

May 25, 1937.

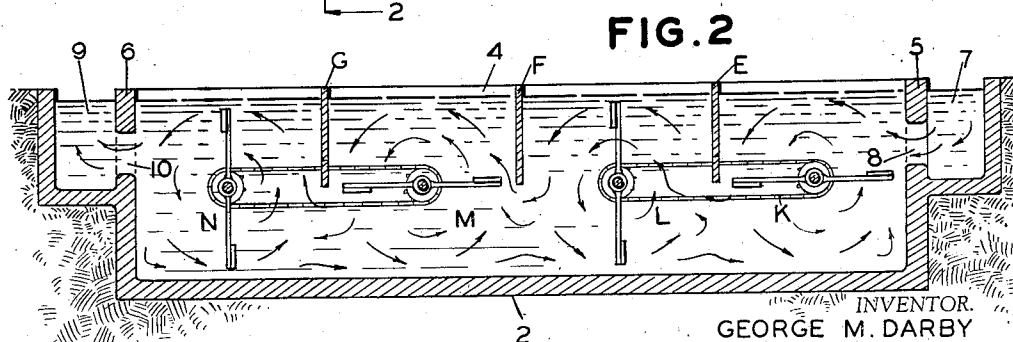
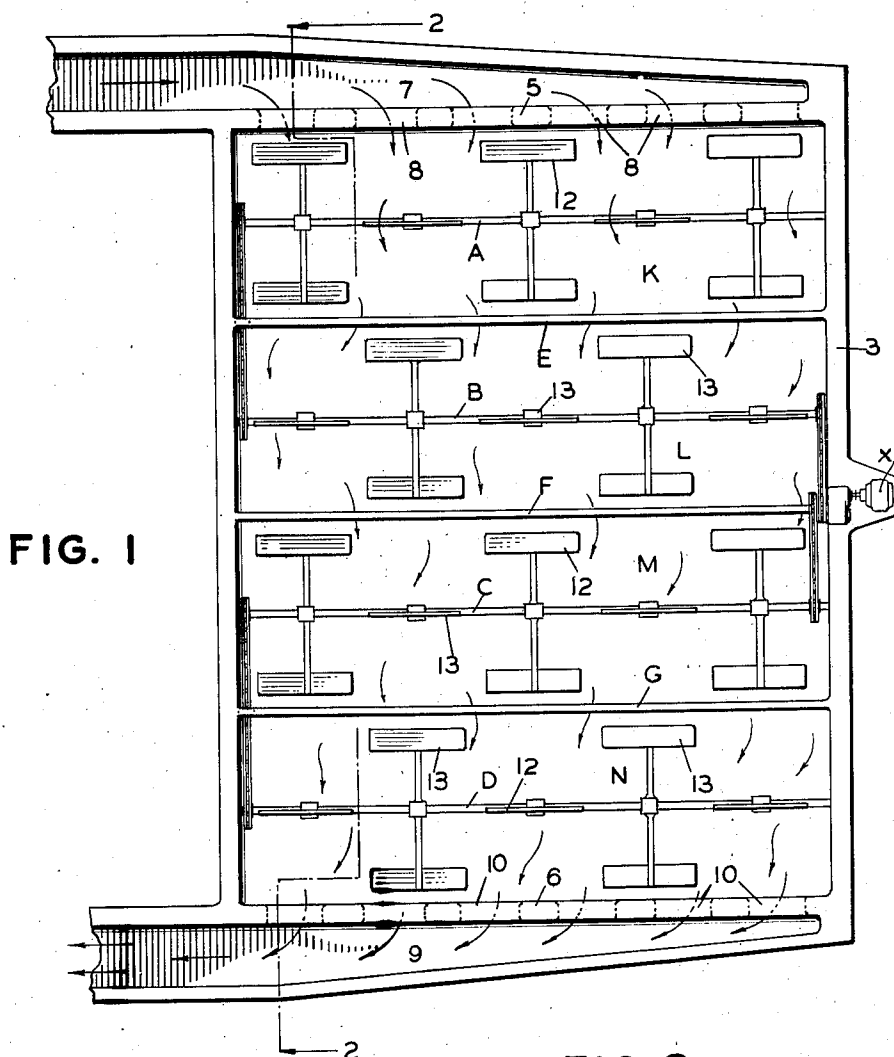
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2,081,851

FLOCCULATION

Filed June 17, 1935

3 Sheets-Sheet 1



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FIG. 3

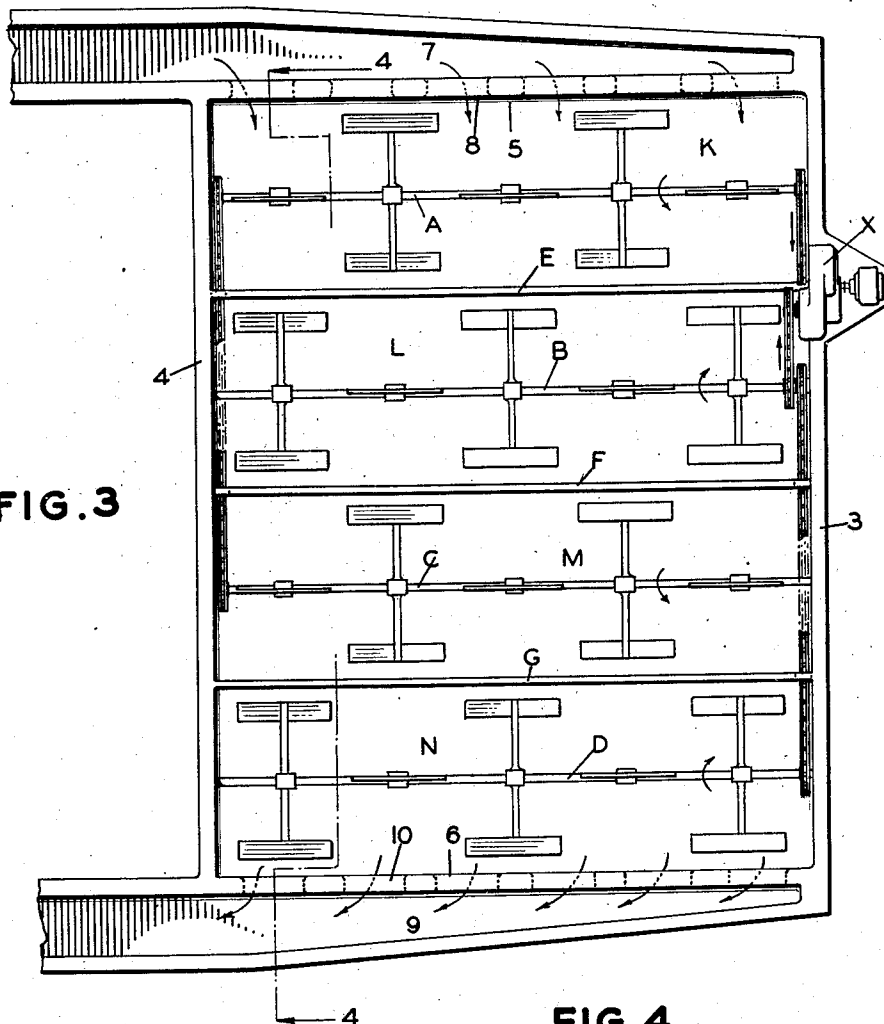
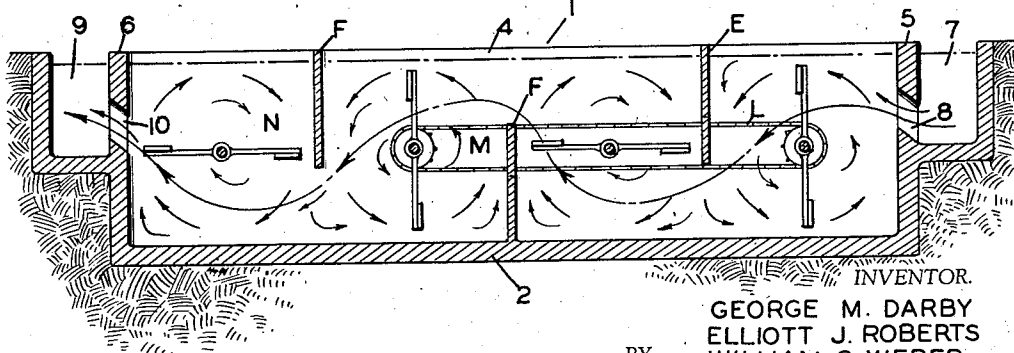


FIG. 4



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FIG. 5

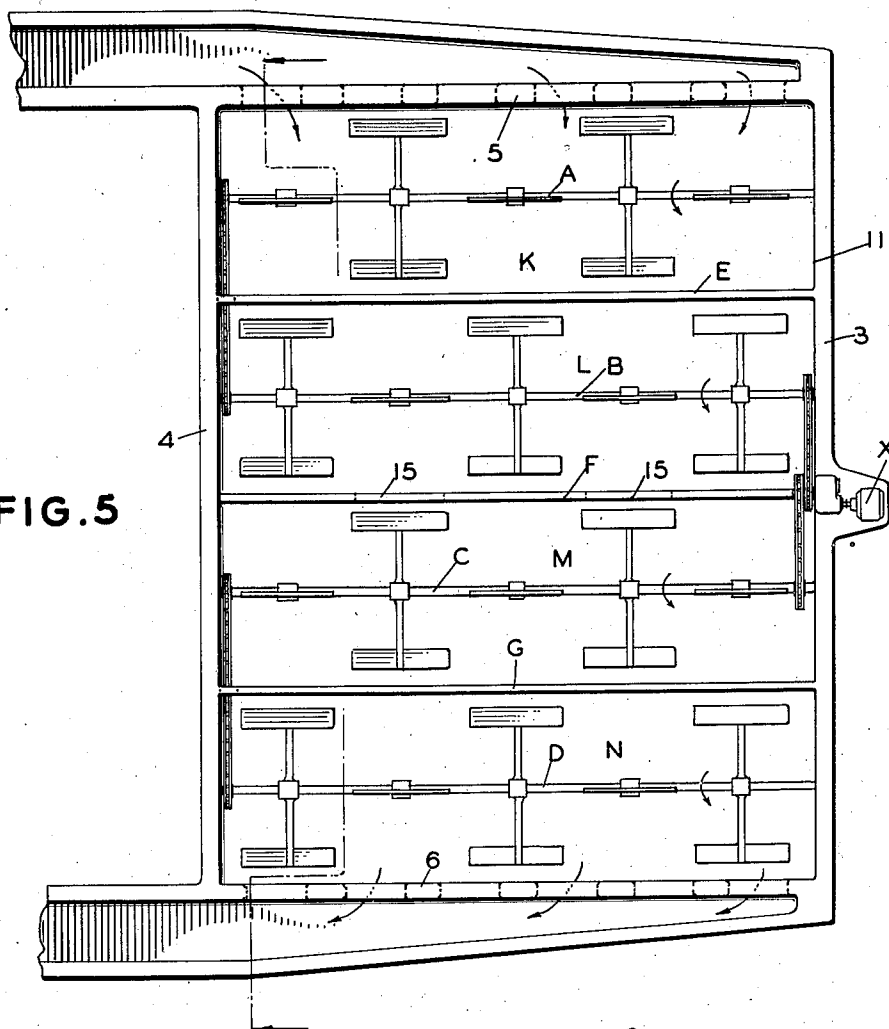
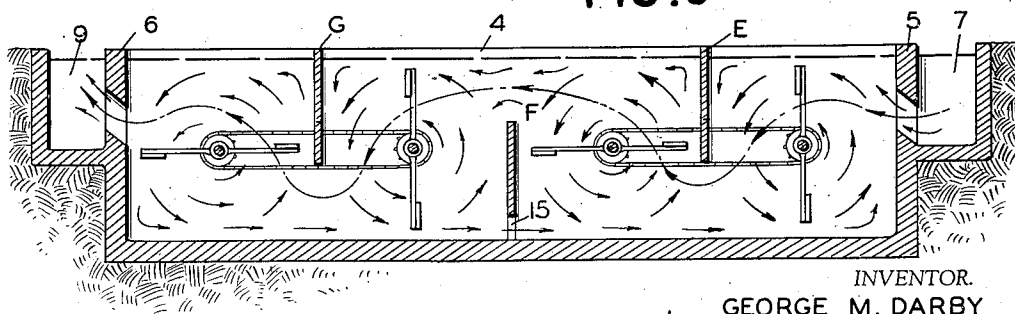


FIG. 6



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2,081,851

FLOCCULATION

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Application June 17, 1935, Serial No. 27,015

13 Claims. (Cl. 210—16)

This invention relates to a method and apparatus for effecting clarification of turbid liquids involving flocculation preparatory to sedimentation or filtration, and particularly to steps or features relating to flocculation when induced by mechanical agitation. This invention is an improvement upon or applicable to the method and apparatus shown, described and claimed in the Smith Patent No. 1,893,451 granted January 3, 1933.

The environment of the present invention and its general position in respect to the art to which it particularly pertains is readily appreciated if one considers the same in connection with the prior Hoover and Downes U. S. Patents No. 1,752,789 and No. 1,752,795, each granted April 1, 1930 and the above-mentioned Smith U. S. Patent No. 1,893,451 granted January 3, 1933.

The three patents just referred to and the subject matter thereof and the locality of employment for the present invention are discussed and tersely pointed out in the early portion of the specification of the parent application, to wit, application Serial No. 27,014 filed on even date herewith.

An object of the invention is to provide a method and to provide apparatus for performing the method according to which there is realized and controlled a degree and type of agitation effective and beneficial in and for the formation of flocs of uniform and substantial size.

A further object of the invention is to provide an arrangement of means by which the liquid undergoing flocculation is subjected to an agitation of a character to effectively aid floc formation and, in association therewith, means for baffling the flow of liquid undergoing treatment in a manner which will result in an effective contacting and such degree of detention as will substantially avoid or eliminate what is frequently referred to as short-circuiting of portions of the flowing stream.

There is being filed concurrently herewith a companion application for patent entitled "Flocculation—Serial No. 27,014" executed by the undersigned as joint inventors on even date with the execution by the undersigned as joint inventors of the present application which has been entitled "Flocculation—Serial No. 27,015". This patent application Serial No. 27,015 may be considered in certain respects as complementing the companion patent application Serial No. 27,014. In said companion patent there appears and have been employed certain terminology or expressions and certain explanatory definitions

which are pertinent to and helpful in connection herewith and for that reason cross reference has herewith been made to said companion patent application Serial No. 27,014 with the understanding that the pertinent matter of said companion case is to be considered as having been set forth and incorporated herein.

The present invention particularly pertains to a flocculation apparatus according to which there is a general longitudinal flow from an influent section at one side or end portion of a tank or basin and an effluent discharge leading from an opposite side or end portion of the tank or basin, according to which the longitudinally flowing stream is subjected to agitation of a character to aid flocculation by means of, several paddle constructions as provided by horizontally and transversely extending shafts upon and by means of which the agitating paddles are carried in a manner to be rotated about horizontally extending axes in vertically extending planes paralleling the general direction of longitudinal flow, and in which there is provided one or more transversely extending baffles or partial partitions (sometimes referred to herein as upper transverse baffles or partial partitions) each of which traverses an upper section of the tank or basin in a manner to prevent a direct short-circuiting of a portion of the liquid undergoing treatment from the influent to the effluent section of the tank. Different forms of apparatus embodying this basic feature are shown.

According to one arrangement (herein referred to as the first arrangement) it will be noted that there is provision for the return of formed flocs along a lower path from subsequent or succeeding sections of the flocculator to preceding sections of the flocculator as such sections are formed and defined by the paddle and baffle arrangements thereof. According to the arrangement just referred to, it will be noted that all the paddles rotate in the same direction, that is, the paddles when they are in their uppermost position move in the general direction of longitudinal flow, whereas when in their lower position they move in a direction counter to the general flow. It will also be noted, as above pointed out, that these upper transversely extending baffles prevent longitudinal short-circuiting even though the paddles when in their uppermost sections are traveling or moving in the general direction of flow.

According to another arrangement (herein referred to as the second arrangement) there is employed in conjunction with the transversely

extending upper set of baffles a lower transverse baffle or baffles that extend the full width of the tank whereby an under-and-over baffle flow in a general longitudinal direction is necessarily realized as the apparatus functions. According to this second arrangement some of the sets of paddles rotate in one direction and others of the sets of paddles rotate in an opposite direction. In conjunction with this second arrangement it is to be noted that the baffles prevent any short-circuiting or longitudinal flow.

According to a third arrangement, all of the paddles rotate in the same direction, to wit, in a manner such that the paddles when in their uppermost position travel in the general direction of flow, whereas when in their lower position they travel counter to the general direction of longitudinal flow. According to this third arrangement, some of the transversely extending baffles may be considered as constituting an upper set and there is also provided a lower transversely extending baffle or baffles whereby a sinuous flow of liquid in a general longitudinal direction is obtained. According to the third arrangement, a certain passageway or passageways are provided through the lower transversely extending baffle or baffles whereby there is permitted a restricted but definite back-flow of formed flocs from a subsequent or succeeding section of the flocculator to a preceding section thereof. The upper transverse baffles in this third arrangement prevent a short-circuiting of longitudinal flow from the influent to the effluent section even though the paddles when in their upper position move in that general direction.

The invention revolves about the features of construction and the mode of operation thereof as above referred to. In the following description and claims, parts or features are identified by specific names for convenience but such are intended to be as generic in their application as the art will permit.

In the accompanying drawings which constitute a part of this specification, there have been illustrated or indicated the best and most characteristic embodiments of the invention known to the undersigned, but such are to be regarded as typical only of many possible embodiments or features and the invention is not to be limited thereto. In the drawings like or similarly functioning parts are indicated by the same reference characters. Reference is hereby made to said drawings which form a part of this specification, and therein

Figs. 1 and 2 are plan and vertical longitudinal sectional views illustrating the first arrangement previously referred to, Fig. 2 being a sectional view taken as on the vertical plane indicated by the line 2—2 of Fig. 1 looking in the direction of the arrows;

Figs. 3 and 4 are respectively plan and vertical longitudinal sectional views of the second arrangement previously referred to, Fig. 4 being a sectional view taken as on the vertical plane indicated by the line 4—4 of Fig. 3 looking in the direction of the arrows; and

Figs. 5 and 6 are respectively plan and vertical longitudinal sectional views of the third arrangement previously referred to, Fig. 6 being a sectional view taken as on the vertical plane indicated by the line 6—6 of Fig. 5 looking in the direction of the arrows.

Reference will now be made to the drawings in detail.

The flocculator tank or basin designated by 1

has a bottom 2, upwardly extending boundary walls 3, 4, 5, and 6, an influent trough or feed supply 7 by which the incoming solids-liquid mixture to be subjected to flocculation is supplied to the tank through the influent openings 8, and an effluent trough or conduit 9 for conducting the solids-liquid mixture from the flocculation zone which has been subjected to the flocculation operation and which passes thereto through the effluent discharge openings or passageways 10. The influent solids-liquid mixture, referred to as being supplied through the influent trough, is frequently a liquid which has been chemically dosed as an important part of the flocculating process and as to which there has been an intimate and violent mixing of the dosing chemical with the liquid to be subjected to flocculation treatment; it is to be understood, however, that the present invention is not necessarily limited to a chemically dosed liquid, as it is applicable to turbid liquids having solids in suspension therein which have not been chemically dosed.

The influent openings 8 and the effluent discharge openings 10 are located in the upper portion of the boundary wall with the result that they determine the minimum height of the body of liquid within the tank, but it is to be noted that the influent supply arrangement and the effluent discharge construction of the tank or flocculation basin can be the same as that shown in said Smith Patent 1,893,451.

In each form of apparatus illustrated there are shown four sets of paddle agitators, shown respectively as A, B, C, and D, each set being provided by a horizontally and transversely extending shaft 11 carrying sets of paddles 12 and 13. Between each set of paddle agitating mechanism there is located a baffle or partial partition that extends transversely the full width of the tank but for only a portion of the vertical depth of the tank. These partitions, designated E, F, and G, in conjunction with the paddle agitators referred to, in effect define a longitudinally arranged series of transversely extending flocculating compartments or spaces which may be designated K, L, M, N. At least some, if not, all, of the transversely extending partitions or baffles referred to are located in the upper interior portion of the sedimentation tank or basin. Suitable mechanism broadly designated X for rotating the paddle agitators, is employed for turning or rotating the shafts and paddles in the directions indicated by the arrows in the respective figures. The mechanism designated X is sometimes referred to as a motivating mechanism from which the several sets of paddles or paddle agitators are driven.

In the arrangement of Figs. 1 and 2—the arrangement herein referred to as the first arrangement—the solids-liquid mixture which is being subjected to the flocculation operation has a path of travel as above indicated longitudinally through the tank or basin and during its passage in this manner it successively passes through the flocculating compartments or spaces K, L, M, N. In each it is subjected to the agitative effect of the paddles, all of which move so that when in their upper positions or upper zones of movement they are moving or traveling in the general direction of flow, and so that when in their lower positions or lower zones of movement they are traveling counter to the general direction of flow.

In this first arrangement, all of the transversely extending baffles are located in the upper

interior portion of the tank or basin. The lower portion of the tank or basin is therefore unobstructed through its entire length and width, with the result that as the apparatus functions flocs which have been more or less completely formed can pass or be passed from the subsequent or succeeding portions of the tank or basin to the preceding sections or portions thereof. In other words, formed flocs can be passed from the subsequent compartment or flocculating space N to and into the preceding flocculating space M, thence from M to a still further preceding section L ultimately to the first or initial preceding section K. In other words, by this mode of operation and arrangement, flocs can be passed from what may be considered as the delivery compartment ultimately into the initial receiving compartment, whereby the formed flocs can in effect inoculate or aid in the formation of flocs as the process proceeds.

In the arrangement of Figs. 3 and 4, to wit, the second arrangement previously referred to, there is a general longitudinal flow through the tank or basin, but in the instance of this second arrangement one of the transversely extending baffles—baffle F—is located at the lower interior portion of the tank whereby in the lower portion of the tank the first half is effectively separated from the lower portion of the second half. According to this second arrangement, the shafts in compartments K and L rotate in opposite directions thus imparting opposite types of rotative effect upon the stream of solids-liquid mixture flowing past the same. The same is true of the paddle arrangements in the second half of the tank and the same is true of the paddle arrangements on opposite sides of the lower transverse partition or baffle F. It will therefore be seen that the lower transverse partition F prevents any longitudinal short-circuiting along the lower interior portion of the tank and that the upper transverse partitions prevent any longitudinal short-circuiting along the upper interior portion of the tank.

As to the arrangement of Figs. 5 and 6, to wit, the third arrangement referred to, the paddles all operate in the same general direction and manner as the paddles of the first arrangement. In the third arrangement, however, one of the transversely extending baffles—baffle F—is located at the lower interior portion of the tank. This lower baffle or partial partition F is approximately half way between the influent and the effluent sections of the tank and is provided with one or more relatively small passageways by which a certain amount of formed flocs can pass or be passed from a subsequent or delivery section of the tank to a previous or initial liquid receiving section of the tank whereby the thus returned flocs can serve or aid in effecting the desired flocculation operation. The arrangement of the baffles or partial partitions of Figs. 5 and 6 is such that there is a sinuous or meandering flow of fluid in a longitudinal direction very much after the order of the flow which will be realized in the apparatus of Figs. 3 and 4.

As has been pointed out in the companion case which is herein referred to, it has been found that the degree of flocculation is in proportion to the number of paddle impacts, that is, a small diameter mechanism, operating at a relatively high speed will give better results than a relatively large diameter unit operating at lower speeds. This is explained due to the multiplied

amount of turbulence set up around the paddle blades. We have found that the best results can be obtained with paddle diameters equal to about 0.6 to 0.8 the fluid depth and paddle speeds with given velocities of from 0.6 to 1.8 ft. per second at the periphery.

It has also been found that the process of flocculation can be greatly accelerated by returning some of the larger and bulkier flocs from the later or subsequent stages of the flocculation reaction to the earlier stages, in other words, by a certain inoculation of the unflocculated liquid with liquid containing flocs in an advance stage of development, and it has also been found that it is better to do this in successive stages, that is, by returning formed flocs from the second stage to the first stage, from the third to the second, from the fourth to the third and so on, rather than by a direct return of flocs from the fourth stage or compartment N to the first stage or compartment K, and it is for this reason that the mode of return illustrated in conjunction with the first and third arrangements described herein has been employed. As to the vertical height or depth of the baffles or partial partitions, these should be from one-third to three-fourths of the fluid depth.

It will be understood that while the elements and advantages of this device have been described by certain specific embodiments, that there are many other possible arrangements which will combine the essential features thereof.

The invention possesses objects and features of advantage other than those which have been specifically enumerated but which will be manifest from the foregoing description.

What is claimed is:

1. In a flocculating apparatus, a tank or basin having an influent section located at one end portion thereof and a submerged effluent outflow section located at the opposite end portion thereof and through which tank the liquid flows along a longitudinally extending path from the influent section to the effluent outflow section; baffles that extend transversely the full width of the tank, that extend only part way of the interior height of the tank and that divide the tank into a horizontally arranged series of transversely extending sub-compartments which are in serial communication with one another; agitator means located within the sub-compartments and provided by a plurality of parallel rotatable paddle sets comprising longitudinally spaced transversely extending rotatable shafts carrying relatively horizontally extending paddles of which paddle sets the adjacent longitudinally spaced sets are disposed at opposite sides of a transversely extending baffle corresponding thereto, which said shafts and paddles functionally operate in submergence in the liquid, the top surface of which liquid is above the lowermost flow defining portion of the effluent outflow section; and means for rotating said shafts.

2. A construction as defined in and by claim 1, according to which all of the transversely extending baffles extend downwardly within the tank from the upper interior portion of the tank but terminate a substantial distance above the bottom of the tank; and according to which the shafts carrying the several paddles all rotate in the same direction and in a manner whereby the paddles when in the uppermost position therefor constantly move in a direction leading from

the influent section of the tank towards the effluent section of the tank, and whereby the paddles when in the lowermost position therefor move in a direction leading from the effluent section towards the influent section whereby a certain amount of formed flocs are caused to countercurrently move from subsequent sub-compartments below and past the lower edge portions of the baffles to and into preceding sub-compartments.

3. A construction as defined in and by claim 1 according to which certain alternate transversely extending baffles extend downwardly from the upper interior portion of the tank for a substantial distance within the liquid within the tank but terminate a distance above the bottom of the tank, and according to which an intermediate transversely extending baffle extends upwardly from the bottom of the tank but terminate a substantial distance below the upper interior portion of the tank whereby the upper edge of the baffle is continuously submerged, thus providing an over-and-under baffle type of construction.

4. A construction as defined in and by claim 1 according to which certain alternate transversely extending baffles extend downwardly from the upper interior portion of the tank for a substantial distance within the liquid within the tank but terminate a distance above the bottom of the tank; according to which another transversely extending baffle extends upwardly from the bottom of the tank but terminates a substantial distance below the upper interior portion of the tank so that the upper edge of said baffle is continuously submerged and whereby because of the baffle arrangement defined there is provided an over-and-under baffle type of construction; according to which a certain portion of each baffle that extends upwardly from the bottom of the tank is provided with a continuously open passageway therethrough for permitting during the normal functioning of the apparatus a back-flow of countercurrent movement along the bottom of the tank of some of the formed flocs; and according to which the shafts carrying the several paddles all rotate in the same direction and in a manner whereby the paddles when in the uppermost position therefor move in a direction leading from the influent section of the tank towards the effluent section, and also whereby the paddles when in the lowermost position therefor move in a direction leading from the effluent section of the tank towards the influent section.

5. In a flocculating apparatus a tank or basin having an influent section located at one end portion thereof and an effluent section leading from the opposite end portion thereof and through which tank the liquid undergoing flocculation has a relatively longitudinal flow past and below baffles that extend transversely the full width of the tank, that extend downwardly within the tank only part way thereof, that divide the tank into a horizontally and longitudinally arranged series of transversely extending sub-compartments which are in serial communication with one another; agitating means located within the sub-compartments and provided by horizontally and transversely extending rotating shafts carrying relatively horizontally extending paddles, which shafts are submerged in the liquid undergoing flocculation; and means for rotating said shafts.

6. An apparatus for flocculation comprising,

in combination, a rectangular basin for holding the liquid undergoing a flocculation treatment and having a feed therefor at one end portion thereof and a discharge at the opposite end portion thereof thus providing for a general longitudinal flow throughout the basin; a plurality of parallel horizontally and transversely extending rotatable shafts located within the basin below the top portion thereof and positioned so as to be submerged in the liquid undergoing flocculation; a multiplicity of horizontally and transversely extending paddles that derive support from and that are spaced from said shafts and which are operated through the medium of said shafts to gently agitate the liquid undergoing flocculation at a rate adequate to maintain the solid matter in suspension but insufficient to interfere with floc formation; said basin being divided into a series of communicating compartments by transverse, vertical baffles constituting partial partitions located between the paddle shafts, extending downwardly from the upper interior portion of the basin and serving to confine upper sections of the liquid against movement in a horizontal path longitudinally past the thus located baffles; said paddles being rotated in such a manner that at the top of the rotational cycle thereof the movement is in a general direction which is the same as that of the general flow from the feed to the discharge portion of the basin and also such that at the bottom of the rotational cycle thereof they move in a general direction which is counter to that of the general flow.

7. An apparatus for flocculation comprising a rectangular basin, a feed therefor at one end portion thereof, and a discharge at the opposite end portion thereof, a plurality of transversely and horizontally extending parallel rotatable submerged shafts located within the basin, a multiplicity of horizontal paddles supported by but spaced from the shafts and so operated as to agitate the fluid undergoing flocculation at a rate adequate to maintain the solid matter in suspension but insufficient to interfere with floc formation; which said basin is divided into series-connected compartments by transverse vertical baffles that are located between the said paddle shafts; which said baffles extend downwardly from the upper interior portion of the basin to a locality from one-third to three-fourths of the depth of the basin, and wherein the paddles are rotated in such a way that at the top of the rotational cycle they are sweeping in the same direction as the general flow, and at the bottom of the rotational cycle counter to the general flow of liquid from the feed end to the discharge end.

8. In a flocculating apparatus, a tank having an influent section at one end portion thereof, a submerged effluent section at the opposite end portion thereof, baffles that extend transversely of the tank for the full width but not for the full depth of the liquid holding section thereof and thus dividing the tank into a longitudinally arranged series of transversely extending sub-compartments in communication with each other, of which baffles those constituting one alternate set extend from the upper interior portion of the tank or basin downwardly within the liquid holding space of the tank but so as to have spaced relationship with the tank bottom, of which an intermediate baffle extends upwardly from the bottom of the tank for a part way only of the liquid holding section of the

tank thus terminating a distance below the uppermost interior portion of the tank whereby the upper portion of the intermediate baffle is normally submerged, the intermediate baffle having a passageway through the lower portion thereof for permitting a backflow in the nature of a countercurrent return of some liquid containing formed flocs from a subsequent section of the tank to a preceding section of the tank.

9. In the art of flocculation apparatus comprising a flocculation tank sub-divided by partial partitions extending the full width of the tank but vertically for only a part of the depth of the interior of the tank into a plurality of serially arranged rectangular compartments disposed parallel to each other and of which adjacent compartments are in constant hydraulic communication with each other through passageways left within the interior of the tank, means by which the incoming liquid to be subjected to a flocculation operation is introduced into the tank at one end section thereof, means located at the opposite end section of the tank providing a submerged discharge through which liquid with floc colonies therein can freely drift from the flocculation zone provided within and by the serially arranged rectangular compartments of the tank, motivating means and successive sets of mechanical means actuated from said motivating means, said sets being disposed for operation in successive compartments, constructed for inducing uniform agitation, for providing flow movements in vertically extending planes paralleling the general direction of liquid flow through the tank, of an intensity adequate to maintain a substantially homogeneous floc suspension but not of an intensity sufficient to interfere with floc formation, and having operative movements of a character for inducing substantially horizontally unobstructed countercurrent flow conditions for localized sections of liquid carrying flocs in suspension.

10. An apparatus for flocculation comprising, in combination, a rectangular basin for holding liquid undergoing a flocculation treatment and having a feed therefor at one end portion thereof and a discharge at the opposite end portion thereof thus providing for a general longitudinal liquid flow through the basin; a plurality of parallel horizontally and transversely extending shafts operatively positioned with respect to the basin; a multiplicity of horizontally and transversely extending paddle sets that derive support from and that are spaced from said shafts, means for operating said paddle sets in a manner to positively but gently agitate the liquid undergoing flocculation at a rate adequate to maintain the solid matter in suspension but at a rate insufficient to interfere with floc formation; transverse baffles extending the full width of the interior of the tank and constituting partial partitions located between the paddle sets subdividing said basin into a series of communicat-

ing compartments by extending downwardly from the upper interior portion of the basin and serving to confine upper sections of the liquid against movement in a horizontal path longitudinally past the thus located baffles; said paddle sets being movable each in a cyclic path in which the movement at the upper portion of the cycle is in a general direction which is the same as that of the general liquid flow from the feed end portion to the discharge portion of the basin and in which the movement at the lower portion of the cycle is in a general direction which is counter to that of the general liquid flow.

11. In apparatus for coagulating flocculable matter in liquid passing therethrough, a basin for holding the liquid while undergoing agitation conducive to flocculation and having a continuous straight longitudinally extending bottom section, means by which the liquid is fed to and distributed at and along one end section of the basin, a submerged discharge disposed along and leading from the opposite end section of the basin, transverse baffles constituting partial partitions located over the straight longitudinally extending bottom section and extending the full width of the interior of the basin but vertically only part way of the height of the interior of the basin whereby the basin is divided into transversely extending sub-compartments longitudinally disposed one after the other and of which the adjacent sub-compartments are in free flow hydraulic communication with each other, agitator means comprising longitudinally spaced horizontally and transversely extending shafts and sets of transversely extending paddles carried from said shafts and positioned so that successive sets of longitudinally spaced paddles are provided for imparting agitative effects conducive to flocculation in successive sub-compartments, and means for imparting agitative movements ultimately to said paddles.

12. In apparatus as defined in and by claim 11 an arrangement according to which the transverse baffles constituting the partial partitions are vertically spaced from the bottom of the tank whereby a free flow passageway is provided for and below each partition.

13. In apparatus as defined in and by claim 11 an arrangement according to which at least one of the transverse baffles constitutes a partial partition which is vertically spaced from the bottom of the tank whereby a free flow passageway is provided for and below the partition while another of the partitions extends upwardly from the bottom of the tank but only part way of the interior height of the tank whereby a free flow passageway is provided for and above the same.

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