March 10, 1959 C. L. CLARK ET AL 2,876,860

DE-AERATING HYDROCYCLONES

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FIG. 1.

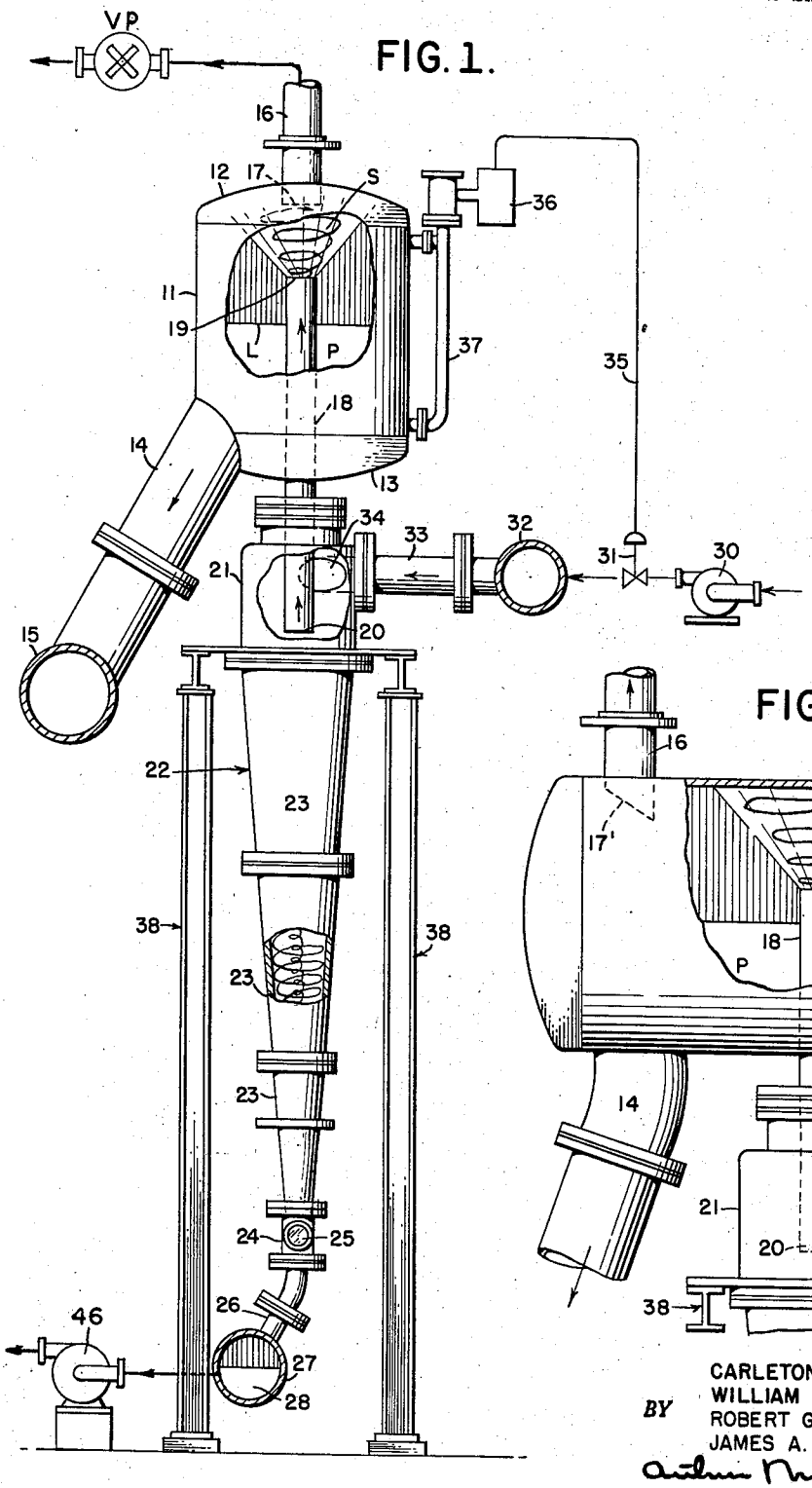


FIG. 2.

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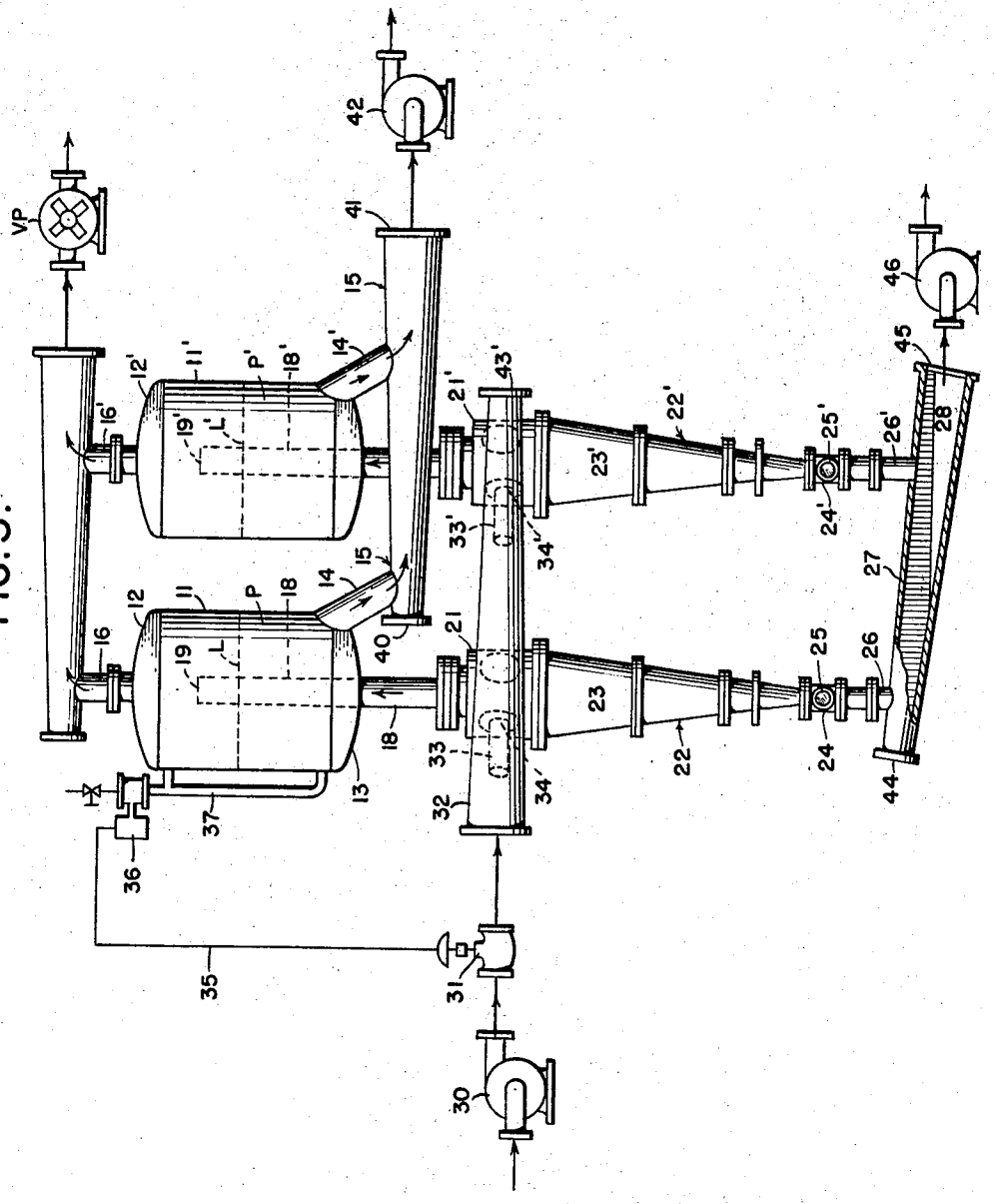
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FIG. 3.



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DE-AERATING HYDROCYCLONES

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3 Claims. (Cl. 183—2.5)

This invention relates to the simultaneous de-dirting and de-aeration of liquid stock that contains some acceptable and some rejectable solids in suspension in the liquid with a view to obtaining a de-aerated acceptable dirt-poor fraction of the treated liquid suspension and a non-de-aerated rejectable dirt-rich fraction of the liquid suspension. More particularly, the invention is directed to the use of a hydrocyclone having in combination therewith a vacuum-influenced chamber into which the acceptable dirt-poor fraction is delivered while the dirt-rich fraction is rejected from entry into the chamber. A hydrocyclone normally has, when in operation, a hard central core of air extending axially therethrough, but since the acceptable dirt-poor fraction from the hydrocyclone is to be de-aerated, it is essential that formation of this air core be obviated. In de-aerating liquid in a vacuum-influenced chamber, it is essential that the liquid be atomized into mist-like droplets to enable the vacuum effect in the chamber to do its proper de-aeration. So it is an object of this invention to combine in a relatively simple unitary apparatus that can be used either alone or in multiple, an air-coreless cleaner-type hydrocyclone carrying as a part thereof a vacuum-influenced chamber on its base-outlet end under conditions whereby the dirt-poor fraction of the liquid issuing from the base outlet end of the hydrocyclone will be atomizingly delivered into the de-aerating chamber thereabove.

Since a de-aerating chamber of this general type has in it a pond of de-aerated liquid from which treated liquid is continually withdrawn, it is another object of this invention to devise means whereby the fraction discharged through the base outlet of the hydrocyclone can rise protectedly through the pond to be delivered expulsively and impingingly against the inside of the shell of the chamber, for thus atomizing the discharged dirt-poor liquid as it enters the chamber. Since the expulsive spraying of the dirt-poor base outlet discharge from the hydrocyclone into the vacuum-influenced chamber atop thereof is so important, it has been found that this effect is diminished unless the apex outlet discharge is emitted in air-excluding non-submergence. Another way of saying this is that there must be a free discharge of the dirt-rich discharge from the apex outlet whereupon it can be collected and conveyed away under air-excluding conditions. So another object of this invention is to devise means for accomplishing this not only on one hydrocyclone, but more particularly when several of the unitary hydrocyclones each having atop thereof its own vacuum-influenced chamber, are used in multiple or parallel.

Indeed, when it is attempted to use a multiple of these cleaner-de-aerator units in parallel, several problems are encountered, of which one is how to regulate by a single control, the liquid-level of the pond in each chamber to be the same.

These objects, and others that will appear hereinafter, can be realized by unitary apparatus usable alone or in multiple provided with a substantially airless fractionating

hydrocyclone having a base outlet and an apex outlet with means for receiving liquid from the apex outlet as free discharge and then conveying it under air-excluding conditions while there is a vacuum-influenced chamber atop the hydrocyclone adapted to hold a pond of de-aerated liquid up through which pond an open-ended pipe extends from the base outlet. Conduit means are provided for conducting liquid from the pond under air-excluding conditions, and pump means are provided for supplying a liquid suspension to be treated into the hydrocyclone tangentially with sufficient force to project therefrom one dirt-rich fraction through the apex outlet and one dirt-poor fraction through the base outlet to project the dirt-poor fraction expulsively as a cone-shaped spray upwardly against the shell of the chamber thereby to atomize it for its ready de-aeration in the chamber atop the hydrocyclone. If and when a plurality of such unitary chamber-bearing hydrocyclones are used in series, certain additional requirements present themselves, namely, one manifold common to the chambers for conducting liquid therefrom; another common to the chambers for applying the effect of vacuum thereto; still another common to the intakes of the hydrocyclones for supplying liquid thereto; and another common to the apex outlets of the hydrocyclones for conveying dirt-rich liquid therefrom under conditions whereby the liquid-level therein is controlled to provide a space in the manifold whereby the apex outlet liquid has free discharge unsubmergedly into that space. And there are constructional details that are advantageous as will appear hereinafter.

The invention is illustrated in the accompanying drawings wherein Figure 1 shows a vertical elevation of one composite unit with parts broken away. Fig. 2 is a partial view like Fig. 1 of a modification. Fig. 3 is a side elevational view of the unit of Fig. 1 used in multiple in parallel with appropriate hook-ups common to the repetitive units.

In the drawings, **11** indicates an enclosed tank chamber, or receiver of liquid to be de-aerated, having a top **12** and a bottom **13**, with a liquid-discharge pipe **14** leading from the bottom section of the receiver **11** to a manifold **15** for conveying the treated liquid to use. **16** indicates a pipe entering the top **12** of the receiver **11** leading to a vacuum-producer and terminating at **17** well above the liquid-level L in the receiver. **18** indicates a pipe entering the bottom **12** of the receiver **11** to terminate at **19** well above the liquid-level L in the receiver, to which elevation it rises from its entrance end **20** lying within the upper base section **21** of a hydrocyclone **22** having a coned body **23** with an apex section **24**, provided with a sight-glass **25**, and terminating in a bent apex-discharge section **26**, that enters a discharge manifold **27** of such a size and shape that it is never filled with discharged liquid **28**, or rather that the exit end of the discharge section **26** is never submerged. Liquid is fed to the hydrocyclone **22**, by means of a pump **30**, whose discharge is controlled by an automatic valve **31**, to enter manifold **32** leading to a feed pipe **33**, entering the base section **21** of the hydrocyclone in a tangential manner at **34**. Control valve **31** is controlled by means of an electrical or pneumatic system **35** having a suitable controller **36** operated by a liquid-level sensing arrangement **37** by the operation of which the liquid-level L in the receiver **11** is maintained substantially constant. The apparatus may be supported from the floor by a stand or framework **38**.

Fig. 2 shows a slight modification by the use of which the pipe **16** leading to the vacuum producer is non-aligned with the pipe **18** so that the spray S emitted from the top of the pipe **18** does not enter the pipe **16**, and this

may be further accomplished by having the pipe 16 terminate at an angle such as shown at 17'.

In Fig. 3 there is shown how two or more such composite units of Fig. 1, each having a combined receiver and a hydrocyclone can be hooked together with common connector elements. The second unit has been given primed numerals to show duplicated parts except that both vacuum-suction pipes 16 and 16' lead to a manifold or header 29 connected with a vacuum-producer VP. The manifold is preferably tapered or trumpet-shaped as shown. Both receivers discharge into a single manifold 15 that is trumpet-shaped or tapered in shape and closed at one end 40, while the other end 41 leads to a pump 42. Both hydrocyclones 22 and 22' are fed from a single manifold 32 also trumpet-shaped or tapered and closed at one end 43, while its larger end receives liquid from pump 30 controlled by automatic valve 31. Only one liquid-level control system 35, 36 and 37 is needed, because if the liquid-level L is controlled in one receiver 11, the liquid-level L' in the other receiver will automatically be the same, as a result of operation of gravity.

The discharge outlets 26 and 26' from both hydrocyclones 22 and 22', respectively, enter the trumpet shaped or tapered manifold 27, having a closed end 44 and whose other end 45 is connected to pump 46. The purpose of the hydrocyclones is to de-dirt or clean the liquid fed thereto, so the dirt-rich fraction, usually called rejects, is discharged through the apex outlets into the manifold 27, while the dirt-poor fraction, usually called accepts, is discharged upwardly through the base pipes 18 and 18' by being expulsively sprayed into the receivers 11 and 11' above the liquid-level therein. Here the accepts, or dirt-poor fraction, is subjected to the de-aerating effect of vacuum or the subatmospheric pressure in the receivers effected therein by the common vacuum producer VP. Cleaned and de-aerated liquid flows from the ponds P and P' thereof in the respective receivers, into the manifold 15 from whence it is conveyed to use by the pump 42. It is to be noted from Fig. 1 that the manifold 27 is off-center or non-aligned vertically with the axis of the hydrocyclone 22, and indeed, it and its pipe 26 lie in a plane about 30° from the vertical. This is for making possible easier assembly and disassembly.

Looking at Fig. 1, for simplicity, the liquid stock to be cleaned and de-aerated is forced by pump 30 tangentially into the base end section 21 of hydrocyclone 22, with sufficient force to swirl by centrifugal action, the liquid into a descending spiralizing outer fraction and an uprising spiralizing inner fraction. The outer fraction collects to itself the dirt of the liquid and is emitted through the apex discharge 26 as a dirt-rich fraction. This fraction should best be emitted from pipe 26 in non-submergence so that it will be emitted in the form of a spray. To that end, the dirt-rich receiving manifold 27 must not be full of liquid 28, and this is accomplished by the trumpet- or tapered-shape of that manifold, as can be seen more clearly in Fig. 3. The sight-glass bearing apex section 24 also serves to some extent as an expansion chamber and the main purpose of the sight-glass is to enable the operator to be sure the dirt-rich fraction is being sprayingly discharged. The liquid 28 in the manifold 27 must be maintained under air-excluding conditions for otherwise air will be sucked back into the center of the hydrocyclone—something that is to be avoided. To this end liquid 28 is sucked from the manifold 27 by means of air-excluding pump 46 from which the liquid goes to discard or to re-treatment in hydrocyclones.

The upwardly spiralizing dirt-poor fraction is emitted upwardly through the base end 21 of the hydrocyclone through pipe 18, sometimes called a vortex-finder, to be sprayed from its upper terminal 19, above the liquid-level of the pond P, of de-aerated liquid in the receiver 11. It is so sprayed expulsively with sufficient force impingingly against the top 12 of the receiver as to be broken down or atomized into droplets so small as to comprise a mist thereof. This facilitates the de-aeration thereof by the sub-atmospheric pressure in the receiver effected therein by the vacuum producer. These mist-like particles rain down as cleaned an de-aerated liquid and collect as a pond P thereof, whose liquid-level is carefully maintained constant. The cleaned and de-aerated liquid is then flowed from the pond thereof in the receiver through pipe 14 and manifold 15 by means of pump 42, under air-excluding conditions, to be delivered to the place of its use. Since the liquid is to be de-aerated in the receiver 11, and since normal or usual operation of a hydrocyclone tends significantly to suck air into its liquid being cleaned, careful effort must be made to keep air from coming into it through the apex discharge liquid and through the base discharge liquid, so both of these must be maintained under air-excluding conditions. More particularly, one of these discharges must be maintained under the effect of vacuum in order to apply vacuum-induced suction to the axially disposed core-shaped space in the hydrocyclone while under air-excluding conditions, for the purpose of pullingly extracting non-condensable gases into that space from the surrounding swirling liquid fractions and air-excludingly conducting such extracted gases along with the discharging liquid fraction to the de-aerating receiver where such gases and air in the liquid fraction are removed therefrom to discard by means of the vacuum producer.

In general, the greater degree of vacuum used in the receiver, the greater the extent of de-aeration, but there is a limit in that the liquid being de-aerated must not boil as a result of high vacuum. That is, the volume of the receiver must be so correlated to the rate of flow-through of the liquid being de-aerated and the degree of vacuum used is such that it is just slightly less than enough to make the liquid in the receiver boil at the somewhat elevated so-called mill temperature at which it may be. Normally, the vacuum system is designed and operated to keep the partial air-pressure down to about 0.3 inch of mercury absolute. Another way of saying this is that the size of the vacuum system used is more than adequate to maintain an approximate boiling point saturation pressure on the liquid being de-aerated. Embodiments of this invention can be used in a number of industries, especially those wherein solids suspended in liquid are to be both cleaned and de-aerated, and more particularly where some of the solids are to be rejected while others are to be retained. And since the spinning force on the liquid in each of the hydrocyclones used is many times that of gravity, they can be used in inverted position or even in a horizontal position.

It can thus be seen that we have devised a single type of unit apparatus that combines the function of cleaning a liquid stock and of de-aerating it. The unit lends itself to off-the-shelf selling rather than the tailor-made designing of an installation to meet all the requirements of each job. This is doubly so because the unit can be used in parallel, although this involves some new type of connections and accessories, which, if anything, add to the effective functioning of the parallel units.

We claim:

1. Apparatus for the de-dirting and de-aeration of a liquid suspension having some rejectable and some acceptable solids, which comprises a hydrocyclone having a base outlet and an apex outlet, an open-ended pipe rising from the base outlet, a chamber atop the hydrocyclone adapted to hold a pond of liquid into which chamber the pipe extends upwardly to an elevation above the pond but below the top of the chamber, a vacuum-producer, a pipe connecting the vacuum-producer with the chamber for effecting high vacuum therein above its pond, air-excluding means for receiving liquid from the apex outlet as free discharge and then conveying it to a place of delivery, conduit means for conducting liquid from the pond under air-excluding conditions, and pump means for supplying a

liquid suspension to be treated into the hydrocyclone tangentially with sufficient force to produce therein two swirling fractions of which one issuing from the apex outlet is dirt-rich and one issuing from the base outlet is dirt-poor and also to project the dirt-poor fraction expulsively as a spray from the open-ended pipe on the base outlet impingingly against the unsubmerged shell of the chamber thereby to atomize it for its de-aeration therein.

2. Apparatus for de-dirting and de-aerating a liquid suspension having some rejectable solids and some acceptable solids, which comprises a plurality of cleaning and de-aerating unitary devices each having a hydrocyclone with a base outlet and an apex outlet and an open-ended pipe rising from the base outlet as well as a chamber atop the hydrocyclone adapted to hold a pond of liquid into which chamber the pipe extends upwardly to an elevation above the pond but below the top of the chamber; a vacuum-producer, a pipe connecting the vacuum-producer with each chamber for effecting high vacuum therein above the pond in each chamber, air-excluding manifold means common to each hydrocyclone for receiving liquid from the apex outlet of each hydrocyclone as free discharge and then conveying it to a place of delivery; manifold means common to each chamber for conducting liquid from the pond in each chamber under air-excluding conditions; manifold means common to the intake of each hydrocyclone, and pump means associated with the intake manifold for supplying a liquid suspension to be treated into the hydrocyclones

tangentially with sufficient force to produce therein two swirling fractions of which one issuing from the apex outlet of each hydrocyclone is dirt-rich and one issuing from the base outlet of each hydrocyclone is dirt-poor and also to project the dirt-poor fraction expulsively as a spray from the open-ended pipe on the base outlet of each hydrocyclone impingingly against the unsubmerged shell of the chamber atop each hydrocyclone thereby to atomize it for its de-aeration therein.

3. Apparatus according to claim 2, with the addition of means for automatically controlling the constancy of the liquid-level of the pond in one of the chambers whereby the liquid-level of the pond in each of the other chambers automatically follows the lead of the controlled level through the medium of the liquid in the manifold common to each chamber seeking a common level.

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