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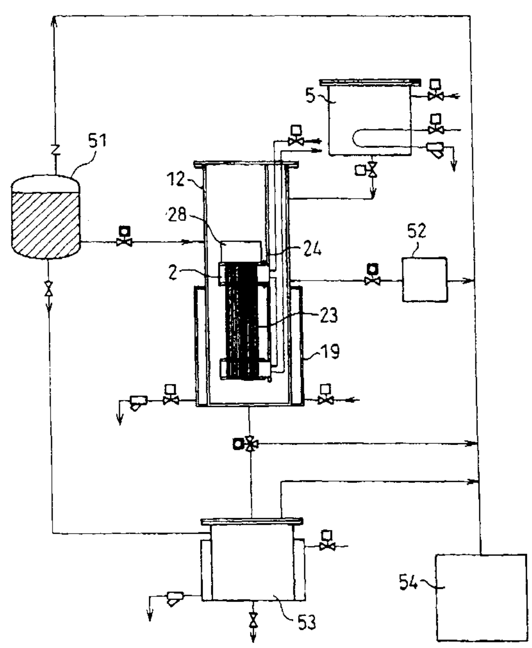
(54) **Processor and process for liquid ammonia treatment of hank yarn**

(57) It is an object of this invention to provide a liquid ammonia treatment technology for producing hank yarn without a dyeing speck. This invention provides a processor for the liquid ammonia treatment of hank yarn and a method, wherein liquid ammonia is supplied to cellulose fibers, liquid ammonia is removed from the hank yarn, the hank yarn is placed under a pressure reduced condition, hot water or steam is supplied to the hank yarn, and the hank yarn is placed under the pressure reduced condition again.

FIG. 1



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Description

[0001] This invention relates to a processor and to a process for a liquid ammonia treatment of hank yarn.

[0002] Traditionally, with respect to a process for a liquid ammonia treatment of yarn, publicly known systems include a continuous type and a batch type. The continuous type may be broadly divided into two methods, i. e. "a continuous ammonia dry method" whereby a great part of ammonia is removed by dry heat and followed by conducting a steam treatment and "a continuous ammonia wet method" whereby a yarn is dipped into ammonia and washed immediately thereafter. Either type of the processor is large and is prone to cause yarn breakage due to a tension applied on the yarn while passing through the processor. As is described in Japanese Utility Model Gazette Number 52-57279, especially for a fine-count single yarn, that type has a further problem as it cannot provide a stable processing.

[0003] Compared to the above-mentioned continuous type, the batch type may be a method processing a cheese as is disclosed in Japanese Laid Open Patent Application Number 10-88465 or may be a method of processing hank yarn as it is disclosed in the first embodiment in the Japanese Laid Open Patent Application Number 9-256271. For processing the cheese, a cheese dyeing machine is used as it is, and ammonia is removed only by blowing hot air. For processing hank yarn, ammonia is removed merely by blowing hot air as well. Such a batch type causes a problem of making a penetration speck or a speck due to uneven penetration when dipping in ammonia, a tension speck or a speck due to uneven tension, or a dyeing speck due to uneven drying created when removing the ammonia.

[0004] It is an object of this invention to provide a processor and a process for a liquid ammonia treatment of hank yarn where no dyeing speck is created on the yarn.

[0005] According to a further aspect of this invention a stable and effective liquid ammonia treatment technology without the danger of yarn breakage even for a fine-count single yarn should be provided.

[0006] According to a still further aspect of this invention a liquid ammonia treatment processor should be compact.

[0007] According to the invention there is provided a processor for a liquid ammonia treatment of hank yarn as defined in claim 1 and a process for a liquid ammonia treatment of hank yarn as defined in claim 5.

[0008] Preferred embodiments of the processor and of the process of the invention are defined in the subclaims.

[0009] This invention provides a stable process without causing yarn breakage even for a fine-count single yarn. Further, this invention does not have a problem of leaving a dyeing speck even if a texture fabric or knit is formed from the yarn after coloring. Still further, this invention provides a compact liquid ammonia treatment processor.

[0010] An embodiment of this invention is explained next with reference to the following figures, in which:

Figure 1 is an explanatory view of the liquid ammonia processor of the invention;
Figure 2 is a plan view of a treatment case thereof;
Figure 3 is a side view of the treatment case;
Figure 4 is an explanatory plan view of a supporting member for the yarn; and
Figure 5 is an explanation side view of the supporting member.

[0011] A processor for a liquid ammonia treatment of hank yarn is used for treating a hank yarn 23 with liquid ammonia. For instance as shown in Figures 1 to 3, the processor comprises a treatment case 1 or tank in which the hank yarn 23 is treated, a hank yarn holding member 2 on which the hank yarn 23 is loaded, a feeder 51 for supplying liquid ammonia into the treatment case 1, a hot water/steam production device 5 for generating hot water or hot steam, a receiver tank 53 for receiving matters such as liquid ammonia and hot water discharged from the case 1, a pressure reducing device 52 for sucking off gas such as air, ammonia vapour, or steam containing ammonia from the case in order to create a reduced pressure atmosphere in the case, a piping 18 connecting the above-members, as well as pipes (not shown in the diagram), valves, and an electric control device for controlling the operation of the processor in an automatic treatment process.

[0012] The hank yarn 23 is a yarn bundle of cellulose fibers. As an example, the hank yarn 23 may be a bundle of yarn produced by reeling yarn while the cellulose fibers may be a cotton, flax, rayon, acetate, polynosic, cupra, regenerated cellulose fibers (e.g. such as are commercially available under the designation "Tencel®"), and the like fibers. Further, these fibers may be of another type, for example, cellulose fibers mixed with synthetic fiber such as a polyester fiber or protein fibers such as wool and silk. In the latter case, the portion of the cellulose fibers in the mixed fibers should generally be more than that of other components, and preferably the weight of the cellulose fibers within the composite fibers should be 50% or more with respect to the total weight. As the hank yarn various kinds of yarns such as single yarn, a plied yarn, twisted union yarn, or a fine-spinning twisted union yarn can be used.

[0013] The holding member 2 is designed to hold the hank yarn 23 in the treatment case 1 and may comprise a plurality of rollers. Figures 1 to 5 depict an example of a mechanism for holding the hank yarn 23 by means of loading the hank yarn 23 on a pair of rollers, i.e., an upper roller 21 and a lower roller 22. The upper and lower rollers 21, 22 are held by a supporting structure wherein the upper roller 21 is held by an upper portion of a supporting member 24 and the lower roller 22 is held by an arm 25. The supporting member 24 may be either of a single-side holding type or of a double-side holding type.

If it is a double-side holding type, for example, the supporting member 24 is designed such that it can be dismounted so that the hank yarn 23 can be loaded on the rollers.

[0014] As shown in Figures 4 and 5, the arm 25 is rotatably connected to the supporting member 24 via a pivot pin 26 but may be locked in an extended position by a lock pin 27. The supporting member 24 may be bent in that the arm 25 is rotated on the pivot pin 26 so as to reduce the distance between the pair of rollers. When loading the hank yarn 23 between the pair of rollers, the supporting member 24 is bent, i.e. the arm 25 is rotated so that the rollers can be placed to be within the bundle of hank yarn 23 and then the arm 25 of the supporting member 24 is rotated back to the initial position, thereby stretching the bundle of hank yarn 23.

[0015] A squeezing roller 28 is located adjacent to the holding member 2. For example, as shown in Figures 1 to 3, the squeezing roller 28 is located adjacent to the upper roller 21. The squeezing roller 28 is utilized to remove liquid ammonia or condensed water from the yarn.

[0016] The interior of the rollers is designed to be provided with hollow portions such that the rollers may be heated or cooled by providing the piping 18 to introduce heating fluid or cooling fluid into the hollow portions of the respective roller.

[0017] In addition, the holding member 2 has a capacity of simultaneously holding and processing plural bundles of hank yarn 23, e.g. 20 bundles.

[0018] The treatment case or tank 1 is a case for conducting the liquid ammonia treatment of the hank yarn 23. For example, as shown in Figures 2 and 3, the treatment case 1 may be divided at its central region into an upper case 11 and a lower case 12. In addition, the treatment case 1 has a coupling member 32 connecting the upper case 11 and the lower case 12. A pressure device 31 is provided for pressurizing the squeezing roller 28.

[0019] The upper case 11 is equipped with a lifting device 3 for lifting the upper structure comprising the upper case 11, the supporting member 24 supporting the holding member 2, a driving unit 4 of the holding member 2, and the piping 18 for injecting or discharging the heating/cooling fluid into and from the rollers.

[0020] The lifting device 3 at least has a capacity of lifting and lowering the upper case 11 relative to the lower case 12. For example, an air cylinder for lifting and lowering may be used for this purpose in this invention.

[0021] The driving unit 4 is adapted to drive the holding member 2 to evenly dip the hank yarn 23 into the liquid ammonia. For example, one of the rollers can be rotated for this purpose to rotate the hank yarn 23 around the rollers. In this case, the driving unit 4 for a roller rotation comprises a motor 41 and a chain 42 for driving the upper roller 21. The lower roller 22 comprises a metal roller and a sheet pipe, covering and slidably rotating over a circumferential surface of the metal roller.

[0022] The lower case 12 is configured with a liquid ammonia inlet 13 for introducing or injecting materials such as liquid ammonia and hot water, a liquid ammonia outlet 14 for discharging these materials, a gas port 17 for injecting or discharging gas, and a heating and cooling section for heating or cooling the inside of the lower case 12. In addition an additional inlet and outlet (not shown in the figures) may be provided for hot water.

[0023] The heating and cooling section should at least function to heat or cool the inside of the lower case 12 and for instance may comprise a jacket 19 for keeping a fluid near the circumference of the lower case 12, so that the temperature within the lower case 12 may be controlled by injecting a heating or cooling fluid into the jacket 19 via a jacket inlet 15 and discharging the heating or cooling fluid from a jacket outlet 16.

[0024] The liquid ammonia feeder 51 is adapted to supply liquid ammonia into the treatment case 1 and for example may be a flash tank. For instance, the flash tank is connected with a high pressure bomb. When liquid ammonia under high pressure with a normal or room temperature is injected into the flash tank, a part of the liquid ammonia is evaporated, thereby lowering the temperature to result in liquid ammonia under normal or atmospheric pressure with a low temperature to be injected into the treatment case 1.

[0025] Hot water containing liquid ammonia or ammonia within the treatment case 1 is discharged or ejected therefrom via the liquid ammonia outlet 14 into a receiver tank 53.

[0026] Ammonia contained in hot water is separated at an ammonia absorption layer. In addition, the liquid ammonia outlet 14 and the receiver tank 53 may be separately provided for liquid ammonia and for hot water containing ammonia.

[0027] The pressure reducing device 52 is provided for reducing the pressure inside of the treatment case 1 to thereby remove gas such as air and ammonia within the treatment case 1 via the gas port 17. Removed ammonia gas is collected by an ammonia absorber 54.

[0028] The hot water/steam production device 5 is provided for heating water to produce hot water or steam. Here, saturated vapor or superheated vapor may be used as hot steam.

[0029] For hot water, a regular temperature should be within the range of 50°C - 100°C and the preferred temperature is 70°C - 100°C and the most preferred temperature is 90°C - 100°C. For example, hot water can be injected via the liquid ammonia inlet 13 commonly used for liquid ammonia.

[0030] For hot steam, preferably, saturated vapor should be 98°C - 100°C under normal or atmospheric pressure while superheated vapor should be over 100°C, preferably more than 100°C but not more than 160°C under normal or atmospheric pressure. Hot steam may be injected via a separate port other than the gas port 17.

[0031] Considering the amount of thermal energy necessary to accomplish the above process, hot steam is preferable since it requires less energy. In addition, although either saturated vapor or superheated vapor may be used as hot steam, the latter is preferable since hank yarn 23 after treatment becomes dry. It is most preferable that the temperature is over 100°C under normal or atmospheric pressure.

[0032] The process for a liquid ammonia treatment according to this invention is explained next.

<A> Loading the hank yarn:

[0033] First, the hank yarn 23 is loaded onto the holding member 2. If the holding member 2 comprises the pair of rollers as described above, the supporting member 24 between the rollers is bent by rotating the arm 25 supporting one of the rollers with the pivot pin 26 as the fulcrum. As a result, the distance between the rollers is reduced, and the pair of rollers may be placed inside the loop of the bundle of the hank yarn 23. Then, the arm 25 rotates to extend the distance between the pair of rollers and is fixed by the lock pin 27, thereby stretching the hank yarn 23. At this time, the squeezing roller 28 is loosened in order to allow insertion of the hank yarn 23.

[0034] The lifting device 3 lowers the upper case 11 of the treatment case 1 to place the hank yarn 23 within the lower case 12. Then, the lower case 12 is connected to the upper case 11 with the coupling mechanism 32 to seal the treatment case 1.

<B> Liquid ammonia treatment of the hank yarn:

[0035] First, the pressure reducing device 52 reduces the pressure in the treatment case. In case the heating and cooling section is the jacket 19 described above, cooling water inside the jacket 19 is discharged to avoid freezing. As the rollers 21, 22 supporting the hank yarn are rotating, liquid ammonia is injected into the treatment case 1, and the hank yarn 23 is dipped into liquid ammonia for a certain period of time. It is preferable that the rollers alternatingly and repeatedly rotate in both directions. "Certain period of time" means a period sufficient for the hank yarn 23 to be evenly dipped into liquid ammonia and depends upon the condition of the hank yarn 23 but generally, for example, is more than 20 seconds, preferably more than 60 seconds, more preferably 60 to 120 seconds. Sufficient dipping time eliminates a problem of a dipping speck or uneven dipping. After dipping evaporated ammonia gas is transmitted to the ammonia absorber 54. The receiver tank 53 removes liquid ammonia discharged from the treatment case 1. At this time, in order to squeeze the hank yarn 23, the squeezing roller 28 is pressurized onto the hank yarn on the upper roller and rotated to squeeze liquid ammonia out of the hank yarn 23.

<C> Hot water/steam treatment of the hank yarn:

[0036] The pressure reducing device 52 reduces the pressure in the treatment case 1 to remove liquid ammonia from the hank yarn 23. The treatment case 1 and the holding member 2 of the hank yarn 23 are heated simultaneously by the heating and cooling device. For example, steam is injected into the jacket 19 and into the interior spaces of the rollers for heating the same. This heating prevents condensation within the treatment case 1.

[0037] For a hot water treatment, hot water from the hot water/steam production device 5 is injected into the treatment case 1. Upon injecting hot water into the treatment case 1, the temperature of the hank yarn 23 including its inside shows a quick increase. At this time, a large part of liquid ammonia within the hank yarn 23 quickly evaporates and a small part thereof is dissolved into hot water. As a result, the hank yarn 23 is dipped in hot water containing only a slight amount of ammonia. The effect of liquid ammonia ceases within a short period of time, and hot water recrystallizes cellulose and rearranges the amorphous portion of cellulose.

[0038] For a hot steam treatment, hot steam from the hot water/steam production device 5 is injected into the treatment case 1. Upon injecting hot steam, a large amount of steam condenses on the hank yarn 23, and this latent heat increases the yarn temperature including its inside approximately up to 100°C within a short period of time. At this time, liquid ammonia within the hank yarn 23 quickly evaporates and a slight amount thereof is dissolved in condensed water. Accordingly, the hank yarn 23 is dipped in hot water including a small amount of ammonia. The effect of liquid ammonia ceases within a short period of time, and hot water promotes recrystallization and rearranges the amorphous portion of cellulose.

[0039] After a certain period of time, supply of hot steam is stopped, the pressure reducing device 52 reduces the pressure in the treatment case 1, and the ammonia absorber 54 receives gas sucked from the treatment case 1. The treatment time of hot water/steam is, for example, not less than 1 minute, but preferably not more than 30 minutes. With respect to superheated vapor, the hank yarn 23 is dried by the superheated vapor and is completely dried by reducing the pressure in the treatment case 1 at the end. Here, the squeezing roller 28 pressurizes the hank yarn, rotates, and thereby squeezes condensed water out of the hank yarn 23.

[0040] As such, for removing ammonia in accordance with this invention, the first step is to reduce the pressure in the treatment case 1 to first remove liquid ammonia, hot water or steam is injected to immediately stop the effect of residual liquid ammonia, and then hot water promotes recrystallization and rearranges the amorphous portion of the cellulose. For superheated vapor, a continuous supply of superheated vapor evaporates most of the ammonia, and reducing the pressure at the end completely removes the ammonia.

[0041] Accordingly, this invention differs from the conventional art of a continuous ammonia dry method, in which a great amount of ammonia is removed by dry heating and residual ammonia is removed by a steam treatment, and from the conventional art of a continuous ammonia wet method, in which the hank yarn 23 is washed in water after dipping in ammonia for a very short time, e.g. a few seconds, or from the hot-air removing method in a conventional batch method.

[0042] In this invention, hot water or steam is injected to immediately stop the liquid ammonia effect and then recrystallization and rearrangement proceed within a certain period of time, so that the hank yarn 23 of cellulose fibers may be treated without a speck, thereby achieving equal coloring.

<D> Removing the hank yarn:

[0043] A process of removing the hank yarn 23 includes the steps of stopping the roller rotation, stopping the heating of the treatment case 1 and of the holding member 2, injecting outside air into the treatment case 1 to maintain normal or ambient pressure, loosening of the coupling mechanism 32 so that the upper case 11 can be separated and lifted from the lower case 12 by means of the lifting device 3, and relieving the pressure from the squeezing roller 28 to remove the treated hank yarn 23 from the holding device 2. For example, the supporting member 24 between the rollers is bent in that the arm 25 is rotated with the pivot pin 26 as the fulcrum to be able to remove the hank yarn 23 from the rollers.

[0044] The mechanism of this invention is now described below. That is, in the traditional understanding, liquid ammonia evenly penetrates into a fabric within a short period of time regardless of its type. Further, crystal conversion is stopped within a short period of time. In addition, steaming after liquid ammonia evaporation is merely for removing residuary ammonia but is not for restructuring the fiber.

[0045] However, according to an extensive research and study by the inventor, the penetration of liquid ammonia, conversion to ammonia cellulose, vaporization, recrystallization, and rearrangement of ammonia cellulose required certain period of time.

<A> Dipping liquid ammonia and converting to ammonia cellulose:

[0046] Liquid ammonia penetration into cellulose fibers by dipping into liquid ammonia is much quicker than that of water due to a smaller surface tension of liquid ammonia. However, cellulose fibers, at the outer side or yarn where the liquid ammonia initially penetrates, immediately swell and shrink, thereby squeezing and collapsing capillaries or lumens inside of the fiber to prevent smooth liquid ammonia penetration. Liquid ammonia penetrates initially into the amorphous portion of the cellulose and converts it to ammonia cellulose. Then, an initially crystallized portion is swelled sequentially from the circumference of the crystal region and is converted to ammonia cellulose.

<B> Vaporization of ammonia, recrystallization, and rearrangement:

[0047] When ammonia evaporates due to the heating, crystals of the cellulose III are gradually created at the region where ammonia is removed, and rearrangement of the fiber bundles occurs at the initial amorphous portion of the cellulose. This recrystallization and rearrangement occur simultaneously and proceed more quickly as the temperature increases. At portions where ammonia remains due to a delay in being removed/dried, ammonia cellulose conversion still continues. At the same time, a treatment time for rearranging fibers is reduced due to the delay, and therefore the fiber structure of the quickly dried portion becomes different from the fiber structure of the portion dried slowly.

[0048] A remarkable point in the process described above is that liquid ammonia penetration, ammonia cellulose conversion, ammonia evaporation, and rearrangement and recrystallization may require a certain period of time.

[0049] Accordingly, the traditional batch-type hot-air dry method on the other hand leaves a clear problem, i.e. in that it causes a problem of leaving a penetration speck in the liquid ammonia penetration process. For instance, an outer circumferential part of the yarn, if cheese, initially absorbs liquid ammonia, swells, shrinks, squeezes its inside, and prevents liquid ammonia from penetrating to the inside. Then, in the drying process, even if the outer circumferential part of the yarn dries, the outer layer of dried yarn functions as a heat insulation layer to prevent its inside from being heated, thereby leaving the inside undried and automatically creating a dry speck.

[0050] As a result, there exist differences between the circumferential and inner parts of the yarn with respect to the degree of ammonia cellulose conversion and the degree of recrystallization from ammonia cellulose to cellulose III and the rearrangement of the amorphous portion of cellulose to ammonia cellulose. As a result, coloring of the processed yarn is not uniform.

[0051] On the other hand, this invention makes use of the detailed understanding of the effect and function of the respective process, wherein the hank yarn is dipped in liquid ammonia, liquid ammonia is discharged from the treatment case, the pressure is reduced in the treatment case, and hot water or steam is injected to uniformly stop the liquid ammonia effect within a short period of time, thereby unifying recrystallization and rearrangement time to prevent a dyeing speck from occuring.

[0052] More concretely, this invention is to reserve sufficient penetration time to eliminate a penetration speck, to remove liquid ammonia by discharging liquid ammonia, to reduce the pressure in the treatment case, to inject hot water or steam to stop the residual liquid ammonia effect at a stretch within a short period of time, and to uniformly promote recrystallization and rearrangement.

Claims

1. A processor for a liquid ammonia treatment of hank yarn, which comprises:

    a holding member (2) for loading hank yarn (23) of cellulose fibers thereon,
    a treatment case (1) capable of receiving said holding member (2);
    a feeder (51) for supplying liquid ammonia into said treatment case (1);
    a receiver tank (53) for receiving said liquid ammonia discharged from said treatment case (1);
    a pressure reducing device (52) for reducing the pressure in said treatment case (1); and
    a hot water/steam production device (5) for supplying hot water/steam into said treatment case (1).

2. The processor for a liquid ammonia treatment of hank yarn as claimed in claim 1, which further comprises
    a heating and cooling device (15,16,19) for heating and cooling said treatment case (1).

3. The processor for a liquid ammonia treatment of hank yarn as claimed in claim 2, wherein

    said heating and cooling device (15,16,19) is installed on an inner or outer surface of said treatment case (1), and
    said heating and cooling device comprises a jacket (19) into which a heating or cooling fluid is to be injected.

4. The processor for a liquid ammonia treatment of hank yarn as claimed in any one of claims 1-3, wherein said holding member (2) comprises a hollow member into which a fluid can be injected.

5. A process for a liquid ammonia treatment of hank yarn, which comprises the steps of:

    treating said hank yarn (23) with liquid ammonia;
    removing said liquid ammonia from said hank yarn (23);
    exposing said hank yarn (23) to a reduced pressure atmosphere;
    treating said hank yarn (23) with hot water or steam; and
    exposing said hank yarn (23) to a reduced pressure atmosphere.

6. The process for liquid ammonia treatment of hank yarn as claimed in claim 5, which comprises the steps of:

    placing said hank yarn (23) of cellulose fibers in a treatment case (1);
    injecting liquid ammonia into said treatment case (1) to treat said hank yarn (23) with said liquid ammonia;
    removing said liquid ammonia from said treatment case (1);
    reducing the pressure in said treatment case (1) to expose said hank yarn (23) to a reduced pressure atmosphere;
    heating said treatment case (1);
    supplying hot water or steam into said treatment case (1) to treat said hank yarn (23) with said hot water or steam;
    reducing the pressure in said treatment case (1) to expose said hank yarn (23) to a reduced pressure atmosphere; and
    removing said hank yarn (23) from said treatment case (1) .

7. The process for liquid ammonia treatment of hank yarn as claimed in claim 6, which comprises the steps of:

    reducing the pressure in said treatment case (1) and
    cooling said treatment case (1) after placing said hank yarn of cellulose fiber in said treatment case (1); and
    cooling said treatment case (1) before removing said hank yarn (23) from said treatment case (1).

8. The process for a liquid ammonia treatment of hank yarn as claimed in claim 6 or 7, wherein

    said hank yarn is loaded on a plurality rollers (21,22);
    said hank yarn (23) on said rollers (21,22) is placed in said treatment case (1); and
    said liquid ammonia is injected into said treatment case (1) and said hank yarn (23) is treated with said liquid ammonia while rotating said rollers (21,22).

FIG. 1

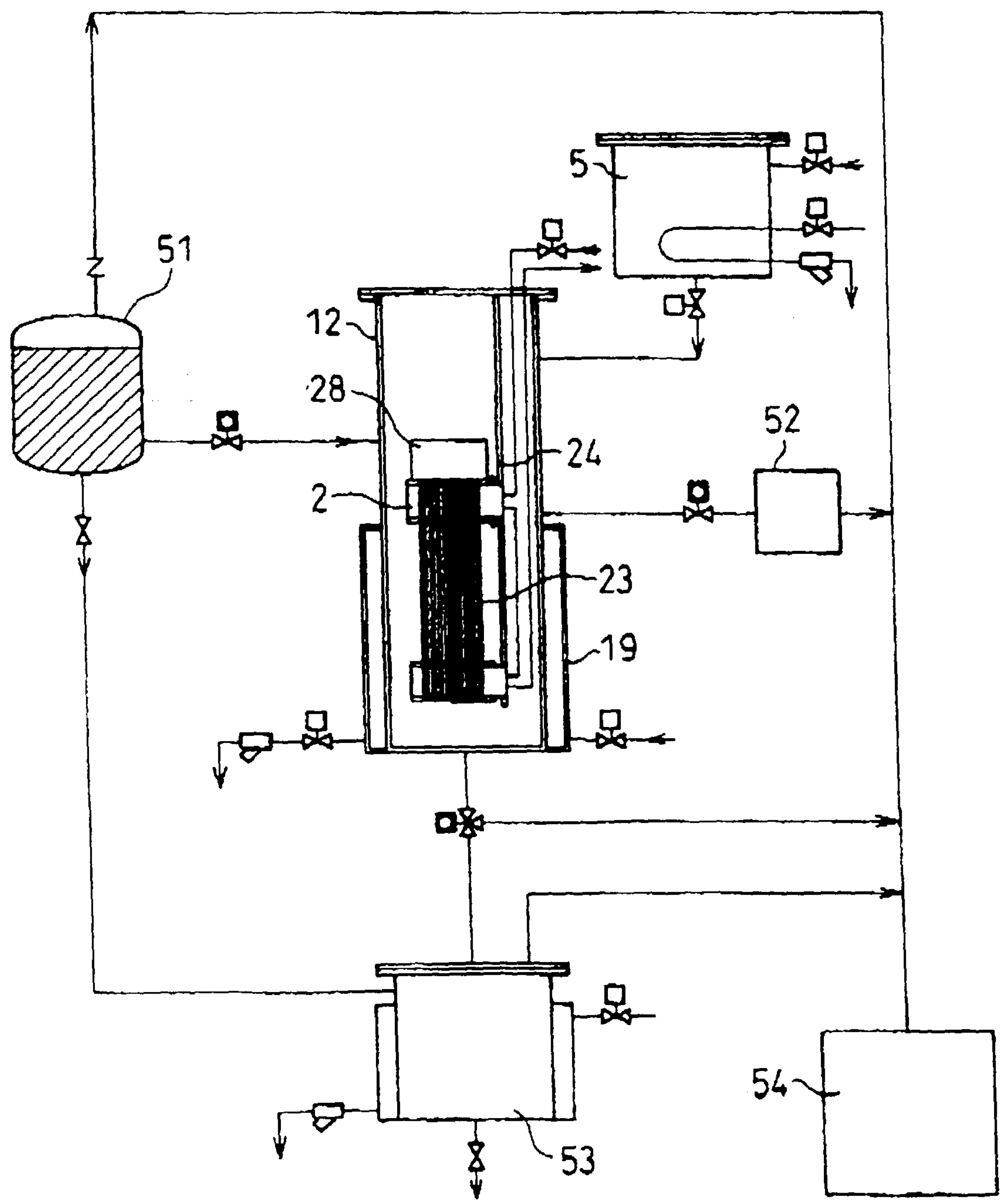

FIG. 2

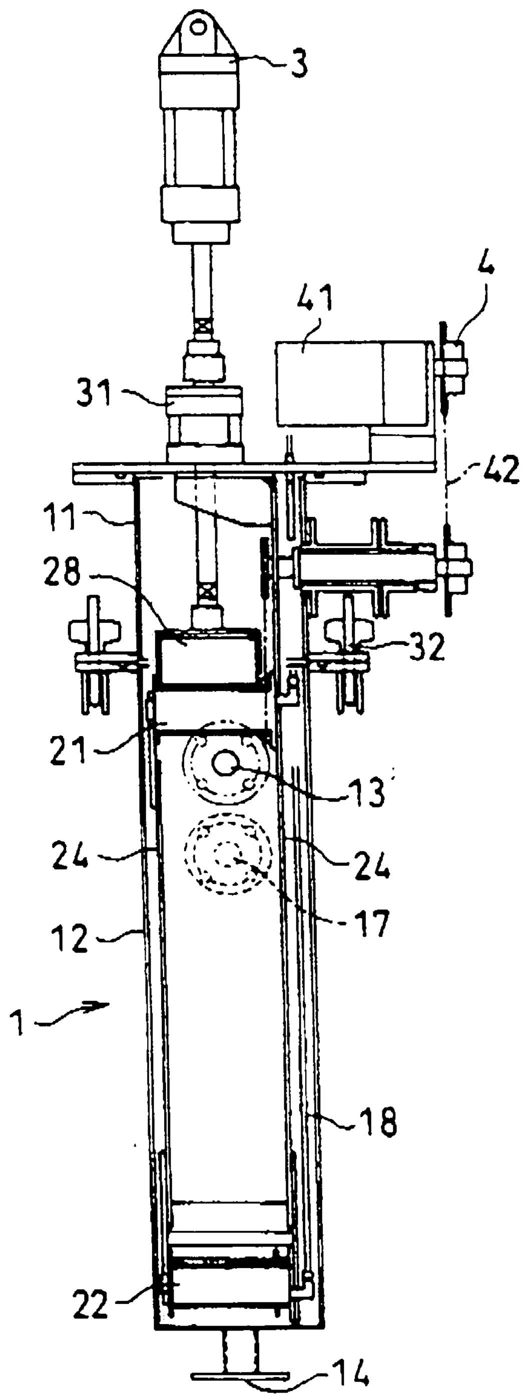

FIG. 3

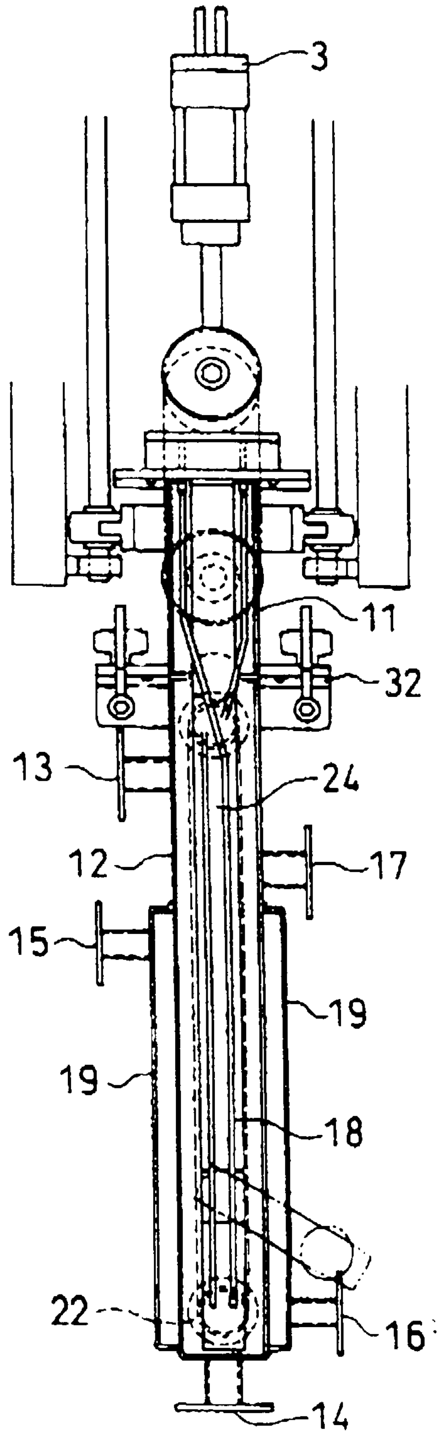

FIG. 4

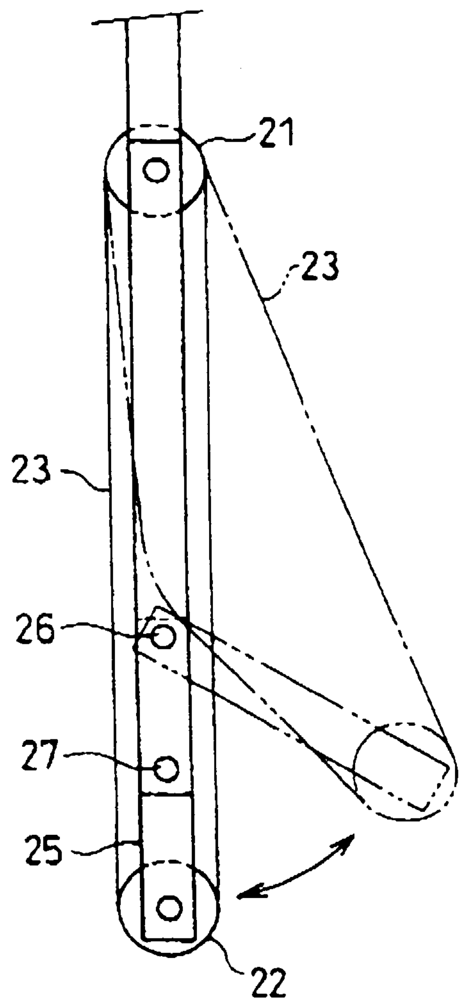

FIG. 5