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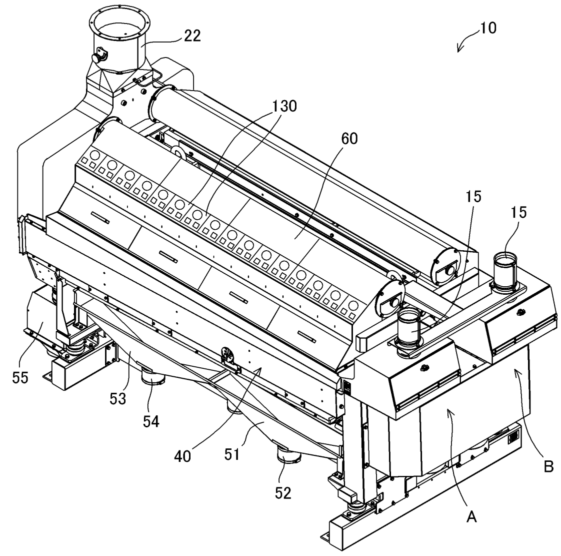
(54) **PURIFIER**

(57) The purifier includes: a sieving part including a sieving screen and configured to sift a processing target while carrying the processing target on the sieving screen in a predetermined direction; a plurality of straightening chambers disposed above the sieving part and in communication with interior of the sieving part, and separated from each other so as to be lined up in the predetermined direction; a plurality of air flow regulating valves respectively provided in the plurality of straightening chambers, and each configured to regulate flow rate of air passing through the sieving screen and flowing upward in the corresponding straightening chamber; a plurality of motors configured to respectively drive the plurality of air flow regulating valves to control opening degrees of the plurality of air flow regulating valves; and a controller configured to control the plurality of motors.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a purifier for purification processing in milling of grains.

BACKGROUND

[0002] Conventionally, a device (which is commonly referred to as a purifier) is known to be used for purification processing in milling of grains such as wheat (see Patent Document 1 listed below, for example). For example, in milling of wheat, wheat kernels undergo processes of sorting, conditioning, and braking to form semi-products called stock. The stock is then sifted and fed to a purifier. In the purifier, the stock is separated into endosperm particles called semolina and epidermal fragments called bran.

[0003] More specifically, the purifier includes: a sieving part configured to sift a processing target while carrying the processing target on a sieving screen in a predetermined direction; a plurality of straightening chambers disposed above the sieving part and in communication with interior of the sieving part, and separated so as to be lined up in the predetermined direction; and a plurality of air flow regulating valves respectively disposed in the plurality of straightening chambers. Each of the air flow regulating valves regulates flow rate of air passing through the sieving screen and flowing upward in the corresponding straightening chamber. Once the stock is fed onto the sieving screen in a vibrational state, the stock is carried on the screen in the predetermined direction. At this time, the semolina, which is relatively heavy, sequentially falls through the sieving screen; whereas the bran, which is relatively light, floats up by air flow flowing upward in the straightening chambers (hereinafter referred to as upward air flow) and then is suctioned. The mesh size of the sieving screen gradually increases towards the downstream side. Therefore, the smaller the particle size of the semolina is, the earlier the semolina particle falls through the screen. This enables the purifier to grade the semolina according to the particle size at the same time as removing the bran.

[0004] In such a purifier, if the upward air flow has insufficient strength, the bran may fail to float upward. This may prevent precise removal of the bran. On the other hand, if the upward air flow has excessive strength, the semolina of relatively small particle size and already granulated wheat may float upward and be suctioned together with the bran. This may result in reduced milling yield. Therefore, in such a purifier, it is desirable to adjust an opening degree of each air flow regulating valve and thereby regulate the strength of upward air flow within an appropriate range.

[0005] In a conventional purifier, an operator uses a knob mechanically connected to such an air flow regulating valve to manually adjust the opening degree of the air flow regulating valve while visually checking circumstance within the straightening chamber from an inspection window.

PRIOR ART DOCUMENT

Patent Document

[0006] Patent Document 1: Japanese Unexamined Patent Application Publication No. H08-39002

SUMMARY

[0007] The above-described conventional purifier still has room for improvement with regard to its operability or purification performance. For example, the strength of upward air flow and the behavior of stock on the sieving screen may vary depending on various operating conditions (e.g., particle size of stock to be processed, flow rate of air, specifications of the sieving screen, ambient environment, and so on). Therefore, manually adjusting the opening degree of the air flow regulating valve may require a seat-of-the-pants skill for fine adjustment. This causes great variability of purification precision and milling yield between a skilled operator and an unskilled operator. In addition, even a skilled operator may require great effort and time to make such fine adjustment according to given operating condition. A purifier of improved operability and purification performance is thus desired.

Solution to Problem

[0008] The present invention is proposed to solve at least a part of the above-mentioned problems, and can be implemented in the following aspects, for example.

[0009] According to a first aspect of the present invention, a purifier is provided. The purifier includes: a sieving part including a sieving screen and configured to sift a processing target while carrying the processing target on the sieving screen in a predetermined direction; a plurality of straightening chambers disposed above the sieving part and in communication with interior of the sieving part, and separated from each other so as to be lined up in the predetermined direction; a plurality of air flow regulating valves respectively provided in the plurality of straightening chambers, and each configured to regulate flow rate of air passing through the sieving screen and flowing upward in the corresponding straightening chamber; a plurality of motors configured to respectively drive the plurality of air flow regulating valves to control opening degrees of the plurality of air flow regulating valves; and a controller configured to control the plurality of motors.

[0010] According to this purifier, the opening degrees of the plurality of air flow regulating valves may be respectively adjusted by the controller controlling the plurality of motors. A greater degree of freedom is thus allowed in the design of purifier compared to the conventional purifier in which the opening degree of each air flow regulating valve is adjusted by manual manipulation of the knob. This allows for implementation of various aspects as illustrated below and thus provides a purifier with improved operability or purification performance.

[0011] According to a second aspect of the present invention, in the first aspect, the purifier includes an inspection window from which interior of each of the plurality of straightening chambers is viewable. The controller includes a plurality of user interfaces arranged near the inspection window at locations respectively corresponding to the plurality of air flow regulating valves. Each of the user interfaces is configured to be operable to change the opening degree of the corresponding air flow regulating valve. According to this aspect, an operator can adjust the opening degrees of the plurality of air flow regulating valves as in the conventional purifier, by manipulating the plurality of user interfaces while viewing the interiors of the plurality of straightening chambers from the inspection window. In addition, the arrangement of the plurality of user interfaces at the locations respectively corresponding to the plurality of air flow regulating valves enables an operator to know easily and intuitively which air flow regulating valve is being adjusted.

[0012] According to a third aspect of the present invention, in the second aspect, the controller includes a plurality of individual controllers configured to respectively control the plurality of motors. The plurality of individual controllers include the plurality of user interfaces, respectively. According to this aspect, the layout of wiring can be simpler compared to the design in which a single controller is electrically connected directly to the plurality of user interfaces as well as to the plurality of motors.

[0013] According to a fourth aspect of the present invention, in any one of the first to third aspects, the controller includes an operation panel configured to enable an operator to set the opening degree of each of the plurality of air flow regulating valves by controlling each of the plurality of motors. According to this aspect, the operator can manipulate the plurality of motors collectively with no need for staying in front of the plurality of straightening chambers.

[0014] According to a fifth aspect of the present invention, in any one of the first to fourth aspects, the controller is configured to be operable in a first operation mode. The controller is configured to, in the first operation mode, : acquire first linked information in which factor information related to a factor influential to purification precision is linked to opening degree information representing the opening degree of each of the plurality of air flow regulating valves; when a new operation of the purifier is performed, acquire information corresponding to the factor information serving as an operation condition of the new operation; and determine the opening degree of each of the plurality of air flow regulating valves in the new operation based on the first linked information and the acquired information corresponding to the factor information. According to this aspect, the desired corresponding relationship between the factor information serving as the operation condition and the opening degree of each of the air flow regulating valves can be preset as the first linked relationship, so that when the new operation of the purifier is performed, the opening degree of each of the air flow regulating valves suitable for the operation condition of the new operation can be automatically determined based on the first linked relationship. This eliminates the necessity for a skillful operator to operate the purifier. The information corresponding to the factor information may be input into the controller by an operator or may be acquired by a sensor of the purifier. The first linked information may be read from a storage device of the controller or may be acquired from an external device via electric communication. The first linked relationship may be determined experimentally in the stage of purifier fabrication.

[0015] According to a sixth aspect of the present invention, in the fifth aspect at least including the second aspect, the controller is configured to, in a case where the new operation of the purifier is performed through a manipulation using the user interfaces, update the first linked information based on a combination of the information corresponding to the factor information which is acquired in relation to the new operation, and history of the opening degree of each of the plurality of air flow regulating valves during the new operation. According to this aspect, the history of the opening degree of each of the air flow regulating valves at the time the opening degrees of the plurality of air flow regulating valves are adjusted manually by a skilled operator using the user interfaces can be reflected in the first linked information and be used as desired opening degrees when the information corresponding to the factor information which is acquired in relation to the new operation matches the operation condition. For example, the combination mentioned above may be overwritten as the first linked information related to the corresponding factor information, or may be added as an option available as the first linked information.

[0016] According to a seventh aspect of the present invention, in any one of the first to sixth aspects, the controller is configured to output operation history information of the purifier that includes the opening degree of each of the plurality of air flow regulating valves. The operation history information may be output to a storage medium, a communication interface, or a printing device. The operation history information may include the factor information at the time of operation or may include operator identification information input into the controller by an operator. According to this aspect, an operator can cause the operation history information to be output and review its contents so as to be utilized in future operation of the purifier. For example, based on a relationship between milling yield separately acquired and the operation history information, the opening degree of each of the air flow regulating valves can be reviewed for improvement of milling field. In a case where the seventh aspect is combined with the fifth or sixth aspect, the first linked information may be corrected based on the relationship between the separately acquired milling yield and the operation history information.

[0017] According to an eighth aspect of the present invention, in any one of the first to seventh aspect, the purifier includes a plurality of static pressure sensors respectively disposed within the plurality of straightening chambers. Each of the plurality of static pressure sensors is configured to detect static pressure in the corresponding straightening chamber. Since static pressure correlates with flow rate, this aspect enables an operator to grasp the flows of air in the plurality of straightening chambers based on the results of static pressure detection. This allows for finer adjustment of the opening degree of each of the plurality of air flow regulating valves, thus resulting in improved purification performance.

[0018] According to a ninth aspect of the present invention, in the eighth aspect, the controller is configured to indicate results of detection by the plurality of static pressure sensors on a real-time basis. According to this configuration, an operator can estimate flow rates of air in the plurality of straightening chambers by checking the results of detection by the static pressure sensors. Further, in a case where the ninth aspect is combined with the second or fourth aspect, an operator can manually adjust the opening degree of each of the plurality of air flow regulating valves while referring to the results of detection by the static pressure sensors. The indication may, for example, be presented on the user interfaces in the second aspect, or may alternatively or additionally be presented on a screen of the operation panel in the fourth aspect.

[0019] According to a tenth aspect of the present invention, in the eighth or ninth aspect, the controller is configured to be operable in a second operation mode in which operations of the plurality of motors are automatically controlled based on the results of detection by the plurality of static pressure sensors and a target static pressure value individually set for each of the plurality of straightening chambers. According to this aspect, the flow rate of air in each of the plurality of straightening chambers is controlled automatically to an appropriate value. This eliminates the necessity for a skilled operator to operate the purifier. Moreover, even in a case where the flow rates of air in the plurality of straightening chambers change due to change of property of stock, uneven distribution of stock on the sieving screen, increase or decrease of stock supply, or the like, the opening degrees of the air flow regulating valves can be adjusted such that the flow rates of air therein return to the suitable range.

[0020] According to an eleventh aspect of the present invention, in the tenth aspect, the controller is configured to, in the second operation mode,: acquire second linked information in which factor information related to a factor influential to purification precision is linked to the target static pressure value; when a new operation of the purifier is performed, acquire information corresponding to the factor information serving as an operation condition of the new operation; and determine the target static pressure value in the new operation based on the second linked information and the acquired information corresponding to the factor information. According to this aspect, the desired corresponding relationship between the factor information serving as the operation condition and the target static pressure value can be preset as the second linked relationship, so that when the new operation of the purifier is performed, the target static pressure value suitable for the operation condition of the new operation can be determined based on the second linked relationship. The information corresponding to the factor information may be input to the controller by an operator or may be acquired by a sensor of the purifier. The second linked information may be read from a storage device of the controller or may be acquired from an external device via electric communication. The second linked relationship may be determined experimentally in the stage of purifier fabrication.

[0021] According to a twelfth aspect of the present invention, in the eleventh aspect, the controller is configured to, in a case where the new operation of the purifier is performed through a manipulation using the user interfaces, update the second linked information based on a combination of the information corresponding to the factor information which is acquired in relation to the new operation, and the results of detection by the plurality of static pressure sensors which are acquired during the new operation. According to this aspect, the history of the static pressure value of each of the plurality of straightening chambers at the time the opening degrees of the plurality of air flow regulating valves are adjusted manually by a skilled operator by using the user interfaces can be reflected in the second linked information and be used as desired target static pressure values when the information corresponding to the factor information which is acquired in relation to the new operation matches the operation condition. For example, the combination mentioned above may be overwritten as the second linked information related to the corresponding factor information, or may be added as an option available as the second linked information.

[0022] According to a thirteenth aspect of the present invention, in the twelfth aspect, the second linked information is a prediction model that takes the factor information as its explanatory variable and the target static pressure value as its object variable. The controller is configured to update the prediction model through learning by artificial intelligence. According to the aspect, purification performance can be enhanced further. For a new operation in which the opening degrees of the plurality of air flow regulating valves are adjusted manually by a skilled operator, the combination of the information corresponding to the factor information which is acquired in relation to the new operation, and the results of detection of the static pressure sensors which are acquired during the new operation may be collected as learning data.

[0023] According to a fourteenth aspect of the present invention, in any one of the eighth to thirteenth aspects, the controller is configured to output the operation history information of the purifier that includes the results of detection by the plurality of static pressure sensors. According to this aspect, effects similar to those of the seventh aspect can be obtained. For example, based on the relationship between the separately acquired milling yield and the operation history information, the target static pressure values can be reviewed for improvement of milling field.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a perspective view of a purifier according to a first embodiment of the present invention.
FIG. 2 is a front view of the purifier.
FIG. 3 is a schematic view that shows the internal structure of the purifier.
FIG. 4 is a control block diagram of the purifier.
FIG. 5 is a block diagram that shows the outline framework of an individual controller and an operation panel.
FIG. 6 is a diagram that shows an example of a user interface from which the opening degree of an air flow regulating valve can be manually manipulated.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] FIG. 1 is a perspective view of a purifier 10 as an embodiment of the present invention. FIG. 2 is a front view of the purifier 10. FIG. 3 is a schematic view that shows the internal structure of the purifier 10. In the following description, the purifier 10 is described as being used in milling of wheat. Note that, however, the purifier 10 may be used in milling of any other grain (for example, soba, soya bean, adzuki bean, coffee bean, corn, and the like). As shown in FIG. 1, the purifier 10 is configured to have two systems: an A system and a B system. The A system and the B system have identical configurations. Components of the purifier 10 discussed below are provided for each of the A and B systems, except for an operation panel 200 which is shared by both systems.

[0026] As schematically shown in FIG. 3, the purifier 10 includes a feed port 15 for feeding stock, a sieving part 40, and a plurality of straightening chambers 20. The sieving part 40 is in communication with the feed port 15. The stock fed from the feed port 15 is fed to the sieving part 40. Sieving screens 41, 42, and 43 are disposed in the sieving part 40. Each of the sieving screens 41, 42, and 43 is inclined such that the screens are located at vertically lower positions toward the opposite side from the feed port 15 in the longitudinal direction of the sieving screens 41, 42, and 43. In the present embodiment, the sieving part 40 has a three-layered structure including the sieving screens 41, 42, and 43 arranged in the vertical direction; however, alternatively, the number of layers of the layered structure may be any number equal to or greater than one. The number of layers of the sieving part 40 may be changed by removing some of the sieving screens 41, 42, and 43 or by adding one or more sieving screens according to the desired level of purification performance.

[0027] As shown in FIG. 3, each of the sieving screens 41, 42, and 43 is configured to be vibratable in a front-rear direction (the longitudinal direction of the sieving screens 41, 42, and 43). The vibration allows the stock fed from the feed port 15 to be carried on the sieving screens 41, 42, and 43 in the longitudinal direction of the sieving screens 41, 42, and 43 (more specifically, in a direction away from the feed port 15). As such, the sieving part 40 is configured to sift the stock while carrying it on the sieving screens 41, 42, and 43 in the longitudinal direction. The mesh size of each of the sieving screens 41, 42, and 43 is set so as to gradually increase towards the downstream side in the direction in which the stock is carried. Specifically, the sieving screen 41 is configured to have a plurality of sieving screen sections arranged in the longitudinal direction such that the further the section is towards the downstream side, the smaller the mesh size of the section is. The same applies to the sieving screens 42 and 43.

[0028] As shown in FIGS. 1 and 3, a collecting gutter 51 and a collecting gutter 53 are disposed below the sieving part 40. The collecting gutters 51 and 53 are provided to collect semolina that falls sequentially through the mesh of the sieving screen 41, the mesh of the sieving screen 42, and the mesh of the sieving screen 43. The collecting gutter 51 includes a discharge port 52 at its lower edge, and the collecting gutter 53 includes a discharge port 54 at its lower edge. A plurality of switching valves (not shown) are disposed between the sieving part 40 and the collecting gutters 51, 53. The arrangement allows the destination of semolina falling from the sieving part 40 to be switched between the collecting gutter 51 and the collecting gutter 53 at each of multiple locations in the longitudinal direction (the locations where the switching valves are placed).

[0029] As shown in FIG. 3, the downstream ends of the sieving screens 41, 42, and 43 terminate within a discharge gutter 55. A discharge port 56 is formed at a lower part of the discharge gutter 55. As shown in FIGS. 2 and 3, the discharge port 56 is separated into three sections such that semolina that reaches and falls from downstream ends of the sieving screens 41, 42, and 43 without falling through the meshes of the sieving screens 41, 42, and 43 can be discharged separately from each other.

[0030] As shown in FIG. 3, the plurality of straightening chambers 20 are disposed above the sieving part 40. The number of the straightening chamber 20 may be set freely; 16 straightening chambers 20 are provided for each system in the example shown in FIG. 3. The plurality of straightening chambers 20 are separated by straightening plates 21 so that the plurality of straightening chambers 20 are lined up in the longitudinal direction of the sieving screens 41, 42, and 43. The plurality of straightening chambers 20 are in communication with interior of the sieving part 40. On their upper sides, the plurality of straightening chambers 20 are connected to one end of a main duct 22. Although not shown, interior of the main duct 22 is separated into an A-system-dedicated region and a B-system-dedicated region. A suction fan (not shown) is connected to the other end of the main duct 22. The suction fan is activated while sifting is ongoing in the sieving part 40. This produces air flow flowing upward from underside of the sieving part 40 through the meshes of the sieving screens 41, 42, and 43, and further flowing upward in the plurality of straightening chambers 20 (herein referred to as upward air flow). In the end, the air flow is suctioned into the main duct 22.

[0031] As shown in FIG. 3, the same number of air flow regulating valves 30 (hereinafter simply referred to as valves 30) as the straightening chambers 20 are provided within the plurality of straightening chambers 20, respectively. That is, one valve 30 is provided for each straightening chamber 20. Each valve 30 is configured to regulate its opening degree so as to adjust the flow rate of the upward air flow in the corresponding straightening chamber 20. Further, air flow regulating valves 31 (hereinafter simply referred to as valves 31) are provided within the main duct 22. Each valve 31 is configured to regulate its opening degree so as to adjust the flow rate of air in the main duct 22 and in the plurality of straightening chambers 20. One valve 31 is provided for each of the A-system-dedicated region and the B-system-dedicated region.

[0032] In the purifier 10 described above, stock undergoes purification processing as described below. Firstly, while a vibration generator 44 is in activation and the air in the sieving part 40 is being suctioned through the main duct 22, stock is fed into the feed port 15. The stock fed into the feed port 15 is fed onto the sieving screen 41 and carried in the downstream direction toward the discharge gutter 55 with the help of the inclination of the sieving screen 41 and the vibration generated by the vibration generator 44. At this time, semolina, which is relatively heavy, falls through the mesh of the sieving screen 41 onto the sieving screen 42. Since the mesh size of the sieving screen 41 increases towards the downstream side, the smaller the particle size of semolina is, the earlier (that is, at a position closer to the upstream side) the semolina particle passes through the mesh of the sieving screen 41.

[0033] Further, when the stock is carried on the sieving screen 41, bran, which is relatively light, floats up by the upward air flow described above. The bran is then suctioned into the main duct 22 together with the air and collected by the collecting device (not shown) such as a bag filter.

[0034] The semolina that falls onto the sieving screen 42 is then carried on the sieving screen 42 towards the downstream side. The smaller the particle size of semolina is, the earlier the semolina particle passes through the mesh of the sieving screen 42 and falls onto the sieving screen 43. Similarly, the semolina that falls onto the sieving screen 43 is carried on the sieving screen 43 towards the downstream side. The smaller the particle size of semolina is, the earlier the semolina particle passes through the mesh of the sieving screen 43 and falls onto the collecting gutter 51 or the collecting gutter 53. As a result, the semolina of relatively small particle size is collected in the collecting gutter 51 and discharged from the discharge port 52. Also, the semolina of relatively large particle size is collected in the collecting gutter 53 and discharged from the discharge port 54.

[0035] The semolina of large particle size that do not fall through the meshes of the sieving screens 41, 42, or 43 is guided to the discharge gutter 55 and discharged from the discharge port 56. At this time, the semolina that has reached the end of the sieving screen 41, the semolina that has reached the end of the sieving screen 42, and the semolina that has reached the end of the sieving screen 43 are separated from each other. This results in semolina being graded according to its particle size at the same time as bran is being removed from stock.

[0036] In such purification processing by the purifier 10, the flow rate of the upward air flow passing through the sieving screen 41 and the straightening chambers 20 can greatly affect purification performance. Therefore, in the present embodiment, the purifier 10 includes various configurations for adequately controlling the flow rate of the upward air flow passing through the sieving screen 41 and the straightening chambers 20 by adjusting the opening degree of each of the valves 30, 31. The following describes such configurations.

[0037] FIG. 4 is a control block diagram of the purifier 10. Although only the configuration of the A system is shown in detail in FIG. 4, the B system also includes an identical configuration to the A system. As shown in FIG. 4, the purifier 10 includes the same number of the motors 80 as the valves 30 disposed in the plurality of straightening chambers 20. That is, one motor 80 is provided for each valve 30. Each motor 80 is configured to drive the corresponding valve 30 and thereby control the opening degree of the valve 30. The purifier 10 further includes, in each of the A system and the B system, a motor 81 configured to drive the valve 31 and thereby control the opening degree of the valve 31. In the present embodiment, the motors 80, 81 are servo motors. The use of servo motors allows for precise control of the opening degrees of the valves 30, 31. Note that, however, any other type of motors may alternatively be used for the motors 80, 81, such as stepping motors, for example.

[0038] As shown in FIG. 4, the purifier 10 includes the same number of individual controllers 100 as the motors 80 and the same number of individual controllers 101 as the motors 81 (that is, one controller 101 for each system). The plurality of individual controllers 100 are electrically connected to the plurality of motors 80, respectively, and each individual controller 100 controls the corresponding motor 80. Similarly, each individual controller 101 is electrically connected to and controls the corresponding motor 81.

[0039] As shown in FIG. 4, the purifier 10 includes the same number of static pressure sensors 90 as the straightening chambers 20. That is, one static pressure sensor 90 is provided for each straightening chamber 20. Each static pressure sensor 90 is disposed within the corresponding straightening chamber 20 and detects static pressure within the corresponding straightening chamber 20. Each static pressure sensor 90 is electrically connected to the corresponding individual controller 100 so that the result of detection by the static pressure sensor 90 is output to the corresponding individual controller 100. The purifier 10 further includes one static pressure sensor 91 for each system in the main duct 22. Each static pressure sensor 91 is connected to the corresponding individual controller 101 so that the result of detection by the static pressure sensor 91 is output to the individual controller 101.

[0040] As shown in FIGS. 2 and 4, the purifier 10 includes the operation panel 200 configured to manipulate and control constituent devices of the purifier 10 in a collective manner. As shown in FIG. 2, the operation panel 200 is disposed in an upper and front part of the purifier 10. As shown in FIG. 4, the operation panel 200 is electrically connected to the plurality of individual controllers 100 and the individual controllers 101. In the present embodiment, they are connected in a daisy chain mode which allows for simplified wiring. The mode of communication can be CAN (Controller Area Network) or Serial Communication (e.g., RS485), for example. When controlling the motors 80, the operation panel 200 controls each target motor 80 through the individual controller 100 corresponding to the target motor 80. Similarly, the operation panel 200 controls each target motor 81 through the individual controller 101 corresponding to the target motor 81.

[0041] As shown in FIG. 1, the purifier 10 includes an inspection window 60. The inspection window 60 is made of a transparent member and is disposed at a location that enables an operator to view interiors of the plurality of straightening chambers 20 from the inspection window 60. For example, the operator can visually check circumstance inside each of the straightening chambers 20: whether the flow rate of air in the straightening chamber 20 is maintained at a suitable level and thus bran has been removed adequately therefrom, or the flow rate of air is too large such that semolina of relatively small particle size and already granulated wheat have been suctioned together with bran (which will result in reduced milling yield), or the flow rate of air is too small such that bran has not floated up (which will result in reduced purification precision). Alternatively, the operator can visually check the opening degrees of the valves 30.

[0042] As shown in FIG.1, the same number of user interfaces 130 as the valves 30 (that is, the same number of user interfaces 130 as the straightening chambers 20) are disposed near the inspection window 60. That is, one user interface 130 is provided for each valve 30. Each user interface 130 is a component of each individual controller 100 and is configured to enable an operation of changing the opening degree of the corresponding valve 30. An operator can easily adjust the opening degrees of the plurality of valves 30 by manipulating the user interfaces 130 while checking circumstances within the straightening chambers 20 from the inspection window 60.

[0043] Each individual controller 100 including the user interface 130 is connected to the corresponding motor 80 via a cable. This allows each user interface 130 to be disposed at a location different from the corresponding motor 80. In other words, the user interface 130 can be located at any location. In this embodiment, this advantageously allows the user interfaces 130 to be located adjacent to and below the inspection window 60. Therefore, an operator's arm manipulating the user interfaces 130 is located below the inspection window 60, which prevents the arm from interrupting the operator's sight to the inspection window 60. This makes the inspection window 60 and then the circumstances within the straightening chambers 20 to be easily viewable.

[0044] Further, the plurality of user interfaces 130 are arranged at locations respectively corresponding to the plurality of valves 30. Specifically, the plurality of user interfaces 130 are lined up in the longitudinal direction (in other words, in the direction in which stock is carried) similarly to the plurality of valves 30, and each user interfaces 130 is at the same location as the corresponding valve 30 in the longitudinal direction. This enables an operator to know easily and intuitively which valve is being adjusted.

[0045] FIG. 6 is a diagram that shows an example of the user interface 130. The user interface 130 includes a close button 131 and an open button 132. Once an operator presses the close button 131, the corresponding valve 30 operates in a close direction. Once an operator presses the open button 132, the corresponding valve 30 operates in an open direction. The opening degree of the valve 30 is changed either stepwise or steplessly, according to the length of time in which the close button 131 or the open button 132 is held down or the number of times that the button is pressed.

[0046] In the present embodiment, the user interface 130 has a function of indicating the opening degree of the corresponding valve 30. In the example shown in FIG. 6, an opening degree indicator 133 can be used to indicate the opening degree of the corresponding valve 30. The opening degree indicator 133 is in the form of 11 LEDs and indicates the opening degree of the corresponding valve 30 in a range from 0% denoted by "close" to 100% denoted by "open" with 10% increments. More specifically, the opening degree indicator 133 is configured such that only one LED that corresponds to the opening degree of the corresponding valve 30 as instructed by the close button 131 or the open button 132 lights up. FIG. 6 shows a state in which the LED that corresponds to the opening degree of 30% is lighted up. Such an opening degree indicating function enables an operator to regulate the flow rates of air in the plurality of straightening chambers 20 while referring to the indications of the opening degrees, and thus allows for improved user-friendliness.

[0047] In the present embodiment, the user interface 130 further has a static pressure indicating function for indicating the result of detection by the corresponding static pressure sensor 90 (that is, the static pressure sensor 90 disposed within the straightening chamber 20 in which the corresponding valve 30 is disposed) on a real-time basis. In the example shown in FIG. 6, the value detected by the corresponding static pressure sensor 90 is indicated numerically by a static pressure indicator 134. Since the flow rate of air in each straightening chamber 20 correlates with the static pressure therein, such static pressure indicating function enables an operator to grasp the flow of air in the corresponding straightening chamber 20 based on the result of detection by the static pressure sensor 90. Therefore, operator can adjust the opening degree of the valve 30 more finely by manipulating the close button 131 and the open button 132 while visually checking the circumstance in the corresponding straightening chamber 20 from the inspection window 60 and also quantitatively grasping the flow of air in the straightening chamber 20 based on the result of detection by the corresponding static pressure sensor 90.

[0048] As shown in FIG. 2, the same number of user interfaces 135 as the valves 31 (that is, two in total, with one for each of the A and B systems) are disposed near the operation panel 200. Each user interface 135 is configured to enable an operation of changing the opening degree of the corresponding valve 31. The user interface 135 has an identical configuration to the user interface 130. The user interface 135 for the A system has an operation function and an opening degree indicating function in relation to the valve 31 disposed in the A-system-dedicated region of the main duct 22 as well as a static pressure indicating function in relation to the static pressure sensor 91 disposed in the A-system-dedicated region. Similarly, the user interface 135 for the B system has the similar functions but in relation to the valve 31 and the static pressure sensor 91 disposed in the B-system-dedicated region. The two user interfaces 135 are disposed at locations corresponding to the two valves 31, respectively. That is, the user interface 135 for the A system is disposed on the A-system's side and the user interface 135 for the B system is disposed on the B-system's side.

[0049] FIG. 5 is a block diagram that shows the schematic framework of the plurality of individual controllers 100 and the operation panel 200. As shown in FIG. 5, the individual controller 100 includes a controller 110, a memory 120, and the user interface 130 described above. Upon receiving an opening degree-setting command for the valve 30 (a command for setting the valve 30 to a predetermined opening degree) from the user interface 130 at the start of operation or during the operation of the purifier 10, the controller 110 sends a control signal to the motor 80 to adjust the opening degree of the valve 30 as instructed by the opening degree-setting command.

[0050] The controller 110 stores, in the memory 120 as operation history information of the purifier 10, the opening degree of the valve 30 set in such a manner. The opening degree of the valve 30 may be acquired from the user interface 130 or may be acquired from the motor 80. Further, the controller 110 receives a detected value of static pressure from the static pressure sensor 90 during the operation of the purifier 10 and stores the value in the memory 120 as operation history information of the purifier 10. In the present embodiment, the opening degree and the detected static pressure value stored in the memory 120 are in the form of time-series data, respectively. Note that, however, a statistical value (e.g., mean value) may alternatively be stored for simplification.

[0051] The controller 110 includes an overcurrent monitor circuit. Upon detecting overcurrent, the circuit sends a predetermined signal to the operation panel 200. Therefore, in a case where the opening degree of the valve 30 fails to be set as instructed by the opening degree-setting command due to clogging of stock or the like, the operation panel 200 can be informed of the issue.

[0052] Although not shown, the individual controller 101 also has identical configuration and functions to the individual controller 100 described above.

[0053] The operation panel 200 includes a controller 210, a memory 220, an operation-and-display part 230, an external storage device 240, and a communication interface 250. In the present embodiment, the operation-and-display part 230 is in the form of a touch-sensitive screen. The operation-and-display part 230 is configured to display a user interface for setting the opening degree of each of the valves 30, 31.

[0054] In response to a opening degree-setting command for each of the valves 30 input by an operator, the controller 210 sends the opening degree-setting command to the corresponding individual controller 100. Each individual controller 100, upon receiving the opening degree-setting command, controls the corresponding motor 80 to adjust the opening degree of the corresponding valve 30 as instructed by the opening degree-setting command. The operation panel 200 is thus configured to manipulate each of the valves 30 by controlling the motors 80 through the individual control devices 100. Similarly, the operation panel 200 is also configured to manipulate each of the valves 31 by controlling the motors 81 through the individual control devices 101. In short, an operator can manipulate the valves 30, 31 either individually through the individual controllers 100, 101, respectively, or collectively through the operation panel

200. Further, by establishing communication between the operation panel 200 and an external device (for example, central operation panel) through the communication interface 250, the motors 80, 81 can also be controlled by the external device through the operation panel 200.

[0055] The operation-and-display part 230 further includes opening degree indicating function for collectively indicating the opening degree of each of the valves 30, 31 and static pressure indicating function for collectively indicating the results of detection by the respective static pressure sensors 90, 91 on a real-time basis. Therefore, an operator can grasp, all at once, the opening degrees of all the valves 30, 31 disposed in the straightening chambers 20 or the main duct 22 as well as the flows of air in all the plurality of the straightening chambers 20 and the main duct 22. This enables an operator to easily find any unsuitable opening degree or flow rate. Therefore, an operator can collectively manipulate the motors 80 with no need for staying in front of the valves 30 (in other words, with no need for facing the user interfaces 130).

[0056] Further, the controller 210 is configured to acquire, from each of the individual controllers 100, the operation history information (that is, the history of the opening degree of the corresponding valve 30 and the history of the detected static pressure value of the corresponding static pressure sensor 90) stored in the memory 120 and store the information into the memory 220. Similarly, the controller 210 is configured to acquire, from each of the two individual controllers 101, the operation history information (that is, the history of the opening degree of the corresponding valve 31 and the history of the detected static pressure value of the corresponding static pressure sensor 91) stored in the memory and store the information into the memory 220. These pieces of operation history information are linked to and stored with identification information of the valves 30, 31.

[0057] Further, the controller 210 is capable of outputting the operation history information stored in the memory 220 to various destinations according to the type of operation on the operation-and-display part 230. For example, the controller 210 may output the operation history information to the operation-and-display part 230. That is, the controller 210 may display the operation history information on the screen. Alternatively, the controller 210 may output the operation history information to the external storage device 240. The external storage device 240 may be any type of removable storage medium (e.g., USB memory, SD card, and the like). Alternatively, the controller 210 may output the operation history information to the communication interface 250. That is, the controller 210 may send the operation history information to other device (for example, central operation panel, personal computer, printing device, and the like) via the communication interface 250. According to these configurations, an operator can cause the operation history information to be output and review its contents so as to be utilized in future operation of the purifier 10. For example, based on a relationship between the operation history information and milling yield (which is separately calculated) in the operation of the purifier 10 from which the operation history information is acquired, the opening degree of each of the valves 30, 31 or the static pressure values in the straightening chambers 20 and the main duct 22 can be reviewed for improvement of milling yield.

[0058] The operation-and-display part 230 may be configured to, in a case where the valves 30, 31 are manually manipulated by an operator by using the user interfaces 130, 135, receive input of identification information (for example, name, or identification number assigned to each operator) of the operator before the start of operation, during the operation, or after the operation of the purifier 10. In this case, the controller 210 may store the identification information of the operator in the memory 120 as a part of the operation history information. That is, the memory 120 may link the history of the opening degree of each of the valves 30, 31 and the history of the detected static pressure value of each of the static pressure sensors 90, 91 to the operator who engages in the operation from which these histories are obtained, and memorize them. This enhances user's convenience when outputting and reviewing of the operation history information.

[0059] Further, the controller 210 may store factor information related to the operation in the memory 120 as a part of the operation history information. That is, the memory 120 may link the history of the opening degree of each of the valves 30, 31 and the history of the detected static pressure value of each of the static pressure sensors 90, 91 to the factor information related to the operation from which these histories are obtained and memorize them. The factor information is information that relates to a factor(s) influential to purification precision.

[0060] The factor information may include the type of processing target. The type of processing target may include at least one of information related to difference in a breed variety and information related to difference in a preceding process. The difference in a breed variety refers to whether stock is hard-type wheat or soft-type wheat, for example. The difference in a preceding process refers to the difference in the number of stages of braking in a process preceding the purification, for example. Further, the factor information may include at least one of the property and the flow rate of processing target. The property of processing target may include at least one of the water content and the range of particle size.

[0061] Further, the factor information may also include feature quantity of the sieving screen of the sieving part 40. The feature quantity of the sieving screen may include the mesh size (which may include at least one of a pattern in which the mesh size changes in a direction in which the processing target flows, and a combination of mesh sizes of equal to or more than two sieving screens layered in the vertical direction). Further, the feature quantity of the mesh may include at least one of frequency of vibration, amplitude of vibration, and an angle of inclination of the mesh. The factor information may further include quality required for the product. The factor information may further include ambient environment at the time of processing. The ambient environment may include at least one of the ambient temperature and the humidity.

[0062] Such factor information may be input by an operator via the operation-and-display part 230. The input may be performed in such a manner that the operation-and-display part 230 displays multiple options on the screen and receives selection of one of the options. Alternatively, the factor information may be automatically acquired by a sensor of the purifier 10. For example, in a case where the factor information includes the ambient temperature and the humidity, the pieces of information may be automatically acquired by a temperature sensor and a humidity sensor, respectively.

[0063] Such factor information can be considered as operation condition influential to purification performance. The desired opening degree of each of the valves 30, 31 or the desired values of static pressure in the straightening chambers 20 and the main duct 22 may vary depending on such an operation condition. Therefore, including the factor information in the operation history information to be output enables the desired opening degree or the desired values of static pressure to be reviewed easily according to the operation condition.

[0064] Further, once an abnormality is detected in any of the individual controllers 100, 101, the controller 210 receives a signal representing the abnormality from the individual controller 100 or 101 and notifies an operator of the abnormality. The abnormality to be notified may be an overload of any of the motors 80, 81. Alternatively, the abnormality to be notified may be that a value detected by at least one of the static pressure sensors 90, 91 is not within a predetermined range. The notification may be in various forms including displaying a sign on the screen of the operation-and-display part 230, beeping out an alarm, putting on a light, and the like. According to such a configuration, in an event that the flow rate in any of the straightening chambers 20 falls outside a suitable range, an operator can notice the event and remove the cause quickly.

[0065] In addition to being manually operable using the user interfaces 130, 135 or the operation-and-display part 230, the purifier 10 is also configured to be automatically operable. The following describes automatic operation of the purifier 10. The purifier 10 is configured to be automatically operable in a first operation mode or a second operation mode.

[0066] The first operation mode is a mode in which the opening degree of each of the valves 30, 31 is determined based on given operation condition. In the first operation mode, the opening degrees of the valves 30, 31 are determined based on first linked information 221 (see FIG. 5) stored in the memory 220 of the operation panel 200. In an alternative embodiment, the first linked information 221 may be acquired from other device through the communication interface 250.

[0067] The first linked information 221 is information in which the factor information described above is linked to opening degree information representing the opening degree of each of the valves 30, 31. The factor information herein may be at least one of the various specific examples described above or any combination thereof. The opening degree information represents the desired opening degree of each of the valves 30, 31 when the factor information linked to the opening degree information is given as an operation condition and the purifier 10 is operated in this operation condition. The desired opening degree of each of the valves 30, 31 may be set as a fixed numerical value or as time-series data that varies with time. The first linked information 221 may be determined experimentally in the stage of purifier fabrication.

[0068] One typical example of the first linked information 221 is a reference table in which the contents of the factor information and the opening degree information are linked to each other and stored. The reference table includes multiple pieces of combined unit data. The combined unit data refers to a type of data in which a piece of opening degree information is assigned to every specific content of the factor information (in a case where there are multiple kinds of factor information, a piece of opening degree information is assigned to every combination of specific contents of the respective kinds of factor information). For example, suppose that there are two kinds of factor information, with one kind of factor information A including specific contents of a1 or a2 and the other kind of factor information B including specific contents of b1 or b2. In this case, four pieces of combined unit data are prepared for four combinations of the specific contents of the respective kinds of the factor information, and are respectively assigned with four pieces of opening degree information, as represented by (Factor information A = a1, Factor information B = b 1, Opening degree information C = c1), (Factor information A = a2, Factor information B = b1, Opening degree information C = c2), (Factor information A = a1, Factor information B = b2, Opening degree information C = c3), and (Factor information A= a2, Factor information B = b2, Opening degree information C = c4). Note that, however, the first linked information 221 is not limited to the form of reference table but may be implemented in any other form. For example, the first linked information 221 may be in the form of a function that takes contents of factor information as its independent variable.

[0069] In a case where the purifier 10 is operated in the first operation mode, the controller 210 of the operation panel 200 first acquires an operation condition regarding the coming operation (hereinafter referred to as new operation). The operation condition acquired here corresponds to the factor information. For example, in a case where the first linked information 221 includes the type and the property of processing target, the controller 210 acquires the type and the property of the processing target used in the new operation.

[0070] The acquirement of the operation condition may alternatively be performed by receiving the operation condition input by an operator's manipulation on the operation-and-display part 230 of the operation panel 200. In this case, the operation-and-display part 230 may display multiple options for each operation condition and receive selection of one of the options. The operation condition may alternatively be acquired automatically from a sensor of the purifier 10, if it is available from such a sensor. Alternatively, the operation condition may be acquired from other device via the communication interface 250.

[0071] Next, the controller 210 determines the opening degree of each of the valves 30, 31 in the new operation based on the acquired operation condition and the first linked information 221. For example, in a case where the first linked information 221 is a reference table, the controller 210 refers to the first linked information 221 and determines the opening degree of each of the valves 30, 31 that is linked to the factor information congruent with the acquired operation condition as the opening degree of each of the valves 30, 31 in the new operation. Then, the controller 210 controls the motors 80, 81 via the individual controllers 100, 101 to adjust each of the valves 30, 31 to the determined opening degree. According to the first operation mode, each of the valves 30, 31 can be set automatically to the opening degree suitable for the operation condition, thus allowing for automatic operation of the purifier 10. Therefore, the flow rates of air in the plurality of straightening chambers 20 can be regulated adequately without relying on the operator's skill. This results in stabilization of purification precision and milling yield.

[0072] The controller 210 may be configured to, upon receiving a command to manipulate one of the valves 30, 31 through the user interface 130, 135 or through the operation-and-display part 230 while the purifier 10 is operated in the first operation mode, change the opening degree of the corresponding valve based on the command. According to this configuration, an operator can correct the valve opening degree as needed, while checking the circumstance in the straightening chamber 20 from the inspection window 60. Further, the purifier 10 can first be operated in a state where each of the valves 30, 31 is roughly set to its suitable opening degree through the first operation mode, and then be finely regulated through manual manipulation. In this case, the opening degrees of the valves 30, 31 can be manually regulated in a shorter time than in the case where the opening degrees need to be manually regulated from scratch.

[0073] In place of or in addition to setting the first linked information 221 experimentally in advance, in a case where a new operation of the purifier 10 is performed through a manipulation using the user interfaces 130, 135, the first linked information 221 may be updated based on the combination of the acquired operation condition described above (that is, the information corresponding to the factor information of the first linked information 221) and the history of the opening degree of each of the valves 30, 31 during the new operation. A command as to whether or not to update the information may be received through the operation-and-display part 230. According to this configuration, the history of the opening degrees of the valves 30, 31 at the time the opening degrees are regulated manually by a skilled operator by using the user interfaces 130, 135 can be recorded, so that such opening degree regulations done by the skilled operator can be reproduced when the purifier 10 is to be operated in an identical or similar operation condition.

[0074] For example, in a case where the first linked information 221 is a reference table, among the first linked information 221 previously stored in the memory 220, the combined unit data in which the factor information having identical contents to the acquired operation condition described above is linked to its corresponding opening degree information may be overwritten with and replaced by the combination described above. That is, the history of the opening degree of each of the valves 30, 31 may become new opening degree information linked to the factor information having identical contents to the acquired operation condition.

[0075] Alternatively, the combined unit data that includes the acquired operation condition as the factor information and the history of the opening degree of each of the valves 30, 31 as the opening degree information may be added to the first linked information 221 as an option available for selection on the operation-and-display part 230.

[0076] According to the first operation mode described above, the valves 30, 31 can be adjusted to the suitable opening degrees (specifically, the opening degrees experimentally set as suitable or the opening degrees that a skilled operator may set) only by simple manipulation such as inputting operation condition into the operation-and-display part 230 or selecting operation condition displayed on the screen of the operation-and-display part 230.

[0077] The second operation mode is a mode in which target static pressure values in the plurality of straightening chambers 20 and the main duct 22 are determined from given operation condition, and the opening degree of each of the valves 30, 31 is controlled based on the target static pressure values and results of detection by the static pressure sensors 90, 91. In the second operation mode, the target static pressure values in the plurality of straightening chambers 20 and the main duct 22 are determined based on second linked information 222 (see FIG. 5) stored in the memory 220 of the operation panel 200. In an alternative embodiment, the second linked information 222 may be acquired from other device through the communication interface 250.

[0078] The second linked information 222 is information in which the factor information described above and the target static pressure value in each of the straightening chambers 20 and the main duct 22 are linked to each other. The factor information herein may be at least one of the various specific examples described above or any combination thereof. The target static pressure value represents the desired value of static pressure in each of the straightening chambers 20 and the main duct 22 when the factor information linked to the target static pressure value is given as an operation condition and the purifier 10 is operated in the operation condition. Since the static pressure correlates with the flow rate as described above, the desired static pressure value can be considered as the desired flow rate. The target static pressure value may be set as a fixed numerical value or as time-series data that varies with time.

[0079] The second linked information 222, in the present embodiment, is a prediction model that takes the factor information as its explanatory variable and the target static pressure value for each of the straightening chambers 20 and the main duct 22 as its object variable. The second linked information 222 can be created by multiple regression analysis, for example. The second linked information 222 may be determined experimentally in the stage of purifier fabrication.

[0080] In a case where the purifier 10 is operated in the second operation mode, the controller 210 of the operation panel 200 first acquires an operation condition regarding the new operation. The operation condition acquired here is information corresponding to the factor information, as in the first operation mode. The operation condition may be acquired in a manner similar to the first operation mode. Next, the controller 210 determines the target static pressure value for each of the straightening chambers 20 and the main duct 22 in the new operation based on the acquired operation condition and the second linked information 222. That is, the controller 210 applies the acquired operation condition to the prediction model to determine the target static pressure value.

[0081] Then, the controller 210 controls the motors 80, 81 through the individual controllers 100, 101 based on the results of detection by the static pressure sensors 90, 91 and the determined target static pressure values and thereby adjusts the opening degree of each of the valves 30, 31. In this procedure, the controller 210 may feedback-control the motors 80, 81 such that the results of detection by the static pressure sensors 90, 91 approach the target static pressure values. Alternatively, the controller 210 may control the motors 80, 81 such that the result of detection by each of the static pressure sensors 90, 91 fall within a predetermined range including the target static pressure value.

[0082] According to the second operation mode, the target static pressure value can be automatically determined for each of the straightening chambers 20 and the main duct 22, thus allowing for automatic operation of the purifier 10 based on the determined target static pressure values. Therefore, the flow rates of air in the plurality of straightening chambers 20 can be regulated adequately without relying on the operator's skill. Moreover, even in a case where the flow rates of air in the straightening chambers 20 and the main duct 22 change due to change of stock property, uneven distribution of stock on the sieving screens 41, 42, and 43, increase or decrease of stock supply, or the like during the operation of the purifier 10, the opening degrees of the valves 30, 31 can be adjusted such that the flow rates of air therein return to the suitable range.

[0083] The controller 210 may update the second linked information 222 based on a combination of the operation condition at the time a new operation of the purifier 10 is performed though a manipulation using the user interfaces 130, 135 (that is, the information corresponding to the factor information of the second linked information 222), and the results of detection by the static pressure sensors 90, 91 during the new operation.

[0084] For example, the controller 210 may be configured to update the second linked information 222 (that is, the prediction model) through learning by artificial intelligence. More specifically, for a new operation in which the opening degrees of the valves 30, 31 are regulated manually by a skilled operator by using the user interfaces 130, 135, a combination of the operation condition (that is, the information corresponding to the factor information) in the new operation, and the results of detection by the static pressure sensors 90 which are acquired during the new operation may be collected as learning data. A command as to whether or not to update the learning data in the new operation may be received through the operation-and-display part 230.

[0085] For each operation done, the controller 210 may receive, through the operation-and-display part 230, at least one actual measured value of an actual measured value of purification precision and an actual measured value of milling yield. In this case, the controller 210 may link operation history information for the operation done and the received at least one actual measured value to each other, store them together into the memory 120, and learn the target static pressure values by which the richest reward can be obtained in the given operation condition (that is, information corresponding to the factor information) by using the received actual measured value of purification precision or milling yield as the reward. Such control using artificial intelligence allows for further improvement of purification performance.

[0086] Similar to the first operation mode, upon receiving a command to manipulate one of the valves 30, 31 through the user interfaces 130, 135 or through the operation-and-display part 230 while the purifier 10 is in automatic operation in the second operation mode, the controller 210 may be configured to change the opening degree of the corresponding valve based on the manipulation command.

[0087] In an alternative embodiment, each of the user interfaces 130, 135 may include a button that allows for switching between automatic operation in the second operation mode and manual operation using the close button 131 and the open button 132. This enables an operator to, while the valves 30, 31 are basically in automatic operation, manually correct only the opening degree(s) of the valve(s) that requires correction among the valves 30, 31 by checking the circumstances within the straightening chambers 20 from the inspection window 60. The configuration successfully reduces burden on an operator.

[0088] In a further alternative embodiment, the second linked information 222 may be a reference table similar to the first linked information 221. In this case, the second linked information 222 may also be updated based on a combination of the operation condition at the time a new operation of the purifier 10 is performed through the manipulation using the user interfaces 130, 135 (that is, information corresponding to the factor information of the second linked information 222), and the results of detection by the static pressure sensors 90, 91 during the new operation. As with the first linked information 221, the updating may be done by overwriting the combined unit data or by adding an option available for selection on the operation-and-display part 230.

[0089] Having described the embodiments of the present invention, the above-described embodiments are intended to only facilitate the understanding of the present invention, and are not intended to limit the present invention thereto. The present invention can be modified or improved without departing from the spirit thereof, and includes equivalents thereof. Further, each of the elements described in the claims and the specification can be combined in any manner or omitted in any manner within a range that allows it to remain capable of achieving at least a part of the above-described objects or bringing about at least a part of the above-described advantageous effects.

[0090] For example, the individual controllers 100, 101 may be omitted. In this case, the user interfaces 130, 135 may be connected directly to the operation panel 200, and the operation panel 200 may directly control the motors 80, 81. Alternatively, only the motors 80 but not the motors 81, of the motors 80, 81, may be controlled in the first or second mode.

DESCRIPTION OF THE REFERENCE NUMERALS

[0091] 10: purifier, 15: feed port, 20: straightening chamber, 21: straightening plate, 22: main duct, 30: air flow regulating valve for straightening chamber, 31: air flow regulating valve for main duct, 40: sieving part, 41, 42, 43: sieving screen, 44: vibration generator, 51, 53: collecting gutter, 52, 54: discharge port, 55: discharge gutter, 56: discharge port, 60: inspection window, 80, 81: motor, 90, 91: static pressure sensor, 100, 101: individual controller, 110: controller, 120: memory, 130: user interface, 131: close button, 132: open button, 133: opening degree indicator, 134: static pressure indicator, 135: user interface, 200: operation panel, 210: controller, 220: memory, 221: first linked information, 222: second linked information, 230: operation-and-display part, 240: external storage device, 250: communication interface.

Claims

1. A purifier comprising:

   a sieving part including a sieving screen and configured to sift a processing target while carrying the processing target on the sieving screen in a predetermined direction;
   a plurality of straightening chambers disposed above the sieving part and in communication with interior of the sieving part, and separated from each other so as to be lined up in the predetermined direction;
   a plurality of air flow regulating valves respectively provided in the plurality of straightening chambers, each of the plurality of air flow regulating valves being configured to regulate flow rate of air passing through the sieving screen and flowing upward in the corresponding straightening chamber;
   a plurality of motors configured to respectively drive the plurality of air flow regulating valves to control opening degrees of the plurality of air flow regulating valves; and
   a controller configured to control the plurality of motors.

2. The purifier according to claim 1, further comprising an inspection window from which interior of each of the plurality of straightening chambers is viewable, wherein the controller includes a plurality of user interfaces arranged near the inspection window at locations respectively corresponding to the plurality of air flow regulating valves, each of the plurality of user interfaces being configured to be operable to change the opening degree of the corresponding air flow regulating valve.

3. The purifier according to claim 2, wherein the controller includes a plurality of individual controllers configured to respectively control the plurality of motors, and
   the plurality of individual controllers include the plurality of user interfaces, respectively.

4. The purifier according to any one of claims 1 to 3, wherein the controller includes an operation panel configured to enable an operator to set the opening degree of each of the plurality of air flow regulating valves by controlling each of the plurality of motors.

5. The purifier according to any one of claims 1 to 4, wherein the controller is configured to be operable in a first operation mode;

the controller is configured to, in the first operation mode,:

acquire first linked information in which factor information related to a factor influential to purification precision is linked to opening degree information representing the opening degree of each of the plurality of air flow regulating valves;
when a new operation of the purifier is performed, acquire information corresponding to the factor information serving as an operation condition of the new operation; and
determine the opening degree of each of the plurality of air flow regulating valves in the new operation based on the first linked information and the acquired information corresponding to the factor information.

6. The purifier according to claim 5 at least dependent from claim 2, wherein the controller is configured to, in a case where the new operation of the purifier is performed through a manipulation using the user interfaces, update the first linked information based on a combination of the information corresponding to the factor information which is acquired in relation to the new operation, and history of the opening degree of each of the plurality of flow regulating valves during the new operation.

7. The purifier according to any one of claims 1 to 6, wherein the controller is configured to output operation history information of the purifier that includes the opening degree of each of the plurality of air flow regulating valves.

8. The purifier according to any one of claims 1 to 7, further comprising a plurality of static pressure sensors respectively disposed within the plurality of straightening chambers,
wherein each of the plurality of static pressure sensors is configured to detect static pressure in the corresponding straightening chamber.

9. The purifier according to claim 8, wherein the controller is configured to be indicate results of detection by the plurality of static pressure sensors on a realtime basis.

10. The purifier according to claim 8 or 9, wherein the controller is configured to be operable in a second operation mode in which operations of the plurality of motors are automatically controlled based on the results of detection by the plurality of static pressure sensors and a target static pressure value individually set for each of the plurality of straightening chambers.

11. The purifier according to claim 10, wherein the controller is configured to, in the second operation mode, :

acquire second linked information in which factor information related to a factor influential to purification precision is linked to the target static pressure value;
when a new operation of the purifier is performed, acquire information corresponding to the factor information serving as an operation condition of the new operation; and
determine the target static pressure value in the new operation based on the second linked information and the acquired information corresponding to the factor information.

12. The purifier according to claim 11 at least dependent from claim 2, wherein the controller is configured to, in a case where the new operation of the purifier is performed though a manipulation using the user interfaces, update the second linked information based on a combination of the information corresponding to the factor information which is acquired in relation to the new operation, and the results of detection by the plurality of static pressure sensors which are acquired during the new operation.

13. The purifier according to claim 12, wherein the second linked information is a prediction model that takes the factor information as its explanatory variable and the target static pressure value as its object variable, and
the controller is configured to update the prediction model through learning by artificial intelligence.

14. The purifier according to any one of claims 8 to 13, wherein the controller is configured to output operation history information of the purifier that includes the results of detection by the plurality of static pressure sensors.

FIG. 1

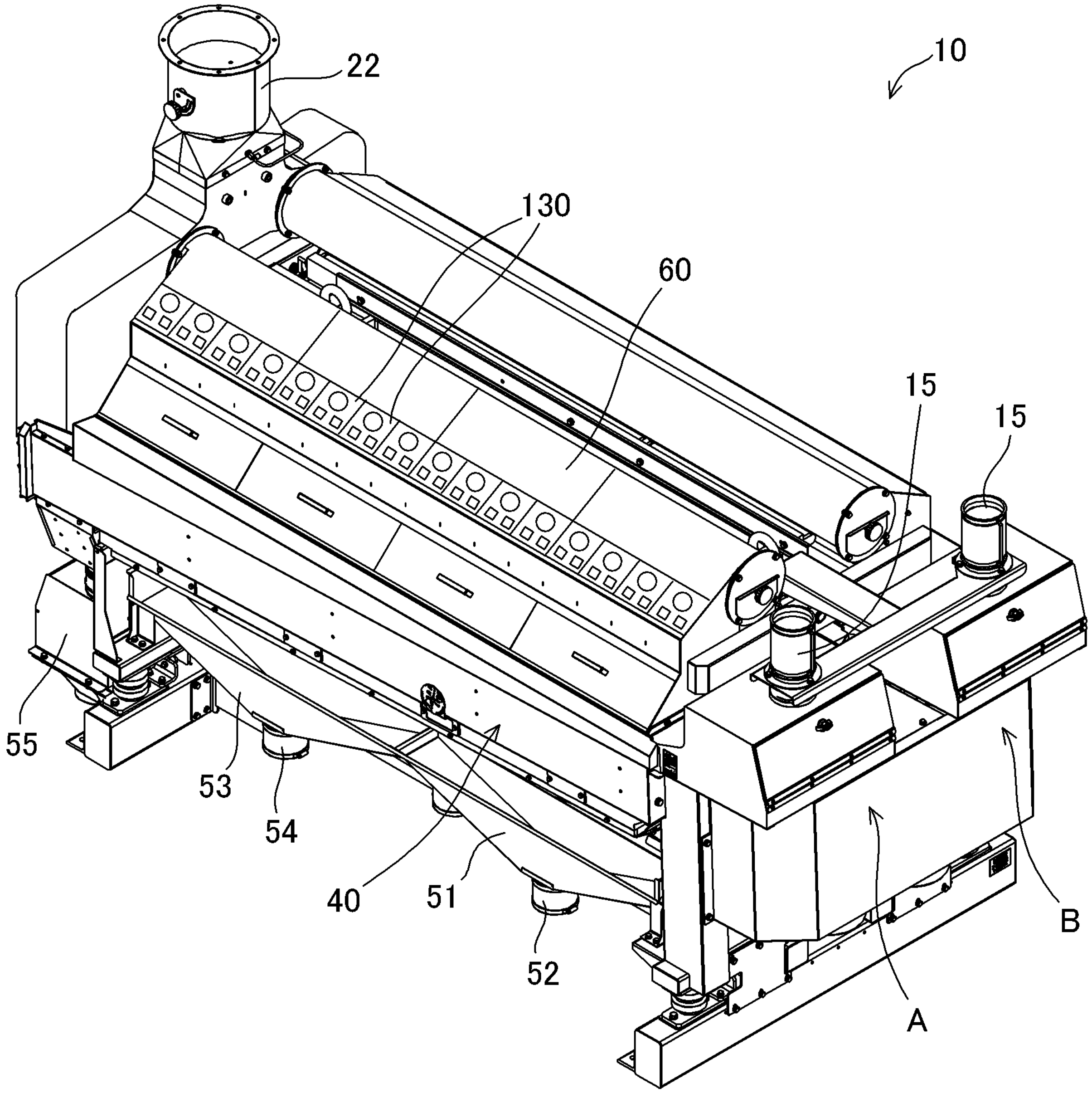


FIG. 2

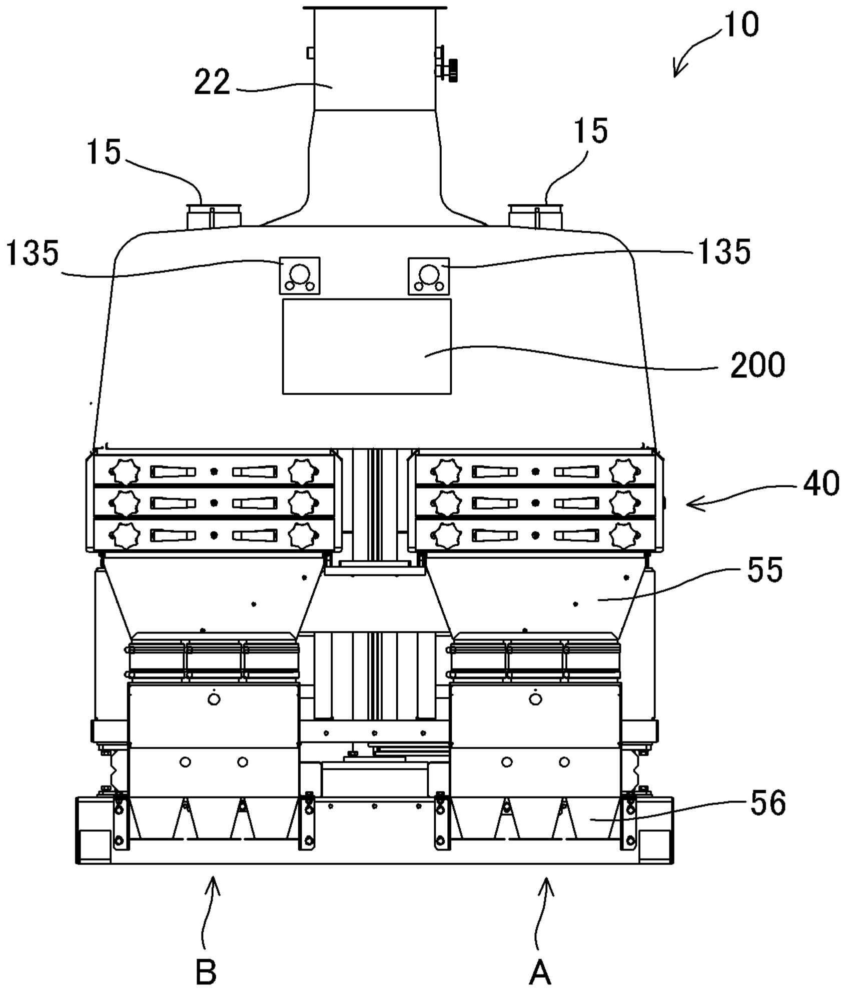


FIG. 3

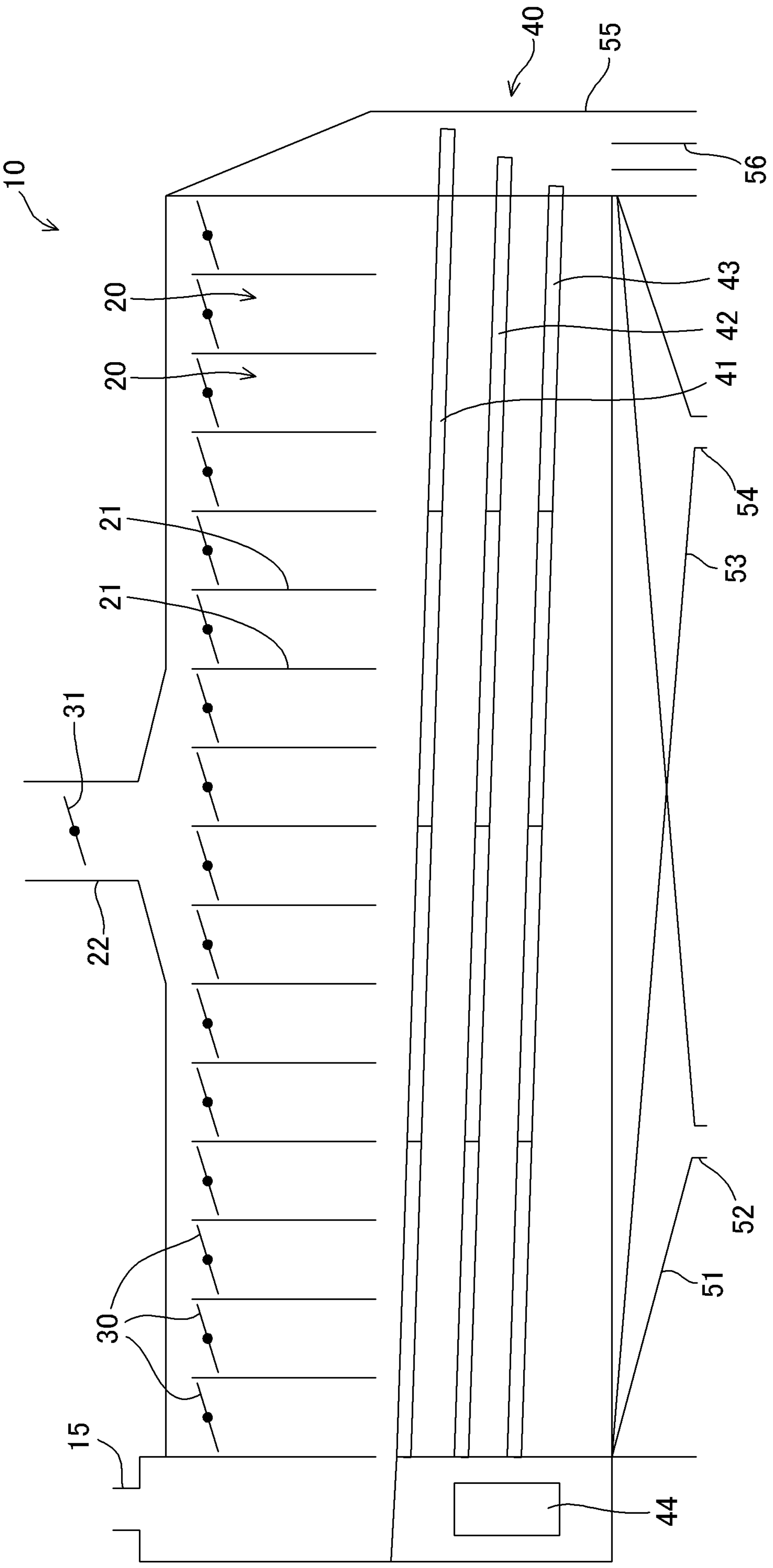
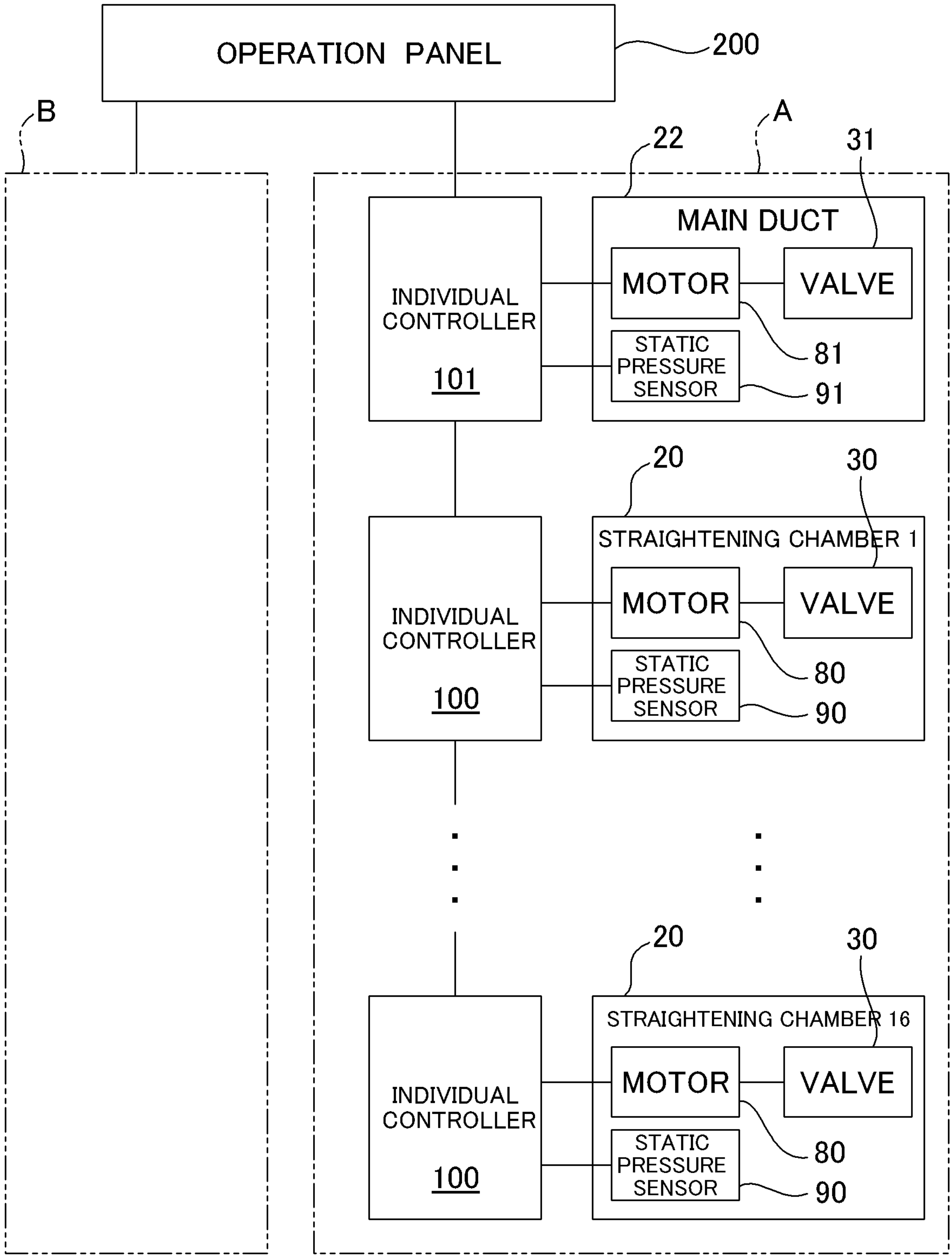


FIG. 4



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101
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STATIC PRESSURE SENSOR
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91
20
30
STRAIGHTENING CHAMBER 1
INDIVIDUAL CONTROLLER
100
MOTOR
VALVE
STATIC PRESSURE SENSOR
80
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STRAIGHTENING CHAMBER 16
INDIVIDUAL CONTROLLER
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MOTOR
VALVE
STATIC PRESSURE SENSOR
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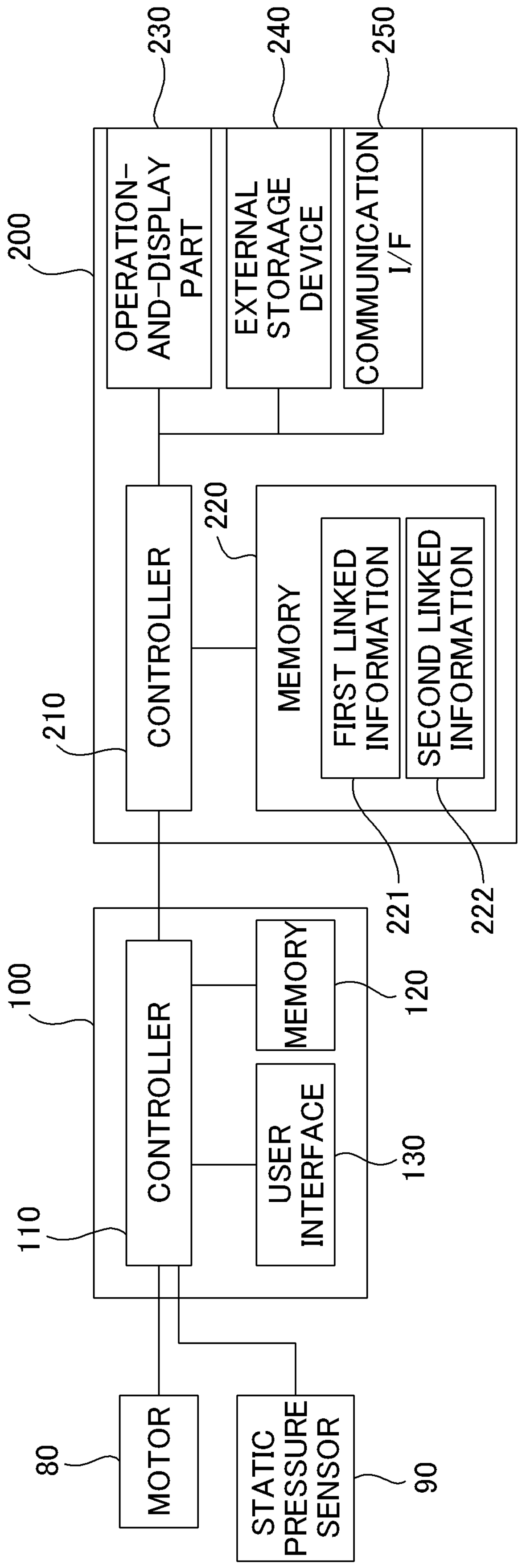
90

FIG. 5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CONTROLLER
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MEMORY
FIRST LINKED INFORMATION
SECOND LINKED INFORMATION
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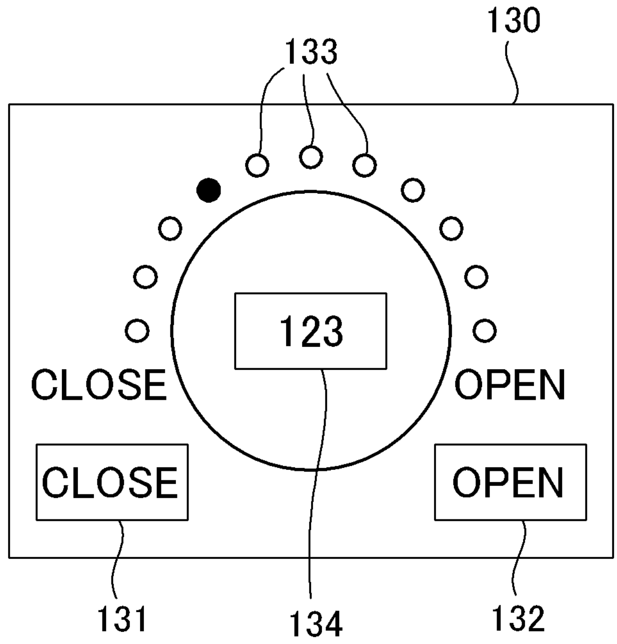
222
100
110
CONTROLLER
MEMORY
120
USER INTERFACE
130
80
MOTOR
STATIC PRESSURE SENSOR
90

FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/027835

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. B07B4/08(2006.01)i, B07B11/04(2006.01)i
FI: B07B4/08 Z, B07B11/04

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)
Int. Cl. B07B4/08, B07B11/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 8-39002 A (SATAKE ENGINEERING CO., LTD.) 13 February 1996 (1996-02-13), claims, examples, fig. 1-6	1-4, 8-9 5-7, 10-14
Y A	JP 2004-181442 A (MEIJI MACHINE CO., LTD.) 02 July 2004 (2004-07-02), claims, paragraphs [0026], [0027], [0035]-[0037], fig. 1-5	1, 4, 8-9 2-3, 5-7, 10-14
Y A	JP 57-153774 A (GEBRUDER BUHLER AG) 22 September 1982 (1982-09-22), claims, fig. 1-12	1, 4, 8-9 2-3, 5-7, 10-14
Y A	JP 11-235553 A (SATAKE ENGINEERING CO., LTD.) 31 August 1999 (1999-08-31), claims, paragraphs [0027]-[0029], [0035], fig. 1, 2	1-4, 8-9 5-7, 10-14

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
09.09.2021	21.09.2021

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/027835

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2001-327923 A (YANMAR DIESEL ENGINE CO., LTD.) 27 November 2001 (2001-11-27), claims, paragraph [0004]	8-9 1-7, 10-14
A	JP 2010-253371 A (NISSHIN FLOUR MILLING INC.) 11 November 2010 (2010-11-11), entire text, all drawings	1-14
A	JP 2006-153372 A (ISEKI & CO., LTD.) 15 June 2006 (2006-06-15), entire text, all drawings	1-14

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/027835

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 8-39002 A	13.02.1996	(Family: none)	
JP 2004-181442 A	02.07.2004	(Family: none)	
JP 57-153774 A	22.09.1982	US 4466542 A fig. 1-12, claims EP 159050 A1 EP 58778 A2 DE 3148475 A	
JP 11-235553 A	31.08.1999	(Family: none)	
JP 2001-327923 A	27.11.2001	(Family: none)	
JP 2010-253371 A	11.11.2010	(Family: none)	
JP 2006-153372 A	15.06.2006	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H0839002 A **[0006]**