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N. E. SVENSJÖ
PROCESS FOR THE CENTRIFUGAL SEPARATION
OF SLUDGE CONTAINING LIQUIDS

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Filed April 13, 1946

2 Sheets-Sheet 1

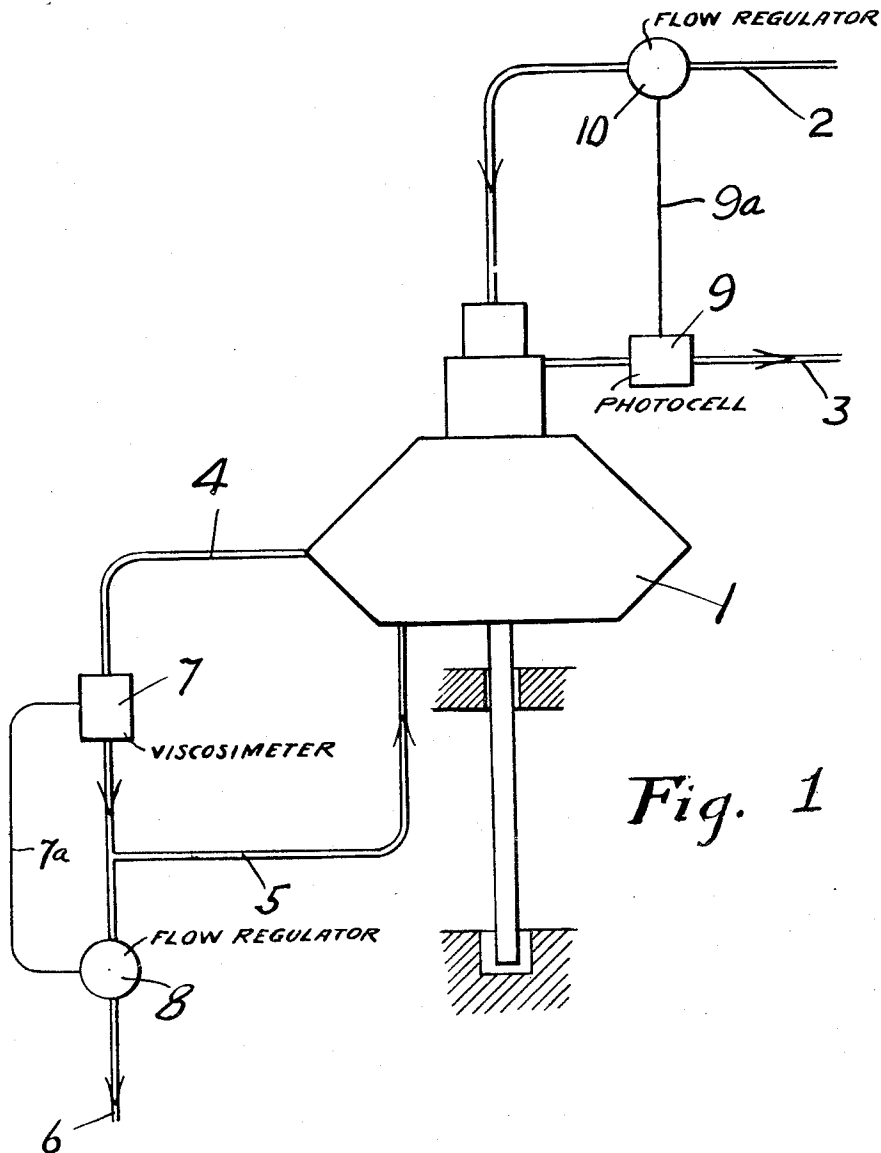


Fig. 1

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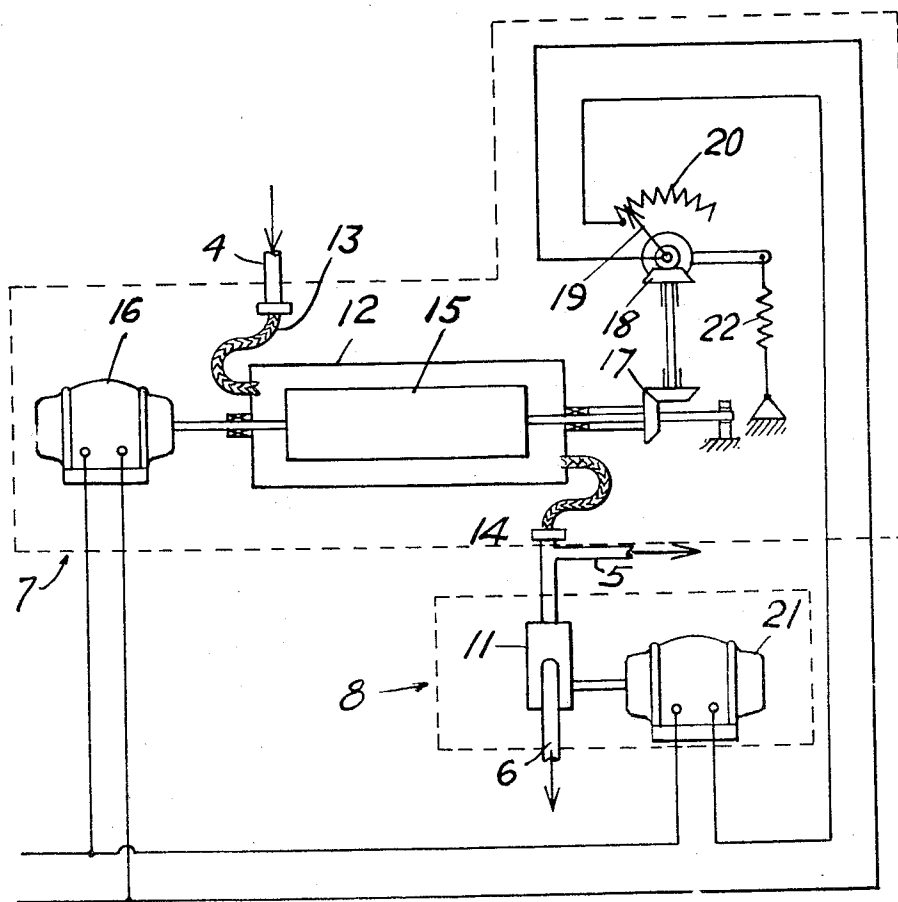


FIG. 2.

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PROCESS FOR THE CENTRIFUGAL SEPARATION OF SLUDGE-CONTAINING LIQUIDS

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2 Claims. (Cl. 233-14)

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This invention relates to a process for the centrifugal purification of sludge-containing liquids. The invention is particularly applicable to the removal of solid particles from a liquid in which they are in suspension, by means of a centrifugal separator of the type in which the bowl is provided at its periphery with outlet-openings through which the solid particles leave the bowl together with a certain quantity of carrier liquid.

The sludge-discharge openings should be large enough to allow solid particles to freely pass therethrough. However, if the content of solid particles is small, a concentrate very poor in sludge is discharged through the openings. This is usually undesirable, as, for example, if the liquid in the concentrate must be removed later on by evaporation.

To avoid this excessive discharge of carrier liquid with the sludge, it has been proposed to return varying amounts of the concentrate into the bowl, whereby is obtained an arbitrary increase in the sludge content of the concentrate in the bowl. However, the concentration must not be too high, since this causes the openings in the bowl to become clogged.

In practice it has been necessary to work at rather low concentrations, it being difficult to judge at what sludge-content of the concentrate clogging takes place. As the sludge-content of the unseparated liquid often varies considerably and as a discharge opening or several of the discharge openings may be clogged by separate large particles which have entered the bowl, the maintenance of a desirable sludge content in the separator is difficult. In practice it has been found necessary to work well below the maximum capacity of the separator.

I have found that a too high sludge content of the concentrate is not the sole cause of the clogging. The size and form of the particles are also contributory clogging factors.

I have found that viscosity is the determining factor influencing the danger of clogging. Viscosity is dependent on many factors, such as the sludge content, the temperature of the liquid to be separated and the size and form of the particles. By determining the viscosity of the sludge-containing concentrate, discharged from the bowl, and by regulating, in accordance with such viscosity determination, either the percentage of the discharged sludge-containing concentrate returned to the bowl, or, less preferably, the rate of feed of the mixture fed to the bowl, the viscosity of the concentrate may be maintained substantially constant.

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The accompanying drawing shows an arrangement in which the above-mentioned method of regulation is employed. Fig. 1 shows diagrammatically the whole installation, whilst Fig. 2 is a detailed illustration of one form of the regulating device. In the drawing, 1 designates the centrifugal separator bowl or locus of centrifugal force, 2 the feedpipe for the mixture to be separated, 3 the discharge pipe for the separated liquid free from sludge and 4 the discharge pipe for the separated sludge-containing concentrate. Part of the concentrate is fed back to the bowl through the pipe 5 to increase the viscosity of the concentrate in the bowl. The remaining concentrate leaves the system via the outlet pipe 6.

According to the invention, the viscosity of the sludge concentrate discharged through pipe 4 is determined, and the quantity of concentrate led back to the bowl through pipe 5 is varied in accordance with any departure of the determined viscosity from a desired viscosity. That is, if said determined viscosity is above standard, the percentage of the discharged concentrate that is returned to the bowl is reduced. If said determined viscosity is below standard, the percentage of the discharged concentrate that is returned to the bowl is increased. The effect is to maintain the viscosity of the discharged concentrate at a substantially constant value.

The drawing discloses means whereby the above described operation may be effected automatically. Interposed in the pipe 4 is a continuous flow viscosimeter 7, which operates through a connection 7a to control a quantity-regulating device 8 in the pipe 6. If, for instance, the viscosity as measured by the viscosimeter rises above a predetermined value, the device 8 is actuated from the viscosimeter to increase the liquid flow through the pipe 6 and so to reduce the flow through the pipe 5 until the viscosity is reduced to the desired value. The predetermined viscosity should be as high as is possible consistent with avoidance of clogging of the sludge discharge openings.

The quantity of sludge in the concentrate may vary and also the temperature and the form and size of the particles, but the concentrate should always have as high a content of solid particles as is consistent with the maintenance of a free discharge from the bowl.

It is important that the quantity-regulating device 8 should control the liquid-flow through the pipe 6. If one of the openings in the bowl should get clogged by a large particle, thus reducing the total flow through the pipe 4, the re-

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turn-flow through the pipe 5 will be reduced immediately, whereby a temporary increase of the concentration in the bowl is prevented. The quantity regulator 8 is so designed that its capacity is not influenced in a substantial degree by the quantity of liquid flowing out through the openings per unit of time. It may comprise, for example, as shown in Fig. 2, a gear-pump 11, or other type of pump, whose speed is regulated by the viscosimeter 7. Such a viscosimeter may consist of a rotatably supported drum 12, connected to the pipe 4 by a flexible inlet 13 and a flexible outlet 14. Thus the concentrate discharged from the separator 1 flows through the drum. In the drum there is enclosed a rotatable element 15, which is driven at a constant speed by an electric motor 16. The rotary motion of the drum 12 is, by means of two gears 17 and 18, transmitted to the movable contact-arm 19 of a variable rheostat. A small or great part of the resistance 20 of the rheostat can be switched in the circuit of an electric motor 21, which drives the pump 11. A spring 22 tends to maintain a certain part of the resistance 20 in the circuit. The torsion moment transmitted from the rotating element 15 to the drum 12 by the intermediary of the flowing concentrate, counteracts this tendency of the spring.

The concentrate flowing through the drum 12 will transmit a torsion moment to the drum from the constant speed rotating element 15, the magnitude of the transmitted torsion moment depending upon the viscosity of the concentrate in the drum. Thus, when the viscosity increases, a greater torsion moment will be transmitted to the drum 12 so that the latter, operating through the gearing 17-18, will act against the spring 22 and cut out additional resistance 20 of the rheostat. As a result, the motor 21 will drive pump 11 at a higher speed and thereby reduce the rate of flow of concentrate through the return pipe 5 to the centrifuge. Conversely, when the viscosity of the concentrate decreases, the torsion moment transmitted from rotating element 15 to the drum 12 will decrease and allow the spring 22 to cut in additional resistance 20 of the rheostat. The speed of the pump 11 will then decrease and cause an increase in the rate of flow of concentrate through return line 5 to the centrifuge.

The viscosimeter may be made to control a quantity-regulating device in the pipe 2, but this arrangement is not as desirable as the control of the flow from pipe 6, since the separator would not then operate at its highest separating capacity.

An arrangement according to the above may comprise a photocell 9, in the purified liquid discharge pipe 3, controlling a quantity-regulating device 10 in the feed-pipe 2 in such a way that the feed to the separator is so regulated that a predetermined degree of purity in the liquid is insured. The separator may be operated at capacity and at the same time badly separated liquid is prevented from passing from the system if some opening in the bowl is clogged.

The photocell 9, of course, will respond to changes in the light transmitting ability of the purified liquid discharging through pipe 3, and operates through a suitable connection 9a to control the flow regulator 10, so that the rate of feed through pipe 2 is reduced when the content of sludge particles in the purified liquid (pipe 3) increases, and vice versa. It will be apparent that if, at a given throughput rate for the separator, the viscosity of the sludge becomes too

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high, the limit of the separating ability of the separator may be exceeded, whereby part of the sludge from the separator will accompany the liquid component flowing through discharge pipe 3. Accordingly, under this condition, not only will the viscosity of the outflowing sludge in pipe 4 increase, but also the light transmitting ability of the liquid component (pipe 3) will decrease, as "seen" by photocell 9, due to such intermixing of sludge with the liquid component. The arrangement of the photocell and flow regulator 10 is illustrated only schematically, as such arrangements per se are well known in the art. As an example of a conventional arrangement, the pipe 3 may have a transparent section located between a light source and the photo-sensitive element, so that the light must pass through the transparent section (and the liquid flowing in it) to reach the photo-sensitive element. The electric current changes in the latter, which are generally amplified, may be used to actuate a servomotor operating through connection 9a to control the flow regulator 10, which may be a valve or a variable speed pump.

A method such as described will separate a concentrate with a varying sludge content, which, however, is at all moments as high in sludge content as possible when either the separator is operating with a free flow through the bowl or is partially clogged. A partial clogging of the discharge effects only a reduction of the capacity, but does not increase the viscosity of the concentrate or involve any deterioration in quality of the separated liquid. Alternatively, the feed need not normally be as low as when the risk of a partial clogging has to be considered.

What I claim and desire to protect by Letters Patent is:

1. In an apparatus for continuously purifying a sludge-containing liquid, comprising a centrifuge having a separating chamber with an outlet for discharging liquid bearing a concentration of separated sludge and also having an outlet for discharging the purified separated liquid, a discharge pipe connected to said first outlet, and a return pipe leading from said first pipe for returning to the centrifuge part of said liquid bearing the sludge concentrate, the combination of a viscosimeter connected to the discharge pipe at a location between said first outlet and said return pipe, flow regulating means in the discharge pipe and located beyond the return pipe with respect to said first outlet, and an operative connection between the viscosimeter and said regulating means for operating the regulating means in accordance with variations in the indications of the viscosimeter, whereby the rate of return of sludge concentrate to the centrifuge is varied.

2. In the process of separating solids from a mixture of solids and liquid, by continuously feeding the mixture into a locus of centrifugal force to separate the same into a purified liquid and a sludge-containing concentrate, continuously discharging said separated liquid and concentrate from the locus in separate streams, and continuously withdrawing from the concentrate discharge stream a part of the concentrate and returning said part to the locus, the improvement which comprises controlling from a region beyond the point of said withdrawal, reckoned in the direction of flow, the rate of flow of the concentrate discharge stream to regulate the rate of said return of the concentrate discharge, by increasing the rate of flow at said region in re-

sponse to an increase in the viscosity of the concentrate discharge, and decreasing the rate of flow at said region in response to a decrease in the viscosity of the concentrate discharge, whereby the viscosity of the concentrate discharge is maintained approximately constant, and in which said changes in the rate of flow at said region of the concentrate discharge stream are effected in response to variations in the viscosity as determined at a part of said last stream between said locus and the point of withdrawal of the return concentrate.

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