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CENTRIFUGAL SEPARATOR

1,933,588

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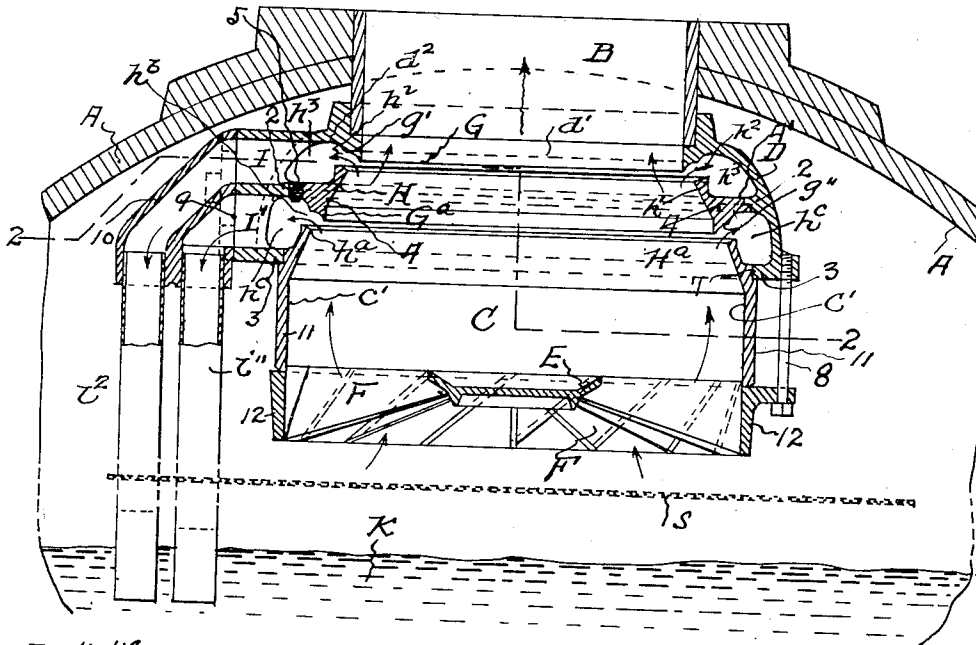


Fig. 1.

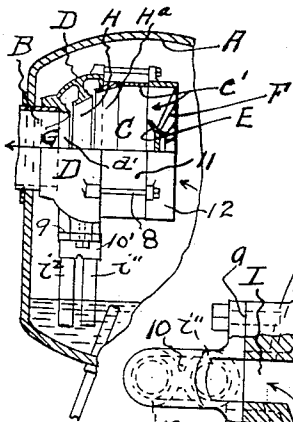


Fig. 4.

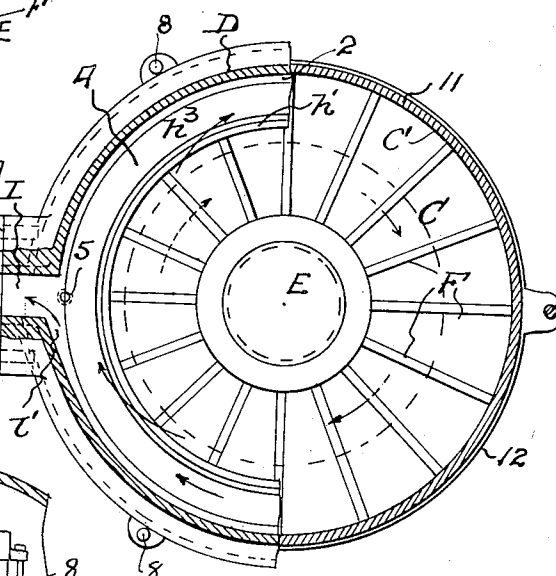


Fig. 2.

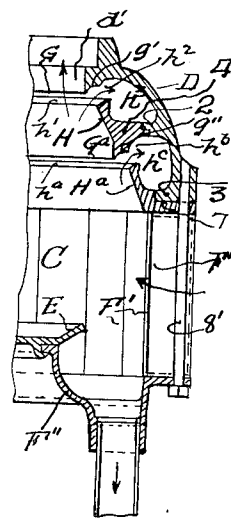


Fig. 3.

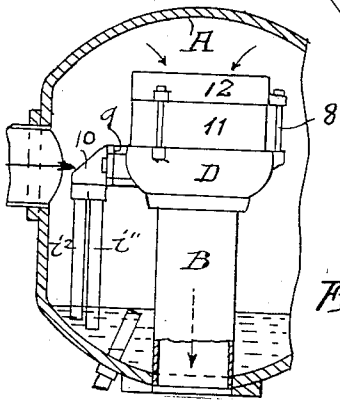


Fig. 5.

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CENTRIFUGAL SEPARATOR

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3 Claims. (Cl. 183—84)

The invention relates to the improvements in the art of separating foreign substances from flowing fluids, using the moving energy of the fluid or carrier to that end. Briefly, the invention comprises a centrifugal separator adapted for use at the starting ends of fluid lines, where they begin in pressure vessels of one kind or another.

In all processes of distillation and evaporation, and throughout the art of carrier purification by means of separators, it is assumed and desired that the fluid evolved or treated shall leave the drum or container in a pure state, free from foreign substances.

This separator is of a centrifugal type which is fixed in the pressure vessel. That is, the device does not itself rotate but upon entering the same the fluid is caused to rotate rapidly and to project the heavier substances against the internal or restraining wall of the separator. The heavier substances progress spirally and are collected and disposed of at the end of that wall; and if desired the invention accomplishes a differentiation and separation of the several heavier substances that may be carried by the fluid.

Such flowing fluids are known as "carriers" and the term carrier is to be understood as meaning any fluid that is directed or kept in motion between given points whether liquid, gaseous or vaporous and whether hot or cold, or a mixture of such fluids; and, the terms "foreign substances" as used herein is to be understood as meaning any and all carrier conveyed substances, whether solid or fluid, or both, and whether of less or greater weight than the carrier. The condition and shape of the foreign particles often permit them to be centrifugally separated even though of less weight than the carrier.

The present invention comprises a centrifugal fixture whereby the foreign substances are certainly and definitely removed from the carrier, and either returned to the container; or discharged externally, if it be desired to rid the container thereof.

The objects of the invention are to perfect the performance of such processes of purification by providing the simplest and most reliable devices or apparatus to that end. These and other objects, and the specific character of the invention, will presently appear in further detail.

The invention will be readily understood on reference to the drawing that forms a part of this specification, in which:

Fig. 1 is a vertical section of a steam boiler, drum or the like equipped with a centrifugal fixture or separator embodying this invention;

Fig. 2 is a horizontal section substantially following the planes of the irregular section line 2—2 on Fig. 1;

Fig. 3 illustrates the substitution of a tuyère of barrel type for the radial type tuyère of Figs. 1 and 2; and,

Figs. 4 and 5 show how the purifier is combined with two different receivers or drums.

This application may be compared with its companion applications Serial No. 217,133, filed Sept. 2, 1927 and Serial No. 236,519, filed November 29, 1927; renewed July 27, 1932 and it will be seen that the structure of this case involves an invention which is basically disclosed in those applications. The present invention however is distinguished therefrom in important particulars which will presently appear.

The separator of this application is of the fixed or non-rotative type and of the thin walled type not adapted to sustain bursting pressures but admirably adapted for suspension within the top of any pressure vessel (A), for direction connection with the outlet or nozzle (B) leading therefrom; whether the nozzle leads upward or downward or laterally through the side of the container, as respectively shown in Figs. 1, 5 and 4; In other words, the present centrifugal separator or fixture is peculiarly adapted to perform in any fixed position.

In every case it has a body portion which is attached to the vessel outlet or nozzle B and is coaxial therewith. The body portion is round or substantially so and contains a generally cylindrical separating chamber C defined either by an imperforate cylindrical wall c' as shown in Fig. 1 or by a tangentially perforated wall as shown in Fig. 3. Such internal walls or surfaces comprise the initial separating surfaces of the respective separators. A ring-like collecting head or race member D containing the hereinafter described successive circumferential eject slots and outlet openings is interposed between the chamber C and the nozzle or outlet B of the pressure vessel A. The opposite end of the chamber C contains a coaxial vortex-defeating member or so-called vortex cone E which is coaxial with the chamber and outlet; and of much less diameter than the chamber C. The carrier enters the chamber C, through tangential tuyères or whirl-promoting devices as about to be described; and, by its own force is set into rapid rotation, creating a strong vortex or whirling carrier body in said chamber C; with the result that the heavier substances are projected and held upon the said inner wall of

the chamber. They whirl spirally upward toward the successive lips G and G^a in the collecting head D and until they reach the circumferential eject slots or openings g'' and h² in the collector head D; where they are finally discharged centrifugally, being thus removed from the carrier stream, before the latter escapes to the outlet.

The means for setting the carrier into rotation in this fashion may comprise a circumferential series of spaced tangential blades F, placed angularly to the direction of carrier flow, and radiating from the member E, as in Fig. 1;—or may comprise the circumferential series of tangential, similarly angular, blades F', the inner edges of which form the said inner wall of the chamber C in Fig. 3. In the latter case the end proper of the separator is formed by a complementary floor F'' again mentioned herein.

Not all of the carrier actually contacts or impinges the inner wall, but the foreign substances contained by the tangentially divided streams are, reliably and dependably, thrown or whirled outward toward that wall and then move spirally toward the outlet. Not all the foreign substances immediately reach the restraining wall of the chamber C when they leave the inclined blades of the tuyère. Every whirling body or vortex tends to draw substances across its end and into its axial center. To nullify this action the central member E is provided to first readily accept the stray substances moving toward the vortex axis, then, with a surprising degree of perfectness to stop such movement, and hold such stray substances under the whirling influence of the vortex until, finally they take on a rotative velocity which causes them to be centrifugally discharged against the restraining wall.

The chief problem in separation is encountered directly in advance of said outlet, for unless the substances are removed before reaching that point they will be taken away by the departing carrier; and, to the extent that the separator fails in the accomplishment of the final complete separation of the foreign substances it obviously fails to perform its proper function.

No separation during movement can be made without some loss of energy, that is without some loss of the power used to cause, or in causing, the movement of the carrier, and it is extremely important that the separator in the first instance shall oppose the least possible resistance to the flow of the carrier, and in the second instance shall completely perform its expected separating function so that the tangible return or benefit shall better justify the expense of its installation and the continuing cost of its operation. The problem of pressure drop is here answered by the use of a chamber C which is only slightly larger than the outlet B and by employing a whirl promoting tuyère having an aggregate inlet area that much exceeds the area of the outlet.

As bearing upon the solution of the second problem, that of final separation, it is important first to realize that the substances to be removed are not uniformly distributed in the entering carrier stream, and next, any method of tangential introduction ultimates in streams which progress quite individually and spirally toward the outlet. On reaching an outlet of less diameter than such spirals the longitudinal movement thereof is interfered with and they strongly tend to form standing or re-entrant waves. Such waves of foreign substances must be expended properly; in brief, outwardly; otherwise much or

all of the initially separated substances will re-enter the outgoing carrier stream. Further, the separated substances must ultimately leave or be discharged from the separator casing at some given point in its periphery; and, an additional difficulty is encountered in dealing with the many spiral streams which are produced by a multiple tuyèred whirl producing element. Even though deflected by an annular shoulder beyond the discharge opening, the spirals will not all terminate at that opening. Means are therefore here provided to receive the spirals under uniform resistant or back pressure conditions and then to direct the substances to the discharge opening.

It has been demonstrated that the pressure drop through a given centrifugal fixture or separator, aside from problems involved by prior changes of direction, are responsive to changes in the relation of the diameter of the outlet to the diameter of the separating chamber. As that difference is increased the pressure drop is increased; while a lessening of the difference, results in lessening the pressure drop.

Therefore, by this invention it is made possible to employ a separating chamber that is only slightly larger than the outlet. Next the carrier is admitted to the chamber in a whirling condition but with little other opposition to its flow, due to the relatively large outlet. And, effective riddance means are provided in advance of the outlet, and yet wholly within the small annular space allowed by said difference of diameter.

Referring again to the drawing, it is to be seen that the direct approach to the outlet B is formed by a conical ring or portion H which receives the described spirals and opposes them; but, so slightly as to avoid the formation of standing waves and yet advantageously lessen the pitch of the spirals at that point. The portion H is referred to as conical; but strictly speaking it is truncated; and its smaller forward edge or end, h', is of slightly larger diameter than the central outlet opening d' in the head D, and, does not quite reach the first transverse plane of that opening. An annular opening h², of considerable longitudinal length, therefore remains between the end h' and the actual top or end wall d² of the separator casing. The annular space h³ surrounding the cone H is termed a race. Arriving at the edge h' the foreign substances fly off centrifugally into the race h³.

At a point in the outer wall of the race (hence in the head D of the separator) is a discharge opening I through which the separated substances are removed. Generally that opening leads to a trap of some kind which prevents the escape of the carrier, or if the operation is being conducted under suction prevents the entrance of external air through the opening I. It will be understood that such trap may be of the ordinary external type, well known and not shown. Preferably however, and as made possible by this invention all substances in liquid form are ejected or returned to the interior of the pressure vessel served by this separator.

The whirling action is communicated to the content of the annular race and unless gravity is entirely relied upon to discharge the substances therefrom it is best to provide the opening I with a tangential entrance i' like that clearly shown in Fig. 2, which facilitates prompt discharge without materially interfering with the whirling motion of the carrier fluid also occupying the race.

Attention is again called to the spacing away of the cone H from the outlet d' , whereby the content of the race is left in direct lateral communication with the whirling body within the separator and hence is rotatively propelled thereby to insure the retention of the separated substances against the outer periphery of the race even when the separator is used upon a horizontal axis. The race, as shown, extends both up and down with respect to the annular entrance crack and thus definitely ensures the proper momentary retention and prompt discharge of the substances when the fixture is inverted or used on its side.

As is well known the sweeping of a stream across an opening tends to create a vacuum therein. Hence the avoidance of that objection is herein attained by the just mentioned spacing and by making the forward end of the accumulator cone H larger than the outlet d' . To the same end, the outlet itself is characterized by a pressure effecting lip G which overhangs the race entrance and tends to direct the marginal portion of the stream into the race I; whereby a high and more uniform pressure condition is obtained in the race, insuring the uniform action of the separated substances therein. The longitudinal thrust of the carrier is successfully expended against the shoulder g' at the base or root of the lip G, and it is substantially true that only a whirling motion exists in the race h^3 . Thus the final separation is quietly completed.

The described capability of maintaining a high definite pressure in the race h^3 is of special importance in cases where (as here shown) it is desirable to discharge the foreign substances back into the vessel from which the carrier is derived as in the case of boilers and evaporators (as in Fig. 1) and as exemplified in the line receivers of Figs. 4 and 5. In such cases the pipe i^2 leading from the separator is opened at a lower point and there sealed by the liquid content of the vessel A. The pressure differences are so slight that the sealing liquid K rises but a little way in the eject pipe i^2 .

It is well to note that the utility of this invention is not limited to the separation of substances differing widely in specific gravities or to such as are suspended in the carrier in the form of fine particles or small globules. Even bulky and also oily materials conveyed by the carrier in the form of particles, globules and flakes, on entering the casing are whirled outward in the separating chamber and are ejected from the race or races. Clearly this invention is adapted for employment with hot and cold carrier fluids under both suction and pressure conditions and at either high or low pressures within the vessels A and under either high or low velocities; and with either heavier or lighter or fluctuating burdens of foreign substances.

This invention lends itself to an advantageous doubling or "staging" of the final separating operation, this being accomplished by the provision of a sequence or succession of races; at slight sacrifice in the matter of increased separator diameter and total pressure drop. As clearly shown in Figs. 1, 3 and 4 the race at the outlet d' is substantially duplicated by another of larger diameter for which the larger end of the cone H becomes the carrier outlet, being compared with the lipped outlet d' in that respect. This larger and interposed race arrangement operates in the same way and its several parts are identified by the corresponding reference characters, g'' , H^a ,

h^a , h^b and I' . The eject pipe belonging thereto is marked i'' .

In dealing with a burdened carrier which contains occasional slugs of liquid, it is desirable to relieve the race next to the outlet from the heavy duty of disposing of the slugs and leave to it only the duty of caring for the normal entrainment. This is the end to which the larger race is devoted and to facilitate the action the accumulator cone H^a is made of less pitch or inclination than the cone H. The pressures maintained in the races h^3 and h^c differ slightly. Therefore when the foreign substances are to be discharged upon the exterior of the pressure vessel, separate automatic traps should be connected with the pipes i^2 and i'' , or the eject pipes i^2 and i should be joined on the exterior by an equalizing trap (not shown) before being led to a single disposal trap.

This invention comprises many other novel features and advantages which will now be described in detail.

The collector head D which is most economical, occupies the least space and is most simple to install in the cast metal dome shaped ring here shown. It is of a size to be easily introduced through the manhole of the pressure vessel and is thin walled, so that it may be almost wholly occupied by the races h^3 and h^c . The lip G is preferably an integral part of the casting and that casting is further characterized by the intermediate inwardly projecting shoulder rib 2 and by the inwardly projecting bottom rib 3.

It will be seen that the parts marked H, h' , G^a and g'' are furnished by a separately machined ring 4 which has an outwardly extending rib 4'. The latter is jointed or seated upon the shouldered rib 2 and is fixedly secured thereto by a number of screw keys 5 or the like. Obviously the whole ring 4 is of a size which permits it to be passed through the opening within the bottom rib 3, before the part marked H^a is put in place. Similarly, the latter is shouldered at 7 and is seated against the bottom of the head rib 3, to which it is secured by a number of clamping bolts, see parts marked 8 and 8' in Figs. 1 and 3.

Integral portions of the head casting contain the discharge ports I and I' and terminate in a face 9. To this face is bolted a double head piece 10 or 10' for the eject pipes i^2 and i'' , see Figs. 1 and 4.

In the case of Fig. 3 the member H^a becomes an integral part of the barrel type tuyère. In the case of Figs. 1, 4 and 5 the conical member or accumulator ring H^a is preferably integral with the deeper ring 11 which comprises the imperforate wall of the separating chamber C. Attention is called to the fact that the whole device, H^a —11, is of a diameter and height which permits it to be introduced through a standard manhole.

The same is obviously true of the tuyère forming member of Figs. 1, 4 and 5. That member, having preferably integral cast members E and F, is completed by a preferably integral band portion 12 which receives the ends of the inclined, radial blades F. Conveniently the bolts 8 extend between the parts D and 12 and the member 11 is clamped between those parts.

When assembled the structure comprises a rigid unit adequately adapted to resist vibration and the torsion exerted by the passing carrier upon the tangentially inclined blades of the tuyère member. This obviously is equally true concerning both separators shown in Figs. 1 and 3.

The part S shown in Fig. 1 is a perforate plate, preferably a wire screen, which is suspended above the water level in the pressure vessel and far enough below the separator to allow free entrance of steam to the latter without counting the opening in the screen as steam passages. The screen serves merely to suppress the bad effects of violent steam disengagement from the surface of the liquid in the vessel, thus in large measure defeating the passage of slugs to the open bottomed separator.

It should be explained that the fixtures herein shown are of a size accommodated to a ten inch outlet B. This fixture and smaller ones may be introduced through the manhole of the pressure vessel. In dealing with outlets of larger size in vessels having standard boiler manholes, it will become necessary to make the top, intermediate and bottom parts of the separators in sections, otherwise there is no change in structure nor any loss of its functions or advantages.

Separators of the kind herein shown are called separators of the "open type", meaning that they are to be suspended in a pressure atmosphere and are not themselves called upon to sustain pressure stresses.

Having thus described my invention I claim as new and desire to secure by Letters Patent:—

1. A centrifugal separator of the open type for unburdening fluids within and emerging from pressure vessels and comprising a member provided with successive outlet orifices, one larger than the other and each marked by an outwardly pitched annular pressure effecting lip in advance thereof, in combination with two accumulator cone frustrums, one for and co-axial with and radially converging toward each said lip, but of slightly larger diameter in each case, means which

cause the burdened fluid to vortexially approach said accumulators in series, first the latter and then the smaller, and an individual race between and external to each said lip and accumulator and adapted to receive and eject burden received from the periphery of the vortex.

2. A centrifugal separator of the open type for unburdening fluids within and emerging from pressure vessels, comprising a member provided with successive outlet orifices, one larger than the other and each marked by an outwardly pitched annular pressure effecting lip in advance thereof, in combination with two accumulator cone frustrums, one for and co-axial with and radially converging toward each said lip, but of slightly larger diameter in each case, means which cause the burdened fluids to vortexially approach said accumulators and said orifices in sequence, a race between and external to each said lip and accumulator and adapted to receive and eject burden received from the periphery of the vortex, and a reaction sink disposed centrally within the base of the vortexial approach to said accumulators and adapted to exclude burden from the axial portion of the vortex.

3. A centrifugal fluid separator of the fixed type, comprising a circular race member containing a central outlet orifice and having a peripheral discharge opening for the ejection of the foreign substances, in combination with an imperforate ring in axial alignment with said race member and engaged with the intake end thereof, a co-axial whirl promoting member next engaged with said ring and composed of a co-axial vortex cone incorporated with said member and a plurality of inclined tuyère blades radiating from said cone.

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