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COLLECTION AND INPUT APPARATUS FOR A BATH UNDERGOING GRAVITATIONAL CLASSIFICATION

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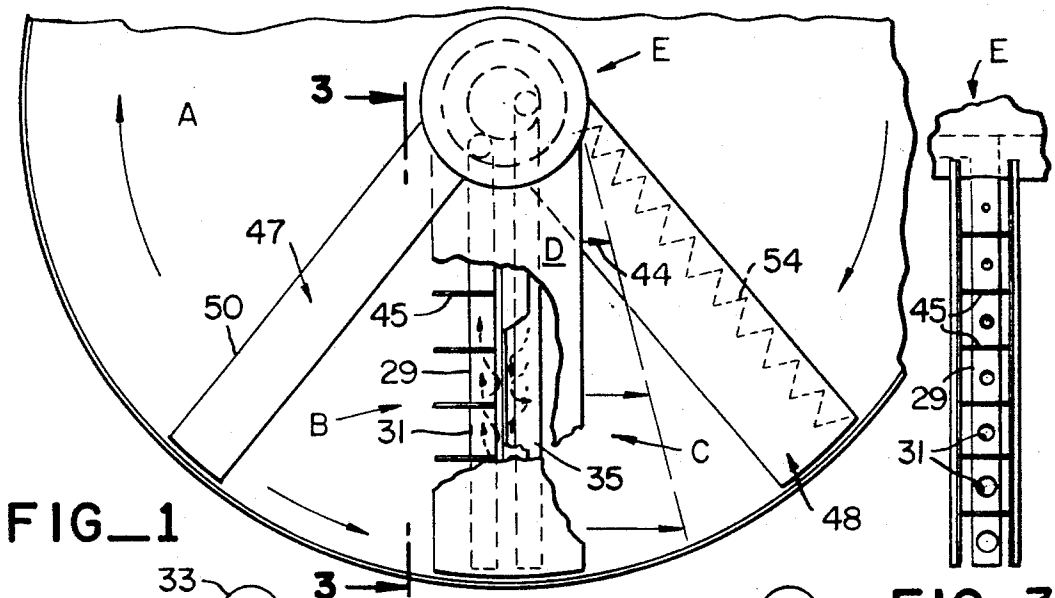


FIG_1

FIG_3

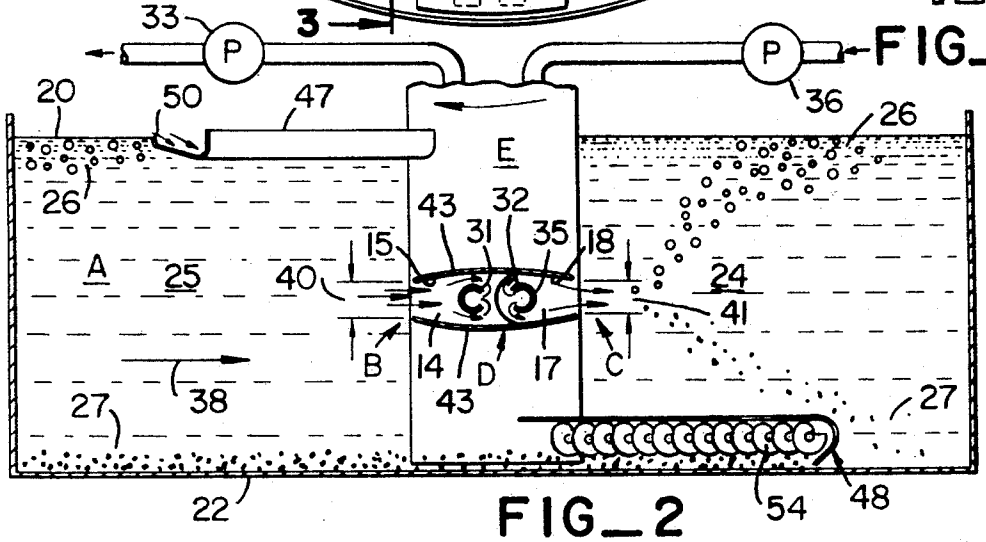


FIG_2

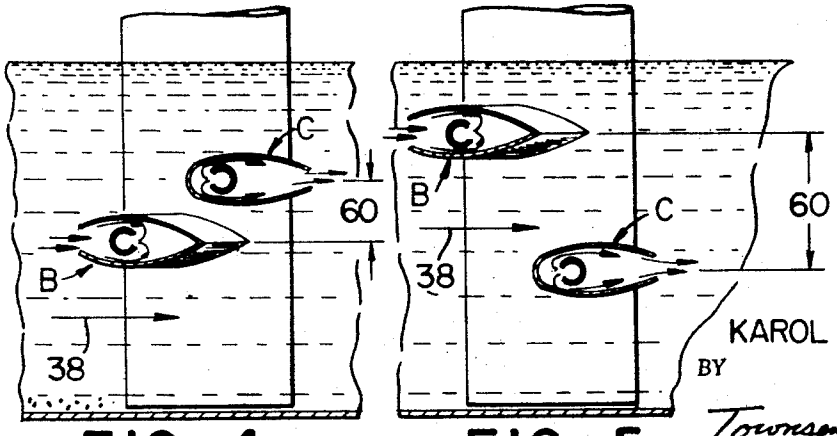


FIG_4

FIG_5

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COLLECTION AND INPUT APPARATUS FOR A BATH UNDERGOING GRAVITATIONAL CLASSIFICATION

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ABSTRACT OF THE DISCLOSURE

For use with a bath containing a mixture of liquid and pollutants for gravitational classification, an apparatus for inserting nonclassified mixture interior of the bath in a first horizontal plane and withdrawing classified fluid from interior of the bath in a second horizontal plane without disturbing the gravitational classification of the fluid not being withdrawn. The classified fluid is withdrawn from the bath by a collector moving relative to the fluid undergoing gravitational classification while mixed fluid is inserted interior of the bath by an input also moving relative to the fluid of the bath. The collector and input are each contained in a streamlined housing shaped and disposed so as to produce minimum turbulence when passing through the fluids of the bath.

This invention relates to the gravitational classification of a fluid bath containing a mixture of liquid and pollutants and more specifically to an apparatus for continuously inserting mixed fluid in a horizontal plane and removing classified fluid in a horizontal plane without disturbing the gravitational classification of those portions of the bath not being removed or deposited.

This disclosure relates to improvements of that apparatus described and claimed in copending patent application Ser. No. 610,098, filed Jan. 18, 1967, entitled "Settling Tank and Method." That application sets forth, among other things, the concept of vertically dividing a fluid body for gravitational classification or settling separation by means of a carriage which moves relative to the fluid body removing gravitationally classified liquid along the leading edge and depositing nonclassified liquid behind the carriage along the trailing edge.

The chief object and purpose of the present invention is to disclose an apparatus capable of restricting collection to those elevational intervals interior of the bath where the classified fluid is gravitationally disposed in a state of optimum purity and further capable of restricting deposit of the intermixed fluid to those elevational intervals where the fluid components disperse and classify with minimum migration through the standing bath. In order to accomplish this objective, a collector is provided which moves horizontally interior of the bath gathering fluid along a horizontal plane in the bath. Similarly, an input is provided which also moves horizontally in the bath placing mixed fluid interior thereof along a same or a second horizontal plane. Both the collector and input gather and deposit fluid, respectively, from portions of the total bath height or depth so as to permit fluid above and below the horizontal planes to remain substantially undisturbed and in a disposition where the desired gravitational classification may continue.

A further object of this invention is to arrest the tendency of the collector and input to stir or create turbulence in a passage through the fluid undergoing gravitational classification. To accomplish this objective, the collector and input are each cooperatively shaped with and placed interior of a streamlined housing which moves relative to the bath. The housing has an airfoil shape along vertical cross-sectional planes taken parallel to the relative movement of the bath with respect to the housing. This same airfoil shape has an angle of attack parallel to the relative movement of the bath so as to produce a minimal reaction in the liquid pollutants when passing therethrough, thus arresting any tendency to unduly agitate the settling bath.

A still further object of this invention is to balance the rate of gathering and discharging fluids from a rotating vane or housing with the increasing instantaneous linear velocity of the vane or housing experienced with increasing radial distance from the center of rotation. A manifold for moving fluids interior of the housing runs through the conduit. Apertures in the conduit permit fluid flow between the manifold and the recess defined by the conduit or channel at a rate which is proportional to the displacement of the bath by the recess. The recess is in turn sized proximate each of the apertures so as to have an area communicating to the bath permitting fluids to move at a velocity proportional to the instantaneous linear velocity of the housing through the bath.

An additional object of this invention is to place the collector vane relative to other vanes, such as the input, skimmer or scraper vanes, where the collection of classified or separated liquid from the bath will not be frustrated by pollutants entrapped and entrained in the collected liquid or turbulence occurring in the vicinity of the collector. To accomplish this objective, the skimmer collects surface settling pollutants in advance of the collector, thus preventing the impurities from being entrapped and entrained in the collected fluid while both the scraper and input move behind or follow the collector so as to prevent any fluid disturbance by these latter vanes from being communicated to the collector.

An advantage of this invention is that the elevation of the collector and input may be varied with respect to one another so as to accommodate the elevational settling disposition of the particular liquid mixture being gravitationally classified. Where the pollutants are predominantly bottom settling, the collector is rotated above the input while where the pollutants are predominantly top settling the collector is rotated below the input.

Other objects, features and advantages of the present invention will be more apparent after referring to the following specification and attached drawing in which:

FIG. 1 is a plan view of a streamlined housing containing a collector and input illustrating in the cut away portions the manifold system for the flow of fluid to and from the rotating housing;

FIG. 2 is an elevation view illustrating a section of a bath undergoing gravitational classification with an end view in section of a collector and input contained interior of a single streamlined housing;

FIG. 3 is an elevation view along line 3—3 of FIG. 1 illustrating in particular the manifold apertures for fluid flow between the interior of the manifold and recesses in the housing;

FIG. 4 is an elevation view similar to FIG. 1 illustrating the separation of the collector and input in separate housings; and

FIG. 5 is an elevation view illustrating the invention of the collector and input of FIG. 4.

With reference to FIGS. 1 and 2, a bath A is illustrated standing for gravitational classification with a collector B and an input C contained in vane or housing D passing through the bath. Collector B in passing relative to the fluid of bath A collects liquid along a horizontal plane including collector recess **14** as defined by collector channel or conduit **15** while input C discharges mixed fluids interior of bath A along a similar horizontal plane including input recess **17** as defined by input channel or conduit **18**. Both the collector B and input C are illus-

trated attached to and rotated about a pedestal E so as to pass through the fluid of the bath A. It is believed apparent that the movement of collector B and input C relative to bath A could be linear as well as rotational or angular and further that the bath itself could be moved while the input and collector remained stationary.

Bath A comprises liquid mixture **24** confined interior of reservoir or tank **22**. Mixture **24** is a temporarily intermixed combination of liquids **25**, top settling pollutants **26** and bottom settling pollutants **27**. Pollutants **26** and **27** have densities or specific gravities relative to liquids **25** which permit their settling separation or gravitational classification when allowed to stand in bath A in a substantially static disposition over a given interval of time. The miscible properties of the pollutants **26** and **27** relative to the liquids **25** are such that when the fluids of bath B are allowed to stand, the forces of gravitation overcome the propensity of the pollutants and liquids to remain intermixed. As is apparent, pollutants **26** and **27** can be in the gaseous, liquid or solid state and comprise those portions of liquid mixture **24** which are not soluble in bath A.

Collector B comprises conduit or channel **15** in vane or housing D defining collector recess **14**. Recess **14**, as illustrated in the sections of FIGS. 1 and 2, has a collector manifold **29** extending the length of housing D having collector apertures **31** therein permitting fluid communication from recess **14** interior of manifold **29**. The collector manifold is in turn fluidly communicated with suction apparatus **33**, commonly in the form of a pump or pressure regulated valve, permitting fluid to be withdrawn from interior of the bath A.

Input C is similar to collector B in that input channel or conduit **18** in housing D defines a recess **17**. Input manifold **35** extends interior of recess **17** and fluidly communicates through pedestal E to a fluid pressure apparatus **36**, also commonly in the form of a pressure regulating valve or pump. Input apertures **32** fluidly communicate manifold **35** with recess **17**.

In operation, housing D typically passes relative to the fluid mixture of bath A by rotating so as to oppose flow arrow **38**. Input C deposits liquid mixture **24** interior of the bath. After passage of the input, these intermixed fluids gravitationally disperse into their respective top and bottom settling pollutants **26** and **27** with classified fluids or liquids **25** therebetween. The housing D upon completing a rotation about pedestal E will trap the classified fluids or liquids **25** at collector B leaving pollutants **26** and **27** behind in their respective settled dispositions interior of bath A. As is apparent, the speed of rotation of pedestal E and its attached housing D may be varied so as to permit all increments of the liquid mixture **24** to remain interior of the bath a sufficient time to permit the settling separation or gravitational classification of the intermixed fluids.

Collector B in passing relative to the fluids of bath A in the direction of flow arrow **38** traps or comes in contact with fluid along a horizontal plane which includes collector recess **14**. Dependent upon both the collector recess width **40** and the rate of fluid flow through collector manifold **29** and collector apertures **31**, classified fluids will be gathered by collector B along the horizontal plane in a thickness or volume which takes away from bath A varied amounts of the fluid between surface **20** and the bottom of reservoir or tank **22**.

It will be noted that the total collector recess width **40** is as illustrated but a small fraction of the total depth of bath A taken along a vertical plane at collector B between surface **20** and the bottom of tank **22**. This relatively small collector recess width **40** permits the mixed fluids of bath A to remain in a substantially undisturbed disposition above and below the collector B permitting continuous gravitational classification to occur in planes above and below that of the collector. As is apparent, those portions of the fluid body of bath A not included within that horizontal plane defined by rotating vane or housing D will remain substantially undisturbed and in a disposition where the desired gravitational classification may continuously proceed despite the collection occurring through collector recess **14**.

The operation of input C is similar in principle to that of collector B in that liquid mixture **24** is inserted interior of bath B through input recess **17** along a horizontal plane which includes the relative passage of input recess width **41** through the bath. Dependent upon both the width of input recess **17** and the rate of fluid flow through input manifold **35** and input apertures **32**, the liquid inserted will comprise a varied portion of the bath between surface **20** and the bottom of tank **22**. As is apparent, once liquid mixture **24** is deposited behind housing D in its passage through bath A, pollutants **26** and **27** will gravitationally settle from their point of deposit to their natural gravitational disposition.

As has previously been noted, one of the primary advantages of vane or housing D and its contained collector B and input C is that in passage through the fluid of bath A there is relatively little or no disturbance above and below those horizontal planes where fluid is gathered or collected. The passage, however, of the vane D through the bath will generate some turbulence or disturbance which may serve to intermix those fluids already classified as well as frustrate and prevent the classification of fluids inserted interior of the bath. To minimize this undesired result, housing D and its contained collector B and input C are cooperatively shaped and disposed relative to their passage through the bath so as to minimize such disturbance.

As is already known, when a body passes through a fluid, turbulence is commonly created. Such turbulence is generated by two sources. First, the passage of fluid over the skin or outer surface of the moving body creates a fluid shear or friction which creates turbulence. Assuming that the body passing through the fluid has an appreciable surface, this effect cannot be althogether eliminated but may only be kept to a minimum by maintaining the skin surface in as small an area as is reasonably possible.

Secondly, fluid friction or turbulence is commonly generated or created by the shape of the body passing through the fluid. This phenomenon is commonly referred to as form drag and relates directly to the cross sectional shape of the body passing through the fluid as taken along planes which are parallel to the flow of the fluid over the body.

Referring specifically to the section of housing D illustrated in FIG. 1, it will be noted that the vertical cross section of the vane or housing containing the collector and input is in the shape of an airfoil and includes an upper and lower complementary arcuate surface **43** between collector recess **14** and input recess **17**. This particular cross section illustrated in FIG. 1 is maintained continuously throughout the length of vane D. The airfoil cross section is further maintained so as to be parallel to flow arrow **38** in its elongate or lengthwise cross sectional width while the narrow or thin section of the housing is normal to the relative flow of the fluid of bath A. This particular disposition or parallel angle of attack of the airfoil cross section relative to the fluid flow presents a minimum interfering area with the passing fluid and therefore creates a minimal reaction or fluid turbulence in the passing fluid mixture.

The rate and velocity of fluid gathering or discharge through recesses **14** and **17** in conduits or channels **15** and **18** may additionally be a source of fluid turbulence. If for example, fluid is collected or discharged from interior of housing D at a velocity which is less than or greater than the instantaneous linear velocity of the housing D through bath A, turbulence may be generated. Additionally, if fluid is collected or discharged at a rate which is out of proportion to the displacement of recesses **14** and **17** as it passes through bath B, further turbulence may be

created. Further complicating both of the above mentioned sources of turbulence is the rotational movement of housing D through the bath A. It will be noted from the diagram of FIG. 1 that the instantaneous linear velocity of any point along rotating housing D (as shown graphically by the length of velocity arrows **44**) will increase proportionally as the radial distance between the center of rotation of pedestal E and any selected point along the housing D. If fluid is discharged or gathered at all points along housing D at a constant velocity, this constant velocity will be out of balance with the varied instantaneous linear velocity along increasing radial distances of the housing. Furthemore, equal radial increments of recess **14** and **17** will displace the fluid of bath A at proportionally varying rates dependent upon the radial location from the center of rotation of pedestal E. As is apparent, if the rate of discharge along radial increments of recesses **14** and **17** is maintained at a constant flow rate, this flow rate will be out of balance with the varied radial displacement along the length of recesses **14** and **17**.

To prevent the fluid flow, from and to recesses **14** and **17**, from becoming a source of turbulence, collector manifold **29** and input manifold **35** are provided with apertures **31** and **32**, respectively, which increase proportionally in size relatively as their radial distance from the center of rotation of pedestal E. As shown in FIG. 3, there are apertures **31** in manifold **29** which are located nearest to pedestal E having small size while those apertures furthest removed from pedestal E having a larger size.

Flow through each of the individual orifices along the manifold may be calculated by the equation:

$$Q=AK\sqrt{2gH} \text{ (g p.m.)}$$

where

A=area of orifice (ft.^{2})
K=flow coefficient of orifice
H=head in (ft.)
g=gravitational acceleration in ft./sec.^{2}

As can be seen from the above equation, the flow rate through an orifice Q is directly proportional to the area of the orifice A. By varying the area of the orifice and consequently the flow rate to balance the displacement of those radial increments of recesses **14** and **17** proximate or nearest to the respective orifice, the rate of fluid discharged through the housing need be balanced with the rate of displacement of the recesses in the housing.

The displacement of the rotating radial increment of the recess may be calculated by the following equation:

$$Q_d=0.4896k(D_o^2-D_i^2)tR \text{ (g. p.m.)}$$

where

k=flow coefficient for the opening in the radial increment
D_o=outside diameter of radial increment in ft.
D_i=inside diameter of radial increment in ft.
t=width of slot in the vane (in.)
R=vane revolutions per minute

As is apparent, the velocity of fluid flow through the recesses may be fluidly balanced to match the velocity of the passing fluids by varying the width of the slot in the vane to increase or decrease the area of the radial increment through which the fluid moves between the rotating recess and the fluid bath.

Referring to FIGS. 2 and 3, recesses **14** and **17** are divided into radial increments by boundaries **45**. The flow rate and velocity of fluid passing through each of said boundaries may be determined by the use of the above mentioned relationships to obtain both the desired velocity and flow rate between the recesses and the fluid bath.

Flow rates and velocities of fluids through recesses **14** and **17** may be made to precisely equal that volume displaced and speed maintained by a vertical plane along recess width **40** and **41**. This effect will balance the displacement created by the channels **15** and **18** in passage through the fluid of bath A. Alternately, the flow may be increased or decreased relative to the displacement of the recess through the bath so as to maintain over the length of housing B a programmed and constant amount of turbulence as may be necessary. This latter effect is extremely useful where one emulsion is being gravitationally classified from another. Typically, one emulsion will be maintained in the miscible or intermixed state by introducing a programmed or predetermined amount of turbulence which is sufficient to maintain its intermixture while insufficient to maintain the undesired intermixture of the second emulsion and thus permitting the separation of the undesirable pollutants.

Referring to FIGS. 1 and 2, it will be noted that the collector is placed on the leading end of housing D while the input is on the trailing edge of the housing. As previously explained, the collector when traversing the bath picks up the classified liquid. In gathering such liquid, it is important that relatively no turbulence be communicated to the collector. By moving the collector relative to the bath ahead of the input, the communication of such turbulence is prevented and the collector is able to gather substantially undisturbed classified fluid.

Top settling pollutants **26** may be skimmed from the surface **20** of bath A by means of trough shaped skimmer vane **47** attached to pedestal E which rotates through the bath in advance of the collector B. The leading edge of skimmer **50** extends below surface **20** of bath A a distance sufficient to provide a constant flow of surface or top settling pollutants **26** interior of a trough formed by the skimmer. This trough may then be drained by conventional means through pedestal E. Similarly, scraper **48** comprises an extending shield from pedestal E which moves in relatively close engagement along the bottom portion of tank **22**. Interior of the shield there is provided a helical faced worm conveyor **54** which rotates so as to entrap solid and liquid bottom settling pollutants along its surface and conveys these pollutants interior of pedestal E where they may be conveniently evacuated.

The location of collector B and skimmer vane **47** with respect to the relative movement of the fluid of bath A is important. It has been found that if top settling pollutants are allowed to be disposed on the surface **20** of the bath immediately over collector B, some of the pollutants are readily entrapped and entrained interior of the classified fluid being gathered. To prevent and arrest this tendency, the surface **20** of bath A is skimmed in advance of collector B.

It has further been noted that scrapers such as the helical conveyor type here illustrated create substantial amounts of turbulence in their engagement with the bottom of tank **22**. To prevent this fluid disturbance from being communicated to the collector and its gathering of classified fluids, the scraper vane **48** is commonly rotated well behind the collector B so that a relative movement of fluids from the collector in the direction of the scraper prevents and arrests the fluid communication of the scraper disturbance to the collector.

With reference to FIG. 4, the collector and input are each illustrated as contained in a separate airfoil shaped housing D. These separately contained housings permit the spacial distance between collector B and input C to be increased so as to prevent fluid communication of any turbulence created by input C to collector B.

It will be further noted, that collector B is illustrated in FIG. 4 as being below input C. Where the pollutants are predominantly top settling, the disposition of the above the collector permits both the disposition of the mixed fluids **24** interior of the bath at an elevation where minimum fluid migration of the respective fluid components takes place and the passage of the collector through the fluid of bath A occurs at second elevation where the desired classified fluids are gravitationally disposed in a state of optimum purity.

With reference to FIG. 5, collector B is shown rotated above end input C. This configuration is obtained for predominantly bottom settling pollutants where similar to that disposition illustrated in FIG. 4, the mixed fluids **24** are inserted interior of the bath A at a disposition where their respective components fluidly migrate with minimal movement through bath A and collector C passes through the fluid in an area having optimum gravitationally classified liquid.

With further references to FIGS. 3 and 4, it will be noted that the elevation **60** between input C and collector B differs in FIGS. 3 and 4. This varied elevational positioning of the collector relative to the input has an advantage not immediately apparent.

Depedent upon the viscosity and miscible propensities of the liquid mixture **24**, the gravitational classification of fluids in the bath may take varying lengths of time for each increment of fluid being classified. Typically, the pollutants in each increment of fluid will migrate a vertical distance which is related to the length of time of their retention in the fluid of the bath A and the velocity of migration. If a relatively long retention is necessary to effect the desired gravitational classification, the vertical distance between the collector and input may be increased. This increased distance will require the classified liquid to migrate interior of the bath a greater distance and hence will increase the time any given increment of classified fluid is retained interior of the bath. Alternately, where the liquid mixture is one of rapid gravitational separation, the distance between the collector and input may be decreased so as to provide only the necessary interval of retention in the separating bath.

The invention described thus far has disclosed the simultaneous use of a collector and input interior of a fluid bath undergoing fluid gravitational classification. It is believed apparent that either the collector or the input could be used individually so as to effect gathering or discharge respectively of fluid interior of a bath undergoing settling separation.

What is claimed is:

1. In combination: means for confining a bath of fluid for standing gravitational classification; an airfoil shaped housing; means for moving said airfoil shaped housing relative to said bath; means for withdrawing fluid from said bath including a manifold within said housing communicated to said bath through the leading edge of said airfoil shaped housing; means for placing fluid in said bath including a manifold within said housing communicated to said bath through the trailing edge of said housing; and, partition means between said manifolds, interior of said housing for preventing communication of said withdrawing means and said placing means within said housing.

2. The invention of claim **1** and wherein said housing includes upper and lower complementary arcuate surfaces.

3. The invention of claim **1** wherein said housing includes a recess along the leading edge thereof; said recess having said manifold of said withdrawing means contained therein.

4. The invention of claim **3** and wherein said manifold of said withdrawing means is disposed to guide fluid from said recess into said manifold in a first direction and said recess is disposed to guide fluid from said bath into said recess in a second direction.

5. The invention of claim **3** and wherein: said manifold means of said withdrawing means includes a plurality of apertures for guiding fluid from said recess into said manifold and said recess is divided by walls for preventing fluid from moving along said recess from one of said apertures to the remaining apertures.

6. The invention of claim **1** and wherein said housing includes a recess along the trailing edge thereof; said recess having said manifold of said placing contained therein.

7. The invention of claim **6** and wherein said manifold of said placing means is disposed to guide fluid from said recess into said manifold in a first direction and said recess is disposed to guide fluid from said bath into said recess in a second direction.

8. The invention of claim **6** and wherein: said manifold means of said placing means includes a plurality of apertures for guiding fluid from said manifold into said recess and said recess is divided by walls for preventing fluid from moving along said recess from one of said aperatures to said remaining apertures.

9. The combination according to claim **1** and wherein said airfoil shaped housing is mounted at an angle of attack for minimal form disturbance of said bath when passing therethrough.

10. In combination: means for confining a bath of fluid for standing gravitational classification; a first airfoil shaped housing; a second airfoil shaped housing; means for moving said first airfoil shaped housing relative to said bath at a first elevation within said bath and said second airfoil shaped housing relative to said bath at a second elevation within said bath; means for withdrawing fluid from said bath including a manifold within said first housing communicated to said bath through the leading edge of said first housing; means for placing fluid in said bath including a manifold within said second housing communicated to said bath through the trailing edge of said second housing.

11. The combination of claim **10** and wherein each of said housings includes upper and lower complementary arcuate surfaces.

12. The invention of claim **10** and wherein said first housing includes a recess along the leading edge thereof; said recess having said manifold of said withdrawing means contained therein; said second housing including a recess along the trailing edge thereof; said recess having said manifold of said placing means contained therein.

13. The invention of claim **12** and wherein said manifold of said withdrawing means is disposed to guide fluid from said recess into said manifold in a first direction and said recess is disposed to guide fluid from said bath into said recess in a second direction, said manifold of said placing means being disposed to guide fluid from said recess into said manifold in a third direction and said recess being disposed to guide fluid from said bath into said recess in a fourth direction.

14. The invention of claim **12** and wherein: said manifold means of said withdrawing and placing means includes a plurality of apertures and each of said recesses is divided by walls adapted to prevent fluid from moving along said recesses to prevent fluid from moving from the vicinity of one of said apertures on each of said manifolds to remaining apertures on said each of said manifolds.

15. The invention of claim **10** and wherein: said moving means is further adapted to move one of said housings relative to said bath in advance of the other of said housings.

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JAMES L. DE CESARE, Primary Examiner

U.S. Cl. X.R.

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