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(54) Method and apparatus for cleaning the inside of a pipe.

(57) The invention discloses a method for cleaning a pipe (4) in the inside comprising steps of inserting a pig (6) into a pipe (4), and reciprocally moving the pig (6) thereafter by aerial vibration to clean the inside of pipe (4). An apparatus for cleaning a pipe (4) in the inside comprises a pig (6) removably inserted into a pipe (4) from an end side thereof and a vibration generating source (8) for transferring the pig (6) in reciprocal motion by means of aerial motion to clean the inside of pipe (4).

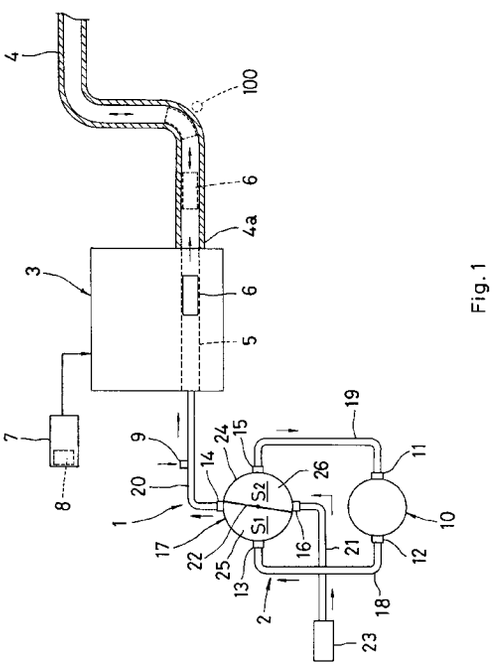

Fig. 1

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BACKGROUND OF THE INVENTION

Field of the Invention

The present Invention relates to a method and apparatus for cleaning inside of a pipe used in pneumatic transportation systems, dryers, dehumidifiers and many other fields, in particular, cleaning in place.

Prior Art

Conventionally, such method of inserting a brush with a brush body attached to a leading end of elongated member such as a wire, and cleaning inside of a pipe by manually sliding the brush with supply water is widely known as a method for cleaning inside of a pipe.

In the case of cleaning inside of a pipe by the conventional brushing method, particularly when multiple short pipes are connected by means of such detachable mechanism as flange joint, short pipes (pipes) required for cleaning have been removed by releasing the detachable mechanism, transported to a cleaning station, then, manually cleaned in the inside thereof by the brush prepared separately, and reassembled again as they were, after they have been dried.

Thus, the conventional brushing method has the following problems:

1. In either case that a pipe comprises a single pipe or a combination of two or more short pipes, because the inside of pipe is cleaned manually by sliding a brush, not only the cleaning operation has been laborsome and time-consuming, but also it has been difficult to uniformly clean the pipe (short pipe) in the inside, and cleaning effect has been insufficient. In addition, there has been such problem that the pipe must be transported to a pipe cleaning station, and the transporting operation is troublesome.
2. Specifically, in the case of a pipe comprising a combination of two or more short pipes, since operations of disassembling, cleaning, drying and assembling pipes to be cleaned must be performed totally manually, the cleaning operation has been troublesome and time-consuming.
3. Because many of pipes (short pipes) to be cleaned are mounted in a high location, the disassembling and assembling operations have been risky.
4. As pipes are cleaned by using water as well as a brush, a dryer for removing the water is required, and there has been a problem of high equipment cost.
5. When cleaning the pipe in the assembled state without disassembling, it was difficult to remove the remainder of transportation protective materials clogged in the pipe joints or moisture.

SUMMARY OF THE INVENTION

(1) It is one of the objects of the invention to present a method of cleaning the inside of a pipe, in which, because the pig is reciprocally moved by aerial vibration to clean a pipe in the inside after it is inserted from an end side of the pipe, the inside of pipe assembled into a pneumatic transportation system or the like can be automatically cleaned in the assembled state without being disassembled, labor and time required for cleaning operation can be reduced, in comparison with prior art, cleaning effect is increased, because the cleaning can be performed uniformly and efficiently, and safety in the cleaning operation is ensured, as operations at a high level is eliminated.
(2) It is other object of the invention to present a method of cleaning the inside of a pipe, which comprises the wetting or solution cleaning step, pig inserting step and pig cleaning step, and therefore since the pipe is cleaned in the inside by transferring the pig in reciprocal motion by aerial vibration, the same effects as that of (1) above are provided.

In such case, by providing the wetting step as in claims 2, 11, deposits adhered to the inside wall of pipe are loosened, and can be more easily cleaned in the succeeding step. In this operation, the deposits are removed even more efficiently by bubbling the cleaning solution supplied by aerodynamic force of the air source, as defined in claim 12.
(3) According to a different object of the invention to present a method of cleaning the inside of a pipe, in the wet cleaning methods of claims 2, 4 and 11, as the pig contracting step for contracting the pig (claims 3, 5 and 11) is added, when water is absorbed by the pig in the pig cleaning and other steps, the water contained in the pig can be removed.

Also, in this case, as specified in claims 6, 11, since the rinsing step is added after the pig cleaning step, deposits remaining in the pipe can be discharged out of the system. In the rinsing step, the deposits within the pipeline can be even more effectively discharged by bubbling the cleaning solution supplied by aerodynamic force from the air source, as defined in claim 12.

Moreover, in such case, as shown in claims 7, 11, the inside wall of pipe that is wet-cleaned can be efficiently dried, because the water droplet removing step is performed after completion of the rinsing step, that is, the dewatered pig is inserted into the pipe, and reciprocally moved in the pipeline by means of aerial vibration, thus, water droplets adhered to the inside wall of pipe is absorbed and removed by the pig.
(4) In another object of the invention, the meth-

ods of the invention according to claims 8 to 10 and 11 assures complete drying of the inside wall of pipe, regardless of dry or wet method, as the drying step for drying the inside of pipe is provided as a final step.

In such case, as described in claims 13, 14, not only the inside wall can be dried approximately at an ordinary temperature without an exclusive heater, but saving of thermal energy is achieved by utilizing aerial vibration wave for transferring the pig in reciprocal motion and waste heat from the air source that constitute the vibration generating source for generating the aerial vibration wave in the drying step.

(5) It is a further different object of the invention to present an apparatus for cleaning the inside of a pipe as defined in claims 15 to 37, so that the methods of the invention can be efficiently conducted.

In other words, the apparatuses of the invention are provided with a vibration generating source for aerial vibration to achieve the pig cleaning step, wetting means for achieving the wetting step, pig contracting means for carrying out the pig contracting step, solution cleaning means for effecting the solution cleaning step, rinsing means for performing the rinsing step, water droplet removing means for carrying out the water droplet removing step and drying means for achieving the drying step.

In particular, according to the invention of claim 15, the pig in the pipe to be cleaned is moved reciprocally by air vibration, and therefore the inside of the piping is cleaned by the sliding pig, and at the same time the vaporization action if activated by the air vibration to obtain a drying effect. Furthermore, the remaining transportation protective materials, dust, moisture, and water drops.clogged in the piping joints can be sucked out and removed by the supplied air vibration, so that cleaning and drying of all piping parts can be achieved at the same time.

Moreover, according to the invention of claim 16, air inlet and outlet are provided in the vibration source, and the pig can be transferred while moving reciprocally, and therefore the entire pipe can be cleaned by reciprocating the pig in small strokes, so that it is easy to handle because large strokes over the entire length of pipe are not needed. Still more, by moving to a desired position, that position can be cleaned particularly, and arbitrary cleaning is realized.

(6) Moreover, in a different object of the invention to present an apparatus for cleaning the inside of a pipe, because a position sensor is provided corresponding to points in the pipe where dirts tend to be accumulated, and a signal transmitted from the position sensor is received by a controller so that the number of reciprocal movements of the pig and waveform of aerial vibration can be adjusted in the vicinity of the position sensor on the basis of the signal received by the controller, the points in the pipe where dirts tend to be accumulated can be cleaned thoroughly, and uniform cleaning effect can be obtained.

(7) Furthermore, in a still different object of the invention to present an apparatus for cleaning the inside of a pipe, since the pig forms a spiral slit groove in the outer surface thereof in the longitudinal direction of a columnar body, and rotated by passing air from the air source through the slit groove, the inside wall of the pipe can be cleaned by the pig in rotation, and the entire circumference of the inside wall of pipe is thoroughly cleaned, thereby, the cleaning effect is further increased.

Incidentally, when the pipe is composed as in claim 31, the water sealing effect of the joint part of the pipe is excellent, and if there is water leak between the sleeve and the tubular joint, the water leak can be sucked into the conduit by the air vibration waves.

Other objects, features and benefits of the invention will be better understood and appreciated in the following description.

In order to achieve the objects, the invention presents a method for cleaning a pipe, according to claim 1, by rendering reciprocal motion of a pig by means of aerial vibration after inserting the pig into the pipe to clean the inside thereof. In other words, the embodiment of the invention is a dry cleaning method comprising steps of inserting a pig into a pipe, and cleaning the inside thereof by rendering reciprocal motion of the pig by means of aerial vibration.

In the method of the invention according to claim 2, the wet cleaning method comprises a wetting step for moistening inside of the pipe, a pig insertion step for inserting the pig into the pipe, and a pig cleaning step for cleaning the inside of a pipe by transferring the pig while moving reciprocally by air vibration. In this wet cleaning method, when the pig adsorbs moisture, a pig squeezing step is provided for squeezing the pig in order to remove moisture from the pig (see claim 3).

A method according to claim 4 of the invention is a solution cleaning method comprising steps of cleaning inside of a pipe with a cleaning solution, inserting a pig into the pipe, and cleaning the inside thereof by transferring the pig in reciprocal motion by means of aerial vibration. In the case of the solution cleaning method, a pig contracting step is added, when the pig contains water absorbed in it (as shown in claim 5).

When the pig cleaning step is performed, it is preferable to conduct a rinsing step after completion of the pig cleaning step (as defined in claim 6). It is preferred to conduct a water droplet removing step for re-

moving water droplets in the pipe after completion of the rinsing step (claim 7).

A method according to claim 8 or 10 of the invention is provided with a drying step for drying inside of a pipe as a final step in the method of claim 1 or 7 of the invention.

As described above, the invention presents such methods of dry cleaning a pipe in the inside by using a pig, wet cleaning by the pig, cleaning by the pig after cleaning with a solution, rinsing after cleaning by the pig, and removing water droplets adhered to inside wall of the pipe, or an appropriate combination of them, for example, by adding a drying step thereto.

In addition, as a method according to claim 11 of the invention, for example, wetting, pig inserting, pig cleaning for cleaning with the pig while feeding cleaning solution, pig contracting, rinsing, water droplet removing and drying steps can be performed. In this case, in the wetting and rinsing steps, it is preferable that a cleaning solution supplied is bubbled by means of aerodynamic force from an air source (claim 12). Moreover, in the drying step, a vibratory wave of air for transferring the pig in reciprocal motion and waste heat from the air source that constitutes a source for generating the vibratory wave of air used for pig cleaning are preferably utilized, thereby eliminating an exclusive heater, allowing efficient drying at ordinary temperature, and contributing reduction of energy consumption (claims 13, 14).

According to claims 15 to 26, the invention relates to an apparatus for cleaning a pipe in the inside for conducting the methods of the invention.

An apparatus according to claim 15 of the invention comprises a pig removably inserted from an end side of pipe and a vibration generating source for cleaning inside of the pipe by transferring the pig in reciprocal motion by means of aerial vibration. In this case, a dry cleaning apparatus is provided. As in claim 16, air inlet and outlet are provided in the vibration source, and the pig moving reciprocally in the pipe to be cleaned can be moved freely in the upstream direction or downstream direction by injection or suction of air from the air inlet and outlet, so that the pig may be transferred while moving reciprocally.

An apparatus according to claim 17 of the invention is provided with wetting means such as water supply and drainage system for wetting inside of a pipe in addition to the pig and vibration generating source of claim 15, and an apparatus according to claim 17 of the invention is provided with pig contracting means additionally to the pig and vibration generating source. In such cases, a wet cleaning apparatus is provided.

An apparatus according to claim 19 of the invention is provided with solution cleaning means for cleaning inside of a pipe with a cleaning solution in addition to the pig and vibration generating source of claim 15, and an apparatus according to claim 19 of the invention is provided with pig contracting means, additionally to the pig, vibration generating source and solution cleaning means, for contracting the pig. In such cases, an arrangement for cleaning with a pig after solution cleaning is provided.

According to claim 23, the invention provides apparatuses of claims 17 to 22 having rinsing means. In such cases, it is preferable that the apparatus has water droplet removing means for removing water droplets adhered to inside wall of a pipe (including means for finely breaking such water droplets, as used in the present specification) (claim 25).

An apparatus according to claim 27 of the invention is provided with drying means for drying inside of a pipe as a final step in an apparatus of claims 15 to 25 of the invention. As the drying means, it is preferred to dry the inner wall of the pipe by the air flow from the air source as the vibration source used in the pig cleaning. By drying inside of a pipe in a final step of cleaning, a pipe ready for use in a succeeding step can be obtained.

An apparatus of claim 29 of the invention is provided with a position sensor corresponding to points in a pipe where dirts tend to be accumulated in an apparatus according to claims 15 to 28 of the invention, and structured such that a signal transmitted by the position sensor is received by a controller, and the number of reciprocal motions of the pig and waveform of aerial vibration can be adjusted in the vicinity of the position sensor on the basis of the signal received by the controller. In such manner, points in a pipe where dirts tend to be accumulated can be thoroughly cleaned, and a uniform cleaning effect is obtained.

In claim 30, the invention presents an apparatus according to claims 15 to 29, wherein the pig forms a spiral slit groove 6 in an outer surface in longitudinal direction of a columnar member, and are rotated by passing air from the air source in the slit groove. Consequently, the pipe can be more uniformly and evenly cleaned, and cleaning effect can be further enhanced. Although any material can be used for the pig, those having a superior chemical resistance and resiliency for not damaging a body to be cleaned, and being superior in hydrophilic property and wear resistance such as polyvinyl alcohol, pulp and urethane rubber (elastomer) are preferred.

According to a method of the invention, both in dry and wet type, the pig is inserted in the pipe to be cleaned and then air vibration is supplied into the pipe, and therefore the pig is moved reciprocally by the vibrating air, and at the same time the degree of air-liquid contact is enhanced in the pipe, and the vaporization of the liquid is activated. Thus, in the pipe, the pig moves reciprocally, and the cleaning of the inside of the pipe by its sliding action and drying by promotion of vaporization by vibration are progressed simultaneously. That is, when using air vibration, both effects of cleaning and drying are brought about at

the same time. Therefore, separate dryer or conventional brush is not needed, and moreover by properly changing the waveform and frequency of aerial vibration, the pig reciprocal stroke and number of reciprocal motions can be adjusted, and an efficient cleaning depending on the dirtiness of the pipe is achieved.

In the case of wet cleaning method, since a wetting step for applying moisture in a pipe is provided, deposits adhered to the inside wall thereof can be thereby loosened, and cleaning in the succeeding step is further facilitated. In this case, it is preferable that a cleaning solution supplied is bubbled by aerodynamic force of an air source.

In addition, as a step for contracting the pig is provided, when water is absorbed in the pig during the pig cleaning step and the like, the water contained in the pig is removed.

Because of a rinsing step provided after completion of the pig cleaning step, deposits remaining in the pipe is washed out by the rinsing solution. In the rinsing step, it is preferable to bubble the solution supplied by aerodynamic force from an air source.

Since a water droplet removing step is provided after completion of the rinsing step, a pig without water content is inserted into the pipe and reciprocally moved by means of aerial vibration within the tubular path, and water droplets adhered to the inside wall of pipe are absorbed and removed by the pig.

As a drying step for drying inside of a pipe is provided in the method of the invention, regardless of dry or wet type, inside wall of a pipe is surely dried.

In this case, it is preferable to utilize the air stream from the air source as the vibration source used in pig cleaning in the drying step.

With an apparatus of the invention provided with vibration generating source, wetting means, pig contracting means, solution cleaning means, rinsing means, water droplet removing means and drying means, above method can be efficiently performed.

In an apparatus of the invention, because a position sensor is provided corresponding to points in a pipe where dirts tend to be accumulated, a signal transmitted by the position sensor is received by a controller, and the number of reciprocal motion of the pig and waveform of aerial vibration can be adjusted in the vicinity of the position sensor based on the signal received by the controller, such points in the pipe where dirts tend to be accumulated are thoroughly cleaned.

Moreover, in the apparatus of the invention, since the pig forms a spiral slit groove in an outer surface in the longitudinal direction of a columnar body, and rotated by passing air from an air source in the slit groove, the pig rotates and cleans inside wall of a pipe, the entire circumference of inside wall of the pipe can be cleaned, and cleaning effect is further increased.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic view showing a part of embodiment 1 of an apparatus of the invention in section.

Figure 2 is a schematic process diagram showing operation of a vibration generating source.

Figure 3 is a process diagram with a valve member rotated at a predetermined angle from Figure 2.

Figure 4 is a process diagram with the valve member further rotated at a predetermined angle from Figure 3.

Figure 5 is a process diagram with the valve member further rotated at a predetermined angle from Figure 4.

Figure 6 is a waveform chart.

Figure 7 is a flow chart of embodiment 1.

Figure 8 is a schematic view of embodiment 2 of an apparatus of the invention with a valve member at an original position.

Figure 9 is a schematic view with the valve member rotated at a certain angle from the original position of Figure 8

Figure 10 is a plan view showing the vicinity of pig contracting means.

Figure 11 is a front view of Figure 10.

Figure 12 is a sectional view along line A-A of Figure 11.

Figure 13 is a left side view of Figure 11.

Figure 14 is a flow chart of embodiment 2.

Figure 15 is a schematic view of embodiment 3 of an apparatus of the invention.

Figure 16 is a schematic view of embodiment 4 of an apparatus of the invention.

Figure 17 is a part of another flow chart of a method of the invention.

Figure 18 is the rest of another flow chart of the method of the invention.

Figure 19 is a perspective view of a modified example of pig.

Figure 20 is a sectional view of a pipe joint.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figs. 1 to 7 showing an apparatus of the invention, embodiment 1 is described as well as a method of the invention.

Fig. 1 is a schematic view showing a partial section of a dry cleaning apparatus 1 of the invention for cleaning a pipe in the inside, Figs. 2 to 5 show an airflow vibrated and reciprocal motion of a pig, when a directional control valve 17 from 0 to 270 deg. in a vibration generating source 2. Fig. 6 is a waveform diagram showing changes of air flow vibrated by one rotation of the directional control valve 17 from Fig. 2 through Figs. 3, 4 and 5 to the original position of Fig. 2. Fig. 7 shows a step diagram of the embodiment.

In Fig. 1, numeral 3 shows a main body of clean-

ing apparatus, a pig inserting tube 5 is employed in the main body 3 of the cleaning apparatus, and a pig 6 is removably inserted into the pig inserting tube 5 beforehand. The pig inserting tube 5 is connected to an end 4a of pipe 4 to be cleaned in one end, while the vibration generating source 2 in the other end. The end 4a of pipe 4 is air-tightly connected in communication with a conduit 20 of the vibration generating source 2 through the pig inserting tube 5. Insertion and removal of pig 6 in the main body 3 may alternatively achieved by arranging the pig inserting tube in T shape or any other arrangement.

The vibration generating source 2 is provided for the purpose of transferring the pig 6 in reciprocal movement by means of aerial vibration to clean the inside of pipe 4. Since the vibration generating source 2 is based on the same principle as an aerial vibration generating apparatus disclosed in Japan Patent Application No. 4-90406 filed by the inventor and an application thereof, refer to the specification and drawings. However, it is desirable that the vibration generating source 2 provides an aerial vibration (sound wave) of low or medium frequency.

The vibration generating source 2 comprises, as shown in Figs. 1 to 5, an air source 10 with an inlet 11 and/or outlet 12, a directional control valve 17 having four or more ports 13, 14, 15, 16 ..., a driving source (not shown) such as a motor for driving the directional control valve 17, a discharge pipe 18 and intake pipe 19 for respectively connecting the air source 10 and directional control valve 17, a conduit 20 for connecting the port 14 and the pig inserting tube 5, and a conduit 21 for connecting a filter 23 and the port 16. In the leading end of conduit 20 in connection with the port 14, the main body 3 of cleaning apparatus is connected, air supplied by the air source 10 is vibrated by directionally controlling a valve member 22 housed in a casing 24 of the directional control valve 17 by means of an inverter 8, then, the pig 6 is aerially vibrated by sound wave effect due to the vibration, and transported in reciprocal motion in the advancing direction, and the pipe 4 is cleaned in the inside. In this case, by providing a pressurized air inlet pipe 9 in the upstream of the pig 6 in the conduit 20 or pig inserting tube 5, and supplying pressurized air through the pressurized air inlet pipe 9, pressure in the upstream (trailing end side) of pig 6 comes to be higher than that of the downstream (leading end side), and the pig 6 can be, accordingly, more easily transferred to the downstream side. In addition, a line of outside air inlet pipe 32 shown in Fig. 8 may be employed in place of the pressurized air inlet pipe 9.

In this embodiment, the vibration generating source 2 is adapted to be capable of providing a sound wave of low or medium frequency band as an aerial vibration and changing the waveform of a pulse wave, sine wave and the like. Waveform of the aerial vibration is changed in accordance to the vibration frequency or frequency, amplitude, cyclic period and the like. As a method of changing the waveform of aerial vibration, the rotating speed of valve member 22 of the directional control valve 17, mounting angle of the valve member 22 in valve chests 25, 26, angle of rotation of the valve member 22, sectional open area of at least one or more ports or sectional shape of the casing 24, or mounting angle of the ports in the directional control valve 17 may be changed, or other various methods may be adopted.

According to an experimental example, the stroke of reciprocal motion of the pig 6 is increased by reducing the frequency of vibration generating source 2, while the stroke of reciprocal motion of the pig 6 is reduced by increasing the frequency. For example, the former was effected at a frequency of 1 Hz, and the latter at 8 Hz. The figures are not limiting.

Thus, according to a method of the invention shown in claim 1, the pig 6 is firstly inserted into the pipe 4. For inserting the pig 6 into the pipe 4, as described above, the main body 3 of cleaning apparatus with the pig 6 pre-inserted into the pig inserting tube 5 may be connected with the pipe 4 so that the pig can be transferred by means of aerial vibration from the vibration generating source 2, the pipe 4 may be connected with the main body 3 after the pig 6 is inserted manually to the inlet side of pipe 4, or other methods may be employed. The air is, then, vibrated by the vibration generating source 2, the pig 6 is transferred in reciprocal motion by means of this vibrational energy, and the inside of pipe 4 is cleaned.

For the air source 10, such as ring blower, Roots blower and vacuum pump may be selected arbitrarily, as far as it has either one or both of inlet 11 and outlet 12.

For the directional control valve 17, although a rotary valve comprising a columnar casing 24 with four or more ports 13, 14, 15, 16 ... and a valve member 22 of moving vane type housed in the casing 24 for rotation by a driving source and sectioning it into two valve chests 25, 26 is preferable, other type of valve such as ball valve may be used.

The two valve chests 25, 26 sectioned by the valve member 22 may be identical in their respective total passage volumes S1, S2, as shown in the embodiment, in such case, the waveform of aerial vibration shows a simple waveform as sine curve a shown in Fig. 6, as far as conditions such as rotating speed of the directional control valve 17 are same. In other words, the waveform is identical in frequency, amplitude and cyclic period.

When the valve chests are formed in such manner that the total passage volumes S1, S2 comes to be different, by changing the cycle of inlet and outlet by means of the directional control valve 17, and changing the frequency, amplitude and cyclic period of aerial vibration as desired, as shown by b and g, the waveform can be arbitrarily changed from a.

As described, the waveform of aerial vibration is changed by rotating the valve member 22 in the directional control valve 17 between normal and reverse directions by the inverter 8. As already described, other various methods may be employed alternatively to the one above.

Succeedingly, principle and operation of generating the aerial vibration (sound wave) by the vibration generating source 2 shown in the embodiment is described below while referring to Figs. 2 to 6.

1. Air intake and exhaust is initiated by driving the air source 10. It is assumed that the valve member 22 of directional control valve 17 is located in position A of Fig. 2 at time 0. The airflow at the time is directed through the discharge pipe 18, valve chest 25, conduit 20 and main body 3 of the cleaning apparatus as shown by arrows. In the main body 3, the air flows from left to right as shown by an arrow 27 in Fig. 2, and a waveform shown in a section a of solid line a in Fig. 6, for example, is observed during a period a from time 0.

2. Subsequently, at time 1, the valve member 22 of directional control valve 17 is driven to position B of Fig. 3 by the driving source. At this time, the air passes from the discharge pipe 18 through the valve chest 26 and conduit 21 to filter 23, while air in the inlet 11 of air source 10 is aspirated from the main body 3 of cleaning apparatus through the intake pipe 19, port 15, valve chest 25 and conduit 20, and returned to the air source 10. In the main body 3, the air flows from right to left, as shown by an arrow 28 in Fig. 3, and a waveform shown in a section b of solid line a, for example, is observed during a period b from time 1.

3. Then, at time 2, the valve member 22 of the directional control valve 17 is driven to position C of Fig. 4 by the driving source. The airflow at this time is directed from the discharge pipe 18 through the valve chest 26 and conduit 20 to the main body 3 in the same manner as in Fig. 2. In the main body 3 of cleaning apparatus, similarly to the case of Fig. 2, the air flows from left to right as indicated by an arrow 29 in Fig. 4, and a waveform shown in section c of solid line a in Fig. 6, for example, is observed during a period c from time 2.

4. Succeedingly, at time 3, the valve member 22 of the directional control valve 17 is driven to position D of Fig. 5 by the driving source. The airflow at this time is directed, similarly to the case of Fig. 3, through the discharge pipe 18, valve chest 25, conduit 21 and filter 23, while the air from the air intake 11 of the air source 10 is aspirated as indicated by arrow from the main body 3 of cleaning apparatus through the intake pipe 19, port 15, valve chest 26 and conduit 20, and returned to the air source 10. In the main body 3, the air flows from right to left as shown by an arrow 30 in Fig. 5 in the same manner as in Fig. 3, and a waveform shown in section d of solid line a in Fig. 6, for example, is observed during period d from time 3.

5. Furthermore, the valve member 22 of the directional control valve 17 is rotated from position D of Fig. 5 to position A of Fig. 2 by the driving source, the air is directed as described in 1, and the airflow in the main body 3 is in the same direction as that of the arrow 27 of Fig. 2. herein, as shown in Figs. 2 to 5, when the valve member 22 of directional control valve 17 is rotated once, the waveform of aerial vibration is repeated in two cycles (Fig. 6).

Such motion is sequentially repeated in time course, and the waveforms of aerial vibration form a continuous wave of simple sine waves as shown by solid line a in Fig. 6.

The waveform of aerial vibration can be changed in accordance to the vibration frequency or frequency, amplitude, cyclic period, continuous wave or pulse wave, and the like. For example, in the embodiment, by changing the rotating speed of valve member 22 in the directional control valve 17, rotating the valve member 22 both in the normal and reverse directions by the inverter 8, or other methods, the waveform shown by the solid line a in Fig. 6 can be changed to that of a broken line b or dotted broken line g.

An example of cleaning process by a dry cleaning apparatus for pipes shown in the embodiment 1 is described by referring to Fig. 7.

By pressing a start button, the pig 6 is inserted into the pig inserting tube 5 in main body 3 of the cleaning apparatus, and the devices are set. Succeedingly, by setting to the desired number of cleaning times, and driving the vibration generating source 2 so that the pig 6 is reciprocally moved within the pipe 4 to be cleaned, the pig 6 is reciprocally moved the preset number of times in the pipe 4 while it is transferred to the leading end of pipe 4 by aerial vibration, and the inside of pipe 4 is cleaned. Then, by removing the devices, cleaning of the pipe 4 is completed. The pig 6 can be set for reciprocal strokes and double acting strokes as desired.

An embodiment 2 of an apparatus of the invention is a best mode of the invention described below on the basis of Figs. 8 to 14. The embodiment is specifically characterized by wetting means 40 for obtaining a wet surface in the pipe 4 and pig contracting means 110 for contracting the pig 6 provided additionally to the apparatus for cleaning a pipe in the inside shown in the embodiment 1.

In other words, in an apparatus 1 for cleaning inside of a pipe of the embodiment 2, as shown in the previous embodiment, a main body 3 of the cleaning apparatus is connected with an end side 4a of pipe 4 to be cleaned in one end, and a vibration generating

source 2 comprising an air source 10, directional control valve 17 and the like and wetting means 40 in the other. In the main body 3, a conduit 20a air-tightly connected with the end 4a of pipe 4 and the conduit 20 of vibration generating source 2 and a pig inserting tube 5 are provided, the pig inserting tube is provided with pig contracting means 110, and the pig 6 is removably inserted beforehand. The vibration generating source 2 of the embodiment comprises the air source 10, the directional control valve 17 with four ports, a driving source 31 for driving the directional control valve 17, a discharge pipe 18 connecting the air source 10 and the directional control valve 17, an intake pipe 19, a conduit 20 connecting a port of the directional control valve 17 and the pig inserting tube 5, an outside air inlet pipe 32 sharing the conduit 20 and introducing the outside air, and is formed generally in similar manner to the embodiment 1.

Numeral 34 is a filter, 35 a valve, 36 a collection filter, and 37 a collection tank.

Although the wetting means 40 may have any structure, in this embodiment, it is structured so as to supply and discharge such cleaning solution as clean pipe water and distilled water. In other words, the wetting means 40 comprises a solution supply source 48, a feed pipe 41 connected with a solution supply source 48, a feed controller 46 connected with the pipe in the other end and feeding the solution while discharging a part of it during feeding, and a drain pipe 42 for discharging the solution fed and used in the pipe 4, the leading end of feed pipe 41 is in communication through the main body 3 with the pipe 4 to be cleaned and with the feed controller 46, and the trailing end of drain pipe 42 is in communication through the main body 3 with the pipe 4. In Figs. 8 and 9, numeral 44 is a feed valve, and 45 a cartridge filter. By supplying a solution into the pipe 4 by means of the wetting means 40, deposits adhered to the inside wall of pipe 4 are loosened, and the cleaning is facilitated. In this case, the cleaning solution is preferably bubbled by aerodynamic force of the air source.

Incidentally, the solution fed to the feed pipe 41 is not limited to water of ordinary temperature, but may be warm water.

The pig contracting means 110 is provided to remove water absorbed by the pig 6. For the pig contracting means 110, such structure as shown in Figs. 10 to 13 may be employed. In other words, the pig contracting means 110 comprises a driving source 112 such as a fluid pressure cylinder provided on a top plate 111 of the box-type pig inserting tube 5, a pressure plate 114 connected with a driving shaft 113 of the driving source 112 and applying pressure to the pig 6 for dewatering, and a duckboard 115 formed with spacings therein so that it can be flexed along the curved surface of pig 6, and the pig 6 is contracted by diving the driving source 112, and vertically moving the pressure plate 114. The contraction of the pig 6 may be achieved automatically as shown in Figs. 10 to 13 or manually. Numerals 116, 117 show valves.

In the feed controller 46 shown in Figs. 8 and 9, an overflow pipe 463 is uprightly provided slightly above a bottom plate 462 that forms a housing 461, a slit 464 is formed between the lower end of overflow pipe 463 and the upper surface of bottom plate 462, and flow rate from the pipe 4 is higher than discharge rate of the slit 464, thus, when overflow exceeding the upper end of overflow pipe 453 occurs in the housing 461, the solution is discharged from the upper part to the lower part in the overflow pipe 463. Initial supply water containing heavy dirt in the pipe 4 that is cleaned by the wetting means is discharged, at the beginning of operation, from the drain pipe 42 through an outlet 465 and discharge pipe 466. The discharge operation can be automatically performed by combining a level sensor 47, timer and the like.

Operation of the embodiment 2 is described below by referring to Figs. 8 to 14.

1. The devices are set to the main body 3 of cleaning apparatus, the pig contracting means 110, that is, the pressure plate 114 provided in the pig station (pig inserting tube 5) is lowered so that the pig 6 is contracted.
2. Then, the cleaning solution is supplied into the pipe 4 from the solution supply source 48 and feed pipe 41 which are the wetting means 40, and discharged from the drain pipe 42 that is the wetting means 40, thus, the inside of pipe 4 is rendered wet or provided with a wet surface. In this operation, initial supply water containing heavy dirt is discharged while the solution is fed, and this can be achieved automatically by combining a level sensor, timer and the like.
3. After being inserted into the pipe 4 from the pig inserting tube 5, the pig 6 is transferred in reciprocal motion by aerial vibration from the vibration generating source 2 and air pressure from the outside air inlet pipe 32 for cleaning the pipe 4 in the inside.

The operation of vibration generating source 2 at this stage is as described in association with the embodiment 1. In other words, upon actuation of the air source 10, the directional control valve 17 initiates continuous rotation, and when the valve member 22 of the directional control valve 17 is in an inclined state as shown in a solid line in Fig. 8, for example, the air discharged from the air source 10 is supplied, as shown by an arrow, from the discharge pipe 18 through the port 49, valve chest 25 and conduit 20b, and from the conduit 20 through the main body 3 of cleaning apparatus into the pipe 4 to be cleaned, so that the pig 6 is subjected to aerial vibration shown in section a of the curve a in Fig. 6, for example, and advanced in the forward direction. When the positioning of valve member 22 is changed from the state of Fig. 8 to that of Fig. 9, in order to suck the air in the con-

duits 20, 20b to the side of intake pipe 19 of air source 10, the pig 6 is subjected to aerial vibration shown in section b of the solid line a in Fig. 6, and advanced in such manner that the central point of amplitude in the reciprocal motion is shifted toward the leading end, while it is repeatedly reciprocated in a state slightly retracted from the first-mentioned position. In this case, the pig 6 may be advanced by applying air pressure from the outside air inlet pipe 32 as supplemental to the reciprocal operation of pig 6 by the vibration generating means 2 so that the central point of amplitude during the reciprocal motion of pig 6 is shifted toward the leading end. The air taken from the conduits 20, 20b through ports 52 and 51, intake pipe 19, air source 10, discharge pipe 18 and ports 49 and 50 is discharged through the filter 34 to outside of the system.

As described above, the inside of pipe 4 is cleaned by aerially vibrating and transferring the pig 6 in reciprocal motion, in which the forwarding step of the pig 6 as shown in Fig. 8 and the retracting step thereof as shown in Fig. 9 are alternately repeated. In this operation, the pig 6 rubs the inside wall of pipe 4 with a medium of water while it is transferred. Such cleaning step by the pig 6 (which corresponds to a solution cleaning step) is repeated the number of times desired.

By changing the waveform of aerial vibration by the vibration generating source 2, the stroke length of reciprocal motion of the pig 6 can be changed as desired. The waveform of aerial vibration can be varied according to the vibration frequency or frequency, amplitude, cyclic period and the like. For changing the waveform of aerial vibration, as already described, such method of changing the rotating speed of valve member 22 in the directional control valve, mounting angle or angle of rotation of the valve member 22, sectional open area of the ports in valve member 22, and mounting angle of the ports may be appropriately adopted, and an arbitrary waveform can be selected without being limited to the waveform shown in Fig. 6. In such case, the waveform is changed by the controller 33 or inverter in the side of air source 10.

When dewatering of the pig 6 is desired upon completion of each cycle of pigment cleaning step, in the case of returning the pig 6 to the original position in the main body 3 after the setting time is passed, the valve member 22 of directional control valve 17 is rotated and stopped at an attitude shown in Fig. 9 by activating the controller 33, and the airflow within the pipe 4 is, as described above, directed in the rearward direction as indicated by an arrow. Thus, the pig 6 is sucked in the rearward direction of airflow, and returned to the original position in the main body 3 of cleaning apparatus.

In such manner, the pig 6 is returned to the original position, and contracted and dewatered by the pig contracting means 110.

The wetting step for wetting the inside of pipe 4 by means of the wetting means 40, pig inserting step, pig cleaning step and pig contracting step can be set for the time, number, sequence and the like as desired by the controller 33.

After the pig cleaning step, a rinsing step for discharging dusts remaining in the pipe 4 out of the system is added, if required, by using such rinsing means 55 as the wetting means 40 or other supply and discharge apparatus provided separately. In the flow chart of Fig. 14, the rinsing step is added. That is, after completion of the pig cleaning step, water is supplied into the pipe 4 by commonly using the solution supply source 48 and feed pipe 41 that are the wetting means 40, and discharged from the drain pipe 42 to outside the system after the inside of pipe 4 is washed with the water. The rinsing step is repeated the predetermined times. In the rinsing means 55, it is preferred that the cleaning solution supplied is not bubbled by aerodynamic force from the air source.

In addition, in this embodiment, a water droplet removing step for removing water droplets deposited on the inside wall of pipe 4 is added. In other words, after the rinsing step is completed, the pig 6 that is dewatered beforehand is inserted into the pipe 4 in the same manner as in the pig cleaning step, and reciprocally moved in the advancing direction the predetermined times in the pipe 4 by aerial vibration from the vibration generating source 2, so that water droplets adhered to the inner circumferential wall and the like of pipe 4 is absorbed and removed by the pig 6. The pig 6 is returned to the original position in the main body 3, and dewatered, and the water removed therefrom is discharged from the drain pipe 42. Although the water droplet removing means comprises the pig 6, the vibration generating source 2 and the pig contracting means 110, it is not limited in the structure, but may have a modified design as desired. The water droplet removing step can be eliminated when unnecessary.

In the embodiment, for a final step, drying means 60 for drying the inside of pipe 4 is provided. As the drying means 60, the vibration generating source 2 comprising the air source 10, directional control valve 17 and the like may be commonly used, means comprising the outside air inlet pipe 32, valve 35 and the like, or both the former and latter may be used. By such means, the inside wall of pipe 4 can be dried approximately at an ordinary temperature with an exclusive heater. In other words, by the former, the inside of pipe 4 can be dried by means of waste heat of the vibration generating source 2 (specifically, the air source 10) without using a heater.

In the case of drying the inside of pipe 4 by commonly using the former vibration generating means 2, the valve member 22 of the directional control valve 17 is positioned in upstanding attitude, as shown by dotted broken line 22' in Fig. 8, by the controller 33,

and air discharged from the air source 10 is continuously directed, as shown by an arrow, from the discharge pipe 18 through the port 49, valve chest 25 and conduit 20b, and from the conduit 20 through the main body 3 into the pipe 4 that is cleaned, thus, through-flow drying the pipe for a predetermined time. In this operation, because the air discharged from the air source 10 is heated, as described, by the waste heat, the inside of pipe 4 is hot-air dried by the waste heat energy. Positioning of the valve member 22 is achieved by such positioning means as photoelectric switch and lead switch. In the case of drying by commonly using the former vibration generating source, in the drying step, wave of aerial vibration used for transferring the pig in reciprocal motion and waste heat from the air source that constitute the vibration generating source for generating the wave of aerial vibration may be utilized.

In the case of drying the inside of pipe 4 by the latter drying means 60 of the outside air inlet pipe 32 and valve 35, by opening the valve 35, outside air, dehumidified air, hot air or the like is directed from the outside air inlet pipe 32 through the conduit 20, collection filter 36 and collection tank 37 into the pipe that is cleaned, thereby, drying the pipe for a predetermined time.

The former drying means 60 and the latter drying means 60 may be selectively or simultaneously employed. Also, the drying means 60 is not limited to the two examples, but may be arbitrarily chosen.

The rinsing, water droplet removing and drying steps can be set for the time, number, sequence and the like as desired.

The steps of Fig. 14 are merely examples of operation of the embodiment, and can be changed as desired.

By using an apparatus of the invention shown in the embodiment 2, methods of the invention as defined in claims 2 to 10 can be conducted.

In other words, as defined in claim 2, the wetting step for wetting the inside of pipe 4 by the wetting means 40, pig inserting step for inserting the pig 6 into the pipe 4 and the pig cleaning step for cleaning the inside of pipe 4 by transferring the pig 6 while aerially vibrating it in reciprocal motion by the vibration generating means 2 can be performed.

A method of the invention according to claim 3 comprising the pig contracting step for dewatering the pig 6, when required, by pig contracting means in addition to the wetting, pig inserting and pig cleaning steps can be conducted. Moreover, as defined in claim 4, a method comprising the solution cleaning step for cleaning the inside of pipe 4 with a cleaning solution by using the wetting means 40, pig inserting step for inserting the pig 6 into the pipe 4, and pig cleaning step for cleaning the inside of pipe 4 by transferring the pig 6 in reciprocal motion by means of aerial vibration by the vibration generating source 2 can be achieved. A method, as defined in claim 5, comprising the pig contracting step for contracting the pig 6 by the pig contracting means 110 in addition to above steps can be conducted.

Furthermore, methods of the invention including, additionally to the steps, the rinsing step by the rinsing means 55 after completion of the pig cleaning step, as specified in claim 6, and further including the water droplet removing step in addition to these steps after completion of the rinsing step, as described in claim 7, can be performed. Also, methods comprising the drying step for drying the inside of pipe 4 by the drying means 60 as a final step as defined in claims 8 to 10 can be achieved.

An embodiment 3 of an apparatus of the invention is now described by referring to Fig. 15.

The embodiment is specifically characterized by a fact that warm water supply means 70 and warm air supply means 80 are added to the structure of embodiment 2, while the other parts are structured generally in the same manner as those shown in Figs. 8 and 9.

In other words, assuming that the feed pipe 41 constituting the wetting means 40 is a line a, in supplying water into the pipe 4, it is supplied from the solution supply source 40 through the line a, a warm water pipe 71 branched from a part of line a and connected in communication with the other part is provided as line b, and a heater 72, filter 73 and warm water valve 74 that constitute the warm water supply means 70 are respectively and sequentially connected to the warm water pipe 71. Therefore, in wetting the inside of pipe 4, water is supplied along the line a as shown in a solid arrow, while warm water is supplied into the pipe 4 by using a line b as shown in a dotted broken arrow and sharing a part of the line a, when warm water is supplied.

A line c is formed by connecting directional control valves 81, 82 such as electromagnetic valve to the conduit 20 on the upstream side of collection filter 36 and downstream side of collection tank 37, and a line d by the conduit 20c connected to the directional control valves 81, 82 in both ends thereof, and a filter 83, heater 84 and filter 85 that constitute the warm air supply means 80 are connected to the line d.

Thus, by actuating the directional control valves 81, 82, when the line d is closed and the line c opened, upon actuation of the vibration generating means 2, the aerial vibration is conducted to the inside of conduits 20b, 20 and 20a including the line c, the pig 6 within the pipe 4 is aerially vibrated and cleans the pipe, and the inside of pipe 4 can also be through-flow dried, as described in association with the embodiment 2, by switching the vibration generating means 2 and valve member 22 as required. In addition, as described with the embodiment 2, the inside of pipe 4 can be through-flow dried by using the route of outside air inlet pipe 32 as well. Upon actua-

tion of the directional control valves 81, 82, when the line c is closed and line d opened, by turning on the heater 84, the thermal energy can be directed with air from the air source 10 constituting the vibration generating means 2, and the inside of pipe 4 can be hot-air dried as well.

The warm water supply means 70 is not limited to the structure shown in Fig. 15, and the design can be modified, for example, so as to separately provide an independent route from the wetting means 40.

The warm air supply means 80 is not limited to the structure shown in Fig. 15, and an exclusive conduit for the warm air supply means 80, for example, can be used instead of sharing the conduit 20, or an air source separately provided may be employed in the warm air supply means 80 shown in Fig. 15 as a ventilation source instead of using the air source 10 of the vibration generating source 2.

An embodiment 4 of an apparatus of the invention is described below by referring to Fig. 16.

In the embodiment 4, as shown in Fig. 16, the wetting means 40 of Fig. 15 is substituted by solution cleaning means 90, in the figure, the solution supply source 48, feed pipe 41, cartridge filter 45, water supply valve 44 and drain pipe 42 are also used as the solution cleaning means 90, the inside of pipe 4 is cleaned with a solution by the solution cleaning means, and the embodiment comprises at least the pig 6 removably inserted from an end side of the pipe 4 and vibration generating means 2 for transferring the pig 6 in reciprocal motion by aerial vibration to clean the inside of pipe 4. Initial supply water containing heavy dirt in the pipe 4 that is cleaned by the solution cleaning means 90 is discharged at the beginning of operation from the drain pipe 42 through the outlet 46 and discharge pipe 466 of the feed controller 46. The discharge operation can be automatically performed by combining a level sensor 47, timer and the like.

In Fig. 16, in addition to the above, the pig contracting means 110 shown in Figs. 10 to 13, rinsing means 55, water drop removing means, warm water supply means 70 and drying means 60 comprising warm air supply means 80, through-flow drying means or the like are provided.

By using the apparatus of embodiment 4, methods of the invention according to claims 4 to 10 can be performed. It means that the solution cleaning, pig inserting, pig cleaning, pig contracting, rinsing, water droplet removing and drying steps can be combined as desired.

Fig. 17 shows a part of another preferred process of a method of the invention, Fig. 18 the remaining part thereof. In association with a cleaning apparatus structured as shown in Figs. 8 to 13, the process of the figures is described below.

The operation for cleaning a pipe in the inside is generally common with the example of process of Fig. 14. In other words, it comprises a wetting step (also referred to as humidifying step), pig cleaning step using a pig and cleaning water, rinsing step, water droplet removing step and drying step. However, those shown in Figs. 17 and 18 are significantly different from that of Fig. 14 by the fact that the cleaning water is bubbled in the wetting and rinsing steps, and that only waste water from the air source constituting the vibration generating source for generating a wave of aerial vibration is utilized in the drying step.

In other words, firstly, the pig 6 in the main body 3 of cleaning apparatus is contracted by the pig contracting mean 11. Succeedingly, the feed valve 116 is opened, discharge valve 117 is closed, water is supplied from the solution supply source 48 into the pipe 4 by the wetting means 40, and the wetting step A is started. Simultaneously with the water supply, the supply solution is bubbled by aerodynamic force from the air source 10 for loosening deposits adhered to the inside wall of pipe 4, and discharged. Such operation is performed the predetermined number of times.

After completion of the wetting step A, a cleaning solution is supplied into the pipe 4, and the pig cleaning step B (solution cleaning step) wherein the inside of pipe 4 is cleaned by transferring the pig 6 in reciprocal motion by aerial vibration (at low frequency) is conducted. After the pig cleaning is completed, the pig 6 is returned to the original position and dewatered. Waste water produced during the operation is discharged from the drain pipe 42. Such pig cleaning step B is repeated the predetermined number of times.

Succeedingly, the rinsing step C for supplying a cleaning solution into the pipe 4 and rinsing the inside thereof is performed. In this case, similarly to the wetting step A, the cleaning solution supplied is bubbled by aerodynamic force from the air source 10. Such operation is performed the predetermined number of times.

After the rinsing step C, a water droplet removing step D is performed for removing water droplets adhered to the inside wall of pipe 4. In the water droplet removing step D and the succeeding drying step E, the vibration generating source 2 is activated, and a low frequency wave is provided. In the water droplet removing step D, the pig 6 absorbs water droplets therein, while being reciprocally moved by the low frequency wave. The pig 6 with water absorbed therein is returned to the original position, then, dewatered.

In the drying step E, by utilizing the energy of aerial vibration wave (at low frequency) for transferring the pig 6 in reciprocal motion and energy of waste heat from the air source 10 that constitute the vibration generating source 2 for generating the wave of aerial vibration, the inside of pipe 4 is dried without using any heater. The drying operation is performed until a set water content of a humidity sensor and set

drying time are reached, when the set water content and set drying time are reached, the vibration generating means 2 is turned off, and the cleaning and drying are completed in the case that a target value is reached after confirming the dryness.

In the embodiments, as shown in Fig. 1, 8, 9, 15 and 16, a position sensor 100 is provided corresponding to points in the pipe 4 (such as bends) where dirts tend to be accumulated, so that such variables as the number of reciprocal movements of the pig 6 and waveform of the aerial vibration can be adjusted in the vicinity of the position sensor 100. Specifically, the waveform of aerial vibration and the like can be adjusted by receiving a signal transmitted from the position sensor 100 by a controller 33, and rotating the valve member 22 in the normal or reverse direction by an inverter 8, or the waveform and the like may be similarly adjusted by changing the rotating speed of air source 10. In such manner, the points in the pipe 4 where dirts tend to be accumulated can be intensely cleaned.

For the pig 6, a columnar sponge is used in the embodiment, the shape is selected as desired. For example, it is preferably that one or more spiral slit grooves 6a are formed in the outer surface in the longitudinal direction of a columnar body with an appropriate length, and the pig 6 is rotated and transferred by passing air from the air source 10 through the slit grooves 6a.

If the pipe used in the air conveying apparatus, drying device or dehumidifier is long, generally plural short pipes are coupled by known means such as flange joint. Hence, when cleaning the inside of the conduit of such short pipes, as mentioned above, it required complicated work of disassembling the plural short pipes, cleaning with brush, drying, and reassembling. If water drops often remained in the joints of the short pipes to lower the quality of the product such as powder material pneumatically conveyed in the duct.

To solve such problem, the pipe of the invention has special means. That is, explaining by reference to Fig. 20, the pipe 4 is combining by connecting two or more short pipes 400, 401, ..., and the end parts 400a, 401a of the adjacent short pipes 400, 401, ... are connected with a pair of tubular joints 410, 411 having a same inner wall surface as the inner wall surface of the same short pipes 400, 401. On the other hand, at the connection ends of the pair of tubular joints 410, 411, outward flanges 412, 413 are formed, and at the inner wall sides of the joints 410, 411 confronting the flanges 412, 413, a sleeve insertion groove 414 is formed, and a sleeve 415 having an O-ring 415 and possessing a greater stiffness than the short pipes 400, 401, ... is inserted in the sleeve insertion groove 414. A clamp band 417 is held and tightened by the outward flanges 412, 413.

By composing the pipe 4 in such manner, when the outward flanges 412, 413 of the tubular joints 410, 411 is tightened by the clamp band 417, since the connection end part of the joints 410, 411 is supported from inside of the duct by the sleeve 416, distortion is not caused in the connection end part. Accordingly, together with the presence of the O-ring 415, the water sealing effect of the joint part is excellent. If the O-ring 415 should deteriorate, or if there is water leak between the sleeve 416 and the tubular joints 4101, 411, since the pig 6 is moving reciprocally in the duct of the pipe 4, air vibratory waves of pulsating waves are generated, and the air vibratory waves suck the remaining leak water into the duct. As a result, the seam of the duct is dried by air, and the quality of the material conveyed in the duct is not lowered.

Although a force feed system such as blower is used, in the apparatus of the invention, for the air source 10 of vibration generating source 2 attached to the trailing end of the pipe 4 to be cleaned, as shown in the embodiment, such suction system as vacuum pump may be used for the air source 10 attached to the leading end of pipe 4 in the apparatus of the invention.

In a method of the invention, as already described, a dry method (claim 1), wet method (claim 2) and solution cleaning method (claim 4) may be independently employed, respectively, or these three method may be performed in an appropriate combination.

In addition, the pig contracting, rinsing, water droplet removing and drying steps (claims 3 and 5 to 8) can be performed in an appropriate combination with above methods. Sequence of the steps can be appropriately combined without being limited in Figs. 7, 14, 17 and 19, and performed.

In an apparatus of the invention, as described above, on the basis of the pig 6 and vibration generating source 2 (claim 15), the wetting means 40 (claims 17, 18), pig contracting means 110 (claims 21, 22), solution cleaning means 90 (claim 19), rinsing means (claims 23, 24), water droplet removing means (claims 25, 26) and drying means 60 (claims 27, 28) can be appropriately combined. Then, these means are adapted to automatically clean the inside of pipe 4.

It is an advantage that the installation space can be saved by housing or attaching the pig 6, vibration generating means 2, wetting means 40, pig contracting means 110, solution cleaning means 90, rinsing means 55, water droplet removing means and drying means 60 comprising the apparatus of the invention in a box-like member (main body 3 of cleaning apparatus).

Meanwhile, the invention may be applied also for the purpose of drying only. In such a case, if it is intended to dry the water drops on the inner wall of the pipe, most water drops are adsorbed on the pig, while water drops are divided into small particles to be dried

easily, and then the pig is removed from the pipe, allowing the aerial vibration to reach easily the end or seam of the pipe, so that an effective drying is achieve. Therefore, the pig is not necessary if it is intended to remove moisture in the pipe or remove water content contained in the seam.

In Figs. 1, 8, 9, 15, and 16, an air lead-in pipe 9 or fresh air lead-in pipe 32 is provided in the vibration source 2 as air inlet and outlet, and the pig 6 moving reciprocally in the pipe 4 to be cleaned is transferred freely in the upstream direction or downstream direction by injection or suction of air from the air inlet and outlet, so that the pig 6 is transferred while moving reciprocally.

Claims

1. A method for cleaning the inside of a pipe by rendering reciprocal motion of a pig by means of aerial vibration after inserting the pig into the pipe to clean the inside thereof.

2. A method for cleaning the inside of a pipe comprising steps of wetting inside of the pipe, inserting a pig into the pipe, and cleaning the inside thereof by transferring the pig in reciprocal motion by means of aerial vibration.

3. A method for cleaning the inside of a pipe according to claim 2 comprising a step of contracting the pig.

4. A method for cleaning the inside of a pipe comprising steps of cleaning inside of the pipe with a cleaning solution, inserting a pig into the pipe, and cleaning the inside thereof by transferring the pig in reciprocal motion by means of aerial vibration.

5. A method for cleaning the inside of a pipe according to claim 4 comprising a step of contracting the pig.

6. A method for cleaning the inside of a pipe according to either claim 2 or 5 comprising a step of rinsing after the pig cleaning step.

7. A method for cleaning the inside of a pipe according to claim 6 comprising a step of removing water droplets after the rinsing step.

8. A method for cleaning the inside of a pipe according to either claim 1 or 5 comprising a step of drying inside of the pipe.

9. A method for cleaning the inside of a pipe according to claim 6 comprising a step of drying inside of the pipe.

10. A method for cleaning the inside of a pipe according to claim 7 comprising a step of drying inside of the pipe as a final step.

11. A method for cleaning the inside of a pipe comprising steps of wetting inside of the pipe, inserting a pig into the pipe, supplying a cleaning solution and cleaning the inside of pipe by transferring the pig in reciprocal motion by means of aerial vibration, contracting the pig, rinsing the inside by supplying a cleaning solution thereinto, removing water droplets deposited on the inside wall of pipe after the rinsing step, and drying the inside of pipe.

12. A method for cleaning the inside of a pipe according to claim 11, wherein the cleaning solution supplied is bubbled by aerodynamic force from an air source in the wetting and rinsing steps.

13. A method for cleaning the inside of a pipe according to claim 11 or 12 comprising the drying step of applying ventilating air from the air source which makes vibration generating source used for cleaning the pig in the drying steps.

14. A method for cleaning the inside of a pipe according to claim 9 or 10 comprising the drying step of applying ventilating air from the air source which makes vibration generating source used for cleaning the pig in the drying steps.

15. An apparatus for cleaning the inside of a pipe comprising pig removably inserted from an end side of pipe and a vibration generating source for transferring the pig in reciprocal motion to clean the inside of pipe by aerial vibration of the pig .

16. An apparatus for cleaning the inside of a pipe according to claim 15 comprising pig transfer means for transfering the pig which reciplocating inside a pipe for cleaning by transfering up or down the air streem at will with blow or intake of air from an access way, while reciplocating the pig. wherein the access way is provided for the vibration generating source.

17. An apparatus for cleaning the inside of a pipe according to claim 15 or 16 comprising wetting means for wetting the inside of pipe.

18. An apparatus for cleaning the inside of a pipe according to claim 17, where in wetting means comprises a source of supply, a supply pipe which is connected to the source, a supply controller which is connedcted to the other side of the pipe

and supplys water during draining a part of water in the progress of supply, and a drainange pipe for supplying it in the pipe and draining it after the use of it, wherein a top side of the supply pipe is connected with a pipe for cleaning and the supply controller through the body of the apparatus, and the base top side of the drain pipe is connected with the pipe through the body for cleaning.

19. An apparatus for cleaning a pipe in the inside according to claim 15 or 16 comprising solution cleaning means for cleaning the inside of pipe with a cleaning solution.

20. An apparatus for cleaning a pipe in the inside according to 19, wherein cleaning means with a cleaning solution comprises a solution supply source, a feed pipe connected with a solution supply source, a feed controller connected with the pipe in the other end and feeding the solution while discharging a part of it during feeding, and a drain pipe for discharging the solution fed and used in the pipe.

21. An apparatus for cleaning a pipe in the inside according to any of claims 17 to 19 comprising pig contracting means for contracting the pig.

22. An apparatus for cleaning a pipe in the inside according to claim 21, wherein the pig contracting means is provided to remove water absorbed by the pig. the pig contracting means comprises a driving source such as a fluid pressure cylinder provided on a top plate of the box-type pig inserting tube, a pressure plate connected with a driving shaft of the driving source and applying pressure to the pig for dewatering, and a duckboard formed with spacings therein so that it can be flexed along the curved surface of pig, and the pig is contracted by diving the driving source, and vertically moving the pressure plate.

23. An apparatus for cleaning a pipe in the inside any of claims 17 to 22 comprising a step of rinsing inside of the pipe the pig cleanig step.

24. An apparatus for cleaning a pipe in the inside according to claim 23, wherein the rising means comprises a solution supply source, a feed pipe connected with a solution supply source, a feed controller connected with the pipe in the other end and feeding the solution while discharging a part of it during feeding, and a drain pipe for discharging the solution fed and used in the pipe.

25. An apparatus for cleaning a pipe in the inside according to claim 20 comprising water droplet removing means.

26. An apparatus for cleaning a pipe in the inside according to claim 25, wherein the water droplet removing means the comprises the pig 6, the vibration generating source 2 and the pig contracting means, the pig that is dewatered beforehand is inserted into the pipe in the same manner as in the pig cleaning step, and reciprocally moved in the advancing direction the predetermined times in the pipe by aerial vibration from the vibration generating source, so that water droplets adhered to the innner circumferential wall and the like of pipe is absorbed and removed by the pig.

27. An apparatus for cleaning a pipe in the inside according to any of claims 15 to 25 comprising drying means for drying the inside of pipe.

28. An apparatus for cleaning a pipe in the inside according to claim 25, wherein as drying means, vibration generating source comprises the air source, the directional control valve with four ports, a driving source for driving the directional control valve, a discharge pipe connecting the air source and the directional control valve, an intake pipe, a conduit connecting a port of the directional control valve and the pig inserting tube, an outside air inlet pipe sharing the conduit and introducing the outside air are utilized in.

29. An apparatus for cleaning a pipe in the inside according to any of claims 15 to 28, wherein a position sensor 100 is provided, corresponding to points in the pipe 4 where dirts tend to be accumulated, in such manner that a signal transmitted by the position sensor 100 is received by a controller 33, and the reciprocal motion of pig 6 and waveform of aerial vibration can be adjusted in the vicinity of the position sensor 100 on the basis of the signal received by the c ontroller 33.

30. An apparatus for cleaning a pipe in the inside according to any of claims 15 to 29, wherein the pig forms a spiral slit groove in an outer surface in the longitudinal direction of a columnar body, and are rotated by passing air from the air source in the slit groove.

31. An apparatus for cleaning a pipe in the inside according to any of claims 15 to 30, combining by connecting two or more short pipes, and the end parts of the adjacent short pipes are connected with a pair of tubular joints having a same inner wall surface as the inner wall surface of the same short pipes. On the other hand, at the connection ends of the pair of tubular joints, outward flanges are formed, and at the inner wall sides of the joints confronting the flanges, a sleeve insertion groove 414 is formed, and a sleeve having an O-

ring 415 and possessing a greater stiffness than the short pipes is inserted in the sleeve insertion groove 414. A clamp band is held and tightened by the outward flanges.

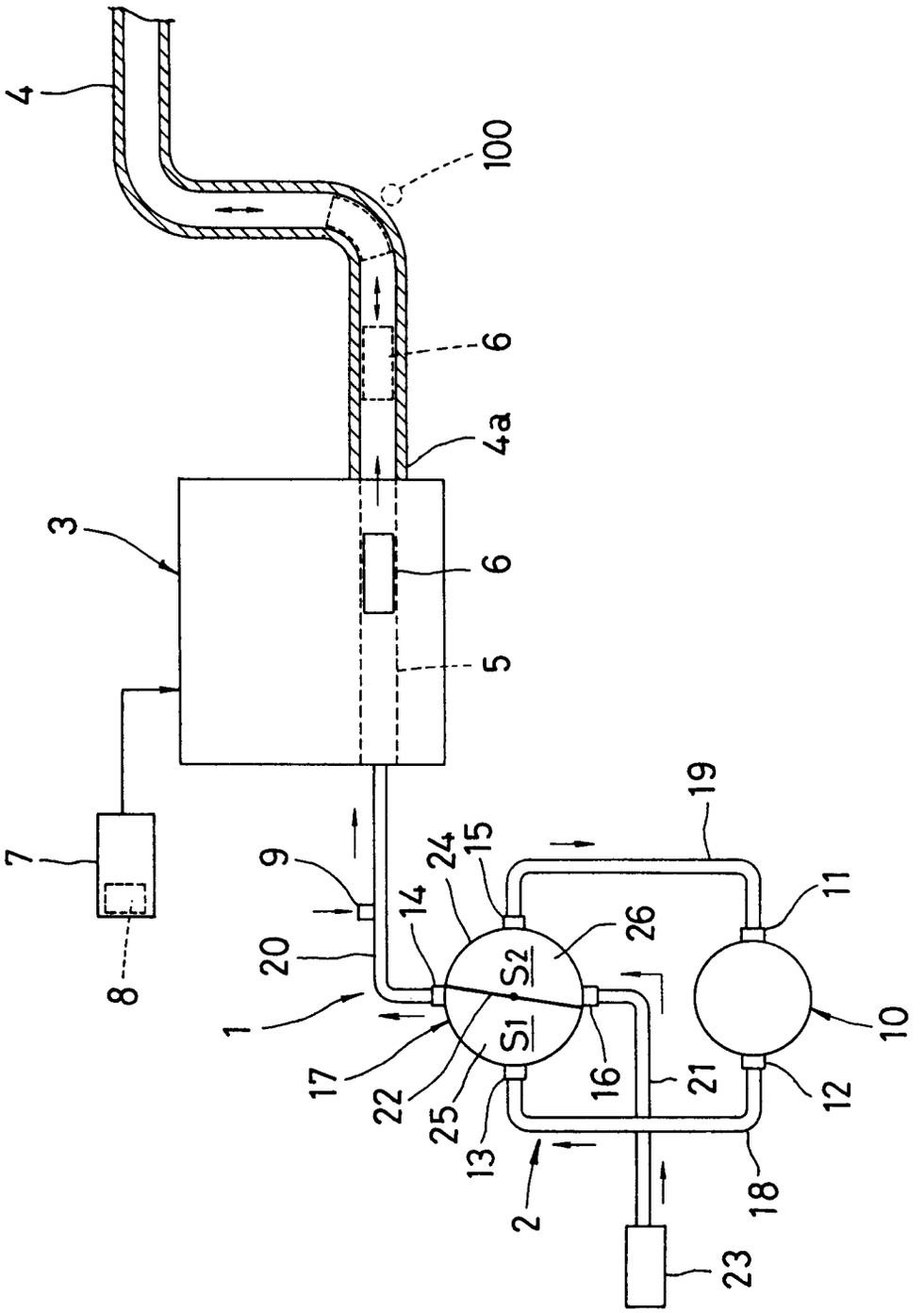
4
100
6
4a
3
6
5
7
8
9
20
1
14
24
15
19
11
26
S2
S1
10
17
22
25
13
16
21
12
2
18
23

Fig. 1

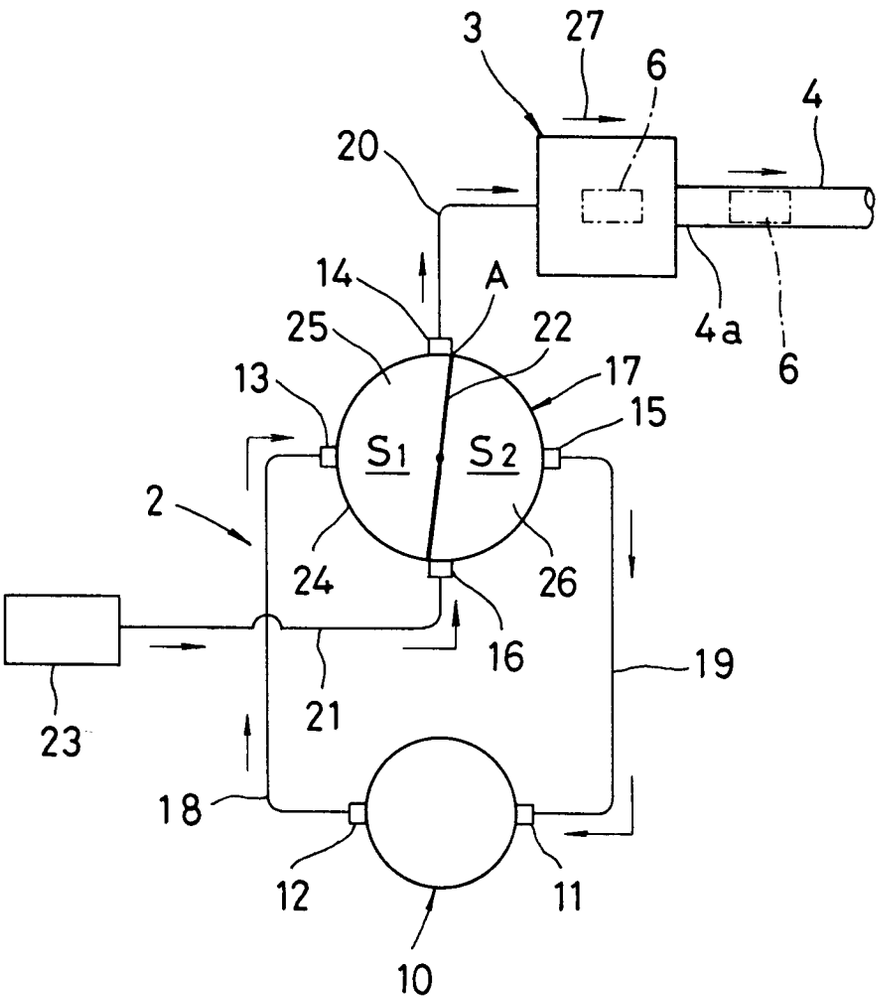

Fig. 2

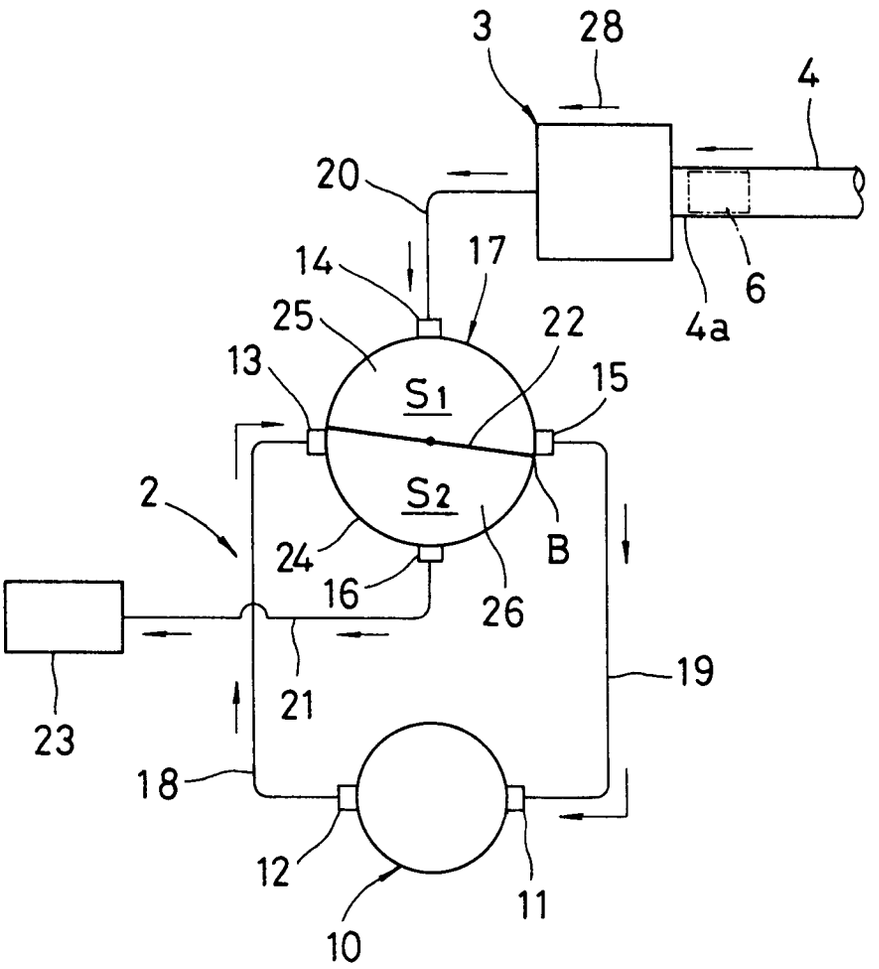

Fig. 3

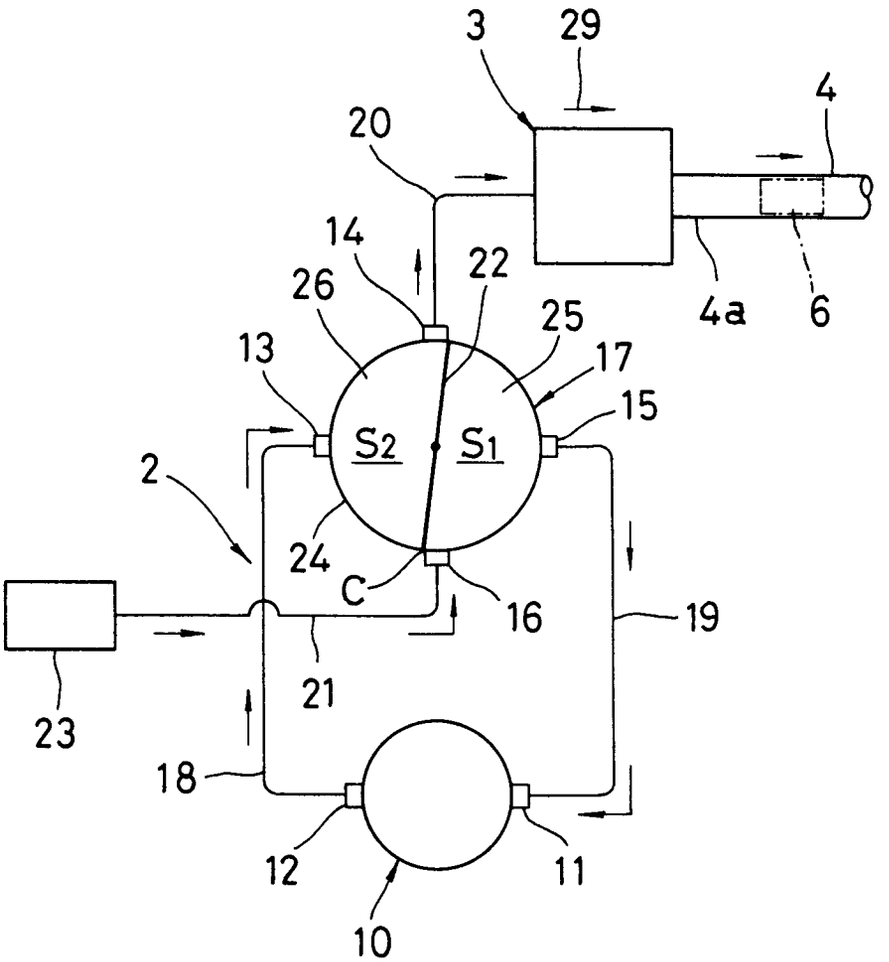

Fig. 4

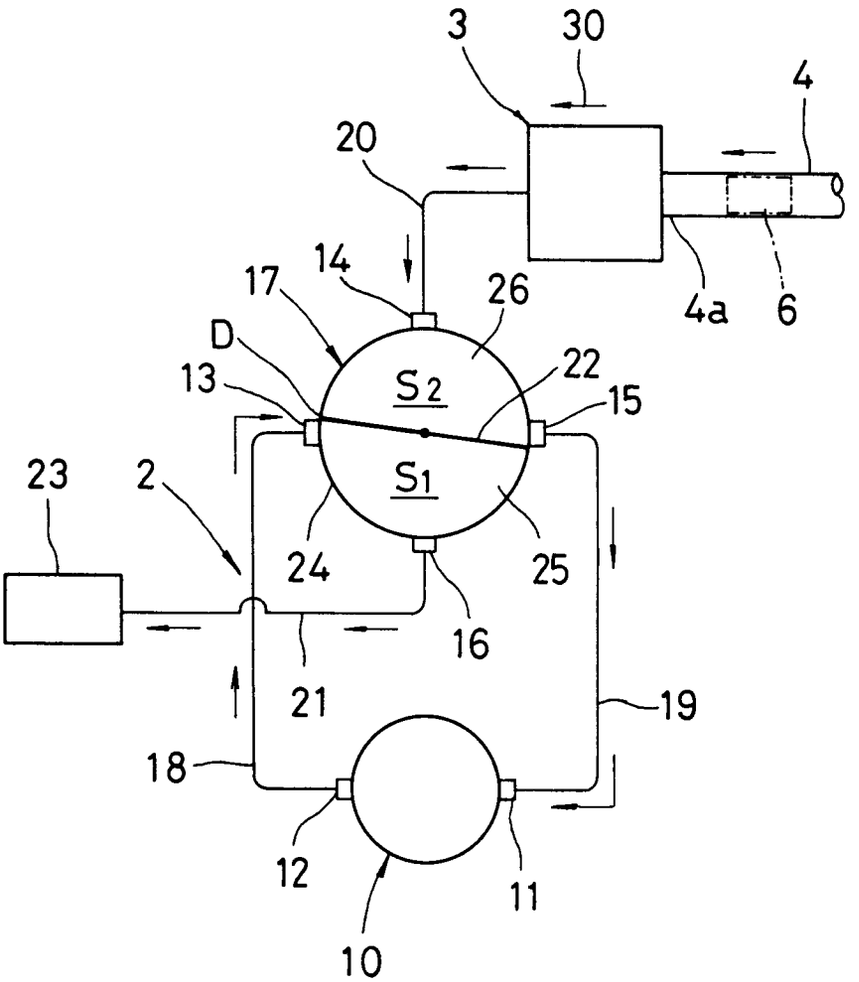

Fig. 5

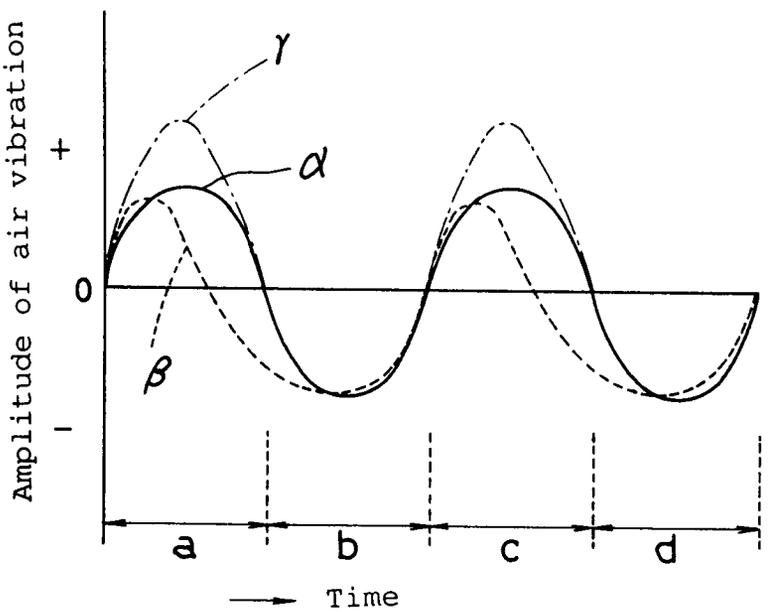

Fig. 6

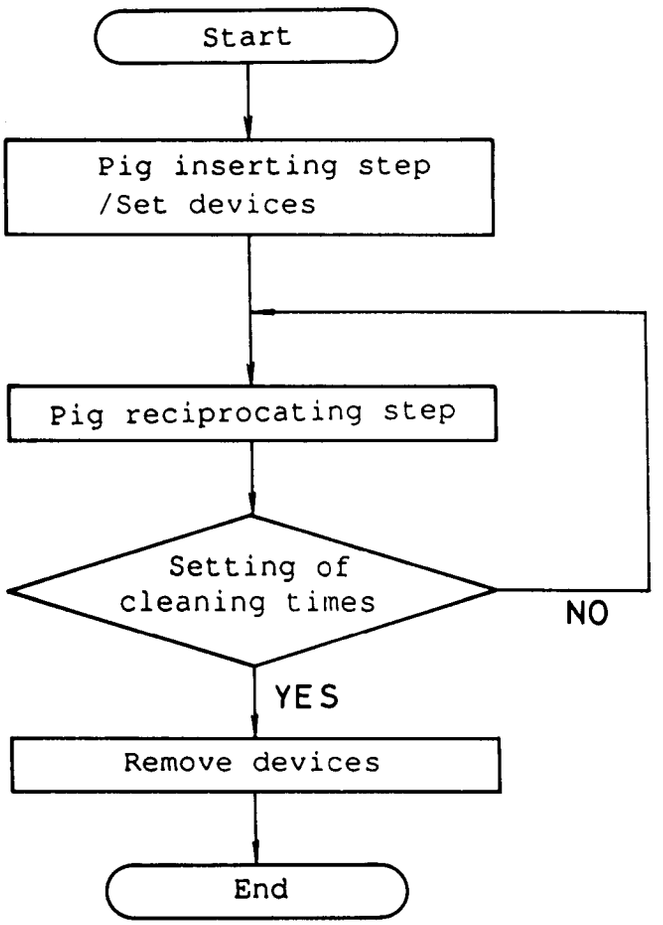
Start
Pig inserting step
/Set devices
Pig reciprocating step
Setting of
cleaning times
NO
YES
Remove devices
End

Fig.7

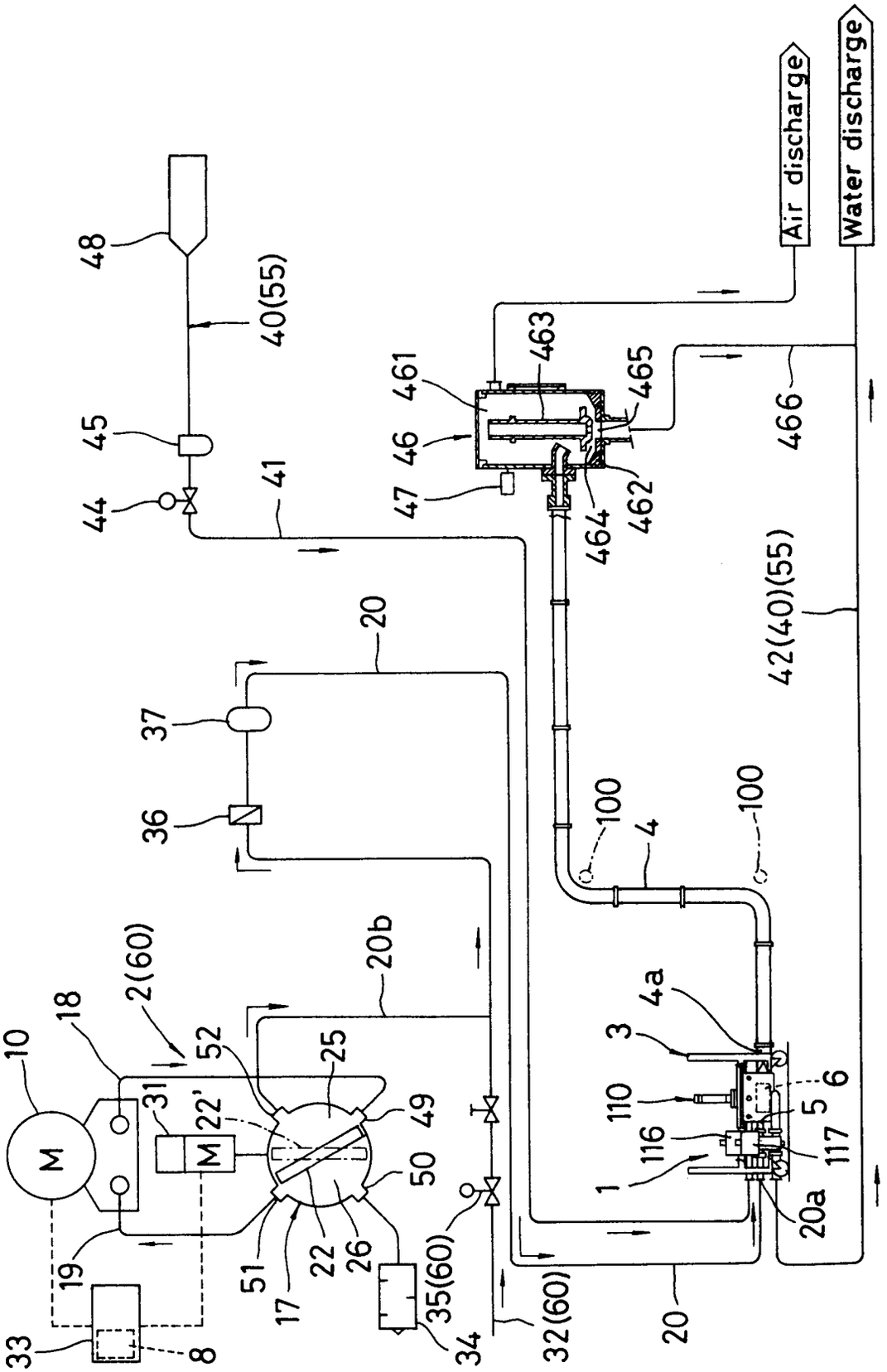
Air discharge
Water discharge
48
40(55)
45
44
41
461
463
465
46
47
462
464
466
42(40)(55)
20
37
36
100
4
100
20b
2(60)
18
10
52
25
4a
3
6
110
5
116
117
1
20a
31
22'
49
50
M
M
19
51
17
22
26
35(60)
34
32(60)
20
33
8

Fig. 8

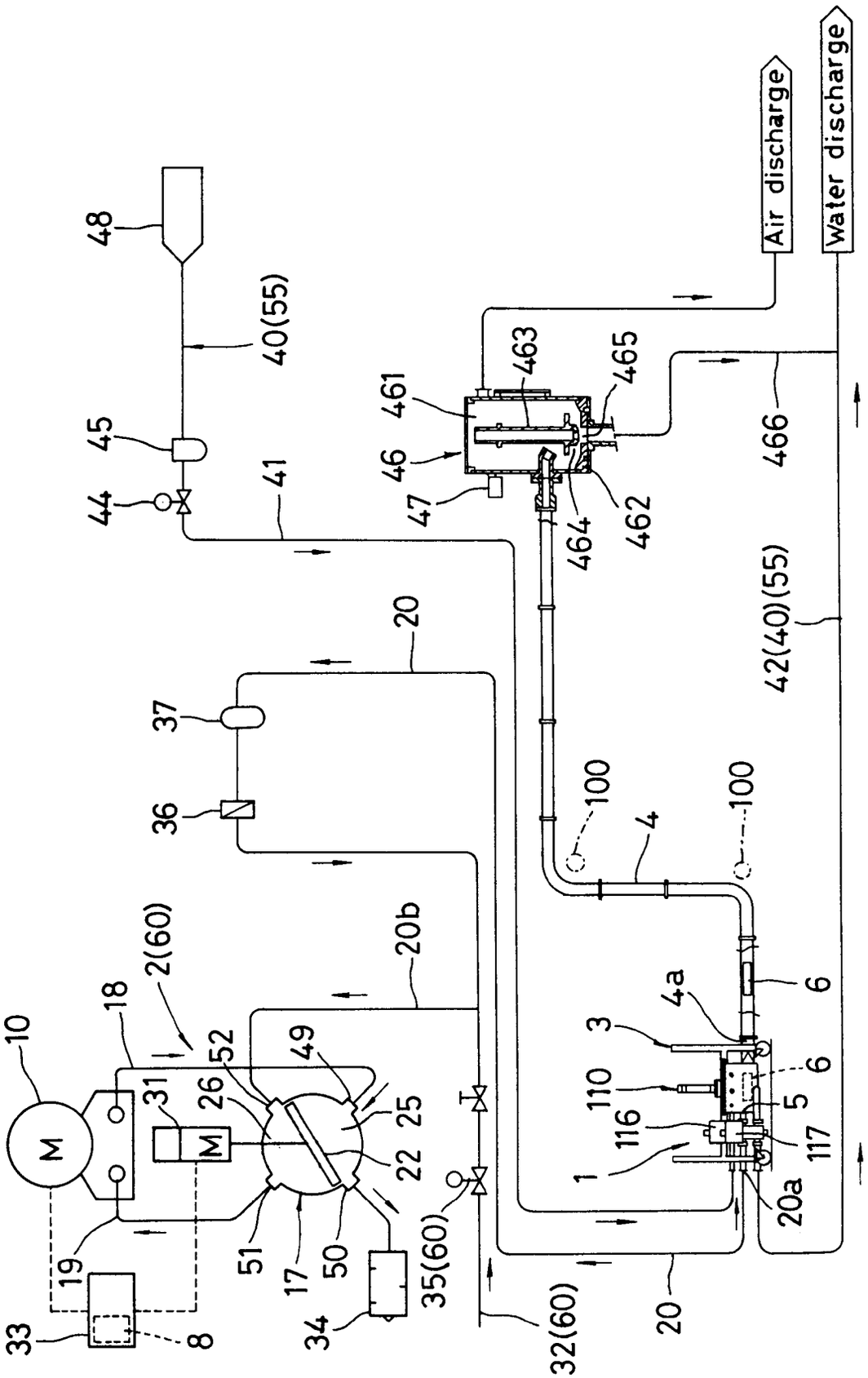
Air discharge
Water discharge
48
40(55)
45
44
41
461
463
465
46
47
462
464
466
42(40)(55)
20
37
36
100
4
100
2(60)
18
20b
10
52
49
4a
3
6
31
26
25
110
6
5
116
22
117
1
20a
51
17
50
35(60)
19
33
8
34
32(60)
20

Fig. 9

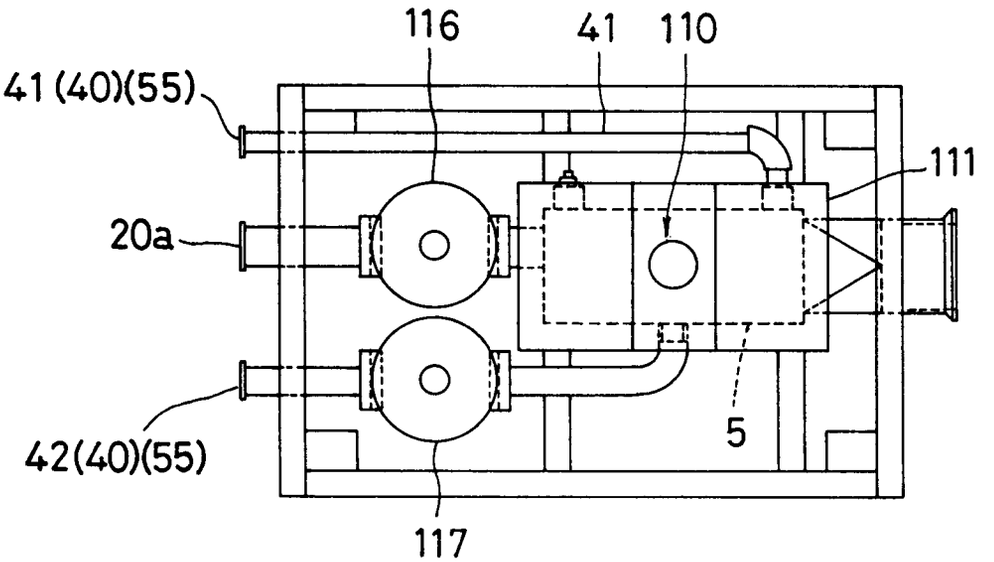
116
41
110
41 (40)(55)
111
20a
5
42(40)(55)
117

Fig. 10

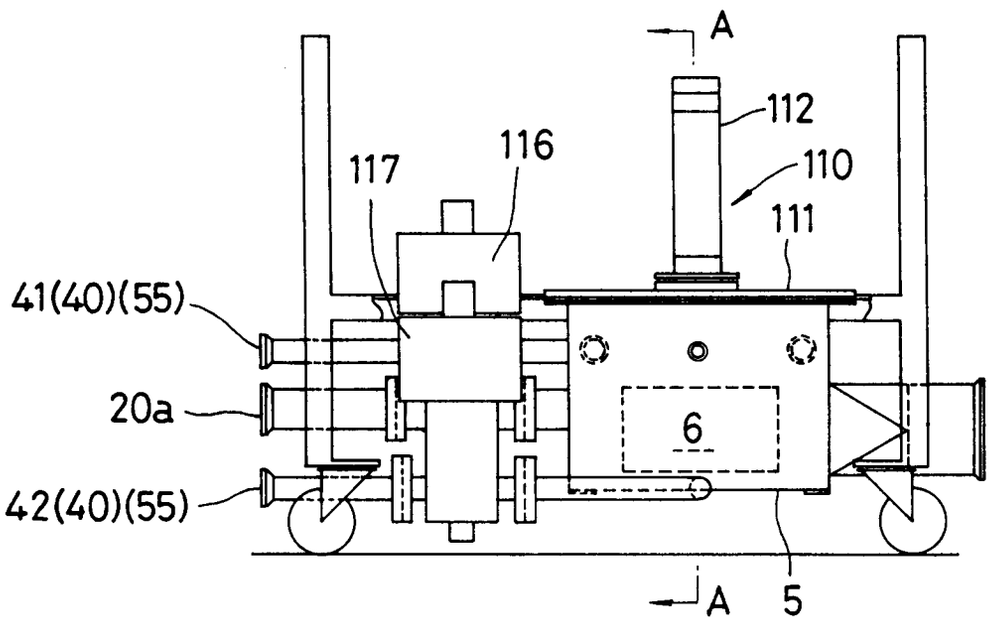
A
112
116
117
110
111
41(40)(55)
20a
6
42(40)(55)
A
5

Fig.11

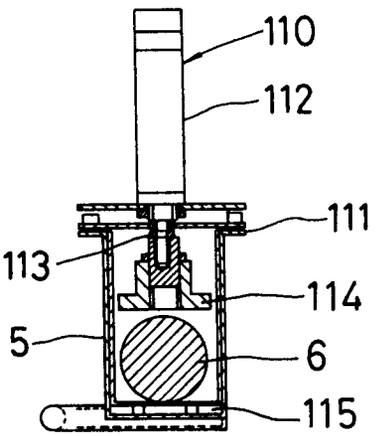

Fig.12

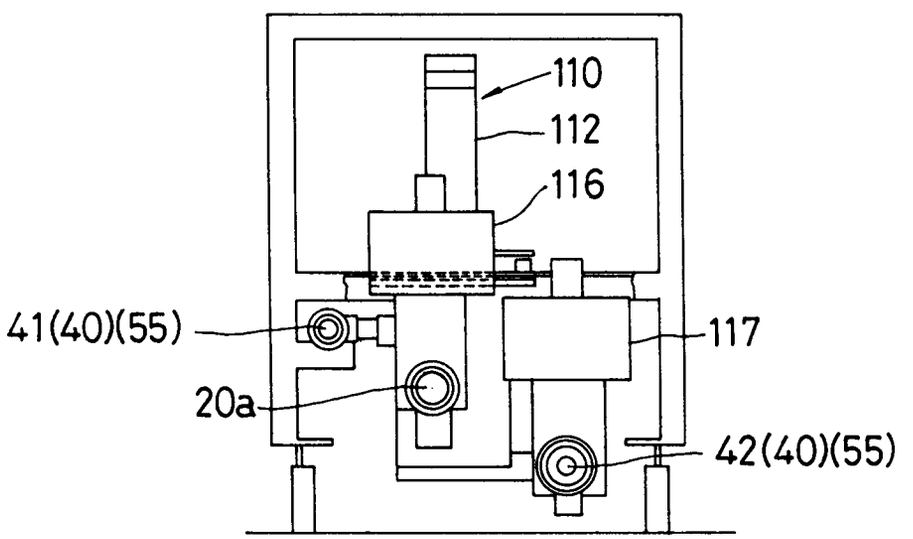

Fig.13

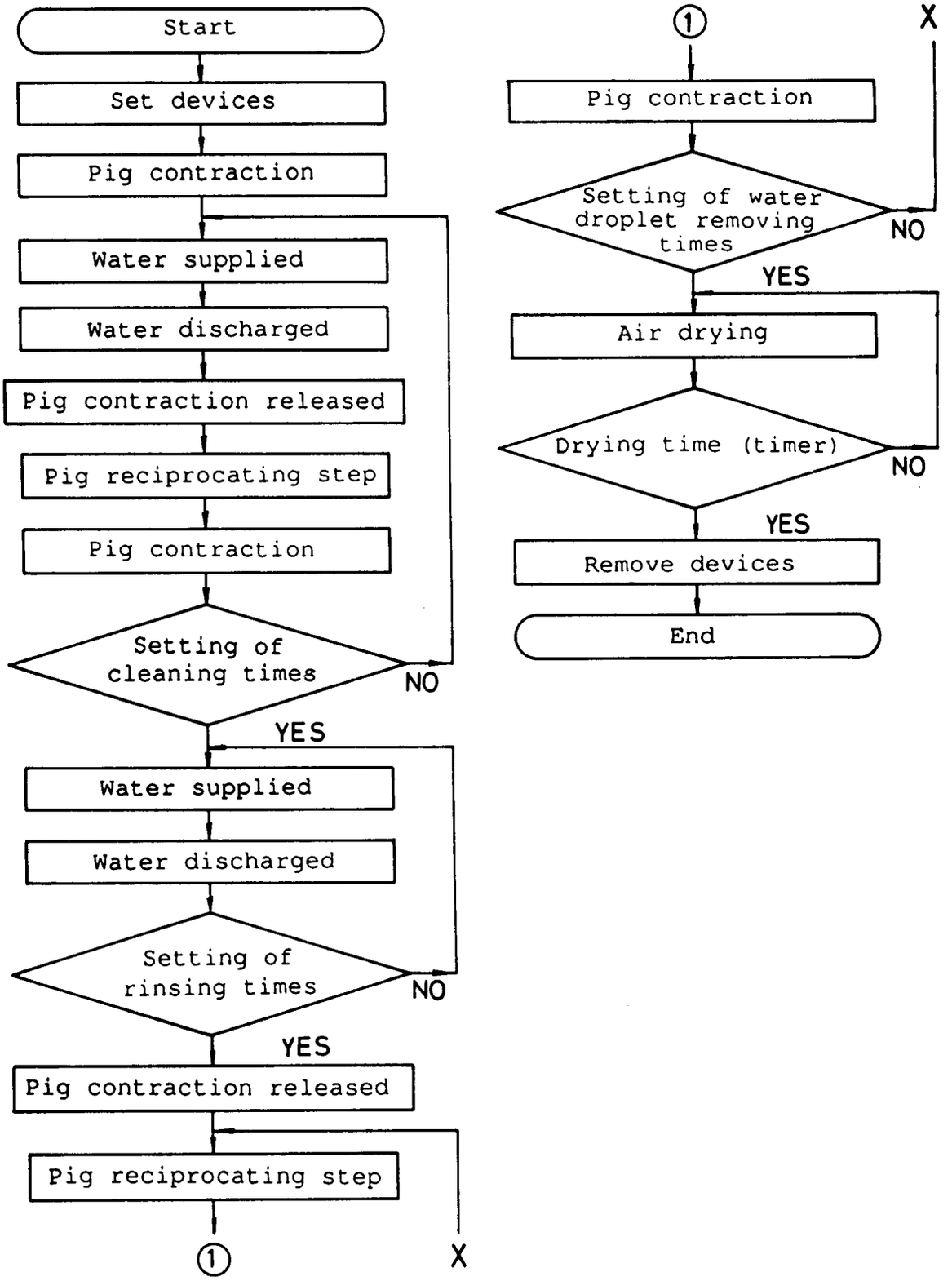
Start
Set devices
Pig contraction
Water supplied
Water discharged
Pig contraction released
Pig reciprocating step
Pig contraction
Setting of cleaning times
NO
YES
Water supplied
Water discharged
Setting of rinsing times
NO
YES
Pig contraction released
Pig reciprocating step
①
X
①
X
Pig contraction
Setting of water droplet removing times
NO
YES
Air drying
Drying time (timer)
NO
YES
Remove devices
End

Fig.14

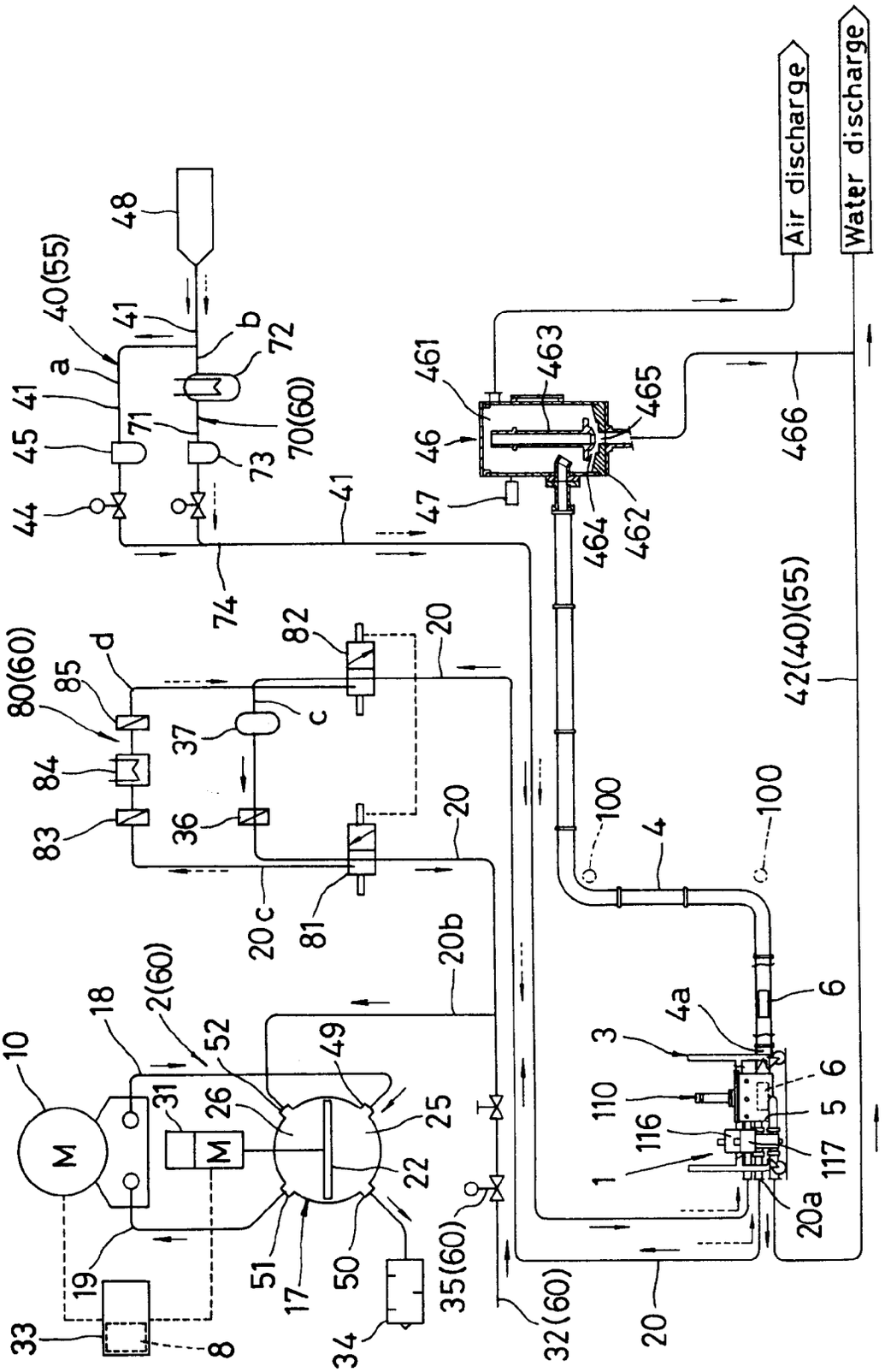

Fig.15

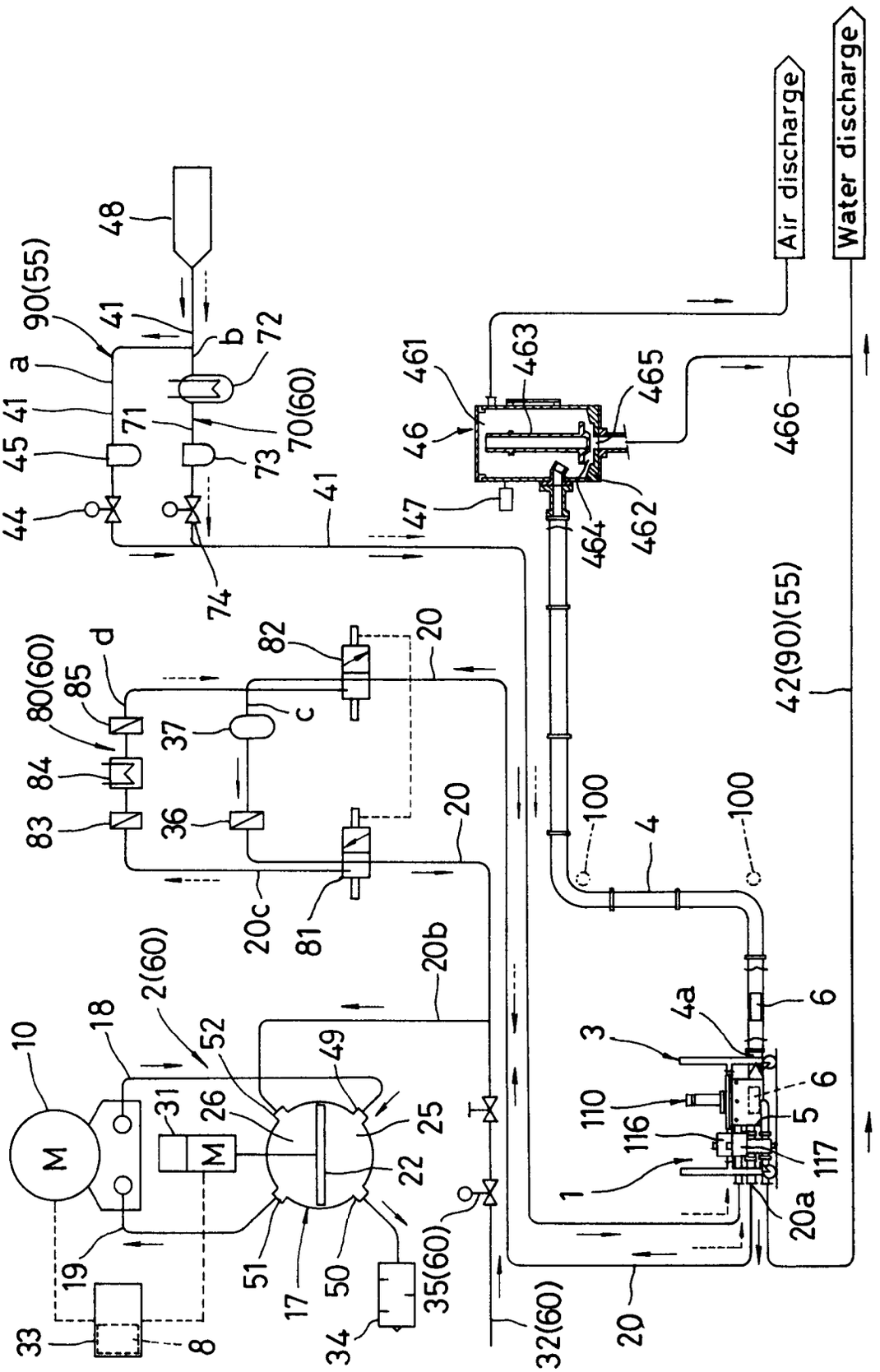

Fig.16

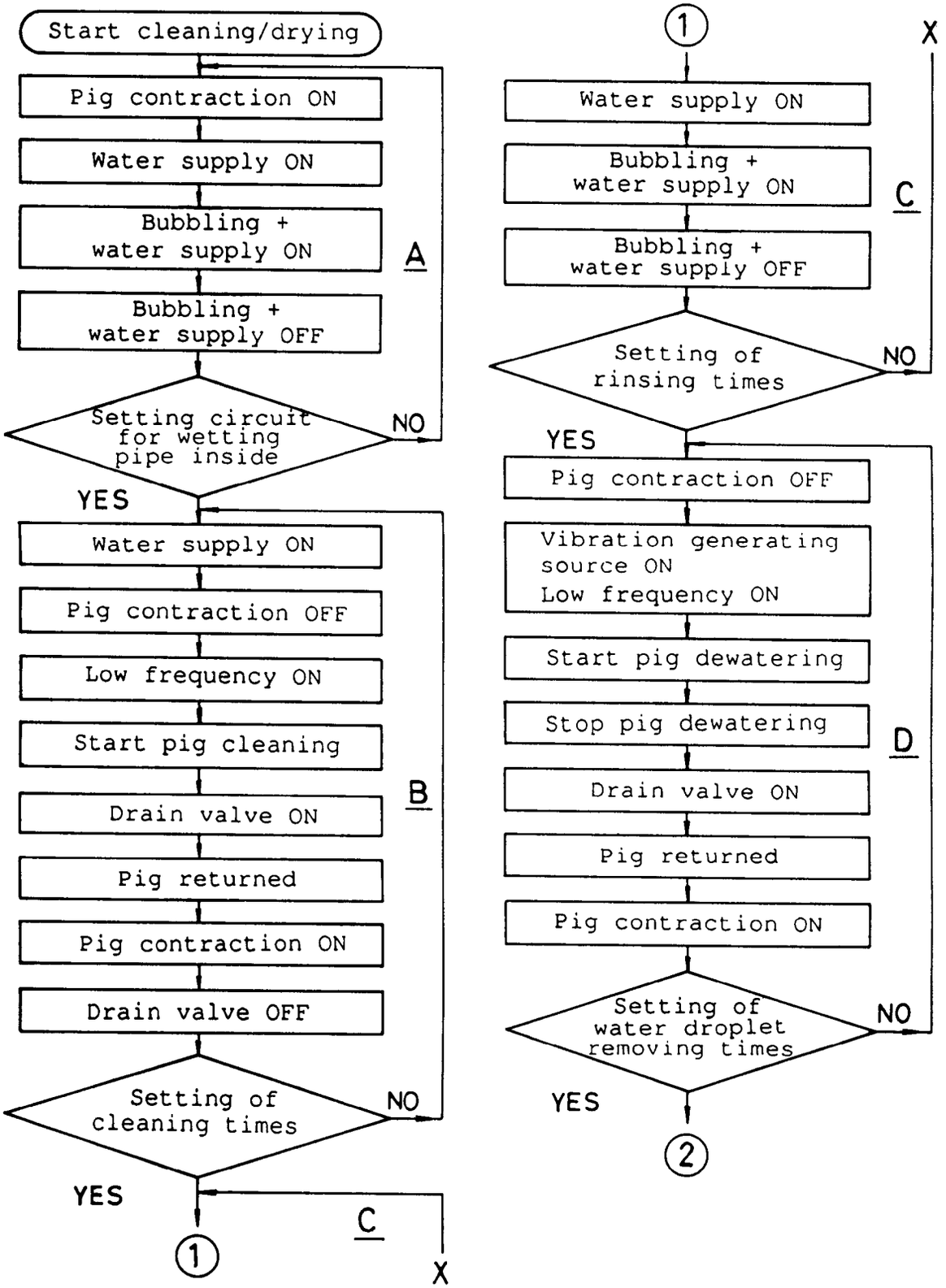
Start cleaning/drying
Pig contraction ON
Water supply ON
Bubbling + water supply ON
Bubbling + water supply OFF
A
Setting circuit for wetting pipe inside
NO
YES
Water supply ON
Pig contraction OFF
Low frequency ON
Start pig cleaning
Drain valve ON
Pig returned
Pig contraction ON
Drain valve OFF
B
Setting of cleaning times
NO
YES
C
1
X
1
X
Water supply ON
Bubbling + water supply ON
Bubbling + water supply OFF
C
Setting of rinsing times
NO
YES
Pig contraction OFF
Vibration generating source ON
Low frequency ON
Start pig dewatering
Stop pig dewatering
Drain valve ON
Pig returned
Pig contraction ON
D
Setting of water droplet removing times
NO
YES
2

Fig.17

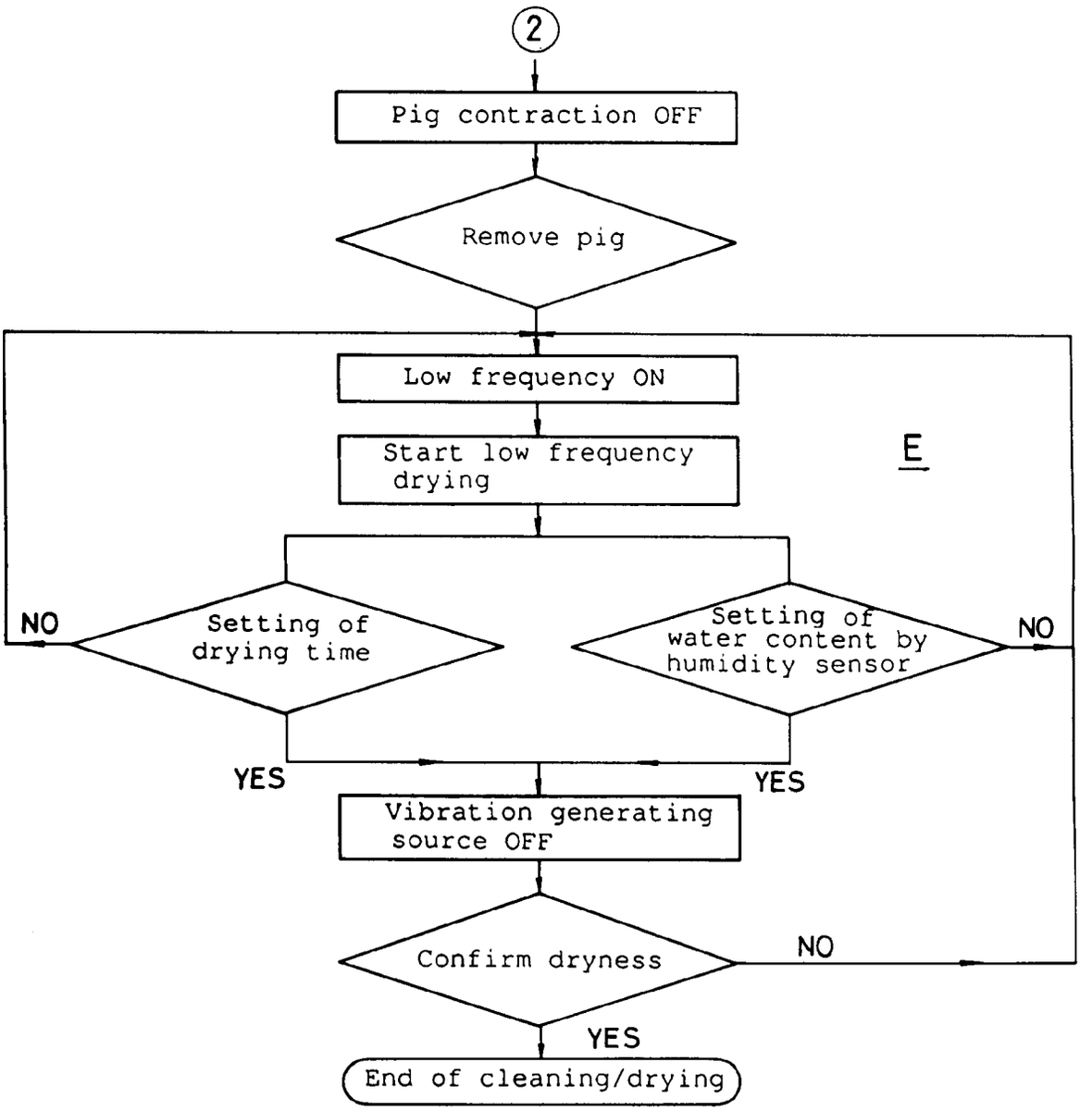
2
Pig contraction OFF
Remove pig
Low frequency ON
Start low frequency drying
E
NO
Setting of drying time
Setting of water content by humidity sensor
NO
YES
YES
Vibration generating source OFF
Confirm dryness
NO
YES
End of cleaning/drying

Fig.18

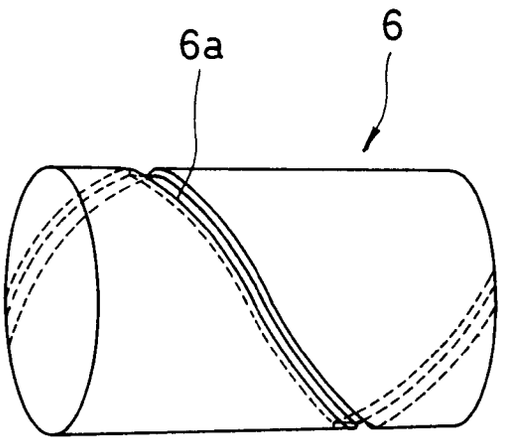

Fig.19

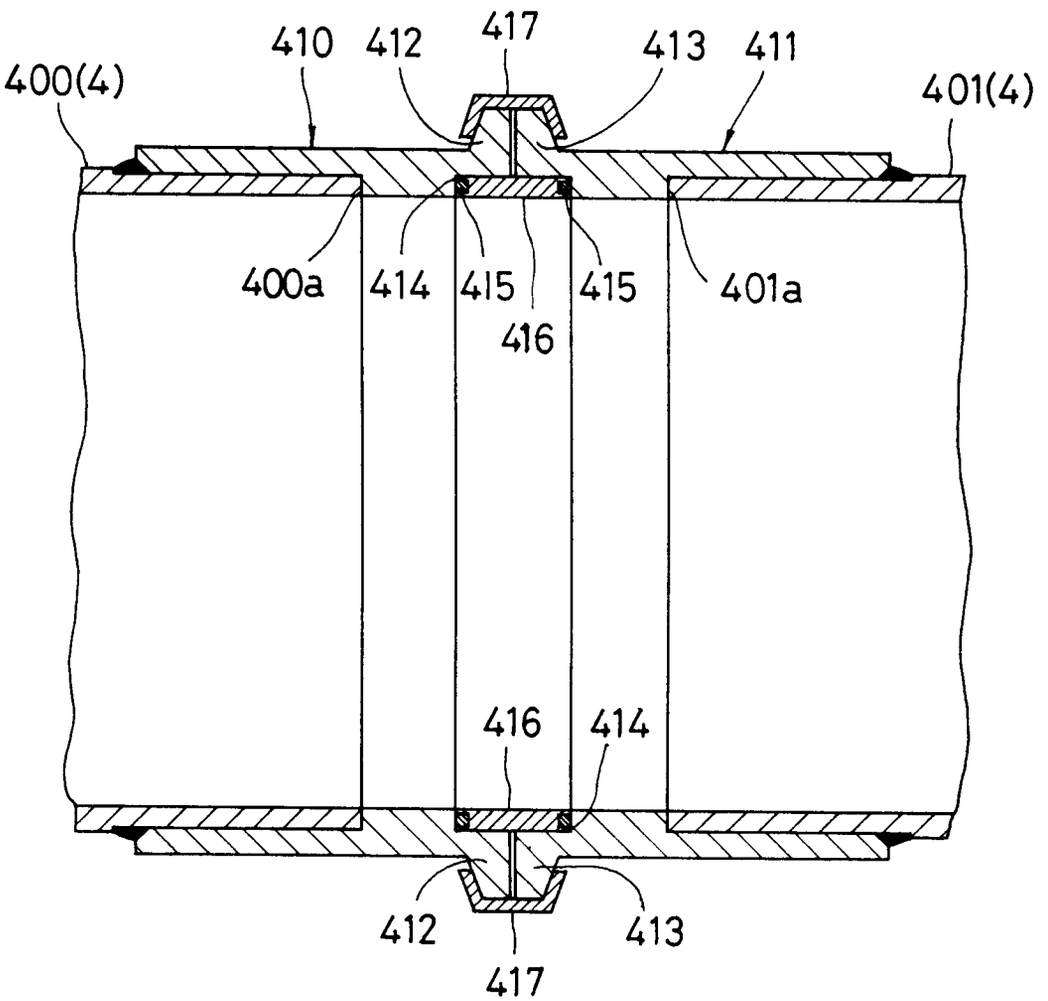
400(4)
410
412
417
413
411
401(4)
400a
414
415
416
415
401a
416
414
412
413
417

Fig. 20

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 5270

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-3 432 383 (RUSSELL) 11 March 1969 * column 3, line 26 - line 32; figures 1-4 * * column 3, line 59 - column 4, line 2 *	1,2,4, 11,15,30	B08B9/06
A	EP-A-0 400 422 (BERSCH) 5 December 1990 * column 3, line 57 - column 4, line 18; figures 1,2 *	1,2,4, 11,15	
A	US-A-3 148 689 (BEAN) 15 September 1964 * column 2, line 55 - column 3, line 25; figures 1-12 *	7,11,25	
A	EP-A-0 104 520 (NUKEM GMBH) 4 April 1984 * page 5, line 1 - page 6, line 11; figures 1-3 *	1,4,5, 11,21, 22,26	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 474 479 (GIRARD) 28 October 1969 * column 1, line 69 - column 2, line 8; figures 1-4 *	30	B08B F28G
A	US-A-4 122 575 (SAGAWA) 31 October 1978 * column 2, line 28 - line 38; figures 1-3 *	30	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 OCTOBER 1993	VOLLERING J.P.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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