Oct. 17, 1933. C. G. HAWLEY 1,930,476

LINE SEPARATOR AND GRADER

Original Filed Nov. 29, 1927 5 Sheets-Sheet 1

Fig. 1.

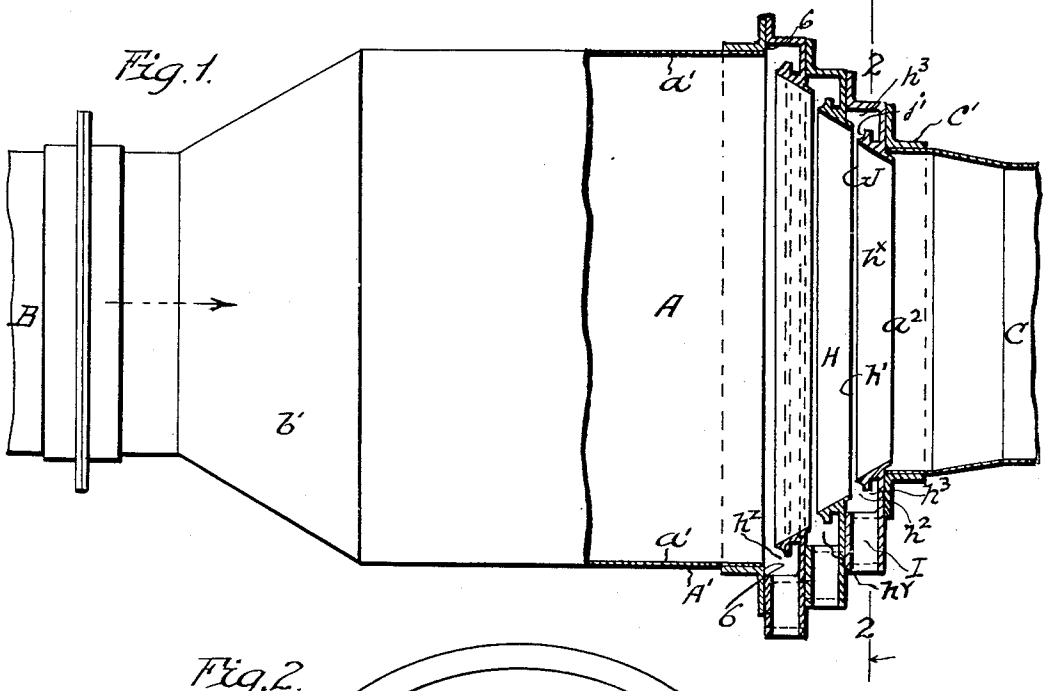



Fig. 2.

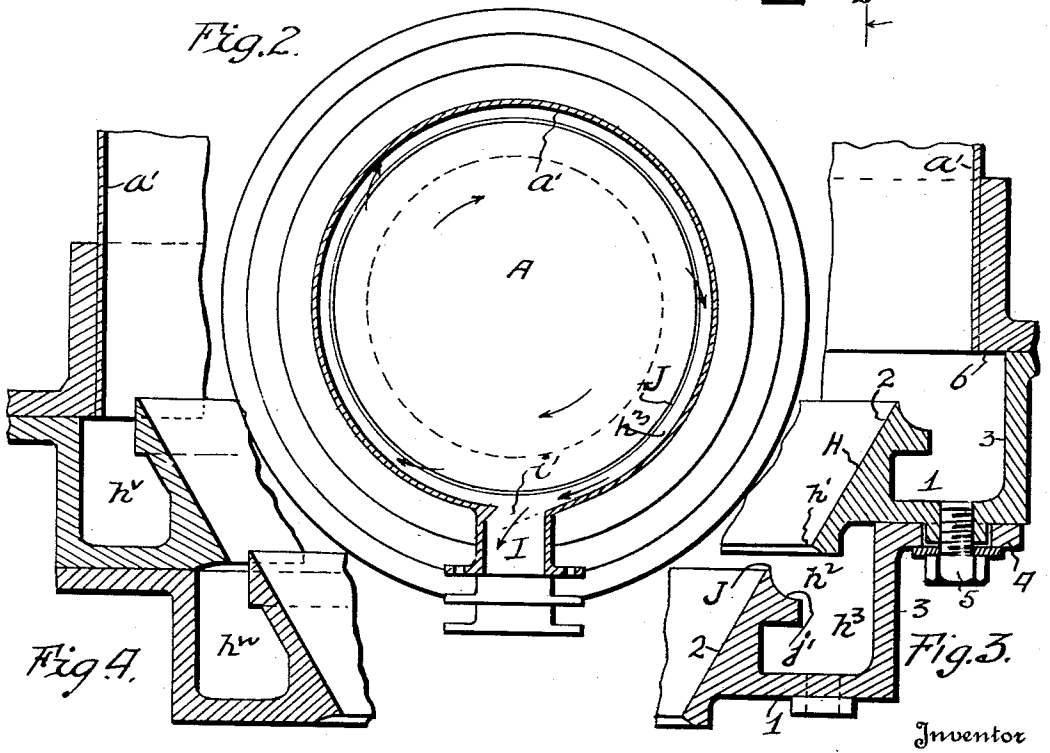



Fig. 4.

Fig. 3.

Inventor

Charles G. Hawley

By C. A. Mason Attorney

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LINE SEPARATOR AND GRADER

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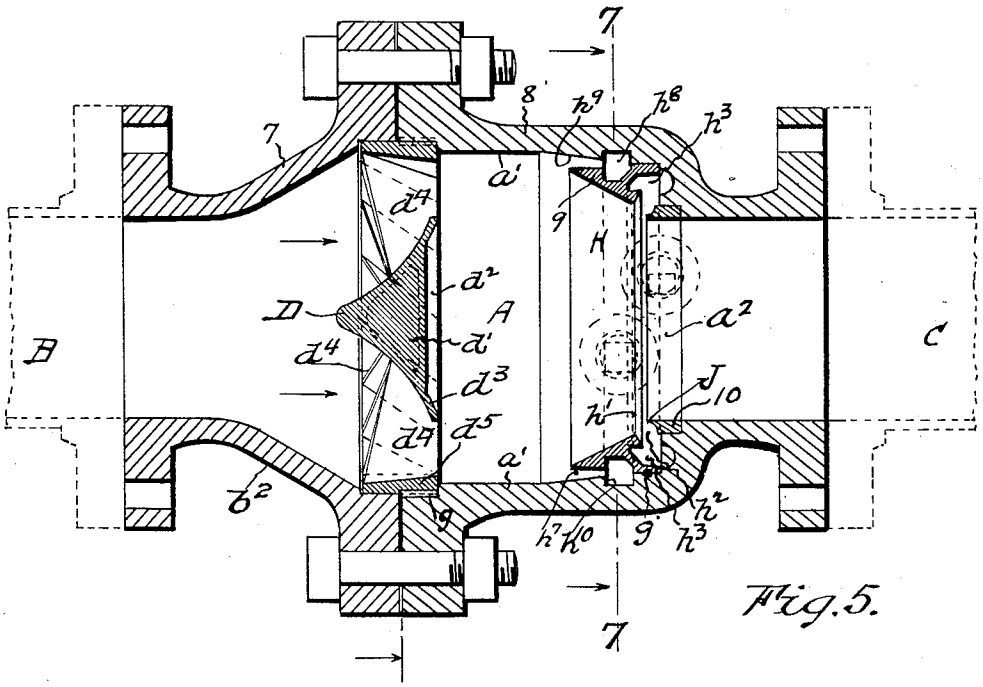



Fig. 5.

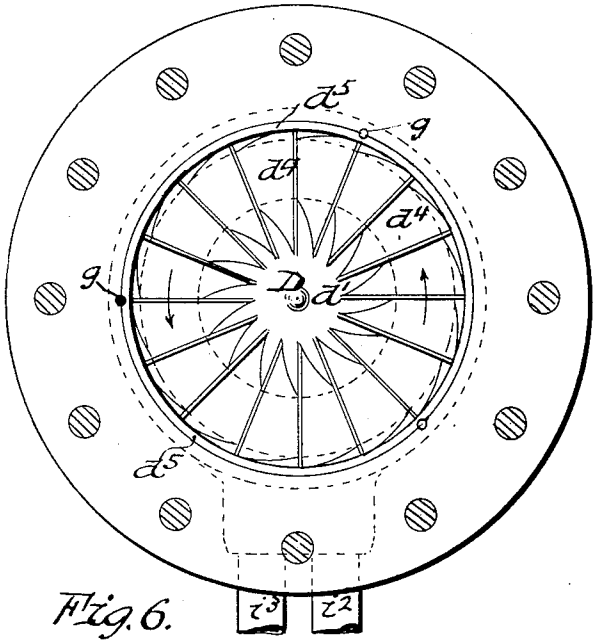



Fig. 6.

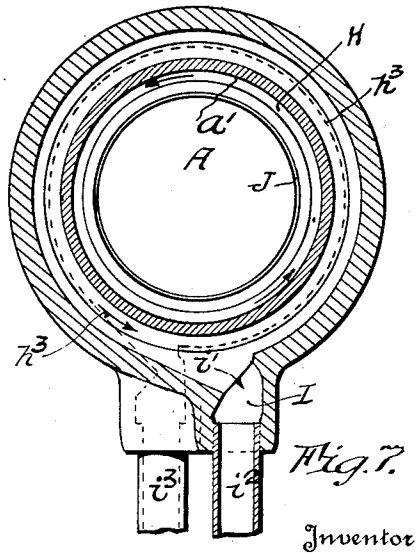



Fig. 7.

Inventor

Charles G. Hawley

By C. J. Mason

Attorney

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LINE SEPARATOR AND GRADER

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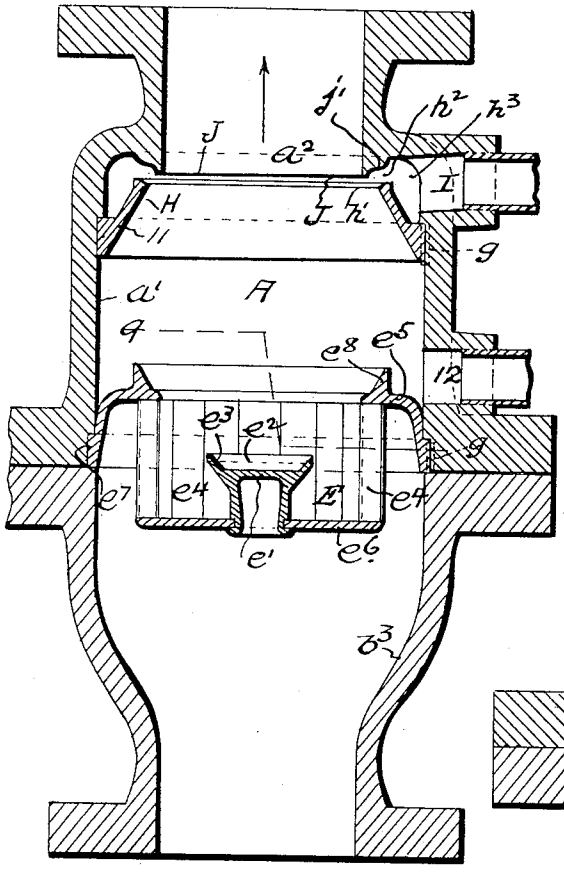


Fig. 8.

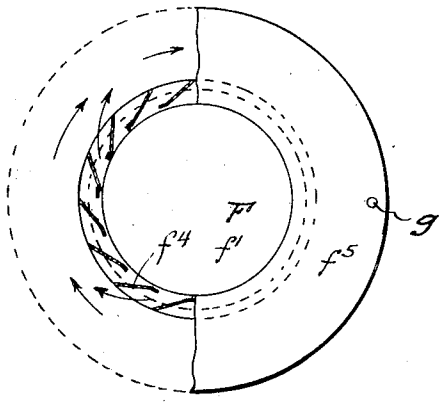


Fig. 11.

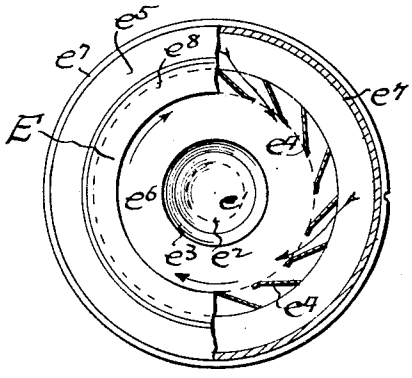


Fig. 9.

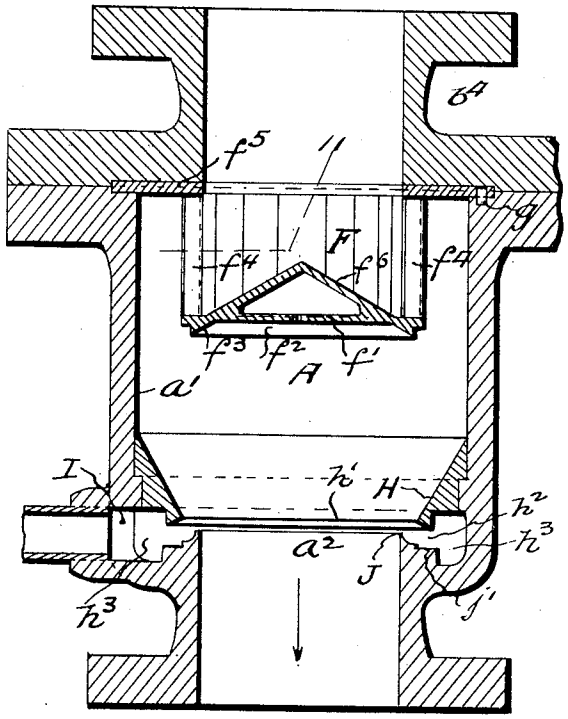


Fig. 10.

Inventor

Charles G. Hawley

By C. A. Mason

Attorney

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LINE SEPARATOR AND GRADER

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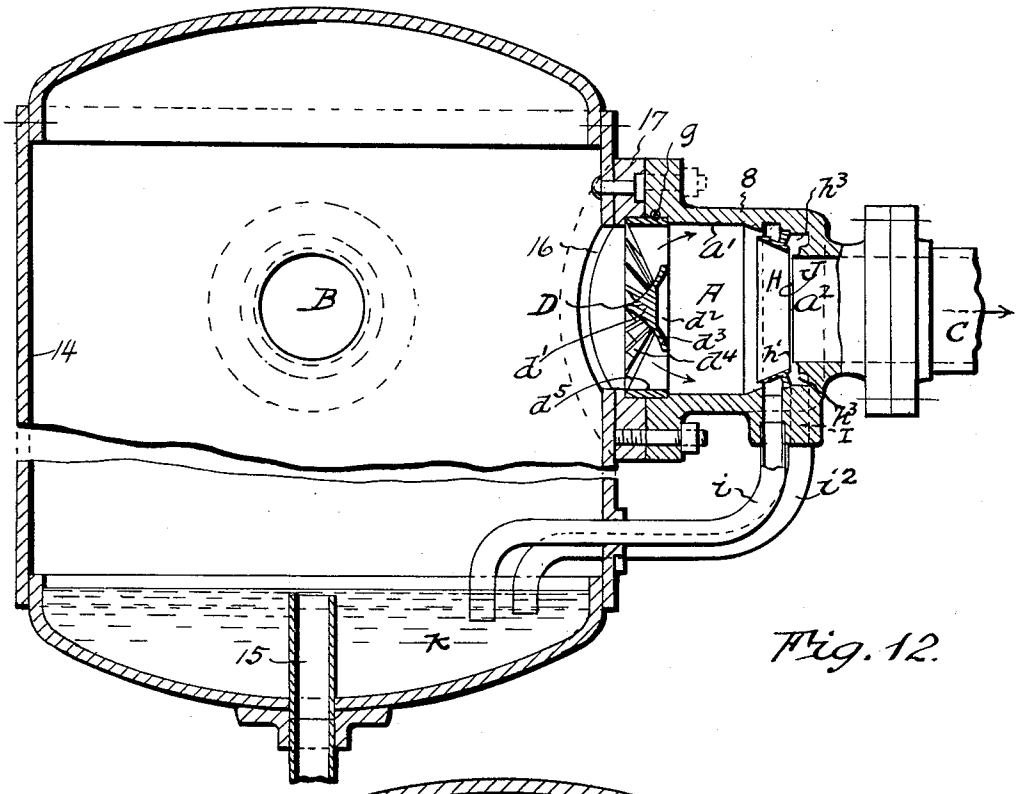



Fig. 12.

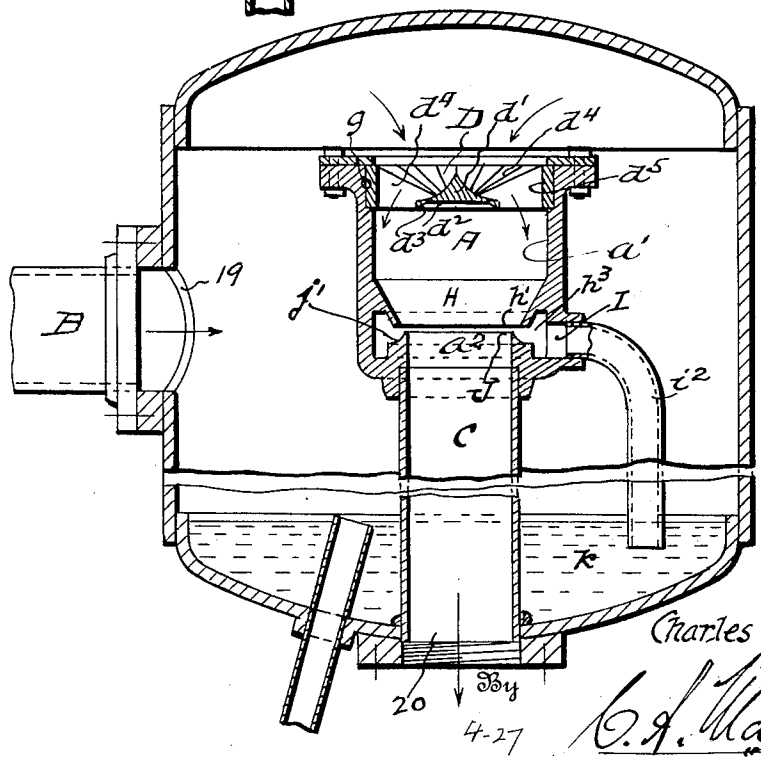



Fig. 13.

Inventor

Charles G. Hawley.

C. G. Mason Attorney

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LINE SEPARATOR AND GRADER

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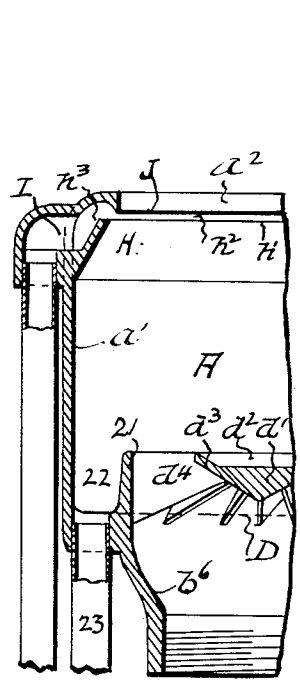



Fig. 17.

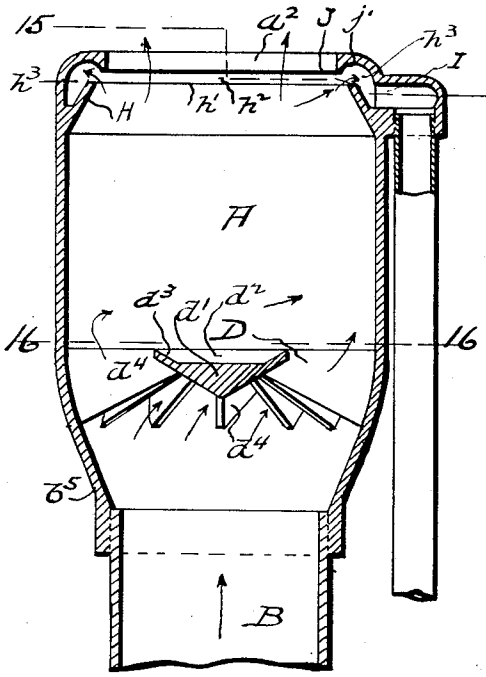



Fig. 14.

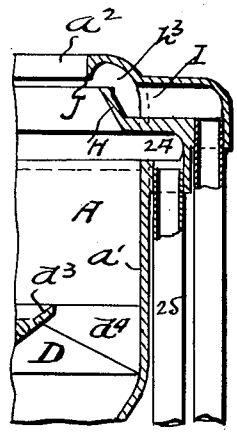



Fig. 18.

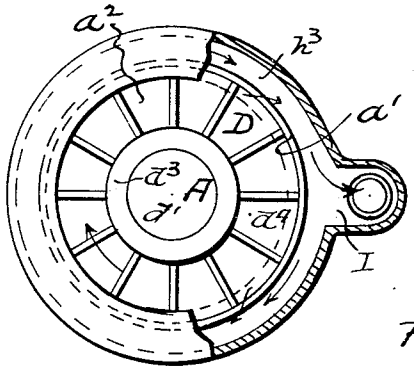



Fig. 15.

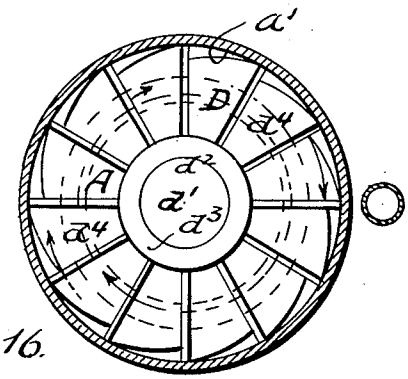



Fig. 16.

Inventor.
Charles G. Hawley.
By C. A. Mason Attorney

Patented Oct. 17, 1933 1,930,476

# UNITED STATES PATENT OFFICE

1,930,476

## LINE SEPARATOR AND GRADER

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

Application November 29, 1927, Serial No. 236,519
Renewed July 27, 1932

7 Claims. (Cl. 183—85)

The invention relates to improvements in the art of separating various substances from flowing fluids, and the invention comprises a separator adapted for inclusion in fluid lines or pipes.

This separator is of a centrifugal type. That is, 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 are collected and removed from 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" and "entrained substances" as used herein are 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.

As will presently appear, the invention is generic in character, being capable of many uses and different embodiments. It is not limited to a special use or class of uses; and, certain of the steps and parts of the highly perfected invention may be omitted in operations of the easier sorts.

The invention as a whole and its several steps, parts and elements will be described by reference to the accompanying drawings. Therein several forms of the novel centrifugal-fixture or separator are shown as a guide to the effective use of the invention.

In the drawings:—

Fig. 1 represents a horizontally positioned line separator adapted for use as a grader;

Fig. 2 is a transverse section on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged sectional detail taken from Fig. 1 and illustrating the preferred construction of the race rings employed in a separator of the grader type;

Fig. 4 is a view illustrating a modified form of the race rings;

Fig. 5 is a longitudinal and horizontal section illustrating the invention as adapted for employment in high pressure lines, such as gas and steam lines;

Fig. 6 illustrates the entering side or end of the whirl promoting tuyère thereof;

Fig. 7 is a transverse section on the line 7—7 of Fig. 5;

Fig. 8 is a longitudinal section of a line separator of slightly modified form and having a whirl promoting tuyère of another type;

Fig. 9 is an end view of such tuyère as it appears when removed from the casing, and, partly in section, as upon the irregular line 9—9 of Fig. 8;

Fig. 10 illustrates another form of the high pressure line separator, having a whirl promoting tuyère of still another kind;

Fig. 11 is an end view of said tuyère, partly in section, as upon the line 11—11 of Fig. 10;

Fig. 12 is a vertical section of a combined line receiver or drum and separator embodying this invention;

Fig. 13 is a vertical section showing the invention in the form of a wholly self-contained line receiver and separator;

Fig. 14 is a vertical section depicting the invention in a form specially adapted for employment as an exhaust head;

Fig. 15 is a plan section on the irregular line 15—15 of Fig. 14;

Fig. 16 is a horizontal section on the line 16—16 of Fig. 14;

Fig. 17 depicts a desirable modification of the exhaust head or vertical separator, which adapts it for use in exhaust or discharge lines which emit very heavily burdened carriers; and

Fig. 18 illustrates another form of the invention which may be employed with heavily burdened carriers.

The invention is of a very simple nature, although the number of drawings would seem to imply an intricate invention. The simplicity of the invention and the scope and dependability of its operation adapt it for extensive use in these and many other forms and the invention is not limited or confined to any one of the designs herein appearing. Its greater scope will presently appear and be further defined by the appended claims.

This novel separator is of the fixed or non-rotative type. In every case it has a casing which extends in the direction of the carrier flow. This casing is generally round; and, contains the generally cylindrical separating chamber A, defined by the inner wall $a'$. The latter comprises the initial separation surface of the device. That surface ($a'$) should be round, rather than polygonal in cross-section or even conical in form,

and while the term cylindrical as used herein and in the appended claims is only relative, it signifies an easily machined and the most efficient form; and, any decided departure from a round shape lessens the efficiency of the separator.

For reasons hereinafter stated the chamber, A, is of only slightly greater diameter than the inlet pipe or conduit B, or than the outlet pipe or conduit C, with which the separator is to serve. The chamber, A, is co-axial with the outlet $a^2$ of the separator, and usually is co-axial with the inlet pipe B. Specifically stated, the diameter of the separator outlet $a^2$ determines the dimensions of the other parts.

The inlet end of the casing may be freely open to the incoming carrier, as represented in Figs. 12 and 13, or various parts may be added (see parts $b'$, $b^2$, $b^3$, $b^4$, $b^5$, $b^6$, respectively in Figs. 1, 5, 8, 10, 14 and 17) to adapt it for ready connection with the carrier inlet pipe B and the easy entrance of the carrier.

The receiving end of the casing contains, in fixed, non-rotative position, a whirl promoting member or tuyère, which serves to subdivide and tangentially divert the flowing carrier and cause the carrier to whirl or rotate vigorously within the separating chamber A; i. e., while passing through the separator. By the tangential direction and whirling motion of the carrier the foreign substances are thrown outward; against the restraining wall $a'$.

Three kinds of tuyères are shown in the drawings. For easy identification and differentiation, these tuyères according to kind, are marked D, E and F. Whatever the individual form, the whirl promoting tuyère is characterized by a plurality of inclined or tangential blades positioned in the path of the flowing carrier; and, serves to subdivide the main stream into many streams tangentially, and, to direct them whirlingly toward the wall $a'$.

Not all of the carrier actually contacts or impinges the wall $a'$, but the foreign substances contained by the tangentially divided streams are, reliably and dependably, thrown or whirled outward and against that wall and then move spirally toward the outlet $a^2$; there to be intercepted and disposed of in the manner presently to be described.

A similar qualification is to be noted concerning the throwing out of the foreign substances. Not all thereof immediately reach the restraining wall $a'$ when they leave the blades of the tuyère. Every whirling body or vortex tends to draw substances across its ends and into its axial center. To nullify this action each tuyère D, E and F is provided with a part or device which in one or another way first readily accepts the stray substances moving toward the vortex axis, then with a surprising degree of perfectness stops such movement, and, then holds such stray substances under the whirling influence of the vortex until, finally, the substances take on a rotative velocity which causes them to be centrifugally discharged against the restraining wall $a'$.

A whirl-promoting element or tuyère of the novel type shown in Figs. 5, 6, 12 and 13, includes a round central portion which, advantageously, may be of equal or less diameter than the separator outlet $a^2$. The inner or forward side of the part $d'$ contains a concavity or sink $d^2$ the margin $d^3$ of which is conical; i. e., forwardly and outwardly inclined. During operation, a void or lesser pressure region exists in the sink; and, it may at once be explained that the stray substances which whirling tend toward the vortex center, are caught on the flaring margin $d^3$ and, as explained, returned or thrown outward to join the major quantity on the restraining wall $a'$. Many substantially radial blades $d^4$ extend from the central part $d'$ and, at their outer ends, are joined by a convenient peripheral band or ring $d^5$. Thus the tuyère unit D is completed, usually in a single casting. The blades $d^4$ are preferably inclined at an angle of forty-five degrees to the axis of the separator, which is sufficient to produce the whirling motion in the passing carrier and not so great as to materially check the movement of the carrier, which would result in an objectionable pressure drop. Finally, and to the same end, the openings or tuyère components between the blades $d^4$ are preferably of an aggregate area that much exceeds the area of the separator outlet $a^2$ so that the carrier shall approach that outlet with the least possible hindrance. The working area of the tuyère D and the ability to use a small part or vortex cone $d'$ have direct relation to the hereinafter explained smallness of the diameter of the separating chamber A in relation to the separator outlet. Most conveniently, and as a means to lessen the obstruction to the incoming carrier, the part $d'$ may be designed as a complete conical part which presents its apex to the incoming stream.

The tuyère E of Figs. 8 and 9 accomplishes the same work of subdividing the incoming stream and projecting or whirling the foreign substances against the separator wall $a'$. However it is of the barrel type and comprises a circumferential series of tangential blades $e^4$, all having the same direction, which join the end plate $e^6$ to the end ring $e^5$. The opening within the ring $e^5$ is of substantially the same diameter as the opening within the circumferential series of blades. The ring $e^5$ in this case is flanged downwardly and provided with an interlocking edge $e^7$ for engagement by the two parts of the separator casing. Thus the tuyère is fixed in the casing. The vortex breaking member or cone $e'$, in this case extends centrally from the end plate $e^6$ and is characterized by the sink $e^2$ and the flaring edge or margin $e^3$, which perform the function of intercepting the stray substances and returning them outwardly. The incoming stream enters the tuyère E from the exterior thereof as shown by the arrows in Fig. 9. The subdivided streams join in producing a violent whirling motion which results in the separation of the foreign substances and in the centrifugal projection of the same from the forward end of the tuyère and against the wall $a'$ of the separating chamber A.

The whirl-promoting tuyère F of Figs. 10 and 11 again accomplishes the same work of projecting the foreign substances against the separator wall $a'$ of that structure. It is of the barrel type, but unlike the tuyère of Fig. 8 receives the carrier stream internally and immediately directs the subdivided streams outwardly. The tuyère F comprises a circumferential series of blades $f^4$ which join the base ring $f^5$ and the smaller end member $f'$. In this case the member $f'$ besides forming the whole bottom or forward end of the tuyère, also forms the vortex cone and is characterized by the concavity or sink $f^2$, presented toward the outlet $a^2$, and by the flaring edge or margin $f^3$. To reduce the resistance to the flow the inner side $f^6$ of the member $f'$ is preferably in the form of a cone which presents its apex to the incoming stream.

Whatever the form of the tuyère, it is held

tightly in the casing and to positively prevent its rotation it is locked thereto by one or more keys *g*, or by being made integral therewith as in the cases illustrated in Figs. 14 to 18.

Being whirlingly thrown against the inner surface *a'* of the chamber A the separated substances are driven spirally forward thereon, toward the outlet of the separator. 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.

As directly bearing upon the solution of the problem of final separation, it is important first to realize that the substances to be removed are not uniformly distributed in the carrier stream, and next, any method of tangential introduction ultimates in streams which progress spirally upon the separating wall. On reaching a smaller outlet, like that shown herein, the longitudinal movement of these whirling streams is partly interrupted and they strongly tend to form standing or re-entrant waves. Such waves 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 somewhat deflected by an annular shoulder beyond the discharge opening, the spirals do not all terminate at that opening; and the separating performance is to that extent defeated. 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 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 differences of diameter.

Referring again to the drawings, it is to be seen that the direct approach to the outlet is formed by a conical ring or portion H (in practice best having a pitch of about thirty degrees to the axis) 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 forward edge or end, *h'*, is of slightly larger diameter than the outlet $a^2$, and, does not quite reach the first transverse plane of that opening. An annular opening $h^2$, of considerable longitudinal length, therefore remains between the end *h'* and the actual end wall of the separator casing. The annular space $h^3$ surrounding the cone H is termed a race. Arriving at the edge *h'* the foreign substances fly off centrifugally into the race $h^3$.

At a point in the outer wall of the race (hence in the wall of the separator) is a discharge opening I through which the separated substances are removed. It is rare that the free escape of carrier is permitted at the opening I. 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 type or merely a large collecting chamber.

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 those clearly shown in Figs. 2, 7 and 15, which facilitates the prompt discharge without materially interfering with the whirling motion of the carrier fluid occupying the race.

Attention is again called to the spacing away of the cone H from the outlet $a^2$ 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.

As is well known the sweeping of a stream across an opening tends to create a vacuum therein. Hence the avoidance of that condition herein is attained by the just mentioned spacing and by making the forward end of the accumulator cone H larger in diameter than the outlet $a^2$. To the same end the outlet itself is characterized by a pressure effecting lip J which overhangs the race and tends to direct the marginal portion of the carrier stream into the race $h^3$ and thereby a 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 *j'* at the base or root of the lip J, 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 definite high pressure in the race $h^3$ is of special importance in cases where it is desirable to discharge the foreign substances directly into the vessel from which the carrier is derived as in the case of boilers and evaporators and as exemplified in Figs. 12 and 13. In such cases the pipe $i^2$ leading from the separator is terminated at a lower point and there sealed by the liquid content of the vessel. The pressure differences are so slight

that the sealing liquid (K in Figs. 12 and 13) rises but a little way in the eject pipe $i^2$.

The operations above described are the same whether the separator is worked under pressure or under suction, but usually a given separator works with somewhat higher efficiency when changed from operation under pressure to operation under suction. Apparently the explanation lies in the fact that under suction a better equalized condition obtains throughout the separating chamber and race.

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 thrust against the wall $a'$ 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 and under either high or low velocities; and with either heavier or lighter or fluctuating burdens of foreign substances. Also that according to the nature or characteristics of the substances caught, the vessel or casing may be upright or upside down or positioned on its side. Also the pocketing, that is the reception and ultimate disposal of the separated substances may be accomplished in any manner best suited to the case in hand, without altering the essential operations within the casing. As indicated, the casings may be of various shapes and axial positions, as best suited to particular conditions and uses.

In cases involving carrier vapors that may or should be either liquefied or withhold from condensation, the operation may be favorably affected by respectively cooling and heating the separator. The jacketing, or the spraying of the separator walls internally or externally, to that end, present no mechanical difficulties; and, may be carried out by means so well known and understood that it has been deemed unnecessary to complicate the drawings by attempting to illustrate them. Nevertheless these temperature-affecting steps are definite features of this invention and may well be relied upon as aids in the many separating operations conducted hereunder.

This invention lends itself to grading operations of various kinds, this being accomplished by the provision of a sequence of the described races; at slight sacrifice in the matter of increased separator diameter and total pressure drop. Examples appear in Figs. 1, 5 and 12 hereof.

The grader illustrated in Figs. 1 to 4 is perhaps the most desirable for use in separating dry materials from carrier streams; and, is of a construction which lends itself to easy manufacture and extension. The race immediately in advance of the outlet or orifice of the separator is identified by the reference characters H, $h'$, $h^2$, $h^3$, I and J, and its operation need not be again described; except that the outlet opening of this particular grader takes the form of a conical throat $h^x$, to ease the outflow and for the purpose of standardizing cross sections of the several race rings. In this case, two races $h^y$ and $h^z$ are added; with increasing diameters in order that the relations before described shall be preserved. There are three race rings, fastened one to the other. The largest ring is fastened to a flange upon the shell A' of the separator. Another flange $c'$ serves to connect the smallest ring with the outlet pipe C. The race rings are identical in axial cross section and will best be understood on reference to Fig. 3. As there shown each ring or race member comprises a ring portion, 1; at the inner periphery of which is the cone portion 2, generally identified as the part H, which bears the dispersing shoulder $j'$. At the outer periphery of the portion 1 is a backwardly turned flange 3 which terminates in a radially disposed flange 4. In each case the flange 4 of one ring rests upon the portion 1 of the next larger ring and is fastened thereto by a plurality of bolts 5. Preferably the shell A' is considerably smaller than the race of the largest ring; whereby an overhanging annular shoulder 6 is provided for that race. Each race as shown in Figs. 1 and 2 has a peripheral discharge opening, presumably leading to a collecting pocket (not shown).

As before stated, the carrier whirls through the chamber A and the separated substances progress spirally on the wall $a'$. At the end thereof the coarser particles, or the heavier, enter the race $h^z$ and are discharged therefrom. The lighter particles are more difficult to retain in the race and are swept upon the first of the accumulator cones, being thus led to the race $h^y$ where the operation of separation between coarser and finer, or heavier and lighter, particles is repeated. Still finer particles are similarly lodged in the last race. The remaining impalpable powder, if any, may pass out through the orifice $a^2$, to be collected by a succeeding separator. Or obviously, the number of races may be increased; to the point where the carrier will be quite completely purified, or for the mere purpose of increasing the number of grades.

The modified race construction shown in Fig. 4 serves to more completely pocket or isolate the content of each race $h^v$ and $h^w$, in effect choking the annular entrances from the races so that the finest material may not even enter the first race or races.

In dealing with steam lines and the like which contain not only the burdened carrier but also 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. To this end, as shown in Figs. 5 to 7, the cone H instead of being an angular continuation of the separating wall $a'$ is spaced therefrom, to provide an initial disposal throat $h^7$ and a second race $h^8$. Further, the wall $a'$ is continued in the inclined portion $h^9$, to somewhat slow down the movement of the foreign substances and to provide the external shoulder $h^{10}$ within the race $h^8$. The race $h^8$ has a peripheral discharge (see dotted lines Figs. 5 and 7). The pressures maintained in the races $h^8$ and $h^3$ differ slightly. Therefore separate automatic traps should be connected therewith or the eject pipes $i^2$ and $i^3$ should be first joined by an equalizing trap (not shown) before being led to a single disposal trap.

Other novel features appearing in Fig. 5 include:—1st, the two-part casing (7) (8) between which parts the tuyère D is clamped; 2nd, the tightly fitted and keyed part (9) which comprises the cone H; and, third, the tightly-fitted part 10 which comprises the pressure effecting lip J of the fixture. Altogether, this fixture is of minimum size, weight and cost. Its usefulness extends

to steam, air, gas and liquid lines, under both high and low pressures.

The separator of Fig. 8 has a separately fitted and keyed cone member 11 which can easily be machined and which obviates the otherwise rather difficult and uncertain "coring" of that end of the fixture. This fixture also takes advantage of the special tuyère shown (one having the central opening and the rib $e^8$) to provide a first stage discharge for the separated substances at 12. This is of use in dealing with slugs when the fixture is employed as an up-goer or even when it is used in horizontal position.

By way of direct contrast, the fixture of Fig. 10 is shown as a down-goer. It may be of less length (for piping of given size) because of the immediate entrance of the carrier through the member $b^4$ and into the tuyère F. Other features of this fixture will be clearly read in Figs. 10 and 11. The fixture is adapted for use in any other position.

Where large or frequent slugs of liquid must be cared for it is well to supplement the primary fixture hereof by combining it with a capacious receiver or drum, such as disclosed in Figs. 12 and 13. Both are ideally adapted for use above steam boilers, to completely rid the steam of moisture and solids before it passes to a superheater or to a prime mover.

Referring to Fig. 12, 14 represents a simple drum or receiver adapted to contain steam or the like at high pressure and having a drain 15 at its bottom. The steam is presumed to enter through the lateral pipe B and to leave through the opening 16 substantially at right angles thereto. The slugs of water fall into the bottom and maintain the before-mentioned seal K. At the opening 16 is a saddle ring 17, and to this is fastened the tuyère D and the member 8, etc., taken from Fig. 5. The outgoing steam or other carrier is therein completely dried or purified. That particular fixture has two ejects, therefore a second pipe *i* also leads through the side wall of the drum 14 and is bent downward to be sealed by the liquid K.

The apparatus of Fig. 13 is of the down-goer type, receiving the steam through the side of the drum at 19 and discharging it through the bottom at 20. The part C becomes a standpipe within the drum and upon its upper end bears the now familiar separator. The latter being much as shown in Fig. 5 but having only a single race at the bottom. Obviously plural races may be used. In this case the tuyère D in itself forms the receiving end of the fixture.

It frequently happens that it is desirable that the outlet of a fixture or separator shall be much larger than the carrier pipe. An example is met in the requirements of steam exhaust heads in which it is desirable to avoid back pressure in the exhaust pipe. In such cases, and as shown in Figs. 14 to 18, immediate advantage is had from the fact that the orifice or outlet may be of nearly the same size as the separating chamber of this separator. The latter and the whirl producing tuyère may therefore be made as large as desired and the orifice may be extended without lessening the efficiency of the typical separating race immediately below the same. Fig. 17 may be compared with Fig. 8 inasmuch as the upstanding rib 21 and the groove 22 with drain pipe 23 correspond in the matter of a first stage separation and relieve the top race from the heavy duty of handling slugs. Fig. 18 illustrates a further manner of handling slugs, the same comprising an intermediate, open race 24 with its drain pipe 25. These structures are extremely simple and each of these exhaust heads if desired may comprise a single thin walled casting.

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

1. A centrifugal line separator for unburdening fluids, comprising in combination, a casing containing a separating chamber provided with a central outlet orifice, the latter marked by an outwardly pitched annular lip in advance of said orifice, an accumulator co-axial with and converging radially toward said lip but of slightly larger diameter and separated therefrom, means which cause the burdened fluid to vortically enter said chamber and approach said accumulator, lip and orifice, the space between said lip and accumulator being formed to eject burden received from the periphery of the vortex, and a reaction sink disposed centrally within the receiving end of said chamber and adapted to exclude burden from the axial portion of the vortex.

2. A centrifugal line separator for unburdening fluids, comprising in combination, a casing containing a separating chamber provided with a central outlet orifice, the latter marked by an outwardly pitched annular lip in advance of said orifice, an accumulator co-axial with and converging radially toward said lip but of slightly larger diameter, means which cause the burdened fluid to vortically enter said chamber and approach said accumulator, lip and orifice, a race between and external to 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 receiving end of said chamber and adapted to exclude burden from the axial portion of the vortex.

3. A centrifugal separator comprising a casing containing a cylindrical separating chamber having at its end a central outlet of less diameter than said chamber, in combination with an interposed accumulator cone radially converging toward and forming the approach to said outlet, a race enclosing the end of said cone and the margin of said outlet, a whirl-producing tuyère at the opposite end of said casing, and a first-stage separating race interposed between said tuyère and said race at the outlet.

4. A centrifugal line separator for unburdening fluids, comprising in combination a casing containing a separator chamber provided with a central outlet orifice, the latter marked by an outwardly pitched annular lip in advance of said orifice, an accumulator coaxial with and radially converging toward said lip but of slightly larger diameter, a second accumulator and lip of larger diameter and interposed between said first named accumulator and said chamber, means which cause the burdened fluid to vortically enter said chamber and approach said accumulators, lips and orifice, and races between and external to said lips and respectively adapted to receive and eject burden successively received from the periphery of the vortex.

5. A centrifugal line separator for unburdening fluids, comprising in combination a casing containing a separator chamber, provided with a central outlet orifice, the latter marked by a series of outwardly pitched annular lips in advance of said orifice, a plurality of accumulators coaxial with and radially converging toward said respective lips but of successively slightly larger diameter, means which cause the burdened fluid to vortically enter said chamber and approach

said accumulators and means adapted to receive the eject burden received from the periphery of the vortex.

6. A centrifugal line separator for unburdening fluids, comprising in combination a casing containing a separator chamber provided with a central outlet orifice, the latter marked by an outwardly pitched annular lip in advance of said orifice, an accumulator coaxial with and radially converging toward said lip but of slightly larger diameter, a race between and external to said lip and accumulator, and adapted to receive and eject burden received from the periphery of the vortex; a second race larger than the first and positioned to first receive the foreign substances from said chamber, and means which cause the burdened fluid to vortically enter said chamber, and approach said accumulator, lip and orifice.

7. A centrifugal line separator for unburdening fluids, comprising in combination a casing containing a separator chamber provided with a central outlet orifice, the latter marked by an outwardly pitched annular lip in advance of said orifice, an accumulator coaxial with and radially converging toward said lip but of slightly larger diameter, a race between and external to said lip and accumulator and adapted to receive the eject burden received from the periphery of the vortex; a second race larger than the first and positioned to first receive the foreign substances from said chamber and being characterized by an annular shoulder over which such substances must pass to enter the same, and means which cause the burdened fluid to vortically enter said chamber and approach said accumulator, lip and orifice.

CHARLES GILBERT HAWLEY.