

PATENT SPECIFICATION

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(54) APPARATUS FOR TREATMENT OF LIQUID HAVING MATTER SUSPENDED THEREIN

(71) We, MITSUBISHI JUKOGYO KABUSHIKI KAISHA, a Japanese Corporation, of 5-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to apparatus for purifying waste liquid by separating therefrom suspended matter.

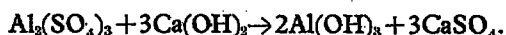
15 In Japan, oil-contaminated waste liquids discharged, for example, from industrial plants have heretofore been purified by an apparatus such as that shown in Figure 1 of the accompanying drawings, but this apparatus has the disadvantage that it is undesirably large in size and installation costs are high.
 20 The apparatus includes an oil-water separator 1, e.g. a gravitational separator, for carrying out a primary separation of oil and water in an oil-contaminated waste liquid. One end of a waste liquid feed pipe 2, having a pump 25 3 provided therein, opens into the oil-water separator 1. In the oil-water separator 1, the major portion of the waste liquid is separated into oil and water (primary treatment).

30 The oil-water separator 1 is connected to a coagulation tank 5 by a pipe 4 and the oil-contaminated waste liquid, having been subjected to the primary treatment in the oil-water separator, is introduced into the coagulation tank 5 through the pipe 4. One end of a coagulant feed pipe 7, having a pump 35 8 provided midway thereof, is connected to the pipe 4 and the other end opens into a coagulant storage tank 6 in which a coagulant such as, for example, alum cake, magnesium salt or sea water is stored. One end of an alkali feed pipe 10, having a pump 11 provided midway thereof, is connected to the pipe 4 at a point spaced apart from the connection of the coagulant feed pipe 7 with said pipe 4, and the other end of the pipe 10 opens into an alkali storage tank 9 in which slaked lime or other alkali compound is con-

tained. One end of a coagulating assistant feed pipe 13 is connected to the coagulation tank 5 and the other end is connected to a coagulating assistant storage tank 12 containing, for example, a polyacrylamide type coagulating assistant therein. The coagulating assistant feed pipe 13 is also provided with a pump 14 midway thereof.

In the coagulation tank 5 the waste liquid, having a low oil concentration, introduced from the oil-water separator 1 is mixed with the coagulant fed by means of the pump 8, the alkali fed by means of the pump 10 and the coagulating assistant fed by means of the pump 14. The coagulation treatment in the coagulation tank 5 is carried out in the following manner:

When, for instance, alum cake is used as the coagulant and a slaked lime solution is used as the alkali, an aluminum hydroxide floc is formed in the tank 5 through the reaction represented by the following formula:



A trace amount of oil contained in the waste liquid is adsorbed on the floc. In this case, anionic compounds are mainly used for the coagulating assistant because anionic compounds will neutralize the positive charges of aluminum ions supplied as the coagulant, facilitating the formation of a floc and also enabling the floc to coagulate into a larger mass.

The coagulation tank 5 is connected to a flotation separation tank 16 by a pipe 15, and the flotation separation tank 16 is provided with a drain pipe 23 at its rear end. One end of a pressurized water feed pipe 22 is connected to the pipe 15 connecting the coagulation tank 5 with the flotation separation tank 16, and the other end of the pipe 22 is connected to a pressurized water tank 17. The pressurized water tank 17 is filled with a filler such as Raschig rings. One end of a water feed pipe 18 is connected to the top

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of the pressurized water tank 17 and the other end of the pipe 18 is connected through a pump 19 to a water tank not shown. A pressurized air feed pipe 20 extends from a compressor 21 and is connected to the lower portion of the pressurized water tank.

During passage through the Raschig rings layer, the water fed into the pressurized water tank 17 from the water feed pipe 18 dissolves therein a predetermined amount of pressurized air supplied via the pressurized air feed pipe 20. The water containing the dissolved air is introduced into the flotation separation tank 16 through the pressurized water feed pipe 22.

In the tank 16, a number of air bubbles form in the water as the pressure reduces to atmospheric pressure. These air bubbles collide with the aluminum hydroxide floc having oil adsorbed thereon and catch on the floc. The floc thus caught by the air bubbles floats with the air bubbles and is separated from the waste liquid.

The waste liquid purified in the manner described is discharged to the outside through the drain pipe 23.

In most oil-contaminated waste liquid treating apparatus such as that described above, the coagulation tank and the flotation separation tank are provided independently of each other and the volume of the former tank is generally twice as large as that of the latter tank. This means that the entire apparatus is large in size; it is impossible to provide the apparatus in a compact form, and the cost of installation is high.

According to the present invention there is provided apparatus for use in treating a liquid having matter suspended therein to remove the suspended matter, which apparatus comprises a coagulation chamber in which, in operation, suspended matter is adsorbed on a floc, means for introducing the liquid to be treated into the coagulation chamber, one or more partitions in the coagulation chamber to lengthen the path of liquid flowing through the coagulation chamber, and a flotation and separation chamber which surrounds the coagulation chamber and into which, in operation, liquid and floc from the coagulation chamber flow, which flotation and separation chamber is divided by partitions into a floc-receiving sub-chamber, a pressurized water injection sub-chamber provided with means to inject water containing air dissolved under pressure, a flotation-separation sub-chamber and a floc-collecting sub-chamber, the arrangement of the partitions in the flotation and separation chamber being such that in operation the liquid flows from the floc-receiving sub-chamber through the pressurized water injection sub-chamber to the flotation separation sub-chamber and treated liquid is discharged from the flotation-separation sub-chamber while floc continues to the floc-

collecting chamber and is discharged therefrom.

The invention will be further illustrated with reference to the accompanying drawings showing in Figures 2 to 5, by way of example, an embodiment of the invention, in which:

Figure 1 is a flow sheet of the apparatus known in Japan and referred to above;

Figures 2 to 5 show an embodiment of the present invention, of which:

Figure 2 is a plan view;

Figure 3 is a vertical sectional view taken along the line III—III of Figure 2;

Figure 4 is a vertical sectional view taken along the line IV—IV of Figure 2; and

Figure 5 is a vertical sectional view taken along the line V—V of Figure 2.

Referring to Figures 2 to 5, the apparatus of the invention includes a substantially cylindrical tank 30 having a funnel shaped bottom. The interior of the tank 30 is divided by a cylindrical partition wall 33 into a central coagulation chamber 31 and an annular flotation and separation chamber 32 surrounding said central coagulation chamber. The cylindrical tank 30 and the cylindrical partition wall are substantially concentric.

In the coagulation chamber 31 there are arranged, concentric with the tank axis, a small diameter cylindrical T1 and a large diameter cylinder T2, open at both ends, in such a manner that the top open end of the small diameter cylinder T1 is at a lower than that of the large diameter cylinder T2. Thus flow passages 31a, 31b and 31c are formed in the coagulation chamber, through which a waste liquid flows successively outwardly from the central portion of the coagulation chamber, i.e. the flow path of the liquid and floc through the coagulation chamber is lengthened. An annular member T3 having an L-shaped cross section is connected to the upper portion of the inner surface of the wall 33 of the coagulation chamber 31 to form a liquid collecting trough 34.

A pipe 35 extends into the tank 30 at or in the vicinity of the centre of the tank through the bottom wall of the tank, the inner open end 35a of the pipe 35 projecting upwardly into the coagulation chamber 31 from the bottom of the small diameter cylinder T1. The pipe 35 serves to feed into the coagulation chamber the waste liquid which has previously been subjected to the preliminary treatment. The waste liquid feed pipe 35 has a coagulant feed pipe 36 and an alkali feed pipe 37 connected thereto, and a discharge pipe 38 is connected to the bottom of the coagulation chamber 30 for discharging sediment from the coagulation chamber.

The flotation and separation chamber 32 is divided by radial partition walls S1, S2, S3, S4 into four sub-chambers, i.e. a floc entrance sub-chamber 32a, a pressurized water injection sub-chamber 32b, a flotation-separation

sub-chamber 32c and a floc collecting sub-chamber 32d. As shown in Figure 4, the top ends of the partition walls S2 and S4 are lower than the top ends of the partition walls S1 and S3.

One end of a conduit 39 is connected to the bottom of the liquid collecting trough 34, while the other end is connected to the lower portion of the floc entrance sub-chamber 32a. A coagulation assistant feed pipe 40 leading from a coagulation assistant storage tank (not shown) is connected to an intermediate point in the conduit 39. A pressurized water feed pipe 41 is connected at one end to a pressurized water tank (not shown) and at its other end is bifurcated and extends into the pressurized water injection sub-chamber 32b. The bifurcated ends of the pressurized water feed pipe 41 located within the pressurized water injection sub-chamber 32b are respectively provided with straight nozzles 41a so as to direct the jets of pressurized water discharged from the respective nozzles obliquely downwardly to collide against each other. The flotation-separation sub-chamber 32c forms a relatively long passage extending circumferentially, and a purified water discharge pipe 42 is connected to the lower portion of the downstream end of this passage. A floc discharge pipe 43 is connected to the lower portion of the floc collecting sub-chamber 32d.

The apparatus of the invention constructed as described above operates in the following manner when used for treating aqueous waste liquid containing oil:

First of all, the waste liquid previously subjected to a preliminary treatment in an oil-water separator (not shown) is introduced through the feed pipe 35 into the coagulation chamber 31. A coagulant such as, for example, a slurry of alum cake and an alkali such as, for example, a slurry of slaked lime are concurrently supplied through the pipes 36 and 37 respectively. An aluminum hydroxide floc is formed inside the coagulation chamber 31 in accordance with the equation previously given.

Therefore, a small quantity of oil contained in the liquid is adsorbed on the floc during passage of the liquid through the passages 31a, 31b, 31c in the direction of the arrows shown. Any matter which precipitates is discharged from the discharge pipe 38. The waste liquid, having been thus subjected to the coagulation treatment, flows into the liquid collecting trough 34, via a plurality of notches T3a formed in the trough, and thence into the floc entrance sub-chamber 32a. During this period, the waste liquid is admixed with the coagulation assistant supplied from the coagulating assistant feed pipe 40 in the conduit 39. It is preferred to provide a mixer, e.g. a Z-pump type mixer, at the connection between the pipe 40 and conduit 39, so as

to effect uniform and rapid mixing of the coagulation assistant with the waste liquid. The aluminum hydroxide floc entering the floc entrance sub-chamber 32a agglomerates into larger masses and flows into the adjacent pressurized water injection sub-chamber 32b over the top end of the partition wall S2. In the pressurized water injection sub-chamber 32b, the floc is contacted uniformly and closely by the pressurized water being discharged from the straight nozzles 41a obliquely downwardly in a manner to collide against each other. The floc, having the oil adsorbed thereon and forming large agglomerates by the effect of the coagulating assistant, flows below the partition wall S3 and into the flotation-separation sub-chamber 32c. During passage in the flotation-separation sub-chamber 32c in the direction of the arrows shown in Figure 2, the floc collides with and combines with fine air bubbles generated from the pressurized water, and floats on the surface of water.

The floating floc then moves into the floc collecting sub-chamber 32d over the top end of the partition wall S4 which is provided at the downstream end of the flotation-separation sub-chamber 32c and serves as a weir. Thus the floc is separated from the purified waste liquid. The purified waste liquid is discharged to the outside via the discharge pipe 42, while the oil-bearing floc is discharged to the outside via the floc discharge pipe 43.

It should be understood that the present invention is not restricted only to the embodiment described and illustrated herein, but many changes and modifications are possible to the embodiment without deviating from the scope of the invention. For instance, the tank may be of a shape other than cylindrical. Further, the invention is applicable not only to the treatment of oil-contaminated waste liquids described herein but also to the treatment of waste liquids from pulp plants or other waste liquids containing suspended matters.

The apparatus of the invention illustrated above has the following advantages:

(a) Since the flotation and separation chamber 32, which is larger in volume than the independent coagulation tank previously known in Japan, is arranged integrally and compactly in the apparatus, the cost of the apparatus is lower than that of an apparatus comprising an independent coagulation tank.

(b) For the same volume, the flotation and separation chamber 32 in the apparatus of the invention can be smaller in width than the one in the apparatus previously known in Japan.

(c) In the apparatus previously known in Japan, when a flotation and separation tank is increased in volume, in order to prevent air bubbles with floc absorbed thereon from separating from the floc, a plurality of flow-

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equalizing plates are usually arranged in the tank to divide the tank width in an attempt to obtain smooth flow of the waste liquid. Such equalizing plates can be eliminated in the apparatus according to the invention as the flotation and separation chamber can be formed with a relatively small width.

(d) For efficient contact between the air bubbles and floc in the flotation and separation tank, it is preferred that the tank is smaller in width and larger in height. The arrangement of the apparatus of this invention is advantageous in this respect.

WHAT WE CLAIM IS:—

1. Apparatus for use in treating a liquid having matter suspended therein to remove the suspended matter, which apparatus comprises a coagulation chamber in which, in operation, suspended matter is adsorbed on a floc, means for introducing the liquid to be treated into the coagulation chamber, one or more partitions in the coagulation chamber to lengthen the path of liquid flowing through the coagulation chamber, and a flotation and separation chamber which surrounds the coagulation chamber and into which, in operation, liquid and floc from the coagulation chamber flow, which flotation and separation chamber is divided by partitions into a floc-receiving sub-chamber, a pressurised water injection sub-chamber, provided with means to inject water containing air dissolved under pressure, a flotation-separation sub-chamber and a floc-collecting sub-chamber, the arrangement of the partitions in the flotation and separation chamber being such that in operation the liquid flows from the floc-receiving sub-chamber through the pressurised water injection sub-chamber to the flotation separation sub-chamber and treated liquid is discharged from the flotation-separation sub-chamber while floc continues to the floc-collecting chamber and is discharged therefrom.

2. Apparatus as claimed in claim 1 which comprises a cylindrical tank which is divided by a cylindrical partition wall concentric with the cylindrical tank into the coagulation chamber and the flotation and separation chamber.

3. Apparatus as claimed in claim 1 or 2 in which the means to introduce the liquid into the coagulation chamber is an inlet located at or in the vicinity of the centre of the bottom of the coagulation chamber.

4. Apparatus as claimed in claim 1, 2 or 3 in which the said means for introducing the liquid also serves as means for introducing the components to form a floc into the coagulation chamber.

5. Apparatus as claimed in any one of claims 1 to 4 in which the said means to inject water containing air dissolved under pressure comprises one or more nozzles via which, in operation, water containing air dissolved under pressure is introduced into the pressurised water injection sub-chamber.

6. Apparatus as claimed in claim 5 in which there are two nozzles which are angled downwards and towards each other.

7. Apparatus as claimed in any one of claims 1 to 6 in which there is provided means to introduce a coagulation assistant into the flotation and separation chamber to cause the flocs to agglomerate into larger masses.

8. Apparatus as claimed in any one of claims 1 to 7 in which the partition between the flotation-separation sub-chamber and the floc-receiving sub-chamber forms a weir over which flocs pass.

9. Apparatus as claimed in any one of the preceding claims which comprises a trough through which liquid and floc pass when flowing from the coagulation chamber to the flotation and separation chamber, a conduit extending between the trough and a lower portion of the flotation and separation chamber and means for introducing a coagulation assistant into the conduit.

10. Apparatus for treatment of a liquid having matter suspended therein to remove the suspended matter substantially as described herein, and as shown in Figures 2 to 5 of the accompanying drawings.

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