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(54) METHOD FOR TREATMENT OF WATER AND WASTEWATER

VERFAHREN ZUR BEHANDLUNG VON WASSER UND ABWASSER

PROCEDE DE TRAITEMENT DE L'EAU ET DES EAUX RESIDUAIRES

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(56) References cited:
DE-A- 2 731 939 GB-A- 1 398 603
US-A- 4 675 112 US-A- 4 997 573

- **PATENT ABSTRACTS OF JAPAN vol. 014, no. 526 (C-0779), 19 November 1990 (1990-11-19) & JP 02 218494 A (HIKARI SEIKO KK), 31 August 1990 (1990-08-31)**
- **PATENT ABSTRACTS OF JAPAN vol. 010, no. 156 (C-351), 5 June 1986 (1986-06-05) & JP 61 011196 A (MITSUBISHI JUKOGYO KK;OTHERS: 01), 18 January 1986 (1986-01-18)**
- **PATENT ABSTRACTS OF JAPAN vol. 010, no. 156 (C-351), 5 June 1986 (1986-06-05) & JP 61 011193 A (MITSUBISHI JUKOGYO KK), 18 January 1986 (1986-01-18)**

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an improved process for removing dissolved and suspended solids from water and wastewater, with a subsequent improvement in the dewatering characteristics of the removed solids.

BACKGROUND

[0002] In order to utilize water for drinking purposes, or to treat wastewater for discharge, it may be desired to remove various dissolved and suspended constituents. These constituents may include heavy metals, oil and grease, calcium, magnesium, iron, silica, and dissolved and suspended organic material. While the quality of water varies greatly between sources, it almost always has one or more of the above constituents. Removal of these constituents is typically done utilizing a physical/chemical treatment process. This type of process uses a combination of chemical reactions and physical separation processes to separate and remove the constituents from the water in a solid form.

SUMMARY OF THE INVENTION

[0003] In one embodiment, the present invention is directed to a method for treating water as claimed in claim 1.

[0004] Other advantages, novel features, and objects of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings, some of which are schematic and which are not intended to be drawn to scale. In the figures, each identical or nearly identical component that is illustrated in various figures is represented by a single numeral. For purposes of clarity, not every component is labeled in every figure, nor is every component of each embodiment of the invention shown where illustration is not necessary to allow those of ordinary skill in the art to understand the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005]

FIG. 1 is a plan view of a prior art treatment process;
FIG. 2 is a plan view of another prior art treatment process;
FIG. 3 is a plan view of another prior art treatment process;
FIG. 4 is a process flow diagram ; and
FIG. 5 is a plan view of one embodiment of the present invention.

DETAILED DESCRIPTION

[0006] The present invention is directed to a method for the treatment of water and wastewater. In one aspect, the invention combines elements of water treatment processes using sludge recycle and elements of processes using ballast into a new method achieving improved efficiency.

[0007] Conventional physical/chemical treatment processes may include some or all of the following steps:

Chemical Precipitation: a chemical reaction that changes the solubility of dissolved compounds in the water, resulting in the precipitation of the compounds and the formation of colloid particles;
Coagulation/Flocculation: Destabilization of colloid particles and aggregation of the colloid particles into larger aggregates, thereby converting the particles from a stable suspension to an unstable one;
Sedimentation: Settling of the aggregates and separation of the settled solids from the liquid in the form of sludge;
Thickening: A settling process used to increase the solids content and reduce the water content of sludge removed in the sedimentation process; and
Filtration: removal of residual suspended solids in the water through mechanical filtration.

[0008] A typical prior art physical/chemical treatment process is illustrated in FIG. 1, and consists of a chemical reaction tank 1 into which chemical 20 and water 21 are added, a flash mix tank 2 into which a coagulant 22 is added, a flocculation tank 3, a clarifier 4, a thickener 5 producing concentrated sludge 23, and effluent filters 6 producing treated water 24. This typical system utilizes a significant amount of space for installation, requires purchase and installation of various treatment units and has relatively high operating costs.

[0009] Numerous technologies have been developed over the years that are designed to maximize the efficiency and minimize the costs of each of the steps performed in a physical/chemical treatment process. Examples of such designs are disclosed in U.S. Patent Nos. 4,388,195, 5,03 9,428, 5,730,864, 5,770,091, 6,210,587, and 6,277,285. The current technologies typically attempt to increase the coagulation and sedimentation rate of the suspended particles in the water. The coagulation and settling rates are influenced by a variety of factors, including the type and density of the particle and the concentration of solids being settled. Typically, increasing the concentration and density of the solids increases the solids settling rate, resulting in smaller equipment sizes, improved effluent quality and increased sludge solids concentration. Particle concentration and/or density is typically increased either through the recycle of settled sludge, or through the addition of a ballast material. These two processes are discussed in more detail below.

[0010] An example of collection and recycle of settled sludge is described in U.S. Pat. No. 3,738,932 and is illustrated in FIG. 2. In this process, a portion of the settled sludge 25 from a sedimentation tank 9 is recycled and reacted with an alkaline slurry stream 26 in a mixing vessel 7. The alkaline slurry is typically a lime slurry mixture. The mixed slurry/sludge stream is then added to the water/wastewater stream 27 that is to be treated. The mixture is reacted in a vessel 8 and then flows to the sedimentation step. On a mass basis, the amount of sludge recycled is on the order of twenty times the amount removed. For most compounds, the recycle of sludge back to the alkaline slurry stream results in the formation of a dense solid, which settles and dewaters well. For metal hydroxide sludges, the final dewatered sludge will contain typically 30-50% water, compared to 70% water without the recycle process. This results in a much lower sludge volume that must be handled and disposed.

[0011] There are several drawbacks to collection and recycle of settled sludge. First, the process is dependent upon the formation of a sufficient mass of sludge in order to operate effectively. During the initial start-up period, the system operates relatively poorly. This makes the process unsuitable for batch or intermittent treatment processes. Second, while the solids settle well, the settling rate is still well below that obtainable by addition of a ballast material. Therefore, the sedimentation equipment must be larger in size. Finally, the process may result in relatively high levels of very fine particulate suspended solids levels in the effluent water. Depending upon the quality requirements, this may require installation of filtration equipment after the sedimentation system.

[0012] In processes using addition of ballast material, an inert granular material, typically sand, is injected into the chemical precipitation step of the treatment process. An example of this process is described in U.S. Pat. No. 4,927,543, and is illustrated in FIG. 3. In this process, the untreated water is mixed with chemicals and ballast material in a reaction tank. The water is then sent to a coagulation tank 10, where the particles aggregate around the ballast material. The water, with the coagulated solids, flows to a sedimentation tank 11, where the solids separate by gravity. The clarified water is discharged and the solids are sent to a separator 12. Separator 12 separates the high-density ballast material from the lower density settled solids. The separator recovers the ballast material for recycle back to the reaction tank. The lower density settled solids are typically sent to additional treatment steps in order to remove water and produce a solid waste for disposal. The ballast material greatly increases the sedimentation rate of the solids, thereby reducing the equipment size required for the sedimentation tank. The process also improves the removal efficiency of the solids, when compared to conventional clarification. However, the ballast/sludge separation step typically produces a low concentration sludge product. It is often necessary to install additional sludge thickening equipment in order to produce a sludge suitable for dewatering and disposal.

[0013] In one embodiment, a method of treating water according to the present invention includes mixing sludge and precipitant with the water to be treated, mixing ballast with the water, and separating the water into treated water and sludge. Some or all of the separated sludge is recycled for mixing with the precipitant and water to be treated. Accordingly, in this embodiment, the present invention combines collection and recycle of sludge with addition of ballast to treat water in a manner never previously done. The combination of these processes has not be achieved before the present, and, as a result, the long-felt, but unaddressed need for improved treatment efficiency has only now been addressed.

[0014] Mixing sludge and precipitant with the water to be treated may be performed in any manner and using any materials or equipment that allow precipitation of a contaminant or contaminants. By contaminant, it is meant any material that is desired to be removed from the water to be treated. The precipitant may be any compound, mixture, chemical, solution, or the like, capable of precipitating a contaminant. For example, the precipitant may be a material that lowers the solubility of the contaminant or a material that reacts with the contaminant to form a material less soluble than the contaminant.

[0015] In one example embodiment of the invention, the precipitant is an alkaline reagent. The alkaline reagent may be any material having a pH greater than about 7 capable of interacting with the sludge and the water to precipitate a contaminant. For example, the alkaline reagent may include an aqueous slurry of calcium hydroxide ($Ca(OH)_2$) or magnesium hydroxide ($Mg(OH)_2$). As an alternate example, the alkaline reagent may be an aqueous solution of sodium hydroxide (NaOH). In embodiments where softening may be desired, a softener, such as soda ash (Na_2CO_3), may be added as an additional precipitant. In some embodiments, materials that improve precipitation, but are not necessarily precipitants, may be added with the precipitant. For example, a material that improves the performance of a precipitant may be added.

[0016] Any amount of precipitant may be mixed with the sludge and water so long as there is sufficient precipitation of the material desired to be removed from the water for a particular treatment application. The preferred amount of precipitant for a particular embodiment may vary with the precipitant, contaminant type and concentration, and the like, and may be selected by the exercise of ordinary skill in the art. Where precipitant is not added in pure form, for example where the precipitant is an alkaline reagent in slurry form, the concentration of precipitant reacted with the sludge and water may vary with the precipitant and manner of its addition. Higher concentrations of precipitant are generally preferred because such concentrations may reduce the required size of equipment used to perform the mixing and the hydraulic flow rate in downstream equipment.

[0017] The water to be treated may be any water from which a contaminant may be precipitated by a precipitant. In one embodiment, the water to be treated may be an acidic wastewater containing dissolved metals. In this embodiment, the precipitant, which may be an alkaline reagent, may neutralize the acidity of the water, resulting in the precipitation of metal hydroxides and/or metal oxides. If iron is one of the metals present, an additional precipitant, such as oxygen, may be added in order to convert the iron from the ferrous (Fe^{+2}) to the ferric (Fe^{+3}) form, which is substantially less soluble than the ferrous form, resulting in better precipitation.

[0018] In another embodiment, the water to be treated may contain relatively high concentrations of calcium and magnesium. These two compounds are responsible for hardness in water. High levels of hardness may cause various adverse affects when the water is utilized for either potable or non-potable uses. Calcium and magnesium may be removed through chemical precipitation by the precipitant, which, in this embodiment, may be an alkaline reagent or soda ash. The calcium may be precipitated as calcium carbonate ($CaCO_3$) and the magnesium may be precipitated as magnesium hydroxide ($Mg(OH)_2$). The reactions involved in the softening process are as follows:

$$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3(s) + 2H_2O$$

$$Ca_2{}^{+}\_+ 2HCO_3^- + Ca(OH)_2 \rightarrow 2CaCO_3(s) + 2H_2O$$

$$Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3(s)\_2\ Na^+$$

$$Mg^{2+} + 2HCO_3^- + 2Ca(OH)_2 \rightarrow 2CaCO_3(s) + Mg(OH)_2(s) + 2H_2O$$

$$Mg^{2+} + Ca(OH)_2 \rightarrow Mg(OH)_2(s) + Ca^+$$

$$Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3(s) + 2Na^+$$

These precipitation reactions are similar to those described above for metal precipitation, however, soda ash may also be used to facilitate magnesium removal.

[0019] Other dissolved constituents present in water or wastewater may be removed by the present invention. For example, dissolved silica may be removed by use of an appropriate precipitant. For example, aluminum and iron containing compounds, such as salts thereof, have been found to be effective precipitants for silica. Suitable compounds include ferric sulfate, ferric chloride and aluminum hydroxide. Any amount of iron or aluminum containing compounds may be added that precipitate the desired amount of silica. The amount of iron or aluminum containing compounds added may be proportional to the amount of silica to be precipitated. For example, in one embodiment, about 3 to about 5 grams of aluminum containing compounds, or about 5 to about 10 grams of iron containing compounds, may be added for each gram of silica desired to be precipitated. These precipitants may also be combined with other precipitants, such as an alkaline reagent and, in some cases, may produce synergistic effects. As another example, fluoride has been found to be able to be precipitated by calcium chloride, which may also be suitable as a precipitant for other materials. Accordingly, it should be understood that the specific embodiments disclosed herein are by way of example and are not intended to identify all potential constituents that may be removed, nor all the precipitants that may facilitate such removal.

[0020] Whatever the nature of the water to be treated and related precipitation reaction, the precipitated compounds may be adsorbed onto sludge particles, forming crystalline particles. These crystalline particles may settle faster, dewater more readily and hold less water than solids formed from a conventional precipitation process not using recycled sludge. The crystalline particles also may be smaller, with a much narrower size range than conventional precipitation particles. The particle size distribution for the crystalline particles is typically in the range of about 1 to about 8 microns, versus a range of about 1 to about 45 microns for conventional precipitation particles. These smaller, more uniform particles also may be capable of flocculating into much more compact, dense agglomerations, thereby resulting in the improved settling and dewatering characteristics mentioned previously.

[0021] Mixing of the sludge and the precipitant with the water to be treated may be performed for any amount of time that results in sufficient precipitation of the dissolved constituents. Such dissolved constituents may precipitate into colloidal form. The amount of time sufficient for precipitation may vary depending upon the precipitant used, but, in a typical embodiment using an alkaline reagent, the minimum time required may be about 5 minutes and the total time is preferably about 20 to about 40 minutes. If sufficient mixing and precipitation time are not provided, it may adversely impact treatment efficiency due to incomplete precipitation and crystal growth. If excess mixing and precipitation time is provided, larger equipment may be required, increasing capital and operating costs. In an embodiment where the precipitant affects the pH of the water, such as where it is an alkaline reagent, the precipitation reaction may be performed in two stages, which may improve process control by minimizing the pH change in each stage. In such an embodiment, each stage may have a reaction time selected as discussed above.

[0022] Mixing a first sludge and a precipitant with the water to be treated may be performed in any manner and using any equipment capable of generating adequate mixing to allow the desired precipitation. For example, a commercial mixing vessel may be used. Mixing may be provided by an agitator, which may be any device capable of creating the desired shear rates to achieve adequate mixing. For example, the mixing may be provided by an agitator including a commercial motor-driven impeller. In other embodiments, mixing may be done in-line, possibly eliminating vessels and/or agitators. In-line mixing, in some cases supplemented by the addition of a static mixer in the line, may be use in any mixing step in the present invention.

[0023] In an preferred embodiment, mixing of the sludge and the precipitant with the water to be treated is performed using a draft tube reactor for the continuous crystallization and/or precipitation of solids. The draft tube reactor may utilize a specially designed agitator to recirculate solids within the reactor. The reactor design may permit large circulation rates of solids through a series of underflow and overflow baffles. The size of the crystal and/or precipitant may be controllable by a number of different factors including; the point at which the feed enters the unit, the means of withdrawal of the solids and the re-circulation ratio.

[0024] In some embodiments, the sludge and the precipitant may be mixed prior to being mixed with the water to be treated. In such an embodiment, the precipitant may react with the sludge and improve the results of the subsequent precipitation when mixed with the water. For example, without wishing to be limited by any particular theory, it is believed that certain precipitants, such as alkaline reagents, may interact with the surface of sludge particles, providing sites for precipitation.

[0025] Where the sludge is mixed with a precipitant prior to mixing with the water to be treated, a conventional mixer as described above may be used to provide the mixing. Any mixing time may be used as long as adequate mixing and interaction time is provided. For example, in some embodiments where the precipitant is an alkaline reagent, a minimum mixing time on the order of about 5-10 seconds is preferred. While there is no maximum mixing time, longer mixing times may lead to larger mixing vessels and increased capital costs. In one embodiment in which the precipitant is in the form of an alkaline reagent, a preferred total vessel size provides between about 2 and about 5 minutes residence time.

[0026] Whether mixed with the precipitant first, or directly with the water, any amount of sludge may be mixed with the water so long as it provides sufficient recycle solids to generate a desired settling rate. In one embodiment, the amount of sludge may be dependent upon the concentration of dissolved material in the water to be treated. In one such embodiment where the precipitant is an alkaline reagent, the amount of recycle solids may be in the range of about 5 to about 100 pounds (2.3 - 45.4 kg) of recycle solids per pound (0.45 kg) of solids formed in the water to be treated for a typical water. Preferably, the amount of sludge added is as low as possible to decrease the capacity required in downstream equipment, yet not so low that the desired settling rate or precipitation efficiency is compromised. Accordingly, in one embodiment using alkaline reagent as a precipitant, the preferred range of sludge added is about 10 to about 30 pounds (4.5 - 13.6 kg) of sludge per pound (0.45 kg) of solids formed.

[0027] Where the sludge to be mixed with the alkaline reagent and the water is recycled, it may be recycled in any manner. For example, ballast in the sludge may or may not be fully separated from the sludge. In an embodiment where the ballast is not separated from the sludge, a portion of the separated sludge generated by the process may be recycled directly back to be mixed with the precipitant and water to be treated without treatment.

[0028] The act of mixing the water to be treated with a ballast may be performed in any manner, with any material, and using any equipment that distributes the ballast a thoroughly as desired. The ballast material may be any insoluble material or materials with a particle size equal to or greater than that of the solids being treated. As used herein, a material described as "insoluble" does not dissolve appreciably in the environment to which it will be exposed over a typical usage period. In one embodiment, the ballast material may also have a density greater than the liquid and solids being treated. In some embodiments, ballast may be chemically or biologically active and may be at least slightly soluble. By way of example, ballast may include micro-sand and/or carbon particles. Preferably, ballast particles are at least 20 microns, and preferably between about 20 microns and about 500 microns, in diameter. The ballast may be added at any rate that produces the desired settling rate. Smaller amounts of ballast may result in less efficient settling, while larger amounts of ballast may increase handling costs. In one embodiment, the ballast is added at a dosage rate of about 1 to about 10 grams/liter. Ballast may be fresh (unused) material, recycled, cleaned ballast, or recycled, uncleaned ballast.

[0029] To improve subsequent flocculation, if any, and separation, the water and precipitated colloids therein may be destabilized. Destabilization may be performed in any manner that sufficiently destabilizes the water and colloids to allow adequate flocculation. For example, destabilization may be performed by adding a material, such as a coagulant, capable of destabilizing colloid particles formed during precipitation. Destabilizing the colloid particles may allow them to flocculate and settle.

[0030] In a preferred embodiment, mixing the ballast with the water and destabilizing the water and colloid particles may be performed together in a single mixing vessel. In such an embodiment, the mixing rate may be sufficient to distribute the insoluble material and the coagulant. Accordingly, it is preferred to use a relatively high mixing rate. A relatively high mixing rate may also mechanically aid destabilization. In one embodiment, the speed gradient in the mixing vessel may be approximately 1,000 s^{-1} to 4,000 s^{-1}, and is preferably in the range of about 3,000 s^{-1} to about 3,500 s^{-1}. The residence time for the combined ballast addition and destabilization is preferably at least one minute.

[0031] To improve separation, contaminants precipitated in the water may be flocculated. Flocculation may be performed in any manner and using any equipment that allows flocs to form as desired. In a preferred embodiment, flocculating is performed as a low energy mixing stage, which allows for the formation of large flocculated particles that may separate better. Such mixing may be performed in a mixing vessel or in-line. In one embodiment, the speed gradient for the mixing is in the range of about 300 s^{-1} to about 900 s^{-1}. The mixing time for the flocculation may be approximately four times that of the ballast addition and destabilization.

[0032] Separating the water into clarified water and sludge may be done in any manner and using any equipment that result in a sufficiently clarified water and/or densified sludge for a particular use. The level of water clarity desired may vary with the intended use of the water and whether it is desired to minimize downstream treatment. Similarly, the density of sludge desired may vary with how the sludge is to be treated; denser sludges may be facilitate disposal with less subsequent treatment. The separation may be performed using any separator capable of separating solid from liquid. For example, the separator may be any type of conventional gravity separation unit, such as a clarifier, tube settler, inclined plate separator or any similar device. As an alternate example, the separator may be a filter or screen. In the embodiment illustrated on FIG. 5, the separator is a conventional tube settler with a bottom scraper. Because of the relatively high density and settling rates of the solids in the water, very high overflow rates may be achieved in such a system. For a typical installation, the expected range of overflow rates, using a tube settler, is in the range of about 30 to about 200 m/hr. Higher or lower rates may be achieved depending upon the water characteristics, the precipitants and ballast materials utilized, and the desired effluent and sludge quality.

[0033] Where the separator is a conventional gravity separation unit, the treated, clarified water generally discharges from the top of the separator. Conversely, the sludge is generally collected at the bottom of the separator and pumped for disposal and at least some recycle. If desired, a part of the sludge may be sent for disposal without removal of the ballast material. A part of The sludge may also be used for recycle back to the alkaline reagent-mixing chamber without ballast removal, as mentioned previously. However, in the embodiment illustrated in FIG. 5, the entire sludge volume is sent through a separator. The separator separates the sludge from the ballast material. Part of The sludge may then be discharged, and at least some will be recycled back to be added with precipitant to the water to be treated. The ballast material also may be recycled back to the equipment where it is added to the water, with or without cleaning.

[0034] To separate the ballast from the sludge, this separation may be performed in any manner and using any equipment that produces the desired degree of separation. For example, it is possible to shear the sludge particles from the ballast particles. The sludge and ballast may then be gravity separated based upon the differences in specific gravity between the two. In the embodiment illustrated in FIG. 5, the separation equipment includes a high shear pump 319 feeding to a gravity-settling tank 320. Such a tank may be large enough to allow the ballast material, with its higher specific gravity and settling rate, to settle, but small enough not to allow a significant amount of the sludge, with its lower settling rate, to settle. Other processes and equipment, such as a hydrocyclone, may also be used for this separation procedure.

[0035] One water treatment method is illustrated in FIG. 4. This includes reacting 200 a precipitant in the form of an alkaline reagent 101 with sludge 102 to form a treatment slurry 103. The method also includes reacting 201 treatment slurry 103 with water to be treated 104 to form treated water and suspended solids (collectively 105). The method also includes mixing 202 treated water and suspended solids 105 with an insoluble granular material 106. The method further includes destabilizing 203 treated water and suspended solids 105 and insoluble granular material 106. The method finally includes flocculating 204 treated water and suspended solids 105 and insoluble granular material 106 and separating 205 treated water and suspended solids 105 and insoluble granular material 106 into clarified water 107 and sludge 102.

[0036] A suitable system for carrying out an embodiment of the method of the invention is illustrated in FIG. 5. This system includes an alkaline reagent mixing chamber 300 provided with an alkaline reagent inlet 301, a recycle sludge inlet 302, an agitator 303 and a treatment slurry outlet 304. A reaction chamber 305 is connected to treatment slurry outlet 304 and provided with a water inlet 306, an agitator 303 and a treated water and suspended solids outlet 307. A flash mix chamber 308 is connected to treated water and suspended solids outlet 307 and insoluble granular material outlet 321 and provided with an insoluble granular material inlet 309, a coagulant inlet 310, an agitator 303 and a treated water, suspended solids and granular insoluble material outlet 311. A flocculation chamber 312 is connected to treated water, suspended solids and granular insoluble material outlet 311 and provided with an agitator 303 and a flocculated water outlet 313. The system further includes a separator 314 connected to flocculated water outlet 313 and provided with settling plates 317, a clarified liquid outlet 315, and a sludge outlet 316. A sludge recycle is connected to sludge outlet 316, recycle sludge inlet 302, and a sludge discharge 318. The sludge recycle is includes a high shear pump 319 and a gravity separator 320 for separating sludge and ballast.

[0037] In an alternate embodiment of the present invention, sludge may be mixed with the water to be treated prior to the addition of a precipitant. For example, the sludge may be mixed with the water in a first vessel and then mixed with a precipitant/sludge mixture in a second vessel.

Claims

1. A method of treating water comprising:

(a) mixing a first sludge and a precipitant with water to be treated;
(b) mixing a ballast comprising an insoluble granular material with the water;
(c) separating the so formed water and solids into clarified water and a second sludge;
(d) separating at least a portion of the ballast from the second sludge; and
(e) recycling at least a portion of the second sludge separated from the ballast in step (d) for use as the first sludge.

2. The method of claim 1 wherein mixing the first sludge and the precipitant with the water is performed before mixing the ballast with the water.

3. The method of claim 2 wherein mixing the ballast with water is performed before separating the water into clarified water and the second sludge.

4. The method of claim 1 further comprising: mixing the first sludge and the precipitant with one another prior to mixing them with the water.

5. The method of claim 4 wherein the precipitant is an alkaline reagent.

6. The method of claim 5 wherein the alkaline reagent is selected from the group consisting of calcium hydroxide, magnesium hydroxide, sodium hydroxide, sodium carbonate, and mixtures thereof.

7. The method of claim 1 further comprising: mixing a coagulant with the water.

8. The method of claim 7 wherein mixing the coagulant with the water is performed after mixing the ballast with the water.

9. The method of claim 1 further comprising recycling at least a portion of the separated ballast.

10. The method of claim 1 including destabilizing and flocculating the water prior to the separating in step (c).

11. The method of claim 1 wherein the separating at least a portion of the ballast from the second sludge comprises shear of the sludge particles from the ballast particles followed by gravity separation.

12. The method of claim 1 wherein the water to be treated is acidic wastewater containing dissolved metals.

13. The method of claim 1 wherein the water to be treated includes high concentrations of calcium and/or magnesium, and wherein the precipitant is an alkaline agent or soda ash.

14. The method of claim 13 including chemically precipitating the calcium as calcium carbonate, and chemically precipitating the magnesium as magnesium hydroxide.

Patentansprüche

1. Ein Verfahren zum Aufbereiten von Wasser, das Folgendes beinhaltet:

(a) Mischen eines ersten Schlamms und eines Fällungsmittels mit aufzubereitendem Wasser;

(b) Mischen eines Zuschlagstoffes, der ein unlösliches granuläres Material beinhaltet, mit dem Wasser;
(c) Trennen des so gebildeten Wassers und der Feststoffe in geklärtes Wasser und einen zweiten Schlamm;
(d) Trennen mindestens eines Teils des Zuschlagstoffes von dem zweiten Schlamm und
(e) Wiederverwerten mindestens eines Teils des von dem Zuschlagstoff in Schritt (d) getrennten zweiten Schlamms zur Verwendung als der erste Schlamm.

2. Verfahren gemäß Anspruch 1, wobei das Mischen des ersten Schlamms und des Fällungsmittels mit dem Wasser durchgeführt wird, bevor der Zuschlagstoff mit dem Wasser gemischt wird.

3. Verfahren gemäß Anspruch 2, wobei das Mischen des Zuschlagstoffes mit Wasser durchgeführt wird, bevor das Wasser in geklärtes Wasser und den zweiten Schlamm getrennt wird.

4. Verfahren gemäß Anspruch 1, das ferner Folgendes beinhaltet: Miteinander-Mischen des ersten Schlamms und des Fällungsmittels, bevor sie mit dem Wasser gemischt werden.

5. Verfahren gemäß Anspruch 4, wobei das Fällungsmittel ein alkalisches Reagens ist.

6. Verfahren gemäß Anspruch 5, wobei das alkalische Reagens aus der Gruppe, bestehend aus Calciumhydroxid, Magnesiumhydroxid, Natriumhydroxid, Natriumcarbonat und Mischungen davon, ausgewählt ist.

7. Verfahren gemäß Anspruch 1, das ferner Folgendes beinhaltet: Mischen eines Koagulans mit dem Wasser.

8. Verfahren gemäß Anspruch 7, wobei das Mischen des Koagulans mit dem Wasser nach dem Mischen des Zuschlagstoffes mit dem Wasser durchgeführt wird.

9. Verfahren gemäß Anspruch 1, das ferner das Wiederverwerten mindestens eines Teils des getrennten Zuschlagstoffes beinhaltet.

10. Verfahren gemäß Anspruch 1, das das Destabilisieren und Flocken des Wassers vor dem Trennen in Schritt (c) beinhaltet.

11. Verfahren gemäß Anspruch 1, wobei das Trennen mindestens eines Teils des Zuschlagstoffes von dem zweiten Schlamm das Scheren der Schlammpartikel von den Zuschlagstoffpartikeln, gefolgt von einer Schweretrennung, beinhaltet.

12. Verfahren gemäß Anspruch 1, wobei das aufzubereitende Wasser saures Abwasser ist, das gelöste Metalle enthält.

13. Verfahren gemäß Anspruch 1, wobei das aufzubereitende Wasser hohe Konzentrationen an Calcium und/oder Magnesium umfasst und wobei das Fällungsmittel ein alkalisches Mittel oder wasserfreie Soda ist.

14. Verfahren gemäß Anspruch 13, das das chemische Fällen des Calciums als Calciumcarbonat und das chemische Fällen des Magnesiums als Magnesiumhydroxid umfasst.

Revendications

1. Un procédé pour traiter de l'eau comprenant :

(a) le mélange d'une première boue et d'un précipitant avec de l'eau à traiter ;
(b) le mélange d'un lest comprenant un matériau granulaire insoluble avec l'eau ;
(c) la séparation de l'eau et des solides ainsi formés afin d'obtenir une eau clarifiée et une deuxième boue ;
(d) la séparation d'au moins une portion du lest de la deuxième boue ; et
(e) le recyclage d'au moins une portion de la deuxième boue séparée du lest à l'étape (d) pour l'utiliser comme première boue.

2. Le procédé de la revendication 1 où le mélange de la première boue et du précipitant avec l'eau est effectué avant le mélange du lest avec l'eau.

3. Le procédé de la revendication 2 où le mélange du lest avec de l'eau est effectué avant la séparation de l'eau afin d'obtenir de l'eau clarifiée et la deuxième boue.

4. Le procédé de la revendication 1 comprenant en outre : le mélange de la première boue et du précipitant l'un avec l'autre préalablement au mélange de ceux-ci avec l'eau.

5. Le procédé de la revendication 4 où le précipitant est un réactif alcalin.

6. Le procédé de la revendication 5 où le réactif alcalin est sélectionné dans le groupe consistant en hydroxyde de calcium, hydroxyde de magnésium, hydroxyde de sodium, carbonate de sodium, et des mélanges de ceux-ci.

7. Le procédé de la revendication 1 comprenant en outre : le mélange d'un coagulant avec l'eau.

8. Le procédé de la revendication 7 où le mélange du coagulant avec l'eau est effectué après le mélange du lest avec l'eau.

9. Le procédé de la revendication 1 comprenant en outre le recyclage d'au moins une portion du lest séparé.

10. Le procédé de la revendication 1 incluant la déstabilisation et la floculation de l'eau préalablement à la séparation à l'étape (c).

11. Le procédé de la revendication 1 où la séparation d'au moins une portion du lest de la deuxième boue comprend la séparation par cisaillement des particules de boue des particules de lest suivi d'une séparation par gravité.

12. Le procédé de la revendication 1 où l'eau à traiter est de l'eau usée acide contenant des métaux dissous.

13. Le procédé de la revendication 1 où l'eau à traiter inclut des concentrations élevées de calcium et/ou de magnésium, et où le précipitant est un agent alcalin ou des cristaux de soude.

14. Le procédé de la revendication 13 incluant la précipitation chimique du calcium en carbonate de calcium, et la précipitation chimique du magnésium en hydroxyde de magnésium.

FIG 1
Prior Art

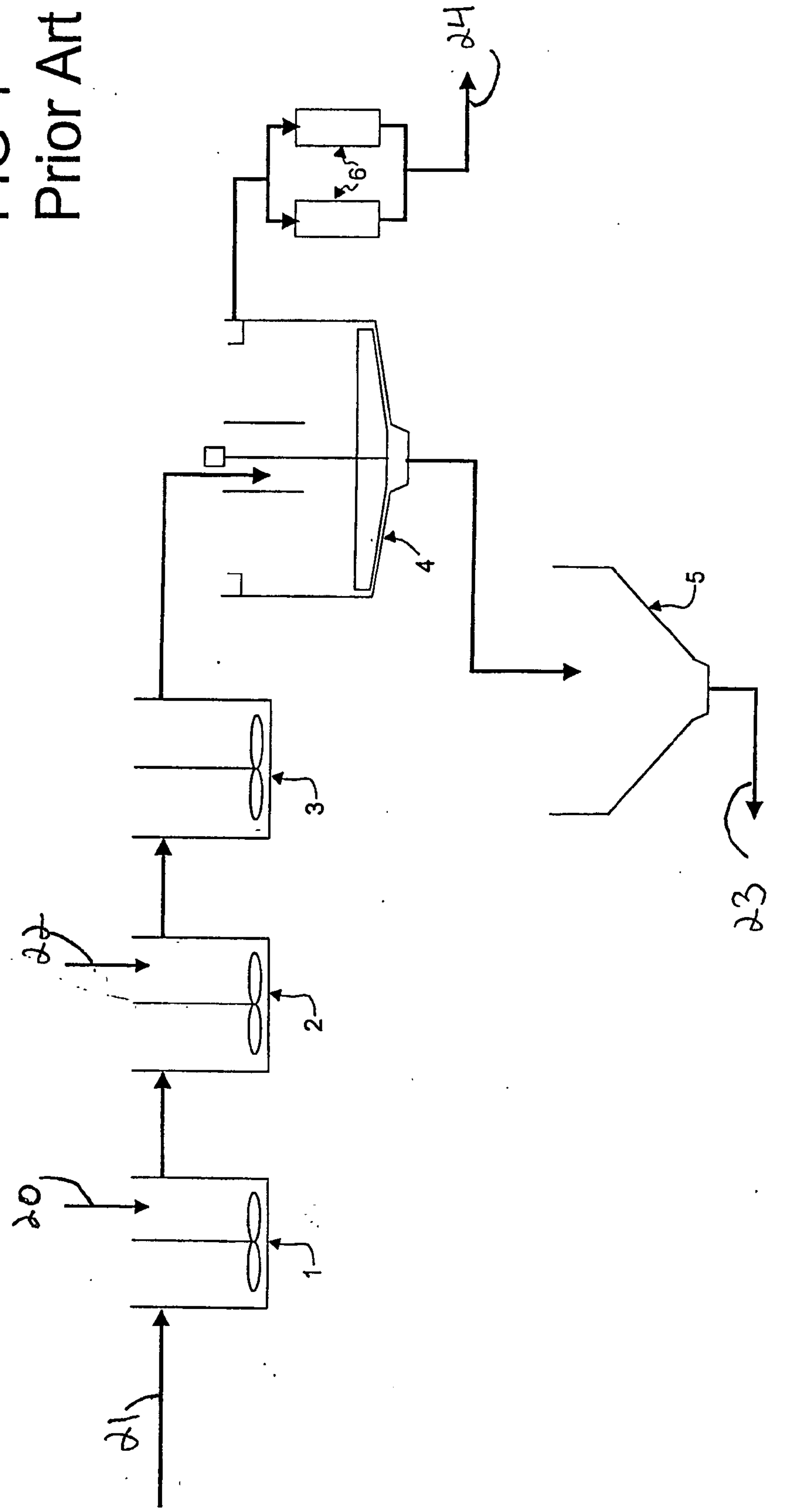

FIG 2
Prior Art

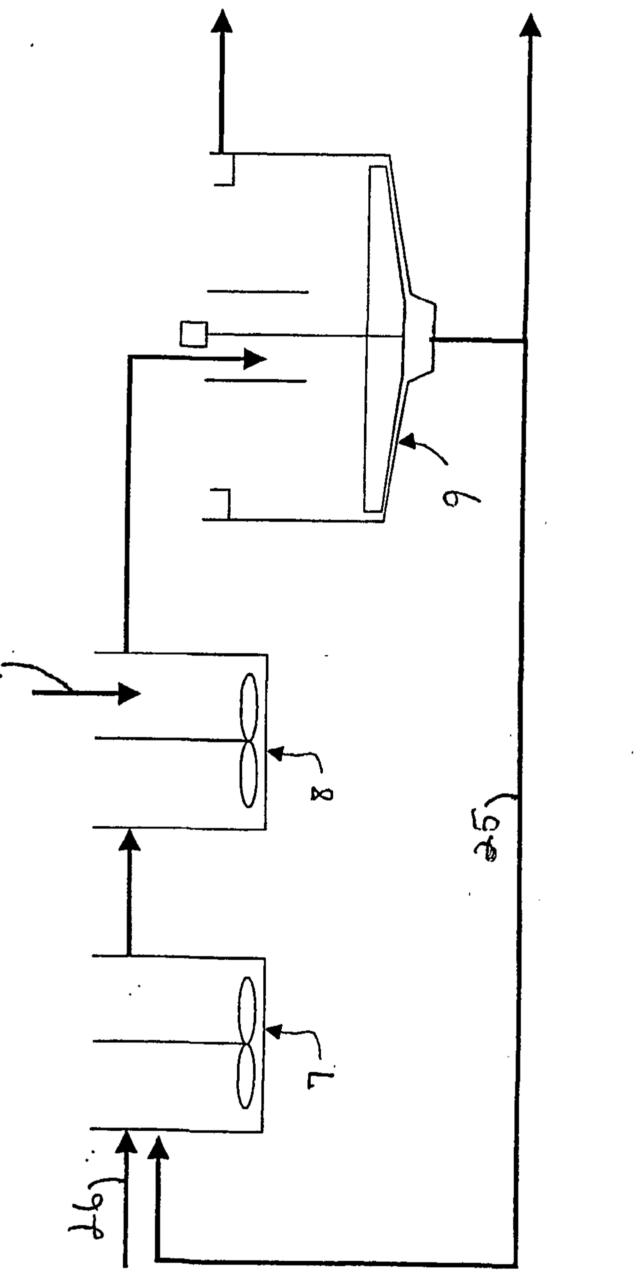

FIG 3
Prior Art

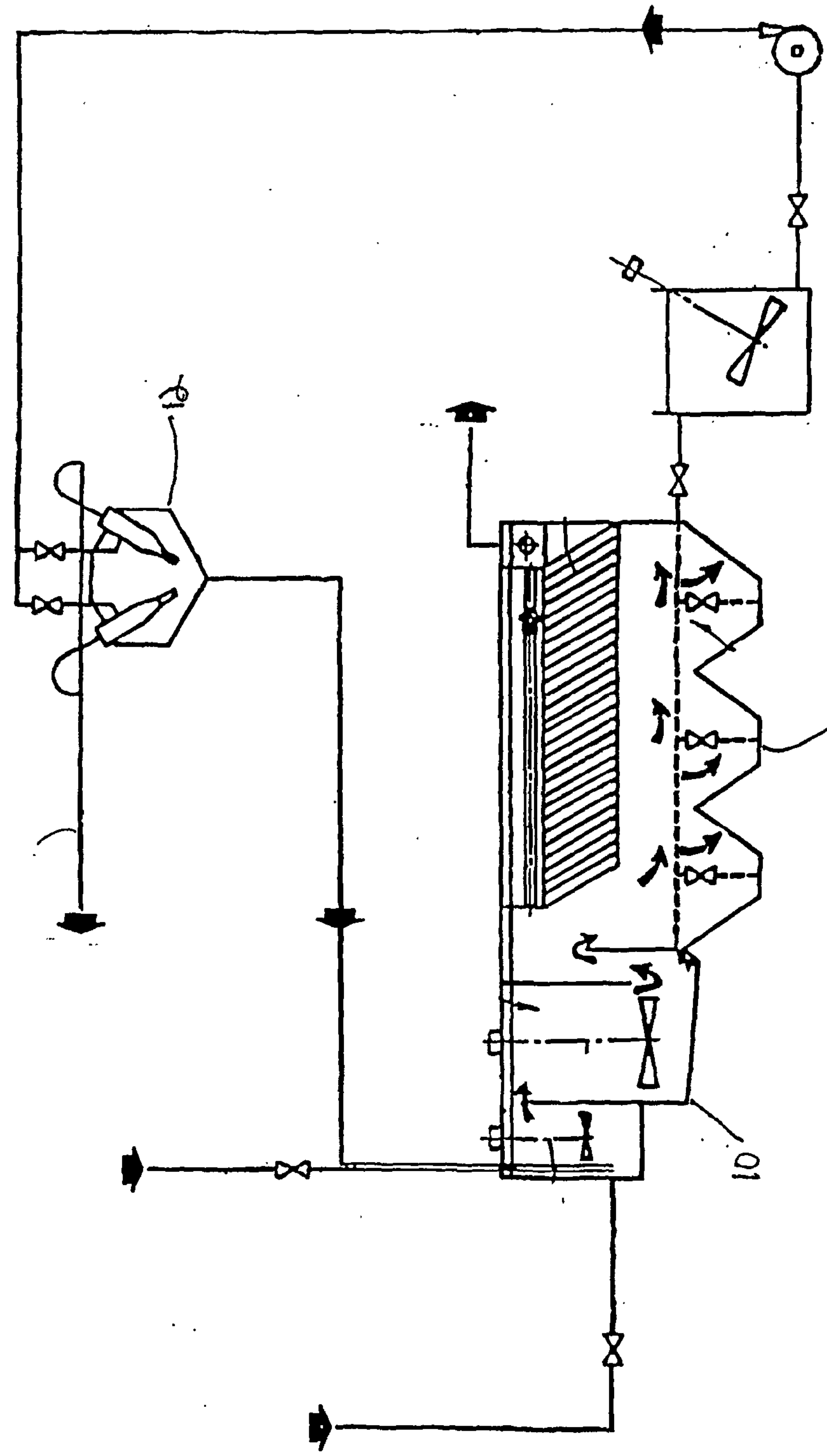

FIG 4

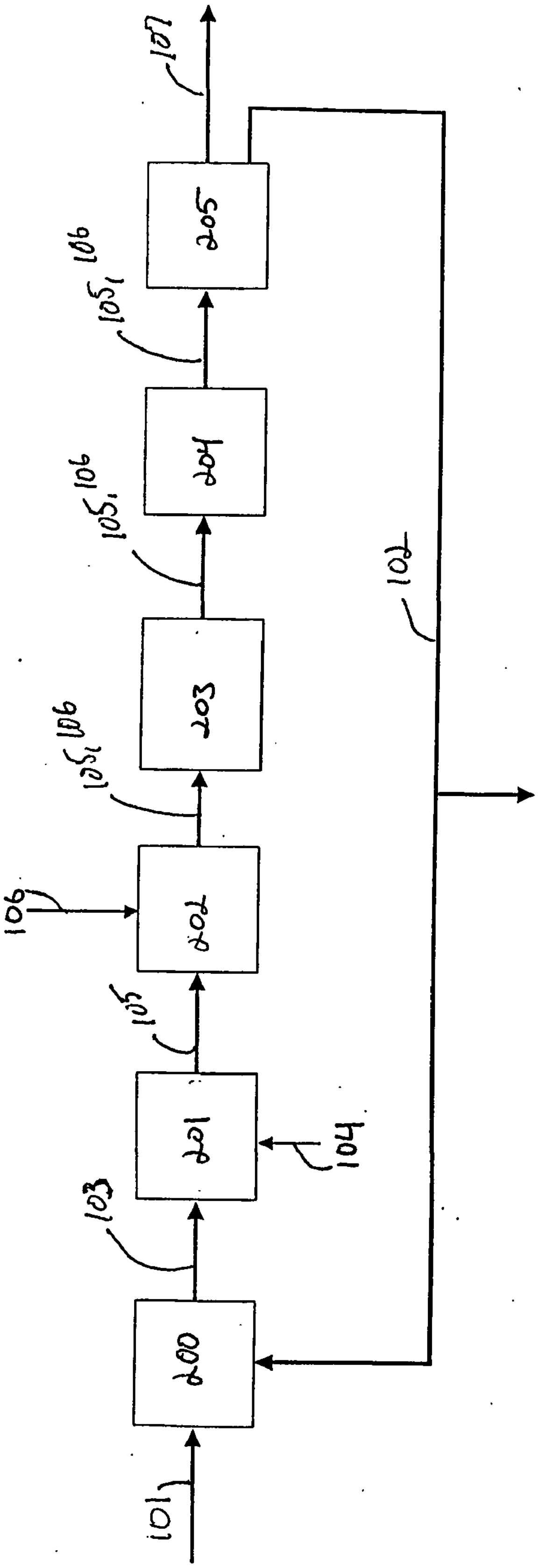
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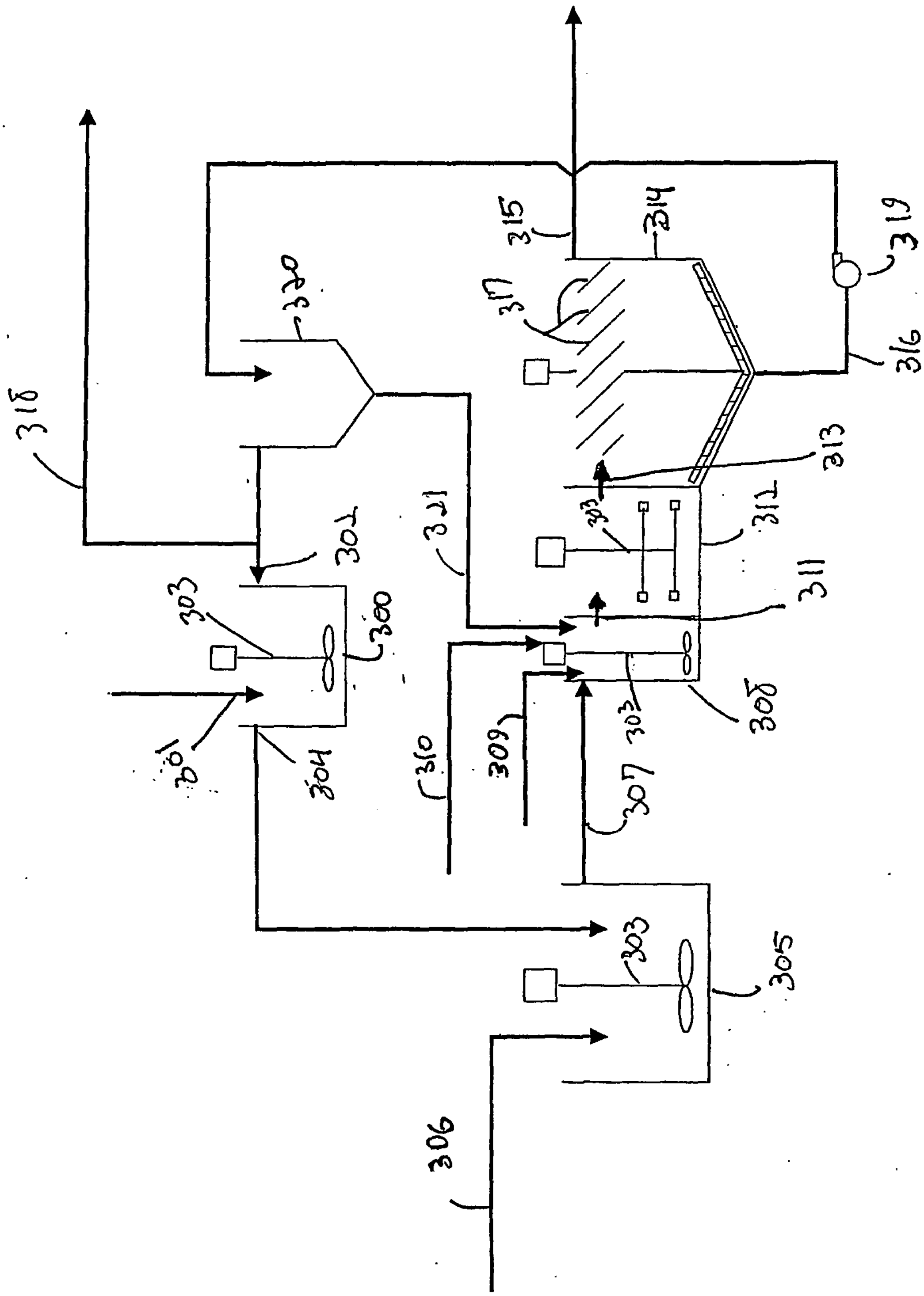
FIG 5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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4388195 A **[0009]**
- US 5039428 A **[0009]**
- US 5730864 A **[0009]**
- US 5770091 A **[0009]**
- US 6210587 B **[0009]**
- US 6277285 B **[0009]**
- US 3738932 A **[0010]**
- US 4927543 A **[0012]**