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

(57) This separator is consisting of two concentric, cylinder shaped chambers or tanks, one for discrimination (1) and the other for dispersion, with open truncated cone-shaped bottom, both lodged in a settling basin (21). The dispersion tank (2) is filled from above with the mixture to be discriminated, whereas the discrimination tank (1) is provided at the top with an overflow (4) with channel (5) for drainage of the light fractions and with an outlet opening (7) at its lower end through which the heavier fractions are discharged. A a spiral chamber (8) fitted with guide blades (9) is located near the lower outlet (7) of the discrimination tank (1) and a chinese hat shaped impeller (13) fitted with blading at its upper and lower end generate flows having a prefixed velocity and direction so as to facilitate separation of the mixture to be discriminated.

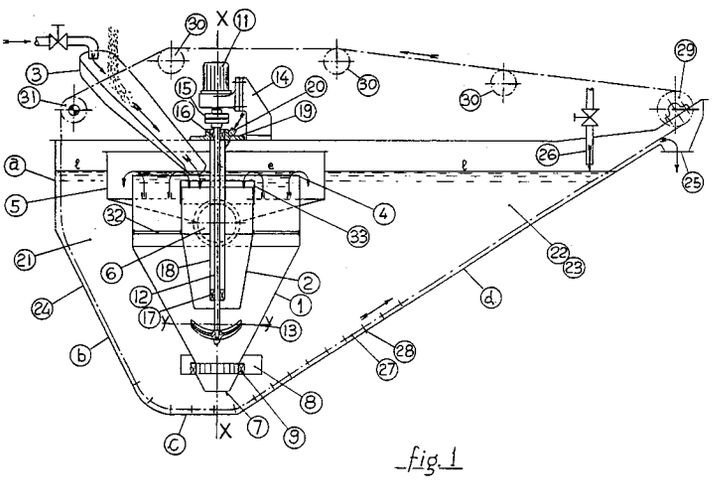

fig.1

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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 descrimination 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.

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 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 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 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 sub-vertical 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 an 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 25 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 "1" 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, **characterized** by the fact that the system is consisting of:
   - an external settling basin (21) having two parallel sides (22, 23), closed at their lower end by a polygonal bottom (24) and provided with an outlet nozzle (25) through which the heavy fractions are discharged and with a feed pipe (24) for water supply,
   - a chain scraper (27) dredging the bottom of the tank (21), thus collecting the heavy fractions which have sunk to the bottom and conveying them to the above mentioned discharge opening (25),
   - a discrimination tank (1) located inside the settling basin (21) at its largest vertical section (XX), which cylinder-shaped tank (1) has an open truncated cone shaped bottom (7), an upper recovery channel (5) with discharge nozzle for the lighter fractions and is kept filled with water;
   - a spiral chamber (8) with inward guide vanes (9), located near the bottom orifice (7) of the discrimination tank (1) and receiving water through the duct (10) ,
   - a cylindrical dispersion chamber 2 with an open truncated cone-shaped bottom, coaxially located inside the discrimination tank (1) and supported by the latter, in which the material to be discriminated is charged from above through the channel (3),
   - a motor-driven propelling assembly consisting of an impeller (13) shaped like an upside-down chinese hat and fitted with blades on its upper and lower surface, mounted between the lower orifice of the dispersion chamber and the spiral chamber (8),

   so that the components of the heterogeneous mixture can be separated either by gravity or under the action of proper whirlpools generated by the impeller and by the spiral chamber .

2. Separator as described in claim 1, **characterized** by the fact that the polygonal bottom (24) of the settling tank (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. Separator as described in claim 1, **characterized** by the fact 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 tank (21) when the discrimination tank (2) is completely immersed.

4. Operation of the separator as described in claim 1, **characterized** by the fact that :
   - 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 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 the action of the impeller (13);
- in the discrimination chamber (1) the lighter floating fractions will spiral upwards along the walls until they reach the free water surface and are discharged over the edge (4) into the drain channel (5) or reach the central zone of the basin 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. Operation as described in claim 4, **characterized** by the fact that an extreme dispersion of the substances to be discriminated is achieved in the water and that, for indicatory purposes, the dry substance content in the mixture ranges between 3% and 8%.

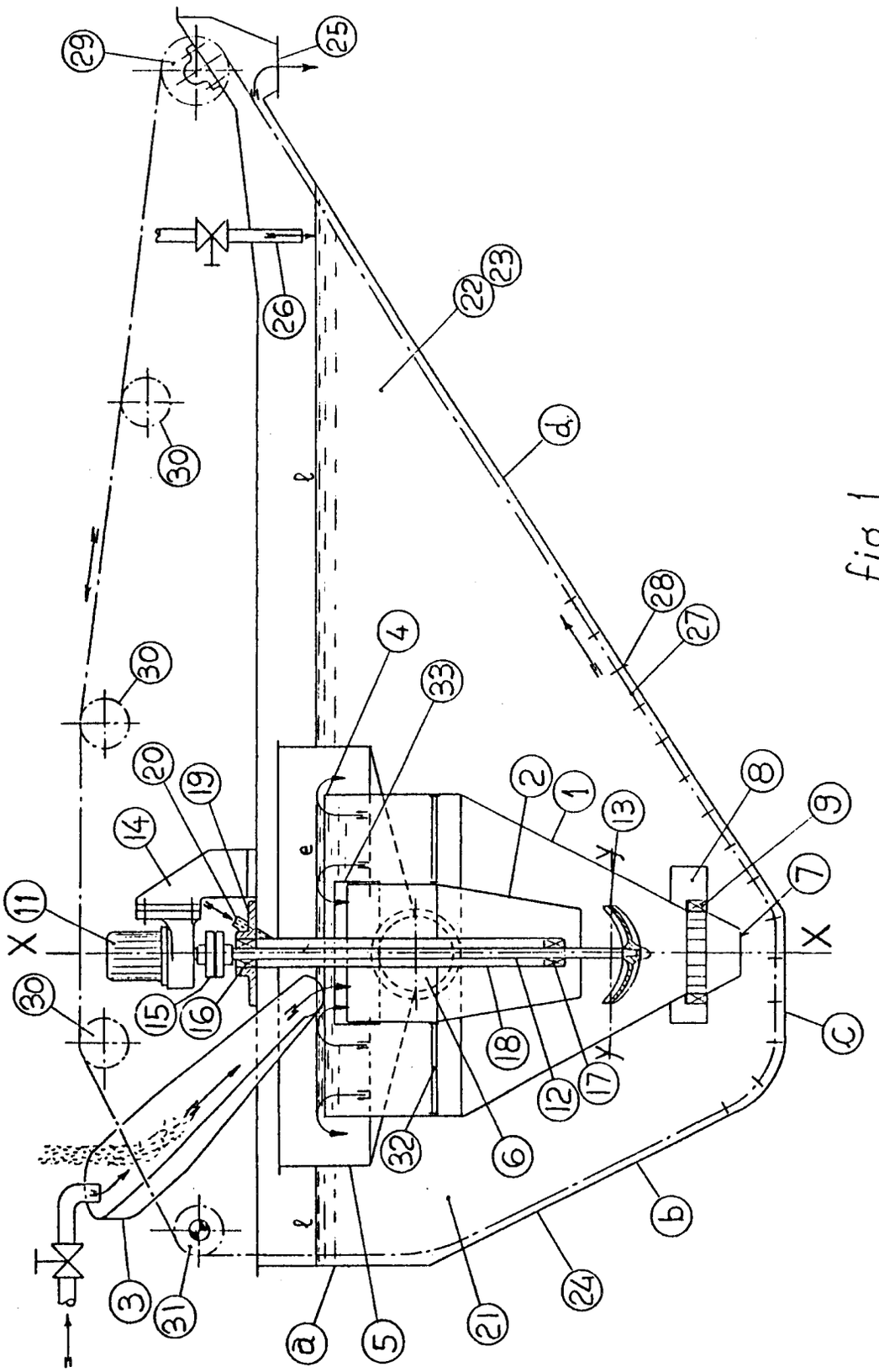
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fig. 1

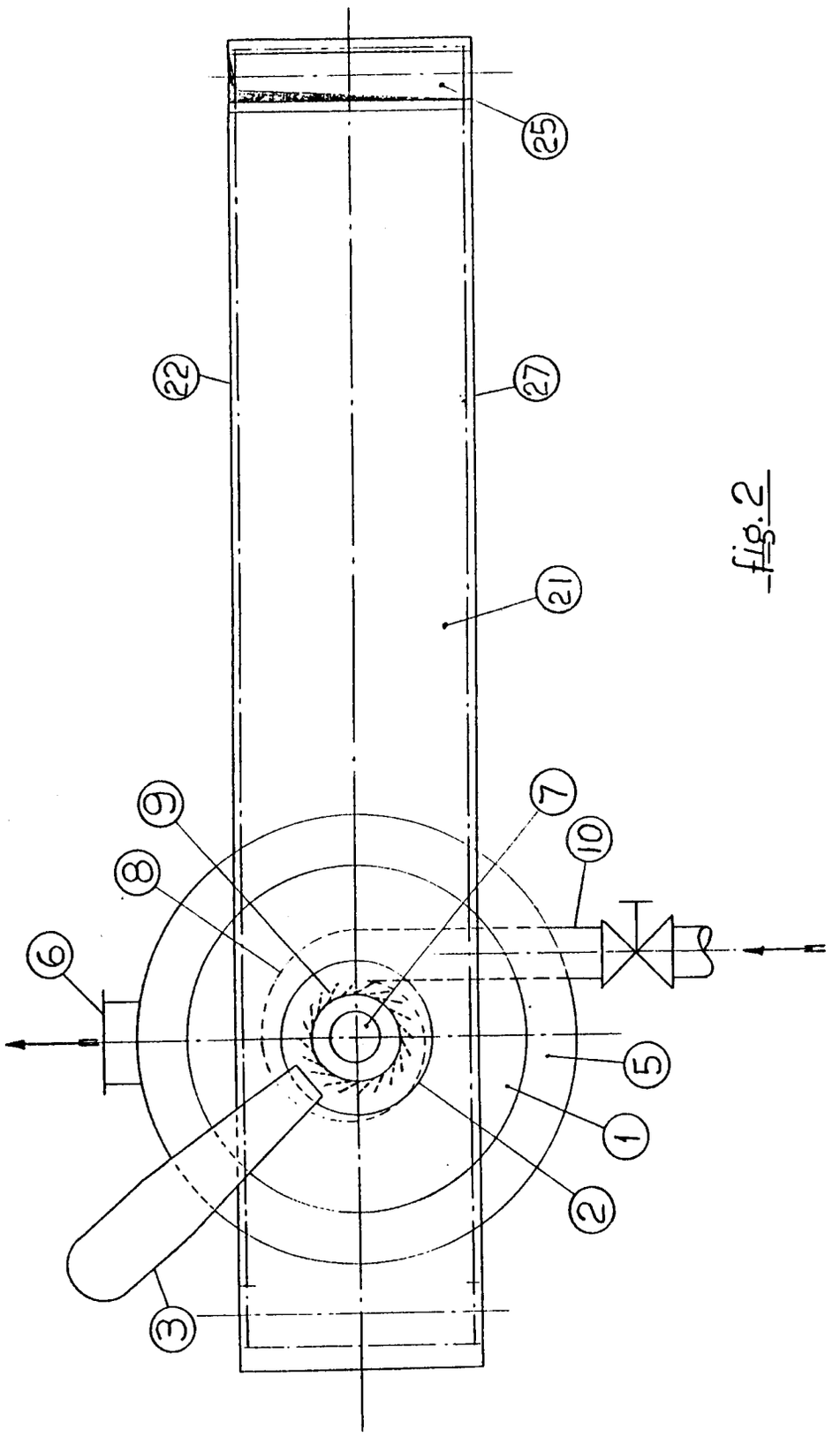

fig.2

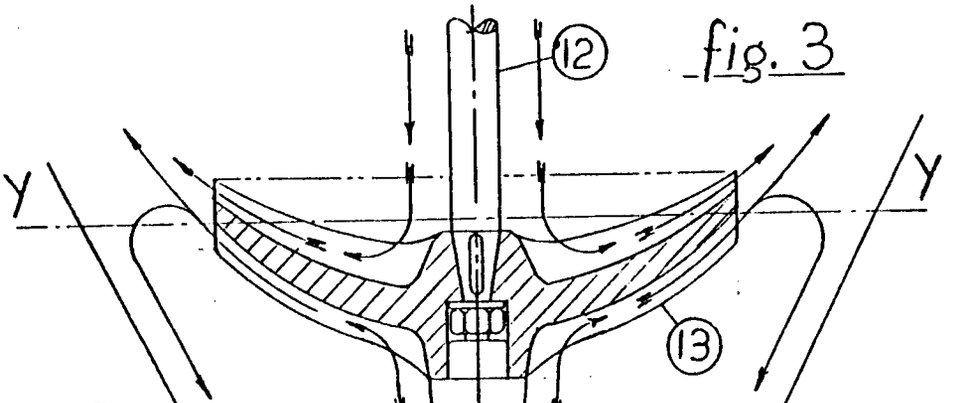

fig. 3

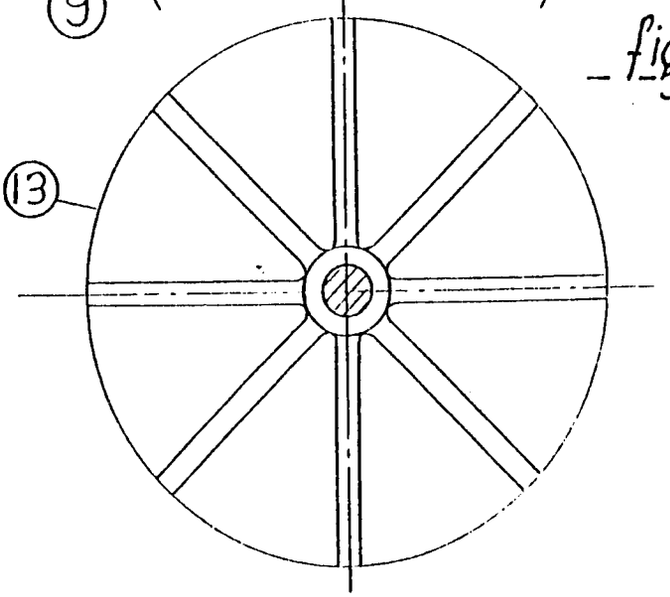

fig 4