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INLET DIFFUSION CONTROL IN VERTICAL FLOW BASINS

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INTRODUCTION

Sedimentation is beyond question the oldest and most widely used process in the treatment of water and wastes. A great deal of both theoretical and empirical study has been given to this subject since the early work of Hazen (1), and the more recent work of Camp (2), by various research groups, consultants and manufacturers.

Sedimentation is a complicated process influenced by a great many variables, some of which are very difficult to inter-relate mathematically in order that performance can be accurately predicted. Such factors as concentration and type of solids, density of the solids and of the liquid-solids suspension, viscosity and temperature of the liquid, flocculation effects and efficiency, bottom scouring, turbulence, density currents, displacement velocities, wall drag, streaming or short-circuiting, surface area and depth all influence the results obtained. Tank dimensions govern only part of these factors, and as a result it has been found necessary in design to temper theoretical approaches with field observations.

Many of the theoretical approaches to sedimentation are more readily applicable to the free settling of discrete particles than to the separation of flocculated solids which, when properly controlled, proceeds with a rather sharp line of liquid-solids separation. Many of our water and waste treatment problems fall in this latter category, and we have spent a great amount of time and study in the development of sedimentation basins ideally suited to function in a stable manner in the separation of chemically or energy flocculated solids at higher than normal overflow rates. This type of separation is more suited to the use of vertical flow basins, and our discussion will be limited to this development. Higher costs and demand for more compact industrial water and waste treatment units focused attention to the design of smaller and more efficient clarification units.

FUNDAMENTAL CONSIDERATIONS

In horizontal flow basins under ideal analysis, theoretically all particles will settle if their settling velocity exceeds the hypothetical overflow rate velocity, and particles of lesser settling velocity will be removed by ratio of their settling velocity to the overflow rate. Radial flow basins have the same general particle removal characteristics as horizontal flow basins (under ideal analysis) and most of the discussions of those two basin forms have to do with their relative stability and the degree of importance of streaming (or short-circuiting) and of density currents upon their performance. In a true vertical flow basin, again, all particles with settling rates higher than the overflow rate will settle; but since the velocity of upward flow in this case is equal to the overflow rate, discrete particles

(1) Trans. ASCE, Vol. LIII, Dec. 1904, p. 63
(2) Trans. ASCE, Vol. 111, 1946, p. 895

with $V < V_0$ cannot settle against this velocity and we must look to flocculation and other factors as a means of removing these particles if we are to operate vertical flow basins at attractive rise rates.

In long rectangular tanks, settling efficiency is not necessarily a direct function of hydraulic efficiency. Hydraulic (or flow-through) efficiency is a more useful tool in the case of vertical flow basins where settling efficiency is more closely related to hydraulic efficiency.

BACKGROUND AND DEVELOPMENT

During the course of our development work on vertical flow basins we have done considerable work testing the flowing through efficiencies of sedimentation basins, and attempting to determine why serious short-circuiting occurred in some basins. This work was done largely thru use of calcium chloride shots and the plotting of dispersion curves. Tanks which showed serious short-circuiting were analyzed to determine the cause. Fluorescein dyes were also used in studies on murky waters, and potassium permanganate crystals suspended from stationary wires were used to study the flow streams in clear waters. Water soaked confetti was used to trace the short-circuiting in some cases. All this background formed the basis for further design and development.

Following is a brief resume of the results of studies at several installations which were helpful in tying down some of the variables and pointing the way to our final vertical flow basin design.

1. Burlington, Iowa

This is a water clarification tank 110' x 40' x 15' W.D. designed to control the length of flow and magnitude of the density current by introducing the influent into the tank in two inlet diffusion bays located at the quarter-points so that hydraulically the tank was to perform as four relatively short cross-flow tanks placed back to back. Effluent weirs were placed uniformly over the surface area (5 gpm/ft.) and the tank functioned as a vertical rise tank. The tank had a flowing thru hydraulic efficiency of around 90% at 1-1/4 GPM/sq.ft. (1800 gpd/sq.ft.) rise rate.

Although the tank was very stable and did a marvelous clarification job at this rise rate, it would not take on much additional flow. It actually performed no better than the best of the small cross-flow tanks we had observed elsewhere.

Merely splitting the inflow distribution into two bays and using a low weir approach rate was not sufficient, and later studies elsewhere showed that the secret of working at considerably higher rise rates than this was largely involved in proper inlet control arrangement as long as reasonable weir overflow rates were not exceeded.

2. Orlando, Florida

This plant turned out to be an experimental dream because the coagulated clarified water was of such crystal clarity that deep tank observations were ideally made. This tank was to operate at a rise rate of 2-1/2 gpm/sq. ft. (3600 GPD/sq. ft.) when clarifying 82° F. water derived from algae laden shallow lakes.

When first constructed, the water entering the rise region of the tank was stilled by very intricate lattice-like baffling arrangement which was supposed to still the kinetic energy and diffuse the flow evenly at the bottom for the start of its rise to the overflow weir trough system. This system did not work as from time to time large thunderheads of floc would develop and rise out of control.

We then entered a long series of tests wherein it was developed that influent control was the answer to stable operation, along with the use of sludge scraper mechanisms to eliminate shoaling of thickened sludge deposits. This influent control was brought about by introducing the flow from the central reaction chamber thru multiple adjustable tangential diffusers just below the water surface into an annular floc-building zone surrounding the mixing chamber. Instead of quieting the flow, considerable energy was added to the flow by adjusting the diffusion ports to head back the water 2 to 6 inches in the inner mixing chamber. The stilling diffusion lattice work was stripped, and with the proper inlet control this basin performed extremely well.

At this same time we had three more installations all working with varying characteristics for test and development purposes, and these were all gradually brought to the same type controlled energy inlet diffusion to give them stable performance. The Orlando installation has operated stably at rise rates as high as 4.5 gpm/sq. ft. (6500 GPD/sq.ft.) on a very light alum floc. However, we would not recommend designing at such a high rate for average design flow, even though this plant suffered no reduction in clarity at the higher flow!

3. <u>Blast Furnace Flue Dust Thickening</u>:

While we were doing our vertical flow basin studies in the water field, we also made an installation of two vertical flow basins at Gary Works of U. S. Steel for clarifying and thickening flue dust wash water. These units were used in place of two two-compartment tray design units of the same diameter. We utilized a large diameter energy inlet diffusion well for flocculation and diffusion control, and a multiple overflow weir system. These units performed exceptionally well at 1.6 GPM/sq. ft. (2300 GPD/sq.ft.) and verified the studies we were making at Orlando, and elsewhere, regarding inlet diffusion control. Flue dust clarification results with vertical flow basins will be discussed in more detail later.

THE CLARIFLOW

Out of these studies at Orlando and elsewhere, the circular Clariflow unit evolved, and at the same period, utilizing the same basic inlet diffusion control, we perfected the rectangular Clariflow unit.

The Clariflow design embodies sound principles of fluid mechanics which have been investigated and confirmed in many large installations in many different types of application during the past years. The Clariflow uses as a team a controlled energy diffusion inlet, and a multiple weir overflow system, in a vertical flow basin designed to minimize the effect of factors normally causing instability of operation. These are discussed in more detail later.

A series of plates will be shown to depict what we call the "Clariflow Principle" for obtaining excellent clarification of hydrated or flocculated solids in a stable short detention period vertical rise unit.

A few specific definitions are in order to tie down some of the terms involved:

1. Tendencies. These are greater than average currents that carry the main flow in a short-circuiting manner. They are caused by unbalancing and training of flow vectors into a well defined path.
2. Coagulated Settleable Solids. These are particles agglomerated into flocs that separate sharply from the bearing liquid when the vertical components of tank currents are less than the subsiding value. They show strong blanket cohesive qualities.
3. Sludge blanket. A mixture of coagulated solids acting cohesively as a strata seeking its own density level and reposing on the bottom of the basin. In most applications we are concerned with, only hindered settling and compaction are involved in this zone.
4. Thunder Heads. These are circulating, rising and seething masses of under water movements carrying coagulated settleable solids to the tank surface. Caused by unbalance of out-flow (generally greater than average currents encountering shoals) of new feed into the tank center. Once established, they persist until tank feed is arrested.
5. Shoal. Classification and piling of relatively heavy similar particles (crystals) in the center of a local horizontal rotation eddy thereby building obstructions in the presence of considerable current.
6. Density Current. An outflowing current of a homogeneous mixture of coagulated settleable solids caused by gravity flow into one fluid by another fluid of slightly greater density which seeks the lower level.

THE CLARIFLOW PRINCIPLE

Plate No. 1 - A general view of a rectangular Clariflow unit showing mixing and reaction zone, the diffusion control gates, the flocculation zone, the diffusion zone, the vertical rise clarification zone and the overflow trough system.

Plate No. 2 - Currents in the mixing and reaction compartment show efficient intra-zonal circulation which gives intimate particle contact without undue turbulence. The influent, admixed chemicals and any recirculated slurry are brought into intimate contact in this chamber so that reactions are driven to completion.

Plate No. 3 - Vertical, multiple adjustable diffusion gates effect equal multiple diffusion of flow into the secondary floc building chamber causing a definite horizontal roll which varies only slightly with in-flow variations. There is considerable (2" to 6") head built up in the reaction chamber by the diffusion gates which imparts energy to the flowing water streams, which causes the definite rolling action desired for good flocculation and balanced diffusion. Thus, we actually controllably introduce energy which is used for flocculation and to give balance and lateral distribution. This energy is then dissipated in the form of a mass rolling action. Training of uncontrolled influent vectors which would produce an undesirable tendency (short-circuiting) is thereby completely avoided.

Plate No. 4 - The horizontal baffle reverses and directs a balanced horizontal roll in the tertiary floc building chamber. The velocity is slowly diminishing, but the definite roll persists. Multitudinous small and equal acting vectors of flow break off or are displaced from the roll and underflow the clear water mass at a design-controlled lateral displacement velocity. This underflow is a balanced, controlled, low velocity density current, the flocculent particles of which form a viscous sludge blanket. The balance and uniform dispersion stop tendencies from forming, and insures that new feed will enter the tank uniformly across the entire width, and be released at controlled displacement velocity at the bottom.

Plate No. 5 - This shows the clarified water (free of coagulated settleable solids) being squeezed out of the sludge blanket and rising vertically to multiple overflow weirs arranged to work the entire surface area of the clarification compartment. Hindered settling and compaction of sludge occurs in the sludge blanket to release the clarified water. The entire system attempts to keep in balance and the denser sludge blanket seeks its level as a mass along the bottom. A positive scraper eliminates any temporary shoaling and assists the thickened sludge in its movement to the pump suction.

Plate No. 6 - This shows one type of circular Clariflow design with all vectors shown. The circular Clariflow embodies the same hydraulic principles as designed into the rectangular Clariflow. The only difference is that energy introduced into the center annular compartment is dissipated in a circulatory motion around a vertical axis instead of around a horizontal axis as in the case of a rectangular unit. The energy is used for flocculation, and to obtain balance and uniform distribution thus eliminating the training of influent vectors into a dominant, undesirable tendency (short-circuiting). Because of the energy of rotation of the falling homogeneous mixture of settleable solids, the controlled outflow along the bottom is equally divided and uniform in all directions and no particular vector becomes dominant.

DESIGN CONSIDERATIONS

The Clariflow principle, which hinges largely around energy inlet diffusion control as its major feature, also involves basin design (and a number of other factors) in creating a vertical flow unit which is unusually stable in operation. Some of these factors are: overflow rate, flocculation and controlled floc growth, weir overflow rate and weir trough placement, control over displacement velocity vectors and control over density currents.

Flocculation:

No clarification basin should be designed without as much knowledge as possible of the flocculation and settling characteristics of the suspension to be clarified. Vertical flow basins must be considered realistically, and if a given flocculation time is required, it must be provided. The basic concept between flocculation and clarification must not be ignored, as an ideal hydraulic condition for clarification does not countenance poor flocculation.

Adequate reaction mixing is important in cutting down the length of flocculation time, and the use of catalysts such as admixture of fresh previous precipitates, silica sol, etc., has greatly improved the uniformity of and somewhat shortened the time of flocculation.

The energy inlet design provides a substantial period of slow mixing for intimate particle contact, and floc formation is brought about by the energy imparted into the flowing water by the multiple tangential diffusers. This continuous, controllable, balanced hydraulic energy sets up a uniform roll which persists (although gradually and ideally reducing) and causes slow mixing and flocculation within the confines of the energy inlet zone. Ideal conditions are thus established for development of a cohesive floc-bearing mass from which the water separates sharply in the sludge blanket.

If flocculation is not adequate, small floc, suspensoids, etc. will escape from the blanket entrapment and will then be subject to the laws of free settling as to whether or not they will settle back or rise to the overflow. Also, even though the clarified liquor flow vectors are substantially vertical, in view of the fact that some traversing of flow streams is involved, with the degree depending on spacing of the overflow troughs and the tank depth, some of the particles with $V < V_o$ will still be removed.

Overflow Rate, Depth and Weir Troughs:

The clarification zone is designed on overflow rate and depth, with overflow rate being of prime importance. Overflow rates vary from 1 GPM/sq. ft. up to 3 GPM/sq. ft., with the type of treatment involved, along with temperature (which also affects flocculation effectiveness), controlling the selection. With the Clariflow used on wastes producing light sludges (such as certain paper mill wastes, soluble oil wastes, plating wastes and magnesium hydroxide) and on other wastes producing heavier sludges (such as calcium carbonate, blast furnace flue dusts or fine mill scale, etc.,) it is logical that overflow rate must be adjusted to the application. Also, the floc concentration varies in different applications which affects the cohesiveness and entrapment characteristics of the outflowing sludge mixture and this in turn affects the maximum rise rate for maximum clarification.

In general 10 ft. depth is considered as absolute minimum, whereas 15 ft. is generally used, and greater depths have proved helpful in the case of light amorphous sludges. Sludge collecting mechanisms are used, and the sludge depth is kept to a minimum by substantially continuous blowdown since the Clariflow is not an expanded blanket unit.

The clarification zone design in a vertical rise basin calls for effectively working the entire surface with weirs to maintain the vertical rise characteristic, and use a low enough weir approach rate to avoid back reach and induced tendencies. Our weir rates vary from 8 to 20 GPM/ft. for various applications.

Tank Size:

Although tank area is determined by the overflow rate there are other considerations which limit the maximum effective size of a circular tank if the tank is to retain its stable operating characteristics and remain a true vertical rise unit. The further a density current has to flow outwardly, the more turbulent and rapid will be its origin; and consequently the more difficult to maintain balance and avoid short-circuiting tendencies. In the case of a radial outflow, the closer to the center of the tank its origin, the more turbulent will be its origin. This situation can be alleviated to a degree by increasing the diameter of the inlet diffusion well. The Clariflow makes use of the density current by keeping it under control but there are practical limits, and in our experience the size of vertical flow basins should not exceed 100 ft. diameter, and never over 120 ft. diameter. Empirical design factors collected on smaller vertical flow units do not apply when the units are too large. The trouble with a lot of very large conventional rectangular tanks is that data found to be satisfactory in performance of smaller units is not realized when scaled up too far.

The advantage of the Clariflow design for rectangular basins is that if long tanks are desired, they can be made stable in operation at high rise rates by using multiple inlet diffusion zones. A good example of this design is the alum clarification plant at Nashville, Tenn., which comprises two basins 193' x 32' which very effectively handles 28 MGD at a 2 GPM/sq. ft. rise rate, and has operated continuously with good stability and clarification up to 3 GPM/sq. ft. This design uses reaction and pre-flocculation ahead of the Clariflow, and then uses three energy inlet diffusion and floc building zones along the basin in order to maintain control of the sludge outflow and retain vertical rise characteristics. These units can handle over four times the flow rate as existing conventional horizontal flow basins at Nashville of the identical dimensions, and with better clarification.

It is apparent that conventional design horizontal flow and radial flow basins are not able to operate stably with good clarification excepting at low rise rates. We have converted quite a number of such basins and the ability to clarify has been increased two to four times previous capacity, reliability of operation has increased and water quality improved.

Control of Density Currents:

The density currents we are mainly concerned with are the gravity flow effects of releasing a floc-bearing fluid of higher density into a relatively quiescent basin. These heavier currents will seek the lower level, and their magnitude is affected by the depth of fall, tank proportions, inlet diffusion arrangement and the relative densities of the two fluids involved. Deep tanks with uncontrolled surface inlets create maximum density current effects, and the magnitude is influenced considerably by the tank proportions, inlet velocity and by the size of influent well in the case of conventional circular tanks. The highest velocities have been found in long rectangular tanks.

In our Clariflow design, by means of our energy inlet diffusion control arrangement, we establish a balanced diffusion rolling action which immediately takes control over the entire flow and dominates any tendency for uncontrolled density currents. This imparted energy is then dissipated by the mass rolling action, and the mass finally released to underflow the clear water at the bottom of the tank at a design-controlled lateral displacement velocity. This underflow is actually a balanced, controlled low velocity density current of a magnitude of 2-3 ft/minute which is low enough to avoid a reverse flow effect above the blanket, and permits vertical rise clarification characteristics.

The same rolling energy dissipation action which continually flocculates until the flow has entered the clarification zone also serves to maintain homogeneity of the floc-water mixture so that pre-separation of heavier particles does not occur. Pre-separation, which always takes place in old style quiescent inlets, will set up dominant density currents and cause short-circuiting. The Clariflow energy inlet avoids this and diffuses the inflow to the clarification zone so that no dominant currents ever form.

ADVANTAGES OF VERTICAL FLOW BASINS

1. The operator working with a short detention vertical flow basin finds his job simplified because he can get immediate response to chemical feed changes or other operation adjustments. This permits him to cope with a changeable waste or water condition and select the most economical method of operation. Old style long detention units take a long time to respond to changes and observations are obscured and hard to interpret.

2. In a Clariflow vertical flow tank there is no stratification. In many other conventional designs even minor temperature changes in the wastes or water can cause extreme thermal vectors and often cause the inflow to either rise and override or else flow along the bottom as a distinct short-circuiting stratification current.

3. With a vertical flow unit, controlled recirculation of precipitates become practical and often very helpful. The bottom area is small and freshly formed thickened precipitates are readily available for recirculation to the mixing and reaction chamber. The age of the recirculated solid is evidently important.

4. The Clariflow does not use blanket filtration. The blanket is confined to the thickening sludge mass. Because of this absence of an expanded blanket, the unit is able to start and stop repeatedly without suffering from heavy turbidity shots.

5. Since the Clariflow is a vertical flow basin for the clarification of sharp-separating floc-water mixtures from a usually cohesive bottom flowing blanket, and since the units are rather deep, the effects of wind currents are minor as compared to their possible effects on radial flow and lateral flow basins.

FINAL ACTIVATED SLUDGE TANKS

The cohesive blanket density current flow characteristics of activated sludge when admitted to a settling basin are well known and have been much discussed. Most of the sedimentation of activated sludge has been accomplished in rectangular or in radial flow circular basins with design overflow rates in the range of *800 GPD/sq.ft., (1200 GPD/sq. ft. at max. hourly flow) and many tanks have been unstable due to poor effluent trough placement, too shallow depth, poor inlet arrangement accentuating density current effects, etc.

Since activated sludge in proper condition (in most applications) settles rather readily, and since it has the same characteristics previously discussed of underflowing the clear liquid as a cohesive blanket, its clarification is ideally suited to use of vertical flow basins. The excellent performance of a great many small size and relatively deep circular basins which approach vertical flow conditions is a good indicator of this.

Both the rectangular and circular vertical flow Clariflow basins should be ideal for activated sludge settling since they would enhance the cohesiveness of the sludge blanket and at the same time keep control over density currents. We have used this design in some relatively small plants, and we know the application is sound. We would recommend this design at overflow rates of 1-1/2 to 2 GPM/sq. ft. (2150-2880 GPD/sq. ft.) without hesitation for standard activated sludge with good sludge index. This rate is assumed at daily max. hourly flow which in turn leaves reasonable latitude for instantaneous flow peaks.

Relative to sludge thickening, it has been our observation that for standard activated sludge the overflow rate for clarification is normally the controlling factor for sizing final settling tanks, and that areas thus derived are adequate to obtain desired underflow thickening. The density of the sludge as drawn is the resultant of the thickened condition at the draw-off point plus any water of inclusion from "post-holing". The latter sometimes controls the density of the underflow. Special consideration must of course be given to tank area in the case of certain industrial wastes which produce sludges slow to settle or thicken.

* - It should be considered that when the Ten State Standards uses a rate of 1000 GPD/sq. ft. for the larger plants that this is based on <u>design</u> or actually maximum daily average flow; which in turn presupposes an average peak operating condition of at least 1-1/2 times this rate, namely 1500 GPD/sq. ft.

BLAST FURNACE FLUE DUST CLARIFICATION

About the time our other vertical flow basin work was being undertaken, more attention was being focused on the need for more stable operation and better clarification of blast furnace flue gas washer water. This waste contains 100-300 grains/gallon of suspended solids which range from 35-65 percent iron and 5-15 percent carbon. As a rule 75-90 percent of the flue dust particles are finer than 325 mesh (43 microns).

The practice in the past had been to use multiple tray thickeners on the theory that the additional sq. ft. per ton of solids was an important design criteria, and that by using multiple tray units the overflow area was used twice or more in effecting separation of the extremely fine dust. Overflow solids concentrations of record averaged 20-30 or more grains/gallon of total suspended solids, with a considerable portion of these solids being settleable and later settling out in large sewers, rivers and harbors. About this time some States started to require not over 10 grains/gallon of suspended solids in the overflow and it was obvious that following past practice was not the answer. Since that time, in order to avoid expensive cleaning of sewers and harbor and channel dredging, the industry has been requiring not over 5 grains/gallon.

It was apparent that hydraulic control in the tray units was inadequate. It was also apparent that this extremely fine material wets as a hydrous oxide and will readily flocculate with a surprisingly small amount of flocculation agitation. Accordingly, our approach to this problem was to abandon any thought of getting improved performance from tray units, and to handle the problem like any other heavy floc clarification problem.

Our first installation for flue dust wash water clarification was at the Gary Works of U. S. Steel where our single compartment Clariflow was selected over a two tray unit of the same diameter to produce a guaranteed effluent with not over 10 grains/gallon, and at least 50 percent solids in the underflow. These units (2 @ 90' dia) were furnished with large diameter energy inlet diffusion wells containing an annular inflow diffusion channel around its periphery.

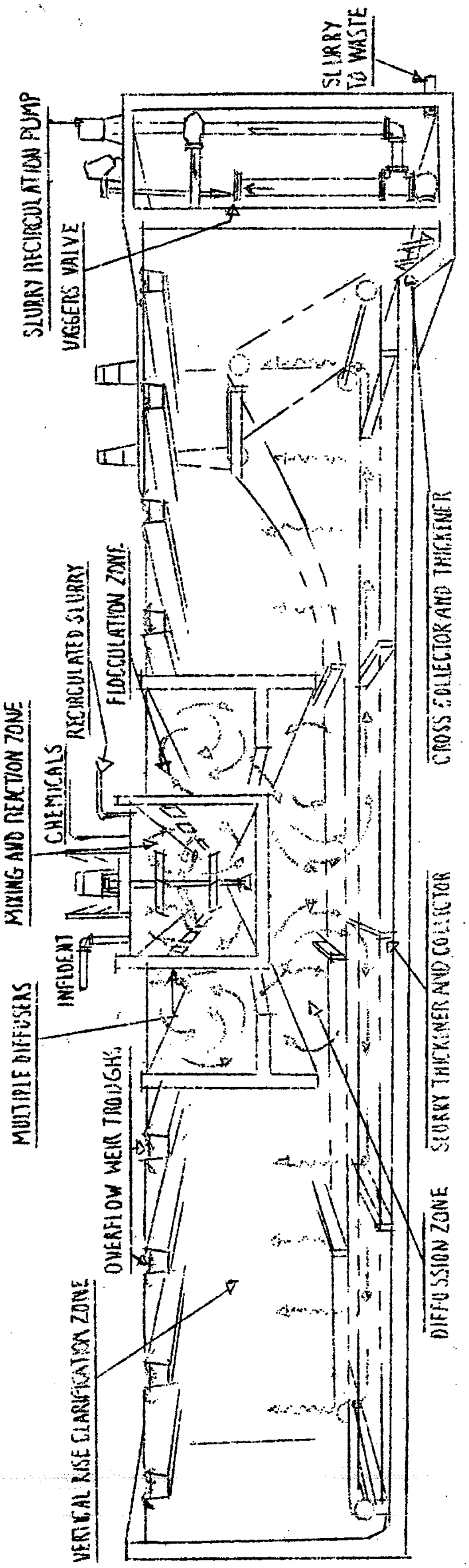
This energy inlet and flocculating center-well utilizes a multiplicity of balanced tangential inlet diffusers to impart a mild adjustable turbulence and mass rotation of the entire center core of the thickener. This action imparts energy into the incoming feed which causes wetting, agglomeration and flocculation of the microscopic particles. It also keeps control of density currents to avoid short-circuiting. The gradually dissipating rotating energy holds control over the homogeneous mass and then allows it to displace uniformly along the floor as a dense sludge blanket which entraps many particles that would otherwise escape and pass off with the overflow.

Clarified water is displaced upwardly from above this sludge blanket and rises to the low-rate multiple overflow weir system. Hindered settling and compaction occur in the sludge blanket, and heavy duty thickener mechanisms assist the flow of the 50-65 percent solids sludge to the center sludge draw-off.

These units were extremely successful, discharging an overflow of 2 grains/gallon, and they established a new standard of design for the steel industry. Since that time a large number of thickeners have been purchased during the big expansion of the steel industry, and all units that we have furnished or know of have been single compartment units and similar in action and design to our Clariflow thickener. Most specifications require an effluent of not to exceed 5 grains per gallon of settleable solids.

Our Clariflow thickener units are normally designed with average rise rates in the range of 1.5 to 1.8 GPM/sq. ft., depending on the clarification required, and we have operated quite a few units with good stability at rates considerably above 2 GPM/sq. ft. Our flocculating energy inlet diffusion design is also varied in volume with the results required.

An interesting study was made of the entire flue dust recovery system at Bethlehem Steel Company's Lackawanna Works by the Chester Engineers in 1955, and part of this work involved a detailed study of comparative performance between several tray thickeners and one of our Clariflow single compartment units. In 1951, a Clariflow thickener was installed and by Bethlehem's 1953 data, (survey run by M.I.T.) it was producing an overflow with an average of only 4.4 grains/gallon total suspended solids with a peak of 7.6 grains/gallon. This compared with a tray unit with similar loading producing an average of 65 grains per gallon in the overflow at that time with a peak of 173 grains/gallon. This tray unit was converted to a single compartment Clariflow thickener by us in 1954, and at the time of the Chester Engineers' survey in 1955 our two units were producing an average of 1.6 and 2.4 grains/gallon of settleable solids in the overflow and only 7.3 grains/gallon of total suspended solids. In 1955 the other two tray units had overflows of 10.4 and 16.2 grains/gallon settleable solids, (14.4 and 19.5 grains/gallon total suspended solids) and in 1956 these two units were also converted by us to Clariflow units, in view of the demonstrated superior performance.



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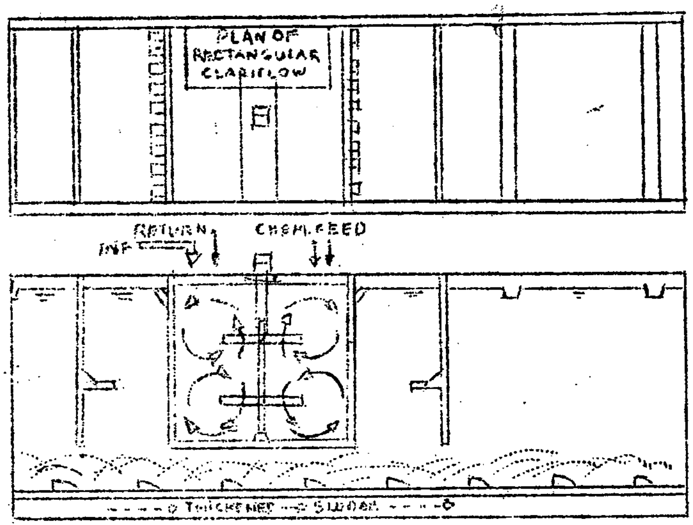

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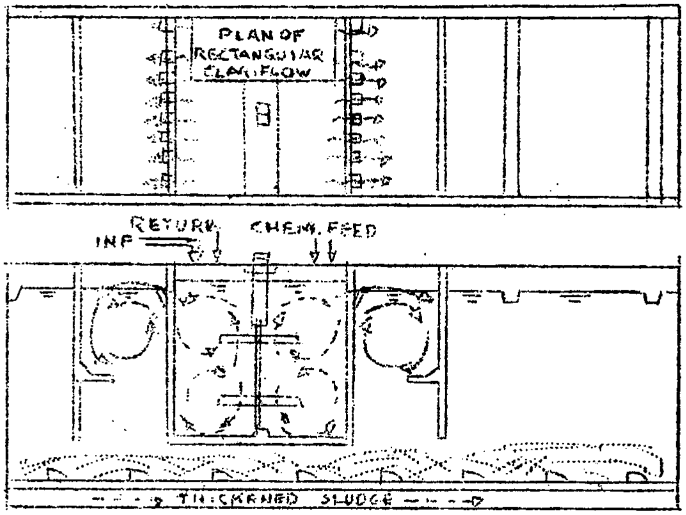

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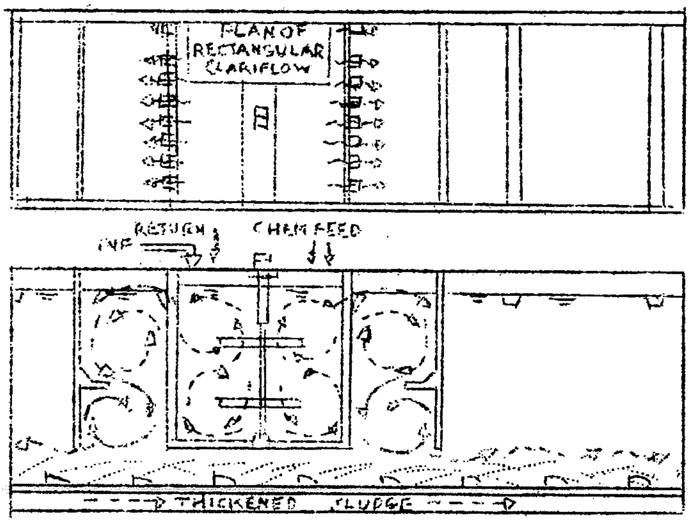

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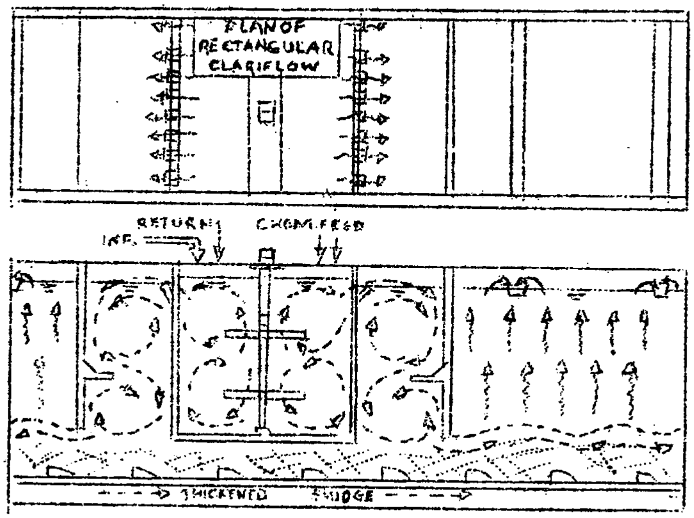

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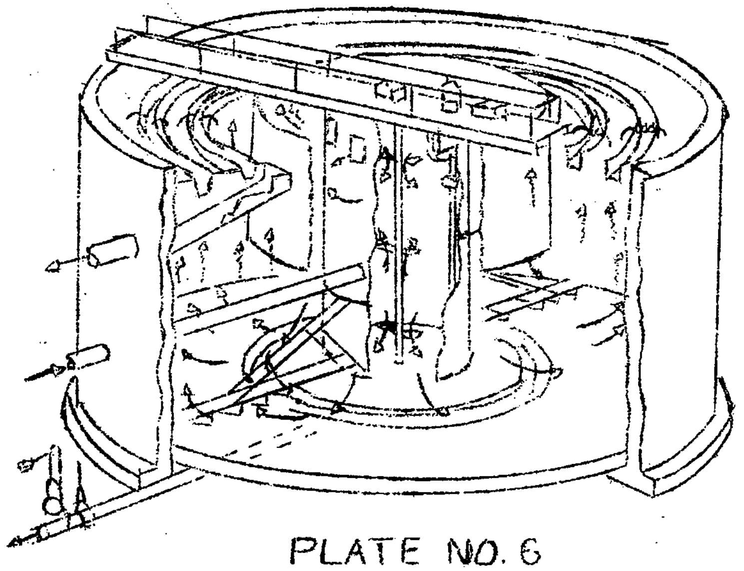

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