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J. W. SCHLUTER

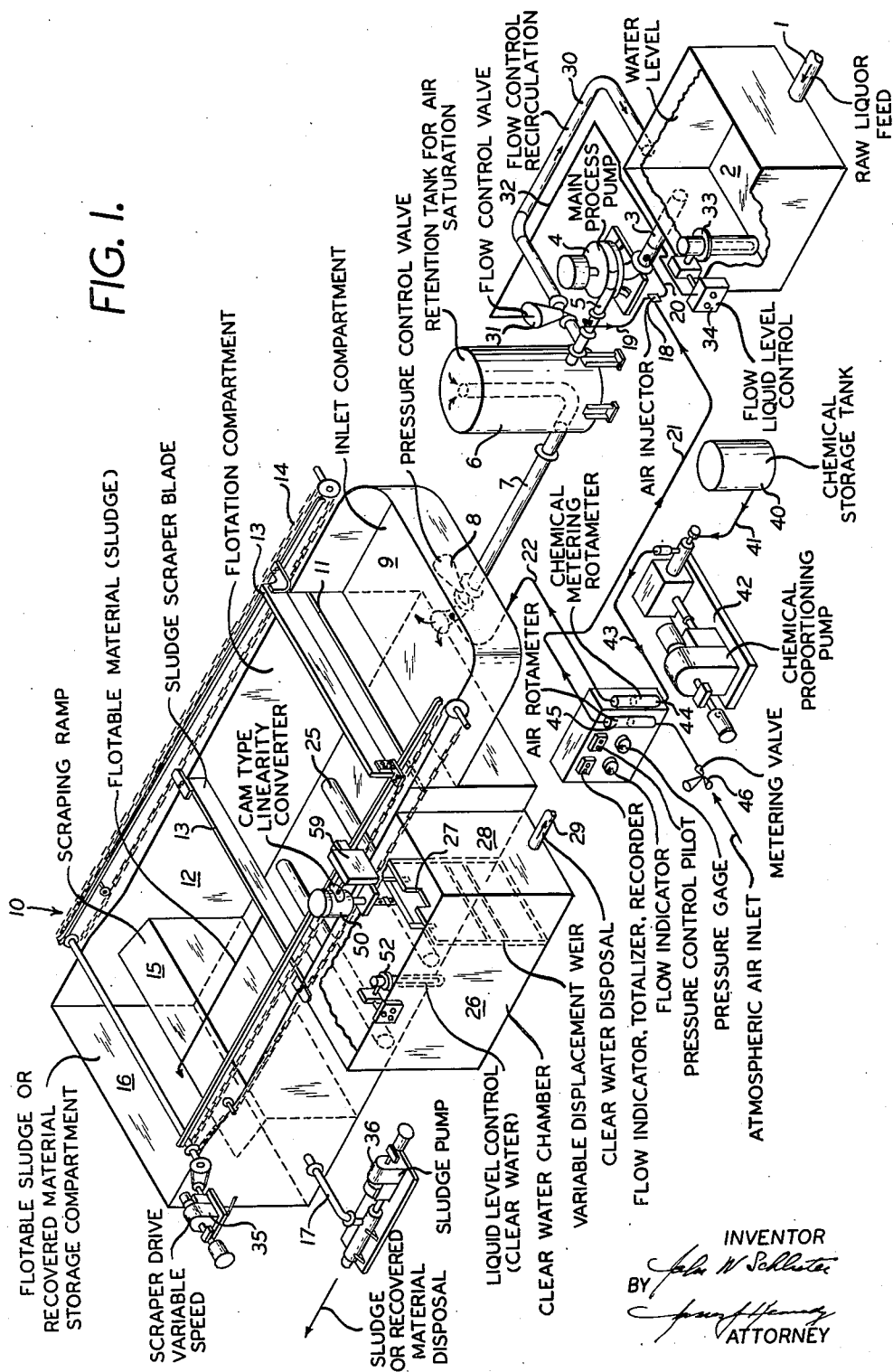
2,994,432

CONTROL FOR FLOTATION SEPARATION SYSTEMS

Filed June 3, 1957

2 Sheets-Sheet 1

FIG. 1.



INVENTOR
BY *John W. Schluter*
ATTORNEY

Aug. 1, 1961

J. W. SCHLUTER

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2 Sheets-Sheet 2

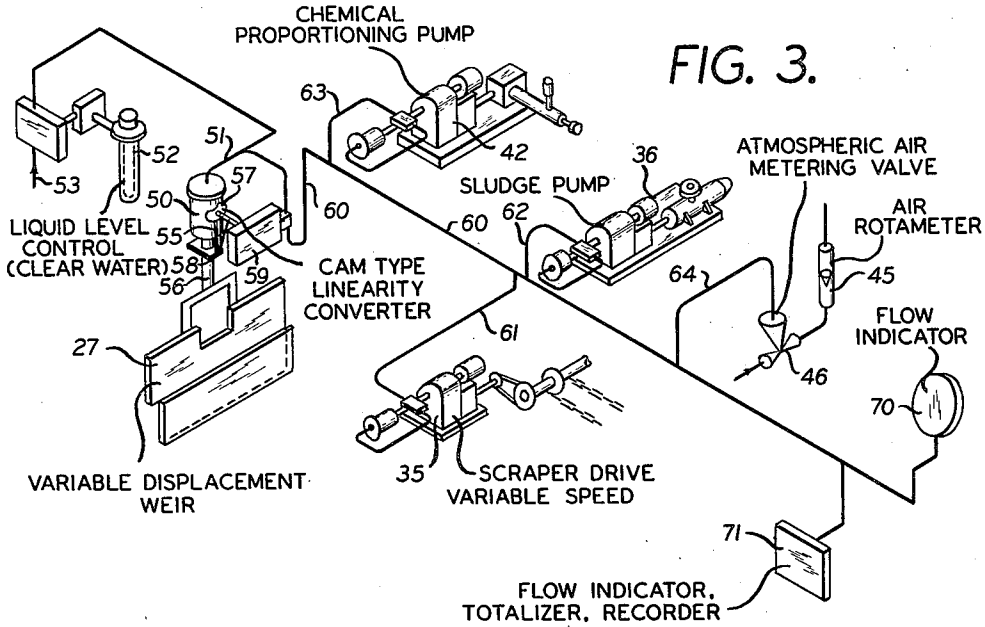
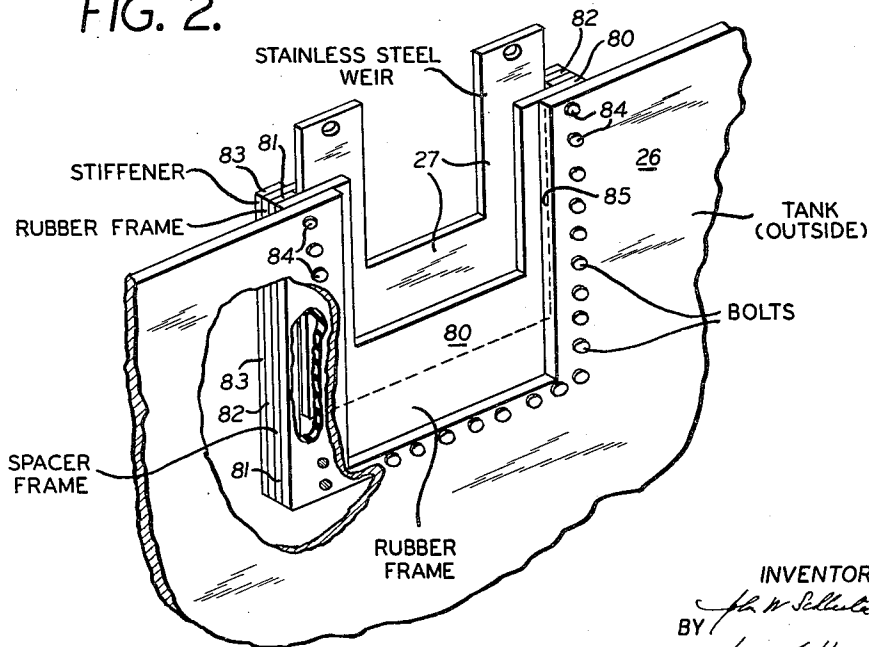


FIG. 2.



INVENTOR
BY *John W. Schuster*
James J. Hennessey
ATTORNEY

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CONTROL FOR FLOTATION SEPARATION SYSTEMS

John W. Schluter, Massapequa, N.Y., assignor, by mesne assignments, to Pfaudler Permutit Inc., Rochester, N.Y., a corporation of New York

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10 Claims. (Cl. 210—101)

This invention relates to flotation separating systems, and more particularly to the regulation of the rate of processing of an influent in such systems.

Flotation separators are used in a large variety of applications for treating influent liquids containing impurities or substances of various kinds, such substances being floated to the top of the liquid level in a flotation chamber generally equipped with paddles for skimming the surface and with means for withdrawing a clarified effluent liquid at a lower point. The separation of the substances to be removed may be and generally is effected or assisted by the introduction at a proper point of suitable coagulants or other chemicals, and the actual separation is assisted by means of air or other gas introduced in such a manner that it is incorporated in or attached to precipitated particles and adds buoyancy for bringing them to the surface in the separation tank.

Systems of this general character have been operated for a considerable time and generally in a satisfactory manner, one such typical system being described, for example, in Juell Patent 2,330,589, granted September 28, 1943. In general, the control of the operation of these separating systems has presented difficulties. For one thing, the influent to be treated may be supplied as the end product of a chemical or other process in a very fluctuating or intermittent way and to an initial storage tank or basin of a limited capacity, while the separating system requires for its most efficient operation steady and stabilized conditions. The synchronizing or correlation of supply of influent with the treatment process has, therefore, presented problems not heretofore solved. Similarly, adjustment of the supply of treatment chemicals has also presented difficulty in view of the inherent variation in operating conditions.

It is the general object of the present invention to provide a control system for liquid flotation separating systems which will obviate the above mentioned difficulties and permit a more efficient operation and also obtain maximum treatment capacity out of equipment of any given size or expense.

A system embodying the invention in a preferred form will now be described with reference to the accompanying drawing, and the features forming the invention will then be pointed out in the appended claims.

In the drawing:

FIG. 1 is a schematic of a system embodying the invention in a preferred form;

FIG. 2 is a detail view showing an automatically controlled weir in the clarified effluent chamber of the installation; and

FIG. 3 is a schematic of the control system.

The majority of the elements of the system as shown are conventional and require but a brief description.

Referring to FIG. 1, there is indicated at 1 a pipe or conduit through which the influent liquid is supplied in any manner and with such fluctuation or intermittency as may result from the manner in which it is produced. This liquid is received in a storage tank 2 of a suitable size but which may be reduced in capacity where necessary or desirable, and in view of the improved control afforded by the present invention. The liquid is taken through a conduit 3 into pump 4, the discharge 5 of which

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leads to a retention tank 6 from which the liquid passes through conduit 7 and pressure control valve 8 into the inlet compartment 9 of a separator, indicated generally at 10. From the inlet compartment, the liquid flows over the edge of a weir 11 into the flotation compartment proper 12 and in which the flotation of the precipitated materials is accomplished. The separated sludge or scum as it rises to the top is forwarded along the flotation compartment by a series of blades 13 carried on sprocket chains 14, and at the far end the sludge or scum is advanced by these blades up and over a scraping ramp 15 from which it drops into the sludge or recovered material storage compartment 16 and is removed in any convenient manner and time, as through outlet pipe 17. In particular, where the sludge may be pumped, a sludge pump, indicated at 36, may be employed for this purpose.

The flotation air may be introduced at any convenient point according to the material to be treated. In particular, this may be accomplished in a generally known manner by means of an air injector indicated at 18 and which is inserted in a by-pass around the pump, including a supply line 19 connected to the pump outlet and a discharge line 20 connected to the pump inlet, the recirculating fluid operating the injector so as to take air from a line 21 and introduce it into the intake of pump 4. Treatment chemicals may also be supplied at any convenient point or points according to the specific process of the materials being treated. In the installation shown by way of example, these materials are supplied through a line 22 to the inlet compartment of the flotation chamber.

The clarified effluent is withdrawn from a number of points near the bottom of the flotation compartment 12, as through perforated pipes 25 leading to clarified effluent chamber 26, from which the liquid flows over a weir 27 into the effluent discharge chamber or space 28 from which clarified water or other effluent is discharged through conduit 29.

A variety of controls may be employed at various points, depending upon requirement, without affecting essentially the operation of the control system of the invention which is described below.

The rate of pumping of the influent from the storage tank 2 may, for example, be controlled by means of a flow control system comprising a by-pass 30 from the outlet of the pump 4 back to the storage tank and the circulation or recirculation through which is controlled by a flow control valve 31 which is regulated as by means of air through line 32 leading to a liquid level controller 33 contained in and responsive to the level in the storage tank 2. The operation of the liquid level control at 33 is preferably regulated by means of liquid level controller 34 referred to hereinafter, and which provides for adjustment of the liquid levels at which controller 33 operates according to the general requirements of the system.

The sludge removal or skimming action may be accomplished by a variable speed motor 35, driving the sprocket chains 14, previously referred to, and the removal of sludge through pipe 17 may be accomplished by means of a variable sludge removal pump unit 36, these instrumentalities, as well as others still to be referred to, being capable of automatic control in the system of the present invention. In particular, the treatment chemicals may be supplied in dissolved form from storage tank 40, leading through a line 41 through a chemical proportioning pump 42 and thence to a discharge 43 through a chemical metering rotameter 44 into the line 22 previously referred to. The air may be supplied to line 21, previously mentioned, through rotameter 45 and air

metering valve 46, from atmosphere or a pressure source according to requirements.

The control system is of an extremely simple and easily regulated character, the basic control element being a control unit associated with and regulating the action of the effluent weir 27, previously referred to. This weir is vertically slidable and its position is adjusted by means of a servo motor mechanism 50, operated through air lines 51 by the clear water tank liquid level controller 52, which is supplied with air through pressure from any convenient source through line 53. The weir position is read off by means of a plunger 55, attached to the servo motor shaft or link 56, and acting against a rotatable cam 57 serving through the shaft 58 to adjust pressure control valve unit 59, which bleeds air into and out of control line 60 so as to maintain a pressure corresponding to the position of the weir 27 but preferably modified by the contour of cam 57 according to the flow characteristics of the weir, so as to produce a linear signal, or signal which is directly proportional to the rate of flow of liquid over the weir. Plunger 55 being a member movable with the weir, thus indicates the rate of flow (although in a manner which is typically not directly proportional to that rate) and it is coupled to the signal generating element (control valve unit 59) through cam 57 which, as above mentioned, is contoured so as to function as a liquid converter, producing a directly proportional signal in response to movement of the member 55 which is not directly proportional. Since the rate of flow depends upon the difference between the liquid level and the height of the weir overflow, and since the liquid is in any case of known characteristics, the conversion of the signal to a linear one does not present any difficulties.

As will now be apparent, the line 60 furnishes a convenient and simply operable means for controlling and correlating the operation of all the instrumentalities involved. In view of the fact that with given influent, definite factors of proportionality will exist in each case. Thus, the quantity of sludge or scum to be removed will vary directly with the quantity of clear effluent being removed, so that connection of the control of the variable speed scraper drive motor 35 and sludge pump 36 to the line 60 through the respective lines 61 and 62 provides for automatic regulation of the speed of operation of these devices. Similarly, the chemical proportioning pump 42 with atmospheric air metering valve 46 are connected to line 60 through the respective lines 63 and 64, thus regulating the supply of chemical and air and proportioning the same as accurately as required to the quantity of material being treated. There may also be attached to the line 60 a rate of flow indicator 70 and an integrating type flow indicator 71, permitting simple reading off of the rate of treatment of materials and a similar reading off of the quantity of material treated at any given time. The clarified liquid tank level controller 52 may also be connected to line 51, thus feeding back the weir position signal and permitting follow up to avoid hunting in the control system.

In operation, the general rate at which the influent is supplied to the system for treatment is controlled according to the level in the storage tank 2, the precise control relationship varying with the requirements, but being established so as to avoid the overflow of the tank or depletion to a non-operating or inefficient operating condition. The design of this control and the capacity of tank required are, as is obvious, factors to be determined in each case according to the service requirements. It may be assumed, however, that since the rate of withdrawal of liquid from the tank is proportional to the level and will follow the rate of supply through pipe 1 as compared with the rate of withdrawal and discharge into the retention tank 6, the rate of supply of influent to this tank will be comparatively steady. Any increase in the rate of supply will tend to increase the liquid level in the flotation compartment 12 and also in the clarified effluent

chamber 26. However, any tendency in this level to rise will, through the liquid level controller 52, operate the servo mechanism 50 to lower the weir 27, simultaneously increasing the rate of discharge of clarified effluent and restoring the liquid level to set value (or, as will be understood, to a point within the dead zone of permissible range of the control system—this permissible range may be only a small fraction of an inch). At the same time, the pressure in line 60 may be adjusted accordingly, so that skimming blade drive motor 35 and sludge removing pump 36 will increase their action, as also will the air inlet valve 46 and chemical supply pump 42. In this way, the action of the entire system is automatically regulated and controlled for the most efficient operation. In consequence, it becomes possible to reduce the size of unit throughout, which is required to handle the effluent produced from any given process and it also becomes possible to obtain a much improved separation with clearer effluent, requiring a minimum of after processing.

With previously used systems, it has been necessary to adjust the various components in a relatively complicated and haphazard manner in order to relate the rate of treatment to the rate of supply of liquid to be treated, or to operate at a constant rate and provide a very large initial storage tank so as to avoid either overflow or drainage of this tank. This procedure, in addition to increasing the bulk and cost of the installation, results in difficulty in many cases due to settling or other change in the influent material due to overlong time of retention in the storage tank before processing. With the system of the present invention, however, a much simpler and more efficient operation is obtained. For example, any given flotation system may operate close to peak efficiency over considerable range and rate of treatment in terms of gallons per minute or other unit of measurement which is employed, and the maximum rate within this range may be a multiple, as, for example, two or three times the minimum rate. It now becomes possible, by assuming maximum rate of processing during periods of maximum supply of influent and minimum rate of processing during periods of little or no supply of influent, and then working back to the corresponding levels in the storage tank, to design a storage tank capacity for the unit, in such a way that operation at an efficient rate of treatment is maintained at all times, the storage tank capacity is reduced to a minimum and the time of retention of the influent in the storage tank is also reduced to a minimum. Since the air and treatment chemical are automatically proportioned to the rate of flow of liquid being treated through the system, a stable, high efficiency operation is obtained despite variations in the supply of the influent liquid.

The adjustable weir 27 may take a variety of forms without departing from the invention in its broader aspect, but a specific form of weir which has been found advantageous is shown in detail in FIG. 2, and has the advantage of simplicity, easy working and ready cleaning and servicing. FIG. 2 shows a portion of the end wall of clarified effluent discharge chamber 26, and the weir 27, which may conveniently be made of stainless steel, as indicated. The weir is mounted in a slot or guideway formed by inner and outer rubber frames 80, 82, separated by a spacer frame 81 and held in place by a stiffener plate 83, this entire laminar structure being secured to the tank as by means of bolts 84. The width of weir 27, being somewhat greater than that of opening or notch 85 in the wall of tank 26, the rubber frame 80 where it supports the weir is backed up by the wall of tank 26, so that there is practically no strain upon the parts and very little operating friction to overcome.

What is claimed is:

1. In a flotation separating system having a flotation tank and means for supplying influent liquid thereto and means for removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid

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therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the flotation tank liquid level substantially constant.

2. In a flotation separating system having a flotation tank and means for treating and supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, means responsive to the position of the said weir for generating a control signal proportional to the rate of flow over the weir, and means actuated by the said control signal for regulating the operation of the treating means according to the said rate of flow.

3. In a flotation separating system having a flotation tank and means for supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, means responsive to the position of the said weir for generating a control signal proportional to the rate of flow over the weir, and means actuated by the said control signal for regulating the said means for removing floated sludge to proportion the rate of sludge removal to the rate of discharge of clarified liquid.

4. In a flotation separating system having a flotation tank and means for supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, means responsive to the position of the said weir for generating a control signal proportional to the rate of flow over the weir, means for aerating the influent liquid and means actuated by the said control signal for regulating the action of the aerating means according to the said rate of flow.

5. In a flotation separating system having a flotation tank and means for supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which

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the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, means responsive to the position of the said weir for generating a control signal proportional to the rate of flow over the weir, means for supplying treatment chemical to the influent and means actuated by the said control signal for regulating the action of the treatment chemical supply means according to the rate of flow.

6. In a flotation separating system having a flotation tank and means for supplying influent liquid thereto, including a receiving tank and pump, and means for removing floated sludge and clarified liquid from the flotation tank, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the weir, automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the flotation tank liquid level substantially constant, and means responsive to the level in the receiving tank for regulating the pump to maintain the level in the receiving tank between predetermined limits.

7. In a flotation separating system having a flotation tank and means for treating and supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, means responsive to the position of the said weir for generating a control signal linearly proportional to the rate of flow over the weir, and means actuated by the said control signal for regulating the operation of the treating means according to the said rate of flow.

8. Flotation separating system control mechanism according to claim 7, in which the means for generating the linear control signal comprises a member movable with the weir, a signal generator and a linearity converter coupling the said member and signal generator.

9. Flotation separating system control mechanism according to claim 8, in which the said linearity converter comprises a cam mechanism.

10. In a flotation separating system having a flotation tank and means for treating and supplying influent liquid thereto and removing floated sludge and clarified liquid therefrom, the means for removing clarified liquid therefrom comprising a clarified liquid chamber connected to the flotation tank for receiving the clarified liquid therefrom, automatic control mechanism comprising a weir over which the clarified liquid is discharged, means movably mounting the said weir in the said clarified liquid chamber, a liquid level controller for controlling the liquid level in back of the said weir and automatic means controlled thereby for moving the said weir and thereby varying the height of the said weir to maintain the liquid level substantially constant, an air line, means responsive to the position of the said weir for varying the pressure in said air line proportional to the rate of flow over the weir, and means actuated by the air pressure in said line

for regulating the operation of the said treating means according to the pressure in the said line.

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