March 27, 1951 W. H. GREEN 2,546,691

COAGULATING APPARATUS

Filed Sept. 3, 1947

Fig. 1.

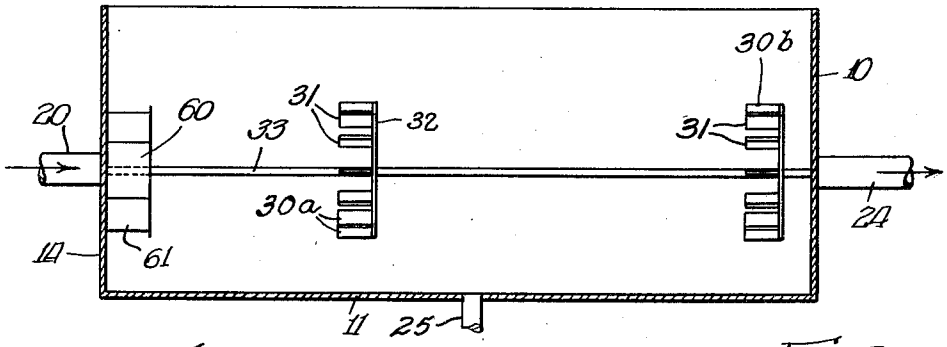


Fig. 2.

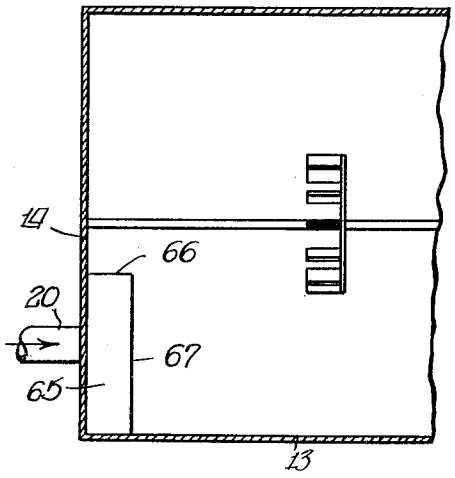
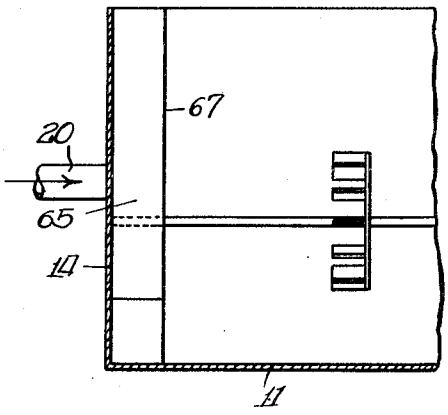


Fig. 3.



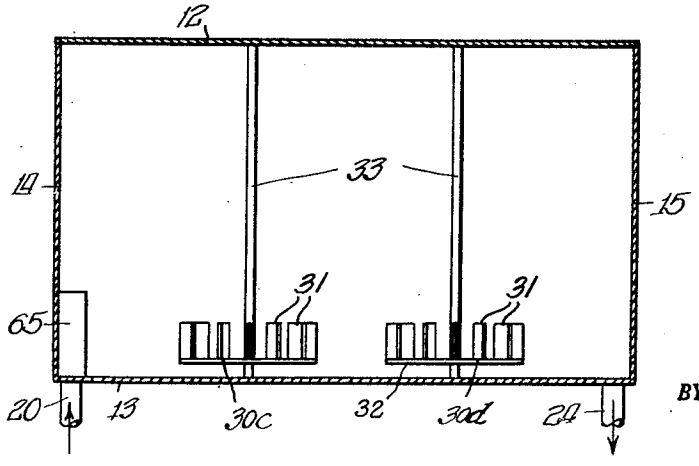


Fig. 4.

INVENTOR.
Walter H. Green,
BY Robyn Hilton
Atty.

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COAGULATING APPARATUS

Walter H. Green, Geneva Township, Kane County, Ill., assignor to Infilco Incorporated, Chicago, Ill., a corporation of Delaware

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9 Claims. (Cl. 259—6)

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This invention relates to a method and apparatus for the mechanical flocculation of solids in liquids, with or without the use of a chemical flocculant.

A main object of my invention is to provide a form of coagulating apparatus whereby or wherein there is set up a pattern of flow of a form particularly favorable to coagulation.

A specific object of my invention is to set up in a flocculation, or coagulation, zone or apparatus a plurality of individual coagulating units, each of which, though not separated from the others by partitions or baffles, maintains a separate zone with a three dimensional flow pattern affording exceptional opportunity for gentle contact of flocs, or coagulum, and for gentle passage from one zone to another.

Another object is to flocculate solids in a liquid by a vortex type of agitation, whereby, due to the intricate pattern of flow in all three dimensions without undue turbulence, the solids in the liquid readily aggregate into larger and denser particles than has been customary heretofore.

Another object is to provide an apparatus that will set up and maintain in the liquid within a basin or chamber that forms part of the apparatus, a type or pattern of flow that in addition to inducing very numerous particle contacts or collisions favorable to floc growth also includes in one or more closed circuit flows all the liquid in the basin or chamber whereby all the volume of the basin is utilized, short circuiting is prevented and a substantially uniform velocity is imparted to the liquid in all parts of the basin.

Another object is to provide, as one member of apparatus of the type referred to, a rotor, the rotor being so fashioned and proportioned and so placed that during operation it will constantly draw in toward itself a major flow of liquid along or in the direction of the shaft on which it is maintained and will discharge this liquid radially outward from the shaft and in substantially equal amounts in all directions.

Other objects of the invention will become apparent upon consideration of the specification and claims which follow.

In the clarification of turbid liquids, as by sedimentation or filtration, it is often found that fine solids in suspension in the liquid to be clarified are exceedingly difficult to remove, being too light to settle in any reasonable time and too small to be retained by any practical filter medium. Liquids containing such fine solids are usually pretreated by coagulation, or flocculation (the terms usually being used interchangeably),

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to improve the settling or filtering qualities of these solids. In the coagulation step the liquid, which customarily will be dosed, either before or during the treatment, with floc-forming chemicals, is subjected to gentle agitation for a period of time to afford repeated contacts between solid particles, or flocs, in the liquid. Such contacts promote their aggregating, as by agglomeration and coagmentation, to form larger particles which are conditioned to settle or filter more easily.

One of the oldest and simplest forms of providing gentle agitation is the baffled basin. Baffles of various kinds, such as for example the so called "round-the-end" type, the "under-and-over" type, have been widely used for this purpose. However the agitation provided by the changes in direction caused by such baffles is often insufficient for proper coagulation of large flows of liquid.

More recently mechanical flocculators have come increasingly into use for coagulating liquids. These flocculators have paddle agitators of the revolving, or sometimes the reciprocating type. The paddles, usually fixed to horizontal shafts, are slowly moved through the liquid to impart thereto a gentle stirring motion. The degree of agitation that may be imparted to the liquid in this manner is quite limited, as the flocs produced by this kind of agitation are fragile and delicate and subject to breaking up by turbulence.

It was generally found that this type of agitation, in an unbaffled basin, did not prevent liquid from flowing in a continuous horizontal flow along the surface of the liquid, or along the bottom of the basin, or both, from inlet to outlet, for, due to the character of the particles, not sufficient positive energy could be applied to the liquid with the stirring devices used to break up this tendency. To avoid such objectionable short-circuiting of part of the liquid, paddle agitation usually has been combined with various types of baffle arrangements. By interposing round-the-end or over-under baffles or the like, the liquid was forced to take a circuitous path which prevented its short-circuiting from inlet to outlet. Between pairs of baffles individual agitation cells, or units, were thus set up, wherein the paddles caused a gentle agitation of the liquid. Thus the general forward flow of liquid through the basin was subjected to deflection, laterally or vertically, by the baffles, and to some kind of agitation in the individual cells by rotation of the paddles. The combined motions re-

sulted in particle collisions conducive to coagulation. In all such apparatus the most apparent and greatest amount of movement of the liquid in passing through the coagulating space is the continuous longitudinal forward movement from inlet to outlet, the moving paddles merely causing some local turbulence in this pattern of flow. Since the greatest permissible velocity of such paddles is generally considered to be 1½ to 2 feet per second it is obvious that a very elaborate paddle system is required to secure enough collisions to produce maximum coagulation. I have found that a greater number of particle collisions suitable for producing coagulation can be had in an apparatus and by the flow pattern herein described in the same or less space and time. It will be noted also that with the apparatus and flow pattern herein proposed the particle collisions are not due primarily or chiefly to local and temporary eddies but to sustained, more or less parallel, somewhat distorted flows or currents between which there is a shearing or rolling action tending to roll up larger flocs.

It will be obvious that a combination of mechanical agitation and baffles, such as used in the prior art, is a very expensive way of providing coagulation. Moreover the flocs formed by this treatment are quite fragile and light so that great care is needed in handling them to avoid breaking them up. Another drawback of such prior art structures is that they have generally submerged bearings and that the agitators are not accessible for inspection and repair without draining the entire basin.

It is the principal object of my invention to avoid these drawbacks and to obtain good flocculation, with the formation of tougher and heavier flocs, in a cheaper manner. More specifically I have found that I can eliminate all baffles and still maintain what may be called self-contained agitation zones which effectively prevent short-circuiting of liquid from inlet to outlet.

These improvements are obtained by using, instead of the paddle agitators of the prior art, a type of rotor which pumps a large volume of liquid and establishes in the liquid what may be termed a closed cycle vortex, and by mounting and dimensioning such rotor, or rotors, in such a manner that the vortex or vortices set up embrace the entire liquid in the basin. I am aware that rotors of the general type employed herein are not new but have been used heretofore for mixing of liquid and chemicals, for stirring liquids to aid in solution of solids or to keep solids in suspension, or the like, but as far as I know, they have not been used in, and not been considered suitable for, flocculation. The vortex created by these rotors has not been thought a proper type of agitation for coagulation, as the general theory of the prior art of flocculation was that only very gentle agitation, without turbulence, was permissible. I believe that I am the first to discover the advantages of such rotors for the present purpose and the need for their being properly designed and placed relative to other parts if all possible benefits are to be had, and to disclose the principles and limitations of such design and placing.

I have found that the vortex type agitation is very suitable for coagulation and affords many advantages over paddle agitation. The number of collisions between particles of different size and age which lead to coagmentation and amassment of flocs, is by far higher in this type of agitation. This is due to the intricate flow pattern set up by these rotors, wherein the liquid moves in all three dimensions instead of the simple rotation of the prior art of coagulation. Therefore flocs form more rapidly and become tougher and heavier. Furthermore the vortex set up around a rotor of this type tends to maintain itself, i. e. the liquid approaching a rotor on its way through the basin is positively pulled into, and held for a period of time in, the vortex. It is desirable that the amount of the vortex flow is such that all liquid in its zone of influence normally passes at least twice through the vortex. Thus the liquid is deflected from its general forward flow through the basin from inlet to outlet, the vortex set up by such a rotor accomplishing what prior art had to accomplish by baffles: it prevents short-circuiting. With a rotor of this type, the direction of forward flow through the flocculation chamber is of no importance. Whether the general direction of through flow be horizontal, as is usual in separate coagulating apparatus, or vertical, as frequently used in a flocculation chamber which is surrounded by a sedimentation chamber, the liquid will be deflected from the forward flow and held for a period of time in the vortex. Therefore, the liquid may enter the flocculation chamber at any convenient point and be withdrawn from any convenient point, as long as the rotor is interposed in the path of the liquid from inlet to outlet. The same is not true of paddle agitation, where a definite relation must be established between the direction of the through flow and that of the rotation set up by the paddles and the inlet and outlet therefore carefully located.

In order to obtain these results the rotor has to be carefully dimensioned and proportioned and properly positioned in relation to the liquid in the basin. Thus, I have found, for instance, that the relative length of the blades to the diameter of the rotor, is of great importance with regard to the flow pattern caused by rotation of the rotor. Too long blades cause the liquid which is drawn into the vortex to flow along the shaft of the rotor in a very tight spiral that may cause breaking up of flocs. Too short blades, on the other hand, do not pump a sufficient volume of liquid into the vortex to utilize all the liquid in the basin. I have found that the length of the blades may range, depending on other circumstances, from about one-fourth to about one-third of the diameter of the rotor. Similarly the diameter of the rotor must be properly proportioned to the size of the basin. With a rotor mounted on a horizontal shaft, the diameter of the rotor must be proportioned to the depth of the liquid in the basin. A diameter ranging from 0.5 to 0.7 the liquid depth is generally satisfactory. It will be understood that such dimensions are not sharply critical and may vary considerably with such things as the number of blades provided, the shape and dimensions of the basin, the number of rotors used and the nature of the liquid to be treated. The important thing is that the flow set up is of the closed cycle vortex type and embraces substantially all liquid within the sphere of influence of a rotor, the liquid being drawn into the rotor and then thrown outwardly substantially uniformly in all directions.

Obviously, to obtain the same amount of agitation the size of the rotor can be smaller with higher peripheral speeds and must be larger with lower speeds. I have found rotors of the dimensions mentioned and with a pheripheral speed of 2 to 3 feet per second very satisfactory.

The rotor may be mounted in various ways in the basin.

In one form of my invention the rotor is mounted on a horizontally extending shaft which may extend either longitudinally or transversely of the basin. In either case the horizontal shaft may be spaced from the floor of the basin a distance less than half the normal liquid depth; I have found it satisfactory to submerge the shaft in a depth of liquid from about one-half to about two-thirds of the normal liquid depth. By maintaining the rotor nearer to the floor I obtain a very good sweeping of the floor by the vortex flow.

My invention will be more fully understood by reference to the detailed description which follows and to the drawings which show preferred embodiments of the invention, and in which like reference characters designate similar elements.

Figure 1 is a cross-sectional view of an embodiment of the invention;

Figure 2 is a partial view of the apparatus of Figure 1 with a modified inlet arrangement;

Figure 3 is a partial vertical cross-sectional view of the apparatus of Figure 2;

Figure 4 is a plan view of another embodiment of the invention.

The apparatus of my invention shown in Figures 1 to 4 comprises a basin 10 of conventional size and shape but without conventional baffles. The basin may be of any desired shape, such as rectangular, as shown. The basin 10 has a substantially flat bottom 11 and upstanding boundary walls, such as side walls 12 and 13, and end walls 14 and 15, or in the case of a round basin, a boundary wall 16. Ordinarily a walkway 18, such as is shown in Figure 4, will run along the top of the basin 10. Liquid to be treated may enter the basin in any suitable manner at one end of the basin as through an inlet 20. Treated liquid is withdrawn from the basin at a location functionally remote from the inlet, as through an outlet pipe 24 leading from the other end of the basin. One outlet 24 is shown in Figures 1 and 4 (and in a separate coagulation chamber the inlet 20 and the outlet 24 may be pipes extending through the same wall of the basin, as shown in Figure 4), but a plurality of ports 24 would be used, or the liquid be permitted to overflow the wall of the coagulating chamber where the flocculated liquid is discharged directly into an adjacent settling chamber. Such relative location of inlet and outlet is permissible and no special means for distribution are needed because the rotor, when properly positioned, will immediately draw the incoming liquid into, and incorporate and retain it in, the vortex flow wherein it is mixed with and distributed through at least an equal quantity of liquid undergoing coagulation. The important thing with regard to the relative location of the inlet and outlet is that they are functionally—but not necessary spacially—remote from each other. By functionally remote I mean that they are located so that the vortex or vortices set up in the basin are interposed in the path of the liquid from the inlet to the outlet. A drain 25 is provided in the bottom of the tank, so that the basin can be emptied if desired. The inlet 20, outlet pipe 24 and drain 25 will be provided with suitable valves, not shown.

One or a plurality of rotors 30 are provided in the basin 10. While two rotors are shown in Figures 1 and 4 it will be obvious that any number of rotors may be provided and that the number will be dependent on the size of the basin and of the individual rotor. In small basins a single rotor is satisfactory.

Each rotor 30 comprises a plurality of horizontal blades 31 which may be mounted on any suitable supporting means, such as a spider, but which are preferably mounted on one side of a plate 32, as shown. The diameter of the plate 32, or the other support, is proportioned to the depth of the liquid in the basin 10 and may be within a range of from about 0.5 to about 0.7 the normal liquid depth. The blades 31 may be mounted on plate 32 either radially or at an angle to the radius. Preferably, at least twelve blades are provided. However, the peripheral distance between blades preferably should not be more than from 15 to 20 inches, so that with large rotors a much larger number of blades is desirable. The width of the blades 31 may be approximately one-seventh the diameter of plate 32 and their length from about one-fourth to about one-third the diameter of the rotor. The plate 32 is mounted on a shaft 33 which is driven by any suitable means, not shown. The shaft 33 may be mounted longitudinally of the basin 10 as shown in Figure 1, or transversely, as shown in Figure 4. While it is generally satisfactory to mount the shaft at a central elevation, I prefer to space the shaft from the floor of the basin a distance less than half the normal liquid depth, a preferred range being between one-third and one-half the normal liquid depth. Obviously the transverse shafts need not extend fully across the basin, as shown for simplification, but only to the rotor, and their inner ends can in such case be supported by any suitable means. Similarly, in Figure 1 the shaft 33 need not extend through the full length of the basin. Instead two short shafts can be used extending from the walls of the basin to the rotors and their inner ends be supported by suitable means. Such things are well known in the art and form no part of this invention.

The operation of my coagulator will be readily understood. The liquid to be treated in the coagulator customarily is dosed with a coagulant either before its entry into the basin 10, or during its treatment therein, or, in some instances, it may be subjected to mechanical flocculation alone. For both purposes my coagulator lends itself very well. Liquid to be treated may enter the basin, as shown, through inlet 20, and is displaced forwardly to the outlet end of the basin and thence into outlet conduit 24, leading to a settler, or filter, or the like, not shown. The inlet 20 and the outlet 24 may even be in the same wall of the basin, as shown in Figure 4. From this forward displacement from inlet to outlet the liquid is repeatedly deflected and drawn into, and held for a period of time in, the vortex set up by the rotor or successive rotors.

Such a vortex is distinguished from the rotational movement caused by the usual paddle agitation by its three dimensional flow pattern. While in the rotation of paddles through liquid the movement of the liquid is always in the same plane, in vortex coagulation the liquid moves through numerous planes. Thus, the liquid pumped outwardly by the rotor will flow radially in all directions; one portion spiraling to the liquid surface and another portion down to the floor of the basin; then horizontally along the floor and liquid surface, respectively, then upwardly from the floor and downwardly from the surface, respectively, to the axis of the rotor; and then horizontally along the shaft, to be again pumped outwardly from the axis of the rotor,

In the embodiment of Figure 1 the axis of the vortex will be longitudinally of the basin, while in that of Figure 4 the axis will be transversely of the basin. It is important that the vortex flow caused by the rotor **30** is greater than the normal displacement through the basin **10**, so that the vortex will overcome the normal forward displacement. Thus any portion of liquid approaching any vortex is prevented from passing across the vortex to the outlet, as it encounters a stronger stream of liquid spiraling countercurrently (Figure 4) or at right angles (Figure 1) to the direction of displacement. Into this pattern the liquid approaching the vortex is forcibly incorporated and will remain part of the vortex flow for a period of time. Forward displacement from the vortex can only take place at the outside of the vortex flow (spiraling away from the rotor) so that it is impossible for a particle to flow across the basin without becoming incorporated in each succeeding vortex. It should be understood that each vortex is greater in volume and velocity than the forward displacement, and that it either is large enough to extend entirely across the basin laterally, or there will be two or more tangential vortices which extend from side to side of the basin. During the time the liquid is retained in the vortex an unusual opportunity for particle collisions is provided as the particles contained in the liquid are moved through a multiplicity of planes instead of the usual rotation in one plane.

Another characteristic of a vortex flow is that the velocity throughout tends to be substantially constant. Earlier flocculators tended to move quite slowly in order to avoid eddies and turbulence, but with a substantially constant velocity throughout the vortex, this limitation becomes less important. Thus the rotors may be driven with a higher speed than is generally thought permissible in flocculation, and I contemplate peripheral velocities from 2 to 3 feet per second. I have found that with the type of agitation and the flow pattern set up by these rotors some turbulence is permissible and often desirable. This may be due to the fact that the intricate flow pattern set up by these rotors provides such unusual opportunity for the contacting of old and new flocs and thus for building up of flocs which are tougher and less subject to breaking up than those formed by gentle paddle agitation. However, with the construction of the rotor, as described, higher velocities of the rotor do not cause the same increase in turbulance as would be the case with similar speeds of paddle agitators. It should be noted especially, that this type of rotor avoids setting up small violent eddies which are conducive to breaking up the flocs.

Each vortex has a tendency to maintain itself and liquid approaching it is positively drawn into it and incorporated into, and held in, the flow pattern of the vortex. Thus any short-circuiting of the liquid in a horizontal flow from inlet to outlet is prevented and in effect a plurality of individual treatment cells are set up. This result is obtained without use of costly baffles or the like, as was necessary in prior art structures, merely by applying a new positive type of agitation. In the present invention the liquid with contained suspended particles is free to drift gently and unobstructedly from vortex to vortex, forwardly and, to some extent, backwardly. As the liquid is passed from unit to unit the solids, or flocs, are agglomerated into large, dense particles that have excellent settling and filtering qualities.

I have found that with a longitudinally extending shaft, carrying several rotors, it is advantageous to space the rotors as shown in Figure 1, i. e. one rotor such as **30***a* nearer to the inlet than to the second rotor **30***b*, and the second rotor **30***b* adjacent the outlet. I have observed that the first rotor **30***a* has more work to do, as the entire burden of accelerating the flow is on this rotor. The second rotor **30***b* receives liquid which has already been accelerated, so that it can deal with a larger flow.

The liquid may enter the basin **10** in any suitable manner. However, undue velocity which might disturb the vortex flow should be prevented. Thus, if the liquid is discharged from a pipe of usual diameter axially to the rotor, as shown in Figure 1, I prefer to place a baffle **60** in the path of the discharging liquid to prevent a stream of higher velocity than the vortex flow reaching the rotor. Vanes **61**, which may be curved or straight, may be provided and extend from the baffle **60** to the wall of the basin and surround the inlet **20**, as shown. This arrangement provides distribution of entering liquid over a large area and dissipates its velocity so that it can be picked up by the vortex flow without distorting it.

Another suitable inlet arrangement is shown in Figures 2 and 3. The inlet conduit **20**, in these figures, discharges into a chamber **65** of suitable size formed by two walls of the basin **10**, such as **13** and **14**, and walls **66** and **67**. The wall **67**, which is parallel to the end wall **14** of the basin, extends from above the normal liquid level to the floor of the basin but only part way the width of the basin. The wall **66** extends from above the normal liquid level to an elevation suitably spaced from the floor of the basin but preferably below the elevation of the shaft **33**, thus providing an outlet from the chamber **65** discharging near the floor of the basin. With this arrangement liquid can be discharged into the lower portion of the basin in a direction across the width of the basin. With the rotor turning clockwise, the discharge from chamber **65** will be in the direction of the vortex flow passing the outlet from chamber **65** so that it is easily picked up without distorting the vortex flow.

With transversely extending shafts I prefer to mount the rotors, as shown in Figure 4, to one side of the basin. The inlet arrangement may be the same as that of Figure 2, in which case the chamber **65** will extend transversely from the wall adjacent the rotors part way across the basin. Any other suitable inlet may be used which dissipates the velocity of the incoming liquid and provides a discharge in the direction of the vortex flow. The shafts, in this embodiment, will be mounted at an elevation and the rotors will be dimensioned to the liquid depth in the basin in the same manner as described in connection with Figure 1. However, in this embodiment, it is desirable that the rotors be mounted so that adjacent rotors will be rotated in opposite direction, such as rotor **30***c* clockwise and rotor **30***d* counterclockwise. I have found that when the rotors are rotated in the same direction there is a certain tendency to a circulation along the walls of the basin, liquid discharged from one vortex by-passing the second rotor and flowing along the wall to the outlet. This tendency is counteracted by vortices moving in opposite directions where water discharged from the first vortex flow meets

a larger flow moving in opposite direction whereby it is deflected from its direction of flow.

It will be seen that the coagulation or flocculation apparatus of my invention affords maximum opportunity for floc coagmentation and amassment with a minimum of structure. The construction of the coagulator is therefore relatively cheap. The floc produced is readily settleable or filterable, being tough and large.

It will be obvious that the embodiments shown and described are only illustrative examples and that my invention is not limited to the exact construction of these embodiments. Because of the small space required my flocculation apparatus is very well suited for combined flocculation and sedimentation units and it will be understood that such a use is contemplated as coming within the scope of the invention. Thus, many changes could be made without departing from the spirit and scope of the invention, and these changes will readily occur to those skilled in the art.

This application is a continuation-in-part of my abandoned application, Serial No. 681,616, filed July 5, 1946.

I claim:

1. Apparatus for coagulation comprising a basin, an inlet into said basin, an outlet from said basin functionally remote from said inlet and establishing the normal liquid level in said basin, said basin being free of partitions interposed in the path of flow from said inlet to said outlet, a rotatable horizontally extending shaft, blade supporting means affixed to, and extending outwardly from, said shaft, a plurality of blades affixed to and extending horizontally from one side of each of said blade supporting means, said blades having a width less than their radial distance from the shaft, said shaft being at an elevation that said blade supporting means are below the normal liquid level in said basin as established by said outlet.

2. The apparatus of claim 1, wherein the diameter of the rotor is of the order of from about one-half to about seven-tenths of the normal depth of liquid in said basin.

3. The apparatus of claim 1, wherein said shaft is spaced above the floor of the basin a distance less than half the normal liquid depth in said basin.

4. Apparatus for coagulation of liquids comprising a basin, inlet means into said basin, an outlet from said basin functionally remote from said inlet means and establishing the normal liquid level in said basin, first and second rotor means mounted in said basin in longitudinally spaced relationship, each of said rotor means including a plate mounted for rotation around a horizontal axis and a plurality of blades rigidly affixed to one side of said plate and extending inwardly from the periphery of said plate only partway to said horizontal axis of rotation, said rotor means being mounted in such manner that said plates are at an elevation below the level of said outlet, and means for rotating said rotor means, said inlet means discharging in the direction of flow caused by rotation of said rotor means.

5. The apparatus of claim 4, wherein said first and second rotor means are mounted so as to rotate in opposite directions.

6. The apparatus of claim 4, wherein said first rotor means is mounted nearer to said inlet means than to said second rotor means and said second rotor means is adjacent said outlet.

7. A coagulation apparatus comprising a longitudinal basin free of partitions that obstruct flow therethrough, an inlet into said basin, an outlet from said basin functionally remote from said inlet and establishing the normal liquid depth in said basin, a plurality of rotatable horizontal shafts extending in spaced relationship from one longitudinal wall of said basin transversely of said basin, a rotor mounted on each of said shafts adjacent said wall, each rotor comprising a vertical plate rigidly affixed to said shaft, and a plurality of horizontal blades peripherally mounted on that side of the plate facing the opposite longitudinal wall of the basin and extending inwardly from the periphery of said plate, the width of said blades being about one-seventh the diameter of said plate and their length within the range of from about one-fourth to about one-third the diameter of the plate, said shafts being spaced from the floor of said basin a distance between one-half and one-third the normal liquid depth in said basin.

8. Apparatus for coagulation comprising a basin, an inlet into said basin, an outlet from said basin functionally remote from said inlet and establishing the normal liquid level in said basin, said basin being free of partitions interposed in the path of flow from said inlet to said outlet, at least two rotors mounted in said basin interposed in the path of flow from said inlet to said outlet, each of said rotors including a blade supporting means, and a plurality of blades affixed to and extending from one side of said blade supporting means, said blades having a width less than the radius of said supporting means, said blade supporting means being rotatably mounted at an elevation below the normal liquid level in said basin as established by said outlet, and means for rotating said rotors.

9. In a coagulating apparatus comprising a basin having an inlet and an outlet, said outlet being functionally separated from said inlet and adapted to maintain the liquid level in said basin within predetermined normal operating limits, a rotor interposed in the flow from said inlet to said outlet, said rotor including a plate mounted vertically for rotation about a horizontal axis at an elevation below said normal liquid level, a plurality of blades rigidly affixed to one side of said plate and extending inwardly from the periphery of said plate only partway to said horizontal axis of rotation, the number of said blades being such that the maximum peripheral distance between said blades is from about 15 to about 20 inches, and means for rotating said rotor.

WALT H. GREEN.

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