June 11, 1935. C. G. HAWLEY 2,004,468

CENTRIFUGAL SEPARATOR

Original Filed April 2, 1932 3 Sheets-Sheet 1

Fig. 1.

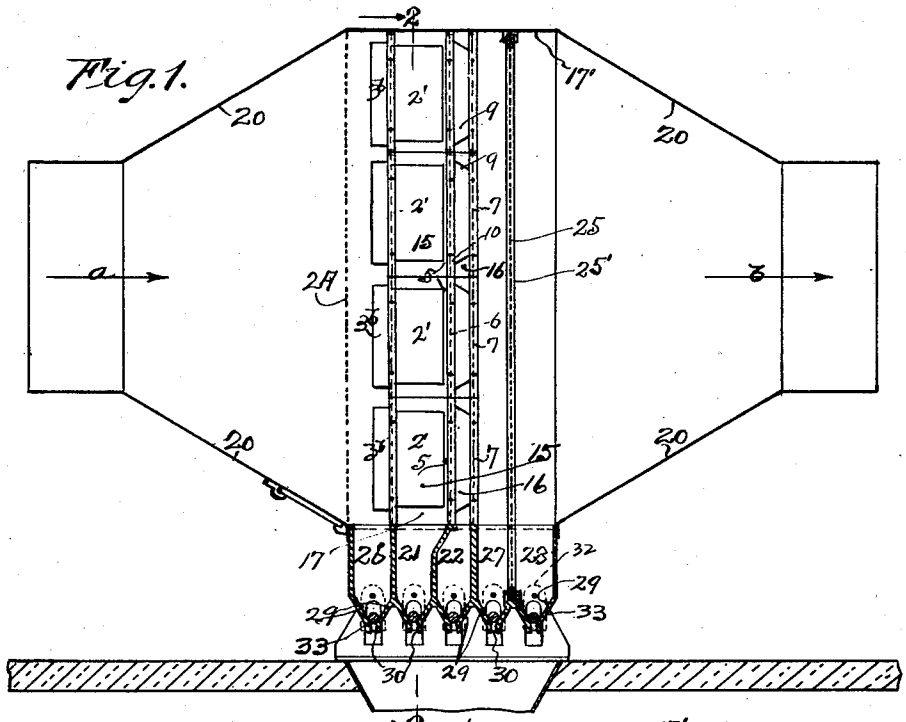
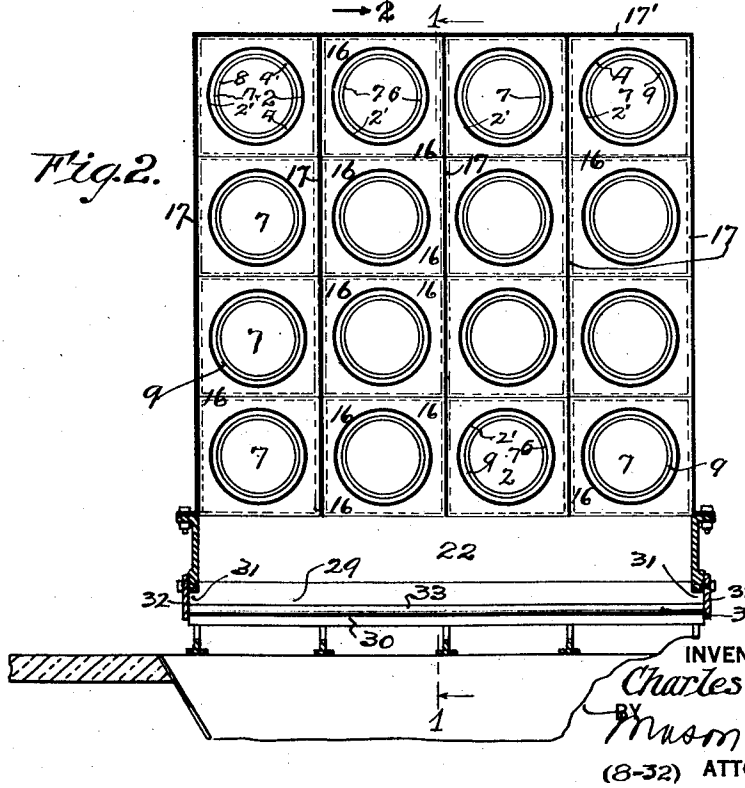


Fig. 2.



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Original Filed April 2, 1932 3 Sheets-Sheet 2

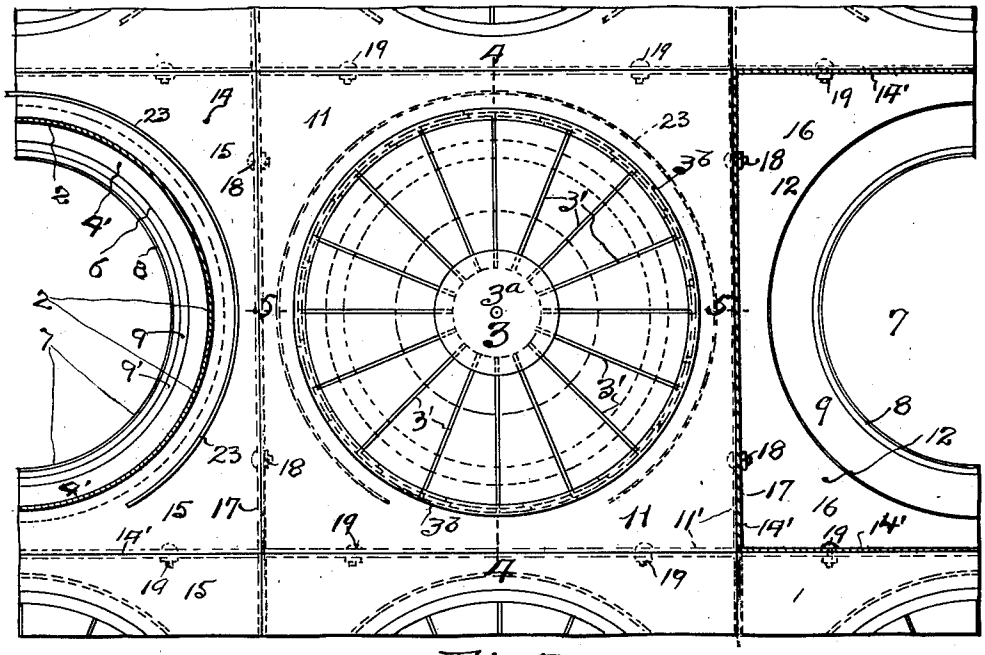


Fig. 3.

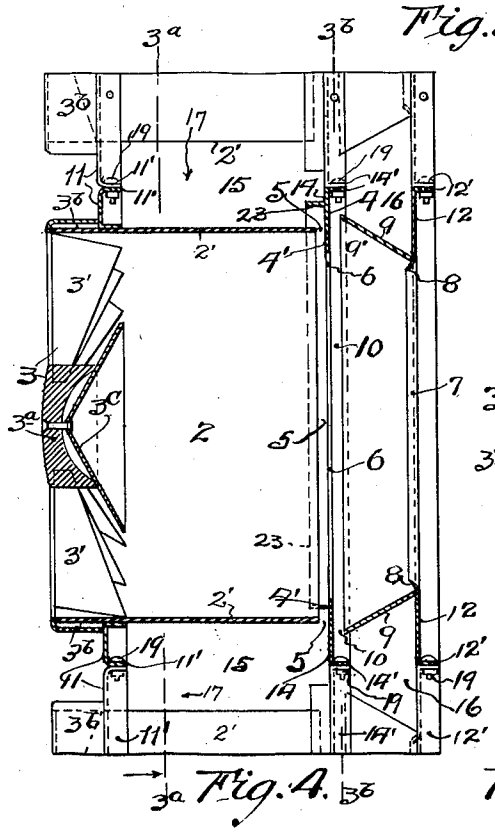


Fig. 4.

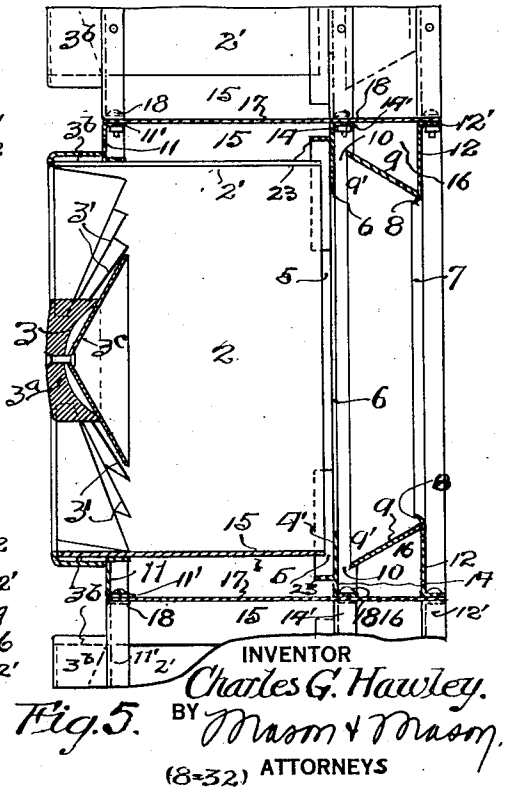


Fig. 5.

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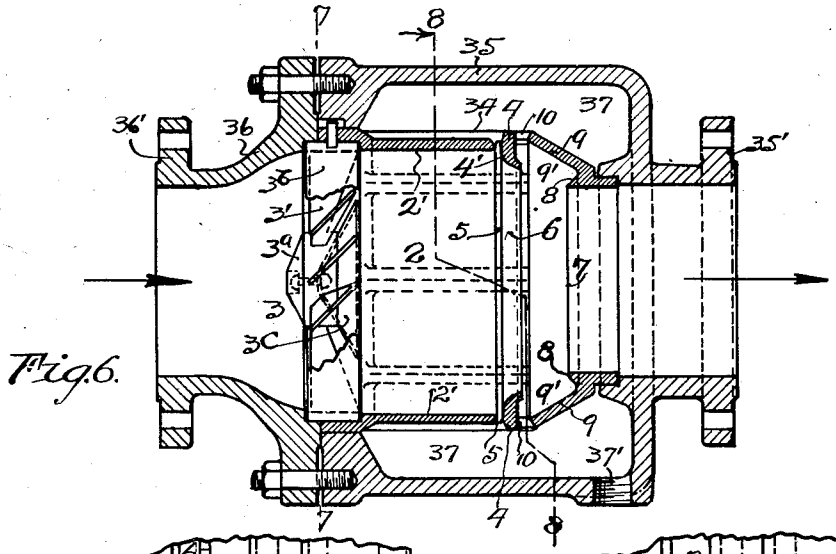


Fig. 6.

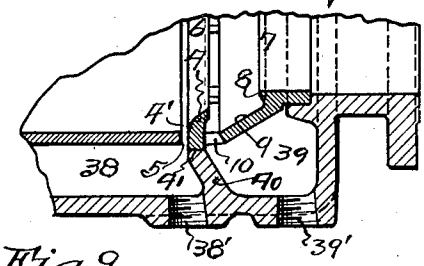


Fig. 9.

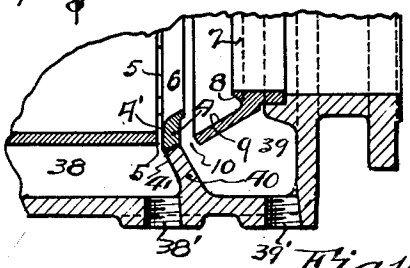


Fig. 10.

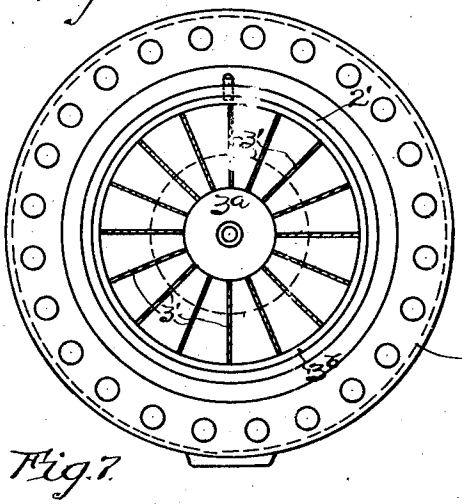


Fig. 7.

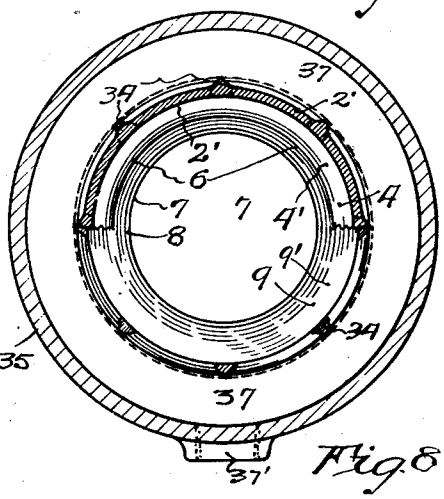


Fig. 8.

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UNITED STATES PATENT OFFICE

2,004,468

CENTRIFUGAL SEPARATOR

Charles Gilbert Hawley, Chicago, Ill., assignor to Centrifix Corporation, Cleveland, Ohio, a corporation of Ohio

Application April 2, 1932, Serial No. 602,765
Renewed November 14, 1934

11 Claims. (Cl. 183—80)

The invention is useful in the art of centrifugally separating various substances from carrier fluids that are in motion. The work is done by the rotation of the fluid but is accomplished within a so-called separator which is fixed against rotation and contains no rotating parts. Instead the separator includes a fixed whirl promoting tuyère and the presence of that element causes a vortexial or whirling movement of the fluid as it passes through the body of the separator. Such movement in turn results in the centrifugal separation of the foreign substances or impurities carried by the moving fluid, allowing the carrier fluid to depart in a well purified state, the impurities in one way or another being definitely removed, discharged, or ejected from the fluid before the latter reaches the fluid outlet of the separator.

This present invention has particular reference to improvements in the construction relied upon to accomplish the centrifugal collection of the foreign substances and which ensure the collection and escape or ejection of the impurities from the separator in advance of its outlet.

High efficiency, high capacity, low original cost and low maintenance expense are all demanded of such separators. They are also required to be efficient throughout a great range of working velocities and to be practical they must be self-cleaning. The separators are small and compact and yet are required to be dependable in all respects. The object of the present invention is to provide a centrifugal separator which shall meet these requirements.

Specifically, the object of the invention is to provide separators of the fixed centrifugal type which in either individual or multiple form shall be adapted for direct inclusion in a small part of carrier line, duct or pipe; that shall oppose little resistance to the passage of the carrier fluid; which shall comprise few parts and all of simple construction; which shall comprise only fixed or stationary parts and none which move or rotate; which shall be effective to remove substantially all centrifugally separable substances from the fluid and to discharge the same from the passing carrier fluid; which shall be of relatively small size, weight and cost as compared with other separators; which shall be substantially self-cleaning; which shall be durable and strong; which shall be easily transportable and installable in unit form; and which shall be adapted for easy dismemberment. Other objects of the invention will appear hereinafter.

With these objects in view, the invention comprises centrifugal separators embodying the novel constructions, combinations and arrangement of parts hereinafter detailed and exemplified in the drawings that form part of this specification.

In said drawings, Fig. 1 is a longitudinal section of a multiple or cellular centrifugal separator embodying the present invention;—Fig. 2 is a vertical cross section thereof on the line 2—2 of Fig. 1;—Fig. 3 is an enlarged front elevation of the cellular portion of the separator, showing one complete unit thereof surrounded by other units. The left hand portion of Fig. 3 is a sectional view substantially on the line 3*a*—3*a* of Fig. 4 and the right hand portion of Fig. 3 is a section substantially on the line 3*b*—3*b* of Fig. 4;—Fig. 4 is a vertical section on the line 4—4 of Fig. 3;—Fig. 5 is a horizontal section on the line 5—5 of Fig. 3;—Fig. 6 is a longitudinal section of a separator embodying this invention, as adapted for use in high pressure fluid lines;—Fig. 7 is an end view on the line 7—7 of Fig. 6, the intake section of the casing being removed;—Fig. 8 is a cross section on the irregular line 8—8 of Fig. 6;—Fig. 9 is a sectional detail resembling the construction of Fig. 6 but illustrating a modification thereof;—and, Fig. 10 is a like view showing still another modified construction of the interior of the separator.

The structure of Fig. 1 comprises a plurality of identical units each of which is a complete centrifugal separator. The units are many in number in order that they may serve to clean or purify a volume of carrier fluid which could not be efficiently treated in a single unit or large stream. Nevertheless all of the units required for any given volume are assembled within small and therefore convenient compass. The relatively small centrifugal separating units insure the high efficiency demanded of the separator as a whole. In contrasts the structure of Fig. 6 comprises a single unit which is adapted for use or inclusion in pressure fluid lines of common sizes. In the case of Fig. 1, the multiple separator as a whole takes its dimensions and number of component units from the volume of the fluid which is to be treated within a given time; whereas in the case of Fig. 6 the complete separator takes its dimensions from the size of the pipe in which it is to serve.

Considered from the standpoint of internal construction and from the standpoints of principle and performance, each unit of the Fig. 1 structure is identical with every other unit and is also identical with the individually complete unit of Fig. 6. Obviously, however, the fixtures

differ in details and appearance. Each separator is of the fixed centrifugal type and each is characterized by a substantially cylindrical separating chamber 2, combined with a whirl promoting tuyère 3 which is positioned at the inlet end of said chamber and also combined with a transverse ring-like element 4 positioned at the outlet end of said chamber but slightly separated from the end thereof to form a narrow eject slot 5; the performance of which combination of parts will be explained. The transverse element 4 contains a central opening 6 which is coaxial with the chamber 2 but is of smaller diameter, thereby leaving a marginal portion 4' to serve as an annular intercepting surface or abutment in the manner hereinafter described. Next to be noted is an opening 7 which is in a plane that is parallel with but widely spaced from the end of said cylinder 2 and the transverse part 4. This opening 7 is coaxial therewith but is of smaller diameter than the opening 6 in the annular abutment portion 4. The said opening 7 is the outlet orifice of this separating unit. The margin of the outlet orifice 7 is marked by a so-called pressure effecting lip 8 which in a measure opposes the exit of the fluid, as will be described. Next, it is to be noted that the wide space between the preliminary orifice 6 and the ultimate orifice 7 is in large measure occupied or closed by a conical reaction element 9. That element is a truncated cone. The small end of the element 9 is of larger diameter than the orifice 7 and merges with the lip 8 thereof to form a shallow circumferential groove 8', to which further reference will be made. As shown the space is not completely closed by the presence of the element 9 for that conical part is of less length than the distance which it partly bridges and thus a second and wider circumferential eject slot 10 is formed between the elements 4 and 9. As will be more fully explained hereafter, the narrow slot 5 and the wider slot 10 open into a surrounding reception space or spaces which are substantially closed. Though filled by the fluid there is little movement of the fluid in such space or spaces, movement or disturbance being limited to that which is occasioned by the separated substances that are ejected through said slots centrifugally, as will be further explained.

The whirl promotion tuyère 3 which is preferred in this construction is of the so-called radial type, characterized by a large number of inclined or angularly positioned radial blades 3' which extend from a smaller central hub portion 3*a*. The outer ends of the blades are held by a band portion 3*b*. The blades are substantially triangular in form and together form a circumferential series of relatively overlapping inclined tuyère openings, all having the same direction. The tuyère 3 is further characterized by a so-called vortex defeating cone 3*c* which is of larger diameter than the hub 3*a* and spaced away from the inner edges of the blades. Tuyères of the constructions here shown are more fully described and claimed in my co-pending applications S. N. 337,598 and S. N. 597,558 to which reference may be made.

When the separator is in operation the entering fluid first encounters the angularly bladed tuyère 3. Due to direction and deflection by that element the fluid takes on a rapid whirling motion within the chamber 2. In order to escape from the chamber the vortex or whirling body of fluid must pass through the smaller central opening 6 suffering relative contraction in so doing. From that point the fluid moves forward toward the orifice 7 and the whirling stream is further reduced in cross section as it passes into that still smaller opening, meantime whirling vigorously within the intervening space 9', which latter is bounded by the parts 4 and 9. The whirling of the burdened fluid within the chamber 2 and also within the annular space 9' causes the centrifugal separation of the impurities. In the case of the chamber 2, they are deposited upon the cylindrical wall 2' of that chamber; and in the case of the space 9' the residual impurities are deposited upon the reversely pitched reaction element 9. The longitudinal and whirling velocities of the fluid within the chamber result in a maximum fluid pressure at the juncture of the wall 2' and the abutment surface 4'; and the foreign substances, centrifugally collected on the wall 2' and urged forward by the whirling fluid, are very positively ejected through the slot 5. The lighter substances still carried by the fluid may impact the surface 4' and yet fail to be whirlingly ejected through the narrow slot 5. Such residues therefore accompany the main stream of fluid and are positively whirled forward and outward through the large central opening 6. Upon entering the annular chamber 9' the residues are promptly separated by centrifugal force and thus are at once deposited upon the conical surface of the reaction element 9. Being in a whirling condition and constantly propelled by the whirling fluid, the residues which reach the conical part 9 are promptly reversed in direction and thus are expelled from the large end of the element 9; in other words, are centrifugally ejected through the wider slot 10. The before mentioned pressure effecting lip 8 performs an assisting function in this ejection of residues by opposing the movement upon the element 9 in the direction of the orifice 7, said lip serving to intercept the outer part or periphery of the whirling stream of fluid and thus causing a somewhat increased pressure at the small end of the conical element 9, as compared with the pressure beneath the relatively overhanging abutment portion 4. As will be apparent, the passage of the fluid through the opening 6 tends to create a void behind or beneath the element 4, thus ensuring a lower pressure region in which the whirling movement of the fluid, assisted by the action of the lip 8, is advantageously expended in the ejection of the residues from the separating space 9' and slot 10. The action of the separator as here described is little disturbed by variations in the velocity of the fluid entering at the tuyère, and fluid which enters in a burdened condition is discharged from the orifice 7 in a well purified state.

As will now be clearly understood, the cylindrical chamber 2 is a primary separating chamber and the conical chamber 9' is a secondary separating chamber but at the same time each said chamber serves as an eject chamber inasmuch as both thereof function, not only to separate but also to eject the separated substances. The ejecting function of the chamber 2 is derived from the spaced annular abutment portion 4 at the delivery end of that chamber, and which portion 4 contains the central opening 6 which is of smaller diameter than the chamber 2. Similarly, the ejecting function of the chamber 9' is derived from the presence of the smaller orifice 7 and the parts 8 and 9 bordering said orifice. In a structural sense each chamber must be referred to as a separating and eject chamber but

for convenience of description and for convenience of definition in the appended claims, the first and larger chamber 2 will hereafter be referred to as the separating chamber inasmuch as the greater part of the separating action takes place therein, whereas the second and smaller chamber 9' will be referred to as the eject chamber by reason of the fact that its function is to separatingly accept and eject a minor quantity of substances that are not completely separated in and ejected from the first or larger chamber.

The multiple or cellular separator illustrated in Figs. 1 to 5 is made up of sixteen separator units of the construction above described. As shown, these units are piled or stacked upon a base which contains a collecting pocket or pockets belonging to all thereof. The stack of units is arranged within the opening or passage through which the burdened fluid is to flow and serves to subdivide the main stream into smaller streams which can be successfully operated upon centrifugally. The units perform the function of intercepting the impurities and throwing them downward into the collecting pocket. That pocket has a valve which may be opened to discharge the accumulated impurities. Obviously, they must be discharged continuously, but in most cases the simple valve arrangement here shown will be preferred. Most conveniently, these separator units are of a cubical form which is afforded by the shapes of rectangular framing parts or plates which serve to hold the circular separator parts hereinbefore described. As will be apparent the many circular separator parts may be fixed in large perforated front and back plates of proper sizes but the unit construction here shown is preferred for obvious reasons of convenience and economy.

Figs. 3 to 5 serve to clearly depict an individual cubical separator unit and its relations to adjacent units of the same construction. As therein shown, each unit is characterized by a rectangular front plate 11 and a rectangular back plate 12. The front plate contains a large central opening in which the previously described parts 2 and 3 are fastened, the plate becoming a fixed flange upon the cylindrical portion 2'. The back plate 12 contains the outlet orifice 7 of the separator and provides the before mentioned pressure effecting lip 8. It carries the conical part 9 which is fixed thereon and the back plate 12 may also serve to support the deflecting ring 4' which is interposed between the parts 2' and 9 as before described; in other words, the construction may follow the suggestion of Fig. 6. For handling dusts it is preferred that the part 4' shall be provided by a third rectangular plate 14 as here shown, such plate serving to form and separate the reception spaces 15 and 16 that communicate with the discharge slots 5 and 10 respectively.

The plates are provided with respective marginal flanges 11', 12' and 14' and they are held in proper relation by means of side plates 17 to which their side flanges are attached by bolts 18 (see Figs. 3 and 5). The top and bottom flanges of the plates meet the corresponding flanges of adjoining units and are attached thereto by like bolts 19 (see Figs. 3 and 4).

By preference, the side plates 17 extend from top to bottom of the stack of units and the outer side plates 17 and a top plate 17' may form parts of the main casing 20 of the machine. The form of that casing is determined by the situation in which the machine is placed and the use to which it is put. The direction of fluid movement through the machine is indicated by the arrows *a* and *b* (see Fig. 1).

As will be apparent the reception spaces 15 and 16 belonging to the units of each vertical tier are in open communication from top to bottom of the stack and the dusts or other separated substances discharged into said spaces through the slots 5 and 10 fall into accumulating pockets 21 and 22 which are provided in the base of the machine.

Interference of one unit with another is obviated by outstanding flanges that are interposed between the opposed discharge slots of adjacent units. In the case of the slots 10 this function is performed by the flanges 14' before described, which obviously stand between the slots 10 of adjacent units. In like manner the slots 5 of adjacent units are separated by circular flanges 23. These flanges are radially spaced from respective slots 5 and are attached to respective plates 14, all as clearly shown in Figs. 3, 4 and 5. With the slots thus separated or defended, substances forcibly discharged from the annular slots of one unit are prevented from entering the corresponding slots of adjoining units and nothing is allowed to interfere with the even discharge of substances from all the units.

The working capacity of these units is gauged by the sizes of the orifices 7 and the number of units to be employed is determined by the total volume of fluid to be treated within a given time. As a rule the velocity of fluid movement through the orifices 7 of these units should not be less than one thousand feet per minute and in many cases may be as high as ten thousand feet per minute. Clearly, the operating capacity of this multiple separator is very large in proportion to the cubical dimensions of the machine.

Where the fluid approaches the separating units at high velocity it is best to protect the units by placing a coarse screen 24 in front thereof as shown in Fig. 1. When called upon to operate with fluids containing some very fine particles, it is best to place a cloth screen or the like 25 behind the separator units. The screen is held in a frame 25' which may be vibrated or readily removed from the casing 20.

By preference, a single base is provided for the complete stack or group of units and the before mentioned underlying collection pockets 21 and 22 take the form of elongated troughs which serve all of the units. Like elongated pockets 26, 27 and 28 may be provided for the reception of substances that fall in the spaces at front and back of the stack of separator units. These parallel pockets may be relatively narrow and are best formed in a single metal casing but if desired the whole base may be made of sheet metal.

Each collecting pocket has a trough-like bottom 29 terminating in a discharge slot 30 that extends from end to end thereof. Openings 31 are provided at the ends of the trough and those openings are normally closed by the bolted plates 32. The slot 30 in the bottom of the trough is normally tightly closed by means of a packing rod or shaft 33 which rests upon the bottom of the trough and extends from end to end thereof. The ends of the rod contact the closure plates 32 and thus the whole bottom of the trough is tightly closed.

When a pocket is to be emptied one of the plates 32 is raised or removed and the rod is either lifted or is taken bodily from the trough. In that manner the slot 30 is opened and the

accumulated substances are allowed to drop into an underlying hopper or tray (see Figs. 1 and 2).

The shaft or rod 33 constitutes a very simple and removable valve element. It may be of solid cross section or it may be tubular and it may have a flexible covering of rubber or the like. Such aids to tightness will be obvious to those who are skilled in the art. Further, the rods may be of polygonal cross section though it is preferred that they shall be made of rolled shafting or drawn tubing.

In order to adapt this invention for inclusion in high pressure steam lines and the like it is made in the form presented in Fig. 6 wherein the characteristic parts have already been identified. Most conveniently, the parts 2', 4 and 9 are here combined in a single casting, such parts being united by the external ribs 34 but being otherwise separated by the now familiar discharge slots 5 and 10.

In the case of Fig. 6, the whirl promoting tuyère 3 is lodged in the intake end of the cylindrical part 2' and the part 9 contains the outlet orifice 7. The unit separator thus formed is contained and clamped by the parts 35 and 36 which form an external casing capable of sustaining high pressure. Those parts have end flanges 35' and 36' for union with the flanged ends of the pipe or line in which this fixture is to be placed. The body portion 35 of the casing is of such size that a large space 37 surrounding the unit proper is provided for the reception of the substances that are discharged from its slots 5 and 10 in the manner before described. That space has a drain opening 37' through which the collected substances are discharged.

In making the line separators next above described a precaution is to be observed by reason of the communication of both slots 5 and 10 with a single reception space 37. The slot 5 should be relatively narrow and the slot 10 relatively wide. The reason for this is that the vigor of the discharge from the first slot (5) is greater than that from the slot (10) which latter is hooded by the relatively overhanging part 4. In consequence there is some movement of fluid from slot to slot within the space 37 and the slot 10 is made capacious in order that the return of the fluid through the slot 10 shall not be so rapid as to prevent the simultaneous centrifugal expulsion of the separated substances therethrough.

The advantages attaching to separate reception spaces for the discharge slots may be obtained in either of the ways illustrated in Figs. 9 and 10 where the reception space 38 belonging to the slot 5 is separated from the lower pressure reception space 39 belonging to the slot 10. The division is accomplished by means of an internal circumferential rib 40 within the casing. The latter contains a central opening and the peripheral portion 41 of the separator unit is finished to tightly fit that opening. As shown in Fig. 9 the parts 4 and 9 are joined together while in Fig. 10 the parts 4 and 2' are joined by the external ribs shown. Obviously the unit structure of Fig. 6, in which all of the parts are connected, may be substituted. Separate drains 38' and 39' are provided for the described spaces 38 and 39.

One obvious modification of this invention which is of special value but has not been specially illustrated is made by simply omitting or closing the described annular slot 5. When thus modified the ring-like part 4 continues to operate to control and prolong the whirling movement of the fluid within the chamber 2 but all of the centrifugally separated substances are swept through the reduced end of the chamber; that is, through the intermediate orifice 6. The collected substances are thus discharged into the re-action cone 9 and are expelled through the single slot 10. Otherwise the construction remains the same as shown in any and all of the figures of the drawings. This paragraph will serve to explain the appended claims which are not specifically limited to two discharge slots or separate openings.

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

1. A centrifugal separator unit comprising a whirl promoting tuyère in combination with separating and eject chambers successively leading therefrom and having coaxial outlets of successively smaller sizes, and, said eject chamber having a relatively narrow annularly circumferential eject opening adjacent the end of said separating chamber, and distant from the smaller outlet.

2. A centrifugal separator unit comprising a whirl promoting tuyère in combination with coaxial separating and eject chambers successively leading therefrom and having coaxial outlets of successively smaller sizes, and, each said chamber having a relatively narrow annularly circumferential eject opening both adjacent the end of said separating chamber and distant from the smaller outlet.

3. A centrifugal separator unit comprising, in combination, a whirl promoting tuyère, a cylindrical separating chamber and a conical eject chamber successively leading therefrom and having coaxial outlets of successively smaller sizes, and, said eject chamber having a relatively narrow annularly circumferential eject opening adjacent the end of said separating chamber and distant from the smaller outlet.

4. A centrifugal separator unit comprising, in combination, a whirl promoting tuyère, a cylindrical separating chamber and a conical eject chamber successively leading therefrom and having coaxial outlets of successively smaller sizes, and, each said chamber having a relatively narrow annularly circumferential eject opening both adjacent the end of said separating chamber and distant from the smaller outlet.

5. A centrifugal separator unit comprising, in combination, a whirl promoting tuyère, a cylindrical separating chamber and a conical eject chamber successively leading therefrom and having coaxial outlets of successively smaller sizes, each said chamber having a relatively narrow annularly circumferential eject opening both adjacent the end of said separating chamber and distant from the smaller outlet, and, a suitably drained casing containing said tuyère and chambers and adapted to receive the ejects from said openings.

6. A centrifugal separator unit comprising a whirl promoting tuyère in combination with separating and eject chambers succesively leading therefrom and having coaxial outlets of successively smaller sizes, said eject chamber having a relatively narrow annularly circumferential eject slot paralleling the end of said separating chamber and distant from the smaller outlet, and, an encasing portion containing a reception space wherewith said eject slot communicates.

7. A centrifugal separator unit comprising a

whirl promoting tuyère in combination with coaxial separating and eject chambers successively leading therefrom and having coaxial outlets of successively smaller sizes, each said chamber having a relatively narrow annularly circumferential eject slot both paralleling the end of said separating chamber and distant from the smaller outlet, and, a hollow casing portion wherewith said slots communicate.

8. The improvement herein described comprising a stack of centrifugal separator units arranged side by side, each having a whirl promoting tuyère in combination with separating and eject chambers successively leading therefrom and having coaxial outlets of successively smaller sizes, each said eject chamber having a relatively narrow eject opening, circumferentially paralleling the end of the separating chamber immediately adjacent thereto and distant from the smaller outlet, and, a collecting pocket common to said units and eject openings.

9. The improvement herein described comprising a stack of substantially cubical centrifugal separator units arranged side by side, each having a circular whirl promoting tuyère in combination with separating and eject chambers successively leading therefrom and having coaxial outlets of successively smaller sizes, each said chamber having a relatively narrow eject opening circumferentially paralleling and immediately adjacent the end of the first or separating chamber and distant from the smaller inlet, and, collecting pockets for and common to the eject openings of respective separator units.

10. A multiple stage separator unit of the centrifugal type comprising a substantially cylindrical separating chamber, in combination with whirl promoting means occupying one end of said chamber and a ring partially closing the other end of the chamber and separated from said end by a narrow circumferential slot, another ring spaced axially from the first mentioned ring and containing a coaxial but smaller central opening and a conical element joining said second ring adjacent the central opening therein and enlarging reversely, that is toward the first-mentioned ring but separated from the latter by a circumferential slot.

11. A multiple stage separator unit of the centrifugal type comprising a substantially cylindrical separating chamber, in combination with a radially bladed tuyère positioned at one end of said chamber and containing a central hub and vortex defeating cone, a ring partially closing the other end of said chamber but separated therefrom by a circumferential slot, a second ring spaced axially from the first-mentioned ring and containing a coaxial but smaller central opening and circumferentially disposed means substantially closing the space between said rings and forming a circumferential slot for the ejection of separated substances, substantially as described.

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