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METHOD AND APPARATUS FOR SEPARATING
SLURRY AND LIKE SUSPENSIONS

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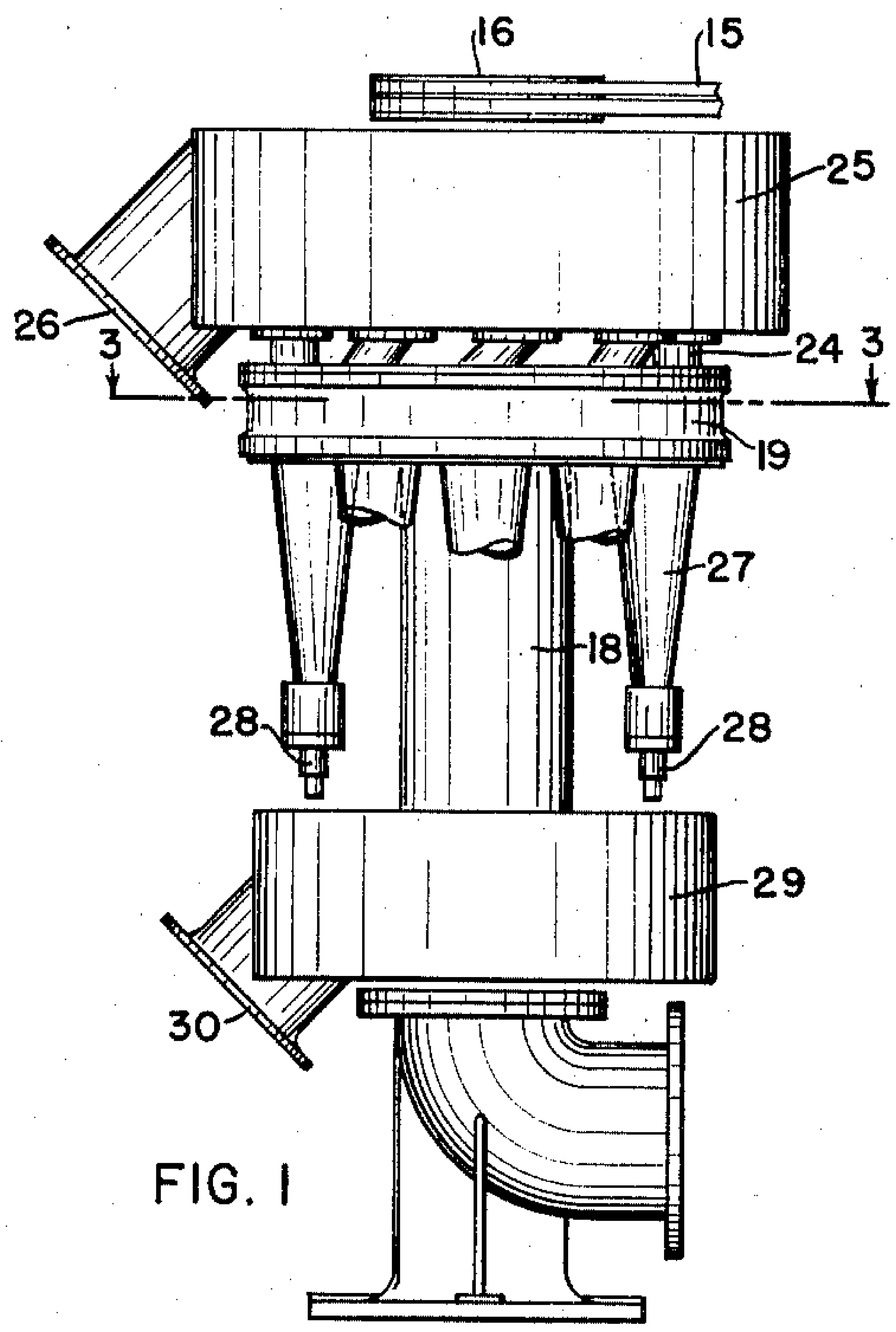

FIG. 1

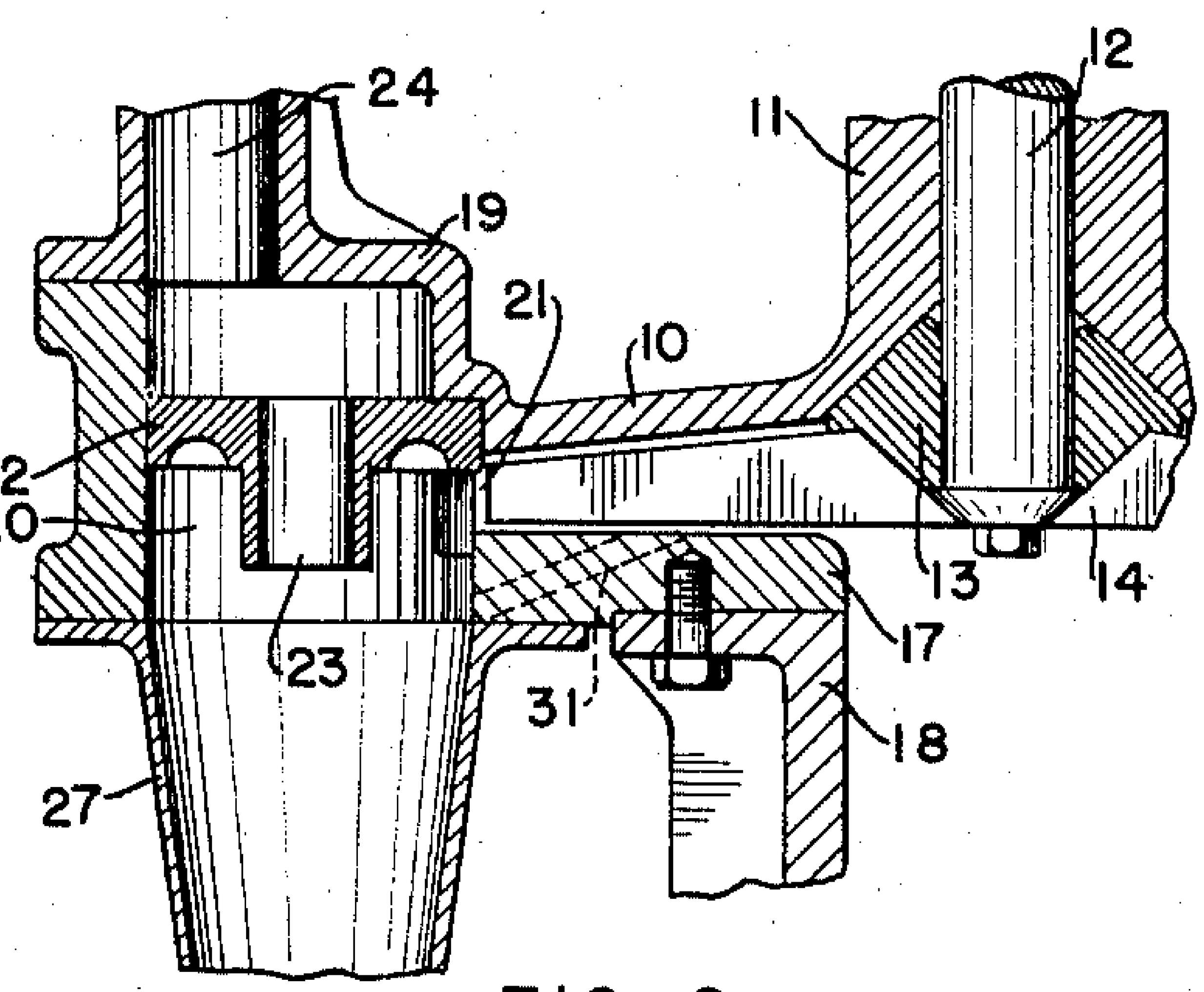

FIG. 2

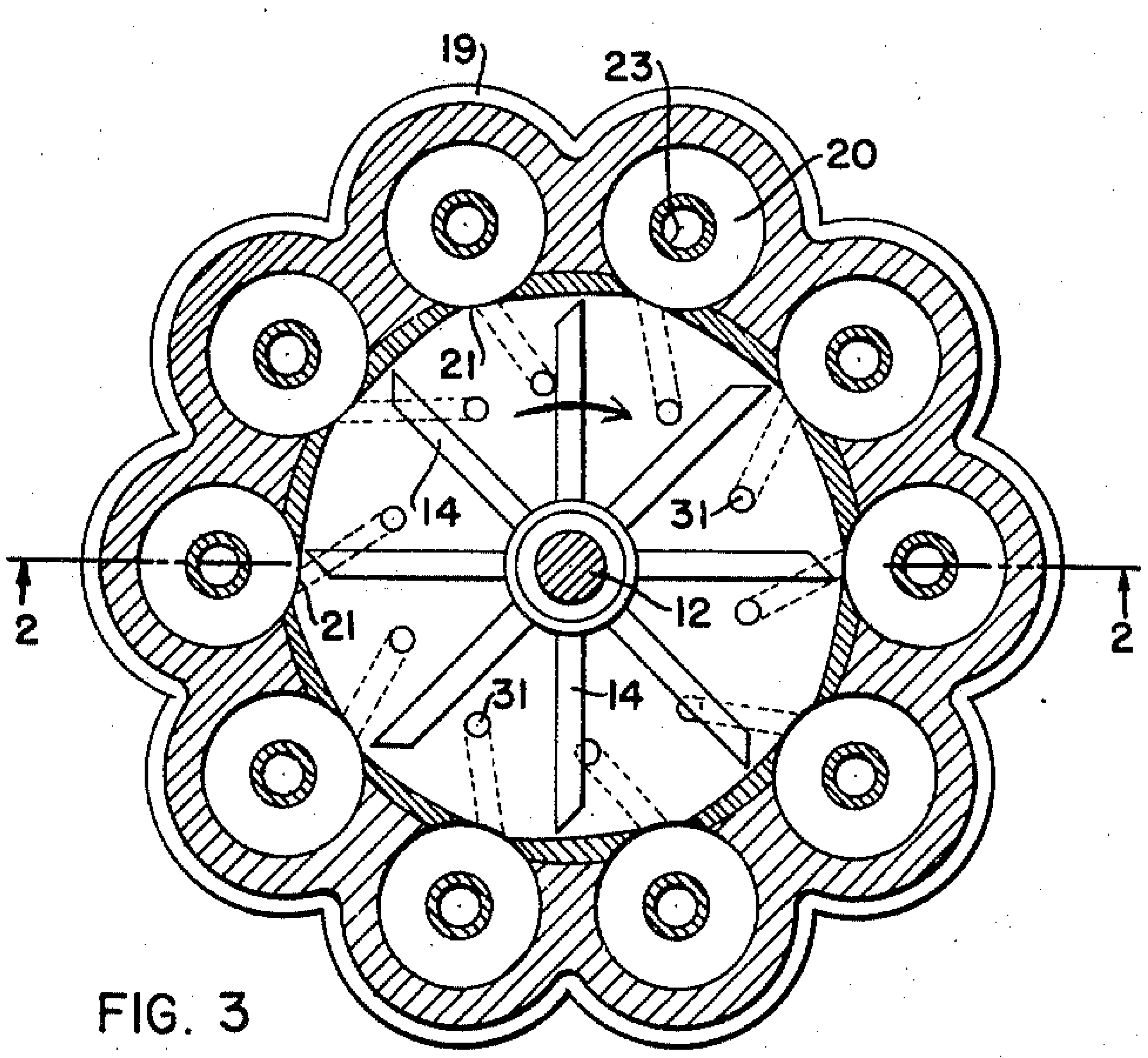

FIG. 3

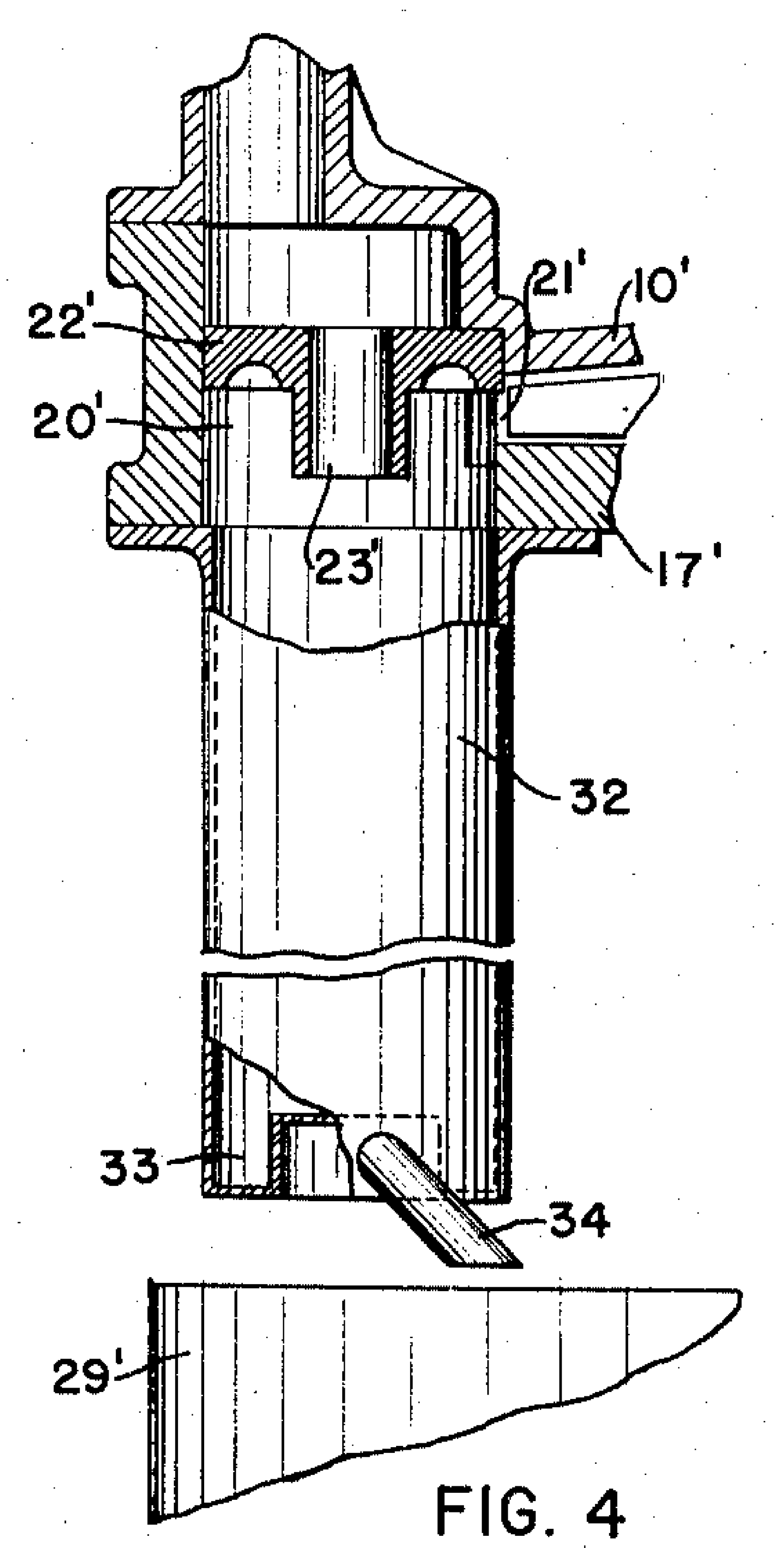

FIG. 4

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METHOD AND APPARATUS FOR SEPARATING SLURRY AND LIKE SUSPENSIONS

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6 Claims. (Cl. 209—211)

This invention relates to the separation of slurry and like suspensions into fractions containing fine and coarse particles and is concerned more particularly with a novel apparatus, by which such separating operations can be performed at a rapid rate and with a lower power cost than heretofore. The invention also includes a method, by the use of which a sharp separation may be obtained without heavy wear on the equipment and high power consumption.

In the separation of suspensions, such as the slurry produced in the manufacture of Portland cement, into fine and coarse particle fractions, it has been common practice to use separating chambers of circular cross-section having a tangential inlet opening and outlets for the two fractions at opposite ends. One such separating chamber is a hydrocyclone, which has a casing of inverted frustoconical shape with the inlet near its upper end. When the slurry is fed into the hydrocyclone casing through the inlet, the heavier particles move toward the casing wall under centrifugal action and travel downward on the wall along helical paths to the bottom discharge opening, while the lighter particles are forced toward the axis of the casing and then upward to the top discharge opening. In order to create a sufficiently powerful centrifugal action, the dimensions of a hydrocyclone must be rather small, so that the capacity is limited and, when large amounts of slurry have to be treated, it is often necessary to use a large number of such hydrocyclonss working in parallel.

In a hydrocyclone installation, a centrifugal pump is connected to the inlet opening of the casing and the velocity of the slurry flowing to the pump is converted in the pump into pressure and the pressure is converted back into velocity in the inlet opening. This double conversion of one form of energy into another involves considerable frictional loss and is an objectionable feature of a hydrocyclone. The double conversion mentioned is avoided in another form of hydrocyclone called a centriclone, in which a rotary impeller in the form of a vane wheel is mounted in the casing and imparts the desired velocity to the slurry immediately after it has entered the casing. However, if it is necessary to use a number of such centriclones in parallel in order to obtain necessary capacity, the drives for the individual impellers in the casings are complicated and expensive both to install and to operate.

The apparatus of the invention is superior to those heretofore used in that it provides the desired relatively high output rate with a lower power cost. The apparatus includes a plurality of separating chambers arranged in a circular series and a single means for introducing the suspension to be separated into the chambers through tangential inlets. The chambers are mounted with their axes parallel and the chambers may be of the hydrocyclone type with frustconical lower ends, or they may be substantially cylindrical. In either case, the suspension is introduced into the chambers by an impeller of vane wheel form, which rotates in a plane through the cham-

ber inlets and to which the suspension is fed at its axis. in its rotation, the impeller introduces the suspension into the chambers at high velocity and the coarse particle fraction leaves each chamber at the lower end, while the fine particle fraction issues at the top.

The sharpness of separation between two fractions of slurry leaving a separating chamber varies directly with the time taken by the slurry in passing through the chamber. With a chamber of the small dimensions necessary to obtain the desired centrifugal action, a long period of travel of the slurry through the chamber requires that the chamber have a small inlet and that the slurry have a high feed velocity. Under such conditions, the resistance to flow of slurry is high both in the inlet and within the chamber, particularly with thick slurry and, as a result, the apparatus is subjected to heavy wear and the power consumption is high.

The practice of the method of the invention makes possible a sharp separation of slurry and like suspensions without the objectionable features mentioned and the method involves proportioning the rate, at which the slurry is fed into a separating chamber, the velocity of flow, and the size of the inlet opening of the chamber, so that the slurry is continually fed into the chamber at a rate greater than the chamber can handle and the excess amount is continually withdrawn from the chamber shortly after it enters the chamber. The excess slurry so withdrawn is combined with the slurry being fed into the chamber. As a result of this action, a high inlet velocity is obtained without the necessity of employing an inlet passage of reduced size, so that wear and power consumption are reduced. After removal of the excess slurry, the remaining slurry undergoing separation has a high velocity, so that its travel through the separating chamber is such as to afford the desired sharpness of separation.

For a better understanding of the invention, reference may be made to the accompanying drawing, in which

Fig. 1 is a view in elevation with parts broken away of one form of the new apparatus suitable for the practice of the new method;

Fig. 2 is a sectional view on the line 2—2 of Fig. 3;

Fig. 3 is a sectional view on the line 3—3 of Fig. 1; and

Fig. 4 is a view similar to Fig. 2 showing a modified construction.

The separating apparatus shown in Figs. 1–3, incl., comprises a casing **10** having a central opening through its top encircled by a hub **11** enclosing a shaft **12** mounted for rotation in suitable bearings and carrying at its lower end within the casing an impeller in the form of a vane wheel made up of a hub **13** and a plurality of radial blades **14**. The shaft may be driven in any suitable way as, for example, by belts **15** encircling pulleys **16** at the upper end of the shaft. The bottom wall **17** of the casing has a central opening, through which slurry is introduced at the axis of the impeller through a pipe **18** connected to the bottom of the casing around the opening.

The casing has a hollow peripheral section **19** subdivided to form a plurality of cavities **20** equiangularly spaced about the casing. Each cavity or chamber has a cylindrical upper section and an opening **21** lying in the plane of rotation of the impeller serves to connect the upper section of each chamber to the interior of the casing and acts as a peripheral outlet opening from the casing and a tangential inlet into the upper section of the chamber. An outlet plate **22** is mounted in the upper section of each chamber above the opening and is provided with an axial outlet tube **23**, which extends downwardly into the chamber and terminates below the level of the inlet **21**. The upper section of each chamber has an outlet opening through its upper end lying offset from the axial outlet tube of the plate in the chamber and a fine particle fraction outlet passage **24** leads upwardly at an angle to the vertical from the top outlet opening from the upper section of each chamber to a circular duct **25**, which overlies all of the passages **24** and has a common discharge outlet **26**.

The upper section of each chamber or cavity **20** acts as a separating chamber which, in the construction shown in Figs. 1–3, incl., includes a frusto-conical discharge section **27** connected to the bottom of the casing **10** in line with the upper section of the cavity. Each of the sections **27** has a bottom outlet **28** discharging into a circular duct **29** having an outlet **30**.

When the apparatus is to be used in the practice of the method, a discharge passage **31** formed in the bottom **17** of casing **10** leads upwardly from a tangential outlet opening in the upper section of each cavity **20** below the inlet **21** into that cavity. Each passage opens at its other end into the casing to discharge slurry into the path of the impeller at a place where the velocity of the slurry in the casing is substantially the same as the velocity of the slurry travelling through the passage.

In the operation of the apparatus, the slurry entering casing **10** through pipe **18** is fed tangentially into the separating chambers at high velocity by the action of the vane wheel impeller. In accordance with the method, the slurry is supplied to the casing at such a rate that more slurry is fed into each chamber than the chamber is capable of handling. The slurry, accordingly, enters each chamber at high velocity and, shortly after the entrance of the slurry, the excess quantity thereof is removed through the tangential outlet and the discharge passage **31** and returned to the casing. The remaining slurry then travels at high velocity and along a helical path of low pitch through the sections **27** of the chamber. The coarse particle fraction is discharged through outlets **28** into the common duct **29**, while the fine particle fraction escapes through the outlet tubes **23** and outlet passages **24** into the common duct **25**.

The slurry enters each chamber **20** through a tangential inlet from the main casing and thus travels rotationally in a counterclockwise direction in the chambers with the coarse fractions moving down and the fine fractions moving up through the axial passages **23** through plates **22**. The rotational movement will continue in the fine fractions as they travel through the outlet passages **23** into the upper sections of the chambers above the plates **22**. In the spaces directly above the plates **22**, the rotational movement of the fine fractions continues and the fine fractions travel upwardly through pipes **24** into the duct **25** against the pressure of the fluid in the duct. As the fractions enter the space above the plates **22** they move outwardly to the peripheries of the spaces, while still maintaining their rotational movement. With the passages **24** leading from the spaces near their peripheries, the fluid can enter the passages **24** more easily than would be the case if the passages **24** were vertically aligned with the axial passages **23**. In each of the passages **24**, the rotational energy of the fluid is transformed into pressure energy, which helps to overcome the back pressure of the fluid in the duct **25**. By making it easy for the fluid to leave the spaces above the plates **22** and enter the passages **24**, there is little energy lost in friction and most of the energy of the rotational movement is transformed into pressure energy serving the purpose indicated above.

The inclining of the passages **24** at the proper angle to the vertical in relation to the rotational movement of the fine fractions through the chambers above the outlet plates further facilitates the transfer of the fine fractions from the chambers **20** to the duct **25** with little energy loss since it causes the fine fractions to flow from the chambers into the passages without abrupt changes in direction, which would result in a loss of energy as well as wear on the walls of the passages.

In the construction illustrated, each separating chamber has a section **27** of inverted frusto-conical form, but it is not necessary that the section be of such form. In the modified construction illustrated in Fig. 4, the separator chamber section **32** is cylindrical and it is attached to the bottom **17'** of the casing **10'** in alignment with a cavity **20'** having a tangential inlet **21'** and a top **22'** having an outlet passage **23'**. In order to reduce the pressure, at which the coarse particle fraction leaves section **32**, the lower end of the section is provided with an annular trough **33** and an outlet pipe **34** for the coarse particle fraction leads from an opening through the outer wall of the trough in a direction opposite to the direction of flow within the section and discharges the fraction into a duct **29'**.

In one form of separating apparatus constructed and operating in accordance with the invention, the greatest diameter of each separating chamber was in the plane of the impeller wheel and was 125 mm. The diameter of the impeller wheel was 400 mm. and the wheel was operated at 900 R. P. M. Such an apparatus having 10 separating chambers had a capacity of about 100 cubic meters of slurry per hour.

I claim:

1. An apparatus for separating slurry and like suspensions into fractions containing coarse and fine particles which comprises a casing of circular section having a plurality of outlet openings through its peripheral wall in spaced relation, an impeller mounted within the casing for rotation on the axis of the casing, a plurality of separating chambers disposed about the casing with their axes parallel to that of the casing, the chambers having cylindrical upper sections with tangential inlets connected to respective outlet openings of the casing, an outlet plate in the upper section of each chamber below the top of the section and above the tangential inlet, an axial outlet for a fine particle fraction through each outlet plate, an outlet for a coarse particle fraction at the lower end of each chamber, a circular duct overlying the chambers, each chamber having an outlet opening through the upper end of its upper section out of alignment with the axial outlet through the plate in said upper section, a pipe leading from the outlet opening of each chamber at an angle to the vertical to the bottom of the circular duct, means for rotating the impeller, and means for feeding the suspension to be separated to the impeller at its axis of rotation.

2. An apparatus for separating slurry and like suspensions into fractions containing fine and coarse particles which comprises a separating chamber having a tangential inlet and outlets for fine and coarse fractions at opposite ends, means for feeding the suspension at high velocity into the chamber through the tangential inlet, and means, including a tangential outlet from the chamber adjacent to and beyond the tangential inlet, for continuously withdrawing suspension from the chamber and combining the suspension withdrawn with that being fed.

3. A method of separating slurry and like suspensions into fractions containing fine and coarse particles in a separating chamber of circular cross-section having a tangential inlet and outlets at its ends for the fractions, which comprises feeding the suspension into the chamber through the inlet at a rate greater than can be separated in the chamber and continuously withdrawing the excess suspension from the chamber adjacent the inlet and combining the suspension withdrawn with that being fed.

4. The method of claim 3, in which the suspension withdrawn is combined with the suspension being fed at a place where the velocities of the suspensions are substantially the same.

5. An apparatus for separating slurry and like suspensions into fractions containing coarse and fine particles which comprises a casing of circular section having a plurality of outlet openings through its peripheral wall in spaced relation, an impeller mounted within the casing for rotation on the casing axis, a plurality of separating chambers disposed about the casing with their axes parallel to the casing axis, the chambers having tangential in-

lets connected to respective outlet openings of the casing and outlets for fine and coarse particle fractions at their opposite ends, means for rotating the impeller, means for feeding the suspension to be separated to the impeller at its axis of rotation, a small tangential outlet from each chamber below the level of the inlet, and a passage leading from the small outlet into the interior of the casing between the axis and the periphery of the impeller.

6. An apparatus for separating slurry and like suspensions into fractions containing coarse and fine particles which comprises a casing of circular section having a plurality of outlet openings through its peripheral wall in spaced relation, an impeller mounted within the casing for rotation on the casing axis, a plurality of separating chambers disposed about the casing with their axes parallel to the casing axis, the chambers being cylindrical and

having tangential inlets, axial fine fraction outlets at their upper ends, and tangential coarse fraction outlets at their lower ends, means for rotating the impeller, and means for feeding the suspension to be separated to the impeller at its axis of rotation.

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