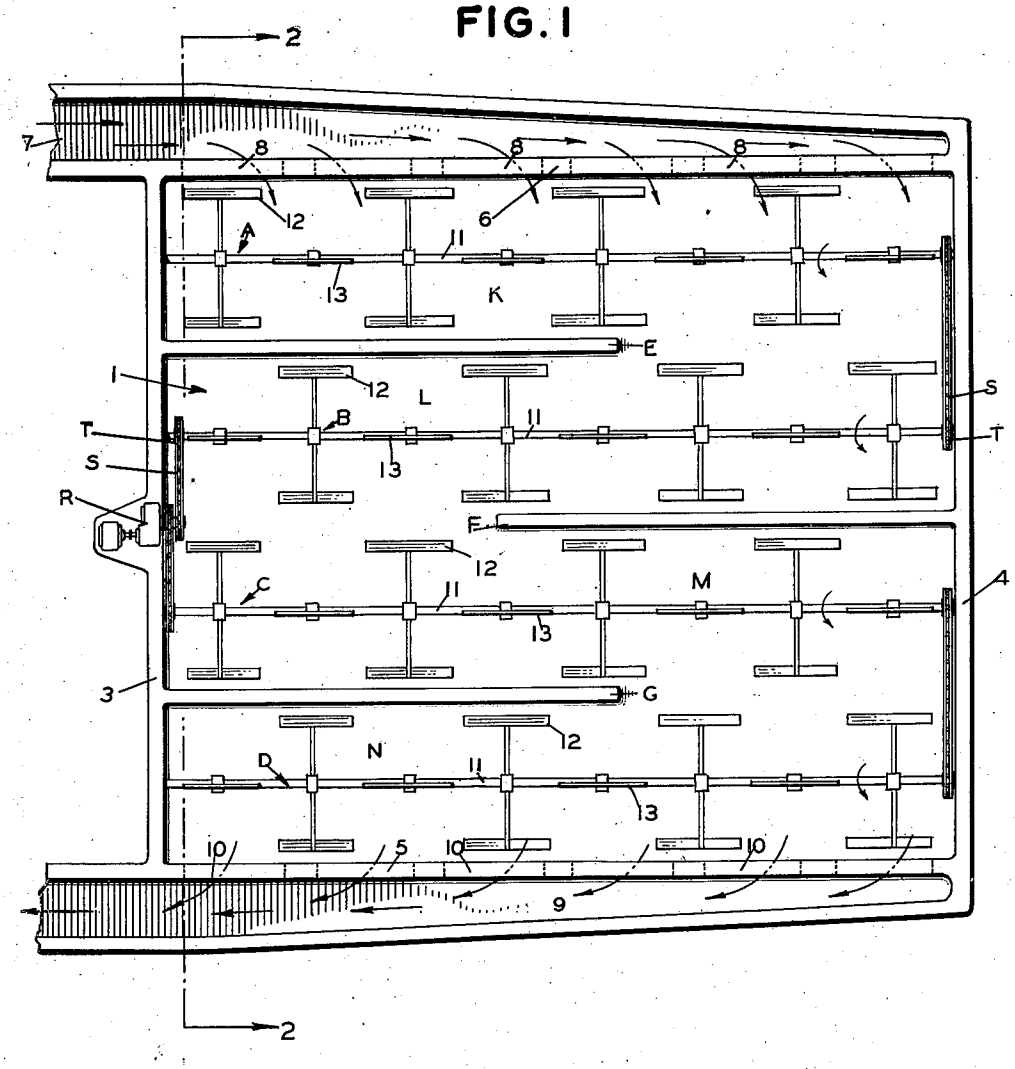
May 25, 1937. G. M. DARBY ET AL 2,081,852

FLOCCULATION

Filed June 17, 1935 2 Sheets-Sheet 1

FIG. 1



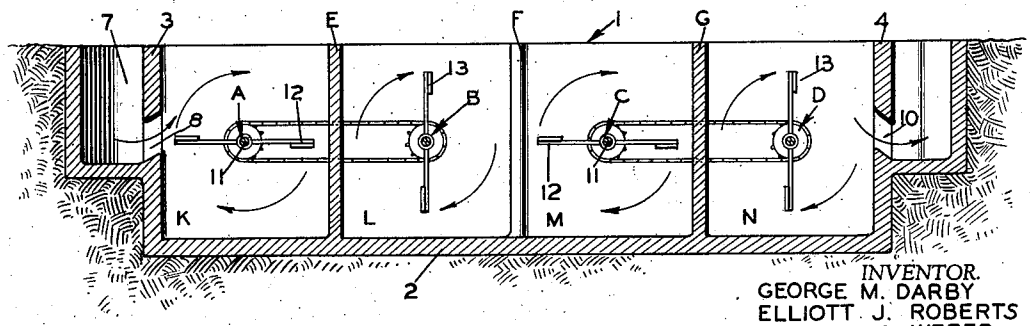


FIG. 2

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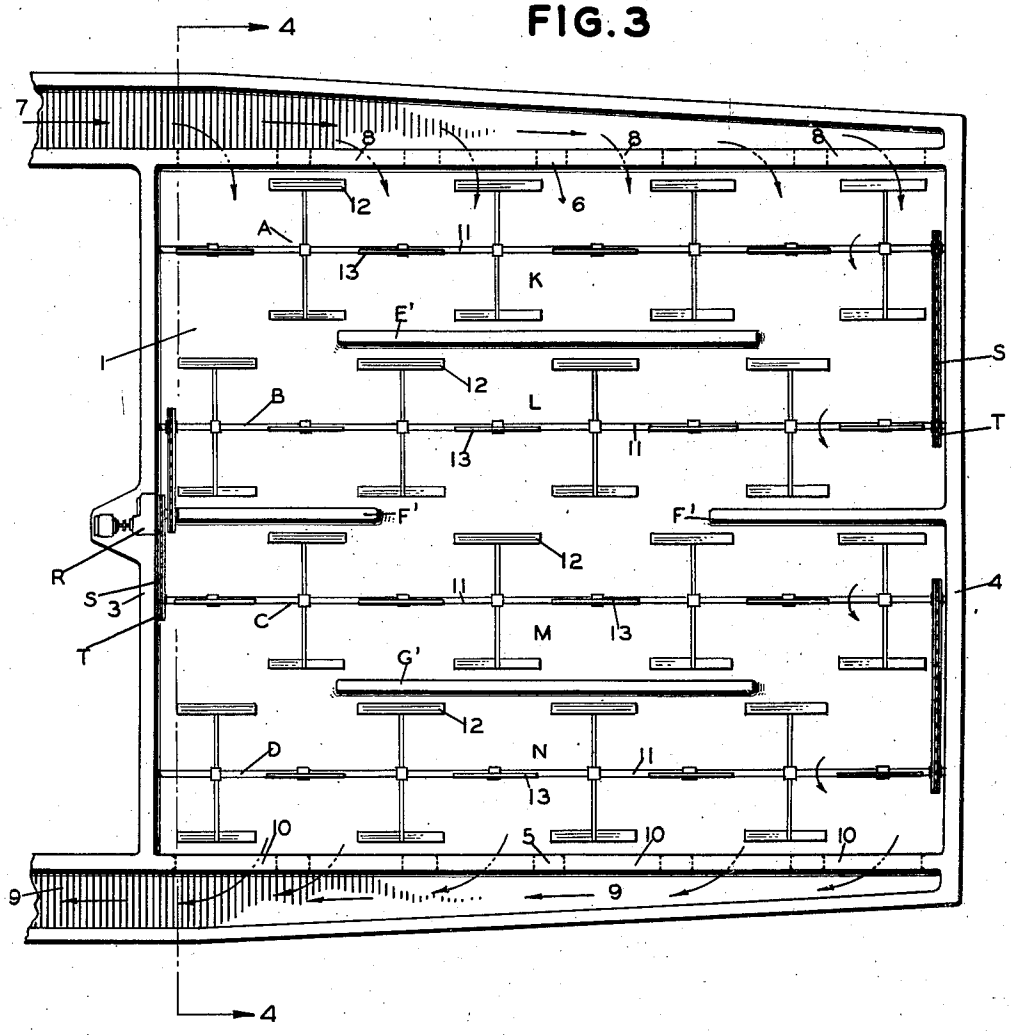
FIG. 3



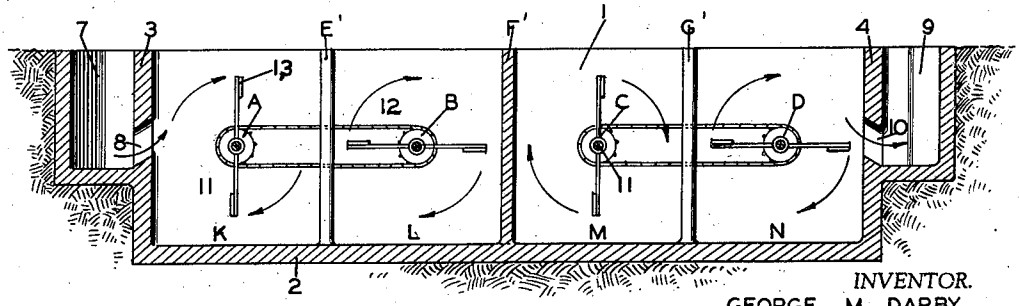


FIG. 4

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UNITED STATES PATENT OFFICE

2,081,852

FLOCCULATION

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Application June 17, 1935, Serial No. 27,016

6 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.

There is being filed concurrently herewith a companion application for patent entitled Flocculation Serial No. 27,014 which has been executed by the undersigned as joint inventors, who also appear as joint inventors of the present application which is entitled Flocculation Serial No. 27,016. This patent application Serial No. 27,016 may be considered in certain respects as complementing the companion patent application Serial No. 27,014. In certain respects this application Serial No. 27,016 may also be considered as complementing another companion application entitled Flocculation Serial No. 27,015 which is also bing filed concurrently herewith. In said companion application Serial No. 27,014 there appears and has been employed certain terminology or expressions, and certain explanatory definitions which are pertinent to and helpful in connection with this application, 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 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. Patent No. 1,752,795, and the Downes U. S. Patent No. 1,752,789, 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.

The present invention particularly pertains to a flocculation apparatus according to which there is a general longitudinal liquid 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 or paddle sets 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 longitudinally spaced baffles or partial partitions that to a certain extent in effect divide or sub-divide the tank or basin into a series of longitudinally arranged transversely extending paddle-receiving spaces, each of which baffles or partitions in the construction shown extend for the full depth or height, or for substantially the full depth or height, of the liquid-holding section of the tank or basin within which the paddle constructions are located, each of which baffles or partitions extend only part of the way across the tank or basin thus properly leaving in the free end or ends of the baffles or partitions a communicating space or spaces of substantial width that are provided for permitting certain countercurrent or backflows for certain sections of the flowing stream, and which countercurrents or backflows are incident to the functional effect of cooperating sets of longitudinally spaced paddle constructions that are positioned in the longitudinally arranged series of paddle receiving spaces above-mentioned. The succeeding baffles or partitions are arranged so that the free end or ends of any one baffle in effect slightly overlap the free end or ends of the preceding or succeeding baffles or partitions, whereby there is avoided an absolutely straight flow from any one section or portion of the flowing stream from the influent section to the effluent discharge, thus having in view the avoiding of a direct path or short-circuiting of a portion of the liquid undergoing treatment.

Different forms of apparatus embodying this basic feature, which has as an object thereof countercurrent movements in certain sections of a forwardly flowing stream and the avoiding of short-circuiting flows in the forwardly flowing stream, are shown in the accompanying drawings.

Two arrangements or embodiments for realizing the invention hereof are illustrated in the drawings, each embodying baffles or partial partitions constructed along the lines generally defined above. These partial partitions, because of the longitudinally-spaced arrangement thereof, in effect define or delineate a longitudinally-ar-

ranged series of transversely-extending paddle-receiving spaces of which adjacent spaces are in constant hydraulic communication with each other through the medium of the relatively wide or substantial space which is left existent at the free end of each partition.

According to one arrangement (herein referred to as the first arrangement) it will be noted that the transversely extending partitions extend inwardly from each side wall of the sedimentation tank or basin to a location slightly beyond the true longitudinal center of the sedimentation tank or basin. Each of these partitions, however, extends only a slight distance past the longitudinal center, and it will be noted that the free ends thereof consequently have a staggered arrangement on opposite sides of the true longitudinal center and that the free end portions of these partitions may therefore rightly be described as having a slight overlapping arrangement with the result that any straight or direct flow, to wit, any short-circuiting flow from the influent section to the effluent section of the apparatus is avoided. Also, according to this arrangement under discussion, the wide space left between each free end of the partition on the one hand, and the side wall on the other hand, provides a communicating space that allows a substantial countercurrent movement of the liquid in the particular lower section of the basin in respect to the general forward flow of the body of liquid through the upper portions of the space.

According to another arrangement (herein referred to as the second arrangement) there are sets of baffles or partial partitions which extend from the side walls towards each other, thus leaving a relatively wide communicating space between the free ends, while other of the partitions are located in the intermediate or central sections of the tank and extend transversely towards the sides but terminate sufficiently short of the sides to provide relatively wide communicating spaces between free ends on the one hand and the side walls on the other. The total area of the communicating spaces at the opposite ends of these last-mentioned partitions, approximately totals the same as that of the free space which is left existent between the free ends of the partitions that extend towards each other. The communicating spaces just referred to allow a counter current flow movement very much after the order of the countercurrent flow movement mentioned in respect to the first arrangement, and it is to be noted that the free ends of the successively arranged partitions have a staggered arrangement and that the several end portions of the several partitions slightly overlap, thus avoiding any direct flow or short-circuiting of liquid from the influent section to the effluent section of the sedimentation tank or basin.

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 these 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 are 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 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; and

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.

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, and an influent trough or feed supply 7 by which the incoming solid-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 solid-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 solid-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 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 shown, there are four sets of paddle agitators, shown respectively as A, B, C and D, each being provided by a horizontally and transversely extending shaft 11 carrying sets of paddles 12 and 13. The several shafts 11 are driven by suitable motor and speed-reducing gearing R through the medium of chains S and sprockets T. The motor and speed reducing gearing R and the chain S and sprockets T just mentioned may be referred to as a motivating mechanism for driving the paddle constructions which collectively are sometimes broadly referred to as agitating means including or providing the transversely extending axle members or shafts D and C and the sets of paddles 12 and 13 carried thereby. The paddle constructions just mentioned are sometimes referred to as paddle agitators and sometimes as agitating paddles. Between each set of paddle agitators or paddle agitating mechanism, as the paddle agitators may be called, there is located a baffle or partial partition. Each baffle or partial partition has a substantial vertical extent within the liquid containing section of the tank and, in fact, it preferably extends for the full height or depth, or at

least substantially for the full height or depth, of the liquid-holding section of the tank. These baffles or partial partitions, in the arrangement of Figs. 1 and 2, are designated as E, F and G, and in the arrangement of Figs. 3 and 4 are designated as E', F' and G'. These partitions do not extend the full width of the tank, as is clear from the drawings. They have, however, a longitudinal spaced arrangement and, in effect, delineate or define a longitudinally arranged series of transversely extending compartments or spaces within which the paddle agitators above referred to are located.

These compartments or spaces may be designated as K, L, M and N. The partitions mentioned in conjunction with the paddle agitators referred to, in effect, provide a longitudinally arranged series of transversely extending flocculating compartments or spaces which are, in fact, the spaces heretofore designated as K, L, M and N.

In both forms of arrangement shown, the free ends of the partitions provide a staggered arrangement and the free-end portions of the successive partitions slightly overlap, whereby there is avoided or prevented any direct flow or short-circuiting of liquid which is supplied at the influent or feeding-in section or end of the tank or basin on the one hand—as provided by the influent openings 8—and to the effluent or outflow discharge section of the tank or basin on the other hand—as provided by the discharge openings or passageways 10.

In the arrangement of Figs. 1 and 2, herein referred to as the first arrangement, the solid-liquid mixture which is being subjected to flocculation operation has a path of travel in a general longitudinal direction through the tank or basin, and during its passage in this manner it successively passes through sections of the flocculating compartments or spaces K, L, M and N. In each it is subjected to the agitative effect of the paddles, all of which rotate in the same general direction. In other words, all of the paddles 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 position or lower zones of movement they are traveling counter to the general direction of flow, or, as otherwise expressed, each paddle in the upper portion of its travel has a component of movement to effect or induce a forward longitudinal movement to a certain upper section of the liquid within the sedimentation basin, and so that each paddle in the lower portion of its travel has a component of movement to effect or induce a rearward longitudinal movement to a certain lower section of the body of liquid, whereby there is a countercurrent movement as between the upper and lower liquid sections just referred to.

According to the arrangement of these Figs. 1 and 2, it is to be noted that the partitions E, F and G extend from the side walls towards and slightly beyond the longitudinal center of the tank or basin with the result that the free ends of the alternately arranged partitions provide the staggered and overlapping arrangement referred to. Each partition also provides or leaves a relatively wide space between the free end of the partition and the side wall toward which it extends. Thus there is provided a relatively wide communicating space which provides communication as between the flocculating compartment or space immediately or directly ahead of the particular partition and the flocculating compartment or space immediately behind the particular partition; and through this communicating space, and particularly because of the disposition of certain of the paddle constructions which are in that immediate vicinity, there is effected and realized the countercurrent movement also just described.

It will thus be manifest that there can be a general forward flow in a longitudinal direction of the water undergoing treatment as a whole, but that in certain sections thereof there can be a limited countercurrent movement, with the result that a certain amount of formed flocs is passed rearwardly from a subsequent compartment or flocculating space to and into a preceding flocculating compartment or space.

In the arrangement of Figs. 3 and 4, to wit, the second arrangement previously referred to, the partitions E', F' and G' have a somewhat different arrangement from that of the first arrangement. Here it will be noted that the partitions E' and G' have a substantial vertical extent within the liquid-holding section of the sedimentation tank or basin, in other words, their vertical extent as shown is for the full height or depth, or substantially so, of the sedimentation tank or basin; and that they are located within and extend transversely of the general longtiudinal central section of the sedimentation tank or basin, leaving or providing at the opposite free ends thereof relatively wide communicating spaces, to wit, the spaces between the free ends on the one hand and the side walls of the tank on the other.

The partitions F' and F', are arranged in pairs and extend from opposite side walls of the tank towards each other, and between the free ends of these partitions there is a relatively wide communicating space. The total width of the communicating spaces provided at the opposite free ends of the partitions E' and G', approximates the total area of the communicating spaces between the free ends of the pairs of partitions F' and F'. These communicating spaces, in conjunction with the paddle arrangements referred to and described, provide and realize a construction according to which there is a general forward flow of liquid throughout the sedimentation basin, with an accompanying countercurrent flow of the lower sections of liquid.

It will be noted that according to this second arrangement there is a staggering of the free ends of the successive partitions, and that the free end portions of the successive partitions have a slight overlapping which precludes any short-circuiting of liquid or of liquid-solid mixture from the influent section of the tank or basin to the effluent section thereof.

In the first arrangement all of the liquid undergoing treatment passes through the same type of general flow. According to the second arrangement it is to be observed that there is in effect a splitting of the liquid so that one section thereof has one type of general flow, while the other section thereof has what may be considered as a complementing type of flow, both of which, however, are in effect the same. As a matter of fact, the ultimate effect of the operation of both types of apparatus illustrated is substantially the same.

As has been pointed out in the companion application Serial No. 27,014, 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 multiple 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 of the fluid depth and paddle speeds with given velocities of from 0.6 to 1.8' 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 certain inoculation of the unflocculated liquid with liquid containing flocs in the advance stages of development,—and it has 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. It is for this reason that the mode of return illustrated in conjunction with the arrangements herein described has been employed.

It will be noted that in order to attain the full benefit of the agitating means that the paddles or the paddle sets function in the lower portions of the body of liquid undergoing flocculation and also in the upper portion with the result that as the liquid passes along the meandering path provided by the successive compartments there is realized a positive agitation throughout each section or portion of the liquid as it travels along the meandering or sinuous path.

The embodiments herein described have been developed in order to realize the benefits resulting from the certain inoculation which can follow the return of flocs and which is accompanied by the countercurrent movements herein described.

It will be understood that while the elements and advantages of this device have been described by certain specific embodiments, there are 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 having an influent section at one end portion thereof, an effluent section at the opposite end portion thereof, baffles providing partial partitions that have substantial vertical depth within the liquid holding space of the tank, which partial partitions extend transversely only part way across the tank thus delineating within the tank a longitudinally arranged series of transversely extending sub-compartments providing spaces which are in communication with each other through the medium of relatively wide passageways provided and left at the free ends of the partial transverse partitions, the free ends of successive longitudinally spaced transverse partitions having a staggered and overlapping arrangement whereby a straight flow of liquid from the influent section of the tank to the effluent section of the tank is prevented and avoided, a motivating mechanism, and agitating means driven from said motivating mechanism and providing longitudinally spaced sets of transversely extending agitating paddles disposed in the sub-compartments at the opposite sides of a partial partition and which sets of paddles have certain longitudinal and forward components of movement within the upper sections of the body of liquid within the tank and have certain longitudinal rearward components of movement in the lower sections of the liquid within the tank whereby countercurrent flow movements are realized through the passageways left within the tank by the particular partial transverse partition.

2. An apparatus as defined in and by claim 1 according to which the partial partitions extend transversely from opposite side wall portions of the tank and overlap in the horizontally extending central section of the tank.

3. An apparatus as defined in and by claim 1 according to which some of the partial partitions extend transversely from the side walls of the tank toward each other, leaving a relatively wide passageway space between the free ends of the thus located last mentioned partial partitions and of which other of the partial partitions are located in the longitudinally extending central sections of the tank and have free ends that are spaced from the side walls of the tank whereby a relatively wide passageway space results because of the space left between each free end of the centrally located partial partition on the one hand and the side walls on the other hand.

4. An apparatus for flocculating liquids comprising a flocculation tank having a transversely disposed influent distributing section by which incoming liquid is relatively uniformly distributed across one end of the tank, a transversely disposed effluent section by which outgoing liquid is passed from the flocculation zone in relatively uniform manner from the opposite end of the tank; transversely and vertically extending partial partitions each of which extend only part way across the tank interior whereby each partition is of the round the end flow type, said transversely extending partial partitions being longitudinally spaced and successive partitions being arranged so that the end portions thereof are in overlapping arrangement thereby providing a meandering horizontal flow path in a general longitudinal direction for the liquid passing from the influent end of the tank to the effluent end thereof, motivating mechanism, and transversely extending longitudinally spaced sets of paddle agitators driven from said motivating mechanism and operable within the successive compartments as defined in part by said partitions, the paddles of which said sets of paddle agitators are arranged for functioning in the lower portion of the body of liquid within the basin as well as in the upper portion of the body of liquid and are operatively connected and actuated for causing countercurrent flow movements in the liquid passing through the communicating spaces at the end of the partitions.

5. An apparatus for flocculating liquids comprising a flocculation tank having an influent feed leading to one end thereof and an effluent discharge leading from the other end thereof; transversely and vertically extending partial partitions each of which extends only part way across the tank interior whereby each partition is of the round the end flow type for providing a meandering horizontal flow path in a general longitudinal direction for the liquid passing from the influent end of the tank to the effluent end thereof, motivating mechanism, and transversely extending longitudinally spaced sets of paddle agitators driven from said motivating mechanism and operable within the successive compartments as defined in part by said partitions, which said sets of paddle agitators are operatively connected and

fctuated for causing countercurrent flow movements in the liquid passing through the communicating spaces at the ends of the partitions.

6. An apparatus as defined in and by claim 5 according to which a meandering flow path is realized because alternate partitions are provided by baffles arranged in pairs and extend horizontally from the longitudinal side portions of the tank toward each other but are transversely spaced so as to leave a centrally disposed passageway and because each intermediate partition is provided by a single baffle centrally disposed in respect to the tank and transversely spaced from the longitudinal sides of the tank so as to have a pair of transversely spaced flow passageways located adjacent the inner side portions of the tank.

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