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(54) **Method and apparatus for the wet separation of heterogeneous mixtures containing solids having different densities.**

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(56) References cited :
DE-B- 1 216 211
GB-A- 962 386
US-A- 1 996 547
US-A- 4 416 764

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Description

This invention covers the implementation of a system, preferentially but not exclusively devised for discrimination of solid fractions having differentiated density in heterogeneous mixtures using water as a fluid and in particular for discrimination of putrescible organic fractions of solid urban waste to be converted into compost or used for biogas production.

This invention will make it possible almost completely to separate the heavy components in the raw organic fraction (glass, fragments of pottery, stones, metal, rigid plastic material, cells and heavy inert matter of any kind) from the lighter fractions (paper, organic matter etc.).

To separate a heterogeneous mixture of solids having different density values into two (or even more than two) fractions, known, so called "sink-float", systems may be used based upon usually dense liquids in which some solids may float while others will sink to the bottom.

Water too may permit, within well defined limits, sink-float operations to separate materials having a higher than 1 density from those whose density is less than 1, i.e. having a lower density than water.

For instance this sink-float system in water is known by DE-A-1 216 211 and GB-A-962 386, which comprise:

- a discrimination cylinder-shaped tank presenting an open truncated cone-shaped bottom, an upper recovery channel with discharge nozzle for the lighter fractions and is kept filled with water,
- a cylindrical dispersion chamber, coaxially located inside the discrimination tank and supported by the latter, in which the material to be discriminated is charged from above through a channel,
- a motor-driven propelling assembly consisting of an impeller.

Besides there are known US-A-4 416 764 and US-A-1 996 547, which disclose methods and apparatuses for separating fine granular materials as sands, comprising a unique tank provided with central agitator. This tank presents an inlet duct for introducing the mixture, an upper conduct for discharging the lighter fractions and presents a bottom opening for discharging the heavy fractions, which are picked up by a conveyor.

There is, however, a large quantity of solid waste components, such as vegetables, some legumes, fruit, paper, organic tissue, just to list a few and many others which may either float or sink with some difficulty (as for instance a leaf of lattuce or onion or paper); they often remain floating midway in the water. A slight current is enough to keep them floating or entrain them without remaining at the surface or sinking down to the bottom.

This means that the systems hitherto known for gravitational "sink-float" separation in water have yielded no practical results, especially for solid urban waste discrimination and can therefore not be used.

This invention has the aim to make it possible to take advantage of gravitational separation in water since this method is most economic because of its low operating cost.

This aim is achieved according to the characterizing part of claim 1 by combining two effects: i.e. gravitational separation and the generation of water streams having differentiated entrainment capacity thus inviting irresolute fractions to follow given routes and hence promoting the desired discrimination.

For this purpose, the invention provides for a cylindrical discrimination chamber having a truncated cone shaped bottom, placed inside an external settling basin filled with water.

Furthermore, an also cylinder-shaped dispersion chamber with truncated-cone bottom fed with the mixture to be treated, is coaxially placed in the discrimination tank. These two settling and discrimination tanks have an open bottom.

The system is completed by a screw distributor located in the lower part of the discrimination tank and a propelling impeller mounted below the dispersion tank just above the distributor, in order to generate adequate current flows to complete the required sorting.

The invention in question is illustrated in its preferable implementation in the enclosed drawings in which:

fig.1 shows a lengthwise vertical section of the separator in question;

Fig.2 shows a top view of the separator illustrated in fig.1;

Fig.3 shows the central vertical section of the propelling unit.

Fig.4 shows a top view of the propeller illustrated in fig.3.

With reference to these figures, the separator is essentially consisting of four assemblies which will be described hereinafter.

The first assembly is consisting of a cyclindrical discrimination tank 1 with truncated cone-shaped bottom which is kept constantly filled with water, surrounding and supporting - by means of four tie rods 32 - the coaxial dispersion chamber 2 with an open truneated cone-shaped bottom, which is completely immersed in the liquid and in which the mixture to be processed is fed through the channel 3 together with most of the process water . The discrimination tank 1 has an overflow 4 through which excess water is discharged together with any supernatant fractions of the mixture which are collected in the ring-shaped effluent channel 5 and are drained through the outlet 6 connected to the channel 5.

The lower orifice 7 of the discrimination tank 1 is

hydraulically closed.

The heavy inert fractions such as glass, stones, metals, cells etc. are discharged through this orifice and are then mechanically removed as will be explained hereinafter.

A "spiral chamber" for distribution of the make-up water 8 is located outside the terminal cone of the discrimination tank, immediately above the orifice 7; this spiral chamber lets the water into the tank 1 by means of the guide vanes 9 conveying the water entering the tube 10, in the correct flow direction of the fluid .

The second assembly is consisting of a propelling unit located inside the discrimination tank 1 along its central vertical axis XX; this propeller is essentially consisting of a geared motor 11, a shaft coinciding with the XX axis and an impeller 13 forged into the shape of an upside-down "chinese hat" fitted with upper and lower radial vanes (fig.3). The "propeller" assembly is completed by a base supporting the geared motor unit and a flexible coupling 15 connecting the driving unit to the impeller shaft. The latter is supported by two water lubricated bushes 16 and 17 mounted at the upper and lower end of the casing 18 resting on the flange 19 with the fitting 20 through which pressurized clean water can be let into the casing 18 for lubrication of the bushes 16 and 17. The impeller is located below the lower orifice of the dispersion chamber 2 and above the row of guide vanes 9 of the spiral chamber 8 as illustrated in fig.1.

The third assembly is consisting of a settling basin 21 surrounding the discrimination tank 1 and extending above the upper level of the fluid overflowing from the spillway 4 of the discrimination chamber 1.

The settling basin 21 has two vertical and parallel sides 22 and 23, separated by a third polygonal traverse wall 24 at right angles to the walls 22 and 23 so as to form the bottom of the sattling basin 21.

Fig. 1 clearly shows that the polygonal wall 24 is consisting of an initial section a, followed by a subvertical section b, a horizontal section c and a final section d gently sloping upwards and extending well beyond the free surface of the liquid.

The section d of the polygonal wall 24 has an opening with a discharge nozzle 25 at its upper end, well above the liquid surface.

The settling basin 21 is communicating with the discrimination tank 1 by means of the orifice 7. Basin 21 and tank 1 are both filled with water and will have the same free surface level e,l according to the principle of communicating vessels.

Therefore, no water should flow through the orifice 7. Actually, there will be a slight upward flow due to clean make-up water entering through the feed cokck 26 which, among others, will make up for any imbibition losses caused by the heavy inert and polluting material discharged through the outlet 25.

From fig. 1, it can be observed that the discrimination and dispersion tanks 1 and 2 have their XX axis in the maximum vertical dimension zone of the settling basin 21.

The fourth assembly is consisting of a chain scraper 27 having the task to collect the heavy inert fractions, discharged through the lower orifice 7 of the discrimination tank 1 into the settling basin 21 where they settle on the bottom of the basin.

The chain scraper 27 is fitted with scraper blades 28 slowly grazing the bottom and dredging the deposited material, dragging it along the section d of the bottom wall 24 of the basin, so that it can be discharged, after a short drying length, above the water surface, through the outlet 25.

Outside the settling basin, the chain scraper 27 is supported by a guide pulley 29 and supporting roller 30. The chain is driven by a properly recessed or toothed driving roller 31, driven by a geared motor so that it will be possible to adjust the scraper speed within a large range and hence to vary its transport and discharge capacity.

Based upon the foregoing, the separator subject matter of this invention is operating as described hereinafter. To obtain acceptable results and yields it is obviously necessary to provide for extreme dispersion of the mixture to be sorted out so that each elementary item in the dispersed mixture has a sufficient degree of freedom.

Dispersions with a 3% to 8% content of dry solid matter are usually adopted. The mixture to be separated is introduced through the channel 3 where a fair amount of water is also added. The heterogenous suspension is let into the dispersion chamber 2 in which downward circulating water is whirling under the helical action of the bladed impeller 13 having the shape of an upside-down "chinese hat".

The mixture is dispersed during its downward motion towards the impeller and even water-repellent items which tend to float are entering the liquid whirlpool and entrained downwards. The dispersed mixture thus obtained is hurled outwards where the lighter and floating fractions (vegetables, paper and organic matter) will reascend in a spiral motion along the wall of the discrimination tank 1 until they reach the water surface where part of it will flow over the edge 4 to be discharged through the drain channel 5 whereas another part will be drawn back to the center of the dispersion chamber 2 to start another cycle together with the material coming from the channel 3.

Heavy fine solid matter will be centrifuged beyond the fluid threads which can be ideally identified in the water flow and these fines will impinge on the fixed wall of the discrimination tank 1. When impinging on the wall, their speed is checked or at least greatly reduced so that the gravity action and the differential downward thrust will prevail.

Thus, the lighter solid fractions or those having a larger wetted surface with respect to their volume will be entrained upwards in a spiral motion toward the

water surface, whereas the heavier fractions such as inert materials, metals etc. will move downwards following the same helical motion. The more or less fast downward movement will bring these heavy fractions below the YY center-line of the impeller 13 where they will be entrained by a secondary whirlpool and hurled outwards and then thrust axially upwards under the action of the radial blades mounted on the lower surface of the impeller 13. The discriminant action leading to complete release and separation of inert solids from the remaining components of the mixture is thus completed in this cone-shaped terminal section of the tank 1.

Inevitably, some fractions having a density of approximately 1 will also be entrained during the downward spiral movement and will zeroize their centrifugal component when impinging on the cone wall so that they will be conveyed downward together with the heavier material.

At a given point during their sinking, the ideal trajectory will convey this mixture of inert and organic matter in front of the blading 9 through which a certain amount of clean (or recycled) make-up water will be let in the same direction of the spiral flow inside the cone.

This strean will ensure that less heavy particles will be directed towards the cone axis where they will be caught by the axial flow towards the impeller and recycled towards the periphery of the YY section.

The reascending water stream, due to the water entering the blading 9, will convey the organic particles back to the upper portion of the YY section so that they will recirculate in the main stream towards the upper edge 4 of the tank where the water and the floating fractions will be discharged into the ring-shaped channel 5 and drained through the outlet 6, as already explained above.

The heavier materials, rigid plastics, sand, glass, fragments of pottery, metal and the like will pass the threshold 7 of the discharge orifice of the cone in a slight counter-current flow of the water entering the settling basin 21 through the feed-cock 26, then flowing upwards through the threshold 7 into the discrimination tank 1, to be discharged into the anular channel 5 together with the purified material and drained through the outlet 6.

Heavy and polluting fractions entering the settling tank 21 where the water is virtually calm, will sink to the bottom 24 of the tank 21. They will be scooped by the chain scraper 27 gently grazing the bottom wall 24 of the settling tank 21 and lifted along the sloping wall section d until they are raised above the liquid surface "l" and, after partial dewatering, are discharged through the outlet 25.

Claims

1. Wet separator for discrimination of two or more solid fractions of heterogeneous mixtures having differentiated density values in water, comprising:
   - a discrimination tank (1), which cylinder-shaped tank (1) has an open truncated cone-shaped bottom (7), an upper recovery channel (5) with discharge nozzle (6) for the lighter fractions and is kept filled with water,
   - a cylindrical dispersion chamber (2), coaxially located inside the discrimination tank (1) and supported by the latter, in which the material to be discriminated is charged from above through a channel (3),
   - a motor-driven (11) propelling assembly consisting of an impeller (13),

   characterized in that:
   - the dispersion chamber (2) has an open truncated cone-shaped bottom,
   - an external settling basin (21), having two parallel sides (22, 23) closed at their lower end by a polygonal bottom (24) contains at its largest vertical section (X-X) the discrimination tank (1),
   - the external settling basin (21) is provided with an outlet nozzle (25) through which the heavy fractions are discharged and with a feed pipe (26) for water supply,
   - the external settling basin (21) is provided with a chain scraper (27) dredging its bottom, thus collecting the heavy fractions which have sunk to the bottom and conveying them to the above mentioned discharge nozzle (25),
   - a spiral chamber (8) with inward guide vanes (9) located near the bottom orifize (7) of the discrimination tank (1) and receiving water through a duct (10),
   - the impeller (13) is shaped like an upside-down chinese hat and fitted with blades on its upper and lower surface, this impeller (13) being mounted between the lower orifize of the dispersion chamber (2) and the spiral chamber (8).

2. Wet separator according to claim 1, **characterized** in that the polygonal bottom (24) of the settling basin (21) has at one end a vertical length (a) followed by a length (b) sloping towards the center, a horizontal length (c) and a final length (d) gently sloping upwards towards the other end of the basin fitted with the water feed pipe (26) and the outlet (25) through which the heavy fractions are discharged.

3. Wet separator according to claim 1, **character-**

ized in that the upper edge (4) of the discrimination tank (1) has an overflow level (e) in the discharge channel (5) coinciding with the water level (1) in the settling basin (21) when the discrimination tank (2) is completely immersed.

4. Method of wet separating through the wet separator according to claim 1, wereby:
   - the mixture to be discriminated is let into the dispersion tank (2) through the channel (3),
   - this mixture in the dispersion chamber (2) is subjected to a whirling downward flow and it is thus dispersed, so that all fractions of the mixture, even the lighter ones, will reach the discrimination chamber (1) where they are flung outwards under action of the impeller (13),
   - in the discrimination chamber (1) the lighter floating fractions will spiral upwards along the walls until they reachthe free water surface and are discharged over the edge (4) into the drain channel (5),
   - the heavy fractions in the discrimination chamber (1) will move downwardly,

   characterized in that:
   - in the discrimination chamber (1) the lighter floating fractions can also reach the central zone of the same chamber (1) to be recycled in the dispersion chamber (2) joining the fresh incoming mixture,
   - the heavy fractions in the discrimination chamber (1) will move downward where they are exposed to the action of the radial vanes (9) of the spiral chamber (8) and to the related upward flow of the water discriminating any light fractions entrained by the heavier fractions in their downward motion, so that the lighter fractions can be recycled by the impeller (13),
   - the heavy fractions are countercurrent discharged through the lower opening of the discrimination tank (1) together with the water let into the settling basin (21) through the feed-cock (26); the heavy fractions will sink to the bottom (c) of the settling tank (21) from where they are dredged by the chain scraper (27) and discharged through the outlet (25).

5. Method of wet separating according to claim 4, **characterized** in that the dry substance content in the mixture ranges between 3% and 8%.

Patentansprüche

1. Nasstrenner zum Trennen zweier oder mehrerer fester Fraktionen heterogener Mischungen, welche unterschiedliche Dichtewerte in Wasser aufweisen, umfassend:
   - einen Trennungstank (1), wobei der zylinderförmige Tank (1) einen offenen, kegelstumpfförmigen Boden (7), einen oberen Rückgewinnungskanal (5) mit Ablauftülle (6) für die leichteren Fraktionen aufweist und stets mit Wasser befüllt bleibt,
   - eine zylindrische Dispersionskammer (2), welche koaxial im Inneren des Trennungstanks (1) angeordnet und von letzterem getragen wird und in welcher das zu trennende Material von oben durch einen Kanal (3) eingetragen wird,
   - eine motorbetriebene Propellerbaugruppe (11), bestehend aus einem Flügelrad (13),

   dadurch gekennzeichnet, dass
   - die Dispersionskammer (2) einen offenen, kegelstumpfförmigen Boden aufweist,
   - ein äusseres Absetzbecken (21), welches zwei parallele Seiten (22, 23) aufweist, die an ihrem unteren Ende durch einen polygonalen Boden (24) abgeschlossen sind, an seinem grössten vertikalen Abschnitt (X-X) den Trennungstank (1) aufweist,
   - das äussere Absetzbecken (21) mit einer Auslasstülle (25), durch welche die schweren Fraktionen abgeführt werden, und mit einem Zuführrohr (26) für die Wasserversorgung versehen ist,
   - das äussere Absetzbecken (21) mit einem Kettenkratzbagger (27) ausgestattet ist, welcher seinen Boden räumt und somit die schweren Fraktionen, die auf den Boden abgesunken sind, einsammelt und sie zur obengenannten Auslasstülle (25) befördert,
   - eine Spiralkammer (8) mit einwärts gerichteten Leitflügeln (9) in der Nähe der unteren Öffnung (7) des Trennungstanks (1) angeordnet ist und Wasser durch eine Leitung (10) erhält,
   - das Flügelrad (13) wie ein auf den Kopf gestellter chinesischer Hut geformt ist und an seiner oberen und unteren Oberfläche mit Flügeln ausgestattet ist, wobei dieses Flügelrad (13) zwischen der unteren Öffnung der Dispersionskammer (2) und der spiralförmigen Kammer (8) befestigt ist.

2. Nasstrenner nach Anspruch 1, dadurch gekennzeichnet, dass der polygonale Boden (24) des Absetzbeckens (21) an einem Ende eine vertikale Länge (a) aufweist, gefolgt von einer Länge (b), welche sich zur Mitte neigt, einer horizontalen Länge (c) und einer abschliessenden Länge (d), welche leicht nach oben zum anderen Ende des Beckens geneigt ist, das mit dem Wasserzufuhrrohr (26) und dem Auslass (25) ausgestattet ist,

durch welchen die schweren Fraktionen abgeführt werden.

3. Nasstrenner nach Anspruch 1, dadurch gekennzeichnet, dass die obere Kante (4) des Trennungstanks (1) einen Überlaufpegel (e) im Ableitungskanal (5) aufweist, welcher mit dem Wasserpegel (1) im Absetzbecken (21) zusammenfällt, wenn der Trennungstank (2) vollständig eingetaucht wird.

4. Verfahren zum nassen Trennen mittels des Nasstrenners nach Anspruch 1, wobei:
   - die zu trennende Mischung durch den Kanal (3) in den Dispersionstank (2) eingelassen wird,
   - diese Mischung in der Dispersionskammer (2) einem wirbelnden Abwärtsstrom zugeführt und somit dispergiert wird, so dass alle Fraktionen der Mischung, selbst die leichteren, die Trennkammer (1) erreichen, wo sie unter der Einwirkung des Flügelrades (13) nach aussen geschleudert werden,
   - in der Trennkammer (1) die leichteren, aufschwimmenden Fraktionen die Wände entlang spiralförmig nach oben kreisen werden, bis sie die freie Wasseroberfläche erreichen und über die Kante (4) in den Ablaufkanal (5) abgegeben werden, und
   - die schweren Fraktionen sich in der Trennkammer (1) nach unten bewegen,

   dadurch gekennzeichnet, dass:
   - die leichteren, aufschwimmenden Fraktionen in der Trennkammer (1) auch die mittlere Zone derselben Kammer (1) erreichen können, um in die Dispersionskammer (2) rückgeführt zu werden und somit mit der frischen, einströmenden Mischung zusammenzukommen,
   - die schweren Fraktionen sich in der Trennkammer (1) nach unten bewegen, wo sie der Wirkung der radialen Flügel (9) der Spiralkammer (8) und dem zugehörigen Aufwärtsstrom des Wassers ausgesetzt sind, wodurch alle durch die schwereren Fraktionen bei ihrer Abwärtsbewegung mitgenommenen leichteren Fraktionen abgetrennt werden, so dass die leichteren Fraktionen durch das Flügelrad (13) rückgeführt werden können,
   - die schweren Fraktionen gegen die Strömungsrichtung durch die untere Öffnung des Trennungstanks (1) zusammen mit dem Wasser, welches in das Absetzbecken (21) durch den Zufuhrhahn (26) eingelassen wird, abgeführt werden; die schweren Fraktionen auf den Boden (c) des Absetzbeckens (21) sinken, von wo sie durch den Kettenkratzbagger (27) geräumt und durch den Auslass (25) abgeführt werden.

5. Verfahren zum nassen Trennen nach Anspruch 4, dadurch gekennzeichnet, dass der Gehalt an Trockensubstanz in der Mischung zwischen 3% und 8% beträgt.

Revendications

1. Séparateur humide pour la séparation de deux ou de plusieurs fractions solides de mélanges hétérogènes présentant différentes densités dans l'eau, comprenant :
   - un réservoir de séparation (1), le réservoir cylindrique (1) présentant un fond tronconique ouvert (7), un canal de récupération (5) supérieur avec verseur d'évacuation (6) pour les fractions plus légères, et restant rempli d'eau en permanence,
   - une chambre de dispersion cylindrique (2) logée de façon coaxiale à l'intérieur du réservoir de séparation (1) et portée par lui, dans laquelle le matériau à séparer sera chargé, d'en haut, à travers un canal (3),
   - un dispositif d'hélices (11) mu par moteur composé d'un rotor (13),

   caractérisé par le fait que
   - la chambre de dispersion (2) présente un fond tronconique ouvert,
   - un bassin de décantation extérieur (21) présentant deux faces parallèles (22, 23) fermées à leur extrémité inférieure par un fond polygonal (24) présente, à sa section verticale maximum (X-X), le réservoir de séparation (1),
   - le bassin de décantation extérieur (21) est pourvu d'un verseur d'évacuation (25) par lequel sont déchargées les fractions lourdes et d'un tube d'alimentation (26) pour l'alimentation de l'eau,
   - le bassin de décantation extérieur (21) est pourvu d'un excavateur à chaîne à raclettes (27) nettoyant son fond et collectant donc les fractions lourdes tombées au fond, les convoyant jusqu'au verseur d'évacuation (25) susmentionné,
   - une chambre hélicoïdale (8) avec des pales de guidage (9) orientées vers l'intérieur est agencée à proximité de l'orifice inférieur (7) du réservoir de séparation (1) et retient l'eau par une conduite (10),
   - le rotor (13) a la forme d'un chapeau chinois à l'envers et est équipé de pales, sur ses surfaces supérieure et inférieure, ce rotor (13) étant fixé entre l'orifice inférieur de la chambre de dispersion (2) et de la chambre

hélicoïdale (8).

2. Séparateur humide selon revendication 1, caractérisé par le fait que le fond polygonal (24) du bassin de décantation (21) présente sur une extrémité une longueur verticale (a), suivie d'une longueur (b) inclinée vers le milieu, une longueur horizontale (c) et une longueur finale (d) légèrement inclinée vers le haut, à l'autre extrémité du bassin équipé d'un tube d'alimentation de l'eau (26) et de la sortie (25) par laquelle sont déchargées les fractions lourdes.

3. Séparateur humide selon revendication 1, caractérisé par le fait que le bord supérieur (4) du réservoir de séparation (1) présente un niveau de trop-plein (e) dans le canal de dérivation (5) concordant avec le niveau d'eau (1) dans le bassin de décantation (21) lorsque le réservoir de séparation (2) est entièrement immergé.

4. Procédé pour la séparation humide au moyen du séparateur humide selon revendication 1,
   - le mélange à séparer étant introduit par le canal (3) dans le réservoir de dispersion (2),
   - ce mélange étant soumis, dans la chambre de dispersion (2), à un courant tourbillonnant vers le bas, et donc dispersé, de telle sorte que toutes les fractions du mélange, même les plus légères, atteignent la chambre de séparation (1), où elles sont propulsées vers l'extérieur sous l'effet du rotor (13),
   - les fractions flottantes plus légères se déplacent dans le réservoir de séparation, dans des mouvements circulaires et hélicoïdaux, le long des parois, vers le haut, jusqu'à atteindre la surface libre de l'eau et être déchargées par-dessus le bord (4) dans le canal d'évacuation (5), et
   - les fractions lourdes se déplacent vers le bas, dans la chambre de séparation (1),

   caractérisé par le fait que :
   - les fractions flottantes plus légères peuvent également atteindre dans la chambre de séparation (1) la zone centrale de la même chambre (1) pour être recyclées dans la chambre de dispersion (2) et donc se joindre au mélange frais qui arrive,
   - les fractions lourdes (1) se déplacent dans la chambre de séparation vers le bas, où elles sont exposées à l'action des pales radiales (9) de la chambre hélicoïdale (8) et au courant y relatif vers le haut, toutes les fractions plus légères entraînées lors de leur descente par les fractions plus lourdes étant séparées, de telle sorte que les fractions plus légères peuvent être recyclées par l'intermédiaire du rotor (13),
   - les fractions lourdes sont déchargées à contre-courant à travers l'orifice inférieur du réservoir de séparation (1) en même temps que l'eau introduite dans le bassin de décantation (21) par le robinet d'alimentation (26) ; les fractions lourdes tombent au fond (c) du bassin de décantation (21), d'où elles sont nettoyées par l'excavateur à chaîne à raclettes (27) et déchargées par la sortie (25).

5. Procédé pour la séparation humide selon revendication 4, caractérisé par le fait que la teneur en substance sèche du mélange se situe entre 3% et 8 %.

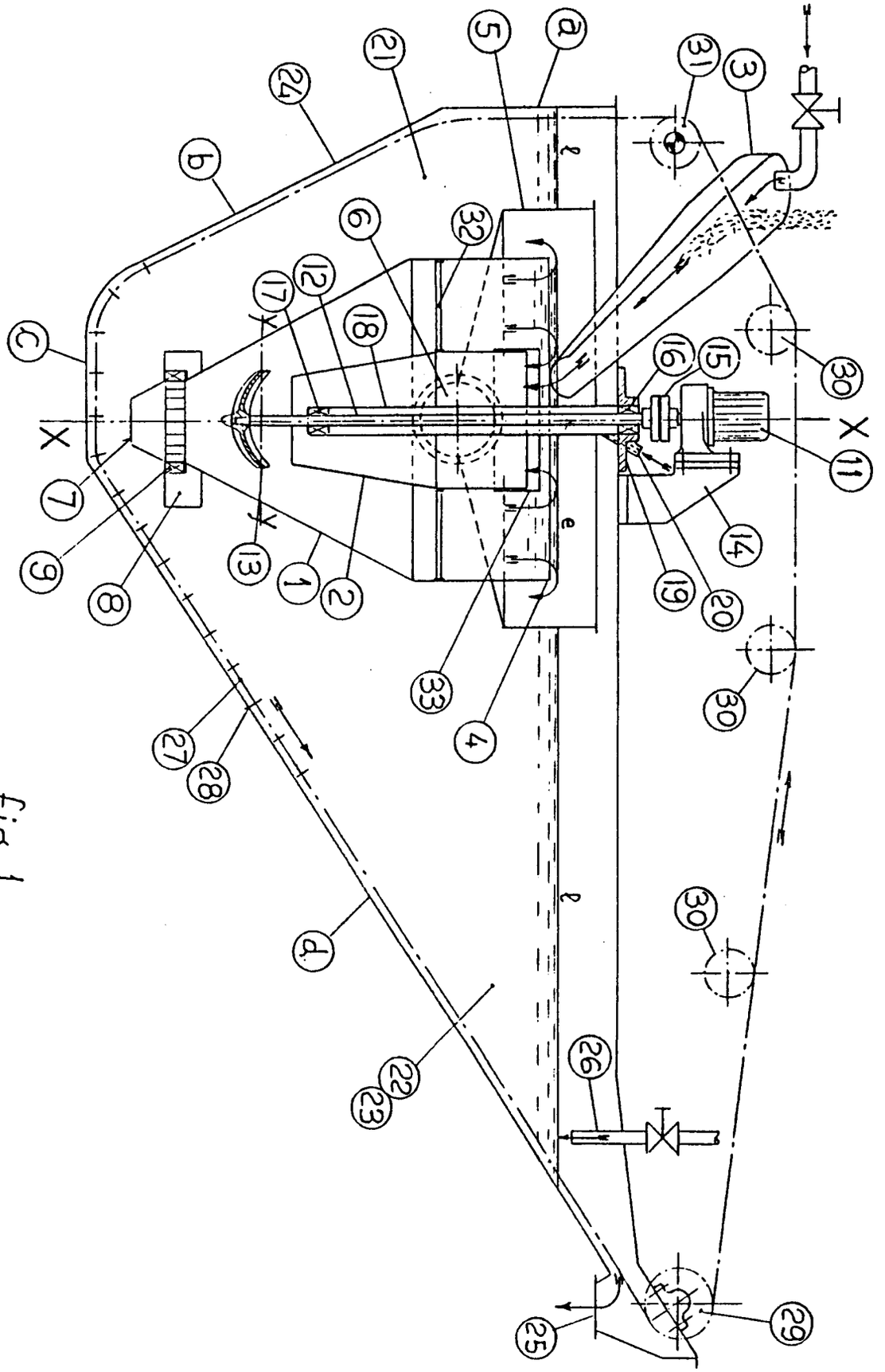
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fig. 1

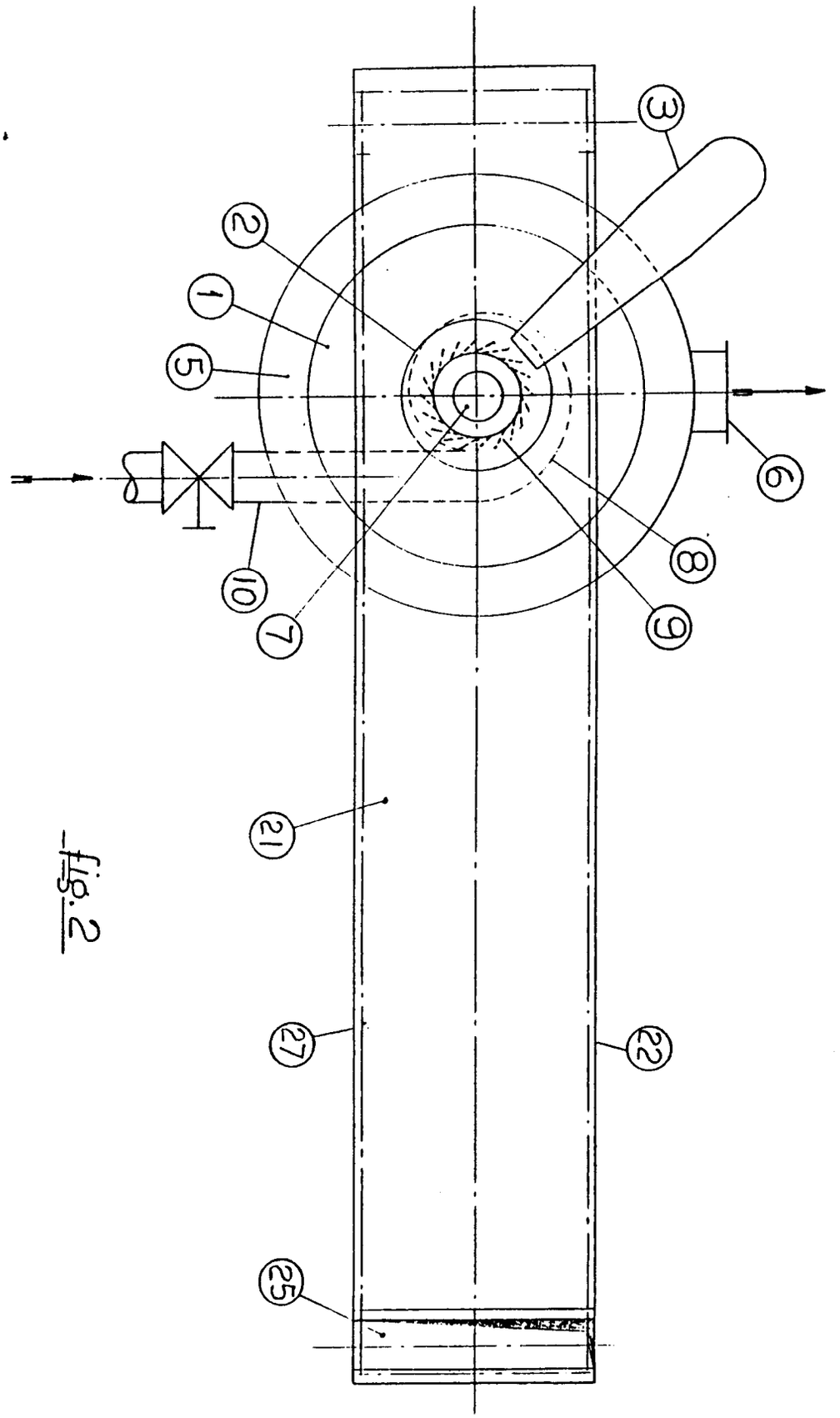

Fig. 2

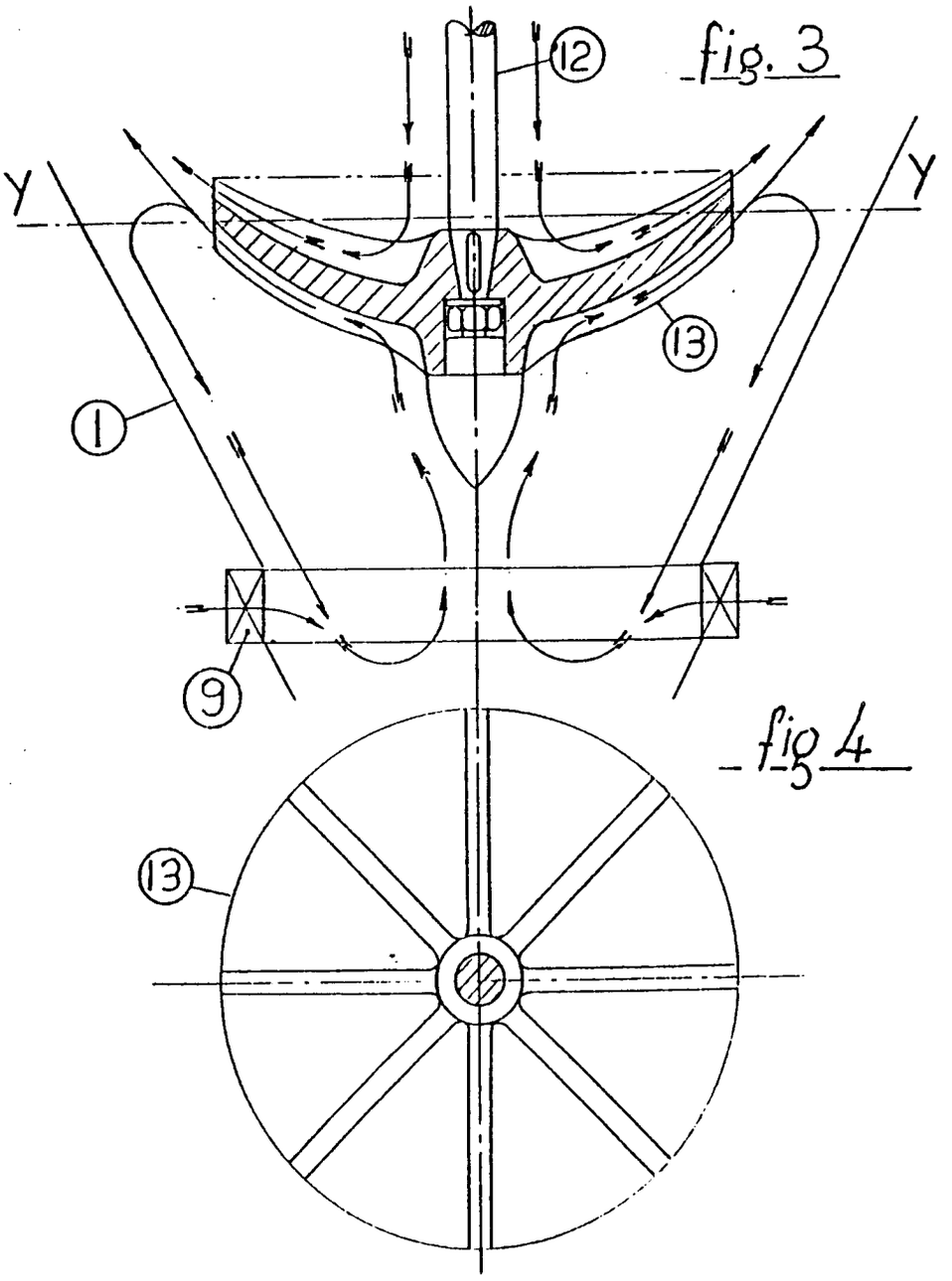

fig. 3

fig 4