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Ryan et al.

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[54] **WATER PURIFICATION APPARATUS**

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[51] **Int. Cl.** **B03d 1/14**

[58] **Field of Search** 210/44, 221, 109, 210/123, 134; 209/170

[56] **References Cited**

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[57] **ABSTRACT**

In a froth flotation type of water purification system, a pump is used to deliver influent from a storage reservoir into a froth flotation tank. The pump is subject to intermittent air-binding thereby introducing air into the influent prior to its delivery to the froth flotation tank. The intermittent air-binding of the pump provides for thorough mixing of fine air bubbles with the influent thereby forming an effective froth for removal of suspended solids from the influent.

4 Claims, 2 Drawing Figures

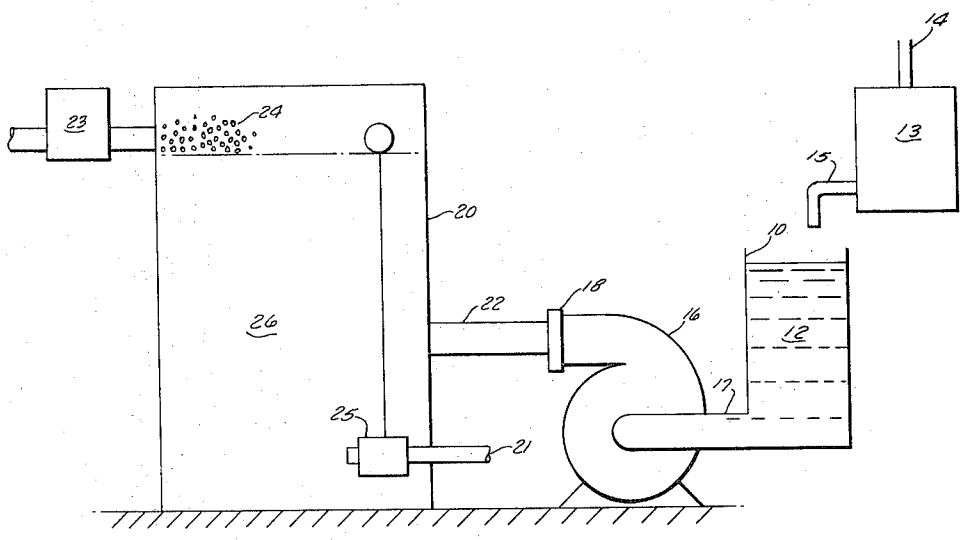
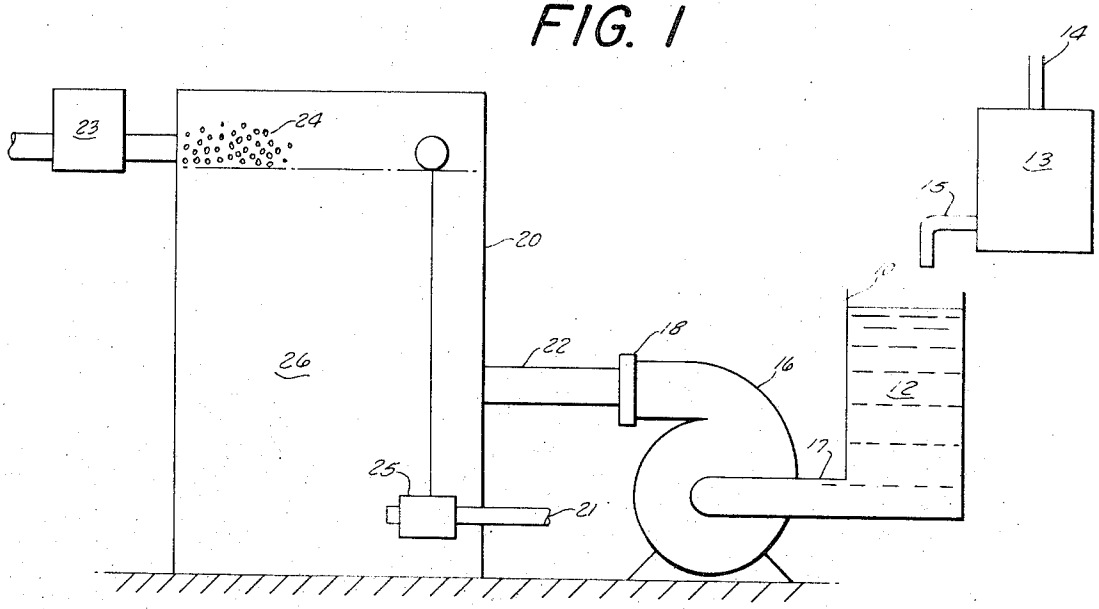


FIG. 1



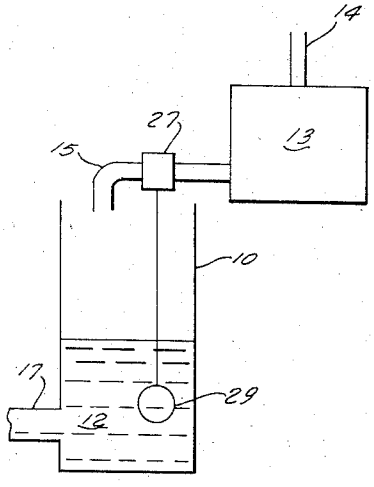


FIG. 2

WATER PURIFICATION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to water purification systems and more particularly to a system utilizing a froth flotation process to remove suspended solids.

2. Description of the Prior Art

Conventional waste water treatment systems do not yield the quality of water attained by evaporation and condensation, which is one of nature's methods of purification. The conventional processes remove only 90 to 95 per cent of the suspended solids and other impurities from waste waters before the effluent is discharged into a body of water such as a lake, stream or river. These conventional methods have resulted in extensive pollution of our water supplies.

Conventional purification processes include a frothing technique which is described in several prior art patents such as U.S. Pat. No. 2,446,655 issued to L. Lawrason, U.S. Pat. No. 2,994,432 issued to J. W. Schluter, U.S. Pat. No. 2,759,607 issued to C. L. Peck. The frothing technique is used in combination with absorption and oxidant enhancement methods which are well known in the prior art.

Frothing depends on the introduction of air into the influent to create a froth which captures solid particles of waste from the influent causing the particles to float to the surface where they may be skimmed off. Froth inducers and collecting agents may be introduced into the influent to control the foaming characteristics of the influent and the particle size and entrapment rate of the pollutants. Various substances have been used as froth inducers and several of these are described in the previously-mentioned prior art patents. The selection of a froth inducer is usually determined by the type of particle to be removed from the influent.

Heretofore, various types of devices have been used for the injection of air into the influent. These devices have ranged from a simple air intake opening utilizing the Venturi Effect to more complex jet injectors. All of the prior art devices required some form of mechanism for the introduction of air into the influent. These additional devices resulted in increased cost and generally did not provide for the formation of fine air bubbles and thorough mixing of air and influent. The formation of fine air bubbles is desirable because they provide a greater air-liquid interface area to which particles may adhere.

SUMMARY OF THE INVENTION

The present invention contemplates a water purification system utilizing a froth flotation process for the elimination of suspended solids. In one embodiment, an oversized pump delivers concentrated influent from a reservoir tank into a froth flotation tank. The reservoir receives influent at a substantially constant rate lower than the pump capacity so that the pump has a tendency to intermittently air-bind resulting in myriads of extremely fine air bubbles being introduced into the influent to cause the formation of a froth which rises to the surface carrying with it suspended solid particles contained in the influent.

One objective of the present invention is to provide a froth flotation system that does not require a separate device for the introduction of air into the influent.

Another objective of the present invention is to provide a froth flotation system that provides for more efficient mixing of air and influent than the systems of the prior art.

Another objective of the present invention is to provide a froth flotation system that is less expensive than those heretofore provided.

The foregoing objectives and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawing, wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for illustrative purposes only and is not to be considered as defining the limits of the invention.

DESCRIPTION OF THE DRAWING

FIG. 1, there is shown a diagrammatic representation of the system and apparatus of the present invention.

FIG. 2, there is shown a diagrammatic representation of a modified embodiment of the system and apparatus of the present invention.

DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown a reservoir **10** containing concentrated influent **12** such as sewage. The sewage is treated by passing through a sedimentation tank **13** having an inlet **14** and an outlet **15** for delivering influent to the reservoir at a substantially constant flow rate. A self-priming centrifugal pump **16** has an inlet conduit **17** extending into the influent **12** contained in reservoir **10**. Pump **16** has an outlet **18** which is in communication with the interior of a froth flotation tank **20** by way of a conduit **22**. Froth flotation tank **20** is constructed in a manner similar to the tanks of the prior art and has a means **23** for skimming froth **24** from the surface of effluent **26** contained within the froth flotation tank **20**. Flotation tank **20** has an outlet **21** that is controlled by a float valve **25** for maintaining a substantially constant effluent level in the tank. Outlet **21** delivers purified water as the effluent.

The centrifugal pump is oversized and delivers the concontrated influent **12** from reservoir **10** into the froth flotation tank **20** at a rate faster than it is supplied to the reservoir from the sedimentation tank. The centrifugal pump drains the reservoir **10** causing the pump to air-bind and thereafter unbind when a pressure head is reestablished as the influent level rises in the reservoir. The alternate binding and unbinding of the centrifugal pump at short intervals produces a myriad of ultrafine air-bubbles that are thoroughly dispersed in the influent which is then passed to the froth flotation tank **20**.

Solid pollutants adhere to the air-liquid interfacial surface of these bubbles and float to the top of the flotation tank forming a froth which is thereafter removed by skimming.

Although the pump provides intermittent delivery, a substantially constant level is maintained within the froth flotation tank by the use of a constant level controller such as the float controlled valve **25**.

Because of the number of extremely fine air bubbles introduced into the influent, a maximum of air-liquid interfacial surface is provided to which pollutants may attach. Thus, a finer and more effective froth is pro-

vided by the use of the oversized pump which alternately binds and unbinds.

In order to obtain the proper interval between the alternate binding and unbinding, the pump characteristics must be selected to have a duty cycle equal to approximately 80 per cent. While 80 per cent duty cycle is preferred, the system will operate satisfactorily with a duty cycle of between 70 per cent and 90 per cent. Operation above the maximum per cent duty cycle will result in insufficient injection of air into the influent while operation below the minimum per cent duty cycle will result in undue inefficiency. Operation below the minimum per cent duty cycle requires the use of an excessively high cost pump and increases the cost of pump operation. Another factor to be considered in operating below the minimum per cent duty cycle is that a cooling problem may result because there may be insufficient liquid passing through the pump to provide proper cooling. During air-binding, the pump may heat up to a dangerous level damaging the pump. If the pump is operated below the minimum per cent duty cycle, additional conventional means for cooling should be provided the pump.

More efficient and effective removal of suspended solids may be realized by the use of froth inducers and collector agents which may be added to the influent at the intake or outlet of the pump. A particularly satisfactorily froth producing agent was found to be coconut oil soap (sodium laurate) mixed with a like amount of kerosene. These agents create air bubbles having a stabilized air-liquid interface laden with monomolecular films, concentrated with sodium laurate attached to pollutants and coated with kerosene hydrocarbon.

In a modified embodiment of the present invention, shown in FIG. **2**, a valve **27** controlled by float **29** is used at the outlet **15** of the sedimentation tank for allowing influent to flow into the reservoir whenever the reservoir is emptied to a level at which the pump will air-bind. Thus, the level of influent contained in reservoir **12** will be controlled so that the pump periodically air-binds thereby mixing air and influent together for delivery to the flotation tank **20**. The remainder of the embodiment is the same as shown in FIG. **1**.

Thus, the present invention provides for the more efficient and effective removal of suspended solids contained in sewage. The system is more efficient in that the apparatus required is less expensive and is readily adaptable to automation and continuous uninterrupted operation. The separation is more effective because the air-binding pump creates a greater number of extremely fine air bubbles which are thoroughly dispersed throughout the influent thereby creating a larger water-air interface and surface area to which pollutants may adhere. Thus, the use of an intermittently air-binding centrifugal pump provides for the formation of a more effective froth.

What is claimed is:

1. A froth flotation apparatus for removing suspended solids contained in a liquid, comprising:

A tank containing said liquid;

A reservoir for receiving said liquid;

means including valve means for supplying said liquid to said reservoir from the tank when the liquid in said reservoir is below a predetermined level;

A centrifugal pump having an inlet extending into said reservoir and terminating at said predetermined level, said pump also having an outlet; and

a froth flotation tank connected to the pump outlet for receiving the said liquid, whereby the pump empties the reservoir to the predetermined level at which level the pump air-binds drawing air into the pump housing and the valve means is actuated to supply additional liquid to the reservoir causing the pump to unbind and mix the air with the liquid.

2. An apparatus as described in claim **1**, additionally comprising means for removing froth collected at the surface of the liquid in the froth flotation tank.

3. An apparatus as described in claim **1**, additionally comprising means for maintaining a substantially constant liquid level within the froth flotation tank.

4. An apparatus as described in claim **1**, additionally comprising means for injecting frothing agents into the liquid passing through said pump.

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