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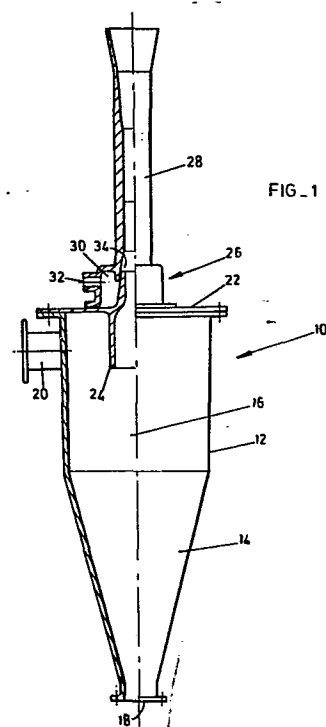
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54 Cyclones.

57 A cyclone separator (10) includes a ring jet pump (26) arranged to promote the flow of the fluid along the light fraction outlet (28). The suction inlet of the pump is constituted by the vortex finder (24) and the discharge outlet is constituted by the overflow branch (28). A vacuum transfer system is also disclosed including a group of relatively small diameter cyclone separators (114) of this construction preceded by a relatively large diameter cyclone separator (112), the small diameter cyclone separators containing such ring jet vortex finders.



- 2 -

"Cyclones"

THIS invention relates to cyclone separators and vacuum transfer systems using such separators.

In a cyclone separator a particle-laden fluid enters the cylindrical body of the cyclone tangentially through an inlet or feed pipe with
5 as little turbulence as possible so that the fluid rotates at a relatively high velocity. In the cyclone the fluid path involves a double vortex with the fluid spiralling downward at the outside and upward at the inside. The particles are subjected to large centrifugal forces and at least the heavy fraction thereof is moved
10 towards the wall of the cyclone. This heavy fraction spirals downwardly along the conical wall of the cyclone body so that the particles fall towards a solids discharge point at the apex of the cone. The fluid in the inner vortex is substantially clean or has entrained therein only the light fraction of the particles which travels upward
15 and leaves the cyclone through the light fraction outlet or clean gas outlet. The closing plate of the cylindrical portion of the cyclone body is perforated axially by a tube which extends part way or all the way along the axis of the cylindrical portion. That part of the tube which extends inside the cyclone body is known as the vortex finder
20 while the part that extends outside the cyclone body will be termed the overflow branch for the purposes of this specification.

It is an object of this invention to provide an improved cyclone wherein the improvement comprises the provision of a jet pump in the light fraction outlet, the jet pump being arranged to promote the
25 flow of the fluid along the light fraction outlet.

The jet pump may conveniently be a ring jet pump, the suction inlet of which is constituted by the vortex finder of the cyclone and the discharge outlet of which is constituted by the overflow branch.

5 The suction inlet of the jet pump may be profiled to decrease the pressure therein immediately downstream of the point of introduction of the motive fluid in sympathy with an increase in the induced flow through the jet pump.

10 It will be appreciated that the efficiency of the jet pump depends on the matching between the divergence ratio of the jet pump nozzle and the pressure into which the nozzle discharges. By profiling the vortex finder or suction inlet of the jet pump much in the manner of a venturi, stability of the pressure at the point at which the jet discharges is afforded as follows: When the flow to the cyclone is restricted the induced flow through the jet pump will be low so that
15 the pressure depression in the jet pump will be high as a consequence thereof. Should the flow to the cyclone be unencumbered the induced flow will be high as a result of which the pressure depression over the profile will be high. The matching of the internal profile of the vortex finder with the jet pump is merely a matter for calculation.

20 The ring jet pump may advantageously include a variable geometry nozzle described in the present applicant's co-pending R.S.A. Patent Application No. 80/4329. In this nozzle the inner and outer boundaries of the nozzle are movable with respect to one another to increase the cross-sectional area of the nozzle and to vary the expansion ratio of the
25 nozzle from a high value to unity upon movement in one direction to a predetermined position. Movement beyond this position will increase the cross-sectional area of the jet but will not alter the expansion ratio. The ratio of the cross-sectional area at the exit of the nozzle to that at the throat is the expansion ratio.

The invention includes a vacuum transfer system using a large diameter cyclone which precedes a relatively small diameter cyclone, or cyclones, arranged in parallel and containing the ring jet vortex finder or finders. The vortex finders may, of course, be profiled as is described above and the ring jet pump, or pumps, may be adjustable as described.

The invention is further described with reference to the accompanying drawings in which;

Figure 1 is an elevation, partly in section, of a cyclone with a ring jet pump incorporated in the light fraction outlet thereof;

Figure 2 is a diagrammatic representation of a vacuum transfer system utilising such a cyclone;

Figure 3 is a side elevation of the vacuum transfer system; and

Figure 4 is a plan view of the vacuum transfer system.

In vacuum transfer systems which involve constantly varying conditions it is often very difficult to maintain a constant pressure within the pump which is necessary to maintain maximum efficiency.

In Figure 1 a cyclone 10 has a body comprising a cylinder 12 attached to a truncated cone 14, the base of which is contiguous with the open end of the cylinder 12 to form a chamber 16. The truncated apex of the cone 14 is the heavy fraction outlet or solids discharge point 18. The cylinder wall is perforated tangentially near the closed end by a conduit 20 which does not penetrate the cylinder. This is the inlet or feed pipe.

The cylinder closing plate 22 is perforated axially by a tube 24 which extends down the centre of the chamber 16. The tube 24 is, in this embodiment, the suction inlet of a jet pump, generally indicated by a reference numeral 26, advantageously with a variable geometry nozzle as described in our co-pending application.

It will be evident that the suction branch 24 of the ring jet pump 26 has been substituted for the vortex finder of the prior art cyclones while the overflow branch of prior art cyclones is replaced by the discharge nozzle or conduit 28 of the jet pump 26. The motive fluid is brought into the plenum 30 of the jet pump 26 via an inlet 32.

The suction branch 24 is profiled in such a manner that, as induced flow increases, the pressure in the suction passage of the nozzle 34 decreases. But, as pressure loading across the pump increases, the flow will decrease in compensation so that a virtually constant pressure is maintained within the pump.

In Figure 2 a vacuum transfer system 100 comprises a large diameter cyclone 102 which precedes a relatively small diameter cyclone 104, or cyclones, arranged in parallel. The small diameter cyclone 104 contains the ring jet vortex finder.

In operation the jet pump causes a depression in the small high efficiency cyclone 104 the feed of which is connected to the overflow branch 106 of the large, low efficiency cyclone 102 which may include a large diameter nozzle or even a divergent nozzle. Thus, a depression exists in the large diameter cyclone 102 as well, inducing a flow along the conduit connected to its feed branch 108.

The vacuum transfer system shown in Figures 3 and 4 is similar to the one shown in the diagram in Figure 2, the system being pneumatic and supplied with compressed air from a manifold 110 which provides the motive fluid for the jet pumps (not shown) in the ring of small, high efficiency cyclones 114 surrounding the large, low efficiency cyclone 112. In Figure 4 it can be seen that the overflow branch 116 of the large cyclone 112 is connected to the inlets of the small cyclones 114 while the large cyclone 112 is fed externally by means of a conduit 120 connected to the feed branch 118 thereof.

Solids in the gaseous conveying medium enter the large cyclone 112 and all large or heavy material is therein removed. Only light or fine material therefore passes to the small cyclones 114 where it is removed from the gas stream. Only the gaseous medium itself
5 passes through the jet pump. Thus, the large cyclone is subjected to little wear owing to the low gas and particle velocities resulting from the large cross-sectional area of the feed nozzle exit. The small high velocity cyclones are subject to little wear owing to the small particle size and mass of the particles while the jet pumps are
10 subject to little wear as only a negligible carry-over passes through them. In addition, the annular jets protect the walls of the mixing chambers in the discharge nozzles of the jet pumps from abrasion.

The result is a vacuum transfer system which has a stability of operating point not possible with any other pneumatic system and
15 which exhibits a very low wear rate and has the advantage of simplicity.

CLAIMS

1.

5 A cyclone comprising a body formed with an inlet for a particle-laden fluid, a heaving fraction outlet and a light fraction outlet, which includes a vortex finder and an overflow branch, characterised in that the light fraction outlet is provided with a jet pump arranged to promote the flow of the fluid along the light fraction outlet.

2.

A cyclone according to claim 1 characterised in that the jet pump is a ring jet pump, the suction inlet of which is constituted by the vortex finder and the discharge outlet of which is constituted by the overflow branch.

3.

10 A cyclone according to claim 1 characterised in that the jet pump is a ring jet pump, the suction inlet of which is constituted by the vortex finder and the discharge outlet of which is constituted by the overflow branch, the nozzle of the jet pump including inner and outer boundaries which are axially movable with respect to one another to increase the
15 cross-sectional area of the nozzle and to vary the expansion ratio of the nozzle from a high value to unity upon movement in one direction to a predetermined position, movement beyond the predetermined position increasing the cross-sectional area of the jet but not altering the expansion ratio.

4.

A cyclone according to claim 3 characterised in that the suction inlet of the jet pump is profiled to decrease the pressure therein immediately downstream of the point of introduction of the motive fluid in sympathy with an increase in the induced flow.

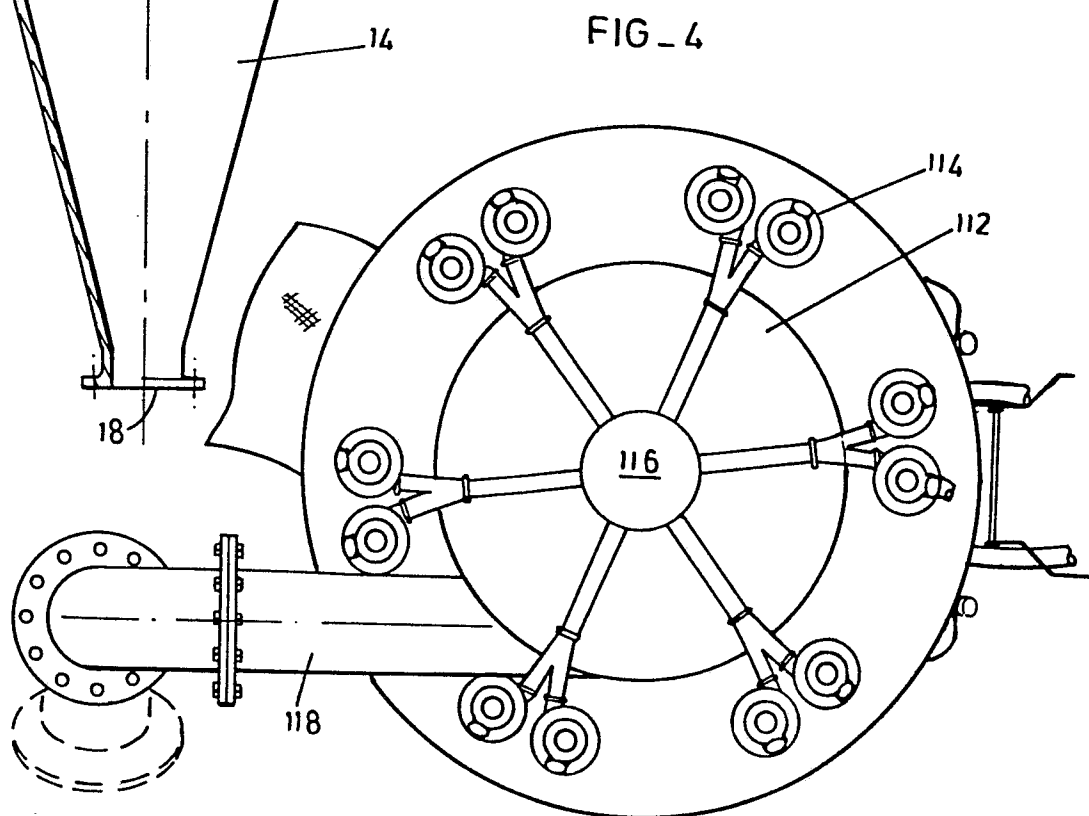
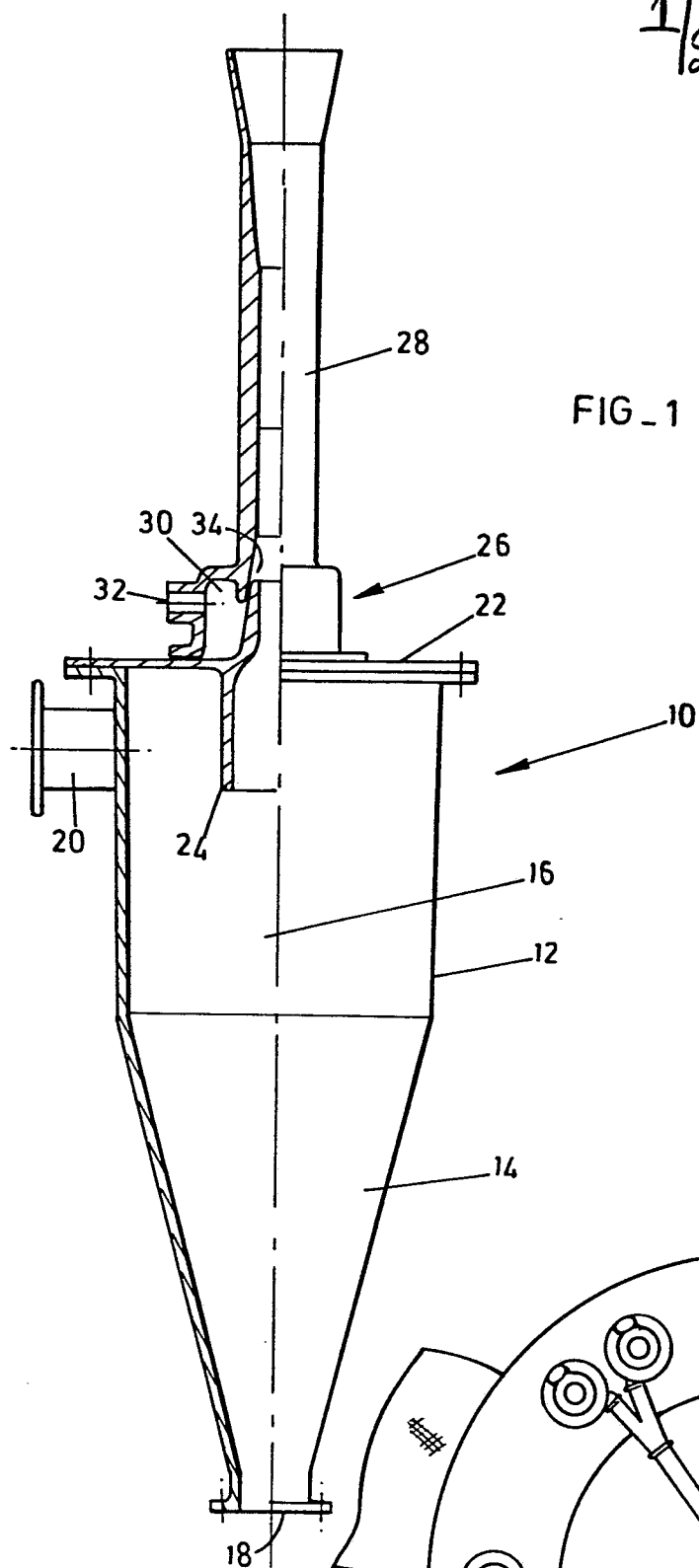
5.

A vacuum transfer system including a relatively small diameter cyclone preceded by a relatively large diameter cyclone, characterised in that the small diameter cyclone contains a ring jet vortex finder.

6.

A vacuum transfer system according to claim 5 characterised in that it includes a small diameter cyclone according to any one of claims 1 to 4.

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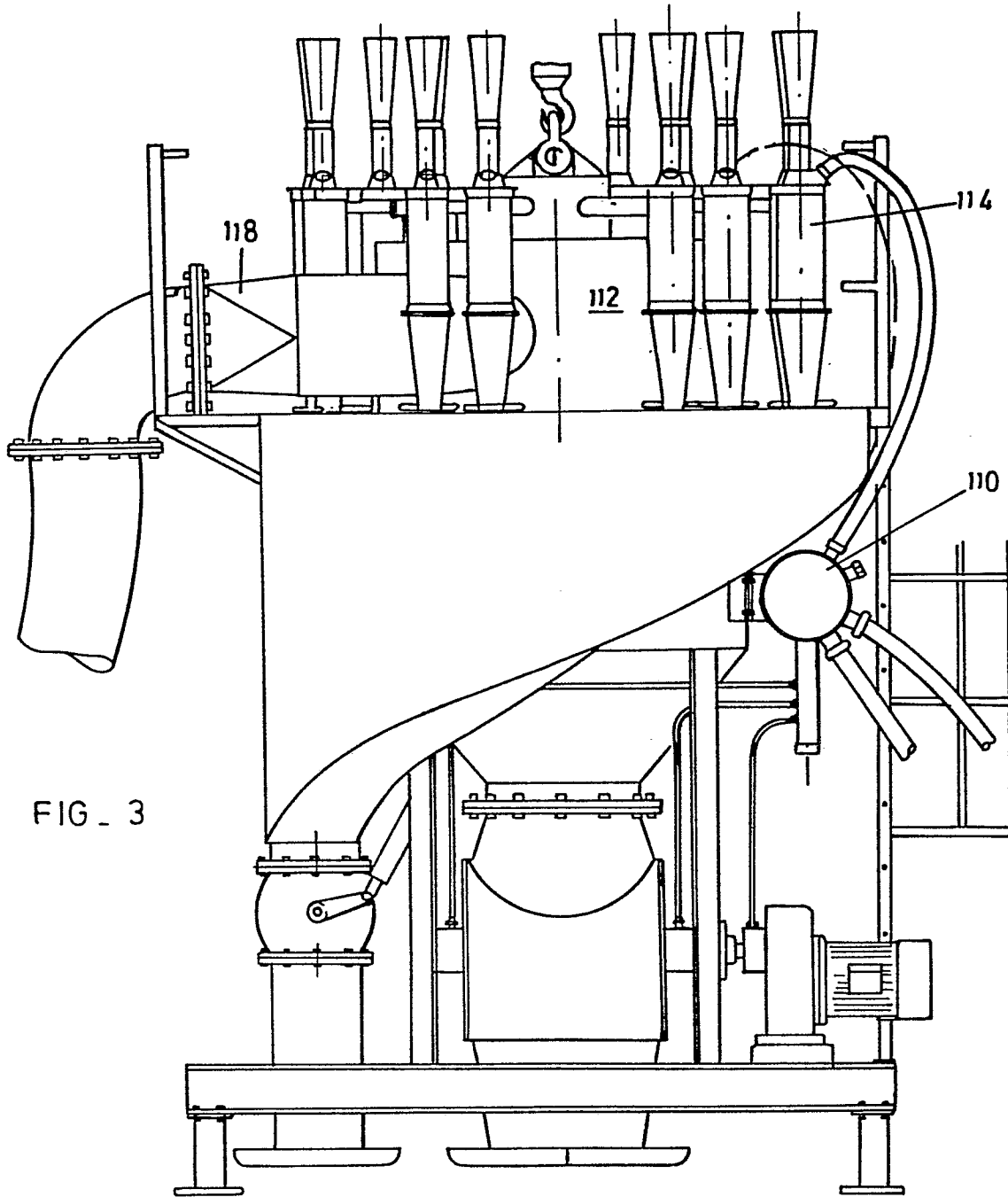


FIG. 3

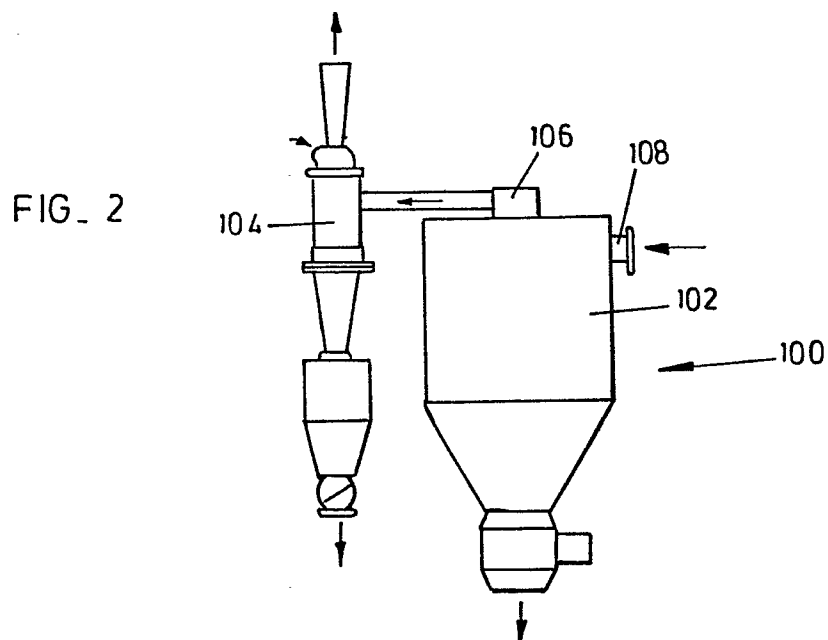


FIG. 2



European Patent
Office

EUROPEAN SEARCH REPORT

0046049

Application number

EP 81 30 3562

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	<u>FR - A - 913 231</u> (JOHN-EARL WATSON et al.) * page 2, lines 12-74; figures 1-3 * --	1,4,6	B 04 C 5/13 9/00 5/24
X	<u>US - A - 1 197 946</u> (F. PARDEE) * page 1, line 64 - page 2, line 65; figures 1,2 * --	1,4,6	
X	<u>US - A - 2 941 783</u> (O.L. STINSON) * column 3, line 57 - column 4, line 11; figures 1,2 * --	1,6	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
	<u>US - A - 2 399 249</u> (J.M. PERIGNAT) * page 1, left-hand column, line 41 - right-hand column, line 26; figure 1 * --	2-5	B 04 C
	<u>US - A - 1 421 845</u> (F. SCHMIDT) * page 1, line 50 - page 3, line 10; figures 1,2 * --	2-5	
A	<u>DE - A - 2 256 678</u> (KÖRTING A.G.) * page 26, line 10 - page 27, line 3; figure 13 * --	1	CATEGORY OF CITED DOCUMENTS
A	<u>FR - A - 1 087 702</u> (PHILIPS) -----		X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
 The present search report has been drawn up for all claims			&: member of the same patent family, corresponding document
Place of search		Date of completion of the search	Examiner
The Hague		12-11-1981	LAVAL