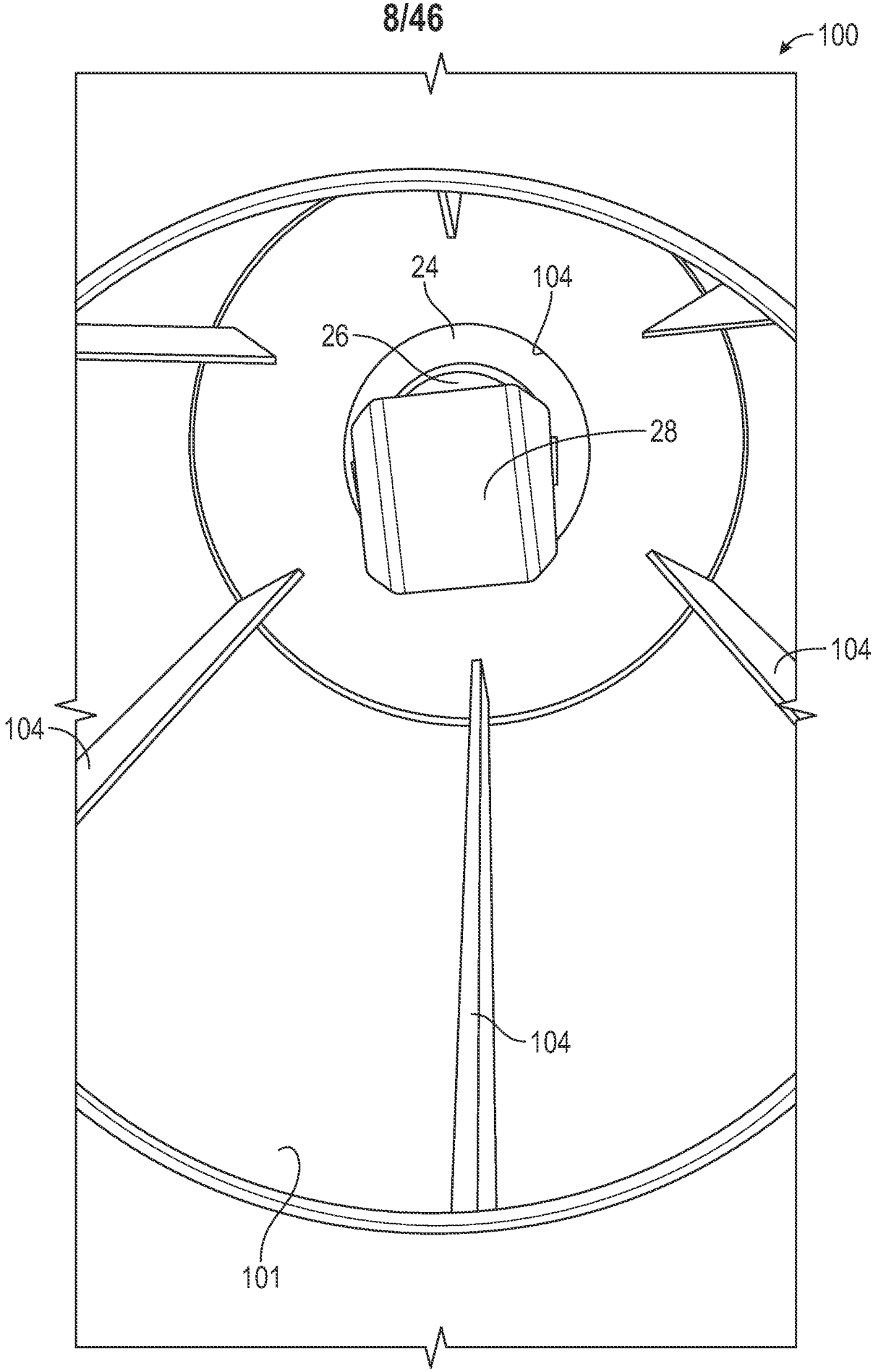

FIG. 6

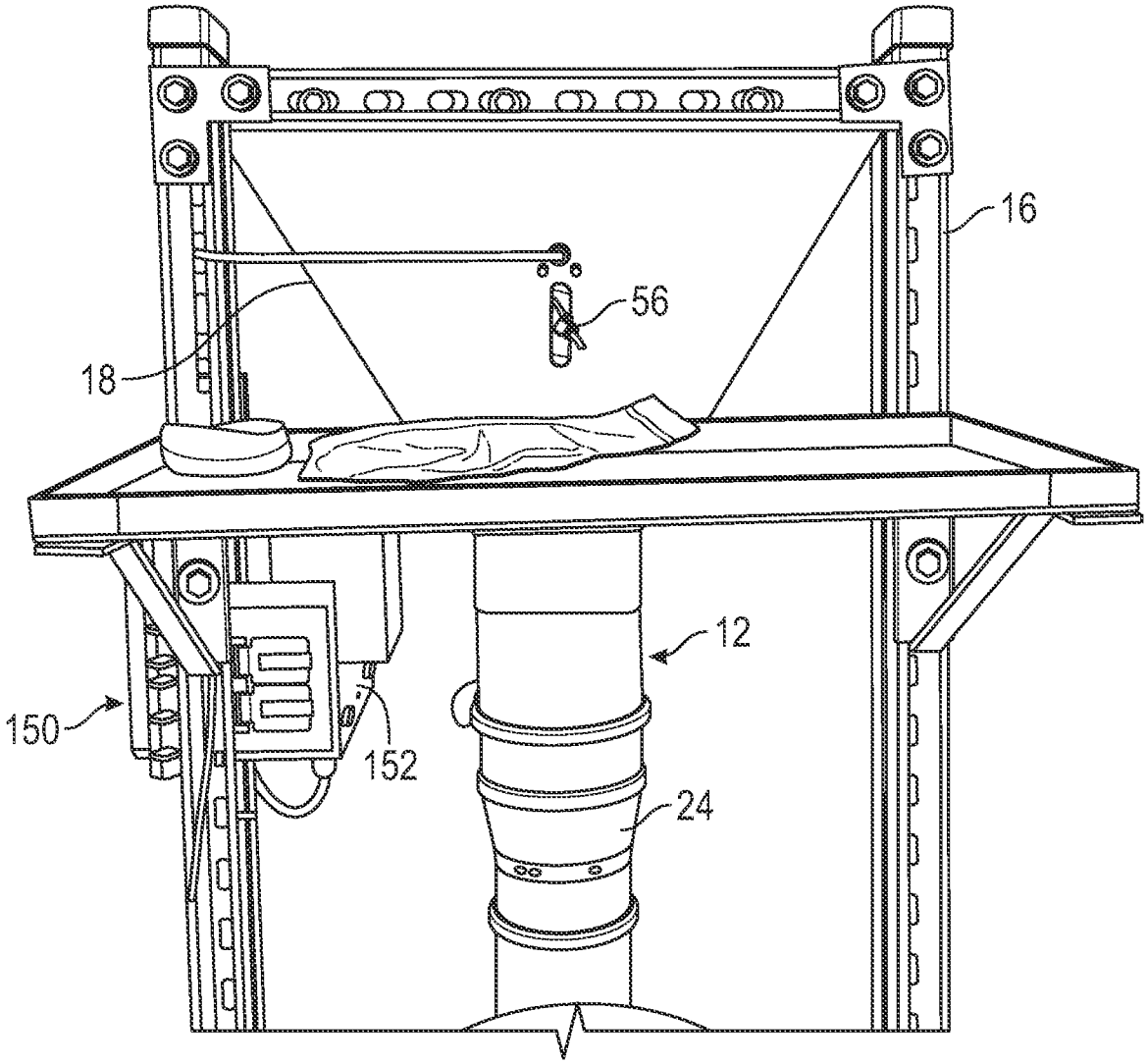

FIG. 7

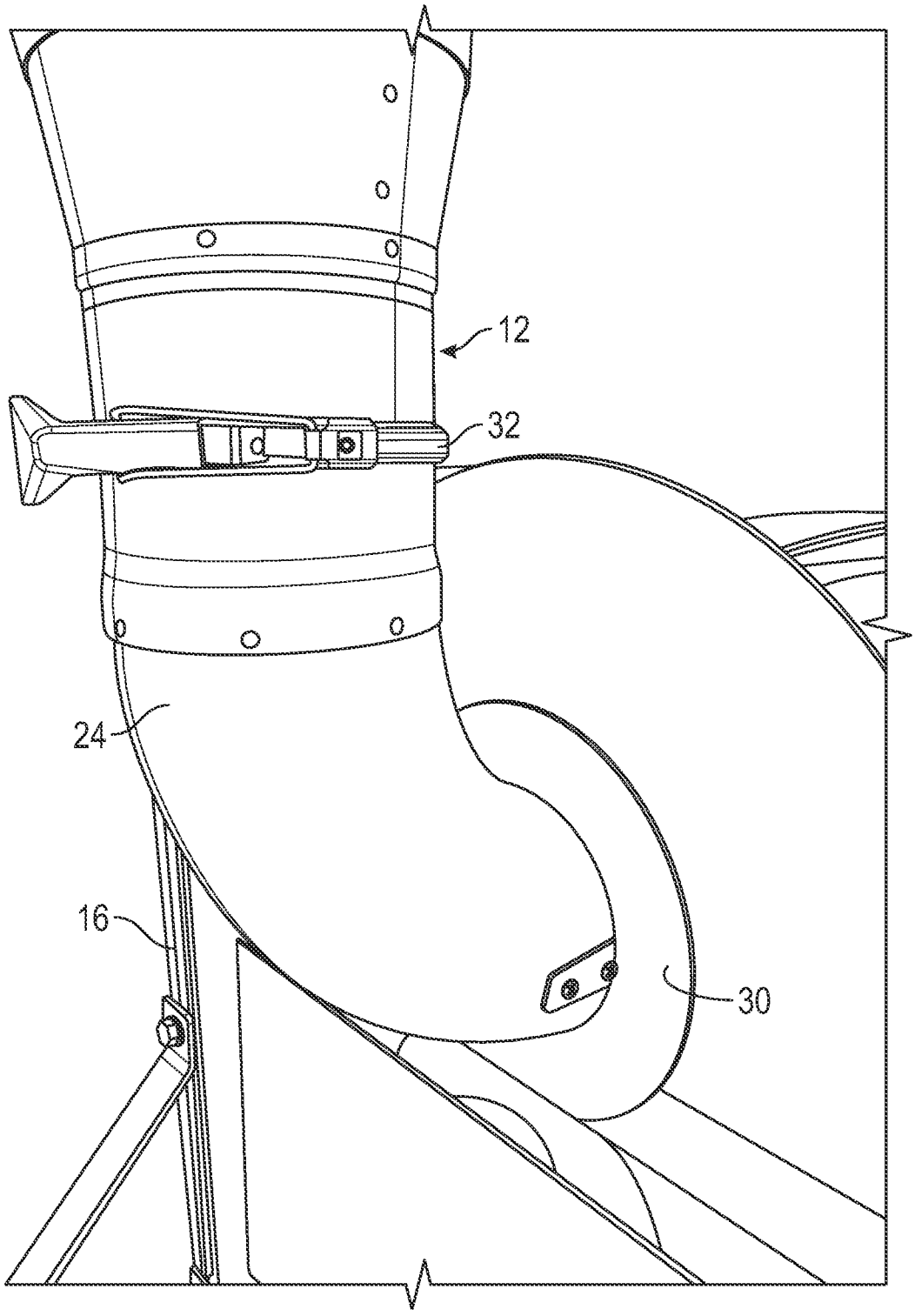

FIG. 8

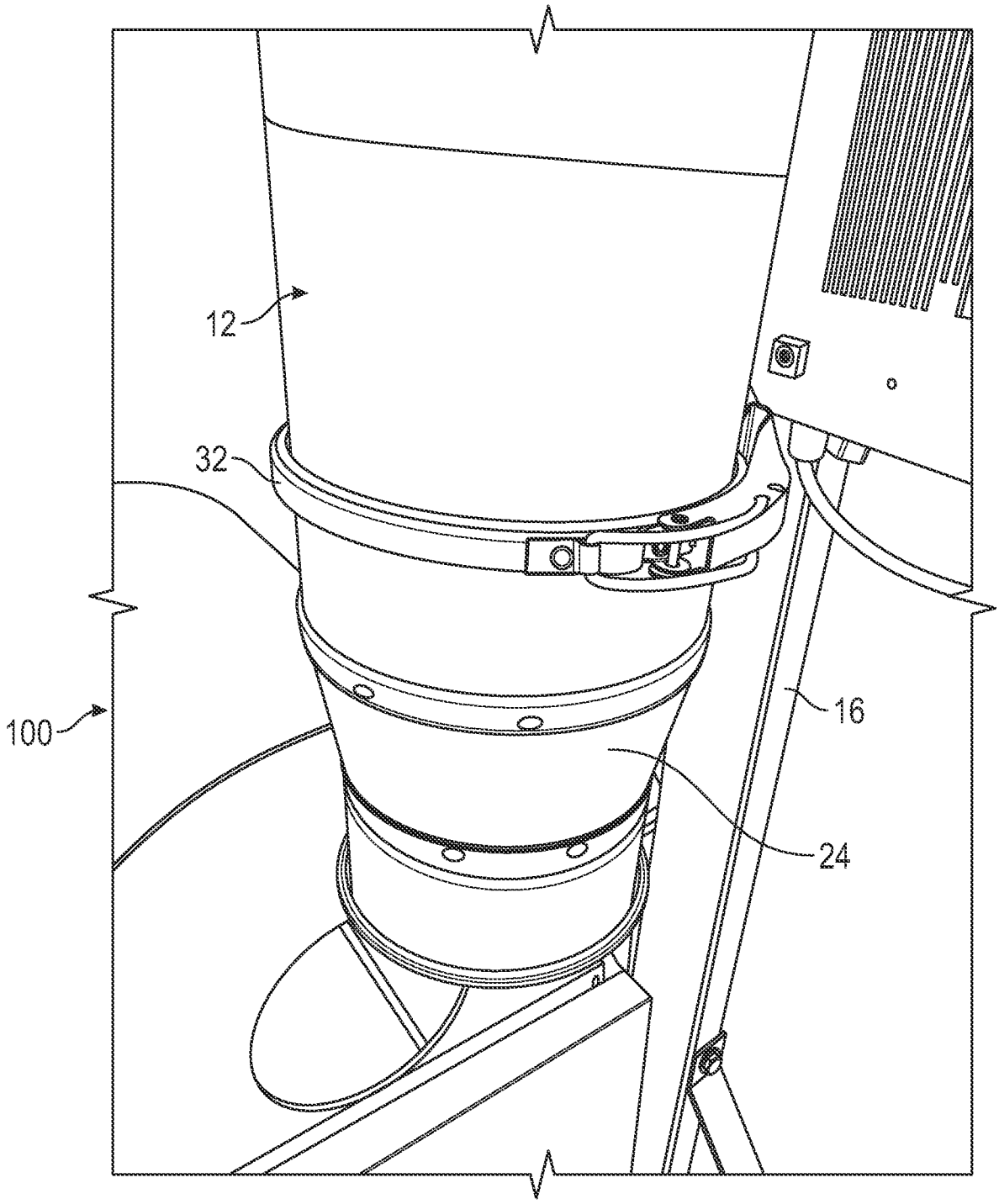

FIG. 9

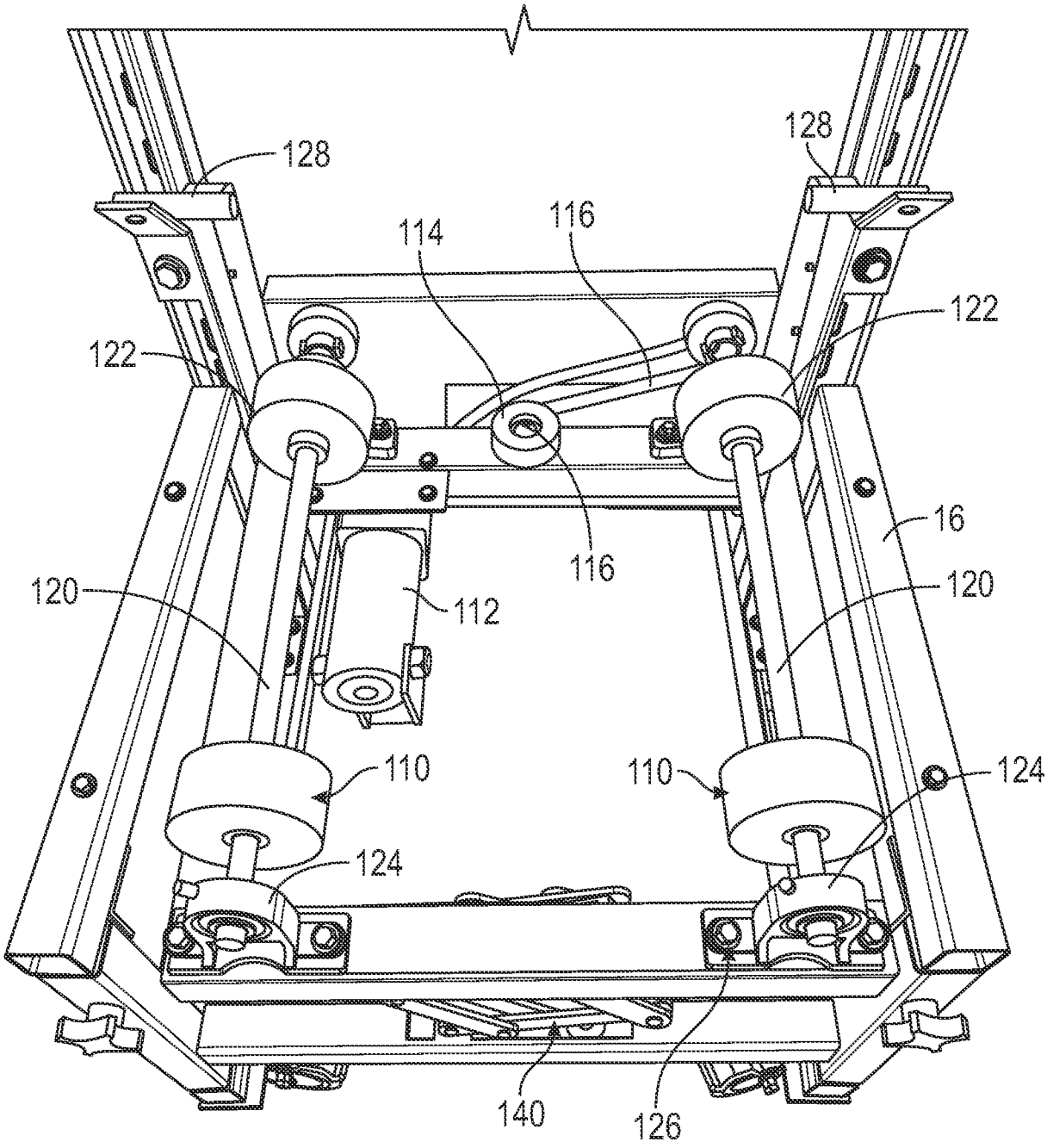
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FIG. 10

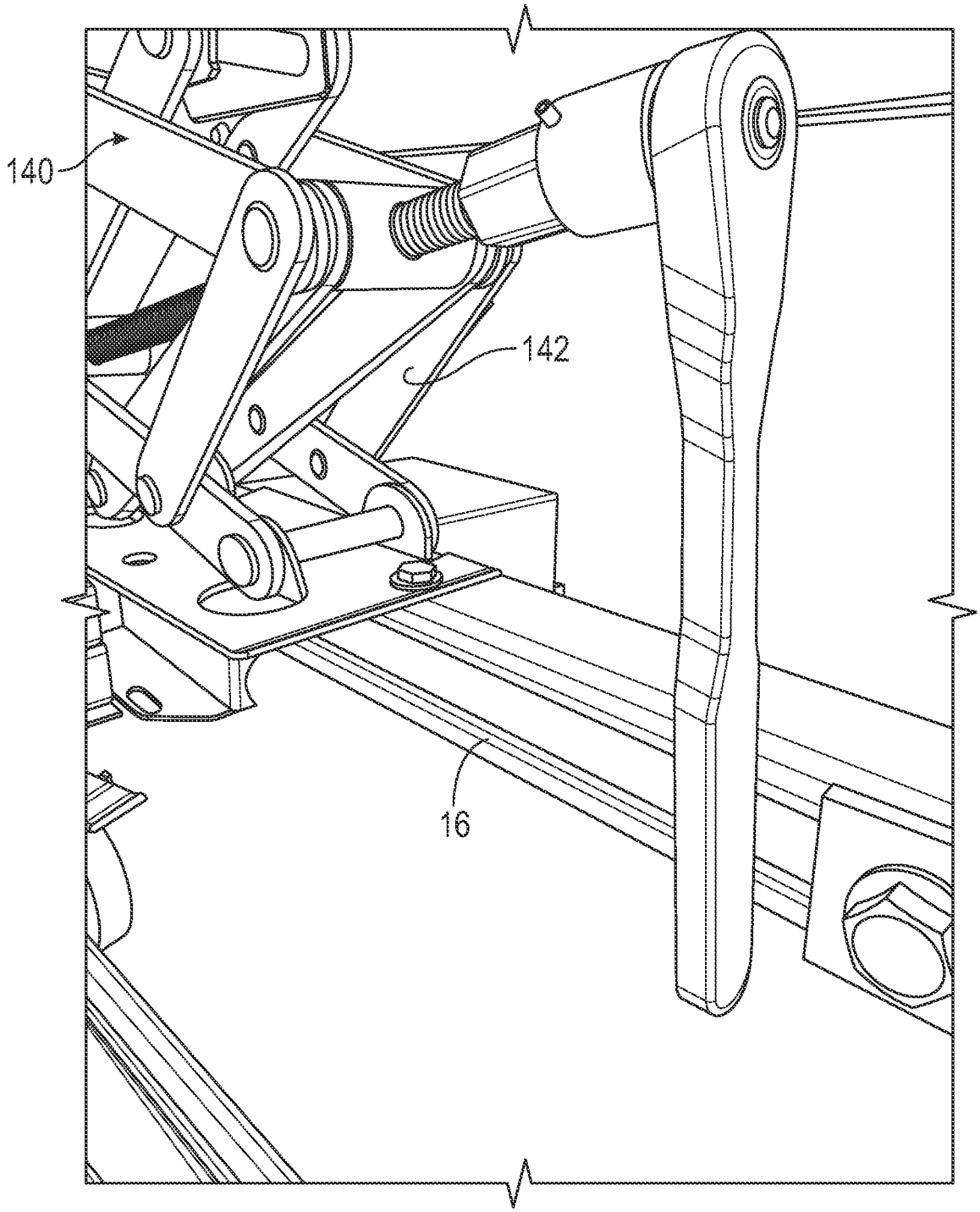

FIG. 11

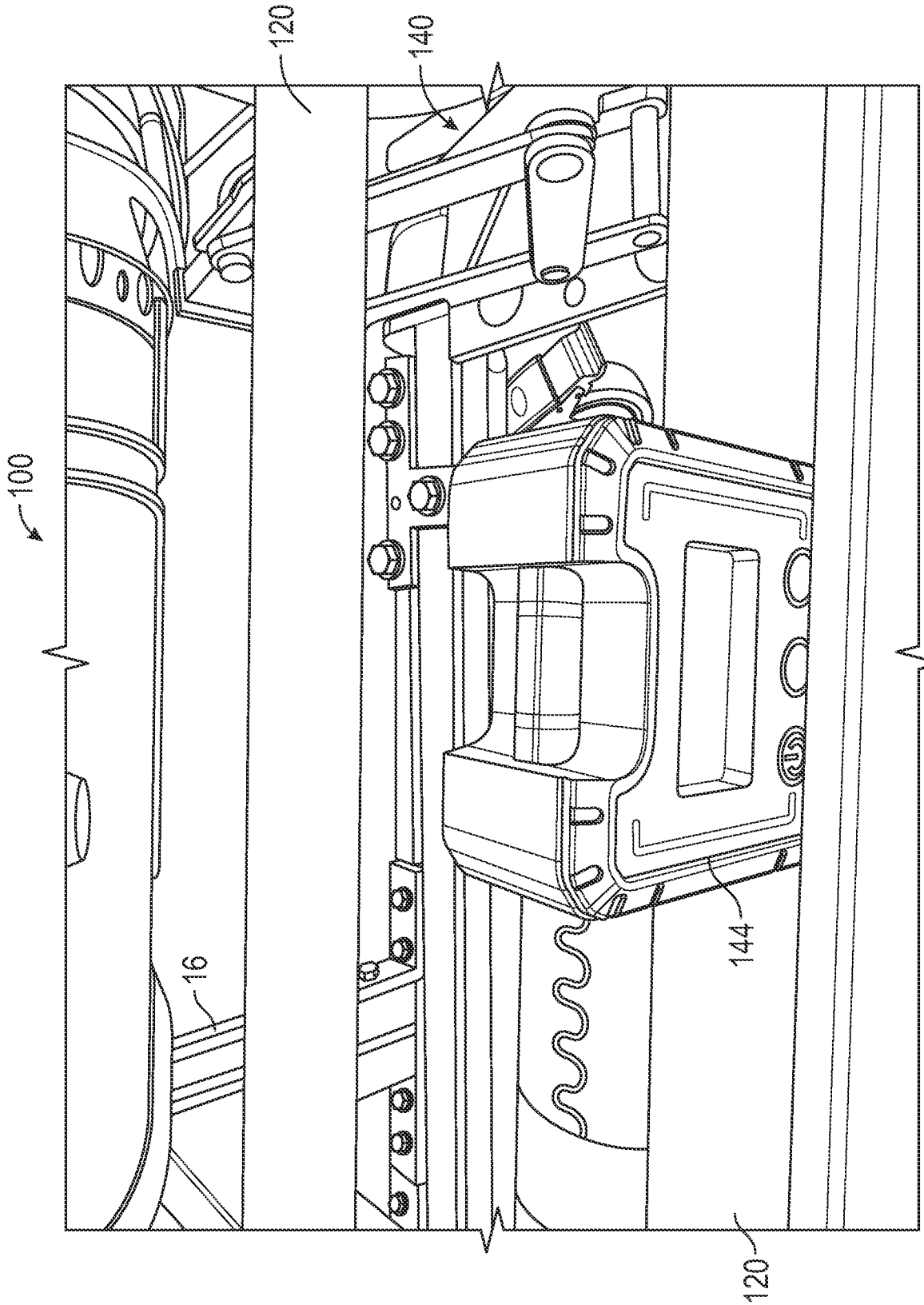

FIG. 12

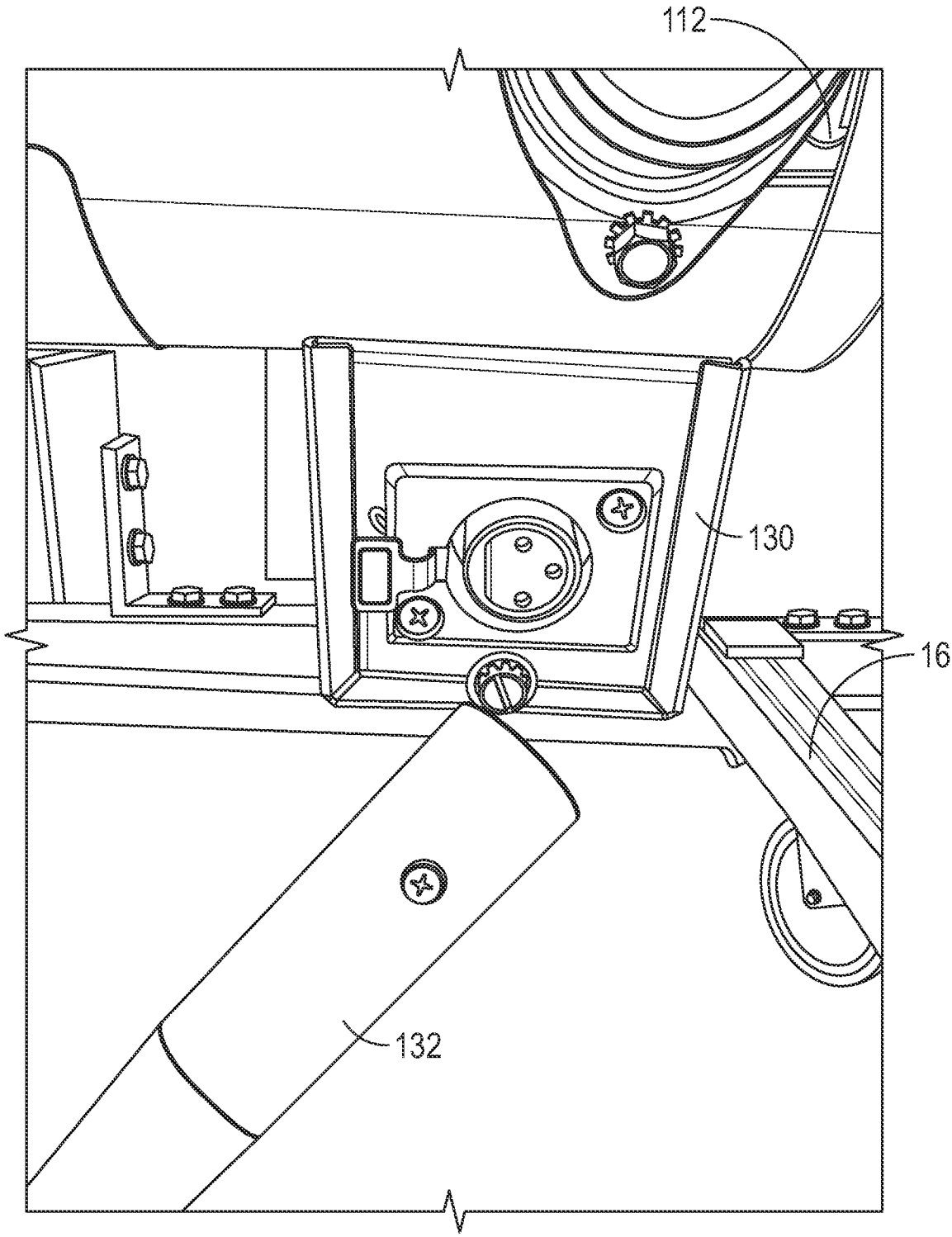

FIG. 13

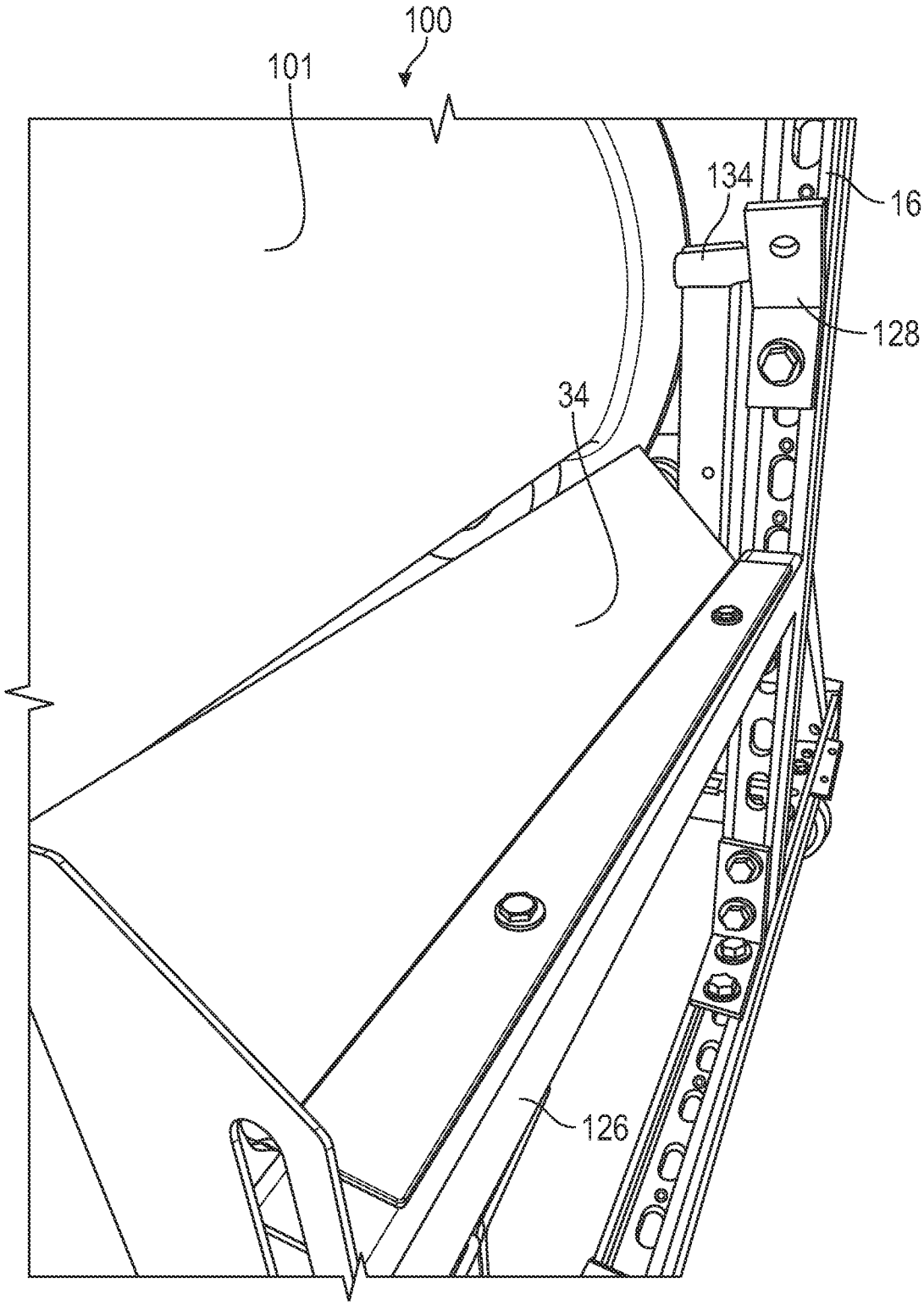

FIG. 14

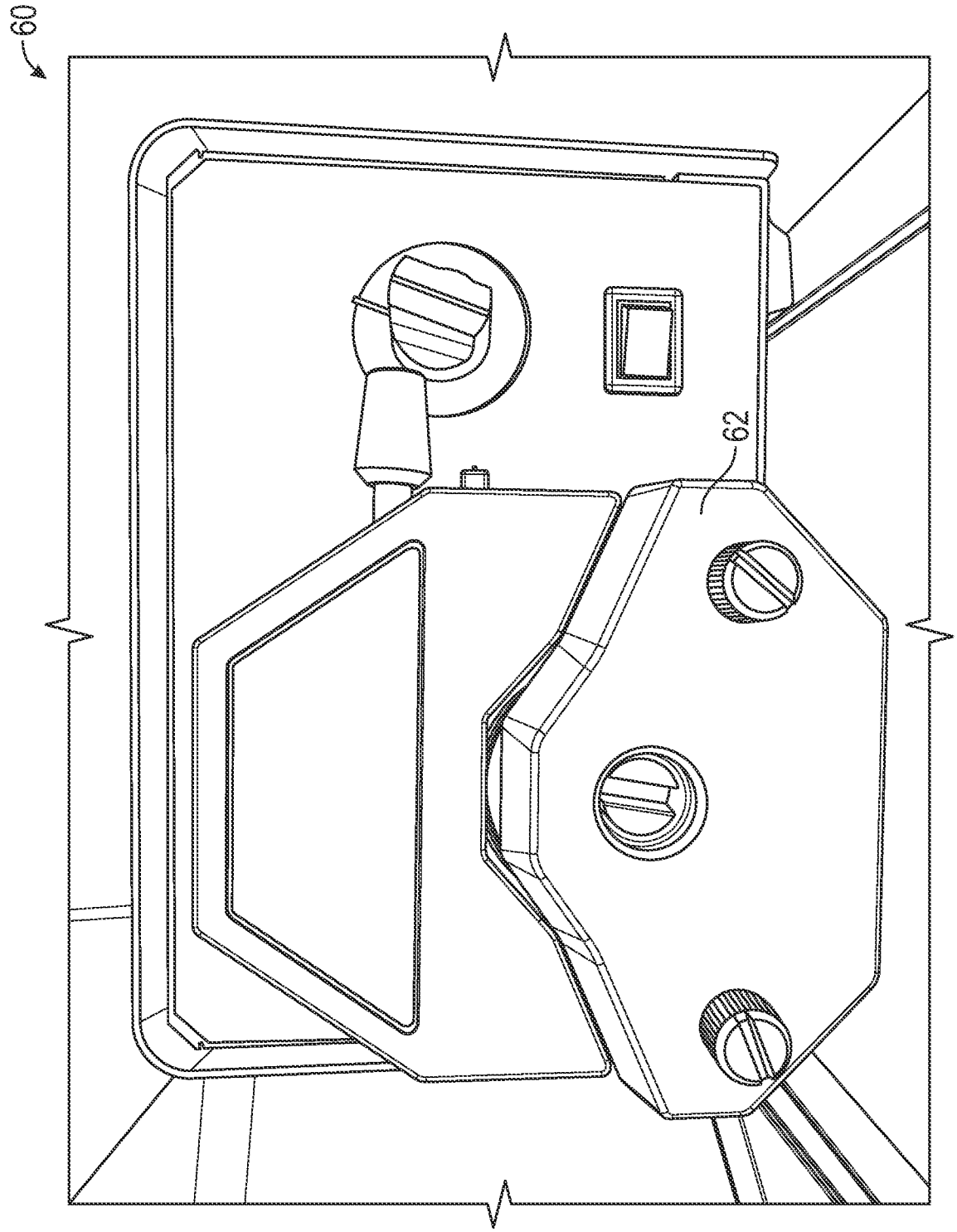

FIG. 15

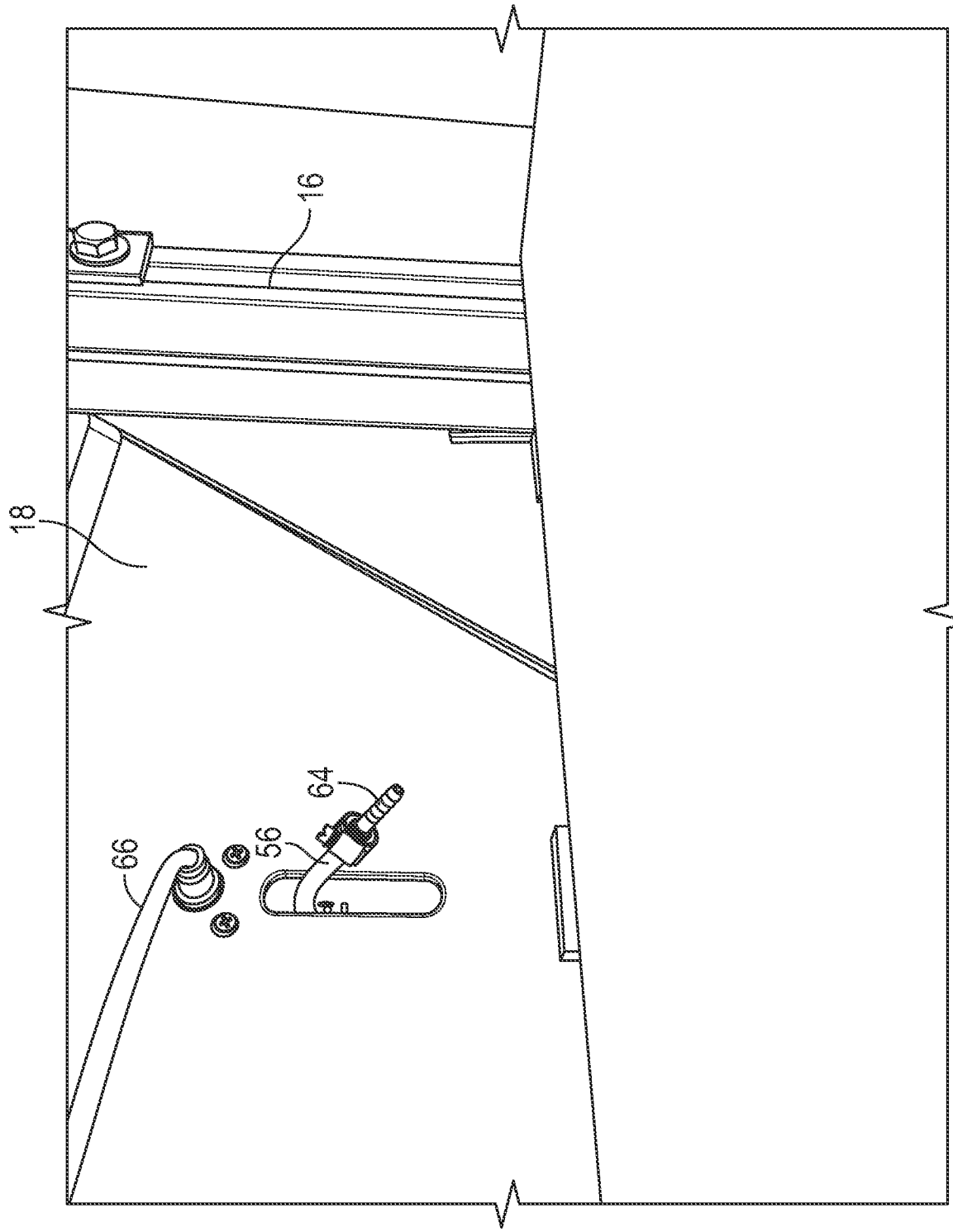

FIG. 16

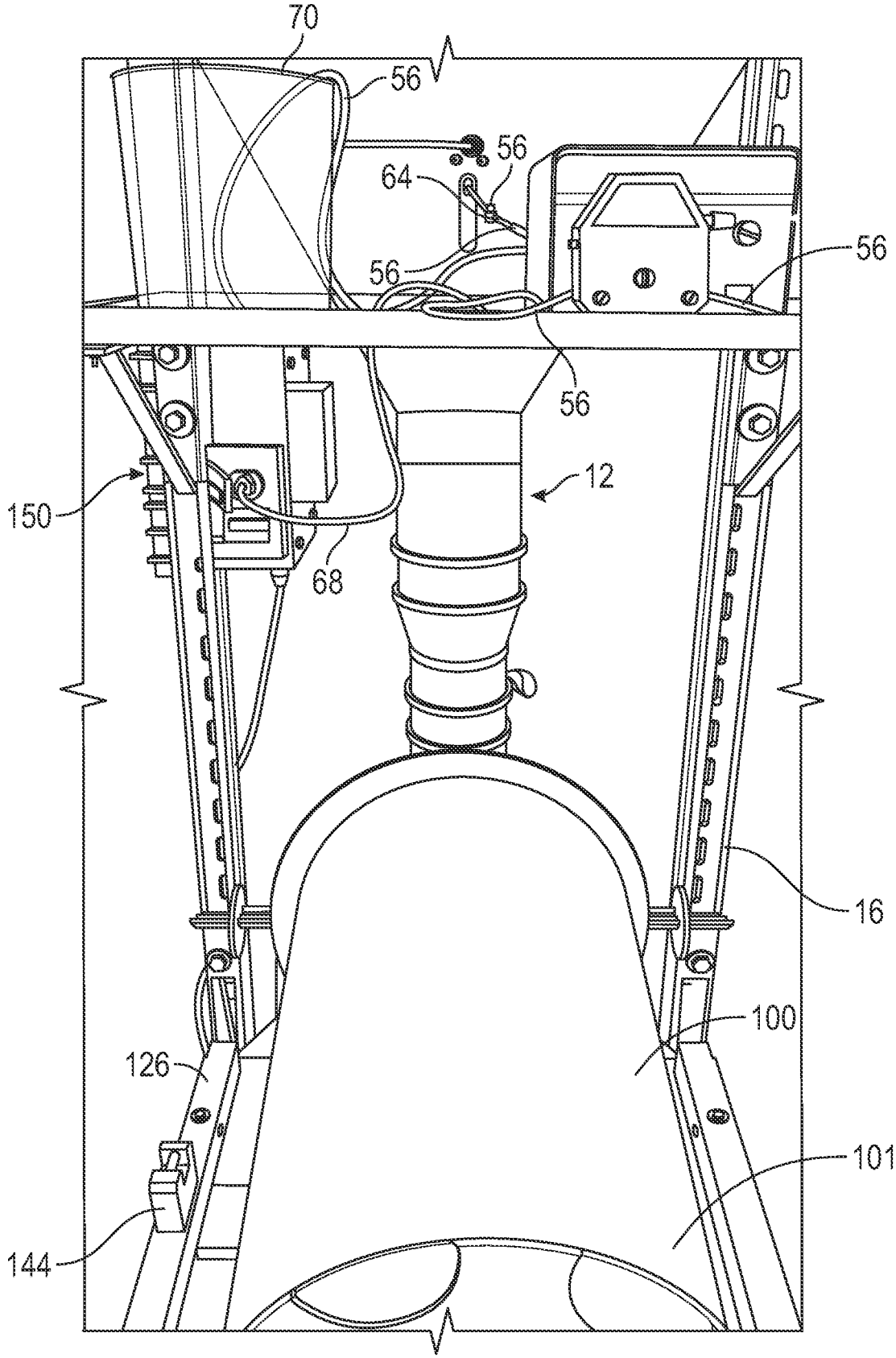

FIG. 17

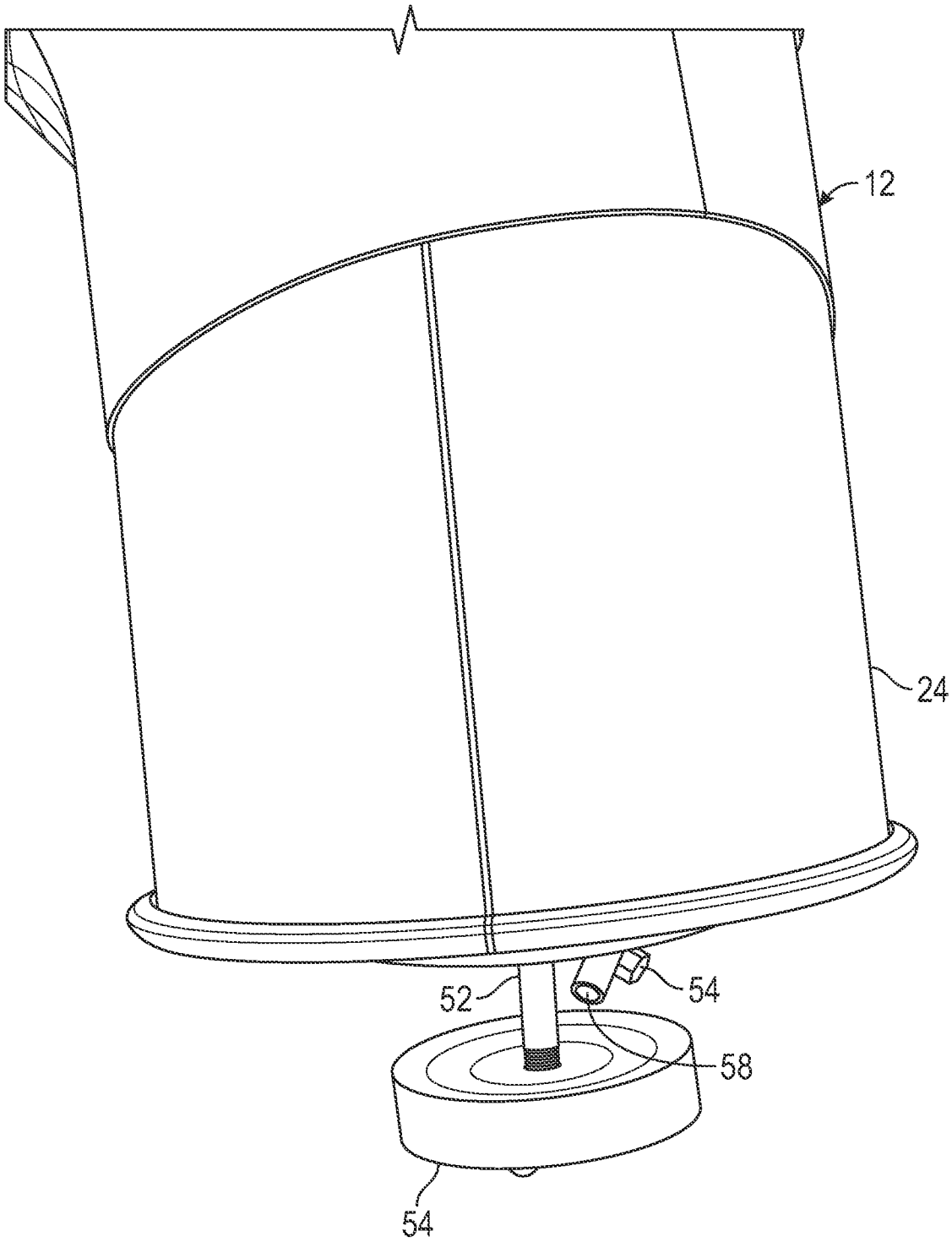

FIG. 18

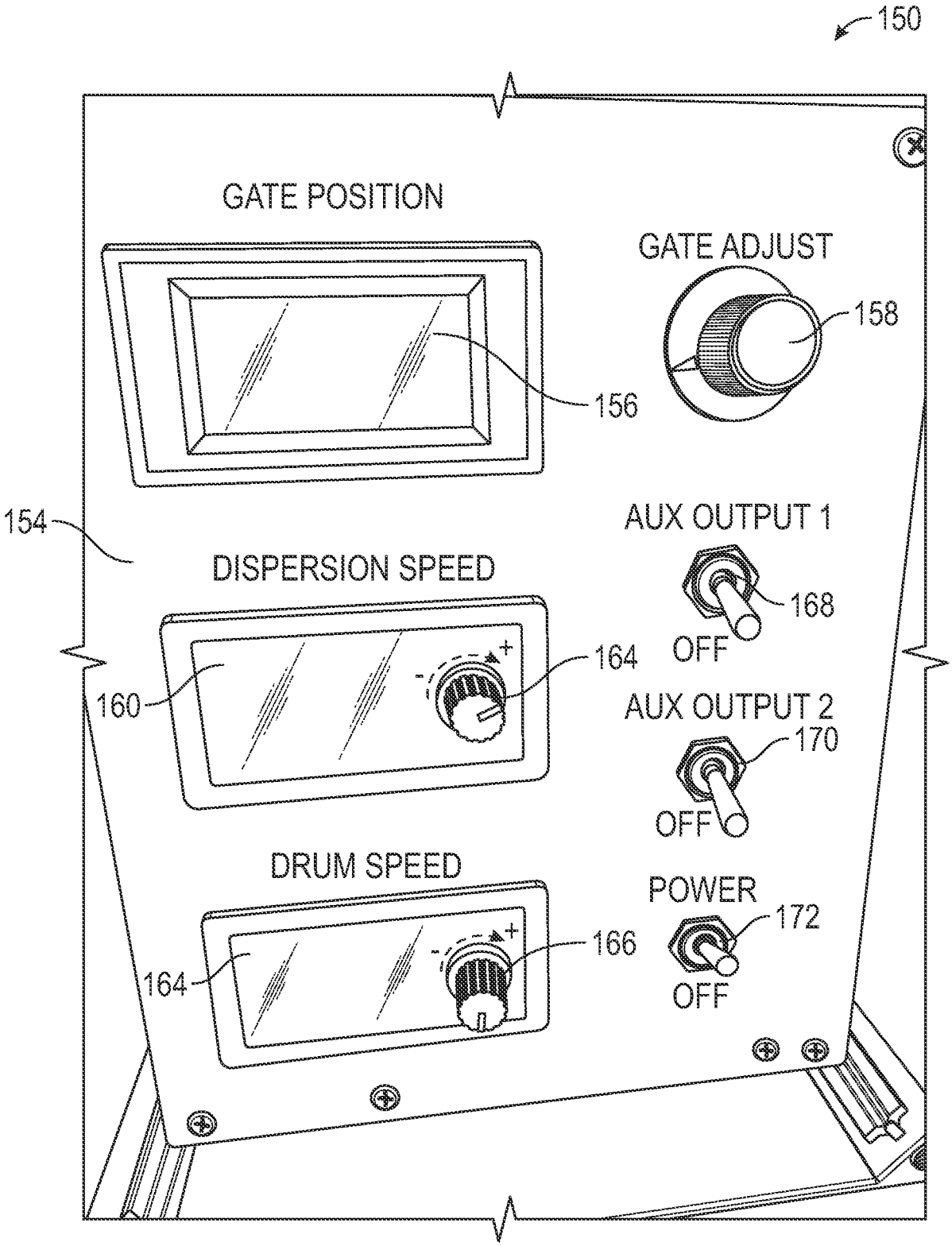
150
GATE POSITION
156
GATE ADJUST
158
154
AUX OUTPUT 1
DISPERSION SPEED
168
OFF
160
164
AUX OUTPUT 2
170
OFF
DRUM SPEED
POWER
172
164
166
OFF

FIG. 19

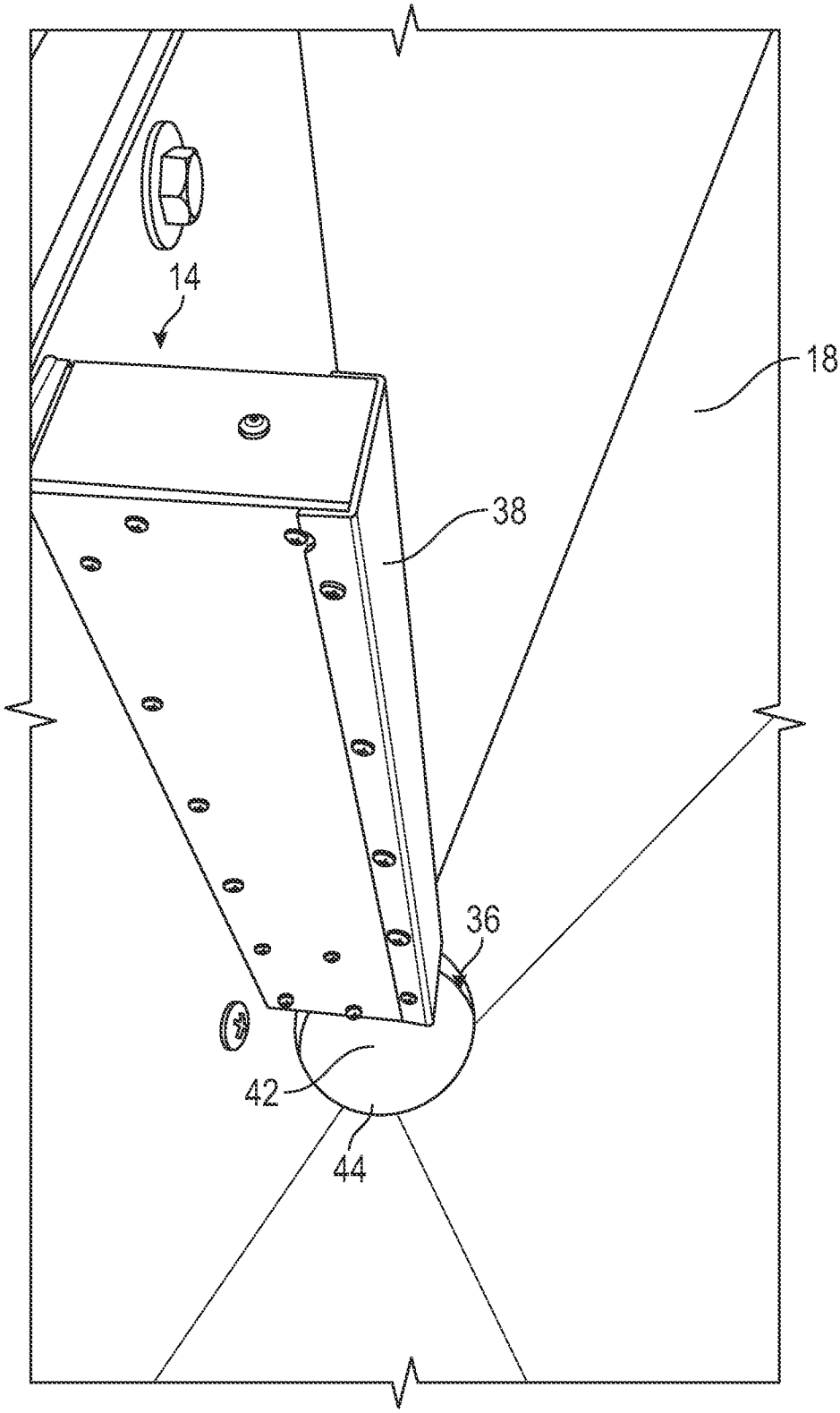

FIG. 20

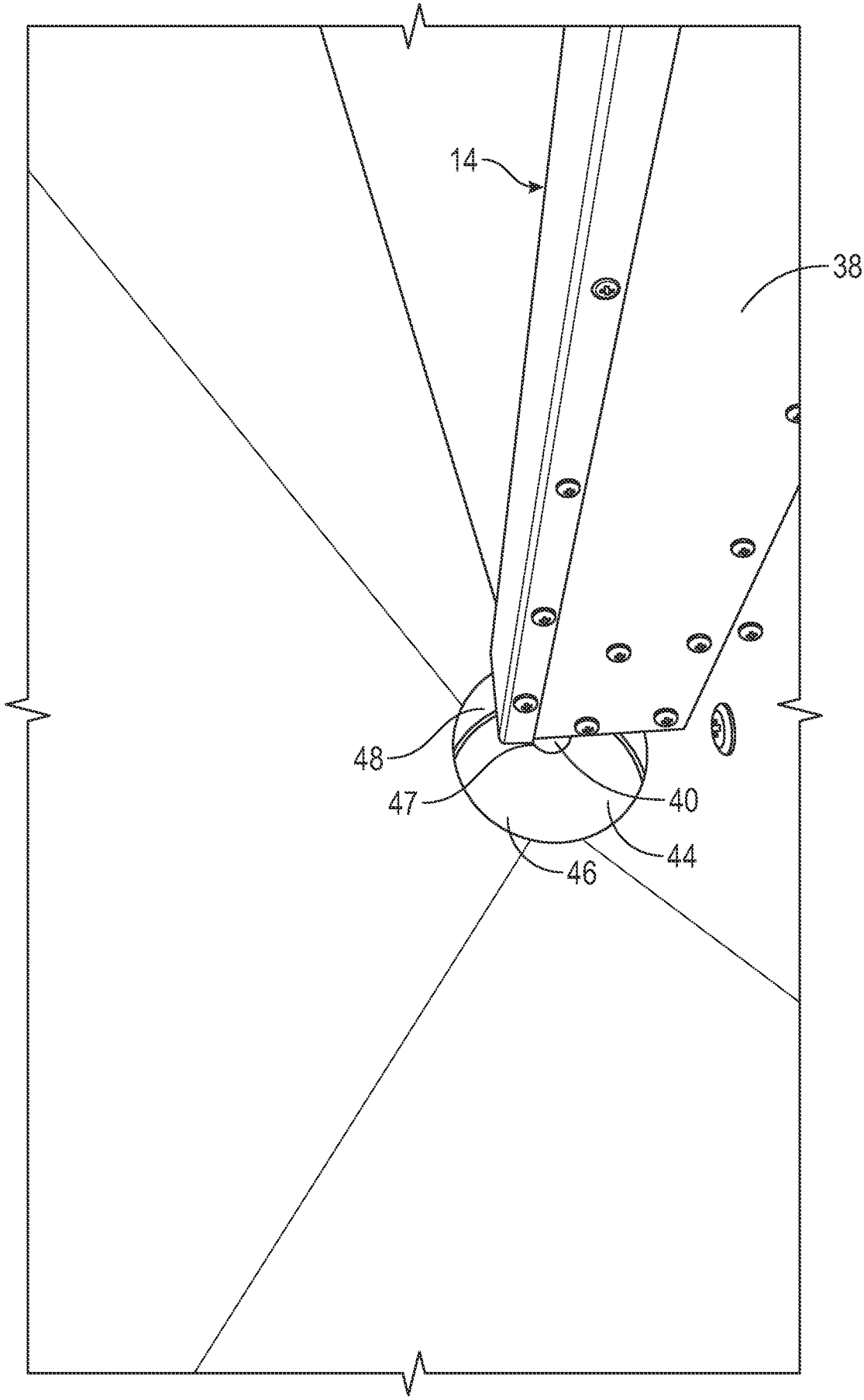

FIG. 21

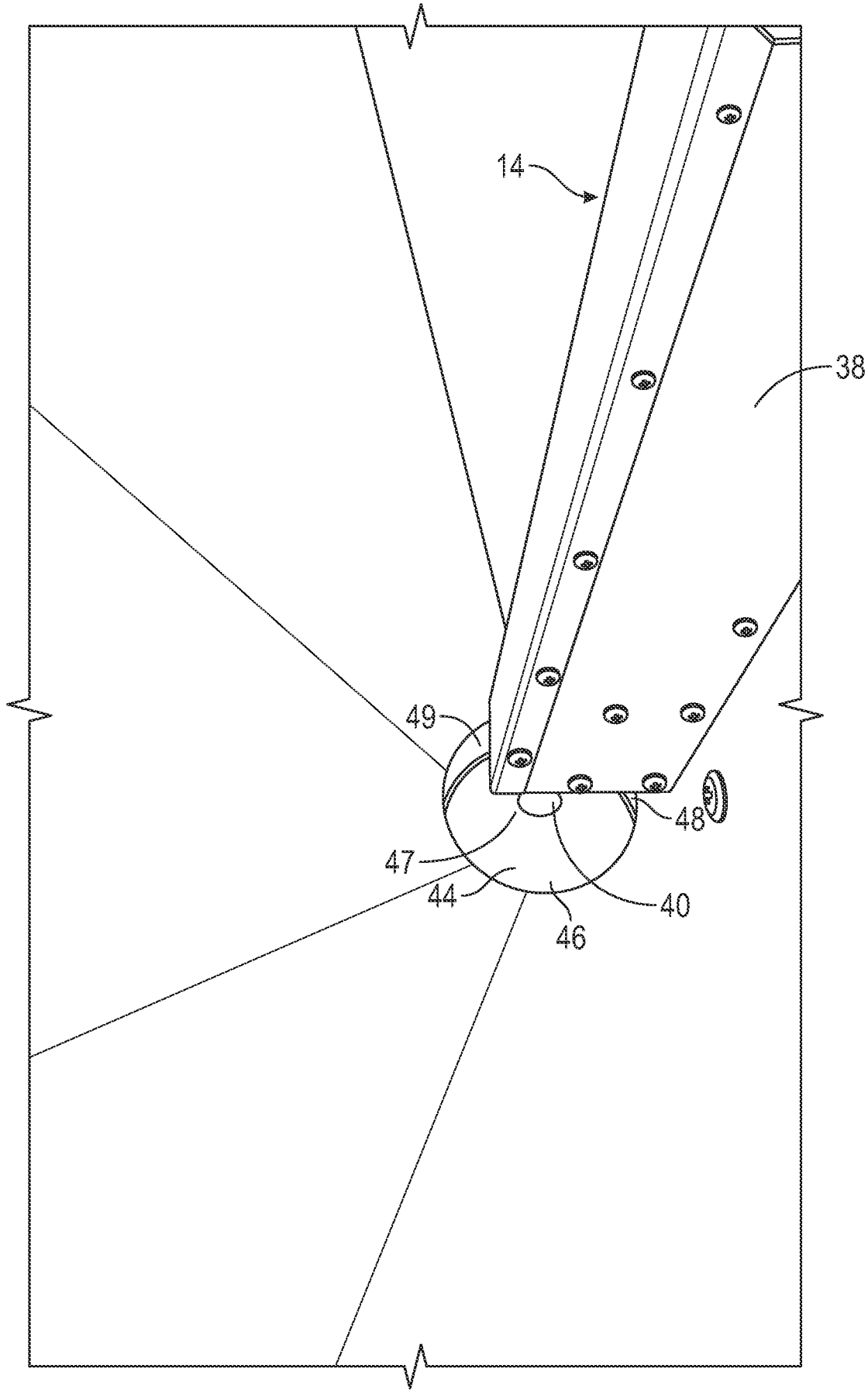

FIG. 22

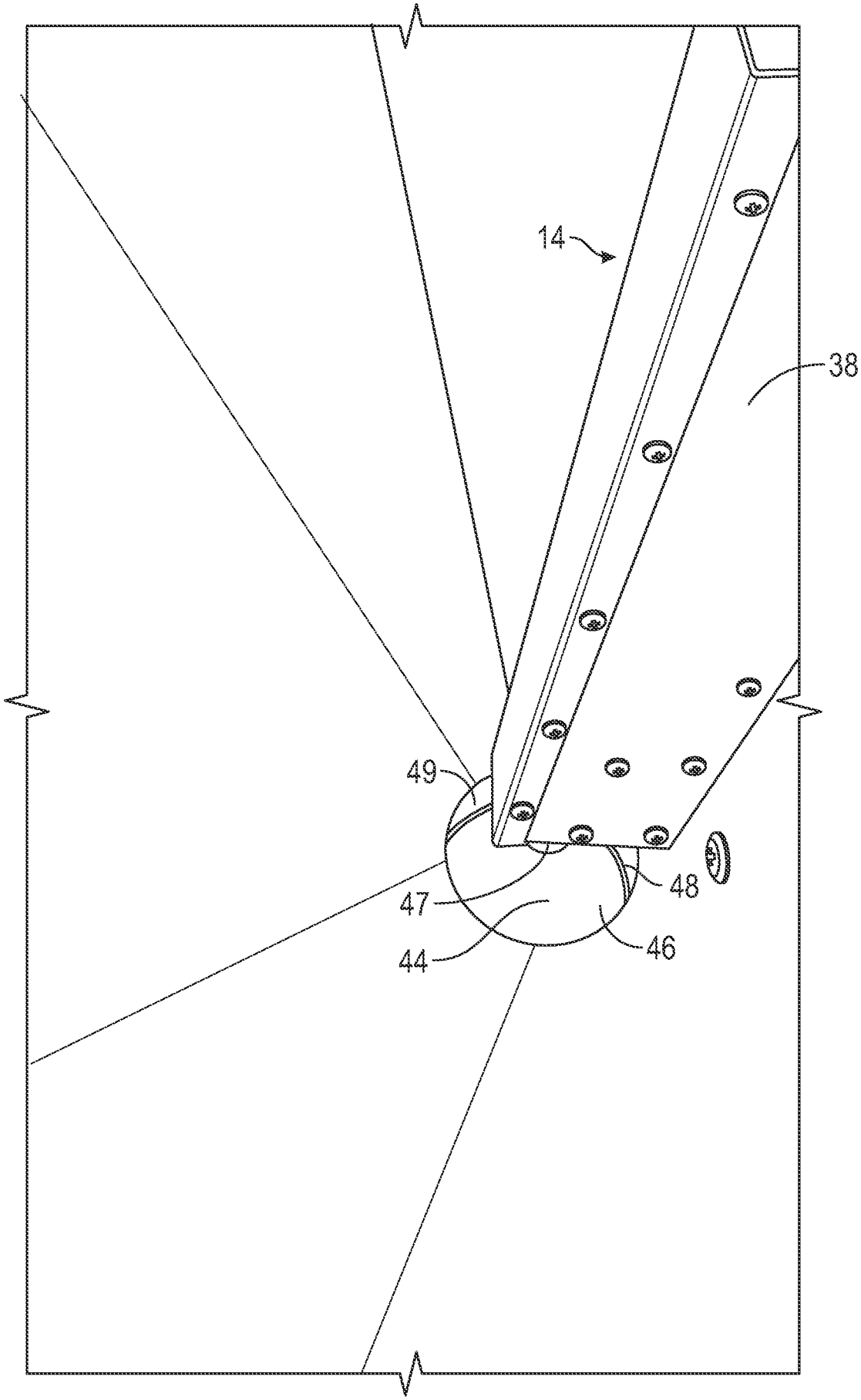

FIG. 23

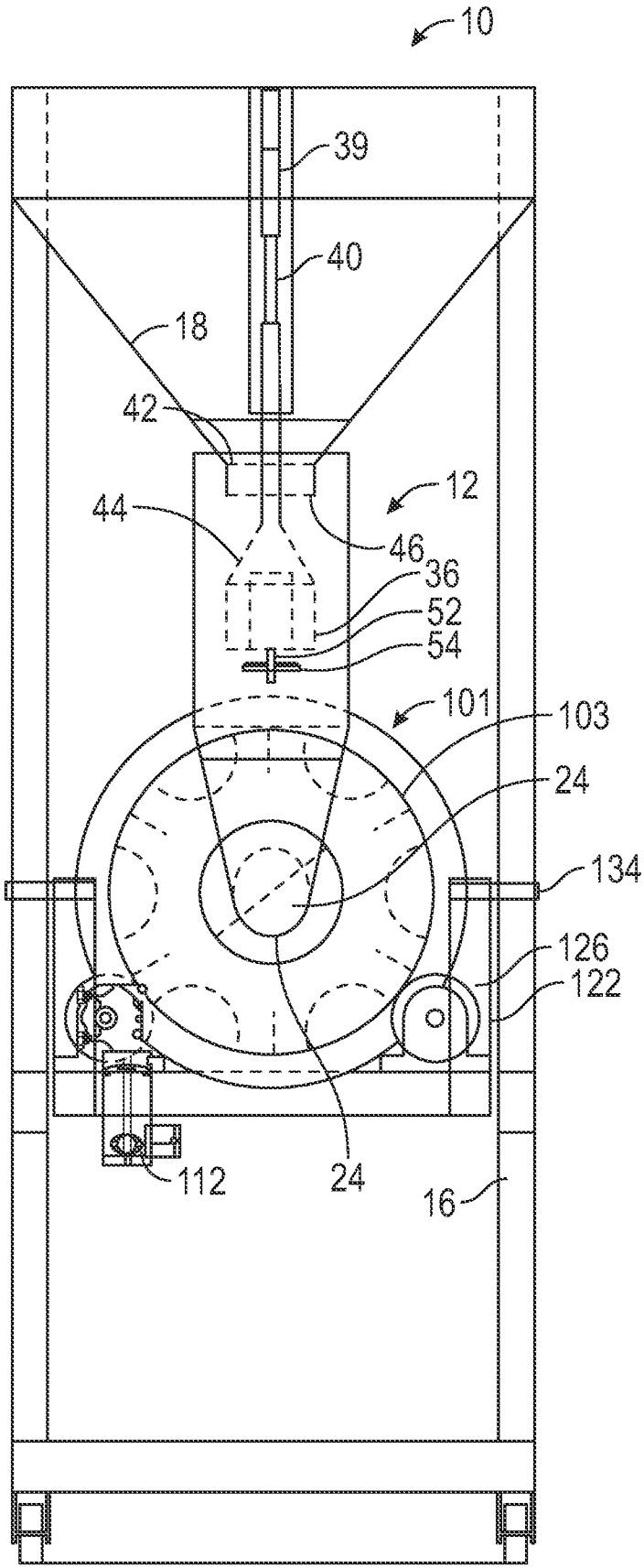

FIG. 24

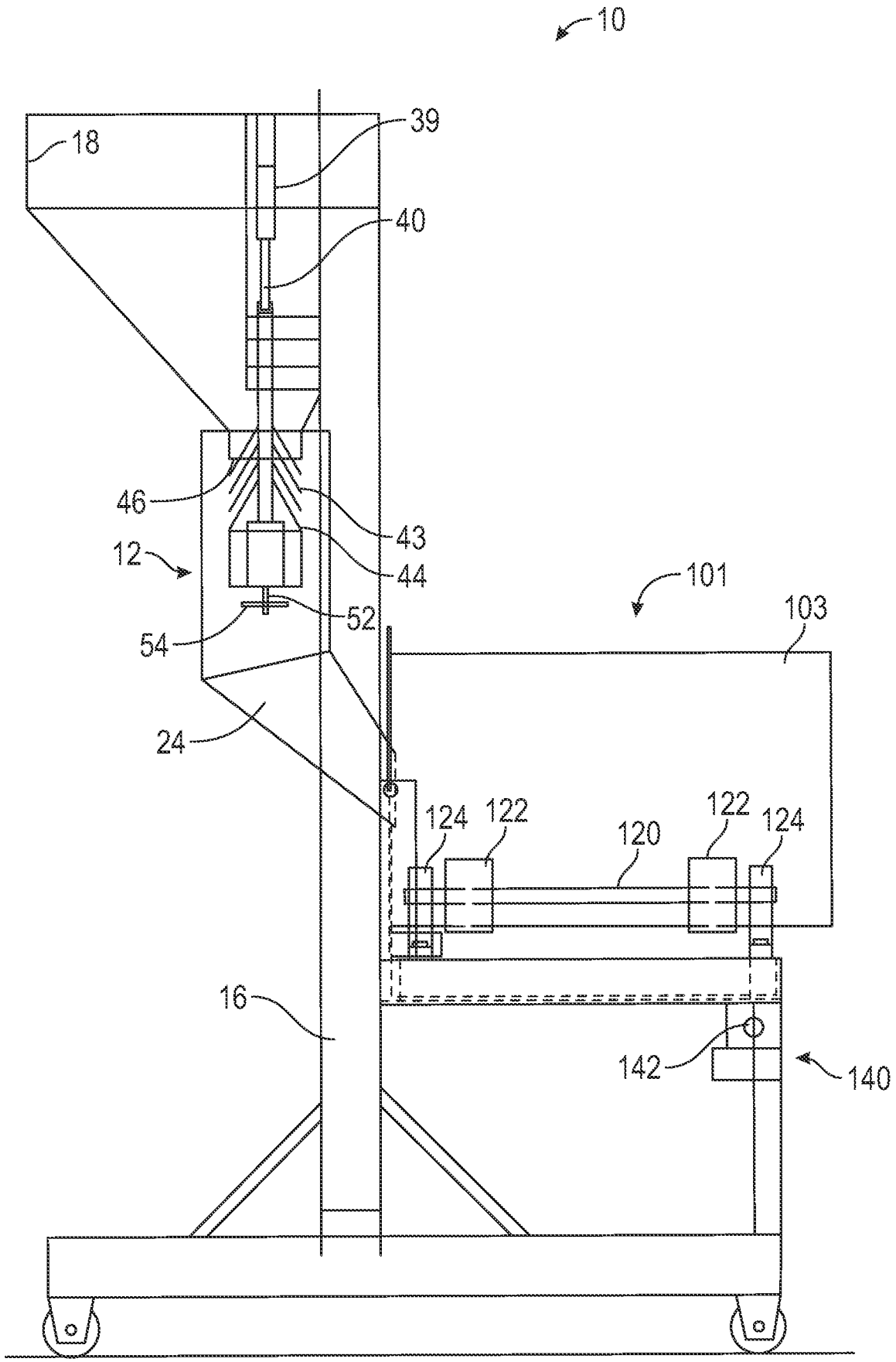
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FIG. 25

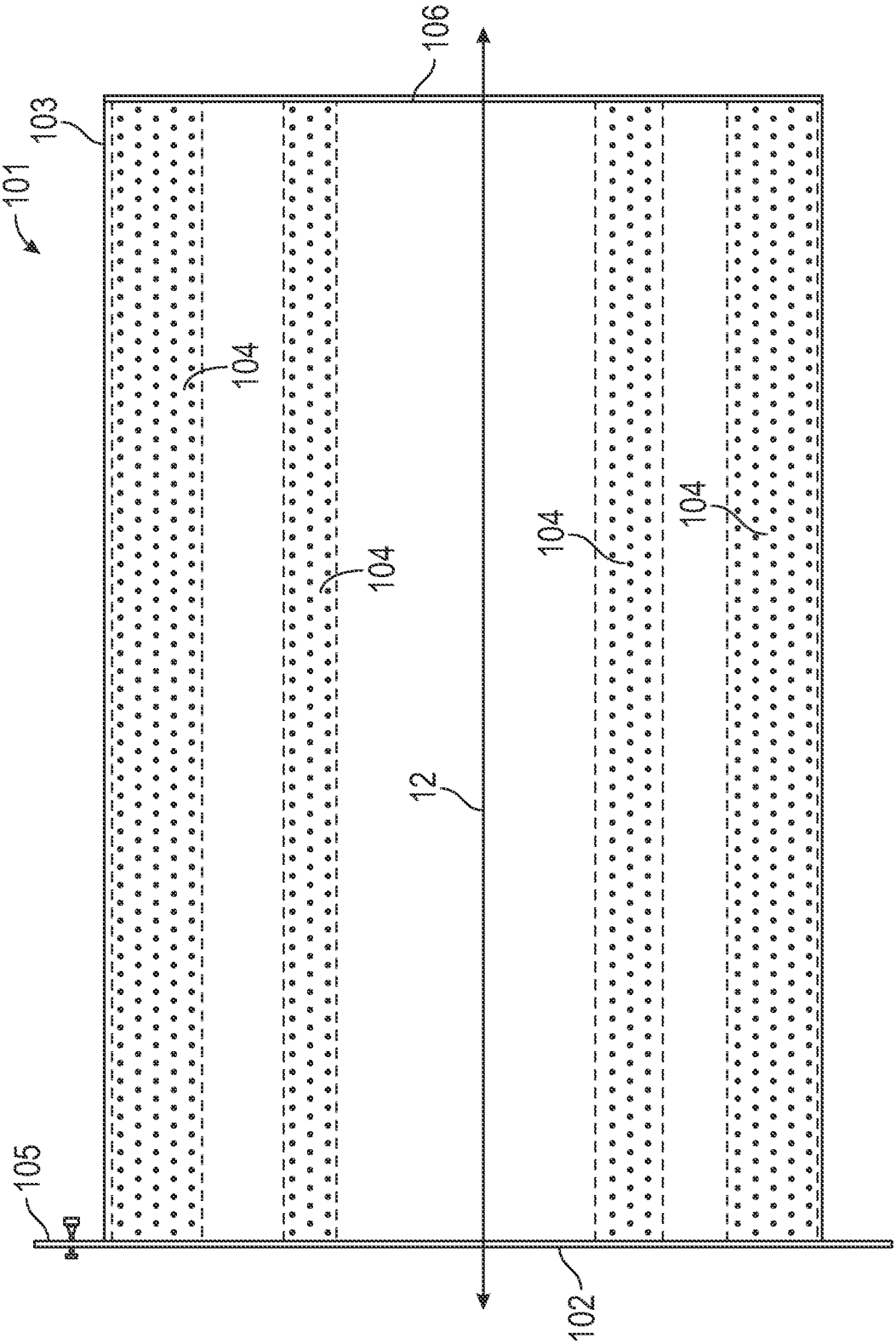


FIG. 26

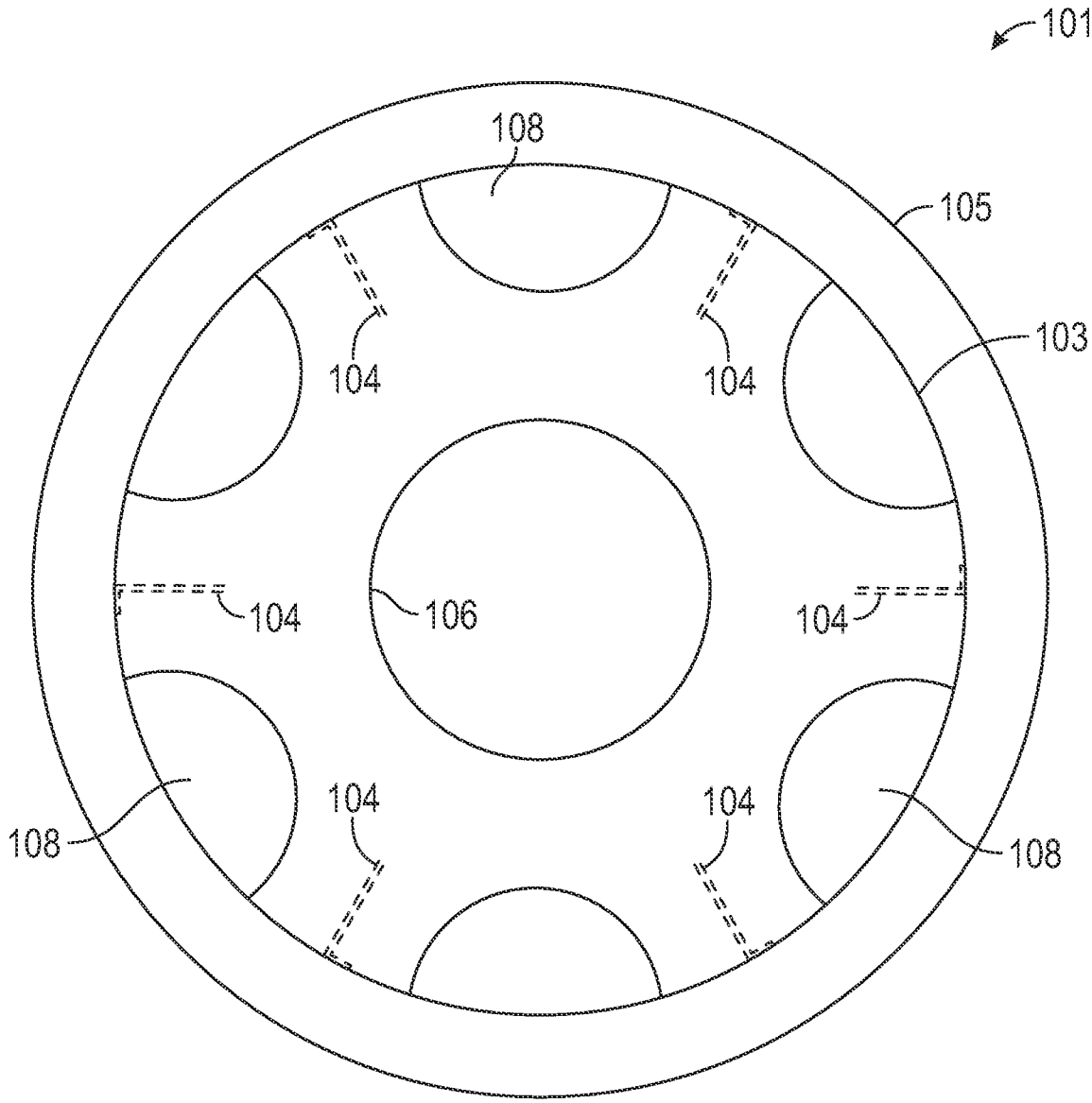
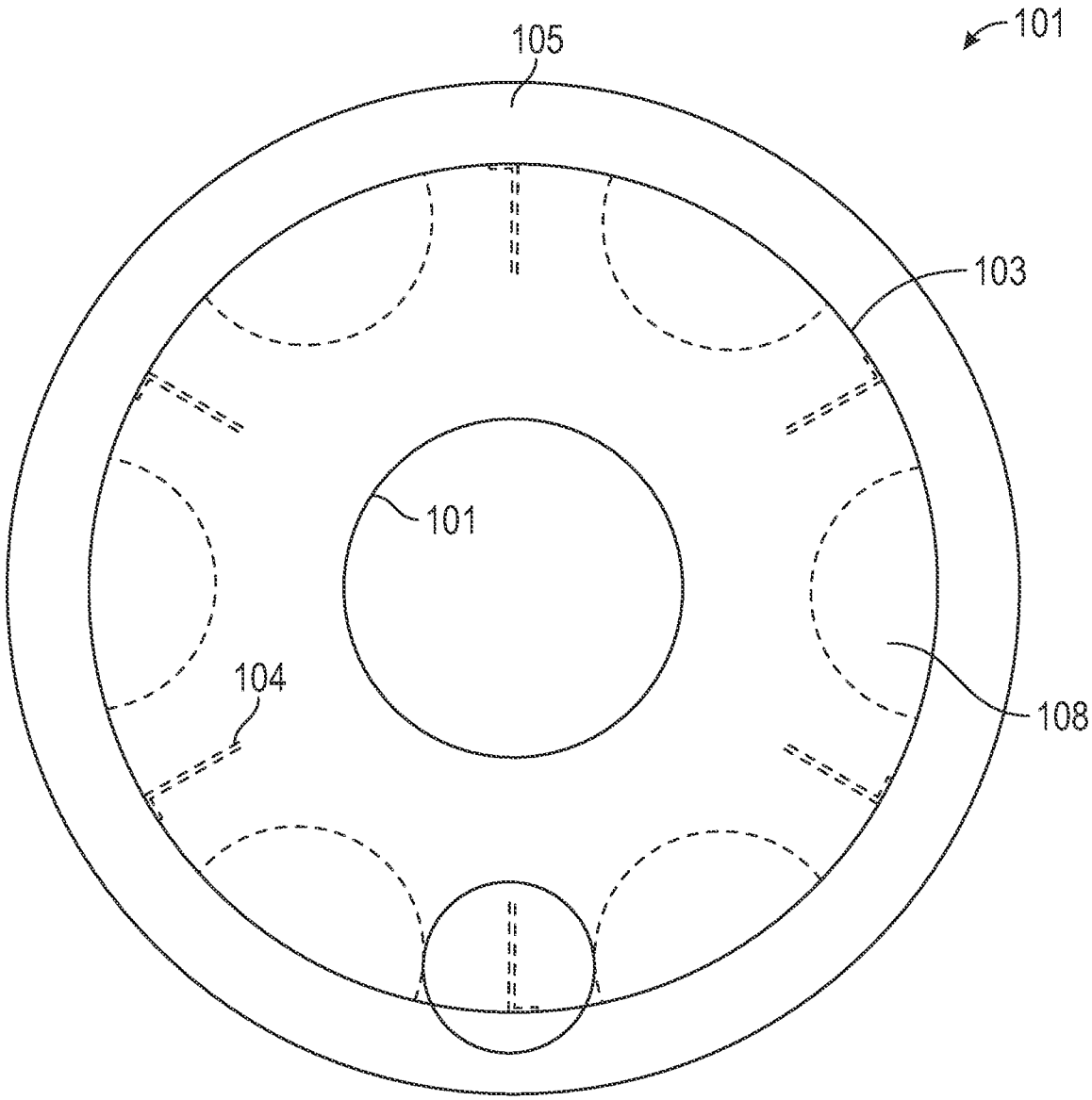


FIG. 27



Inlet End View

FIG. 28

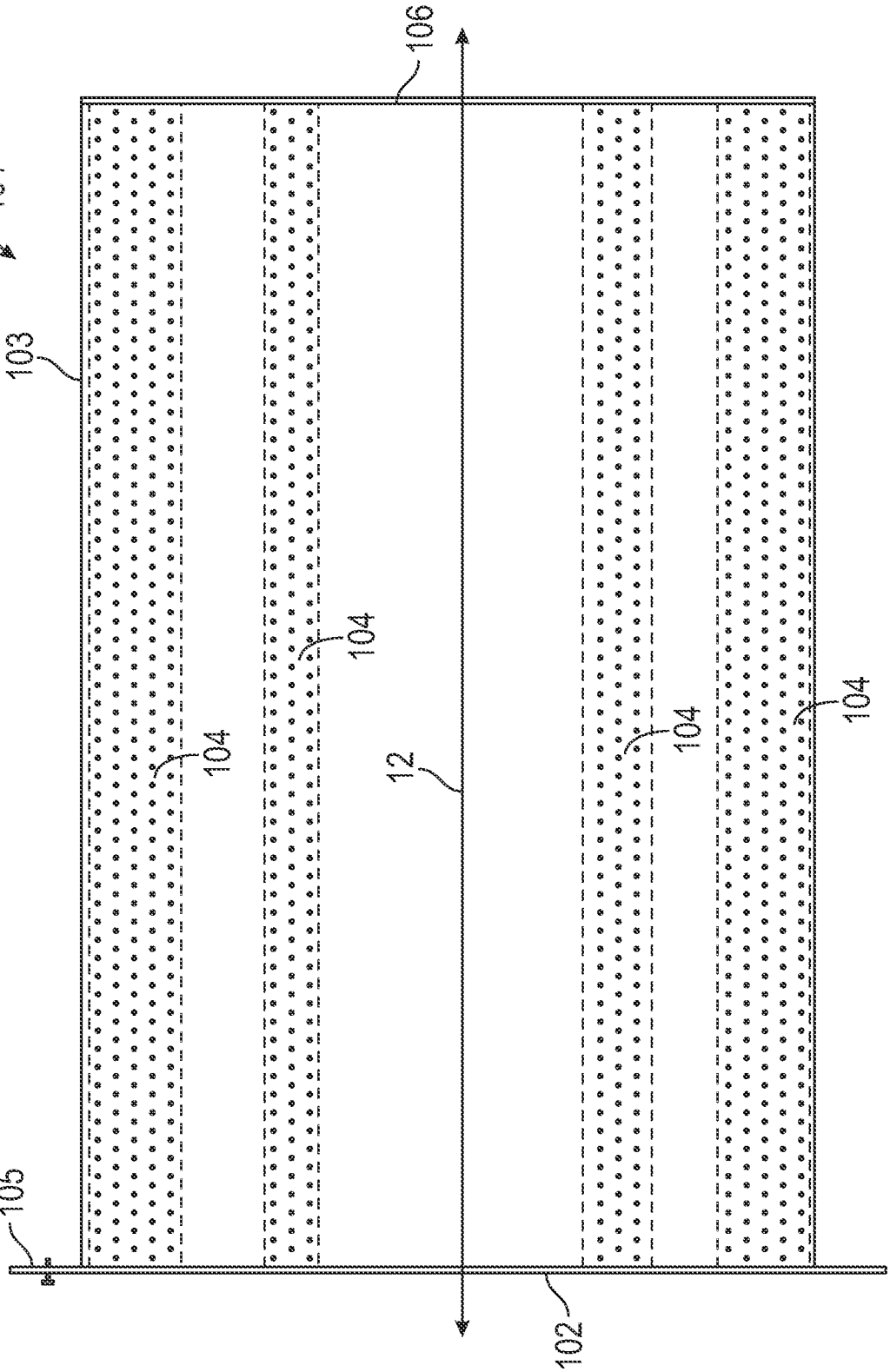
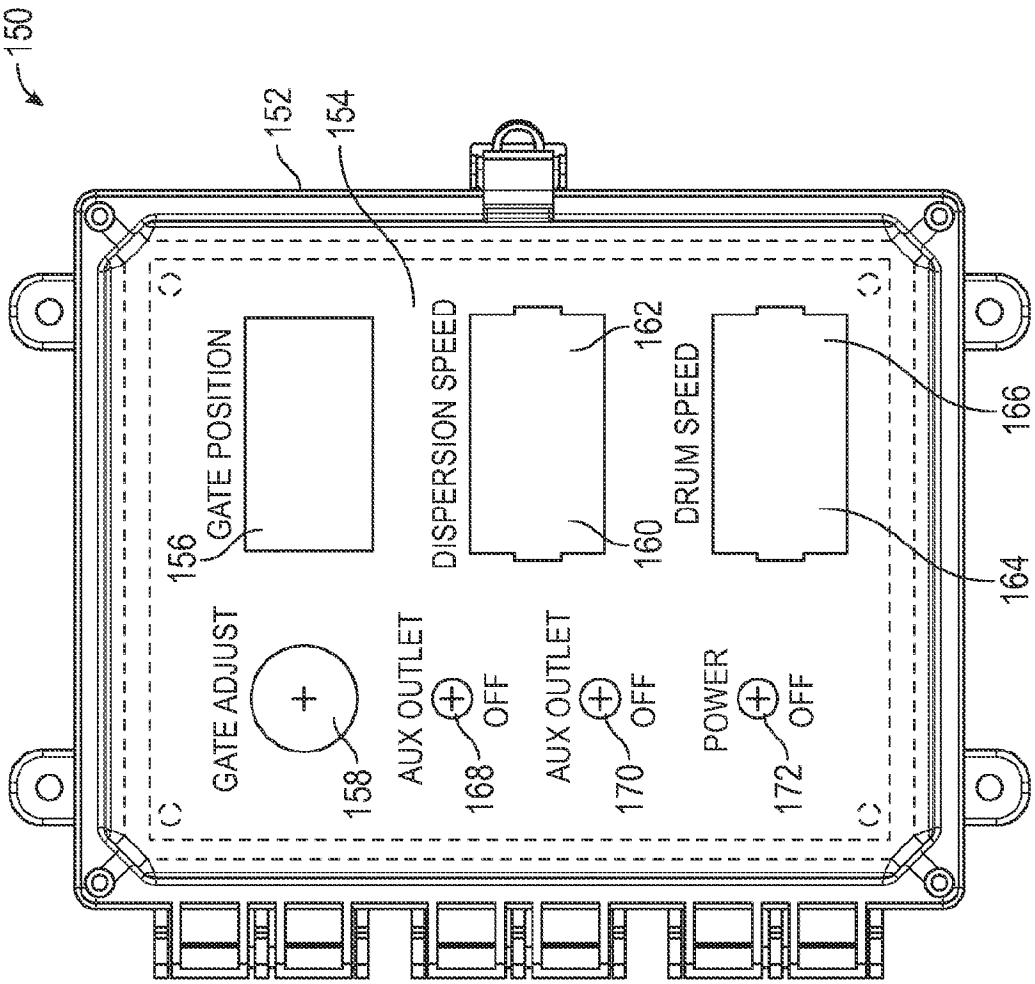


FIG. 29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GATE POSITION
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DISPERSION SPEED
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DRUM SPEED
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164
GATE ADJUST
158
AUX OUTLET
OFF
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AUX OUTLET
OFF
170
POWER
OFF
172

FIG. 30

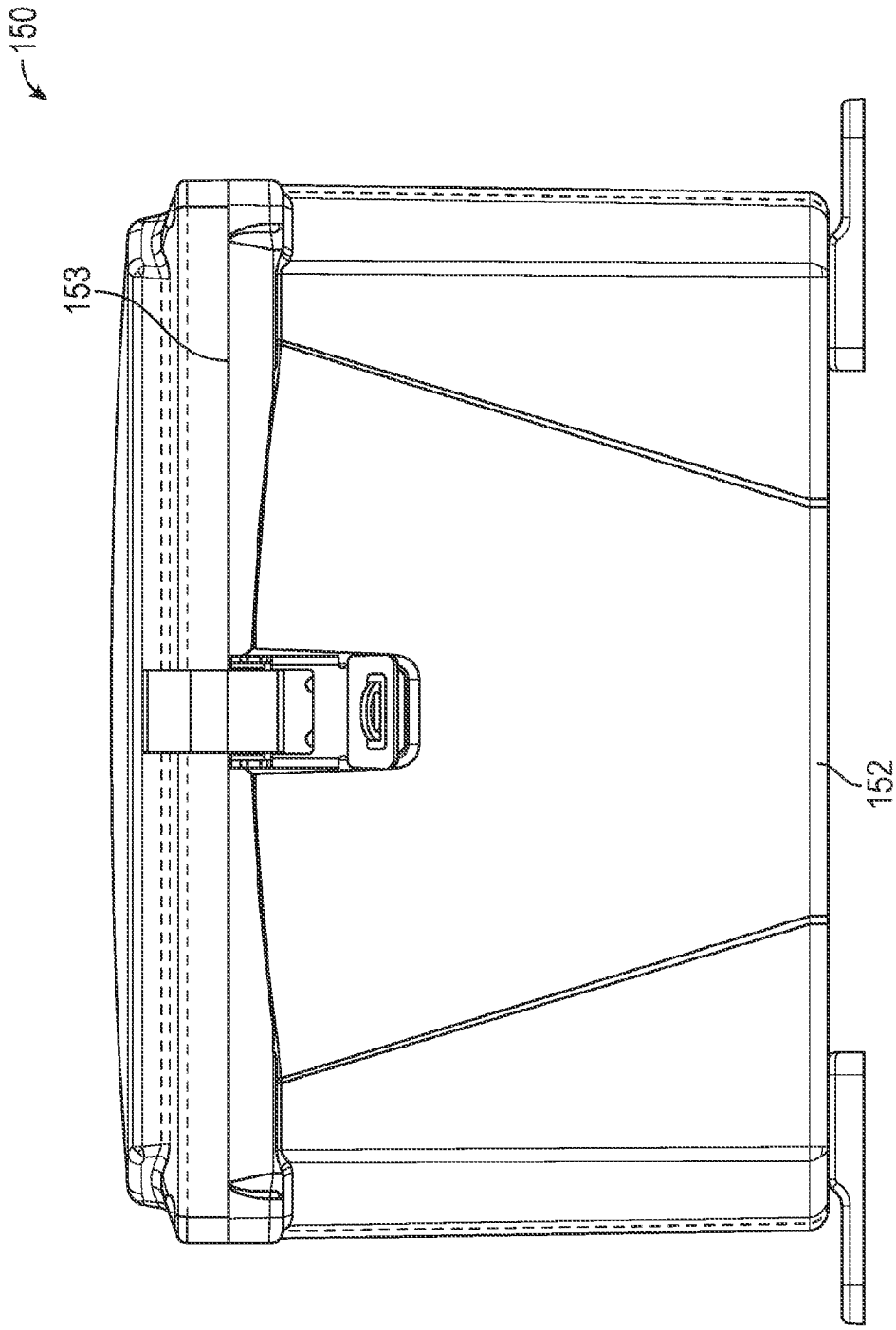


FIG. 31

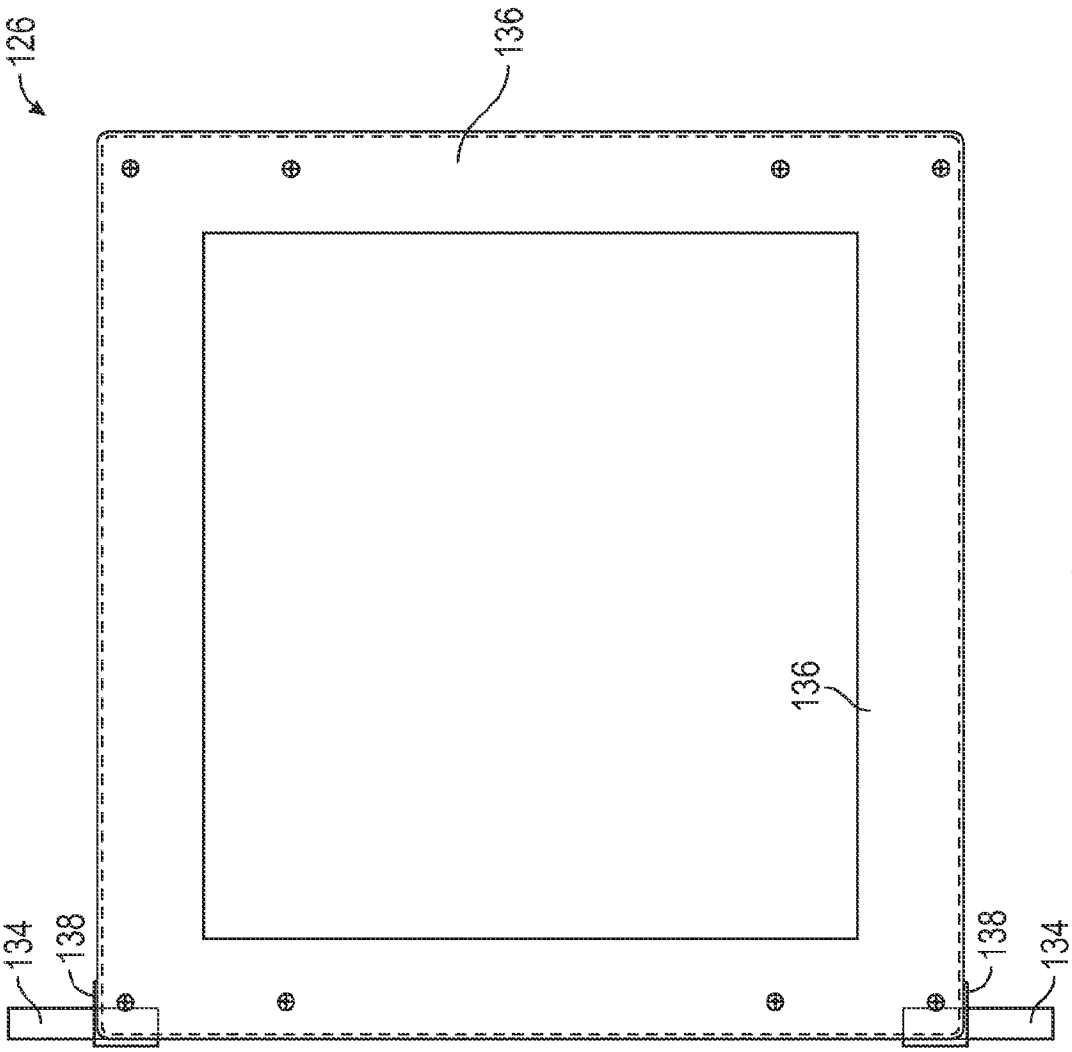


FIG. 32

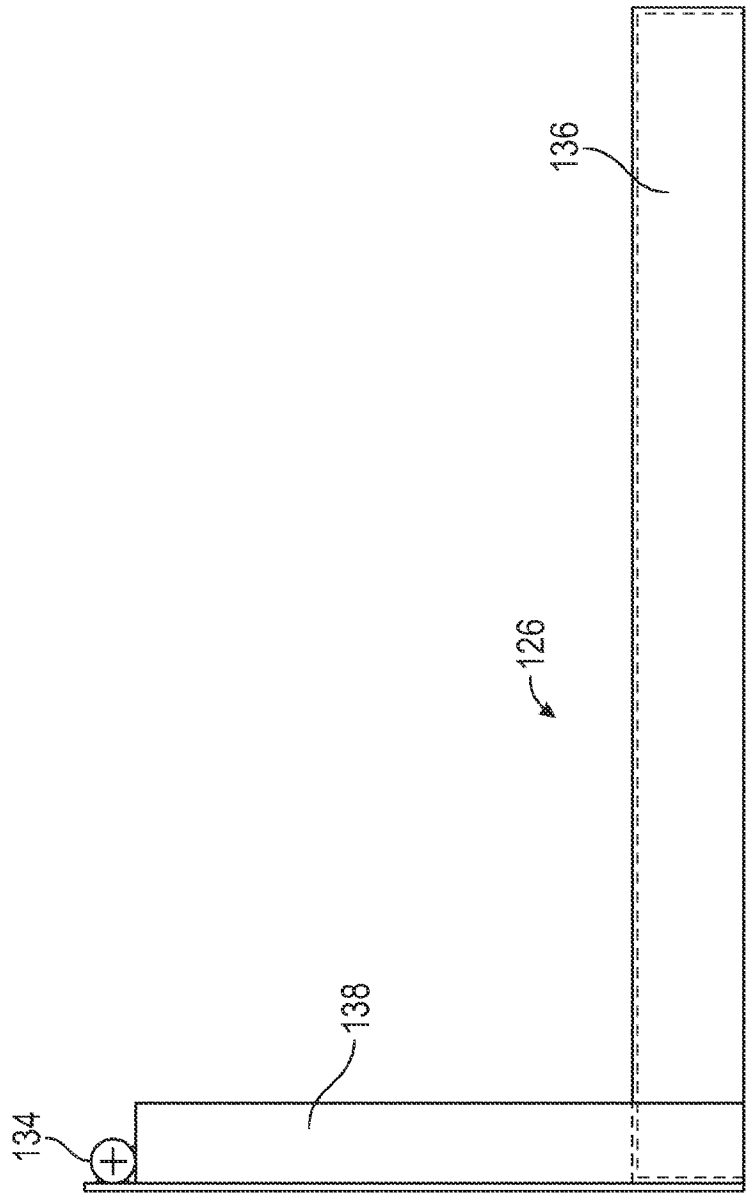


FIG. 33

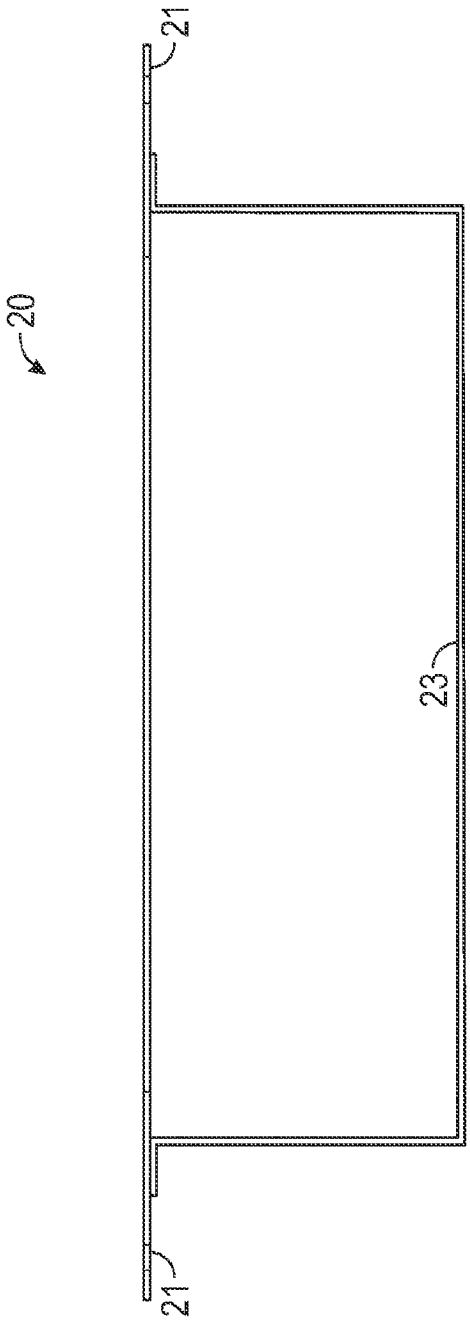


FIG. 34

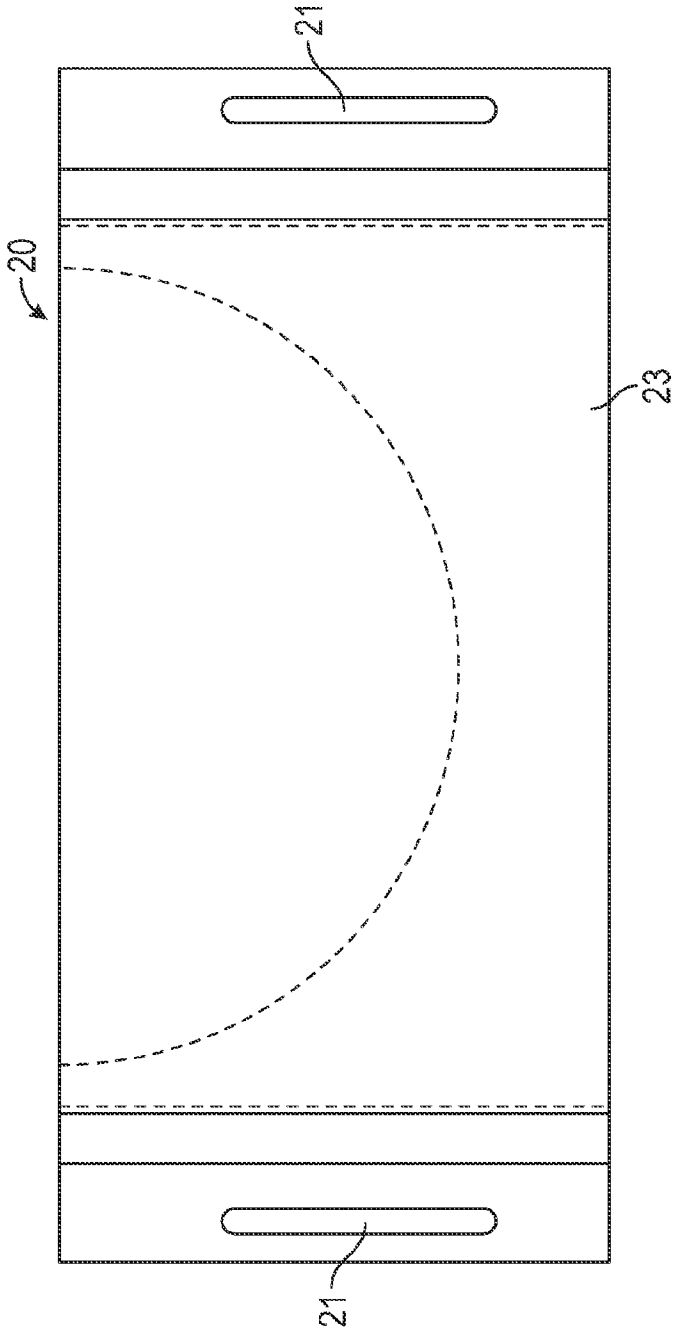
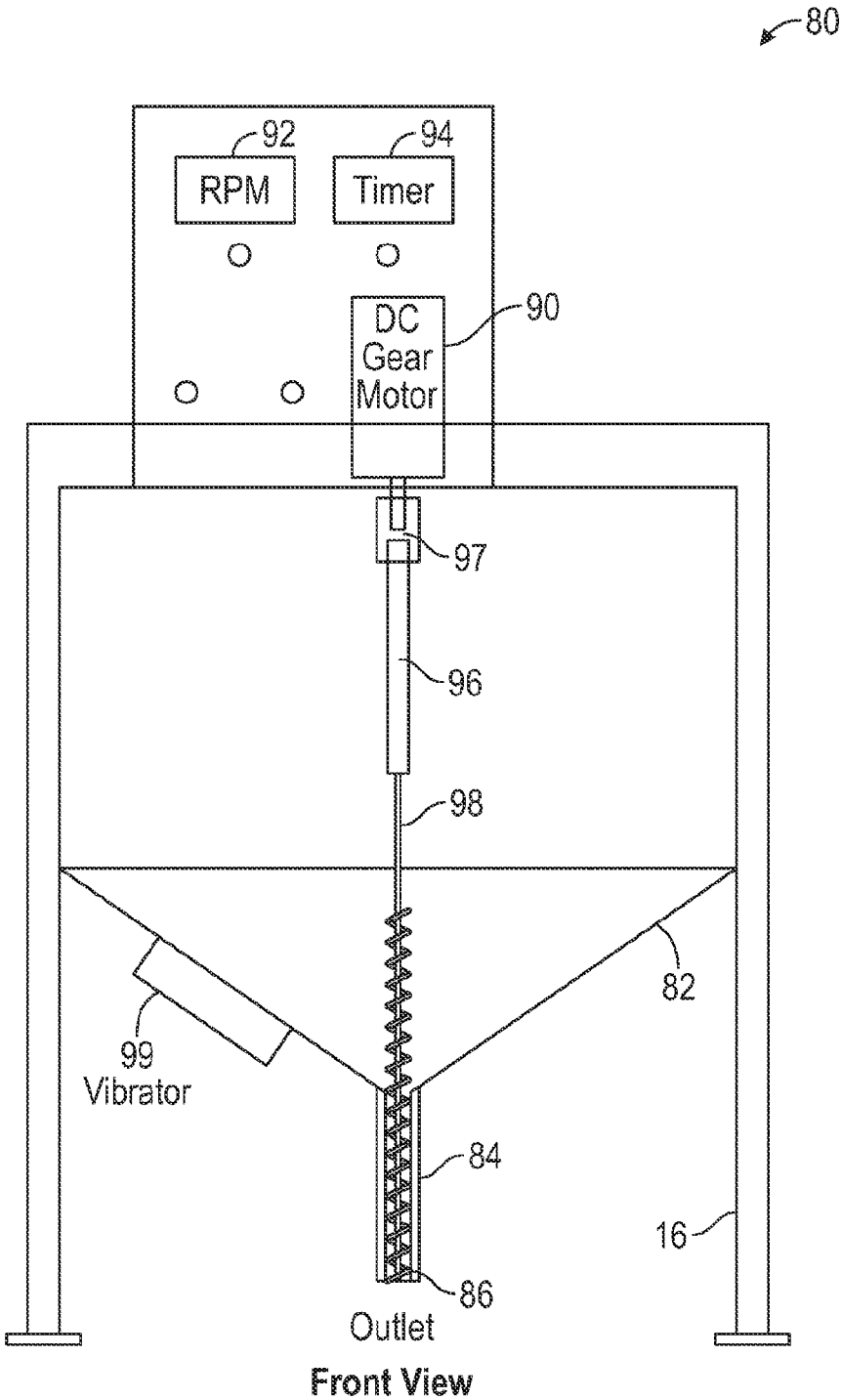


FIG. 35



Front View

FIG. 36

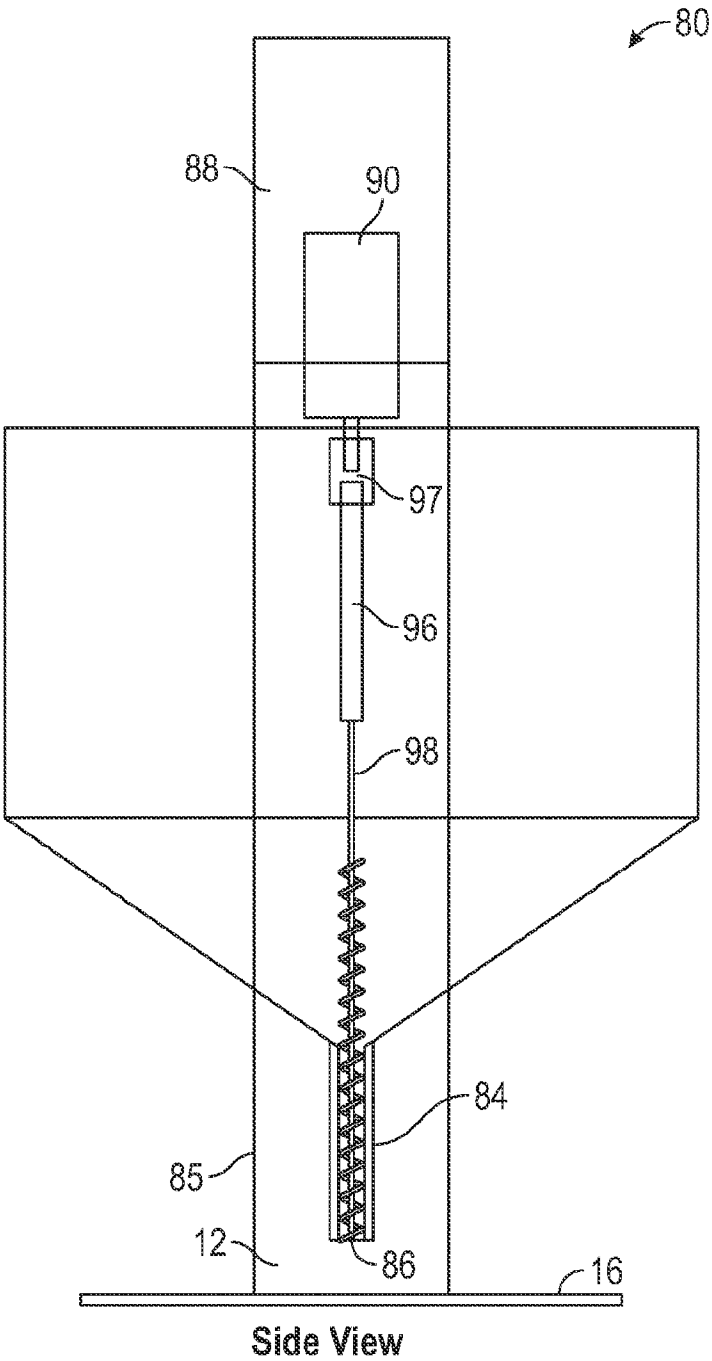


FIG. 37

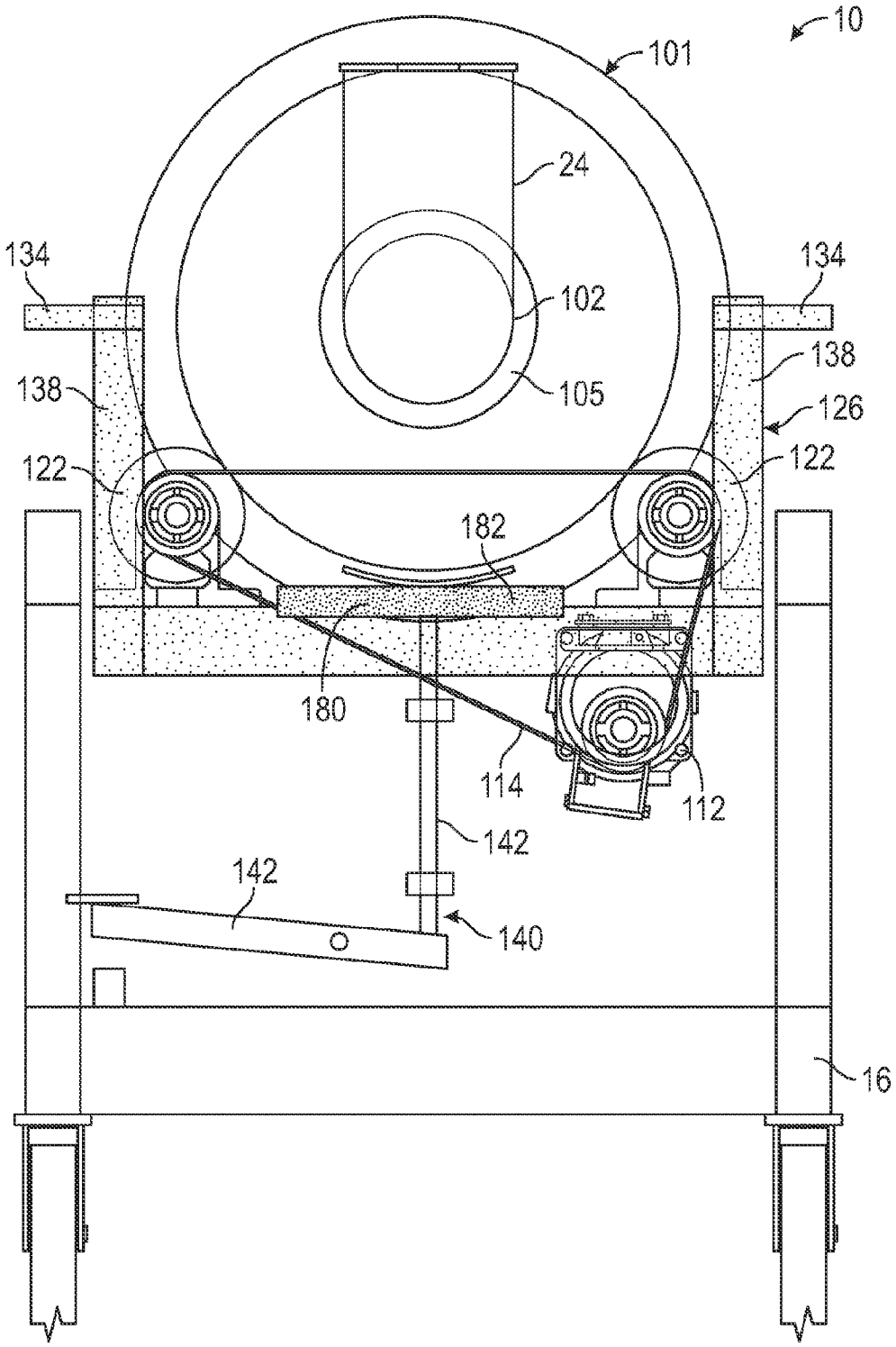

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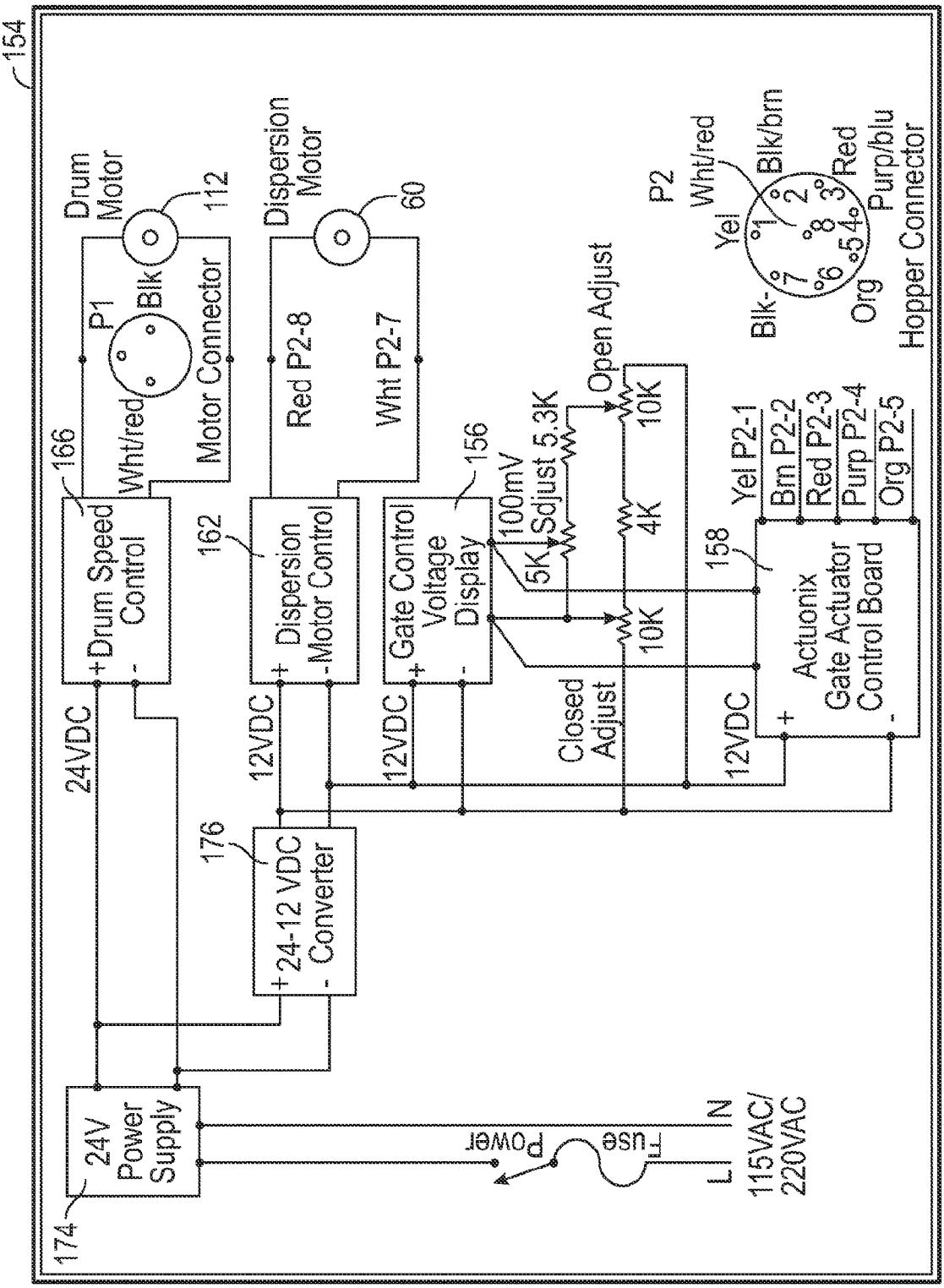
FIG. 38

FIG. 39


154
Drum Motor
112
P1
Blk
Wht/red
Motor Connector
166
Drum Speed Control
24VDC
Dispersion Motor
60
Red P2-8
Wht P2-7
162
Dispersion Motor Control
12VDC
156
Gate Control Voltage Display
100mV
Sdjust 5.3K
5K
Open Adjust
10K
4K
10K
Closed Adjust
P2
Wht/red
Blk/brn
Yel
Blk
Org
Red
Purp/blu
Hopper Connector
158
Yel P2-1
Brn P2-2
Red P2-3
Purp P2-4
Org P2-5
Actuonix Gate Actuator Control Board
176
24-12 VDC Converter
174
24V Power Supply
Power
Fuse
L1
N
115VAC/ 220VAC

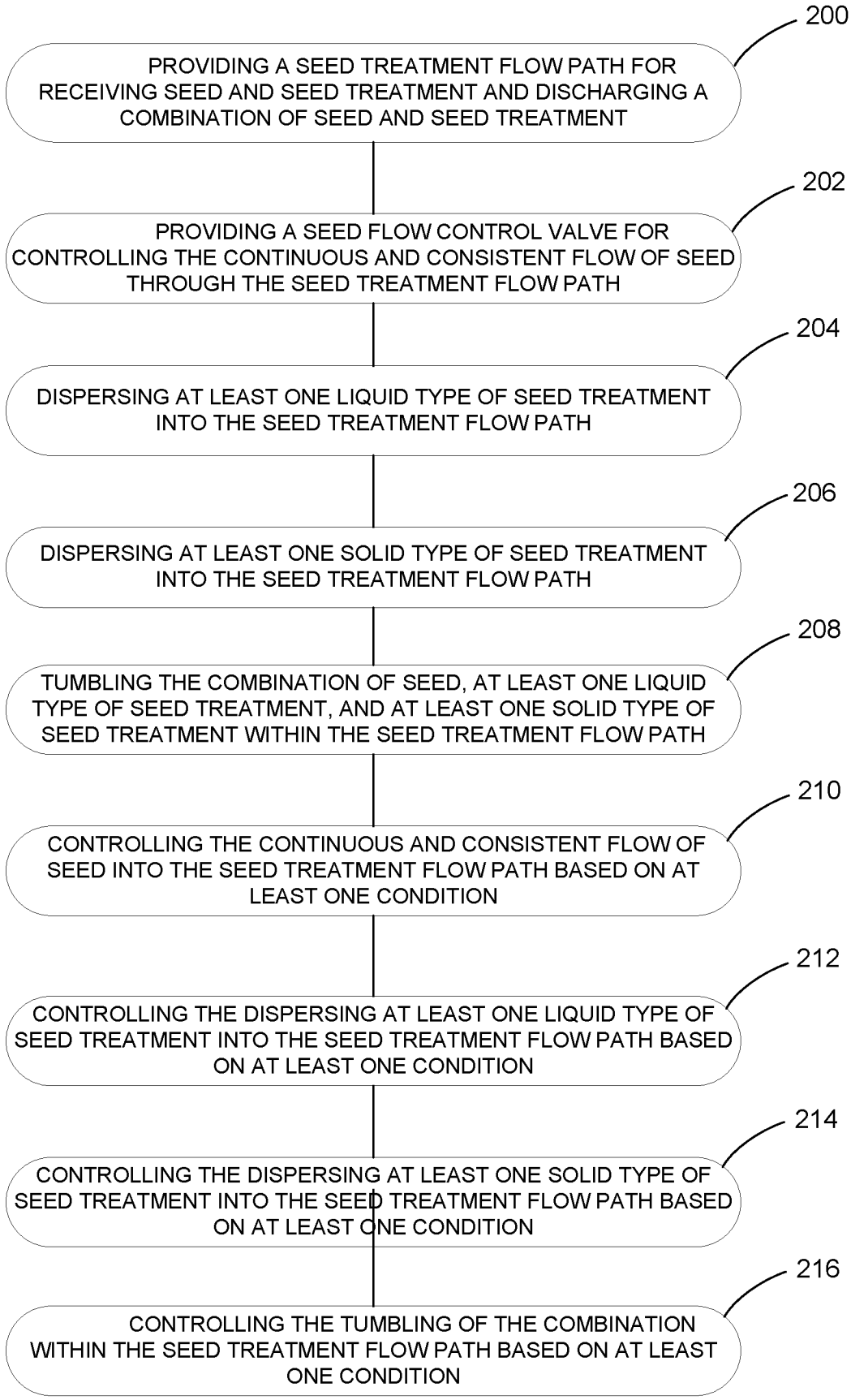

200
PROVIDING A SEED TREATMENT FLOW PATH FOR RECEIVING SEED AND SEED TREATMENT AND DISCHARGING A COMBINATION OF SEED AND SEED TREATMENT
202
PROVIDING A SEED FLOW CONTROL VALVE FOR CONTROLLING THE CONTINUOUS AND CONSISTENT FLOW OF SEED THROUGH THE SEED TREATMENT FLOW PATH
204
DISPERSING AT LEAST ONE LIQUID TYPE OF SEED TREATMENT INTO THE SEED TREATMENT FLOW PATH
206
DISPERSING AT LEAST ONE SOLID TYPE OF SEED TREATMENT INTO THE SEED TREATMENT FLOW PATH
208
TUMBLING THE COMBINATION OF SEED, AT LEAST ONE LIQUID TYPE OF SEED TREATMENT, AND AT LEAST ONE SOLID TYPE OF SEED TREATMENT WITHIN THE SEED TREATMENT FLOW PATH
210
CONTROLLING THE CONTINUOUS AND CONSISTENT FLOW OF SEED INTO THE SEED TREATMENT FLOW PATH BASED ON AT LEAST ONE CONDITION
212
CONTROLLING THE DISPERSING AT LEAST ONE LIQUID TYPE OF SEED TREATMENT INTO THE SEED TREATMENT FLOW PATH BASED ON AT LEAST ONE CONDITION
214
CONTROLLING THE DISPERSING AT LEAST ONE SOLID TYPE OF SEED TREATMENT INTO THE SEED TREATMENT FLOW PATH BASED ON AT LEAST ONE CONDITION
216
CONTROLLING THE TUMBLING OF THE COMBINATION WITHIN THE SEED TREATMENT FLOW PATH BASED ON AT LEAST ONE CONDITION

FIG. 40

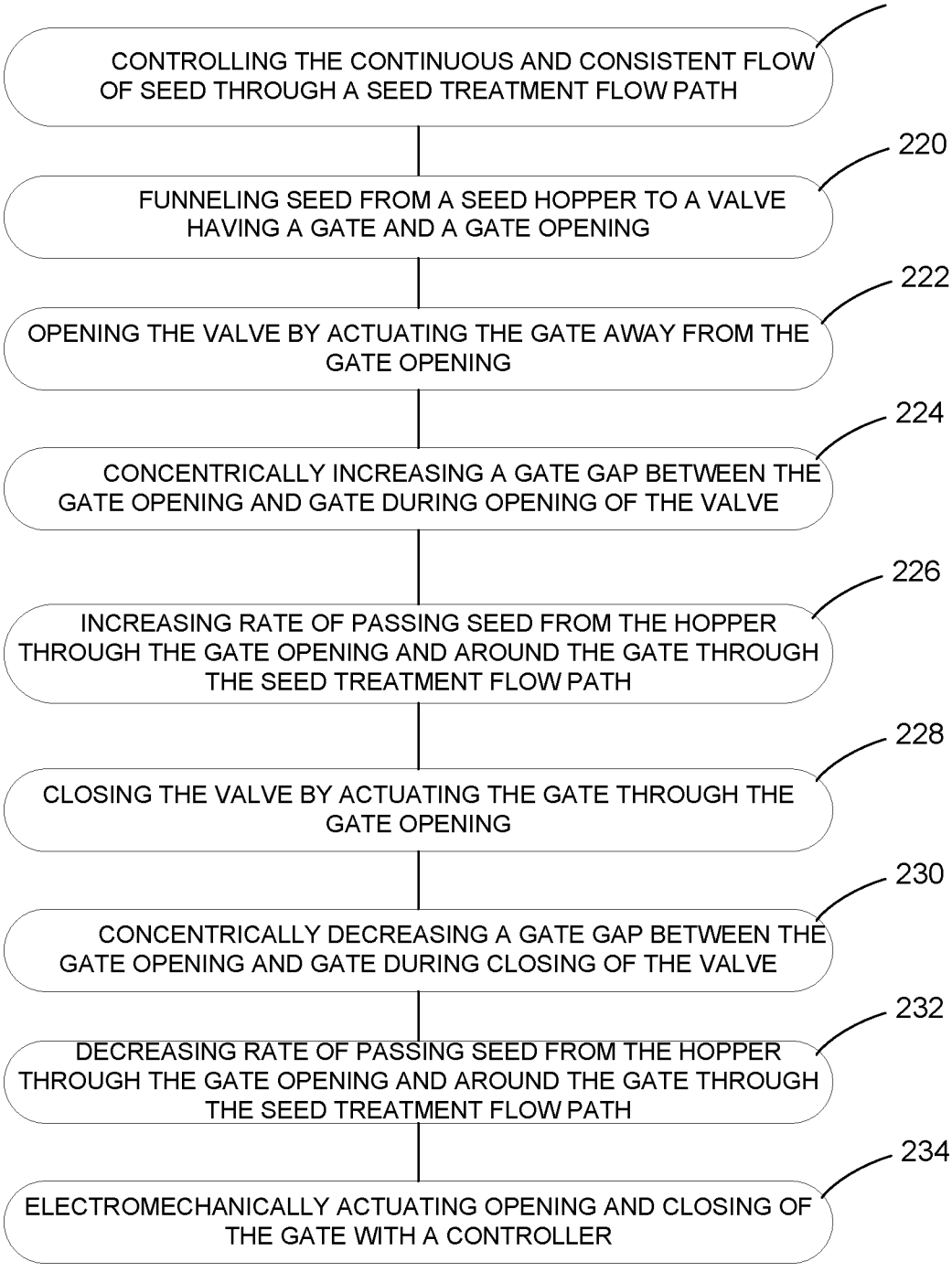

CONTROLLING THE CONTINUOUS AND CONSISTENT FLOW OF SEED THROUGH A SEED TREATMENT FLOW PATH
220
FUNNELING SEED FROM A SEED HOPPER TO A VALVE HAVING A GATE AND A GATE OPENING
222
OPENING THE VALVE BY ACTUATING THE GATE AWAY FROM THE GATE OPENING
224
CONCENTRICALLY INCREASING A GATE GAP BETWEEN THE GATE OPENING AND GATE DURING OPENING OF THE VALVE
226
INCREASING RATE OF PASSING SEED FROM THE HOPPER THROUGH THE GATE OPENING AND AROUND THE GATE THROUGH THE SEED TREATMENT FLOW PATH
228
CLOSING THE VALVE BY ACTUATING THE GATE THROUGH THE GATE OPENING
230
CONCENTRICALLY DECREASING A GATE GAP BETWEEN THE GATE OPENING AND GATE DURING CLOSING OF THE VALVE
232
DECREASING RATE OF PASSING SEED FROM THE HOPPER THROUGH THE GATE OPENING AND AROUND THE GATE THROUGH THE SEED TREATMENT FLOW PATH
234
ELECTROMECHANICALLY ACTUATING OPENING AND CLOSING OF THE GATE WITH A CONTROLLER

FIG. 41

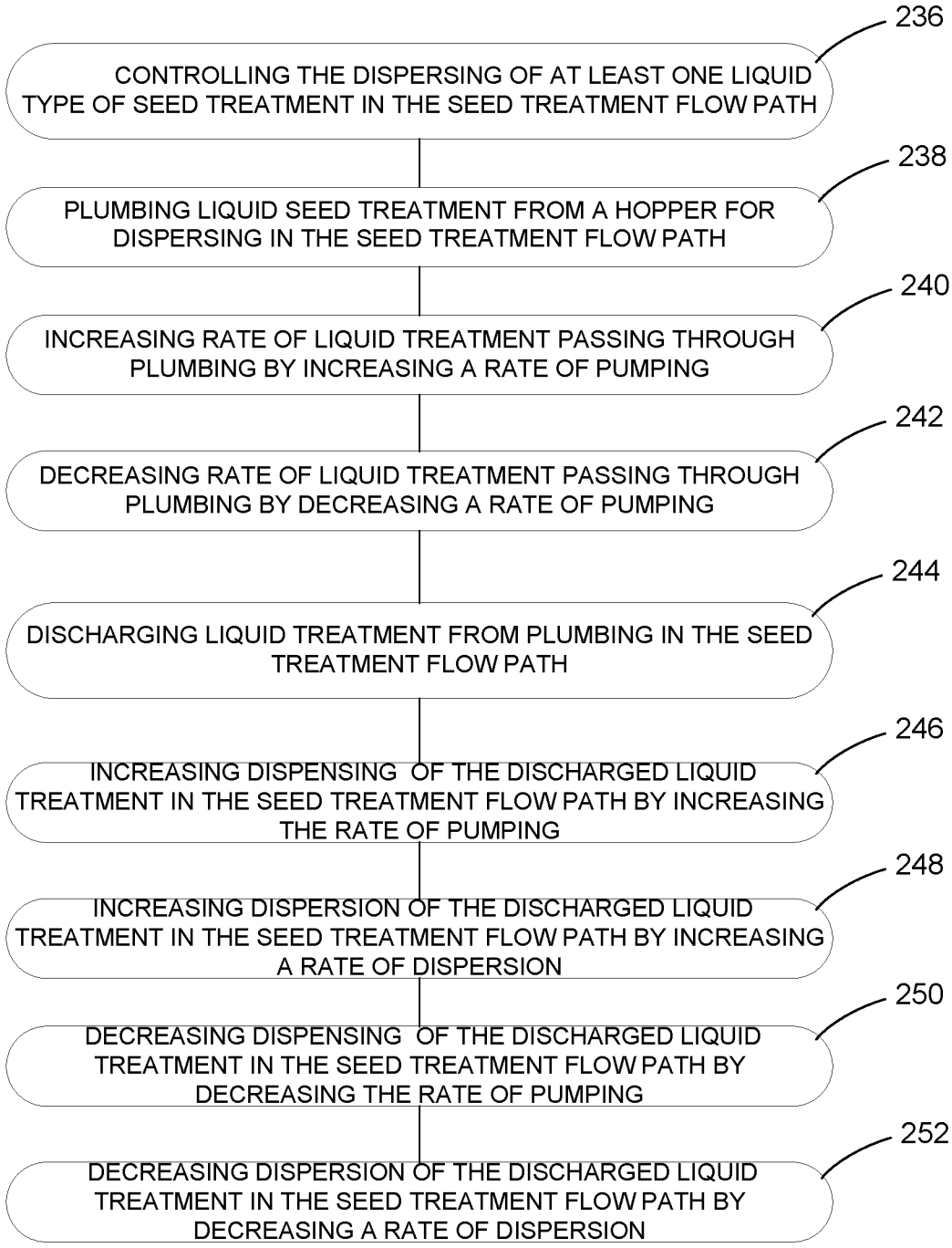

236
CONTROLLING THE DISPERSING OF AT LEAST ONE LIQUID TYPE OF SEED TREATMENT IN THE SEED TREATMENT FLOW PATH
238
PLUMBING LIQUID SEED TREATMENT FROM A HOPPER FOR DISPERSING IN THE SEED TREATMENT FLOW PATH
240
INCREASING RATE OF LIQUID TREATMENT PASSING THROUGH PLUMBING BY INCREASING A RATE OF PUMPING
242
DECREASING RATE OF LIQUID TREATMENT PASSING THROUGH PLUMBING BY DECREASING A RATE OF PUMPING
244
DISCHARGING LIQUID TREATMENT FROM PLUMBING IN THE SEED TREATMENT FLOW PATH
246
INCREASING DISPENSING OF THE DISCHARGED LIQUID TREATMENT IN THE SEED TREATMENT FLOW PATH BY INCREASING THE RATE OF PUMPING
248
INCREASING DISPERSION OF THE DISCHARGED LIQUID TREATMENT IN THE SEED TREATMENT FLOW PATH BY INCREASING A RATE OF DISPERSION
250
DECREASING DISPENSING OF THE DISCHARGED LIQUID TREATMENT IN THE SEED TREATMENT FLOW PATH BY DECREASING THE RATE OF PUMPING
252
DECREASING DISPERSION OF THE DISCHARGED LIQUID TREATMENT IN THE SEED TREATMENT FLOW PATH BY DECREASING A RATE OF DISPERSION

FIG. 42

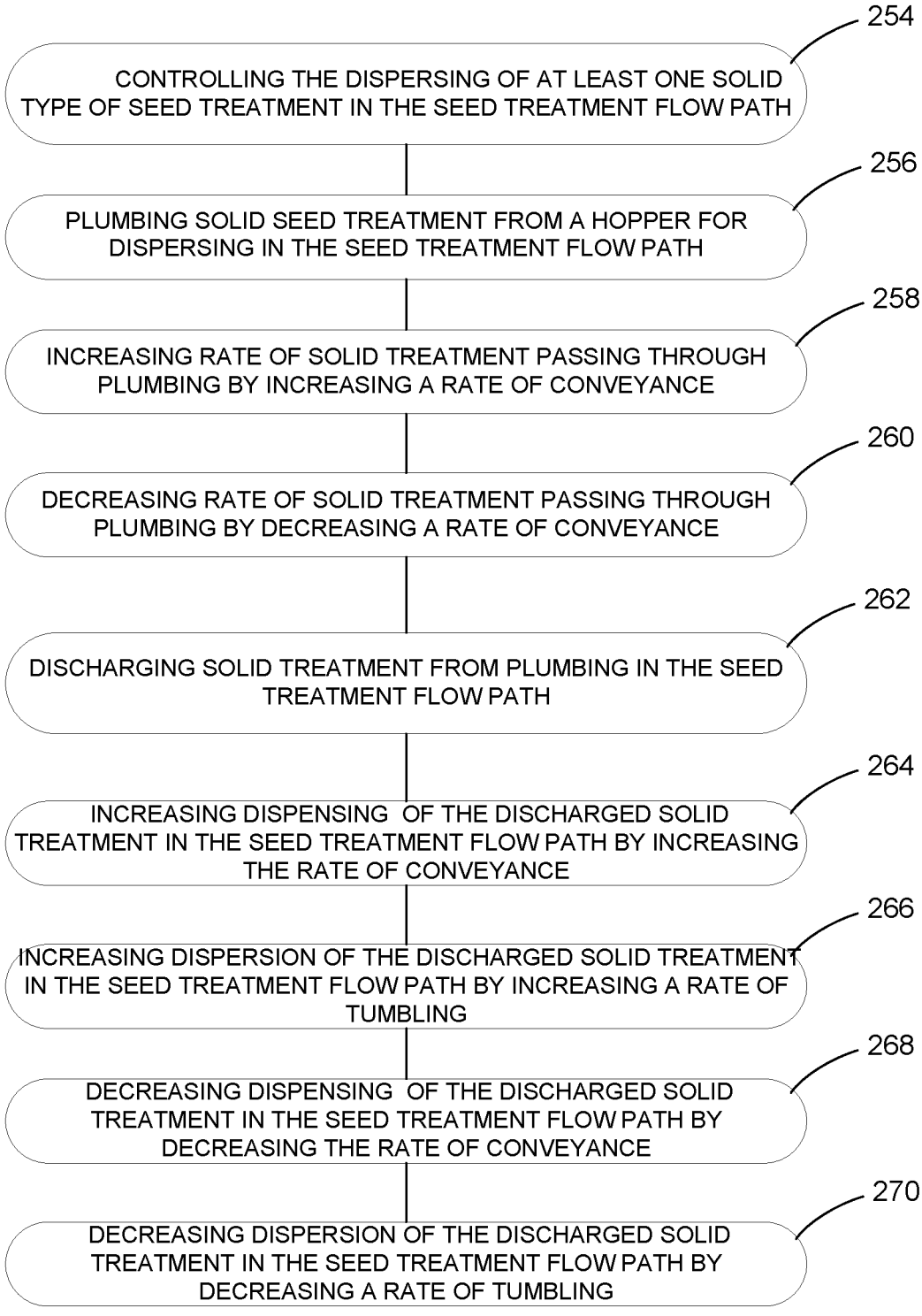

254
CONTROLLING THE DISPERSING OF AT LEAST ONE SOLID TYPE OF SEED TREATMENT IN THE SEED TREATMENT FLOW PATH
256
PLUMBING SOLID SEED TREATMENT FROM A HOPPER FOR DISPERSING IN THE SEED TREATMENT FLOW PATH
258
INCREASING RATE OF SOLID TREATMENT PASSING THROUGH PLUMBING BY INCREASING A RATE OF CONVEYANCE
260
DECREASING RATE OF SOLID TREATMENT PASSING THROUGH PLUMBING BY DECREASING A RATE OF CONVEYANCE
262
DISCHARGING SOLID TREATMENT FROM PLUMBING IN THE SEED TREATMENT FLOW PATH
264
INCREASING DISPENSING OF THE DISCHARGED SOLID TREATMENT IN THE SEED TREATMENT FLOW PATH BY INCREASING THE RATE OF CONVEYANCE
266
INCREASING DISPERSION OF THE DISCHARGED SOLID TREATMENT IN THE SEED TREATMENT FLOW PATH BY INCREASING A RATE OF TUMBLING
268
DECREASING DISPENSING OF THE DISCHARGED SOLID TREATMENT IN THE SEED TREATMENT FLOW PATH BY DECREASING THE RATE OF CONVEYANCE
270
DECREASING DISPERSION OF THE DISCHARGED SOLID TREATMENT IN THE SEED TREATMENT FLOW PATH BY DECREASING A RATE OF TUMBLING

FIG. 43

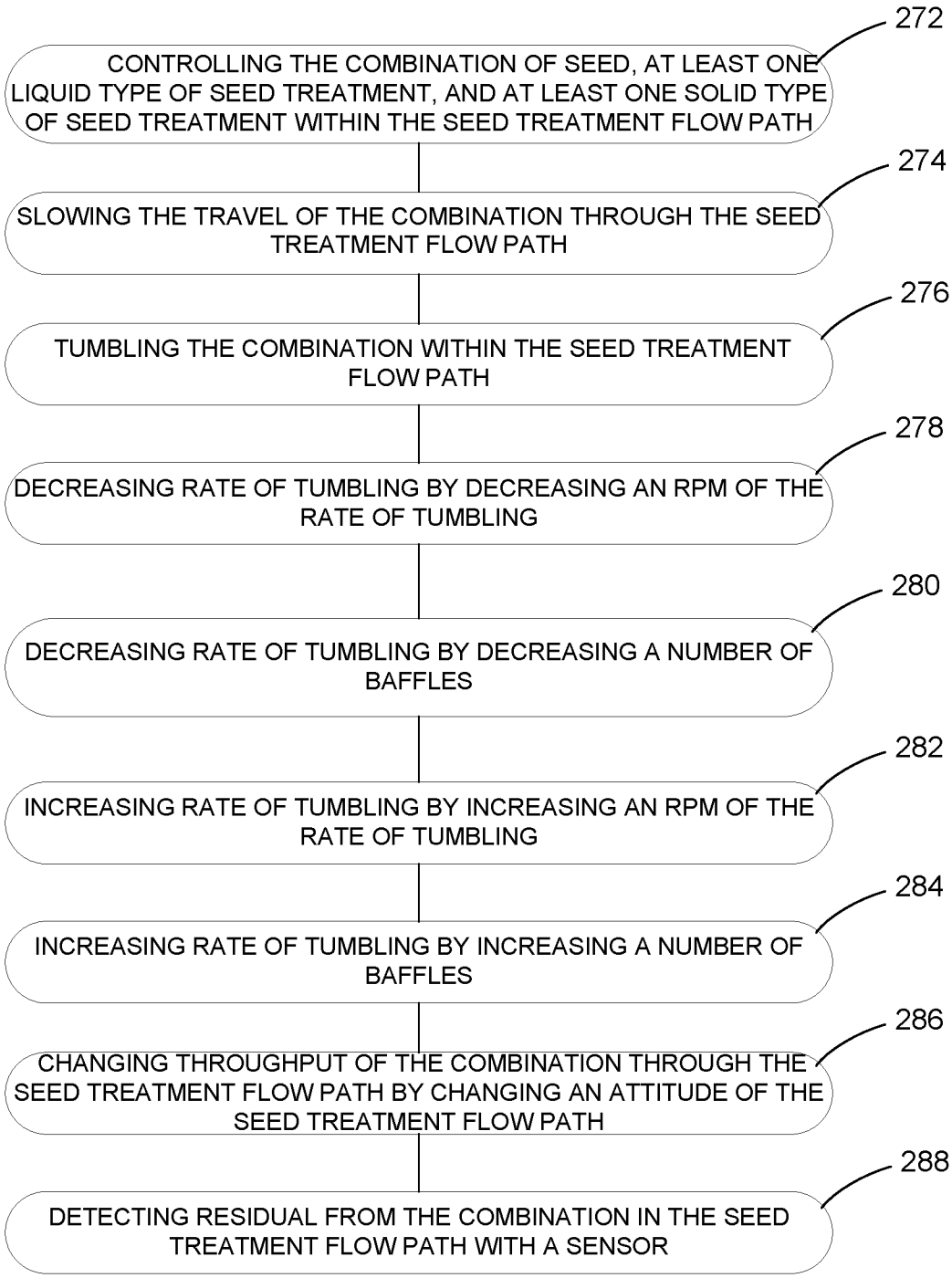

272
CONTROLLING THE COMBINATION OF SEED, AT LEAST ONE LIQUID TYPE OF SEED TREATMENT, AND AT LEAST ONE SOLID TYPE OF SEED TREATMENT WITHIN THE SEED TREATMENT FLOW PATH
274
SLOWING THE TRAVEL OF THE COMBINATION THROUGH THE SEED TREATMENT FLOW PATH
276
TUMBLING THE COMBINATION WITHIN THE SEED TREATMENT FLOW PATH
278
DECREASING RATE OF TUMBLING BY DECREASING AN RPM OF THE RATE OF TUMBLING
280
DECREASING RATE OF TUMBLING BY DECREASING A NUMBER OF BAFFLES
282
INCREASING RATE OF TUMBLING BY INCREASING AN RPM OF THE RATE OF TUMBLING
284
INCREASING RATE OF TUMBLING BY INCREASING A NUMBER OF BAFFLES
286
CHANGING THROUGHPUT OF THE COMBINATION THROUGH THE SEED TREATMENT FLOW PATH BY CHANGING AN ATTITUDE OF THE SEED TREATMENT FLOW PATH
288
DETECTING RESIDUAL FROM THE COMBINATION IN THE SEED TREATMENT FLOW PATH WITH A SENSOR

FIG. 44

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/079161

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - INV. - A01C 1/06 (2022.01)
ADD.

CPC - INV. - A01C 1/06; B01J 2/006 (2022.08)

ADD.

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)
See Search History document

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

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,465,017 A (SIMMONS) 14 August 1984 (14.08.1984) entire document	8
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Y		1-7, 9-20
Y	CN 211607308 U (TIANJIN JINSHISHENNONG SEED IND CO LTD) 02 October 2020 (02.10.2020) machine translation	1-7, 17, 20
Y	US 2011/0027479 A1 (REINECCIUS et al) 03 February 2011 (03.02.2011) entire document	3-7, 9-20
Y	US 2018/0352719 A1 (PIONEER HI-BRED INTERNATIONAL INC. et al) 13 December 2018 (13.12.2018) entire document	15
Y	US 2016/0302352 A1 (DANIEL TRAMP et al) 20 October 2016 (20.10.2016) entire document	16, 18
Y	US 4,596,206 A (BERGE et al) 24 June 1986 (24.06.1986) entire document	19
A	US 6,582,516 B1 (CARLSON) 24 June 2003 (24.06.2003) entire document	1-20
A	US 2006/0236925 A1 (LUND) 26 October 2006 (26.10.2006) entire document	1-20
A	US 6,202,346 B1 (LYONS et al) 20 March 2001 (20.03.2001) entire document	1-20

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* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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	Date of mailing of the international search report
26 December 2022	FEB 01 2023
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Taina Matos Telephone No. PCT Helpdesk: 571-272-4300