

Refuse Collection Device and System and Method of Collecting Refuse

Technical Field

The present invention relates to pneumatic refuse collection and transfer from a
5 collection point to an apparatus for further disposal.

Background

In many urban environments, people tend to live and work in multi-storey, if not
high-rise, buildings. In such densely populated environments, common facilities are
10 usually provided, for example, for removing unwanted materials or waste for further
disposal.

Figure 1 is a schematic view of a multi-storey building 10 with a known refuse
disposal and collection system 20. A common refuse chute or riser 22 is provided to
15 serve homes located in a vertical section of the building. Each home accesses the refuse
riser 22 through its own chute opening 24. At the base of each chute/riser 22, a collection
chamber 26 is provided. Each collection chamber 26 is connected to a suction system 30,
via a pipe 28 with a valve 29 between the collection chamber 26 and the pipe 28. A
single clearing pipe 28 may service several such collection chambers 26. The suction
20 system 30 is located at a refuse collecting centre 14 and connects to the clearing pipe 28
by a docking port 34. A controller 32 controls the operation of the suction system 30 and
valves 29. In use, the refuse accumulated at each collection chamber is periodically
sucked through the clearing pipe 28 into a refuse bin 16 located in the refuse collecting
centre 14 for temporary storage and further disposal. The refuse bin 16 may typically be
25 a large container, which, once full, is hauled away by a hook-lift truck.

These known refuse collection and transfer systems are expensive and once they
are built, they are even more expensive to upgrade or replace. There is a need for more
adaptable methods of collecting and disposing of refuse, in which the capacities are
30 scalable according to the needs.

Summary

According to one aspect of the present invention, there is provided a refuse suction device. The refuse suction device comprises: a suction pump, a pre-pump inlet duct and a post-pump outlet duct, the pre-pump inlet duct and the post-pump outlet duct being in fluid communication with each other through the pump. The refuse suction
5 device also comprises at least one pre-pump or post-pump external port in fluid connexion with the pump; and a refuse collection compartment comprising a refuse and air inlet port and an outlet, the refuse and air inlet port and the outlet being in fluid communication with each other through the refuse collection compartment. The refuse collection compartment outlet is in fluid communication with the pre-pump inlet duct.
10 The at least one pre-pump or post-pump port is operable to connect to a port, pre the pump, of another, similar refuse suction device.

According to a second aspect of the present invention, there is provided a refuse collection system comprising a plurality of individual refuse suction devices, each as
15 defined in the first aspect. The devices are connected in parallel to add airflows together and/or in series to add suction pressures together.

According to a third aspect of the present invention, there is provided a refuse collection system comprising a plurality of interconnected individual refuse suction
20 devices. Each of the refuse suction devices comprises: a suction pump, a pre-pump inlet duct and a post-pump outlet duct, the pre-pump inlet duct and the post-pump outlet duct being in fluid communication with each other through the pump, at least one pre-pump external port and at least one post-pump external port in fluid connexion with the pump. At least one pre-pump external port or at least one post-pump external port of one of the
25 devices is connected to at least one post-pump external port of another one of the devices.

According to a fourth aspect of the present invention, there is provided a system according to the third aspect, wherein one or more of the suction devices is as defined in
30 the first aspect.

According to a fifth aspect of the present invention, there is provided a system for collecting refuse comprising a plurality of suction devices. The suction devices are

connected together in parallel, to add airflows together, in series with a refuse collecting line.

According to a sixth aspect of the present invention, there is provided a system
5 for collecting refuse comprising a plurality of suction devices. The suction devices are connected together in series, to add suction pressures together, in series with a refuse collecting line.

According to a seventh aspect of the present invention, there is provided a
10 method of providing a refuse collection system comprising providing a system according to any one of the second, fifth and sixth aspects.

According to an eighth aspect of the present invention, there is provided a method of collecting refuse comprising providing a system according to any one of the
15 second, fifth and sixth aspects and activating one or more of the suction devices of the system to suck up refuse.

According to a ninth aspect of the present invention, there is provided a method of collecting refuse comprising connecting a plurality of suction devices. The suction
20 devices are connected in parallel to add airflows together, in series with a source of refuse through a refuse collecting line. The method further comprises activating one or more of the suction devices to suck refuse from the source of refuse, through the refuse collecting line.

According to a tenth aspect of the present invention, there is provided a method of collecting refuse comprising connecting a plurality of suction devices. The suction
25 devices are connected in series to add suction pressures together, in series with a source of refuse through a refuse collecting line. The method further comprises activating one or more of the suction devices to suck refuse from the source of refuse, through the
30 refuse collecting line.

According to an eleventh aspect of the present invention, there is provided a method of assembling a refuse collecting system comprising connecting together a

plurality of refuse collection devices as defined in the first aspect, in parallel to add airflows together and/or in series to add suction pressures together.

Brief Description of the Drawings

5 This invention is now described by way of non-limiting examples, with reference to the accompanying drawings, in which:-

 Figure 1 schematically illustrates a known refuse disposal and collection system in a multi-storey building;

 Figure 2 is a schematic internal side view of a combination refuse suction unit of
10 the present invention;

 Figure 3 is a schematic internal top plan view of the refuse suction unit of Figure 2;

 Figure 4 is a schematic perspective view of two combination suction units linked together;

15 Figures 5A and 5B illustrate two parallel arrangements of two combination suction units;

 Figures 6A and 6B illustrate a series arrangement of two combination suction units;

 Figure 7 is a schematic internal side view of a split suction unit of the present
20 invention;

 Figure 8 is a schematic internal top plan view of the refuse suction unit of Figure 7;

 Figure 9 is a schematic internal side view of a refuse unit of the present invention;

25 Figures 10A and 10B illustrate a parallel and series arrangement, respectively, of two split suction units;

 Figures 11A and 11B illustrate scaled-up arrangements of pairs of split suction units;

 Figure 12 illustrates an arrangement of multiple refuse units and multiple suction
30 units; and

 Figures 13A and 13B illustrate valve positions of the multiple refuse units of Figure 12.

Detailed Description

Figure 2 is a schematic side view of a combination refuse suction unit 100 according to a first embodiment of the present invention. Figure 3 is a schematic internal
 5 top plan view of the refuse suction unit of Figure 2.

The combination suction unit 100, in non-limiting summary, is a mobile pneumatic combination suction and refuse storage unit 100 having a housing with two compartments 102, 104. The first compartment 102 is an air suction compartment and
 10 contains a blower or vacuum pump 112 and has pre-pump, inlet ports 114 and post-pump, outlet ports 116. The second compartment 104 is a refuse storage compartment and has a refuse collection portion and an inlet port 122 and an outlet. An interconnecting duct 124 connects the outlet of the second compartment 104 to the inlet of the first compartment 102. An input hose 126 connects the inlet port 122 of the
 15 second compartment 104 to a source of refuse. When the vacuum pump 112 is turned on, it draws refuse and air along the input hose 126 into the second compartment 104. The refuse drops onto the floor of the second compartment 104 and the air passes out to the first compartment 102 and to the vacuum pump. A plurality of such suction units can be connected in series and/or in parallel, using post-pump and pre-pump ports as
 20 appropriate. A series connexion allows the suction pressure to be scaled up according to need. A parallel connexion allows the air flow to be scaled up according to need. The capacity of the pneumatic system made up of such units is thus flexible and scalable.

The combination suction unit 100 has a housing 132, in the form of a mobile
 25 container, shaped and sized to be mounted onto a vehicle, such as a lorry or truck or railway wagon. The housing 132 is substantially a parallelepipedon having a length of between about 2m and 8m, and a width and a height of about 3m in each direction. It may, for instance be shaped and sized as a standard freight container. The sides of the housing 132 are enclosed with side and top and bottom panels 134. Some of these panels
 30 134 are fixed whilst others may be detachable, openable or hinged in whole or in part. Some of these panels 134 have openings and others have ventilation louvres (not shown).

The refuse combination suction unit 100 has two compartments, a first, air suction compartment 102, and a second, refuse storage unit 104, at opposing first and second ends of the housing 132. The two compartments are separated by a partition wall 136.

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The first compartment 102 has a vacuum pump 112 situated in a main duct, which extends between a water scrubber 138 and a first air filter 140, also in the first compartment 102. The water scrubber 138 is mounted at the base of the housing 132, near the partition wall 136. The first air filter 140 is mounted at the top of the housing 10 132 near the first end of the housing, at the opposite end of the first compartment 102. The first air filter 140 exhausts air to the atmosphere.

A pump inlet portion 142 of the main duct, between the pump 112 and the water scrubber 138 has two pre-pump branch ducts 144 extending off it, one to each side of the 15 first compartment 102. A pump outlet portion 146 of the main duct, between the pump 112 and the first air filter 140 also has two post-pump branch ducts 148 extending off it, also one to each side of the first compartment 102. An outlet portion 150 of the main duct extends from where the two post-pump branch ducts 148 branch off, to the first air filter 140.

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The pump inlet portion 142 of the main duct rises vertically from the water scrubber 138 to about half the height of the housing 132, then extends in a horizontal direction to the pump 112. The pre-pump branch ducts 144 extend from the main duct in this horizontal portion. The pump outlet portion 146 of the main duct extends 25 horizontally from the pump 112, close to the end of the housing 132, then turns vertically upward to the first air filter 140. The post-pump branch ducts 148 extend from the main duct at the elbow where this horizontal portion joins the vertical portion.

The two pre-pump branch ducts 144 extend through panels on either side of the 30 housing 132 and each terminates with a flanged pre-pump side port 114. The pre-pump side ports 114 are closeable with matching flange plates. Likewise the two post-pump branch ducts 148 extend through panels on either side of the housing 132 and each terminates with a flanged post-pump side port 116. The post-pump side ports 116 are

closeable with matching flange plates. The pre-pump side ports 114 and post-pump side port 116 are of the same size and have the same cover fittings. The flanges on the pre-pump side ports and the post-pump side ports 116 act as connectors for connecting hoses thereto, for connexion to connectors or ports of other suction units.

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A pre-filter valve 156 sits in the vertical portion of the pump outlet portion 146 of the main duct, above the post-pump branch ducts 148. The pre-filter valve 156 is operable to open or close the pump outlet portion 146 of the main duct, between the post-pump branch ducts 148 and the first air filter 140. A pre-pump branch valve 158 sits in
 10 each of the pre-pump branch ducts 144, between the pump inlet portion 142 of the main duct and the pre-pump side ports 114. A post-pump branch valve 160 sits in each of the post-pump branch ducts 148, between the pump outlet portion 146 of the main duct and the post-pump side ports 148. Each of the branch valves 158, 160 is independently operable to open or close the respective branch duct 114, 148.

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An engine 162 is also mounted in the first compartment 102 for running the vacuum pump 112. Other types of primer may be used for running the pump, for example an electric motor or a fluid motor, as appropriate.

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The second compartment 104 has a compactor plate 164 within it. The compactor plate 164 extends substantially across the width of the second compartment 104. The compactor plate 164 is operated by means of actuators (not shown) which push (or pull) it from its rest position by the partition wall 136 to an extended position nearer an opposing wall of the second compartment 104, at the second end of the housing 132.

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The second compartment 104 has an inlet port 122 in its ceiling, to which is attached the outlet of a refuse inlet hose 126. A mesh filter 166 extends across much of the rest of the ceiling of the second compartment 104 and is enclosed above the ceiling by an end of an interconnecting duct 124. The interconnecting duct 124 extends between
 30 from above the ceiling of the second compartment 104, through the ceiling of the first compartment 102, beside the partition wall 136, and terminates just above the water level in the water scrubber 138. A flexible rubber flap 168 extends down from the end of the interconnecting duct 124 into the water in the water scrubber 138.

The water scrubber 138 is provided to clean incoming air of dust. The water scrubber 138 also includes a second filter 170, in this example of plastic material, above the water. The second air filter 170 acts as a barrier to prevent water droplets in the air coming off and out of the water from escaping the water scrubber 138.

The combination suction unit 100 provides a closed fluid path from the second end of the inlet hose 126 to the ends of the four branch ducts 114, 148 and to the output of the first air filter 140.

When the primer is turned on, the vacuum pump 112 sucks air in from the pump inlet portion 142 of the main duct. Provided the two pre-pump branch ducts 144 are closed, this, in turn reduces the pressure in the water scrubber 138. Air is then drawn down the interconnect duct 124 and through the water scrubber 138. This, in turn takes air from the second compartment 104, which, in turn draws air into the refuse inlet hose 126. Thus, there is a suction or vacuum at the second end of the refuse inlet hose 126. Water from the water scrubber 138 is not drawn up into the pump inlet portion 142 of the main duct due to the presence of the rubber flap which flexes and allows air to pass over the water if the pressure difference is sufficiently large.

Air from the pump 112 is expelled through the pump outlet portion 146 of the main duct. Assuming the post-pump branch ducts 148 are closed and the pre-filter valve 156 is open, the air passes to the first air filter 140 and thence to the atmosphere. The first air filter 140 typically includes activated charcoal to remove odours.

The first air filter 140 and the water scrubber 138 can be at interchanged positions. In that case the second filter may not be necessary, as it may not matter if there water in the air being exhausted. The aim is to remove the dust and odours before the air is exhausted. Alternatively, the first air filter 140 and the water scrubber 138 may be at the same end (before or after the pump 112).

In use, as shown in Figure 2, the vacuum generated by the vacuum pump 112 draws in air and refuse through the flexible hose 126 into the second compartment 104.

Due partly to the decrease in the velocity of the air stream C1 as air is sucked into the second compartment 104, and partly due to the effect of gravity, the refuse or waste materials separate from the air stream C1 and accumulate at the bottom of the second compartment 104. The air C2, mostly devoid of refuse, is then evacuated at the top of the
 5 second compartment 104 through the mesh filter 166 to the inlet of the interconnect duct 124, the interconnect duct 124, the second air filter 170, the water scrubber 138, the vacuum pump 112 and the first air filter 140.

The end panel of the second compartment 104 has a tailgate 172, for external
 10 access. The tailgate 172 is pivoted along its top edge and is openable by means of actuators (not shown in Figure 3). The tailgate 172 allows the refuse collected in the second chamber 104 to be discharged and allows cleaning and maintenance of at least the second compartment 104.

15 On the underside of the combination suction unit 100, near both ends of the housing 132 is a pair of rollers 174. These rollers 174 are arranged along a common axis parallel to the width of the housing 132 but are spaced apart so that each roller 174 is near the edge of the housing 132.

20 At the end of the housing 132, on the outside of the end of the first (suction) compartment 102, is a lug 176 for mechanical handling of the combination suction unit 100. There is also a similar lug 176 on the other (refuse compartment) end, for improved flexibility of handling.

25 The combination suction unit 100 is typically used to replace both the suction system 30 and bins 16 at the refuse collecting centre 14 (of the system shown in Figure 1). The free end of the hose 126 is connected to the docking port 34 at the bin end of the pipe 28 to allow refuse to be sucked out from the collection chambers 26. The combination suction unit 100 may either be left at the refuse collecting centre 14 until it is full, or else driven
 30 to the location, filled up and taken away, without having to be lowered to the ground. Thus it can operate in a hybrid fashion, on the ground or on a truck. For use on the truck, the combination suction unit 100 may be provided with a drive input to drive the pump 112, rather than using the internal primer of the combination suction unit 100. The

hybrid operational capability enables a combination suction unit 100 to be used more efficiently than if it were stationary. For example if the access to the refuse is at different points (i.e. there are multiple docking stations), as happens in larger developments or several small developments, the one combination suction unit 100 on a truck can be driven round to each of them in turn. The refuse from all the multiple docking stations can be emptied into the combination suction unit 100 before it proceeds to the dump, transfer station or incineration plant. This contrasts with a separate unit sitting by each single docking station and remaining idle most of the time.

The suction unit 100 does not kept operate continuously but is used occasionally as necessary. After each use, the compactor plate 164 is driven in the lengthwise direction of the second compartment 104 to compact the refuse therein.

When the second compartment 104 of a combination suction unit 100 is filled up with refuse, or otherwise to be removed from the refuse collecting centre 14, the combination suction unit 100 is hoisted up, for example by a hook-lift truck. This can be in a single action or by lifting up one end by way of one of the lugs 176 and dragging the unit 100 over the end of a truck with the help of the rollers 174 supporting the lower end of the unit. A hook lift truck can also be used to deliver the combination suction unit 100 and push it into place on its rollers 174.

The suction units 100 not only can be used alone, but can also be used in pairs (or in greater numbers if necessary).

Figure 4 shows a parallel arrangement of two suction units 100A, 100B, side by side. In this arrangement, the pre-pump and post-pump ports 114, 116 of the suction units 100A, 100B, which are on the outside sides of the combinations units (i.e. on the sides not directly facing the other suction unit) are closed by their flanges (and/or by their branch valves). A connector station 182 is sited between the two suction units 100A, 100B, at a position roughly in the centre between the four pre-pump and post-pump ports 114, 116 on the inside sides of the two suction units 100A, 100B.

The inside side (right side) pre-pump port 114A and the post-pump port 116A of the first suction unit 100A are connected to the connector station 182. The connexion is via a first, three-way connector hose 184A. The inside side (left side) pre-pump port 114B and the post-pump port 116B of the second suction unit 100B are also connected to the connector station 182. The connexion is via a second, three-way connector hose 184B. The first connector hose 184A has a first pre-pump inlet 188A and a first post-pump inlet 190A, connected to the pre-pump port 114A and the post-pump port 116A, respectively, of the first suction unit 100A. The second connector hose 184B has a second pre-pump inlet 188B and a second post-pump inlet 190B, connected to the pre-pump port 114B and the post-pump port 116B, respectively, of the second suction unit 100B. The input hose 126 of one of the suction units (in the case of Figure 4, the input hose 126A of the first suction unit 100A) has its free end attached to a port on the top of the connector station 182. The input hose 126 of the other suction unit (in the case of Figure 4, the input hose 126B of the second suction unit 100B) has its free end attached to a port on the top of a docking station 192.

The connector station 182 is a generally cuboid block with four ports to it: one in each of two opposing sides and one in one of the other sides and one in the top. Within the block the ports all interconnect, such that there can be fluid flow between any and all of them. Any port can be closed from the outside by way of a cover plate. Alternatively, closeable gates may be provided at each port to close the port even when a hose is connected to the outside of the port. The docking station 192 is similar, except that it lacks the additional port in one of the sides and may have a port in its underside instead of or in addition to that in the top side. Connector stations and docking stations may even be the same, except in their use.

Figures 5A, 5B, 6A and 6B are top plan views of the arrangement of Figure 4. The valves in the suction units (and gates in the connector station, where present) are opened and closed in particular arrangements to obtain parallel and series airflows through the suction units, as described below. In each Figure, in the arrangement being exemplified, the air flow is shown by way of arrows through those portions of the various hoses that are not closed off at one end. The solid arrow lines in Figures 5A and

5B represent airflow in a parallel arrangement (as described). The dashed arrow lines in Figures 6A and 6B represent airflow in a series arrangement (as described).

5 The dotted arrow lines in Figures 5A and 5B and the combined dotted and dashed arrow lines in Figures 6A and 6B represent airflow routes from the connector station 182 that may be used as alternatives to using the input hoses 126A, 126B, as are also described later.

10 In Figures 5A and 5B a higher flow of air, compared with that achieved by a single suction unit, can be achieved to convey waste materials through the refuse collection system, by arranging the various gates and valves to provide a parallel suction arrangement. The pre-pump branch valve 158A and the post-pump branch valve 160A of the first suction unit 100A are closed, as is the post-pump branch valve 160B of the second suction unit 100B. The pre-pump branch valve 158B of the second suction unit
15 100B is open. The pre-pump branch valve 158A of the first suction unit 100A is shown in dotted lines because, in the alternative arrangement of Figure 5A, described later, it is open.

In Figure 5A, the flow of air between the two suction units 100A, 100B, is:

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- i) through the input hose 126B of the second suction unit 100B;
 - ii) from the left side pre-pump port 114B of the second suction unit 100B;
 - iii) through the pre-pump inlet 188B of the second connector hose 184B, to a side port of the connector station 182;
 - iv) through the connector station 182, to the top port of the connector station
25 182;
 - v) through the input hose 126A of the first suction unit 100A; and
 - vi) to the input port of the first suction unit 100A.

30 There is further airflow within the two suction units 100A, 100B. Within the second suction unit 100B, the airflow splits at the pre-pump branch duct, with some air passing out through the left side pre-pump port 114B, as mentioned above. The rest of the air passes through the main duct of the second suction unit 100B, including through the blower 112B and the outlet portion 150B. In the first suction unit 100A, all the air

passes through the main duct, including through the blower 112A and the outlet portion 150A.

There is no airflow through the first connector hose 184A, since it is closed at
 5 both connexions to the first suction unit 100A (alternatively, it could be due to the relevant port at the connector station being closed). The pre-filter valves of the first and second suction units 100A, 100B are open. With this arrangement, the suction of the first suction unit 100A is added in parallel to the suction of the second suction unit 100B, joining together in the pre-pump duct of the second suction unit 100B, for increased
 10 airflow in the input hose 126B of the second suction unit 100B. Refuse 194 is drawn into and deposited in the refuse storage compartment of the second suction unit 100B. All that passes through to the refuse storage compartment of the first suction unit 100A is air.

15 Once the refuse storage compartment 104 of the second suction unit 100B is (sufficiently) full of refuse 194, the free ends of the two input hoses 126 are swapped over, to the position shown in Figure 5B. That is that the input hose 126A of the first suction unit 100A is connected to the top port of the docking station 192 and the input hose 126B of the second suction unit 100B is connected to the top port of the connector
 20 station 182. The only valve and gate positions that are different are those to the pre-pump inlets 188A, 188B of the first and second connector hoses 184A, 184B. The pre-pump inlet 188A of the first connector hose 184A is open while the pre-pump inlet 188B of the second connector hose 184B is closed. The pre-pump branch valve 158B of the second suction unit 100B is shown in dotted lines because, in the alternative arrangement
 25 of Figure 5B, described later, it is open.

The flow of air in the parallel arrangement of Figure 5B, between the two suction units 100A, 100B, is:

- i) through the input hose 126A of the first suction unit 100A;
- 30 ii) from the right side pre-pump port 114A of the first suction unit 100A;
- iii) through the pre-pump inlet 188A of the first connector hose 184A, to a side port of the connector station 182;

- iv) through the connector station 182, to the top port of the connector station 182;
- v) through the input hose 126B of the second suction unit 100B; and
- vi) to the input port of the second suction unit 100B.

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There is further airflow within the two suction units 100A, 100B. Within the first suction unit 100A, the airflow splits at the pre-pump branch duct, with some air passing out through the right side pre-pump port 114A, as mentioned above. The rest of the air passes through the main duct of the first suction unit 100A, including through the blower 112A and the outlet portion 150A. In the second suction unit 100B, all the air passes through the main duct, including through the blower 112B and the outlet portion 150B.

In Figure 5B, there is no airflow through the second connector hose 184B, since it is closed at both connexions to the second suction unit 100B (alternatively, it could be due to the relevant port at the connector station being closed). With this arrangement, the suction of the second suction unit 100B is added in parallel to the suction of the first suction unit 100A, joining together in the pre-pump duct of the first suction unit 100A, for increased airflow in the input hose 126A of the first suction unit 100A. Refuse 194 is drawn into and deposited in the refuse storage compartment of the first suction unit 100A. All that passes through to the refuse storage compartment of the second suction unit 100B is air.

Figures 6A and 6B show a series arrangement for increased suction pressure. The greater suction pressure can be achieved to convey waste materials through the refuse collection system, by arranging the various gates and valves to provide a series suction arrangement. For these arrangements the post-pump branch valve of one of the post-pump ducts leading to one of post-pump inlets of one of the connector hoses is open, whilst the pre-pump branch valves of the pre-pump ducts leading to both pre-pump inlets of both connector hoses are closed.

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In Figure 6A, the second connector hose 184B is connected between a side port of the connector station 182 and the post-pump port 116B of the second suction unit 100. The pre-pump branch valve 158A and the post-pump branch valve 160A of the first

suction unit 100A are closed, as is the pre-pump branch valve 158B of the second suction unit 100B. The post-pump branch valve 160B of the second suction unit 100B is open. The pre-pump branch valve 158A of the first suction unit 100A is shown in dotted lines because, in the alternative arrangement of Figure 6A, described later, it is open.

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In Figure 6A, the flow of air between the two suction units 100A, 100B, is:

- i) through the input hose 126B of the second suction unit 100B;
- ii) from the left side post-pump port 116B of the second suction unit 100B;
- iii) through the post-pump inlet 190B of the second connector hose 184B, to a
10 side port of the connector station 182;
- iv) through the connector station 182 to the top port of the connector station 182;
- v) through the input hose 126A of the first suction unit 100A; and
- vi) to the input port of the first suction unit 100A.

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There is further airflow within the two suction units 100A, 100B. Within the second suction unit 100B, the air passes through the main duct including through the blower 112B, as far as the left side post-pump port 116B. In the first suction unit 100A, all the air passes through the main duct, including through the blower 112A and the
20 outlet portion 150A.

In Figure 6A, there is no airflow through the first connector hose 184A, since it is closed at both connexions to the first suction unit 100A (alternatively, it could be due to the relevant port at the connector station being closed). Further the pre-filter valve of the
25 second suction unit 100B is also closed. The pre-filter valve of the first suction unit 100A is open. With this arrangement, the suction of the first suction unit 100A is added in series to the suction of the second suction unit 100B, coming into the second suction unit 100B at the post-pump duct. Thus the pump of the second suction unit 100B is further increasing the suction pressure (reducing the absolute pressure). Refuse 194 is
30 drawn into and deposited in the refuse storage compartment of the second suction unit 100B. All that passes through to the refuse storage compartment of the first suction unit 100A is air.

Once the refuse storage compartment of the second suction unit 100B is (sufficiently) full, of refuse 194 the free ends of the two input hoses 126 are swapped over, to the position shown in Figure 6B. That is that the input hose 126A of the first suction unit 100A is connected to the top port of the docking station 192 and the input hose 126B of the second suction unit 100B is connected to the top port of the second connector station 184A. The only difference in valve and gate positions are that the post-pump branch valve 160A of the first suction unit 100A is open, while the post-pump branch valve 160B of the second suction unit 100B is closed. The pre-pump branch valve 158B of the second suction unit 100B is shown in dotted lines because, in the alternative arrangement of Figure 6B, described later, it is open.

The flow of air in the series arrangement of Figure 6B, between the two suction units 100A, 100B, is:

- i) through the input hose 126A of the first suction unit 100A;
- ii) from the right side post-pump port 116A of the first suction unit 100A;
- iii) through the post-pump inlet 190A of the first connector hose 184A, to a side port of the connector station 182;
- iv) through the connector station 182, to the top port of the connector station 182;
- v) through the input hose 126B of the second suction unit 100B; and
- vi) to the input port of the second suction unit 100B.

There is further airflow within the two suction units 100A, 100B. Within the first suction unit 100A, the air passes through the main duct including through the blower 112A, as far as the right side post-pump port 116A. In the second suction unit 100B, all the air passes through the main duct, including through the blower 112B and the outlet portion 150B.

In Figure 6B, there is no airflow through the second connector hose 184B, since it is closed at both connexions to the second suction unit 100B (alternatively, it could be due to the relevant port at the connector station being closed). With this arrangement, the suction of the second suction unit 100B is added in series to the suction of the first suction unit 100A, coming into the first suction unit 100A at the post-pump duct. Thus

the pump of the first suction unit 100A is further reducing the pressure. Refuse 194 is drawn into and deposited in the refuse storage compartment of the first suction unit 100A. All that passes through to the refuse storage compartment of the second suction unit 100B is air.

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In the arrangements of Figures 4 to 6, the input into every suction unit is via its input hose. In alternative arrangements, the air input for the secondary suction unit, that is the one whose input hose is not connected to the docking station, is via the pre-pump port, via the pre-pump inlet to the relevant connector hose. This is the arrangement that is illustrated by way of the dotted arrow lines in Figures 5A and 5B and the combined dotted and dashed arrow lines in Figures 6A and 6B. The valves to the relevant ports in each Figure is shown in different dotted lines to indicate that for these alternative arrangements, those valves would be open rather than closed. The input hose of the secondary suction unit in each case is disconnected from the connector station and the top port closed with a plate. Alternatively, the gate to the top port is closed instead.

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With the alternative arrangement of Figure 5A, airflow is:

- i) through the input hose 126B of the second suction unit 100B;
- ii) from the left side pre-pump port 114B of the second suction unit 100B;
- 20 iii) through the pre-pump inlet 188B of the second connector hose 184B, to a side port of the connector station 182;
- iv) through the first connector hose 184A (and out through the pre-pump inlet 188A); and
- v) through the pre-pump port 114A of the first suction unit 100A, without
- 25 passing through the second compartment of the first suction unit 100A.

With the alternative arrangement of Figure 5B, airflow is:

- i) through the input hose 126A of the first suction unit 100A;
- ii) from the right side pre-pump port 114A of the first suction unit 100A;
- 30 iii) through the pre-pump inlet 188A of the first connector hose 184A, to a side port of the connector station 182;
- iv) through the second connector hose 184B (and out through the pre-pump inlet 188B); and

- v) through the pre-pump port 114B of the second suction unit 100B, without passing through the second compartment of the second suction unit 100B.

For the alternative arrangements of Figures 5A and 5B, the only difference
 5 between them is the input hose that is connected to the docking station. The positions of the valves and gates are unchanged between them.

With the alternative arrangement of Figure 6A, airflow is:

- i) through the input hose 126B of the second suction unit 100B;
- 10 ii) from the left side post-pump port 116B of the second suction unit 100B;
- iii) through the post-pump inlet 190B of the second connector hose 184B, to a side port of the connector station 182;
- iv) through the first connector hose 184A (and out through the pre-pump inlet 188A); and
- 15 v) through the pre-pump port 114A of the first suction unit 100A, without passing through the second compartment of the first suction unit 100A.

With the alternative arrangement of Figure 6B, airflow is:

- i) through the input hose 126A of the first suction unit 100A;
- 20 ii) from the right side post-pump port 116A of the first suction unit 100A;
- iii) through the post-pump inlet 190A of the first connector hose 184A, to a side port of the connector station 182;
- iv) through the second connector hose 184B (and out through the pre-pump inlet 188B); and
- 25 v) through the pre-pump port 114B of the second suction unit 100B, without passing through the second compartment of the second suction unit 100B.

The interconnections between the pre-pump and post-pump ports of the suction units may be direct, rather than through an intervening connector station.

30

The arrangements of Figures 4 to 6 show just two suction units together. It is possible to use more in series or parallel, or even in a combination of both, but may be economically disadvantageous compared with the further embodiments described below.

The use of three such suction units is more likely where a pipe to the docking station 192 is blocked. For example, where two suction units on the ground are joined in series (for example as in Figure 6A) and a third suction unit is brought along on a truck. The input hose of the additional suction unit is then added in series, connected to the outside (left side) post-pump port of the first suction unit 100A. The connexion would be in a similar manner to the connexion of the input hose 126A of the first suction unit 100A to the left side post-pump port 116B of the second suction unit 100B.

In the arrangements of Figures 4 to 6, a two three-way hoses 184A, 184B and a single connector station 182 are used. The two three-way hoses 184A, 184B may be replaced with two two-way hoses. Thus when changing arrangements to that of either one of Figures 6A and 6B, the ends of the hoses connected to the one or both of the connector station 182 stay in place, but the other end of one or both hoses will have to be moved to the other of the relevant pre-pump or post-pump output port. In another alternative arrangement, there are two connector stations, one connected to both pre-pump ports and the other connected to both post-pump ports. A connector hose runs between an additional side port in the two connector stations.

The hoses between suction units and the connector station and the docking station are generally flexible (although they can be rigid).

Figure 7 is a schematic internal side elevation of a separate, split suction unit 200, according to a second embodiment of the invention. Figure 8 is a schematic internal top plan view of the split suction unit 200 of Figure 7. The split suction unit 200 of Figures 7 and 8 is similar to the combination suction unit 100 described above, except that it lacks the second compartment 104 and has no pre-pump side ducts and pre-pump ports, except a single inlet.

The split suction unit 200, in non-limiting summary, is a mobile pneumatic suction unit 200 having a housing with a single compartment 202. The compartment 202 is an air suction compartment and contains a vacuum pump 212 and has post-pump, outlet ports 216. An interconnecting duct 224 connects an input hose 226 to the inlet of the compartment 202. When the vacuum pump 212 is turned on, it draws air along the

input hose 226 to the vacuum pump. A plurality of such suction units can be connected in series and/or in parallel, using post-pump and pre-pump ports as appropriate, usually by way of suitably positioned connector stations. A series connexion allows the suction pressure to be scaled up according to need. A parallel connexion allows the air flow to be scaled up according to need. The capacity of the pneumatic system made up of such units is thus flexible and scalable. A scalable pneumatic suction system uses separate (split) suction units 200 and refuse units 300. The suction units 200 are combined in series and/or parallel to produce a combined airflow of a desired speed and pressure. The combined airflow is linked to a parallel arrangement of refuse units 300, to fill those units from a refuse source, one by one.

The split suction unit 200 has a housing 232, in the form of a mobile container, shaped and sized to be mounted onto a vehicle, such as a lorry or truck or railway wagon. The housing 232 is substantially a parallelepipedon having a length of about 6.5m (a standard container size) and a width and a height of about 3m in each direction. It may, for instance be shaped and sized as a standard freight container. The sides of the housing 232 are enclosed with side and top and bottom panels 234. Some of these panels 234 are fixed whilst others may be detachable, openable or hinged in whole or in part. Some of these panels 234 have openings and others have ventilation louvres (not shown).

The compartment 202 has a vacuum pump 212 situated in a main duct, which extends between a water scrubber 238 and a first air filter 240, also in the compartment 202. The water scrubber 238 is mounted at the base of the housing 232, near an end wall of the suction unit. The first air filter 240 is mounted at the top of the housing 232 near the first end of the housing, at the opposite end of the compartment 202. The first air filter 240 exhausts air to the atmosphere.

A pump inlet portion 242 extends from the water scrubber 238 to the pump 212. A pump outlet portion 246 of the main duct, between the pump 212 and the first air filter 240 has two post-pump branch ducts 248 extending off it, one to each side of the compartment 202. An outlet portion 250 of the main duct extends from where the two post-pump branch ducts 248 branch off, to the first air filter 240.

The pump inlet portion 242 of the main duct rises vertically from the water scrubber 238 to about half the height of the housing 232, then extends in a horizontal direction to the pump 212. The pump outlet portion 246 of the main duct extends horizontally from the pump 212, close to the end of the housing 232, then turns vertically upward to the first air filter 240. The post-pump branch ducts 248 extend from the main duct at the elbow where this horizontal portion joins the vertical portion.

The two post-pump branch ducts 248 extend through panels on either side of the housing 232 and each terminates with a flanged post-pump side port 216. The post-pump side ports 216 are closeable with matching flange plates. The flanges on the post-pump side ports 216 act as connectors for connecting hoses thereto, for connexion to ports of connectors or other suction units.

A pre-filter valve 256 sits in the vertical portion of the pump outlet portion 246 of the main duct, above the post-pump branch ducts 248. The pre-filter valve 256 is operable to open or close the pump outlet portion 246 of the main duct, between the post-pump branch ducts 248 and the first air filter 240. A post-pump branch valve 260 sits in each of the post-pump branch ducts 248, between the pump outlet portion 246 of the main duct and the post-pump side ports 248. Each of the branch valves 260 is independently operable to open or close the respective branch duct 248.

An engine 262 is also mounted in the compartment 202 for running the vacuum pump 212. Other types of primer may be used for running the pump, for example an electric motor or a fluid motor, as appropriate.

The interconnecting duct 224 extends through the ceiling of the compartment 202, beside an end wall of the suction unit, and terminates just above the water in the water scrubber 238. A flexible rubber flap 268 extends down from the end of the interconnecting duct 224 into the water in the water scrubber 238.

The water scrubber 238 is provided to clean incoming air of dust. Above the water of the water scrubber 238 is a second air filter 270 to clean the air of any

components that passed between the rubber flap 268 and the water, and to reduce the water content of the air coming off and out of the water scrubber 238.

5 The suction unit 200 provides a closed fluid path from the free end of the inlet hose 226 to the ends of the two branch ducts 248 and to the output of the first air filter 240.

When the primer is turned on, the vacuum pump 212 sucks air in from the pump inlet portion 242 of the main duct. This, in turn, reduces the pressure in the water
10 scrubber 238. Air is then drawn down the interconnect duct 224 and through the free end of the inlet hose 226. Thus, there is a suction or vacuum at the second end of the inlet hose 226.

Air from the pump 212 is expelled through the pump outlet portion 246 of the
15 main duct. Assuming the post-pump branch ducts 248 are closed and the pre-filter valve 256 is open, the air passes to the first air filter 240 and thence to the atmosphere. The first air filter 240 typically includes activated charcoal to remove odours.

The first air filter 240 and the water scrubber 238 (together with the second air
20 filter 270) can be at interchanged positions. The aim is to remove the dust and odours before the air is exhausted. Alternatively, the first air filter 240 and the water scrubber 238 may be at the same end (before or after the pump 212). With such an arrangement, the second air filter may not be necessary.

25 On the underside of the suction unit 200, near both ends of the housing 232 is a pair of rollers 274. These rollers 274 are arranged along a common axis parallel to the width of the housing 232 but are spaced apart so that each roller 274 is near the edge of the housing 232.

30 At the end of the housing 232, by the interconnecting duct 224, on the outside, is a lug 276 for mechanical handling of the suction unit 200. There is also a similar lug 276 on the other interconnecting duct end, for improved flexibility of handling.

Figure 9 is a schematic internal side elevation of a refuse unit 300. The refuse unit 300 is similar to the second compartment 104 of the combination suction unit 100 described earlier.

5 The refuse unit 300 has a closed housing 332 with a refuse storage compartment 304 containing a compactor plate 364. The compactor plate 364 extends substantially across the width of the refuse storage compartment 304. The compactor plate 364 is operated by means of actuators (not shown) which push (or pull) it from its rest position by a first internal wall 336, near a first end of the refuse unit 300 to an extended position
10 nearer an opposing, second end of the refuse storage compartment 304.

 The refuse storage compartment 304 has an inlet port 322 in the first end wall 320. The inlet port 322 has mountings for attachment thereto of an inlet hose, whose other end is connected to a refuse source. An inlet duct 330 extends into the refuse
15 storage compartment 304 and passes down through a mesh filter 366 extending across most of the ceiling of the refuse storage compartment 304. The first internal wall 336 is spaced a short distance from the first end wall 320 of the first end of the refuse unit 300. The space between the first internal wall 336 and the first end wall 320 of the refuse unit 300 forms an outlet duct 324, which joins up with the space above the mesh filter 366
20 and below the top of the refuse unit 300. The outlet duct 324 exits the refuse unit 300 at an outlet port 350. The outlet port 350 has mountings to allow attachment of the free end of an input hose of a suction unit.

 In use, if the inlet port 322 of the refuse unit 300 is connected to a refuse source
25 and the outlet port 350 is connected to a suction source, the vacuum generated by the suction source draws in air and refuse through the inlet port 322 into the refuse storage compartment 304. Due partly to the decrease in the velocity of the air stream as air is sucked into the refuse storage compartment 304, and partly due to the effect of gravity, the refuse or waste materials separate from the air stream and accumulate at the bottom
30 of the refuse storage compartment 304. The air, mostly devoid of refuse, is then evacuated at the top of the refuse storage compartment 304 through the mesh filter 366 to the outlet port 350, and thence to the suction source.

The end panel of the refuse storage compartment 304 has a tailgate 372, for external access. The tailgate 372 is pivoted along its top edge and is openable by means of actuators (not shown). The tailgate 372 allows the refuse collected in the second chamber 304 to be discharged and allows cleaning and maintenance of at least the refuse storage compartment 304.

On the underside of the combination suction unit 300, near both ends of the housing 332 is a pair of rollers 374. These rollers 374 are arranged along a common axis parallel to the width of the housing 332 but are spaced apart so that each roller 374 is near the edge of the housing 332.

At the first end of the housing 332 is a lug 376 for mechanical handling of the combination suction unit 300. There is also a similar lug 376 on the other (tailgate) end, for improved flexibility of handling.

A set including at least one split suction unit 200 and at least one refuse unit 300 is typically used to replace both the suction system and bins at the refuse collecting centre (of the system shown in Figure 1). The free end of the inlet hose of a suction unit 200 is connected to the outlet port of a refuse unit 300. The free end of an inlet hose to the refuse unit 300 is connected to a docking port at the bin end of the pipe to allow refuse to be sucked out from the collection chambers. The refuse unit 300 may either be left at the refuse collecting centre until it is full, or else driven to the location, filled up and taken away, without having to be lowered to the ground. Thus it can operate in a hybrid fashion, on the ground or on a truck. Such an arrangement requires an accessible docking port for the refuse unit 300 and an additional hose to pass between the refuse unit 300 and the docking port.

The refuse unit 300 does not operate continuously but is used occasionally as necessary. After regular use, the compactor plate 364 is driven in the lengthwise direction of the refuse storage compartment 304 to compact the refuse therein.

When the refuse storage compartment 304 of a refuse unit 300 is filled up with refuse, or otherwise to be removed from the refuse collecting centre, the refuse unit 300

is hoisted up, for example by a hook-lift truck. This can be in a single action or by lifting up one end by way of one of the lugs 376 and dragging the unit 300 over the end of a truck with the help of the rollers 374 supporting the lower end of the unit. A hook lift truck can also be used to deliver the refuse unit 300 and push it into place on its rollers

5 374.

The split suction units 200 may be connected in parallel and/or series, based on similar principles to the parallel and series arrangements of the combination units described above. Figure 10A is a schematic view of a parallel pair arrangement 400 of

10 two split suction units 200. Figure 10B is a schematic view of a series pair arrangement 420 of two split suction units 200.

In Figure 10A, the input hoses 226A, 226B of two suction units 200 are connected to separate ports of a modulator unit 402. The modulator unit is made up of

15 four connector stations: first and second output connector stations 404A, 404B; and joining connector station 406; and an input connector station 408. The input hose 226A of the first suction unit 200A is connected to the top port of the first output connector station 404A. The input hose 226B of the second suction unit 200B is connected to the top port of the second output connector station 404B. There is no connexion between the

20 post-pump ports of the suction units. The two output connector stations 404A, 404B connect to separate side ports of the joining connector station 406. A third side port of the joining connector station 406 connects to a side port of the input connector station 408. Thus, when both suction units are operating, they draw air in parallel, through the input connector station 408 to the joining connector station 406, where the airstream

25 splits, some going to the first output connector station 404A and thence to the first suction unit 200A, the rest going to the second output connector station 404B and thence to the second suction unit 200B.

In Figure 10B, the input hose 226A of the first suction unit 200A is connected to

30 the top port of a first connector station 282. A post-pump port of the second suction unit 200A is connected by a connector hose to a side port of the first connector station 282. The input hose 226B of the second suction unit 200B is connected to the top port of an input connector station 422. Thus, when both suction units are operating, they draw air

in series, through the input connector station 422 to the second suction unit 200B, through the pump of the second suction unit 200B and thence through the first suction unit 200A.

5 Figure 11A shows an exemplary scaled up arrangement 410 of suction units in parallel. Four parallel pair arrangements 400A, 400B, 400C, 400D, each of two split suction units 200 are themselves arranged in parallel. The first and second parallel pair arrangements 400A, 400B are arranged in parallel through a first second-level modulator unit 412A. The input connector stations 408A, 408B of the two first-level modulator
10 units 402A, 402B act as the output connector stations to the first second-level modulator unit 412A. Likewise the third and fourth parallel pair arrangements 400C, 400D are arranged in series through a second second-level modulator unit 412B. The input connector stations 408C, 408D of the two first-level modulator units 402C, 402D act as the output connector stations to the second second-level modulator unit 412B. A final
15 joining connector station 414 connects the two second-level modulator units 412A, 412B. An airstream input line 416 provides an input to the final joining connector station 414.

 In use, when all the suction units of the scaled up arrangement 410 are operating,
20 the air flows add up in parallel to generate a large airflow at the final joining connector station 414, which is then split up over different levels to the individual suction units. Various of the ports and connector stations can be closed, as and if appropriate to reduce the airflow to what is necessary at any particular occasion.

25 Figure 11B shows an exemplary scaled up arrangement 430 of suction units in series and pairs of series suction units in parallel. Four series pair arrangements 420A, 420B, 420C, 420D, each of two split suction units 200 are themselves arranged in parallel. The first and second series pair arrangements 420A, 420B are arranged in parallel through a first first-level modulator unit 402A. The input connector stations
30 422A, 422B of the first and second series pair arrangements 420A, 420B act as the output connector stations to the first first-level modulator unit 402A. Likewise the third and fourth series pair arrangements 420C, 420D are arranged in parallel through a second first-level modulator unit 402B. The input connector stations 422C, 422D of the third

and fourth series pair arrangements 420C, 420D act as the output connector stations to the second first-level modulator unit 402A. A final joining connector station 414 connects the two first-level modulator units 402A, 402B. An airstream input line 416 provides an input to the final joining connector station 414.

5

In use, when all the suction units of the scaled up arrangement 430 are operating, the series air flows add up in parallel to generate a greater pressure and large airflow at the final joining connector station 414, which is then split up over different levels to the individual suction units. Various of the ports and connector stations can be closed, as
10 and if appropriate to reduce the pressure and airflow to what is necessary at any particular occasion.

For the above scaled up arrangements, the inputs are intended to be air only, without any refuse. The refuse is removed upstream. These arrangements just exemplify
15 variations in providing the necessary suction using scaling of smaller suction units.

The above scaled up arrangements are exemplary and may involve more or fewer parallel and series pairs, or triplets of suction units in series or parallel, and other combinations of series and parallel. The use of three suction units in parallel is seldom
20 necessary, except when to clear a blockage. Usually, it is more useful to provide a greater airflow. The use of the split suction units 200 is preferred, but the arrangements would work using large numbers of the combination units.

Figure 12 illustrates a combined arrangement, with a string of refuse units 300
25 arranged in parallel connected to an airstream inlet line 416, leading to two series pair arrangements 420A, 420B mounted in parallel. The airstream inlet line 416 is connected up, in parallel to each of the outlet ports of the refuse units 300. The inlet ports of the refuse units 300 are all mounted on a common refuse intake line 442, which connects to a clearing pipe of a refuse disposal and collection system. Arrows are shown in various
30 of the pipes. These do not represent simultaneous airflow, but the direction in which the air flows in each pipe.

In the exemplary arrangement shown in Figure 13, the refuse intake line 442 branches several times, one branch for each refuse unit 300, except the last refuse unit 300A in the arrangement, into which the line 442 leads without a branch. A first, branch valve 444 is provided in each branch between the refuse unit 300 and the line 442 (except the branch to the last suction unit). The branch valves 444 are used to close off the respective refuse units 300 from the line 442. Additionally, each refuse unit except the last one has a second, line valve 446 in the line 442, immediately downstream of the respective branch, to close off the line 442 to the refuse units 300 behind a closed second valve 446.

10

In use, amongst the refuse units 300 that are not full, the refuse unit 300 that is furthest along the intake line 442 from the clearing pipe is selected as the next refuse unit 300 to fill. All the branch valves 444 upstream of the selected refuse unit 300 are closed (those downstream of the selected refuse unit 300 may also be closed). The branch valve 444 of the selected refuse unit 300 is kept open. Further all the line valves 446 upstream of the selected refuse unit 300 are opened, whilst the line valve 446 of the selected refuse unit 300 is closed (those downstream of the selected refuse unit 300 are also generally closed).

15

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By closing all the branch valves 444 upstream of the selected refuse unit 300, refuse is not sucked into any of the upstream refuse units 300. By closing the line valve 446 of the selected refuse unit 300, refuse is not able to pass through the line 442 to any downstream refuse units. Thus refuse is only able to enter into the selected refuse unit 300. When the selected suction unit 300 has filled up, the branch valve 444 of the next upstream suction unit is opened and its line valve 446 closed. The branch valve 444 of the just filled suction unit 300 is closed. The just filled suction unit 300 can then be taken away for emptying.

25

The various branch and line valves 444, 446 (and the pumps of the suction units) can be controlled automatically to allow automatic emptying of a clearing pipe.

30

Figures 13A and 13B illustrate the valve positions and associated degree of emptiness of the refuse unit arrangement of Figure 12. Figure 12 has four refuse units

300. Therefore four refuse units 300 are shown in solid lines in Figures 13A and 14A. However a fifth refuse unit 300 is shown in dotted lines to indicate that the series can be of other numbers of refuse units, more than five or fewer than five. Figure 13A illustrates the arrangement 440 of refuse units 300 with all refuse units 300 empty. Thus, all the branch valves 444 are closed and all the line valves 446 are open. Figure 13B illustrates the same arrangement 440 of refuse units 300 but with the end two refuse units 300A, 300B full. Thus the branch valve 446 for the third last suction unit 300C is open, whilst all the others are closed. Additionally, the line valves 446 for the second last and third last refuse units 300B, 300C are also closed.

Although the arrangements of Figures 11 to 13 show specific numbers of units (suction and refuse), other embodiments would have similar arrangements but with different numbers of units as appropriate. Embodiments of the present invention are well suited to growing developments, where it is preferred to reduce the initial capital outlay where possible, or where the final size is not yet known. The number of refuse units and suction units present depends on the actual size of the development. As the development grows, so additional units, especially refuse units can be added. The only planning necessary is that there should be space available to lay out the various units and that all refuse pipes can be laid out to the same area. The available layouts enable efficient and organised use of land space

The above embodiments show all the units side by side. However, the invention is not so limited. Various units may be mounted on top of each other, for instance in stacks of two or more.

Variations in the use of the split suction units may also apply to the use of the combination suction units, and vice versa.

The embodiments of the present invention are able to provide refuse systems, for instance as shown, whose capacity can be scaled up or adjusted according to what is needed. Further, these suction and refuse collection units are mobile units and can be moved to a site as and when required, for example, when an existing pneumatic system might have broken down. Such suction and refuse collection units can be hooked up to

an existing system without interruption to the refuse collection system. Suction and refuse collection units can also be hooked up to an existing system as a back-up system, for example during maintenance.

- 5 While various embodiments of a refuse suction unit and their method of use have been described and illustrated in detail, it is to be understood that many changes, modifications and variations could be made to the present invention without departing from the scope of this invention.

CLAIMS

1. A refuse suction device comprising:
a suction pump, a pre-pump inlet duct and a post-pump outlet duct, the pre-pump
5 inlet duct and the post-pump outlet duct being in fluid communication with each other
through the pump;
at least one pre-pump or post-pump external port in fluid connexion with the
pump; and
a refuse collection compartment comprising a refuse and air inlet port and an
10 outlet, the refuse and air inlet port and the outlet being in fluid communication with each
other through the refuse collection compartment; wherein
the refuse collection compartment outlet is in fluid communication with the pre-
pump inlet duct; and
the at least one pre-pump or post-pump port is operable to connect to a port, pre
15 the pump, of another, similar refuse suction device.
2. A device according to claim 1, wherein the at least one pre-pump or post-pump
port is operable to connect to a port of the refuse and air inlet of another, similar refuse
suction device.
20
3. A device according to claim 1 or 2, wherein the at least one pre-pump or post-
pump port comprises at least one post-pump external port.
4. A device according to claim 3, wherein the at least one post-pump port is
25 operable to connect to the inlet of the refuse and air inlet port of another, similar refuse
suction device.
5. A device according to claim 3 or 4, further comprising a valve between the post-
pump inlet duct and each of the at least one post-pump ports.
30
6. A device according to any one of claims 3 to 5, further comprising an air filter on
the post-pump duct, after the at least one post-pump port.

7. A device according to claim 6, further comprising a valve for closing the air filter off from the post-pump duct
8. A device according to any one of the preceding claims, wherein the at least one pre-pump or post-pump port further comprises at least one pre-pump external port.
9. A device according to claim 8 when dependent on at least claim 3, wherein at least one post-pump port is operable to connect to at least one pre-pump port of another, similar refuse suction device.
10. A device according to claim 8 or 9, wherein the at least one pre-pump port is operable to connect to at least one pre-pump port of another, similar refuse suction device.
11. A device according to any one of claims 8 to 10, wherein the at least one pre-pump port is operable to connect to the inlet of the refuse and air inlet port of another, similar refuse suction device.
12. A device according to any one of claims 8 to 11, further comprising a valve between the pre-pump inlet duct and each of the at least one pre-pump ports.
13. A device according to any one of the preceding claims, further comprising an input hose connected in series with the refuse and air inlet port.
14. A device according to any one of the preceding claims, housed in a container of a size and shape corresponding to a standard freight container.
15. A device according to any one of the preceding claims, which is mobile and is operable on a vehicle and operable on the ground and/or further comprising roller means on its underside.
16. A refuse collection system comprising a plurality of individual refuse suction devices, each as defined in any one of the preceding claims, wherein the plurality of

devices are connected in parallel to add airflows together and/or in series to add suction pressures together.

17. A system according to claim 16, wherein the individual refuse suction devices are each as defined in any of claims 3 to 7 or any of claims 8 to 15 when dependent on at least claim 3, wherein the plurality of devices are connected in series, with at least one post-pump port of one of the devices connected to a port, pre the pump, of another one of the devices.

18. A system according to claim 16 or 17, wherein the individual refuse suction devices are each as defined in any of claims 8 to 12 or in claim 13, 14 or 15 when dependent on at least claim 8, wherein the plurality of devices are connected in series, with at least one post-pump port of one of the devices connected to a pre-pump port of another one of the devices.

19. A system according to any one of claims 16 to 18, wherein the plurality of devices are connected in parallel, with at least one port, pre the pump of one of the devices connected to a port, pre the pump, of another one of the devices.

20. A system according to claim 19, wherein the individual refuse suction devices are each as defined in any of claims 8 to 12 or in claim 13, 14 or 15 when dependent on at least claim 8, wherein the plurality of devices are connected in parallel, with at least one pre-pump port of one of the devices connected to pre-pump port of another one of the devices.

21. A system according to any one of claims 16 to 20, wherein the individual refuse suction devices are each as defined in any of claims 3 to 7 or any of claims 8 to 15 when dependent on at least claim 3, wherein at least two of the devices are connected in series, with at least one post-pump port of one of the devices connected to a port, pre the pump, of another one of the devices and at least two of the devices are connected in parallel, with at least one port, pre the pump of one of the devices connected to a port, pre the pump, of another one of the devices, and wherein one of the devices connected in series is also one of the devices connected in parallel.

22. A refuse collection system comprising a plurality of interconnected individual refuse suction devices, wherein

5 each of the refuse suction devices comprises: a suction pump, a pre-pump inlet duct and a post-pump outlet duct, the pre-pump inlet duct and the post-pump outlet duct being in fluid communication with each other through the pump, at least one pre-pump external port and at least one post-pump external port in fluid connexion with the pump; and

10 at least one pre-pump external port or at least one post-pump external port of one of the devices is connected to at least one post-pump external port of another one of the devices.

23. A system according to claim 22, wherein a plurality of the refuse suction devices are connected in parallel, to add airflows together.

15

24. A system according to claim 23, wherein parallel connexions comprise the pre-pump external ports of two refuse suction devices connected together.

25. A system according to any one of claims 22 to 24, wherein a plurality of the refuse suction devices are connected in series, to add suction pressures together.

20

26. A system according to claim 25, wherein series connexions comprise the pre-pump external port of one refuse suction device connected to the post-pump external port of another refuse suction device.

25

27. A system according to any one of claims 22 to 26, wherein the plurality of interconnected individual refuse suction devices are connected in series with a refuse collecting line from a source of refuse.

30 28. A system according to any one of claims 22 to 27, further comprising at least one refuse collection compartment in series connexion with a pre-pump port of at least one of the refuse suction devices.

29. A system according to claims 27 and 28, wherein the at least one refuse collection compartment is mounted in series between the plurality of interconnected individual refuse suction devices and the refuse collecting line.
- 5 30. A system according to claim 28 or 29, wherein the at least one refuse collection compartment comprises a plurality of refuse collection compartments mounted together in parallel.
31. A system according to any one of claims 28 to 30, wherein the or each refuse
10 collection compartment comprises an individual refuse unit.
32. A system according to any one of claims 22 to 31, wherein one or more of the suction devices is as defined in any one of claims 1 to 15.
- 15 33. A system according to any one of claims 22 to 32, wherein individual refuse suction devices further comprises an input hose connected in series with the pre-pump port of the device.
34. A system according to any one of claims 16 to 33, further comprising one or
20 more individual connector stations within the connexion between ports of different devices.
35. A system according to claims 33 and 34 or according to claim 34 when
25 dependent on at least claim 16, comprising one or more series connexions, where the input hose of one suction device is connected to the post-pump port of another suction device through a connector station.
36. A system according to claim 35, according to claims 33 and 34 or according to
30 claim 34 when dependent on at least claim 16, comprising one or more parallel connexions, where the input hose of one suction device is connected to the pre-pump port of another suction device through a connector station.

37. A system according to claim 36, wherein the input hose of one suction device is connected to the pre-pump port of another suction device through a connector station and the input hose of the another suction device.
- 5 38. A system according to claim 36, wherein the input hose of one suction device is connected to the pre-pump port of another suction device through two connector stations and the input hose of the another suction device.
39. A system according to any one of claims 16 to 38, wherein each of the suction
10 devices comprises an independent housing.
40. A system according to any one of claims 16 to 39, wherein each of the suction devices is independently mobile.
- 15 41. A system for collecting refuse comprising a plurality of suction devices connected together in parallel, to add airflows together, in series with a refuse collecting line.
42. A system for collecting refuse comprising a plurality of suction devices
20 connected together in series, to add suction pressures together, in series with a refuse collecting line.
43. A system according to claim 42, further comprising a plurality of suction devices in parallel with the suction devices connected together in series, to add airflows together.
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44. A system according to any one of claims 41 to 43, further comprising a plurality of refuse collection devices connected together in parallel, in series between the suction devices and refuse collecting line.
- 30 45. A system according to any one of claims 41 to 44, being a system as defined in any one of claims 16 to 40.

46. A method of providing a refuse collection system comprising providing a system according to any one of claims 16 to 45.
47. A method of collecting refuse comprising providing a system according to any one of claims 16 to 45 and activating one or more of the suction devices of the system to suck up refuse.
48. A method of collecting refuse comprising connecting a plurality of suction devices together in parallel to add airflows together, in series with a source of refuse through a refuse collecting line, and activating one or more of the suction devices to suck refuse from the source of refuse, through the refuse collecting line.
49. A method of collecting refuse comprising connecting a plurality of suction devices together in series to add suction pressures together, in series with a source of refuse through a refuse collecting line, and activating one or more of the suction devices to suck refuse from the source of refuse, through the refuse collecting line.
50. A method according to claim 49, further comprising connecting a plurality of further suction devices in parallel with the suction devices connected together in series, to add airflows together, to the refuse collecting line.
51. A method according to any one of claims 48 to 50, further comprising sucking the refuse into a plurality of refuse collection devices connected together in parallel, in series between the suction devices and refuse collecting line.
52. A method according to any one of claims 48 to 51, wherein individual suction devices comprise a pump and are mounted in an independent mobile housing
53. A method of assembling a refuse collection system comprising connecting together a plurality of refuse suction devices as defined in any one of claims 1 to 15, in parallel to add airflows together and/or in series to add suction pressures together.

54. A method according to claim 53, comprising fluidly connecting the pre-pump duct of at least one of the devices with the pre-pump duct of at least another one of the devices.
- 5 55. A method according to claim 53 or 54, comprising fluidly connecting the post-pump duct of at least one of the devices with the pre-pump duct of at least another one of the devices.
56. A refuse suction device constructed and arranged to operate substantially as
10 hereinbefore described, with reference to and as illustrated in accompanying Figures 2 to 13.
57. A refuse collection system constructed and arranged to operate substantially as
15 hereinbefore described, with reference to and as illustrated in accompanying Figures 2 to 13.
58. A system for collecting refuse constructed and arranged to operate substantially
as hereinbefore described, with reference to and as illustrated in accompanying Figures 2
20 to 13.
59. A method of providing a refuse collection system substantially as hereinbefore
described, with reference to and as illustrated in accompanying Figures 2 to 13.
60. A method of collecting refuse substantially as hereinbefore described, with
25 reference to and as illustrated in accompanying Figures 2 to 13.
61. A method of assembling a refuse collection system substantially as hereinbefore
described, with reference to and as illustrated in accompanying Figures 2 to 13.